BUILDING YOUR STRAW BALE HOME

FROM FOUNDATIONS TO THE ROOF

Brian Hodge

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Please note: This book provides information on building and construction principles of a broad nature. Any decision in relation to your specific building project should only be made after exercising the necessary personal due diligence, researching the topic and obtaining professional advice from engineers, building consultants and building inspectors.

Dedication

This book is dedicated to a great man.
A man that at 14 years of age worked a team of 10 horses,
and was productive.
A man that survived almost five years of combat in World War II.
A man that survived the great depression.
A man that had his land forcibly acquired by the government and started again.
A man that faced financial hardship and defeated it.
A man that faced incredible changes, and embraced them.
A man that undoubtedly despaired at my youth, but never rejected me.
A man that taught me to love my wife and be honourable.
A man of great intelligence and ethics.
A man that taught me that a man's word is his bond.
A rational man that embraces a challenge with confidence.
A man that taught me that there is a solution to every problem.
Proudly, this man is my Father.

Athol Stanley Hodge, born September 1919

Foreword

Humans have a long history of using straw in one way or another in the construction of shelters. The use of straw in a baled form for wall construction was pioneered by the early settlers in America out of a desperate need to protect their farm animals from severe winter cold weather, and the practice was later extended to build houses for humans. That was more than a century ago.

Our recent rediscovery of straw bale construction is largely derived from the realisation that our way of living is not sustainable if we keep doing things as we do now. Resources that support our materialistic lifestyle are depleting fast; animal species that are a vital part of our living environment are becoming extinct at an alarming rate.

Providing safe shelters has always occupied a position of utmost importance in any culture and in any society, be it simple or complex. However, in our effort to achieve that goal in a modern society, which is spreading fast all over the globe as traditional society is taken over by western influence, we are contributing to the destruction of our mother earth. Construction activity is the single biggest contributor to global warming.

Straw bale is a renewable resource. Compared with timber, which is regenerated typically every 20 to 30 years, straw is generated once or twice per year. As long as people need grain as a food source, straw will be generated as a by-product. Straw in many parts of the world is still regarded as a waste. Even its disposal has become an environmental issue, like burning in the field. On the other hand, straw has certain excellent properties as a building material, such as its thermal capacity. In baled form, it keeps its integrity reasonably well. Once rendered, straw is durable and strong.

Straw bale building has seen a renaissance in recent years. It is spreading fast like a wildfire to every corner of the earth. *Building Your Straw Bale Home* is a how-to book for people interested in straw bale building. It is a practical book reflecting the author's personal experience, with tips and wisdom learned from his own pitfalls and mistakes. The book deals with every facet of building a straw bale house, from council approval and insurance to construction and finishing. The hand-drawn illustrations in the book are most informative.

Importantly, this book is written in the context of Australian building practice, which is quite different from the practice in America or Europe. With admiration, I present to you this practical text on straw bale building. Believe me, you will be 'bitten' by the straw bale bug once your eyes open to the wonderful world of straw bale building. You will be infected and become a 'baler'.

Dr John Zhang
Hillbridge Designers and Engineers
May 2006

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Preface

Brian Hodge is a builder of some 30 years' experience, and has been involved in many aspects of the building industry – from levelling houses for the South Australian Housing Trust and replacing windows, to solving various building defects and helping owner-builders realise their dreams.

This book covers construction methods used in the standard processes of building. In the first chapter, 'Councils and straw bale houses', Brian discusses the various roles of architects, designers, engineers, certifiers and council officials. There is a simple way to succeed – use professional people who understand straw bale construction to document, approve and help build your home.

Site selection, the implications of sloping sites on construction costs, how to manage difficult sites and the importance of soil tests are covered early in the book. Chapter 3, 'Floors and foundations', has a very detailed description of stump and bearer construction, which is a widely adapted practice in Victoria, and a short description of concrete footings and slab construction. Brian provides an interesting comparison of the thermal properties of timber and concrete floors that should start many discussions among the design fraternity. As a matter of particular interest, Brian has just received a 5-star rating on a straw bale house with an insulated timber floor that is to be built in Churchill, Victoria.

I found Chapter 4, 'Straw bale walls', to be the most interesting and informative chapter. It describes the three wall types – loadbearing, infill straw bale and structural infill straw bale. Together with Chapter 5, 'Window and door openings', these two chapters give a detailed description about selecting straw bales, raising walls, compressing walls, lintels, and fixing windows and doors to straw bale walls. The important issue of weatherproofing wall openings is also covered.

Chapters 6 to 9 provide the reader with a carpenter's manual of constructing wall, ceiling and roof framing, and a description of the Kram internal walling method. This construction is commonly known in the building industry as 'first fix' or 'frame stage'. Chapter 10 then discusses the 'second fix' or 'lock-up stage' of carpentry, covering the installation of doors and windows. The installation of internal doors and the construction of staircases are covered in Chapters 14 and 17. Brian concludes this section of the book with a chapter on purchasing building materials, including second-hand materials that have many pitfalls. These chapters on building construction will be most useful to both owner-builders as well as students of building construction.

Brian also pays close attention to the proper installation of services such as electrical conduits and plumbing pipes, as both can cause moisture to build up in straw bale walls and ultimately cause the walls to fail. Interestingly, the book mainly covers earthen rendering of straw bale walls. There are other rendering techniques, including cement and lime render, but Brian does not cover them in great detail. Owner-builders, however, should be aware that other options are available. Inadequately rendered walls can lead to problems other than those caused by moisture. In Chapter 16, 'Mice', Brian tells us a story about mice making their home in a cosy straw bale house, entering through a poorly rendered section of a wall near the floor joists. Despite further rendering, the mice survived by drinking water that condensed on cold water pipes. Thankfully, he also tells how the mice were finally evicted.

This book is a good reference for anyone who has a desire to understand building construction or a desire to build a straw bale house to a high standard using well-researched methods.

Bohdan Dorniak
Architect
Townplanner
Licensed Builder
Designer of over 50 straw bale projects
President of Ausbale (The Australasian Straw Bale Building Association)

Introduction

Before venturing into the expedition of new developments within straw bale construction, it is imperative that all readers understand that this is not a new building system. Building with bales of straw has a successful history of over 100 years. Our ancestors were not bogged down with rules, regulations public liability insurance and the fear of litigation; they simply had a need to keep warm and dry. They were a people deeply reliant and connected to God and the land, and were totally reliant on both for their survival. They understood the concepts of cause and effect. They knew from experience that for the roof to withstand the pressures of the elements its timber frame would need to be a particular size. Most people think that this art died out a hundred years ago, but they are mistaken. The light timber framing code that specifies what size timber to use in particular applications did not exist in the 1960s. I often hear it said, 'they don't build houses like they used to'. My answer to this is 'thank goodness'. There is no doubt that the houses built since the inception of the timber framing code and a range of other codes are significantly stronger than their predecessors. Yet we cannot ignore the physical proof that the early buildings still standing, stand as monuments to their builders' understanding and capacity. It is for this reason you can be confident in your financial security in investing in a straw bale home.

Not withstanding the success of early straw bale builders, I applaud the modern day adventurer in the development of our modern day straw bale building. Today, more so than ever before, we have the capacity to calculate and test our building systems. At the University of Western Sydney, straw bale walls have been built within huge testing frames with pressure applied to the wall, the outcome is then digitally monitored for future engineering scrutiny and referral. Rendered walls have been tested for fire resistance and heat transfer. Not only are the actual walls tested, but also all the other components that make up a house thus ensuring everything meets the requirements of the relevant building code. Today is a day of information and technology, and today's straw bale buildings are part of this. You have every reason to be confident in the longevity of your new straw bale home. Those built by the simplest method without the technology and information that we have at our disposal have lasted over 100 years, who's to say how much longer our new buildings will last.

The materials available to builders today are far greater than even 30 years ago when I first started working in the industry, and the range of products grows yearly. The incorporation of these new materials are heralded by some and snubbed by others. We walk a fine line between embracing all without question and throwing out the baby with the bath water. Many of the new materials are, to say the least, ecologically unsavoury. It may however be the embracing of some of these products that will increase the life expectancy of our new generation of straw bale houses. If the ecological issue is only its longevity in our landfill, perhaps these may well be the type of products that are ideal for use in the construction of a dwelling that we want to last forever.

The aim of this book

While I am concerned about the ecological issues associated with providing housing for our population, I will not delve into that area in this book. There are many people much better qualified than I to deal with these issues. This book is written in response to the request by many owner-builders for uncluttered information on how they can build their own home. It is not an encyclopaedia of all of the research into straw bale construction or the various approaches to straw bale construction. There is a wealth of information available in good books and on the Internet that provide a broader approach to straw bale building, many of these are listed in the rear of the book. The recommended construction systems described in this book are not merely theories that should work; they are tried methods, which have been incorporated into real buildings that stand today without sign of failure. They are methods established from research and consultation with structural engineers – people with a deep understanding of the properties of straw, having had many years of experience in the design and manufacture of straw related products. These are people at the cutting edge of technology, who will soon release new straw products with huge ecological and structural benefits to the building industry in general. Overlay this knowledge with 30 years of personal experience and you have a clear and concise description of how to build your straw bale home.

The aim of this book is to provide you with the basic information required to build your own home. In my training courses I explain to people that they should be able to build a simple straw bale home after reading the book and completing the training course. I am constantly amazed at the capacity of my owner-builders. The homes they are building range from 9 squares to 38 squares. I am constantly encouraged by the strength of character and determination that they exhibit to fulfil the dream of building their own homes. I count it a privilege to be able to contribute to their capacity to achieve their dream, and trust that this book will inspire you with the confidence that you too can live the dream of building your own straw bale home.

The costs of straw bale houses

One of the most common questions I am asked is 'how much will it cost to build my own straw bale home?' This question cannot be answered without information that is not available until the design is completed and the site chosen. However, in an attempt to provide an idea of what is possible, I have listed the costs associated with the actual construction of a two-bedroom, one-bathroom home of approximately 95 square metres (10 squares), which was completed in 2005 by my son, Brad Hodge. All costs listed below and elsewhere in this book are in Australian dollars.

The home is a load-bearing straw bale home with a timber floor supported on concrete stumps. The costs listed are related to everything within the building envelope including the gutters on the roof. It does not include the cost of the septic tank, the power connections to the property and other site-specific costs. While it does include the cost of plumbing and electrical work within the house, it should be noted that a friend fitted the roofing iron and gutters at no cost, which would have otherwise cost approximately $1000. Furthermore, the electrician allowed the owner to provide their own labour to fit the cables into the wall, which would probably equate to savings of $300–400. The costs related to bank fees, engineering, drafting and the actual building permit are also excluded, and, obviously, given that Brad is my son, I did not charge him for my consulting services. Just prior to building this home Brad was a manager of a retail outlet. Brad's main attributes regarding the construction were his determination and rational approach to construction. Brad had no previous building experience so this house is an example that could be duplicated by any rational owner-builder with the drive to achieve the end result. Brad was given a second-hand upright oven, and using second-hand windows, doors and roofing iron reduced costs further. Apart from these, all materials were purchased new.

Building costs for the two-bedroom, one-bathroom, 10 square home in Heathcote, Victoria, completed in 2005.

Timber and roof trusses for the house frame	$6538
Straw bale walls and render	$2358
Lock-up, including second-hand windows and doors	$651
Fix – internal doors, ceiling linings, etc.	$1503
Fittings, including bathroom, kitchen, laundry, toilet and hot water service	$1094
Electrical	$3362
Plumber	$5092
Insulation	$766
Miscellaneous	$440
Total actual house cost	$21,804

Figure I.1 The straw bale home in Heathcote, Victoria

Figure I.2 The lounge room of the straw bale home

The three construction methods for straw bale houses

Straw bale houses are constructed in one of three different methods. The first and oldest method is that of load bearing. As the name suggests, the bales of straw support the roof. The second is infill construction. This has been particularly popular in the revival of straw bale building, as it has been easier to convince the regulatory authorities that this is a structurally sound system. This building type has either a steel or timber structure that is totally self-supporting with the straw bales fitted between the supports to fill in the gaps. The third method is a combination of both of the above, and is referred to as structural infill. The structural infill home has a substructure to carry the vertical load of the roof and/or upper floor joists, however it is not self-supporting. As opposed to infill construction, it has no bracing to provide the lateral stability of the structure. This lateral stability is achieved through the installation of straw bales into the walls.

The two major threats to a straw bale house

1. It is widely accepted around the world that the primary enemy of a straw bale building is water. Because straw is an organic material, the introduction of moisture will promote the organic breakdown of the straw. This is also an issue for timber frames, although it takes considerably longer for the long-term affects to become evident. In many ways it is an advantage that straw responds more quickly, as greater care is taken to avoid the problem in the first case. In the chapters following, I will

explain the hidden traps in construction that might result in the increase of moisture in the bale walls, and how to avoid them.

2. In Australia termites are a constant threat to buildings. These creatures were created to clean up the timber on the ground so it can return to the soil to be the source of nutrients for future trees. We have interrupted the natural cycle and built houses in the place of forests. Their creator programmed them to eat timber and some to eat grasses. The original programming has not been altered just because we changed their environment, so now they eat the timber in our houses, which to them is just as good as fallen timber on the forest floor. The use of treated timber and steel in the frame of a house is a short-sighted solution, for they will merely move onto the next available timber. The only solution is to prevent their entry into the house. Given this solution, I believe the most appropriate solution financially and ecologically is the use of untreated plantation timber in the frame of the house.

Questions to ask yourself

1. Do you have the physical capacity to lift a bale of straw?
2. Are you a rational person? Building a house is the most rational thing you will ever do. It is all about cause and effect.
3. Are you a good communicator? You will have to negotiate with suppliers, contractors and probably the building inspectors. To get upset and shout doesn't achieve anything in the building industry. This is an industry that does not respond well to bullying.
4. Are you humble? To be a successful owner-builder you will have to acknowledge your inadequacy and need for help. Many times throughout the construction of your home you will be unsure of what to do next. It is imperative that you seek help rather than press on and make mistakes that might cost thousands of dollars to rectify.
5. Do you have the financial capacity to see the job through to the end? When building, particularly for the first time, there are always hidden extras. Make sure that you have the capacity to cover the extras. I would strongly recommend that you allow a minimum of 10% over and above your estimated costs to cover the unavoidable, but don't use this allowance as an excuse to be sloppy in your costing of the job.
6. Do you enjoy a challenge, or are you going to collapse at the first sign of hardship? Building your own home is the most challenging and most rewarding thing you will ever do. For the average Joe, it is like climbing Mt Everest. It will make you hurt. It will make you cry. It will probably cause you and your partner to have disagreements. But most of all, you will never forget the elation from the view from the top of the mountain of completion. The difference between this and Mt Everest is that you get to live in that victory for as long as you choose.

The joy of building your own straw bale home

The one thing that cannot be adequately explained in the pages of a book is the emotional environment that can be created in a straw bale house. I can explain that the walls can be as lumpy or as smooth as you like in white, brown or any other colour. The surface of the walls can have a smooth metal-trowelled finish much like that of concrete or a rougher foam block finish. You can have skirting and architraves or simply blend the render into the windows and floors. You can include beautiful sculptures into your walls or cut niches into the walls to hold your most prized possessions. You can have a flat roof or a steeply sloped roof. You can have timber ceilings or flat plaster. All of these things are true, but none of them explain what it is like to live in a straw bale home. I am yet to meet a person who has lived in a straw bale home who then wanted to return to living in the conventional brick veneer house. There is a peace and tranquillity that cannot be explained. I don't know whether it is because of the lack of chemicals in the wall, the soft appearance of gentle undulations in the walls or the sense of security that comes from the deep mansion-like walls. If you are yet to experience life in a straw bale home, do yourself a favour; rent one for the weekend. While the numbers are still limited, there are straw bale bed and breakfast facilities throughout Australia and I have no doubt other parts of the world. Track one down and set aside time to live the experience. Take a good book, playing cards, a board game or two, or maybe some sweet smelling candles and take the time to breathe in and out. Leave the rat race to the other rats for a weekend or better still a week or two. You will never regret it.

1

Councils and straw bale houses

City officials and private inspectors

Regulatory bodies and the owner-builder

The building departments of local councils put off many owner-builders. Many councils have a bad reputation for being uncooperative and difficult to communicate with. I believe that to a large extent this is merely a misunderstanding of what they are trying to achieve in the thankless task that they perform. There are however exceptions to this, where an individual in a council for some reason seems to be completely uncooperative. Maybe that person has their own barrow to push, or you may have just caught them on a bad day.

Remember that it is impossible to know what another person is going through, or what life pressures they are living with. We all need to be more patient with one another. From my experience, unlike what seems to be popular opinion, city officials are people just like you and me. I know I respond best when people are polite, if not kind, to me. If I think I can help you I will feel rewarded by the experience. Give them the opportunity to help you – you might just make their day. I once had a good friend and pastor tell me, 'if you are having a hard time, do something for someone else, it will lift you above the circumstance that is bogging you down'. I have found this to be true.

The building department has the arduous task of maintaining the general quality, both structurally and aesthetically, of the housing developments within their jurisdiction. If they weren't doing their job you could have shanty towns resembling the humpies that once occupied the rubbish dump in Manila next door to your property. If you can gain the understanding that they are not actually against you but for you, your relationship with these departments will bring you much greater rewards.

The council

The council determines who can build what on what land. If you need a town-planning permit prior to constructing a house on your property you will have to do this through the local city council. I might mention at this point that if you have not yet purchased land, before you sign anything, check with the local authority first to ensure that you will be permitted to build on the land. You can often gain other details from the council as well. For instance, was there a dam on the property that has been filled, are you likely to strike rock, or is the area prone to flooding? All of these scenarios would cause an increase in foundation costs – sometimes dramatic increases. This type of information is often only available to people with the right approach, as it will take some effort on the part of the official to get this for you.

Private building surveyors

In Victoria, it is possible to employ the services of a private building surveyor to issue your building permit. The private surveyor will issue the permit to construct the dwelling and do all necessary on site inspections rather than the local authority. On behalf of my owner-builders, I employ the services of a building surveyor who is able to issue permits for anywhere in Victoria or NSW. I have been associated with this particularly surveyor for four or five years so he is up to date with the new technology in straw bale construction. If you are able to employ the services of a surveyor such as this, it will certainly reduce the anxiety in gaining a building permit. With all the new developments in straw bale construction it would be difficult for local councils to stay abreast of every change. Their inability to keep up is often reflected in their insistence on the inclusion of time consuming and costly practices that are, in my opinion, often detrimental to the longevity of the building – practices such as stitching wire netting to the straw bales, or insisting on cement render.

It should be remembered that while the private inspector is working for you, just like a city official, he is legally obliged to ensure that the house is built in accordance with the building code. You may think that this is unreasonable as you may not be concerned that the house does not comply – but what about the future owner? One thing you can be sure of; if you are born, you are going to die. Not only do private inspectors have legal and moral obligations, but significant financial liability if his inspection fails to detect a problem that has legal ramifications later on. Imagine if your house collapsed and people were maimed or killed. Who takes the rap? Who pays the compensation? Anyone in the chain of events with the financial capacity to cough up. That's what the escalating public liability insurance costs are all about.

The basic criteria for authorities

Construction details and material specifications

You need to provide the building surveyor unquestionable proof that the house you want to build can and will be built in compliance with the law. Primarily, this is proof that it will not fall down, a requirement that I believe all owner-builders would seek to fulfil. Most owner-builders will need the services of a building consultant, and more often than not, an engineer. A good consultant will be able to ascertain the appropriate construction type to best suit the owner-builder's ability and the desired end result. A good consultant can establish timber sizes and other materials to be used that are within the realm of normal construction. Most owner-builders would benefit from a construction schedule that a good consultant can supply. This will negate many of the problems caused by doing work out of the correct sequence – a challenge that many owner-builders face.

Depending on your personal ability, it may be appropriate to get the consultant to produce a timber list for the construction. If you do get the timber list, be sure to get specific details as to where each individual piece of timber is to be used, otherwise you will likely cut the wrong timber for the wrong position and end up in a totally confused mess. I have found that this type of confusion is what causes owner-builders to get bogged down and disheartened. Make sure you understand the instructions about what timber is to be used where. It needs to be clear and concise. Many owner-builders will order materials in small quantities to avoid supply errors. This will reduce the likelihood of errors, however, it is likely to lift the cost of the job, as it is difficult to buy materials at a competitive rate when just buying bits and pieces. Furthermore, it is very frustrating if you have three hours of daylight left and no materials to work with.

Engineering requirements

It is advisable to have an engineer check your plans for any areas that require specific specifications prior to lodgement for a building permit. This may save you weeks when getting the permit. Plans with incomplete documentation have a habit of ending up on the bottom of the pile. It is the engineer that will supply the building surveyor with proof of the structural integrity of the house. This is particularly important when building a straw bale house, as it is still deemed as an alternative construction type.

The architect or draftsperson

Most owner-builders will employ the services of a draftsperson or architect to prepare the plans and details for submission to the building surveyor. I have on one occasion submitted drawings that I drew on graph paper and photocopied. It was a very small extension for a customer with severe financial limitations and too few bedrooms to cater for the needs of his growing family. I didn't have any difficulties getting the permit, however it should be noted that it was a very simple weatherboard extension that did not require a town-planning permit and was prior to the five-star energy rating requirements. I would not recommend this approach for a straw bale house.

You need the building surveyor to have confidence in you as an owner-builder. If the plans are not presented in a professional manner it may cause the building surveyor to doubt your capacity to complete the project without causing him or her undue stress. First impressions really do count. This does not mean that you should pay thousands of dollars for fancy coloured plans. When the time comes to construct the house you need drawings that are simple and clear. It is the general consensus of carpenters that drawings from some architects have so much information that they are confusing. If the drawings are confusing to a tradesperson, then how much more confusing would they be for an owner-builder? Our building surveyor is sharp enough to look past fancy drawings to ensure the details are full and correct. I would hope that your surveyor would do likewise. If fancy plans are enough to influence your surveyor you have got a problem.

The price of drawings

Does a high price for drawings ensure you have good drawings? The cost of drafting varies incredibly. Ensure that you get a quote or at least an estimate for the work before you employ their services. It is one area of construction that frequently catches people off guard. Last year I had one of my owner-builders bring plans to me that were unsatisfactory. I had to have the plans redrawn before they could be submitted to the building surveyor. The new plans, at a cost of about $1500 did not have pretty colours or drawings of cars parked in the driveway, but they gave us the details required. I am sure it was disappointing for the owners when they realised that the original unsatisfactory drawings had cost almost three times that of the new drawings. Little wonder then that some owner-builders lose heart.

Plans not only supply details required for a town planning permit and the building permit, but should also provide important assembly details that the owner-builder may not otherwise be aware of. Money spent in the planning stage is money well spent. If it is well targeted it is likely to save you thousands in construction costs to say nothing of time; a commodity in short supply for most owner-builders. It is much easier to shift a door or wall on a piece of paper than on the building after it has been constructed.

Checklist

The following is a checklist of documentation required when lodging an application for a building permit.

1. Relevant fees and charges
2. Completed 'Application for a Building Permit'
3. Copy of Title and Plan of subdivision
4. Proof of ownership of the land or permission from the owner to apply for a building permit
5. Water authority consent – sewer plans
6. Town Planning Permit
7. Septic Tank Permit or details of the application for the permit (the Septic Permit will be required prior to the issuing of a building permit)
8. Project specifications (these details will be on the drawings)
9. Certified computations (engineer will supply this)
10. Energy rating
11. Soil report and classification
12. Footing, slab design
13. Rescode site analysis – private open space, overshadowing, overlooking
14. Site levels
15. Plans (three sets): site plan, floor plan, section, and elevations
16. Roof truss design and layout

There may be additional requirements in specific areas such as areas prone to bushfire. Some of the details in this list may not be required in your area, or may not be relevant to your house. For example, if your house is being built on stumps, you will not need to supply a footing, slab design. If you are not using roof trusses you will not be supplying the roof truss design and layout.

This list is a guide to the type of information that you will be required to supply as part of your application for a building permit, however you should contact your building surveyor to confirm the details required in your area.

On site inspections

The building inspector's responsibility

It is the building inspector's responsibility to ensure that the construction of any dwelling under their supervision complies with the details submitted and approved in the building permit application. For example, if the building permit is issued with the specifications of timber floor joists being fitted 450 mm apart, it is the inspector's responsibility to ensure that this is adhered to. If you decide that fitting them at 455 mm apart works better for you, the inspector is obliged to demand that you bring the construction in line with the specifications – even if it means that you must demolish the work done and start again.

Inspectors are wary of owner-builders for fear that the owner-builder has misinterpreted the construction details or missed something. If you make it known that you have a qualified tradesperson or consultant assisting you, it is likely to remove some of their concern. Also, detailed drawings that provide clear and concise details on how to build your home will further increase the inspector's confidence. If the inspector knows that you are well informed and supported by knowledgeable experienced people he will be a lot more comfortable with the whole process.

It is inappropriate to pretend that you have all the answers if you don't. Neither is it appropriate to present yourself as ignorant of the requirements of the construction. If the inspector suggests that part of the construction does not comply with the building permit, or if he or she asks a question that you do not have a clear answer to, refer back to the approved drawings and building permit. It is your responsibility to build the house in compliance with the building permit. It is the inspector's responsibility to ensure that you do that.

Normal inspections required

Most houses will have an inspection of trenches for foundations prior to the insertion of plastic. Another inspection of plastic, formwork and steel just prior to pouring the concrete for slab floors, and stump holes for houses with timber floors is required.

Houses with timber floors where sheet flooring is used will often require a sub-floor inspection of the structure before the sheet flooring is laid.

All homes and extensions will require a frame inspection, and if a bathroom is involved you may be asked to have a flashing inspection prior to fitting the sheeting over showers and baths.

The final inspection is of the completed house. At this point you will have to supply the building inspector with certificates of compliance from your electrician, plumber and for termite treatment if it is required in your area. You will be required to supply a plumbing certificate not only for the hot and cold water, but also the disposal of black and grey water, and all roofing work.

It is following the final inspection that you will receive a certificate of occupancy.

It should be noted that a certificate of occupancy for a house is equivalent to a roadworthy certificate for a car. If you don't have one, it is against the law to live in the house. Furthermore, just as with car insurance and un-roadworthy vehicles, while you may have paid the premium on the insurance for your house, without a certificate of occupancy you may not be covered by your insurance policy.

Complaints from building inspectors

Both you and the inspector have the same goal, the construction of a compliant building. If the inspector is unhappy with the construction, it is more than appropriate to have them go over the drawings and specifications with you to determine if there is any variance from the specifications, or if it is simply a matter of the inspector's personal preference in construction. If you have varied from the specifications, fix it without complaint. Actually, you should thank the inspector for bringing the error to your attention.

If it is found that the complaint is based on the personal position of the inspector rather than the job specifications, you might still choose to alter it if there is not too much involved. It is often prudent to comply with the inspector's personal preference rather than to make a 'mountain out of a mole hill'. However, it is best to do this after you have both reviewed the drawings, whereupon it is established that this is a matter of the inspector's personal preference rather than a requirement of the job specifications. If the inspector has a personal barrow to push, rather than a true concern for the building's compliance with the specifications, this approach will normally overcome personal biases and negate future bogus complaints.

Write down, and be seen to write down the inspector's directions and/or grievances. This will enable you to rectify the problems without missing anything. It will also show the inspector that you take this very seriously, to say nothing of establishing accountability on the inspector's part.

The inspector's requirements

From my experience, most inspectors are particularly concerned with the transfer of roof and floor loads to the ground below the structure. For example, when a house has a large roof beam to support a big section of the roof, it will require a post to hold the beam up. The details of the material and dimensions of the post will be specified in the building permit. The approved plans, which form part of the building permit, should also show how the bottom of the post is to be supported. In the case of a timber floor, you will normally be required to have a stump or pier directly below the bottom of the post. This will enable the weight of the roof to be transferred through the beam to the post, which will in turn transfer the weight through to the stump or pier to the ground below.

These areas of concentrated load are, for good reason, of particular concern to the building inspectors. One of the other major concerns for building inspectors is the preparation of foundations for the house. Ensure that there is no loose soil or clods of dirt in the trenches or stump holes at the time of the inspection and check it again before pouring any concrete.

2

Site preparation and marking for foundations

It is not my intention to give any consideration to the positioning of your house in order to take advantage of passive solar gain to reduce winter heating costs or any other environmental issues. There are many good books that deal with these issues, written by very qualified experts.

Considerations when choosing a building site

Foundations and soil types

Foundations are designed to suit the soil type. The soil type is determined by a soil report. The soil testers will go on site and drill several holes within the building envelope to ascertain the capacity of the soil to support a structure. The reason there are several tests taken is to reduce the likelihood of any surprises when it comes time to dig the foundations. The engineer you are using to do computations for the building will be able to arrange a soil report for you, and do any design work necessary for the foundations.

Building site excavation

Once you have established where the house is to be situated and the direction that the building is to face, it may be necessary to do some excavation prior to construction. Whether you are employing a contractor or doing the excavations yourself will have little bearing on the marking on the ground required to ensure the correct shape area and depth of the final excavation. In some instances it will be appropriate to excavate a site for a house built on stumps, however it is more likely to be required for houses with a concrete floor.

Building on sloping sites

There are many contributing factors to consider when looking at purchasing land, not the least of which is the slope of the land. There is no question that it costs more to build a house on a sloping site, however this extra cost in many instances is counteracted by a lower land price. Unfortunately the land with views are most often those with sloping sites. When building on a sloping site the workload can be dramatically increased. I remember a house I built in Ferntree Gully, Victoria. This property had magnificent views of the city. On a clear night you could see the windows of the Rialto, then the tallest building in Melbourne. The house was on the high side of the road at the very back of the property. We had an earthmoving contractor excavate a flat area for the garage and office in front of the house, but in order to capture the city views, the house was built on stumps rather than excavate.

The highest corner of the house was 3.9 metres high to the ground floor. Only the smaller timber trucks were able to access the excavated flat area, and so the bulk of the materials to build this 35 square house were dropped at the street. It was approximately 80 metres from the street to the front of the house. There was about a twenty metre climb in the land to the front of the house, almost 4 metres up a ladder to the ground floor of the house, another 2.7 metres to the next floor and a further 5 metres to the peak of the roof. It was a mammoth task just to get a piece of timber. If this is your situation, and there is any way you can gain access to the rear of the house through a neighbouring property, I strongly suggest that you do so. Even if it costs you money to get the back access, it is worth it. Even on a small house it will save you weeks of time to say nothing of the energy you will waste climbing the hill time after time.

Fall of the land

There is a simple and cost effective method of getting a rough idea of the fall of the land, but this is not recommended for the actual construction. If after checking the fall of the land by this method you find that the theoretical fall in the land is less than 600 mm it will probably be accurate enough for supply to the engineer and for the purposes of costings. This depends of course on how accurate you perform this task.

The simplest method is to utilise a string level. A string level is manufactured from plastic. It has two hooks to attach it to a string line, and a bubble the same as a normal spirit level to indicate when the string is being held level (see Figure 2.1). Alternatively a standard 1.2 metre spirit level can be used.

Establishing the approximate fall of the land

Hammer a stake into the ground at the probable corner of the house that is at the highest point of land. Pull a string line from this stake to any other position on the property that you want to measure to. Hold the string against a vertical piece of timber to enable you to pull the string tight across the timber. Have a second person hold a spirit level with one end of the level near the peg in the ground. When using a string level the second person will monitor the level to determine at what point the string is held level. The level is to be held in the horizontal position by getting the bubble in the level to stay central between the two lines marked on the level. The person holding the string line at the vertical timber is now to lift or lower the string line until the string is parallel with the spirit level while held in the horizontal position. Once the string is deemed to be horizontal as determined by the spirit level, mark the position of the string where it sits across the vertical timber. The measurement from the bottom of the vertical timber to the mark on the string line is, in theory, the fall of the land between the peg and the base of the vertical timber.

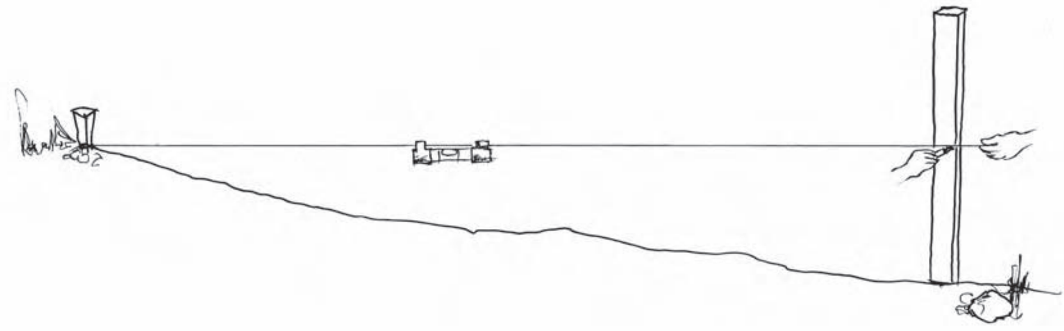


Figure 2.1 String line level to establish the basic fall in the building site

Tying a string line

When using a string line, avoid tying knots in the line. The string line should have a permanent loop in the end of the line, which will often be used to loop over a nail (Figure 2.2a). To fix the other end of the string line, create a loop of line over your finger (Figure 2.2b). Using four circular motions of your finger around the string line (Figure 2.2c), the string leading to the loop of the line will become twisted. Place this loop over the nail and pull the loose end of the line back toward the opposite first nail and loop of the string line (Figure 2.2d), thereby tightening the line. Once the line is at the desired tension, pull the loose end of the line in the opposite direction (Figure 2.2e). This will cause the twisted section of the line to become entangled on itself thereby fixing the line in the taught position (Figure 2.2f).

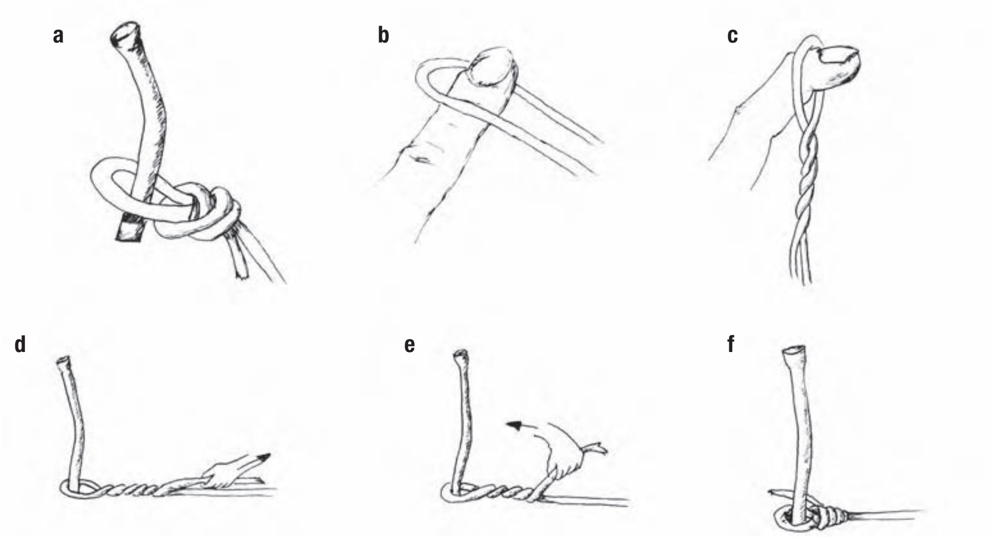


Figure 2.2 Tying a string line

Why you need to know the fall of the land

It is necessary to supply your draftsperson with details of the fall in the land, as this must be indicated on your application for a building permit. It is also paramount in determining the engineering requirements and final cost of the building. To look at it and guess is not good enough. A difference of even a hundred millimetres can make a significant difference. Underestimating this may mean that all the engineers' calculations are incorrect and that the recommended construction system is inappropriate. Any decent building equipment hire company will be able to hire you either a dumpy level or a laser level. The dumpy level is simple to use and accurate to a few millimetres, more than sufficient for the initial site inspection.

Ensure that you get instructions on how to set up and use the level that you hire prior to leaving the hire company. Dumpy levels enable you to measure the variance in height from one position to another. Mark the likely positions of the corners of the house on the surface of the ground. Set up the dumpy level just outside the area of the house on higher ground. One person will look through the dumpy level while another holds the staff on the positions that you wish to take a reading from. A tripod on which the dumpy level is to be mounted, and the staff will both be supplied with the dumpy level. Reading the measurements off the staff in the various designated positions on the property will give you comparative measurements. The smallest reading is to be the term of reference back to which all other readings shall refer, and shall be deemed as zero or home base. Deduct this smallest reading from the other readings to establish the height variance in the land between the home base and each of the other positions. This is roughly the height the stumps will protrude above ground level, or alternatively the depth of excavation required.

If you do not feel confident to measure the fall of the land yourself, contact your building consultant who may be able to assist you. If not, you will need to employ the services of a land surveyor.

Excavation of a building site

What to allow for in the area of excavation

Prior to marking for excavation, establish the total flat area required for the house and any surrounding landscape area. Include a drainage area for the removal of surface water that may gather around the house, particularly between the house and the face of the cutting, the deepest part of the excavation. If sullage lines and/or a septic tank are required, discuss with your plumber their likely position and any necessary allowances for them in the excavation.

Cut and fill excavation

On many occasions a building site is prepared by a method known as cut and fill. In this method the soil removed is put on top of the lower area of the building envelope thereby raising the lower land to the height of the excavation area, as shown in Figure 2.3.

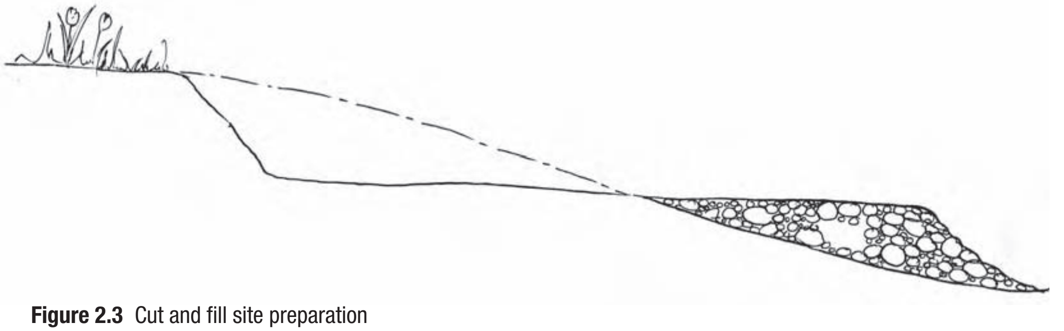


Figure 2.3 Cut and fill site preparation

Personally I am not a great supporter of this method of excavation. It is ideal if you are building a farm shed or doghouse where it matters little if the floor moves and cracks, but for a house it is important that the foundations are set on solid ground. This method is fine for a house with stumps, although it may mean that the stump holes are quite deep which makes them difficult to clean out. The depth of the hole is determined by the depth into natural ground level as specified on the soil report for the property, not the actual depth of the hole.

Potential problems with cut and fill excavations.
I have seen many concrete floors that have been poured on a cut and fill excavation that have cracked. I have a factory in central Victoria that has been constructed in this way and the floor has cracked. It is not too much of a concern in this application, however it is a totally different situation for a house. If the floor of a house cracks it will have an impact on termite treatment, floor coverings and moisture penetration. If the floor continues to drop and the crack in the floor worsens, it is more than just a little serious. These are all complications that I would rather do without.

A cracking concrete floor on cut and fill
Some time back I purchased an existing house on acreage in Ravenswood just out of Bendigo in Victoria. It was a house that needed some love and attention in a position that suited our needs at the time. I managed to gain a copy of the original plans submitted to the council for the original building permit, and was amused that instead of the tile roof specified on the plans the builder had fitted an iron roof. Furthermore, the roof trusses were set out to carry roof tiles rather than iron. It wasn't until we removed the old carpet that things became somewhat clearer. There were cracks across the centre of the lounge room floor from one side of the room to the other – cracks approximately 5 or 6 mm wide. I was not surprised, for the line of the cracking was in line with the junction of the fill to the excavation.

These cracks had been filled with an epoxy resin, probably in the early stages of construction, and there was no sign of further movement. I would assume that there were some anxious moments for the builder, and an appropriate solution of deleting the heavy cement tiles and fitting iron instead was the most feasible solution to the problem. This is not a problem I have ever faced with any of the homes I have built, for I have never built a home on a cut and fill site. If this was a requirement of the job I have always decided to allow the customer the benefit of finding another builder.

Cut and fill is ideal if the fill is used to provide a flat area for a garden, as is the case with our home in central Victoria. Many an engineer would disagree, but I would prefer to risk developing my vegetable garden on the fill rather than my house. The veggie garden will benefit from the looser soil and it will be easier to dig. I strongly suggest you keep the fill area for the garden.

Retaining the soil at the face of a cutting

Having established the total area that needs to be flat, including the required solid area as opposed to fill, you will need to decide on your method of retaining soil at the face of the cutting. The method of retaining this soil will have a bearing on the area to be marked out on the surface of the site to produce the appropriate flat area. If you are planning on building a retaining wall to stabilise the cutting, the surface markings will need to be increased to accommodate the installation of this wall plus the drainage and aggregate to be used behind the wall. If the retaining wall is greater than 900 mm high you will need to have an engineer design the retaining wall. This design forms part of you application for a building permit. The other method of dealing with the face of the cutting is to do what is known as 'batter back'. This method simply modifies the face of the cutting from a vertical face to a 45-degree angle. With this method it will be necessary to increase the dimensions of the surface marking by one metre back into the cutting, for every metre in depth. This method is extremely popular in a rural setting where there are fewer limitations on space. In a city environment it is often difficult to accommodate this method, as the total land area available is much more restricted.

Disposal of the soil removed

It is important when deciding on the total area of the fill and excavation, to take into consideration where the excavated soil is going to be put. If the excavated soil is to be removed from the property it will not affect the job. However if the soil has to be accommodated on the building site this needs to be kept in mind when designing the cutting.

When soil is excavated it will double in volume, so allow for this in your calculation for the disposal and/or relocation of this soil. If you are planning to remove the soil from your land, it will save you a considerable amount of time and money if you can locate a site as close as possible to your property to dump the soil. You might consider advertising in the local paper for anyone that requires free clean fill.

The excavator may give you a quote for the work including disposal of excess soil but it is more likely they will charge by the hour. To have a place to dump the soil in close proximity to your property will affect any quote you are given. When it comes to excavations time really is money. If you are unable to dispose of the soil free of charge there will be additional cost for dumping the soil in land fill. This is a lesser issue in smaller towns where you can sometimes negotiate a special rate for disposal of clean fill, but the cost can get away from you in a city setting so don't make the assumption it will take care of itself.

Marking the ground to guide the excavator

Products used to mark the excavation

There are various ways of marking the surface of the site. The least offensive ecologically is to create lines on the ground with lime or plaster dust. I have even seen the use of white sand as a marker. There are ground-marking paints specifically for the task which come in pressure packs and are designed to be sprayed upside down as opposed to normal pressure packs. They come in a variety of fluorescent colours and are quite simple to use. Most good hardware stores will either have these products or be able to order them in for you.

When marking the site for excavation start with the area of hard excavation as opposed to the filled area. If the site has a significant gradient you will need to allow additional area due to the fall in the land. If in doubt add a little more area than necessary, as there is nothing worse than having to wait for the excavator to return to extend the cutting. Earthmovers charge travelling time plus hours worked. You do not want to duplicate the charges for travelling.

If the building is an odd shape then it would be beneficial for the cutting to emulate the shape of the building, and this can be accommodated.

Marking the site to guide the excavator

Mark the ground at the outer corners of the area that is to have the solid excavated area (see Figure 2.4).

Figure 2.4 Establish the required cut and fill area

Next you will need to mark the total area of the cutting including any area of fill and the allowance for the treatment of the face of the cutting. Mark the extremities of this with a simple mark that distinguishes it from the excavated flat area markings. If you mark the base cutting area with a cross you might use a simple dot as marking for the outer limits. The next part of the process is easiest with two people. Take a string line and stretch it first of all over two of the external markings that represent an edge of the cutting thereby forming a straight line between the two marks. Extend the string line ideally 3 or 4 metres past the actual marked position and hammer in a robust peg. A short star dropper is ideal. On a residential block it is unlikely that you will have the space to extend the lines so far in each direction, so fit these pegs against a fence. The reason the pegs are fitted so far from the actual excavation is to prevent the machine from accidentally removing the pegs. These pegs are your terms of reference during and after the excavation process. Use lime or your chosen product to mark a line on the ground between the original marks, this line will be a guide for excavation. Repeat this process for each of the marked positions for the internal excavation area for the house.

Once completed you will have an area marked on the ground that includes the house and the additional area of clearance around the house that is to be on a solid excavated surface. Repeat this process for the outer markers that will include the areas of fill and any battering back of the cutting face. Once all these pegs are in position and all the lines drawn on the ground you are ready for stage one of the excavation, the site preparation. Having the permanent pegs in the ground will allow you to pull the string line between the pegs at any point during the excavation if you need to clarify the required excavation position. Regardless of the complaints that may come from the excavator, restring the lines between the pegs at the completion of the excavation to ensure that the excavation meets your requirements. If it is not right get the excavator to fix it then and there. It is extremely frustrating to do the next stage of the job if this initial cutting is incorrect.

Checking the levels during the excavation

During the process of the excavation there should be constant checks on the level of the cutting. It is bad form for the excavator to remove too much soil and simply back fill the hole. This can lead to the failure of the concrete as it effectively causes a weak spot where the concrete is unsupported by solid ground, as the filled soil will settle. A good operator should be able to get the cutting flat to within 50 mm over the building site. If the cutting has a variation of 150 mm it translates to an additional 150 mm of crushed rock and or concrete to fill the holes. It is desirable to keep the amount of crushed rock to a minimum, as this too will settle. Concrete is expensive both financially and environmentally. Before you employ and excavator tell them what you expect, if they are hesitant it may be worth looking for another contractor. It is ideal if you can get a concreter who will arrange and supervise the excavation as they then hold the responsibility. If the excavation is too deep, and the concreter is supervising the excavation, they should wear the cost to fix it. You should still be on site to check the excavation is done correctly. You would be surprised at how many legitimate excuses that concreters can come up with to charge more.

At this point the exact position of the house has not been plotted, as this can only be done accurately once the initial cutting is done.

Marking the site for construction

When marking the site for the excavation for concrete or the siting of stumps you will build profile stump markers commonly known as hurdles. A hurdle is made up of two pegs with a cross bar (see Figure 2.5). I prefer to use metal star droppers rather than wooden pegs, as the hurdles are to remain in position as an important term of reference until after the concrete is poured or the stumps and timber floor is in place.

A pair of hurdles will be used to determine the actual position of each wall. On a rectangular house there will be eight hurdles, two for each external wall of the house.

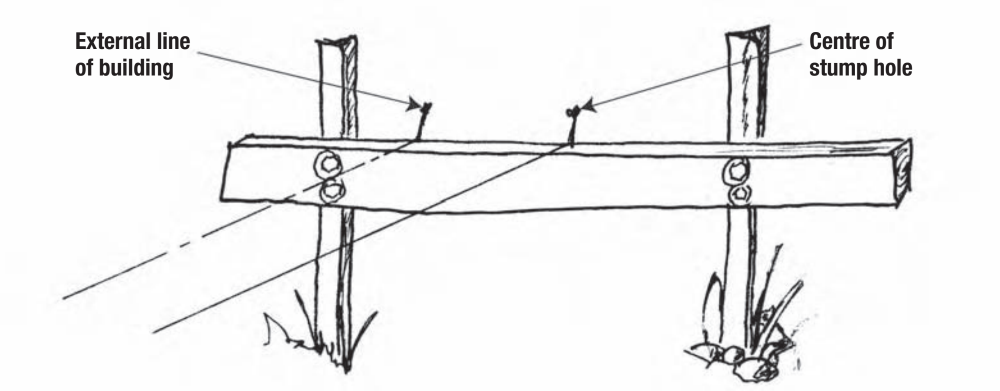


Figure 2.5 Profile hurdle for the location of the stump holes and the outside line of the building

An L-shaped house will require 12 hurdles. If your house design lends itself to it, you may be able to combine two hurdles into one simply by making the cross bar longer. If this is feasible it will be evident at the time of installing the hurdles.

The horizontal rail of the hurdle will have lines marked on them representing various construction points on the house. A 50 mm nail is to be hammered into the rail of the hurdle at the lines marked on it. A string line will be strung between the nails on the two opposing hurdles as a reference to the actual building line.

Setting out the hurdles for the house location

The procedure detailed below is for the setting out of hurdles for a flat or excavated building site.

Fit short pegs, ideally 50 × 50 × 200 mm long, into the ground representing the actual position of the two external corners of the building on one wall. Where it is an excavated site this will be done for the wall nearest the cutting face. Fit a nail into the top of each peg to show the exact position of the external corners of the wall. Next we need to fit a third peg, complete with nail, for an end wall which we will assume is at right angles to the first wall. You will need two pieces of black cotton or soft string about 200 mm long to help with the next process.

Determining the right angle

To determine the position of the first two walls of the house at right angles to one another, fit a string line between the nails on the two pegs that designate the corners of the building, make sure the string is not fouled on anything that prevents it from forming a straight line. Measure from one of the nails 4 metres back along the string line. Tie the cotton or string at the 4-metre mark so that you can refer back to this position a little later on. With one tape measure, measure three metres from the same nail in the general direction of the new wall to be plotted. Have your assistant hold the end of a second tape measure at the cotton tied to the original string line. Extend the second tape measure to 5 metres and bring the two tape measures together. Using Pythagoras's theorem, that in a right-angled triangle the square on the hypotenuse is equal to the sum of the squares on the other two sides, where the 3 metres of one tape measure intersects the 5 metres of the second tape measure you have a position that is square to the original string line. Insert a third peg at this position and fit a nail at the exact junction point. Extend a string line from the nail in the corner peg directly across the nail in the third peg to determine the line of the new wall. Extend a tape measure in the same line to determine the position of the new corner peg lengthwise (see Figure 2.6).

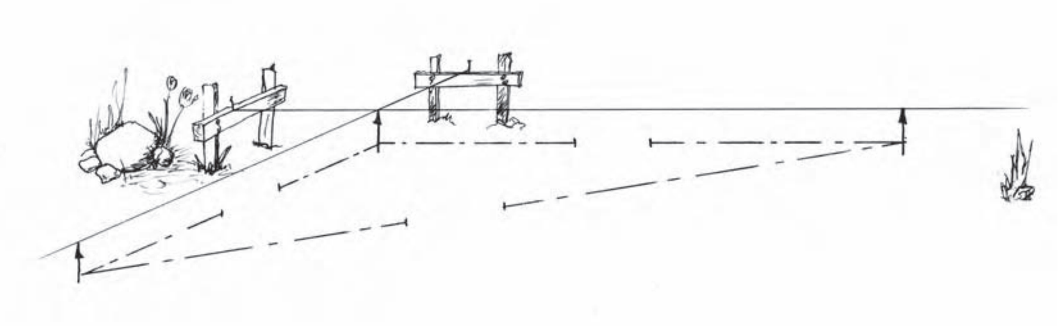


Figure 2.6 Marking the position of the wall at a right angle to the first wall

To plot the position of the final peg, simply measure from the nail in the third peg the correct length of the wall back to the position of the final corner peg. Now measure the length of the remaining wall. Where the two measurements intersect will in theory be the final position of the last peg. As a double check, measure the diagonal distance across the building site between the diagonally opposite pegs, and then for the opposing diagonally opposite pegs. If the measurement is the same then your markers are square. If not you may need to adjust the corner peg positions slightly to gain a true square position. The external corners of the building are now established, however this information will be lost with the first stroke of the backhoe or as soon as the holes are dug for the corner postholes. Consequently, this information will be transferred to hurdles as shown previously.

Transferring the details to the hurdles

You will need to transfer the house position details to the hurdles for future reference. Tie a string line to the nail on one of the corner markers and then pull the string line directly across the nail in the corner peg representing the other extremity of that wall – just as you did when marking for the original excavation. Extend the string about 3 metres past the marker, as this will be the location of the hurdle. Ideally the hurdles should be placed approximately 3 metres beyond the actual building area to reduce the possibility of the backhoe or posthole digger moving them. Hammer a peg into the ground at this distance from the building site, approximately 300 mm to one side of the string line, and a second peg 300 mm to the other side. Fit the cross rail that will need to be about 800 mm long to these pegs approximately 300 mm above the ground. Mark a line on the hurdle directly above the string line. You could use a level or a plumb bob to transfer this line vertically to the hurdle. Repeat this process first for the other end of the same wall and then for each of the walls. Once you have all the hurdles in position with marks in each of them, hammer a 50 mm nail into the hurdle at the mark. Stretch a string line between all these nails thereby representing the outside walls of the house.

Again measure the distance between the diagonally opposing corners of the building where the string line crosses (see Figure 2.7). If the distance between the opposing diagonals is different use a level or plumb bob at each of the corner markers to ensure that the string line is directly above the nail in the corner markers. Make any necessary adjustments. It is important that these hurdles are true representation of the final building position as they will be your only term of reference once the digging of foundations begins.

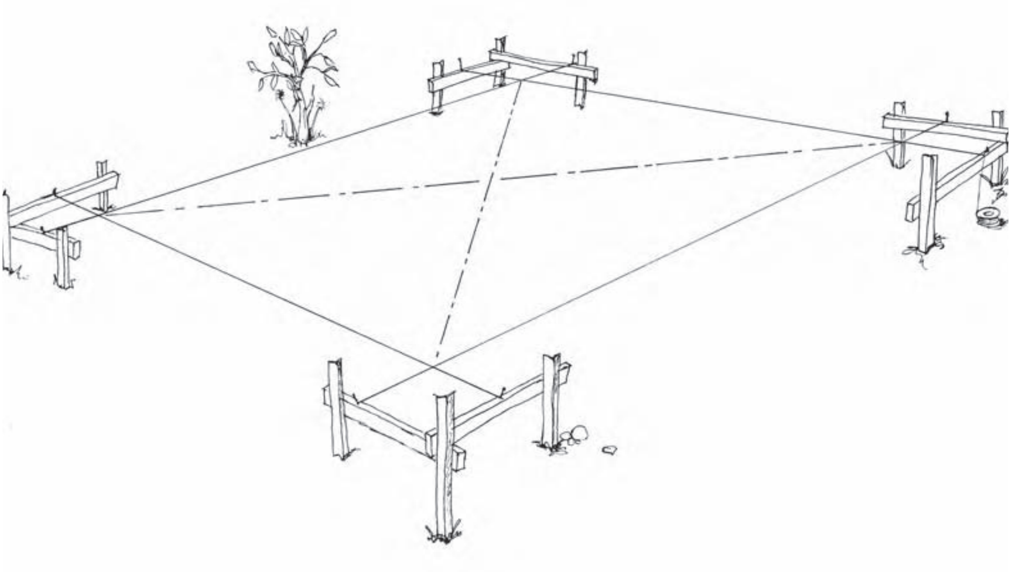


Figure 2.7 Check the diagonals of the setout to ensure the building is square

The purpose of hurdles during construction

You will use the string line on the hurdles to determine the position of any boxing for concrete or the position of the external stumps. In the case of stumps you will mark the hurdle for the centre position of the stump hole. In the case of 100 mm stumps this will often be 50 mm inside the marker representing the exterior face of the wall. For concrete footings or a concrete slab the existing markers represent the outside line of the trench to be dug for the foundations. Ensure the person digging the footings is aware that the line represents the outside of the building, as some builders work to the centreline of the trench.

As previously noted I prefer the use of metal star droppers for the pegs of the hurdles, and suggest that 90 × 35 or 90 × 45 pine would make a good cross rail. As the hurdles can be removed once the floor is completed, the cross rails will not go to waste, for they can later be used in the construction of the house. The cross rails can be fitted with roofing screws, which fit snugly through the pre-drilled holes in the star droppers and have sufficient length to hold the cross bar securely.

Hurdles for houses with stumps

The ideal is to have all the hurdles on a level plain however this is not strictly essential. If the house has stumps rather than a concrete floor you will need to fit the stumps with their tops on a horizontal plain. This is simple with timber stumps as they can be cut to the correct height after installation, however if you are using concrete stumps they need to be fitted at the correct height from the outset. If the hurdles are level and at the height of the top of the stumps, the string line pulled between the hurdles can be used as a reference for the required height of the stump. If the hurdles are not set to match the height of the stump you would simply use a dumpy level to set the four outside corner posts at the correct height and then work off them to position all the other stumps. The height of the boxing or formwork for a concrete slab would normally be set using a laser level. A dumpy level can be used to achieve the same results, however it is slower and requires two people to operate it. Now days most concreters have laser levels.

Hurdles on sloping sites

If the height variance of the land within your house is greater than 1.5 metres and you are not intending to excavate it is probably worth considering employing the services of a land surveyor. Land surveyors are able to accurately plot the position of your house on the land taking into consideration the fall of the land. They use an instrument called a theodolite.

In 1976, just prior to starting my own building company, I took on a sub-contract job in Cockatoo, Victoria, to construct the frame of a single-storey house of about 12 squares. The builder had fitted the hurdles for the house so it was ready for me to get in a stump hole digger and start the job. I had a feeling early in the job that all was not well, but because of the fall of the land it was not possible to check the diagonals of the job until I was at floor stage. Once I had the stumps, bearers and floor joists fitted it was quite obvious that the builder had not employed a land surveyor to erect the hurdles. When I went to fit the sheet flooring, which in 1976 was a fairly new product on the market, the problem was exposed. In the 900 mm width of the flooring the floor joists were almost 40 mm out of square. This meant that the end of the house was approximately 360 mm out of square. If you do not have any pride in your work it is possible to build a house this far out of square, but by no means advisable.

3

Floors and foundations

Timber versus concrete floors

Concrete floors have long been heralded as the best option for controlling heat loss and gain in domestic buildings, however I have serious reservations about it. I have never heard anyone speak against the thermal benefits of a concrete floor so I guess I am stepping out on my own by raising the next issue for your consideration.

I would be interested to see a study done into the embodied energy of a concrete slab versus the savings of energy through passive solar heating as a consequence of having a concrete floor. It would also be interesting to establish whether the mass of earthen rendered internal straw bale walls are sufficient to compensate for, if not neutralise the loss of thermal mass as a consequence of building with an insulated timber floor rather than a concrete one.

Consider the real cost

It is important to consider the real cost of a concrete floor compared to a timber floor. I was recently contacted by one of my owner-builders who was looking to reduce the cost of her new home. She was quoted around $20,000 (2005) for the concrete slab, whereas a timber floor with insulation would cost less than $5000. One of the primary reasons people owner-build is to save money so that they can be financially independent sooner, which will enable them to reduce their work hours. A saving of $15,000 on the cost of a home has long-term consequences. As most new homes have some finance on them, it is a $15,000 reduction of debt, plus the interest added to this. The total savings on reducing your initial loan by $15,000 will equate to a much earlier reduction of working hours. Every day you don't work is another day that you don't have to use your fossil-fuel vehicle pumping out its pollutants and destroying our ozone layer to go to and from work. If all this were taken into consideration, I doubt that a concrete slab would be heralded in such high regard.

Thermal mass, is it for you or against you?

Our straw bale house in Heathcote has a concrete floor downstairs with slate tiles. I find in summer that it is terrific. The floor is cool and I am sure it contributes to the low temperatures in the house on the hottest days. However, having a cool floor in winter, which certainly is my experience, is not so appealing. Because the floor is so cool, a direct consequence of sitting on the ground, which is cool, the heat that we generate to heat the room also has to heat the floor. The benefits of thermal mass are heralded as a solution to heating and cooling, but it can work against you.

If you have a large mass of material that is cool, and you want to heat the area, the coolness contained in that mass must be displaced with warmth. With a concrete floor you have the added disadvantage that the earth below the concrete also represents a more than significant mass, and it is cool. So to warm the concrete slab we are also fighting against the temperature of the earth. The concrete will consume a huge amount of energy to achieve a neutral temperature. Whereas a timber floor with appropriate insulation is probably more likely to gain a neutral temperature with much less heat generation, as the heat is contained in the cocoon of the room without the complication of having to convert a cold mass before the room is warmed.

Soil reports

A soil report and how to get one

As briefly mentioned in Chapter 2, a soil report is required to determine the type of soil and its capacity to carry the load of the building. The soil tester may use a machine to dig the test holes or a simple hand-operated auger. They will do several test diggings on the site in an attempt to establish continuity of soil on the property. On occasions one or two of the tests may indicate stable soil while a third may indicate that the land has been filled. It is necessary to have a soil report as this forms part of the application for a building permit. Most engineers can arrange to have a soil report done for you.

When buying land it is a simple process to make the purchase conditional upon the results of a soil report. The agent will probably want you to specify what test results are acceptable, and will most likely include this detail as part of the special condition on the contract. I will cover the various soil classifications and their definitions shortly, but I would suggest that soil of class A, S, or M would be good. I would be hesitant about buying a site with rock if you are on a tight budget, as the cost of rock removal can run into thousands of dollars. A site with rock would most likely be class A.

The soil report saved the day

Some years back I was asked to do a quote on an extension to a brick veneer home in Doncaster, Victoria. Fortunately, while it was not required in those days, we had a soil report done. One of the tests revealed that the site had slightly reactive clay, which was quite acceptable. The other two tests revealed that the land had been filled. Further investigation revealed that the proposed site for the extension was on the edge of what used to be a dam that had been filled prior to the subdivision of the land. There was over three metres of fill in the dam. The solution was to drive piles four metres into the ground to gain a solid bearing to support the weight of the building. Our engineer specified the size and frequency of the piles, and the details for the construction of the concrete strip footing that was poured on top of the piles. As you can imagine, the cost was significant and added three days to the job.

Soil classifications

The ideal building site would have class A soil as long as there is no rock to be removed, as this is expensive. Small rocks are fine; it is the large rocks or reefs of rock that are a problem. This classification embraces the sandy or rocky sites that have little or no ground movement associated with moisture fluctuations.

A building site with the S classification is good to build on. While the soil is generally clay it has only minimal movement with the fluctuations in moisture content.

A building site with the M classification is still a good site for construction, but care needs to be taken to carefully follow the engineers' design of the foundations. This soil is made up of silt or clay and can have a medium level of reaction or movement from moisture variances.

A clay site that has significant movement associated with moisture fluctuations would be specified as class H. This is still a good building site but there will be additional cost associated with the foundations. The engineers will take the reactive nature of the clay soil into consideration when designing the foundations. Ensure that all the engineers' requirements are strictly adhered to.

In Adelaide there are many building sites with a soil type of classification E. I remember fences built at 1.65 metres high that four or five years later were less than 1.5 metres high. It is as if the earth was eating them. The clay is so reactive to moisture variations that stumps just sink into the ground. In central Victoria stumps are replaced because they rot out, but in Adelaide they just sink. While doing maintenance for the housing trust in SA we regularly had to do what is commonly termed as a jack up. It is not the replacement of stumps, rather lifting the house off the stumps and fixing blocks to the top of the existing stump to support the house in a level position. Obviously a good engineer can design foundations for almost any soil type, but this is one soil type I would prefer to avoid.

When the test results come back as classification P it is not a time for celebration. These sites are quite unstable, prone to erosion and ground movement. While it is possible to build on these sites it is likely to be quite expensive. It brings back horrible memories of the house in Eltham that began the slow but steady decent down the hill. Much musing if not gnashing of teeth followed this realisation of the dilemma. The concrete raft slab was extremely strong. Even when the house was sliding down the hill it did not crack. Given that the slab had not cracked, we knew that if we could just stop the house sliding down the hill it could be levelled and underpinned. The house could be saved. It would just be in a new position: a trivial issue considering the magnitude of the problem. As is often the case, the solution was really quite simple. A huge chain wrapped around a mammoth gum tree. The gum tree had its roots very deep. Way past the unstable surface soil that the house had been relying on. We have all seen images on television of houses sliding down mountains after downpours of rain. It is likely that these sites would have been of P classification.

Basic configuration of a timber floor

The basic configuration of a timber floor is as follows. Holes are dug into the ground. Placed in the bottom of the holes are the sole plates. Stumps are seated into the ground on the sole plates. On the stumps are the bearers. On the bearers are the floor joists. On the floor joists is the floor.

Stump holes

Stump locations on your schedule

If you have employed a consultant to write a construction schedule or to produce a material list you should have a plan detailing the required position of each stump hole, their theoretical depth and diameter. This schedule should also have details of the soil type required in the bottom of the hole. If you do not have this detail it can be found within the documents that form your building permit.

Stump positions not on your schedule

When the required position details for the stumps are not supplied on a stump layout schedule you will need to establish them. First you need to find the cross section of your house which is part of the drawings that form part of your building permit. This cross section should have details on the diameter of the stump holes, the sole plates and the stumps to be used on the job. You will also need to refer to the soil report to ascertain the likely depth of the stump holes and a description of the soil type that is to be found at the bottom of the stump hole. If the recommended depth of stump hole does not uncover the soil type described in the soil report you will need to dig down until it is found. If the soil type is found prior to getting to the full depth of the hole recommended you still have to dig to that depth.

On a number of occasions when digging stump holes I have struck shale or rock that cannot be penetrated to the recommended depth. If this occurs it is not the end of the world. Contact your engineer to establish how to overcome the problem. There are a number of solutions to this problem so do not be concerned. If you are unable to contact the engineer at the time of digging, contact your consultant. If you are unable to contact the consultant, dig each hole as deep as possible and then move onto the next hole.

If you have a stump hole plan you simply refer to it to ascertain the positions of the stump holes. If not you will again need to refer to the details on your building permit.

Bearer locations

As the bearers are fitted directly onto the top of the stumps, the position of the bearers will determine the location of the rows of stumps. You first have to discover the direction of the bearers. This information will be found on the cross section drawing on your plans. Next you need to ascertain the distance between the rows of bearers, as this is the same as the distance between the rows of stumps. This information may or may not be on the cross section drawing, however it will be detailed in the timber specification section. In the timber specification schedule it will probably look something like this:

Bearers 100 × 75 F8 OBHW @ 1.8 crs

The term bearer refers to the timber that is fitted directly to the top of the stump.

100 × 75 refers to the dimensions of the timber to be used.

Note: unless otherwise specified, always fit timber with the greater dimension vertical. So in this case the bearer would be fitted with the 100 mm vertical, making the horizontal width of the top of the bearer 75 mm.

F8 refers to the stress grade or strength of the type of timber that is required

OBHW refers to the type of timber. In this example: Ordinary Building Hardwood.

@1.8 crs refers to the position of each bearer relative to the neighbouring bearer.

The crs is short for centres. This means that the measurement of 1.8 metres is to be measured from the horizontal centre of each bearer. An easier way to measure this is from the common side of each bearer. That is, if you measure from the northern side of the first bearer to the northern side of the next bearer it will give you the same result as measuring from centre to centre on each bearer, and is much easier (see Figure 3.1).

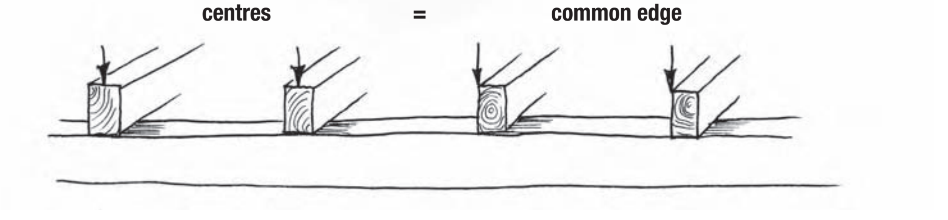


Figure 3.1 The centres and common edge are the same measurement

Stumps distance

The distance between the stumps is detailed in the timber specification schedule. Having established the position of the rows of stumps we now need to find the position of each stump along the rows of stumps. Again this may be on the cross section drawing but it is unlikely. The cross section drawing will only detail the position of the rows of the stumps or, the distance between the stumps along the rows as it is a two-dimensional drawing. Refer to the timber specification schedule where you should find a description of the stumps and their spacing. Care should be taken when gaining this information, as there are often different spacings for the stumps in different positions within the building to support differing building loads. For example, the outside walls of a straw bale house are likely to have stumps every metre whereas the stumps supporting only the floor on the inside of the house may be at 1.5 metres or even greater. If you are unable to find the details on the stump spacings in the timber specification schedule, which is likely if you are using concrete stumps, you will need to refer to the details supplied by your engineer. The stump spacing details in the specification schedule should read something like this:

Stumps 100 × 100 F7 Cypress Pine @ 1.5 crs.

Again 100 × 100 refers to the dimensions of the stump.

F7 refers to the strength or stress grade of the timber.

Cypress Pine is obviously the type of timber.

@1.5 crs refers to the spacing of the stumps.

On occasions you may find that the term spacings is used rather than centres (crs). In this instance the measurement refers to the actual gap between the timber.

During the process of fitting the stumps you are going to need to put all the dirt that comes out of the stump holes back into the hole. There is nothing more frustrating than trying to separate the dirt from long grass and sticks that happen to be on the building site, particularly if there has been some rain and the dirt has turned to mud. If the building site has not been excavated I would highly recommend that you clear any sticks from the site and mow the grass before you start marking the site for the stump holes. It may seem pedantic, but you will be pleased you went to the trouble when you are laying the stumps

Digging the stump holes

Now that we have determined the position of the rows of holes and how far apart they are you will need to mark these positions. On a number of occasions owner-builders have told me that they are going to dig the holes by hand with a crow bar to save the money. Apart from when the holes are being dug in sand, I am yet to find someone that has completed the job by hand. You can hire handheld motorised augers. Some require two people to operate while others can be operated by a single person. The single person machines are normally mounted on a cradle with the motor acting as a counter weight. These are good if the soil is not rocky and has sufficient moisture in the soil. In most areas you will be able to employ a contractor who can dig the holes for you. Many of the bobcat operators have auger attachments for their machines. Ensure that you specify the required dimension of the holes prior to booking the contractor. The specifications of hole size detailed on your building permit are the minimum size. It is OK to increase the size, however if you are using concrete sole plates this is going to increase your costs.

If you are using a contractor measure the depth of the auger on the machine before they begin to dig so that you have a theoretical depth that the auger needs to penetrate in the soil to meet the requirements of the specifications. If you shovel some of the dirt out of the way while the machine is digging it will reduce the amount of dirt that has to be removed after the digger has left the site. The auger draws the dirt out of the hole so there is little chance of having the shovel pulled into the machine, BUT accidents do happen. Keep your shovel out of the realm of the machine. You can remove plenty of dirt around the hole as the machine spews it out.

When unable to get a contractor I have hired a Dingo Digger from a building hire company. These machines are much quicker and easier than handheld augers, however if the ground is hard they are still quite slow. If this is the case you will find it quicker to dig a smaller diameter hole and then open it out with the larger auger.

Marking the stump hole positions

You will need to mark the positions where the stump holes are to be dug. I have used stakes and lime to mark these. I find that the stakes are more likely to be lost under the wheels of the digger but not so much with lime. If the digger drives over the lime some of it will stick to his tyres, but there will normally be enough left on the ground to mark the position. If you are concerned about this it is probably worth using both stakes and lime. Alternatively you could use ground-marking spray paint from a pressure pack. Spray paint is certainly not my chosen method.

Stump hole inspection

The holes must be free of all loose material prior to the stump hole inspection. Once all the holes are dug all of the loose dirt must be removed from the holes. The building permit will specify that you need to have the stump holes inspected prior to laying the stumps. The bottom of the stump hole must be basically flat and be free of all loose material. This is often a somewhat frustrating and time consuming job so don't fall into the trap of calling for the inspection the same day as you dig the holes. I would suggest that you contact your building surveyor once you have arranged the time of the digging to book the inspection for the following day.

There have been owner-builders that were impatient and did not wait for the stump holes to be inspected prior to laying the stumps. Do not be mistaken and think that you can bypass this inspection. If you lay the stumps and build the floor on top of them without an inspection of the stump holes you WILL be dismantling all your work and cleaning out the stump holes for the inspection.

Sole plates: materials and installation

Let me first clarify terminology. When I speak of foundations I am not speaking of the concrete, timber, or other materials that we put into the ground, rather the earth that these materials are positioned on. I am told that the pressure applied by a 65 kg woman wearing stiletto heeled shoes is greater than that of an elephant's foot. The reason of course is that the load of the stiletto heel is focused on a very small area, whereas, while the weight of the elephant is obviously much greater in total, the load is spread over a significantly bigger area of its four big flat feet. The purpose of the sole plates under stumps is to give the house elephant feet. That is, to spread the load over a greater area so that the stumps will not puncture through the earth in the bottom of the stump holes.

Refer to the approved plans for details on the depth and diameter of the holes to be dug for the stumps. The bottoms of the stump holes need to be free of any loose material. If the sole plate is fitted on loose material, the loose material will compact under the weight of the house and cause the sole plate to drop, thereby causing the house built on the sole plates to drop. Your building permit calls for a stump-hole inspection. The inspector will be checking that the holes are of the correct diameter, that the holes are down into solid material as described in the soil report, and that the holes are clean of debris and loose material. The soil report will describe the material in the ground that is deemed as providing a solid foundation. It will also specify the likely depth of the holes to establish a solid base. While digging the holes it is crucial that you ensure that the soil described in the soil report is accessed. The depth of the hole is secondary to the material in the bottom of the hole.

Timber sole plates

Timber sole plates are only used in combination with timber stumps. While timber has limited capacity to support a heavy load it is a very simple sole plate to install. Most weatherboard homes built in the last hundred or so years will have been built on timber sole plates. The most common timber used for sole plates is Red Gum, Cypress Pine and Jarrah. When installing timber sole plates it is important to ensure that the bottom of the hole is not only clean but also flat. Refer to your approved plans for details on the materials and required size of the sole plates. Commonly the sole plate will be 250 × 200 × 50 mm. The sole plate is to be positioned in the hole so that the stump will sit near enough to the centre of the sole plate. If the hole is not positioned correctly to allow this, it should be extended to facilitate the correct positioning of the stump on the sole plate.

Concrete sole plates or pads

While not strictly the correct terminology, to save confusion I shall refer to the concrete pad in the base of a stump hole as a concrete sole plate. Concrete sole plates when used in conjunction with timber stumps should be poured into the bottom of the stump hole and allowed to set before the timber stump is inserted into the hole. When pouring the concrete into the hole, ensure that the top of the concrete is flat and as smooth as possible so that the total surface of the bottom of the stump will be in contact with the concrete sole plate.

Concrete and timber stumps

The most common mistake that people make when using concrete as the sole plate is the belief that the concrete is to encase the stump to prevent it from moving. It is a standard requirement for there to be 150 mm of concrete *under* the stump, however this should be verified on your approved plans prior to construction. If the stump is positioned into the hole and then the concrete poured around the stump, the stump will inevitably sink. Whether it is a concrete or timber stump is of little consequence. When the concrete is poured around the stump rather than under it the capacity of the sole plate is limited by the adhesion of the concrete to the sides of the stump. When using concrete stumps this is very limited. With timber stumps it is virtually nonexistent, as the timber stump will react to the concrete and shrink away from it. An even worse scenario would be the use of timber stumps with concrete sole plates where there is sufficient concrete under the stump to prevent it from puncturing through the sole plate, and yet the concrete surrounds the bottom of the stump (see Figure 3.2).

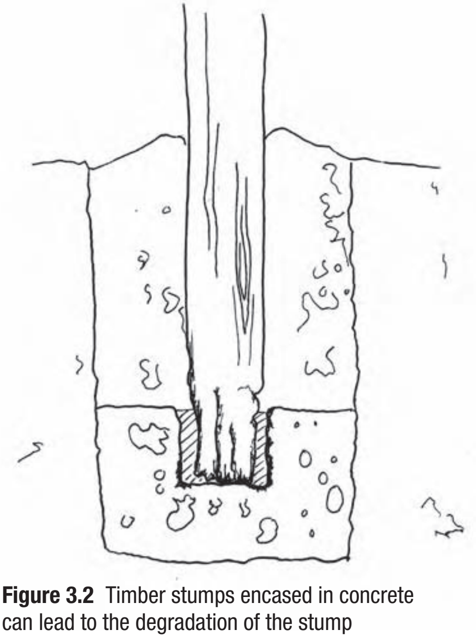


Figure 3.2 Timber stumps encased in concrete can lead to the degradation of the stump

Water will travel through and around the timber stump and create a pool of water at the bottom of the stump. The concrete will act as a reservoir for the water to sit in; thereby keeping the bottom of the stump wet for prolonged periods. Timber stumps that are constantly in a wet environment will rot. As if this is not enough of a problem, when it comes time to remove the rotted stump you will have to remove the mass of concrete at the bottom of the hole before fitting the new stump. If a timber stump that has been fitted onto a flat sole plate has to be replaced, it is simply a matter of removing the stump, dig the soil out of the original hole until the existing concrete sole plate is uncovered. The new stump can then be mounted on top of the existing concrete sole plate.

Stumps: materials and installation

Timber floors are required to have clear ventilation space between the ground and the underside of the bearers. Unless there is a recognised termite barrier on top of the stumps the minimum clearance is 450 mm. It should be noted that an ant cap is no longer deemed as a recognised termite barrier in its own right. The combination of a metal ant cap and Kordon, a product produced by Bayer, would meet this requirement. If you have an approved termite barrier the minimum distance from the ground to the underside of the bearer is dramatically reduced. When using strip flooring this minimum clearance is 150 mm, however if using particleboard flooring it is increased to 200 mm. This air space is to be clear of obstructions to allow uninterrupted airflow between the floor and the earth. This prevents the moisture of the earth penetrating the timber causing it to remain damp. If insufficient airflow were provided below the bearers, you would quite quickly notice a musty smell in the house. This smell is a tell-tale sign that the timber is wet and most likely rotting.

Stumps are used to support a timber floor. In many instances a house may have a concrete strip footing around the perimeter of the building, a process that I will cover later in this chapter, or it may be that stumps support the external walls.

Concrete stumps

The most cost-effective and commonly used stumps are the precast concrete stumps. These stumps have a steel pin protruding from the centre of the top of the stump. This pin is fed through a hole drilled in the bearer. Timber stumps are more user-friendly, as they can be cut to the correct height once in position. It is significantly easier and cheaper to fit sub-floor bracing to timber stumps. The issue of bracing shall be covered later in this chapter.

Calculating the length of concrete stumps

Concrete stumps are supplied in lengths with multiples of 100 mm. Only once the stump holes are dug and cleaned out should you then measure and order the stumps. Let's assume for a moment that the stump we are measuring for needs to protrude 200 mm above ground level and that the stump hole is 600 mm deep. At first it would appear that the stump required would be 800 mm long, but this is not correct. We need to deduct 150 mm from the length of the stump to allow for the required depth of concrete under the stump: 800 – 150 = 650 mm. Unfortunately, concrete stumps are supplied in multiples of 100 mm. As 150 mm is the minimum of concrete to be under the stump we will have to purchase a 600 mm stump and increase the concrete under the stump to 200 mm.

Timber stumps

Timber stumps will be cut to the correct height once the stumps are laid. When pre-cutting the stumps for each hole, add approximately 50 mm to the required length to allow for cutting. If in doubt add more. It is simple to cut a stump but frustrating to have to remove it because it is too short.

Installation of stumps

Installation of timber stumps

Timber stumps are to be placed on the sole plate, held in the correct position and then backfilled with the soil that originally came out of the hole. There is no need for additional concrete. When backfilling the hole put about 70 to 100 mm of soil in the bottom of the hole around the stump. Ram the soil down so that it is quite firm. Keep checking through this process that the stump has not moved out of position. Next fill the hole to half full and then ram it again. Backfill the remainder of the hole, mounding the soil up around the stump. Tightly ram the soil around the stump. Once completed it is best to have a small mound of excess soil around the stump to stop water pooling around the stump if water does get under the house later on.

Installation of concrete stumps

When laying concrete stumps the process is somewhat different. First and foremost you do NOT ram the soil around the stump when it is being backfilled. Place the wet concrete in the bottom of the hole. Now gently lower the stump into the hole on top of the concrete, with the stump in the correct vertical position. Push the stump into the concrete until the stump is 2 or 3 mm above the final height required. If there is insufficient concrete to support the stump at this height, remove the stump and add more concrete. If the stump does not easily drop to the correct height you should use a small twisting motion, as this will tend to screw the stump into the cement without changing the required vertical position.

Once the stump is at the desired height, support the weight of the stump, but do not lift it above the position attained. Now backfill the soil into the hole being careful not to strike the stump as this may cause it to drop. Once about half of the soil is backfilled, twist the stump down to the final height required. Continue to support the stump vertically while the remainder of the soil is backfilled. The following day the soil around the stump is to be rammed tight using a crow bar. Again, try to have a mound of soil around the stump to prevent water pooling there. If the stump drops a few millimetres during this process, simply mark the stump with a pencil so that appropriate packers can be placed on top of that stump just prior to installing the bearers. While it is not ideal, you can probably use packers up to about 20 mm. Anyone that needed to do this would have good reason for being disappointed, and it would most likely influence the attitude of the building inspector toward your work. If an inspector thinks that your attitude is that 'rough enough is good enough' they are going to pay much more attention to your job when they inspect it at the various stages of construction if for no other reason than just to protect themselves.

Laying stumps without an assistant

If you are laying the stumps alone, which is possible, use a small hoe with a handle about 600 mm long to draw the loose soil around the hole to backfill the stump hole. To wield a shovel while holding the stump in position is near on impossible. When fitting timber stumps, the handle of the hoe can be used to ram the soil for the first and second stages of backfilling until the stump is self-supporting. The final ramming should be done with a crow bar. Obviously, when fitting concrete stumps you will not ram the soil around the stump at the time of installation.

Stumps must be vertical

The stumps need to be accurately positioned both laterally and vertically. Each stump must be vertical, as this will allow the load of the house above to be transferred directly to the foundation below without adding stress to the stump. You use the string lines fitted to the nails in the hurdles that represent the outer perimeter of the house as your guide. In many instances the one string line will be used to set both the height and lateral position of the stump, if however the string line does not reflect the required position for the height of the stump, then a second string line should be installed for this (see Figure 3.3).

Stumps fitted between strip footings

When fitting stumps between strip footings, pull the string line taught over the footings to establish the height of the stumps. If you do not have the hurdles or a strip footing as a guide for the height of the stumps, set the height of the four corner stumps with a water level, dumpy level or laser level. For details on a water level refer to page 46. Once the corner stumps are secured, including time for concrete to set, draw a string line over the top outer edge of the two outer stumps (see Figure 3.3). Do this across the ends of the rows of stumps, as then once these stumps are set you will use the second batch of stumps as a guide for installing the rows of stumps. It is often difficult to get the string line to stay on the top of the stump at its outer corner. Position the string line on top of the stump and then place a half brick on the top of the stump, thereby holding the string line in position on the outer corner of the top of the stump. Use a wire cut brick rather than a solid brick, as they have holes in them that can be threaded over the pin of the concrete stump (see Figure 3.3).

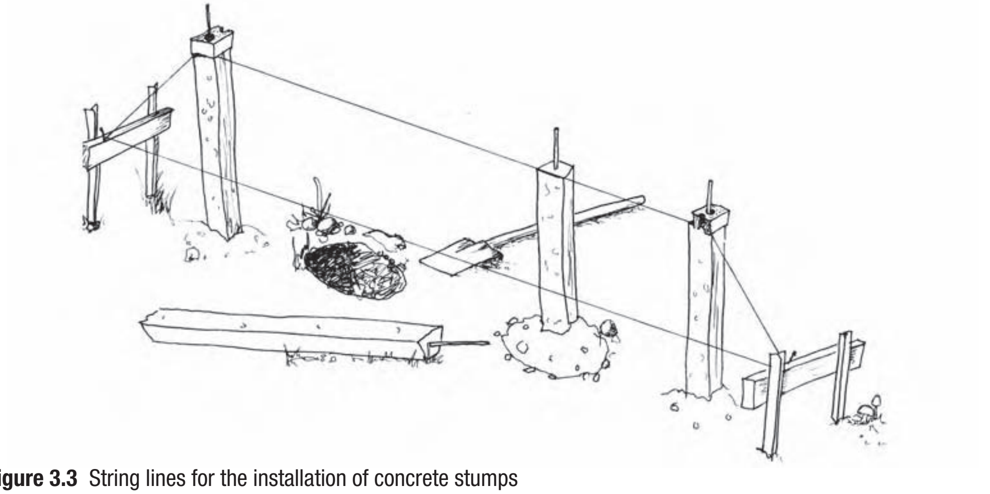


Figure 3.3 String lines for the installation of concrete stumps

Cutting timber stumps to the correct height

As previously detailed, timber stumps are to be cut approximately 50 mm longer than required to allow for accurate cutting to length once all stumps are installed. To cut the stumps to length you will need a circular saw with a minimum cut depth of 50 mm, string line and a level as per concrete stump installation.

Establish the correct height the stumps are to finish and mark this position on the stumps. Use a square to mark a pencil line around the stump, as it will be necessary to cut the stump from two sides, as the cut depth of standard circular saws is insufficient to cut the stump in one go. Cut the external corner stumps at the position marked. Ensure that the cut stumps are level with one another. Fix a string line to the top outer edge of the stumps around the perimeter of the house. Using the string line as a guide, mark the intermediate stumps with a pencil, using a square to transfer the position of the string line onto the stump (see Figure 3.4).

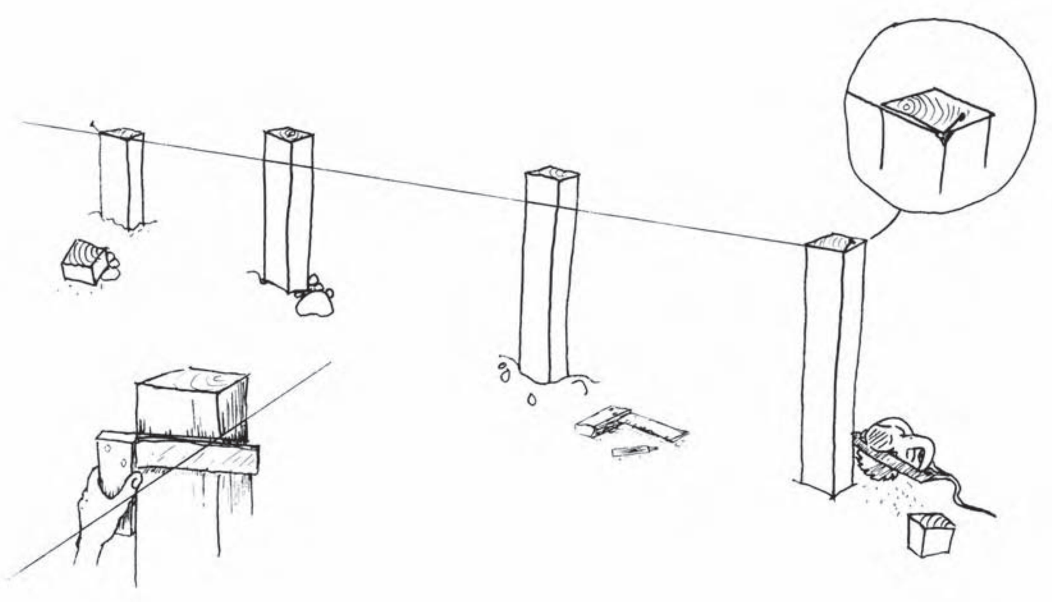


Figure 3.4 String line to ascertain the cut off point of timber stumps

Height limits for stumps and stump bracing

When do stumps have to be braced? The building code has guidelines for the height that a stump is permitted to be above ground level. If you multiply the width of the smallest face or the least diameter of the stump by 12, this will give you the maximum height of the stump to protrude above ground level without bracing. In this application there must be a minimum of 30 per cent of the stump embedded into the ground. If the calculation of the depth of 30 per cent is less than that specified on the soil report, the soil report recommendations take precedence. When the portion of the stump above ground level is greater than this, but not greater than 15 times the smallest face or least diameter of the stump it is permissible to brace the stumps without engineering calculations. It would be best to speak to your consultant or a carpenter to ascertain the requirements for your particular house. Obviously, once the 15-times rule is exceeded you will need to have an engineer calculate the stumps and bracing details to suit your property.

Installation of the sub-floor bracing

Bracing

Beware of fitting the bearers and joists before fitting the stump bracing. You will have details from either your consultant or engineer showing the requirements for bracing in the sub-floor. If you need to fit bracing do not go on with any other work until all the bracing is fitted. Stumps can easily be bumped out of position. Bearers and floor joists fitted to incorrectly positioned stumps will more than likely be too long, or even worse, too short. Either way, you will have to disconnect the stumps and reposition them. It may be that all the bearers and joists have to be removed. It is not uncommon to damage timber when removing it, which will increase the cost of the job. Do everything in its right order and things will flow much more smoothly. The building regulations require that sub-floor bracing material is to be not less than 150 mm above the ground. This detail should be on your specifications, but if not, you will need to contact your consultant or engineer.

Sub-floor bracing of timber stumps

With timber stumps it is a simple process. Measure the brace length once the stumps are in position. Ensure that the stumps are vertical, and check on the string line, which should still be on the hurdles, that the stump is in the correct position relative to the external wall requirements: then nail the brace to the stumps. When nailing do not be over zealous as you are going to have to drill a hole through the brace and stump to fit a bolt. Once all the braces are in position, again check that the stumps are vertical and in particular check the external stumps. If the external stumps are out of alignment your floor is going to be wrong. The floor will set the position of the wall, which will cause the roof to be out of shape. The quickest way to detect misaligned stumps is to look along the plinth boards fitted to the stumps. I wish I could say that this has never been a problem for me, but I must admit I have on more than one occasion had to remove braces and adjust the position of the stumps.

Bolting sub-floor bracing to the stumps

Timber stumps

The junctions of all the braces to stumps are to be bolted. A 10 mm bolt is the most common size used, however check your engineers' details. You could use a coach bolt or a hex head bolt. I would recommend that you use hex head bolts, as it is much easier to do these up tight. A coach bolt has a dome head with a square protrusion below the head. This protrusion is designed to lock into the timber so that the head will not spin when the bolt is tightened. If these bolts are not put in cleanly this protrusion will have little affect and it will be almost impossible to tighten the bolt adequately.

Concrete stumps

Not only would it be difficult to drill holes in concrete stumps, but it is not permitted. A 'U' bolt specifically made to suit the concrete stump is used to fix a brace to a concrete stump. Hold the brace in position next to the stump and mark the brace with the required location of the holes into which the U-bolt will be inserted. Once the two holes are drilled, wrap the U-bolt around the stump and insert the threaded ends through the two holes in the brace. Place nuts and washers onto the U-bolt and then tighten to secure the brace to the stump. Care must be taken to tighten the nuts so that the brace is held securely but not so tight so as to crack the stump. I suggested earlier that timber stumps are more costly than concrete, however if the job requires many sub-floor braces the cost of the U-bolts and the additional time required fitting them should be entered into the equation.

Installation of bearers

Check stump heights before fitting the bearers

Before starting the installation of the bearers, double check that the tops of the stumps are all level. Any that are slightly low can easily be packed up. Those that are too high can be cut down in the case of timber stumps. Alternatively, for concrete stumps, it may be possible to take a checkout of the bearer thereby dropping it over the stump so that the top of the bearer is in the correct position. Check with your consultant or engineer first to ensure that this is permissible with the timber you are using.

Moisture barriers

Prior to fitting the bearers to the top of the stumps it will be necessary to provide a moisture barrier between the stumps and the sub-floor timbers. This moisture barrier might be metal, plastic or malthoid: malthoid is a bitumen product sold in rolls at any good hardware store. You could use metal ant caps or for the plastic barrier, plastic window flashing would suffice. The termite barrier Kordon will also meet the moisture barrier requirements.

When concrete stumps are used the pin that protrudes from the top of the stump is inserted through the bearer and bent over to secure the bearer in position. More often than not, bearers are fitted to timber stumps with skew nails through the bearer into the top of the stump. Bearers can also be fitted to timber stumps with bolts, spikes, vertical nails or metal strapping.

Legal requirements for nail fixings

When nailing the components of a house together there are stipulations set down in the building code for nail penetration, nail size, and the quantity of nails to be used. Furthermore, there are specific requirements for the application of skew nails.

Where skew nailing is required the angle of the nail penetrating the timber shall be no less than 30 degrees but no greater than 45 degrees. The nail shall be driven into the first piece of timber not more than 38 mm from the junction of the timber that it is being joined to, but not less than 25 mm from that junction (see Figure 3.5).

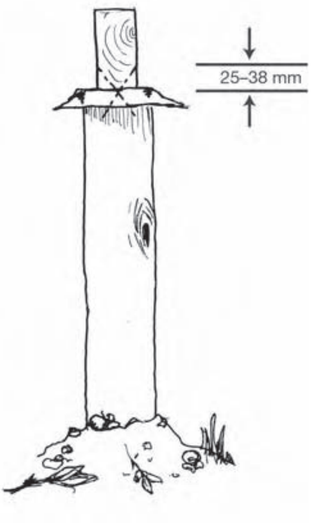


Figure 3.5 The application of skew nailing

The diameter of the nail required could be briefly described as being the thickest nail that can be driven into the timber without causing the timber to split. It is widely accepted that a 75 mm nail is acceptable for most applications for the construction of a residential house frame. It is worth noting that a hammer-driven 75 mm nail is 3.75 mm thick whereas gun nails are generally 3 mm thick

Pre-drilling to avoid timber splitting

If the engineers' specifications for a particular application call for a nail with a diameter that causes splitting of the timber, you will have to drill a hole for the nail. The diameter of the hole drilled shall be 80 per cent of the diameter of the nail. If exactly 80 per cent cannot be achieved drill a slightly smaller hole.

Nail requirements to laminate structural timber

It may be necessary to laminate two pieces of structural timber together and there are nail requirements for this. On many occasions it will not be possible to purchase the timber size required to fulfil the specifications detailed in the timber schedule on the approved plans. For example, a common bearer specification would be 90 × 70 MGP12 pine. 90 × 70 pine is not a common product therefore it will be necessary to join two pieces of timber 90 × 35. Always remember that when joining timber that the joint is to be vertical. The nails to laminate the two pieces of timber together shall not be less than 2.8 mm. The nails shall be no further apart along the timber, than double the depth of the timbers being joined. The nails shall be staggered. One nail at the upper edge of the timber, and the next at the lower edge. If there is no nail over the stump when the bearer is in place, an additional nail should be inserted.

Lay bearers with any bow in the timber facing up

The ends of the bearers need to be fully supported on the stumps. Where concrete stumps are used it will be a little more difficult to gain this bearing, as the metal pin of the stump will prevent the bearer being joined at the centre line of the stump. It is however crucial that the bearer have a full 20 mm of support on the stump. When timber stumps are used the bearer should be joined at the centre line of the stump.

Bearers are to be fitted to the top of the stumps with the bow up. That is, the bearer will rest on the stump at either end of the bearer, and any bow will cause the bearer to be off the stump or stumps within the length of the bearer.

You will have to cut the bearer to a length to suit the position of the stumps. Cut one end of the bearer square. In the past the bearers were halved over each other however this is no longer necessary. This was a method of preventing the bearers from pulling apart, thereby ensuring constant support of the bearers on the stumps. Sit the bearer in position on the stumps and then mark the required length that the bearer is to be cut to. In the case of concrete stumps, you will also mark the position of the steel pins of the stumps to enable the holes to be drilled in the bearers.

Drill holes for a concrete stump

You will need to drill holes to accommodate the still pin of a concrete stump, so drill 10 mm holes in the bearers for these steel pins to pass through. It should be noted that when marking the bearer to go on concrete stumps it is best to place the bearer upside down on the stumps so that the markings for drilling the holes is relative to the pin where it comes out of the stump. Marking this way negates the problems associated with drilling off square to the bearer. If when drilling the hole in the bearer it is drilled off square, the hole at the other side of the bearer could be as much as 20 mm out of position relative to the stump. The stump when fitted correctly will not move sideways to accommodate this variance. If the bearer was forced onto the stump regardless it will almost certainly crack the stump, which would then need to be replaced.

Straightening bowed bearers

On many occasions during installation there is a large bow in the bearer that cannot be straightened to enable correct positioning onto the stumps. In this instance you can cripple the bearer. To cripple the bearer refers to cutting the top of the bearer to allow it to bend down into the correct position more easily (see Figure 3.6).

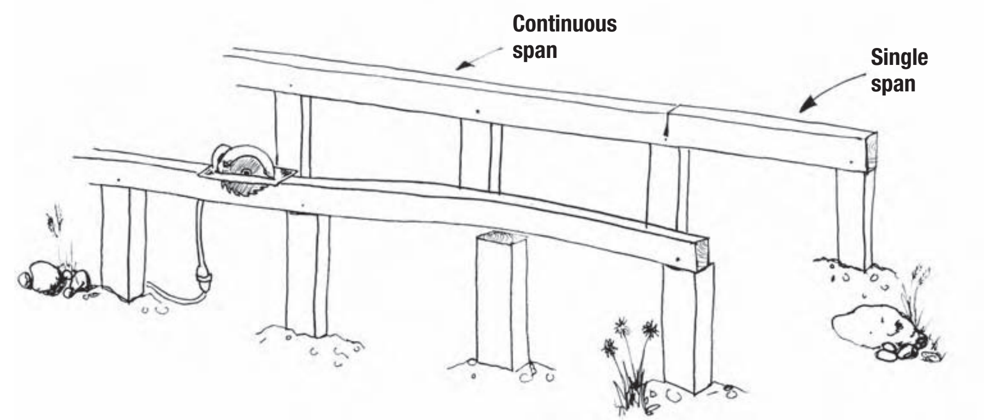


Figure 3.6 Crippling the bearer reduces it to a single span and reduces its span capacity

When a bearer is crippled it may result in a reduction of the carrying capacity of the bearer so you should check with your building consultant or engineer to ensure that the bearer has the excess carrying capacity to allow for this. The carrying capacity of timber changes if the timber is supported in at least three places rather than just two. When the timber is supported in three places the timber is deemed to be continuous and thereby often able to carry a greater load than a single span that is supported in two places only. You will note in Figure 3.6 that the bearer is positioned over four stumps. The bearer is then crippled over one of the stumps, which will result in part of the bearer being continuous span and the balance being single span.

Fixing bearers to timber stumps

To fix bearers to timber stumps, you will insert a skew nail through each side of the bearer into the top of the stump. If you prefer, you can use long heavy gauge screws through the top of the bearer down into the stump, however I find this unnecessary.

Drive the nails through the moisture barrier including the ant cap, if ant caps are to be installed.

The challenges of using a nail gun to fit bearers

These days, owner-builders have a huge range of tools available to them at minimum cost. Not the least of which is a framing gun that will fire 75 mm nails. While the framing gun will certainly speed up some of the processes it is not always appropriate to use it rather than to hammer in nails. From my experience many owner-builders take some time to master the use of the framing gun. Straight nailing seems to cause little problem, however skew nailing is a totally different affair. There are jobs assembled by tradesmen that do not meet the fixing requirements that the building code calls for, as to skew a nail with a nail gun takes some expertise.

If you have not used a framing gun much in the past I would suggest that nailing the sub-floor is not the ideal time to learn. If, when skew nailing with a nail gun, the angle of the nail is not correct, the nail will hit the ant cap and bend. You are then left with a nail wedged between the ant cap and the underside of the bearer. This is not too difficult to remove if it is the first nail in the bearer, however if it is at the second or third stump it may mean you have to remove the complete bearer and start again.

Incorrectly fitted timber

Incorrectly fitted timber must be removed and often replaced due to damage. Every time you remove a piece of timber that has been fitted, there will be some damage. If the damage is minimal you will be able to refit the timber, if not it will have to be replaced. When hand nailing it is much easier to guide the nail into the timber on the correct angle with the initial penetration of the nail in the correct position. Your skill will improve quickly as you persist with hand nailing. Throughout the process of building a house there are many occasions that a nail gun cannot be used so it is better to hone your nailing skills on the ground rather than up in the roof. As previously mentioned, gun nails are 3 mm thick whereas hand nails are 3.75 mm thick. This will also help when piercing the ant cap situated on the top of the stump.

Fixing bearers to concrete stumps

Bearers fixed to concrete stumps should be held in place by the steel pin that protrudes from the top of the stump. You may have seen concrete stumps with a threaded rod protruding from the stump. These stumps are used when replacing the stumps under an existing house. I would not suggest that you use these on a new house, as the pin is likely to foul on the floor joists to be fitted later on. The stumps with the plain metal pin are simple enough to fit at a lower cost than stumps with threaded pins.

Fitting bearers to concrete stumps

Lower the bearer onto the stumps inserting the pins through the holes. Remember that the markings to drill the holes were put on the bottom of the bearer, so be sure to lower the bearer onto the stumps with the markings to the bottom or you may break some of the stumps. The pins are to be bent across the side of the bearer to secure the bearer tightly down onto the top of the stump. If all the pins are bent to one side of the bearer the bearer will tend to twist and lean in the direction of the pins. To avoid this, bend every second pin to the other side of the bearer (see Figure 3.7). Chisel a 'V' out of the top of the bearer to accommodate the steel stump pin.

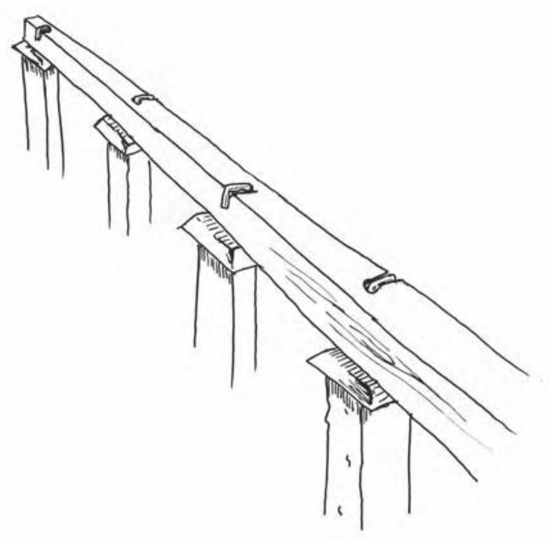


Figure 3.7 Pins of concrete stumps are bent to the left and right of the bearer

You will inevitably find that it will be necessary to fit a floor joist exactly over the top of the pin from the stump so the top of the bent pins are not to protrude above the top surface of the bearer. Particularly when using hardwood bearers it will be necessary to chisel a 'V' in the top of the bearer to accommodate the pin in its bent position. When bending the pin, first hit the pin at the point that it protrudes from the bearer. Do this while holding the bearer tightly down onto the top of the stump. Once you have completed the process of fitting the bearers over the material used as a moisture barrier, you should not be able to move the material.

Fitting bearers tightly to the stump

If the bearer is bowed off the stumps you could get an assistant to sit on the bearer. This is one time that to have a BIG assistant is beneficial. You will find that you too can put your weight onto the bearer by sitting or squatting on it while you bend down the pins.

If the moisture barrier on top of the stump can still be moved, you need to force the pin more tightly down onto the bearer. Again start hammering the pin at the bearer with 5–10 mm progressions along the pin. It is the tension of the pin against the edge of the hole that will provide the tightness of the bearer to the stump. With practice you will be able to hammer the pin in a rolling motion so that the pin is constantly driven down and over the edge of the bearer tightening it to the stump.

Bouncing up and down

As strange as it might sound, if you balance on top of the bearer and bounce your body weight onto the bearer in time with striking the hammer against the pin at the bearer, you can add a significant amount of tension to the connection which tightens the stump pin to the bearer.

Joining bearers

The bearers are to be skew nailed with 75 mm nails where they join. Ensure that all bearers are supported on the stumps by a minimum of 20 mm. The skew nails are to be inserted in each side of the bearer, but preferably not in the top of the bearer, as it may be necessary to plane the top of the bearer and the nails would prevent this.

Fit a gang nail approximately 100 mm long × 50 mm wide across the joint of the bearers on each side. The easiest gang nails to fit are those with the pins raised up in the plate giving you a flat base to sit on the timber. The pins are then hammered down into the timber. These gang nails will prevent the bearers from separating, which might lead to one of the bearers dropping off the stump.

The case of the squeaky floor in Lower Templestowe

A house in Lower Templestowe, Victoria, was suffering from the age-old problem of a squeaking floor. The standard solution for this problem is to lift the carpet, locate the squeaky floorboards and punch the nails to tighten the fixing to the floor joists. On many occasions it would be necessary to re-nail the offending boards. Since the inception of construction adhesives we would also glue nail blocks against the floor joists to the flooring. Movement between floorboards due to a broken tongue on one or more of the floorboards often causes the problem. We investigated under the floor to ascertain whether there was a quantity of moving or broken floorboards, but were unable to locate any. It was then assumed that it must be the floor joist moving off the bearer and so we made small wedges in readiness to insert between the floor joists and bearers, which would be glued, in place. There were a couple of floor joist to bearer junctions that looked to be unlikely but possible offenders, so these had wedges glued into them to remove any movement. Feeling certain that the problem was now solved all tools were packed away with a sense of gratification at having solved the annoying squeak.

The following morning the squeak was back again. So under the floor we went, again. One man was in the house bouncing to try to get the floor to squeak, the other under the floor trying to hear where the noise was coming from. It was truly the illusive squeak that would not reveal its whereabouts. Like a car that will not play up when the mechanic is looking at it. It was pain that eventually located the source of the problem. The unexpected pinching motion of the bearer to the stump applied to the sensitive tissue on the end of the index finger brought revelation and alarm all in one.

The bearer, which had been installed as a green material, had shrunk thereby creating the space for it to slide up and down along the pin protruding from the stump. This is a problem that we do not face today with seasoned timber. What a dilemma! Without removing the flooring it is impossible to get access to the stump pin to tighten it down onto the bearer. To remove the flooring was a mammoth and costly job. Before removing the flooring, the carpet, skirting and architraves would all have to be removed and replaced. There was only a small amount of movement that was of no structural concern; it was simply an irritating noise. We slept on the problem and in the morning came up with the solution.

We had established that the bearer was sliding up and down the pin, so it could be deduced that the noise was coming from the metal pin rubbing on the now very dry timber. Dad had the simple and yet ingenious solution. If a car squeaks you lubricate it. The timber was squeaking so how could we lubricate it? We could wet it but it would only dry out again. We could oil it, but we felt this too would dry out or be absorbed into the timber away from the area that needed lubricating. The solution: grease it. The grease gun had a flexible hose attachment, so we stuffed its nozzle in the hole on the top of the bearer, and pumped the hole full of grease until it was oozing out everywhere. As far as I am aware, this bearer has never been regreased and the stump pin is still gliding smoothly and quietly up and down in its slippery environment.

Installation of floor joists

Check the bearer positions

Before starting work on the floor joists, check that the bearers are sitting flat on the same plane. It is sometimes necessary to plane timber off bearers that are too high, or alternatively fit packers where the bearers are too low.

Floor joists are mounted straight on top of the bearers. I have known of people fitting light wire netting between the floor joists and the bearers. Bulk insulation is then laid on top of this netting just prior to installing the flooring. While I agree that this method will work I have some reservations. It is important to have the floor joists fixed securely to the bearer to avoid movement between the joint that will generate noise in the floor. To fix the floor joists over wire netting is likely to increase the possibility of movement in this junction as the wire could hold the two surfaces apart initially. After some time the wire netting would bed into the timber and thereby create space between the timbers generating noise.

When building a straw bale house on stumps it is much easier to lay a sheet flooring prior to erecting the walls. Strip flooring would suffer greatly from the amount of water that will get on it during the rendering process. If the bulk insulation was inserted prior to the floor it is still likely to get wet from water that leaks through the flooring. There are other alternative methods of insulating the floor that are covered in Chapter 13.

Details of floor joist material

The materials to be used for floor joists will be specified on the approved plans, as will the spacings of the floor joists. As a general rule the floor joists are fitted at 450 mm centres. On a recent inspection of a house being built by an owner-builder I discovered that the floor joists had been fitted at 460 mm centres. The owner explained that by just stretching the floor joists out that little bit he saved a whole floor joist.

When the specifications stipulate that the joists are to be fitted at 450 centres, to fit them at 460 is breaking the law. The building surveyor would not only have the power to force you to rectify it, but would be doing the morally correct thing. This particular job had progressed well beyond the floor joist stage. The floor had been fitted and most of the walls built and in place. Consequently it was unrealistic to remove and refit the floor joists, so the only remaining solution would be to fit a second floor joist between each of the existing floor joists so that the span between the floor joists was legal. To save one floor joist can end up being a very costly and time-consuming saving.

Legal variations from the specifications.

The only way to vary from the materials specified on the approved plan with the building permit is to have an engineer provide calculations for the alteration. In most situations it is possible to use a range of timber types and sizes or even steel to perform a particular task. A good consultant will often be able to advise you on variations that will not require engineering calculations but it is wise to check before you change any thing.

If the material schedule on the approved plans specifies that the timber used for the floor joists is 'continuous span', the floor joist has to be supported in a minimum of three places. When fitting the floor joists avoid using bowed materials that are to be fitted in a continuous span application, as you will not be permitted to cripple the floor joist (see Figure 3.6).

Floor joists to support a straw bale wall

Check your plan for details on the requirement for the floor joists that support your straw bales. If you are unsure contact your engineer or building consultant to ensure that you provide the appropriate floor joists to support this load. If this is not done correctly you will have problems with cracking in your walls and bowed flooring, to say nothing of doors and windows that jamb.

Floor joists supporting internal walls

When the roof and/or ceiling of a house are supported on the internal walls it is necessary to fit two floor joists directly under the wall. If this is not done the weight of the wall, the ceiling and the roof load will be held only by the flooring, which would of course bow down, if not break. When trusses are being used the weight of the ceiling and roof is transferred to the outer walls of the house. In this instance a single floor joist to support the wall may be sufficient, however this should be checked with your engineer or building consultant.

Floor joists supporting sheet flooring

There are specific requirements for floor joists supporting sheet flooring. When using sheet flooring you will have to support the ends of the flooring on a floor joist. It is much better to install floor joists in the correct position rather than to cut the flooring to match the floor joists. Sheet flooring is to be laid in a running bond pattern like bricklaying. When establishing the required position of the floor joists, ensure that you position a floor joist to support these staggered joints. When joining the factory ends of the flooring the joint will be tight and clean. The ends of the flooring have a waxy seal on them, which serves to reduce water penetration into the end grain of the flooring.

Installing floor joists

The first floor joists to be fitted are those supporting walls, both internal and bale walls. The next floor joists to be fitted are those that support the end joints of the flooring.

Mark the bearers for the floor joists

Before carrying any floor joists onto the job, mark on the bearers the required placement of the floor joists for walls and end support of the flooring. The standard length for yellow tongue particleboard sheet flooring is 3.6 metres. Measure along the bearer in 3.6 metre intervals from the very outside of the house. This 3.6-metre mark is to represent the centre of the floor joist so that where the flooring meets each piece will have 50 per cent of the floor joist as support (see A on Figure 3.8).

You should note the markings on the bearer for a special single floor joist. There is one line that is approximately square to the timber with a second line off to an angle creating an arrow. The floor joist will cover the line off to the angle. This line represents which side of the arrow the timber is to be fitted on. The junction of the two lines indicates the position of the side of the floor joist. It should be noted at this point that it is unnecessary to mark the positions of the common floor joists. Common floor joists are fitted after the special joists (see B on Figure 3.8). A piece of timber indicating the spacings of the joists will be used to locate the fixing position of the common joists rather than to locate them on marks on the bearer.

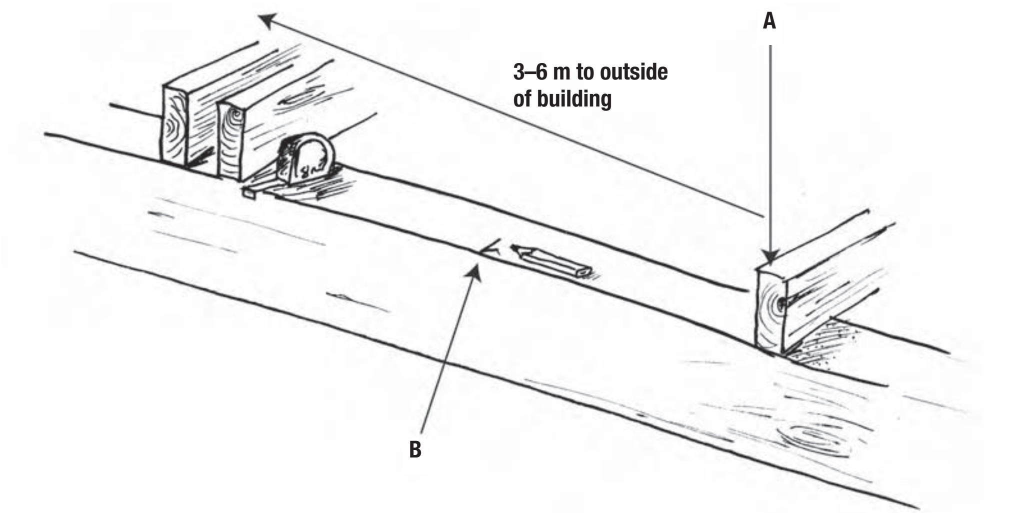


Figure 3.8 Mark the bearer for floor joist positions

Cutting the floor joists to length

Once you have marked the bearer with the specific requirements for the special floor joists, you can carry all the floor joists into the house, placing them on the bearers. Place the correct quantity of floor joists on the positions marked on the bearers plus additional common floor joists between them. If the specifications call for floor joists at 450 crs you will obviously place additional floor joists at roughly 450 crs. Ensure that the floor joists are square to the bearers and that the overhang of the floor joist on the inside end of the house is not greater than 100 mm. You will now proceed to cut the excess off the end of the floor joist that extends over the outside floor joist. Simply use the bearer beneath the floor joist as a guide to cut the floor joist square and to the correct length.

Joining floor joists

Around the outside wall it will be necessary to join the floor joists end to end with each floor joist utilising 50 per cent of the width of the top of the bearer as support. This is also required for the support of the end joints of sheet flooring and for internal walls extending beyond the length of one floor joist. Where it is required to have double joists to support the wall above, it is best to fit the double joist with a 45 mm gap between the joists. A block of 45 mm timber can then be nailed between the two joists to help stabilise them. All other floor joists can be overlapped at the bearer where they meet. It is best to fresh cut the ends of floor joists where they butt together, as they are less likely to split and will fit together well. To state the obvious, the ends of the floor joists are to be supported by the bearer unless otherwise stipulated in the specifications on the approved building permit plan.

Fixing requirements of floor joists

Each floor joist is to have two skew nails from the floor joist into the bearer where possible. Where the floor joists overlap the first floor joist is to have two skew nails while the second will have one skew nail with an additional nail horizontally into the adjoining floor joist. Floor joists that are butt jointed are to be skew nailed into the bearer as per normal with an additional skew nail in the side of the floor joist joining the two joists together. Care must be taken not to split the timber when nailing so close to the ends of the floor joists. The requirement for butt-joined floor joists is predominantly where double joists are required. In this instance, fixing a block of timber between the floor joists at the butt joint of the two joists will add considerable stability to them (see Figure 3.9). Extra stability can be achieved at the butt joint of a single floor joist by fixing a block to the bearer at the junction of the two joists. The two floor joists are then nailed back to the block (see Figure 3.10).

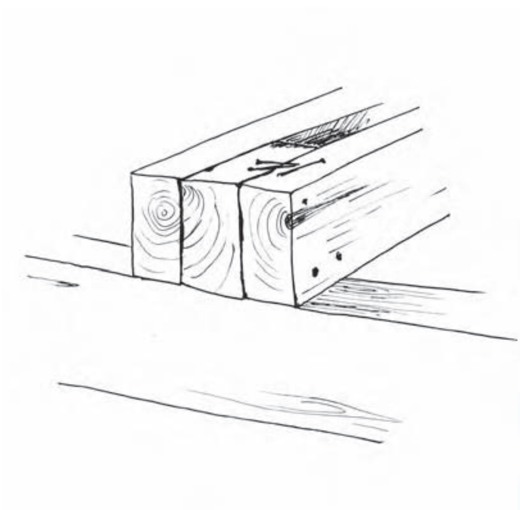


Figure 3.9 Insert stabilising blocks between double joists

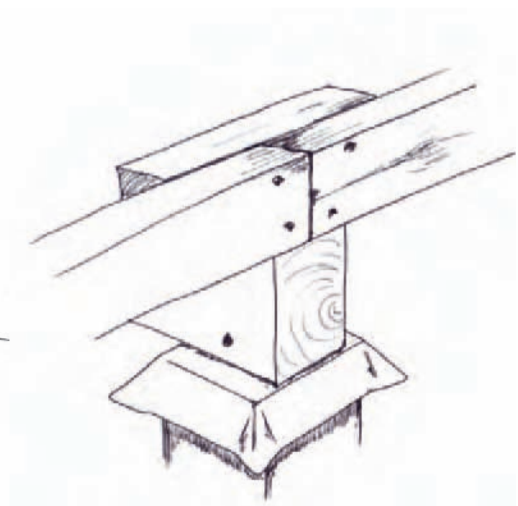


Figure 3.10 Stabilising block to support butt-joined floor joists

Flooring

Plumbing installation

It is standard practice for your plumber to install all sub-floor plumbing prior to the installation of the flooring. This includes hot and cold water lines and the sewer lines. It may also be that the electrician has some cabling to do prior to flooring so check with them prior to installing the flooring. Remember! You will need to give your tradesperson time to schedule in your work so allow them plenty of time to avoid the frustration of the job being held up.

Preparations required prior to installing flooring

The floor joists have to be in a level line prior to the installation of the flooring material. It may be that some of the floor joists are low while others are too high. The floor joists that are too high will need to be planed down to the correct height. An electric planer is by far the most appropriate piece of equipment for this task. If you are only building one house the low cost tools will do the job, however if you are considering a change of career to that of a carpenter it would be better to buy equipment from a tool shop that supplies tradespeople rather than a hardware store. The specialist shops can advise you on what the tradespeople prefer, which is a good guide.

The floor joists that are too low will need to be packed up to the correct height. Good timber yards will sell masonite packers. Masonite packers are 3 mm thick, about 2440 mm long and obviously made from masonite. Glue the masonite packers to the floor joist with construction adhesive prior to fitting the floor. By laying a straight edge across the floor joists you will quickly see which floor joists need adjusting. Ideally the straight edge should be about 2 metres long. A string line stretched very tightly across the floor joists also works well. When you use a string line in this application, place a packer under the string line to lift it slightly above the floor joists so that the high floor joists do not foul on the string.

Fixing requirements for installing flooring

When installing flooring you are required to use nails with minimum length of 2.5 times the thickness of the flooring being fitted. Strip flooring up to 75 mm wide can be fixed with a single nail. Boards wider than 75 mm are to be fixed with two nails on a slight skew.

Strip flooring

Strip flooring is only to be fitted once the house has all roofing and glazing in place, as moisture from rain will quickly destroy the floor. You are required to leave a 10 mm gap between the side of the flooring and any walls to allow for some expansion and contraction.

Once the internal wall lining and skirting is in place this gap will not be seen. Even though there is an expansion gap around the floor it takes very little rain on strip flooring to cause it to swell and buckle. As the floor swells it will take up some or the entire expansion gap and then buckle up. Once the floor is buckled up it is extremely difficult to save. The tongues of the flooring often crack and the flooring itself will dry in the new buckled position that is most often twisted.

Alternatively, if the flooring is not clamped tight enough, any shrinkage will cause the floor to squeak and groan. This is difficult to rectify, however I know of one person whose solution, while being effective, was short-lived. He fed a hose into the sub-floor cavity and fixed a soaker hose (a fine spray water sprinkler) approximately six metres long under the offending area of floor. He then proceeded to water the underside of the flooring, causing the flooring to swell thereby eliminating the squeak. At least until the timber dried out, which was undoubtedly some time after the property was sold.

Particleboard sheet flooring

Particleboard sheet flooring is the most common product used in the construction of straw bale houses on stumps. The flooring will be laid on the floor joists covering the complete area of the house including the floor area that the bales are to cover. This provides an extremely good seal against air and bugs. Sheet flooring has a weather guarantee. Check with your supplier to ascertain the guarantee period for the flooring to be used on your job.

It is now a requirement that all two-storey houses have sheet flooring fitted to the upper floor joists so that the tradespeople have a platform to work on rather than to walk on the floor joists with open space below them. Our experience shows that render being spilt on it during the process of rendering the walls does not adversely affect the sheet flooring. For convenience we loosely lay builders plastic on the floor prior to rendering to speed up the process of cleaning. If you don’t use plastic, I would recommend that you scrape the floor clean of lumps of render as soon as possible after the rendering of the walls is completed.

The likely cause of squeaky sheet flooring

I have heard the complaint that sheet flooring is squeaky. I agree that there are many particleboard floors that are noisy, however from my experience this can be attributed to the installation of the floor with one exception. The early sheet flooring, which from memory first came on the market around 1976, had a moulded tongue and groove, rather than the strip of high strength plastic that now forms the tongue. This tongue was easily broken during installation, and has been known to break once installed.

Installing sheet flooring

Prior to installing the flooring, it is essential that the top edges of the floor joists are level. Check this either using a straight edge or by pulling a string line across the top of the floor joists. A joist may be level in one position and high further along the joist due to bow in the timber. You will trim down the high floor joists ideally using an electric planer. The low joists will have to be packed up. As mentioned above, you can purchase 3 mm thick and 30 mm wide masonite packers approximately 2440 mm long from your timber supplier.

The first row of sheet flooring to be fitted

The first row of flooring is to be laid with the tongue of the flooring facing the outside wall, so that the next row of flooring will be fed into the groove of the first row of flooring.

It is essential that the first sheets of flooring be laid in a straight line otherwise you will have gaps between the flooring. Use a string line pulled taught over the top of the floor joists from one end of the house to the other. This will be your positioning guide for the first row of flooring. Apply about a 6 mm bead of construction adhesive to the top of the floor joist and then lay the flooring down onto the adhesive. If it is necessary to fit a packer, lay the packer onto the adhesive on the floor joist and then apply another bead of adhesive on top of the packer onto which the flooring will sit. Complete laying the first row of flooring, ensuring that the ends of the sheets of flooring are supported by floor joists, and that adhesive is placed between the end joints of the flooring, as this helps prevent moisture penetration into the end of the sheets. This is particularly important when sheets have been cut to length.

Staggering the joints of sheet flooring

The first sheet of flooring of the next row of flooring will be 1.8 metres long, so as to stagger the joints of the flooring. The balance of the flooring will be laid in the same manner, however you will apply about a 3 mm bead of adhesive to the top of the plastic tongue prior to joining the sheets together. I find that applying the adhesive to the joint of the boards causes the tongue to more easily slide into the groove of the partnering board. The adhesive seems to work as a lubricant while it is still wet. If the weather is hot you will have more difficulty joining the sheets together, as the sheets tend to twist slightly in the heat. If you have floor clamps available they will overcome this problem. If not, place a piece of timber 90 × 35 or 90 × 45 against the tongue of the flooring being fitted and then use a sledge hammer against this timber to ram the sheets together.

When the sheets are joined there should be sufficient adhesive to have it visible at the surface of the board. It is best not to have it oozing out too much as this will be quite slippery and coat anything that comes in contact with it. The standard nailing requirement for fixing sheet flooring is to evenly distribute five nails across the board into the floor joist in the body of the board. The ends of the sheets are to each have six nails that are to be evenly distributed across the breadth of the board. Ideally the nails should be slightly skewed in opposition to one another. You can use 75 mm framing nails to fit the flooring. If using 75 mm nails take extra care to ensure that the extra long nails do not damage any plumbing or electrical installations that are fixed to the side of the floor joists.

Insulation of timber floors for 5-star energy rating

It is now necessary to insulate timber floors to comply with the 5-star energy requirements. This can be done by fitting bulk insulation between the floor joists, supported on roofing safety wire, or by installing Air-Cell building insulation.

Air-Cell looks like a section of heavy duty bubble wrap material sandwiched between two layers of a reflective sizalation. Air-Cell, when fixed below the floor joists, fulfils all 5-star energy requirements. A newsletter put out by Air-Cell in April 2005 states that 'Air-Cell is cost effective and allows better thermal resistance than a 100 mm concrete slab'.

Air-Cell is to be fixed perpendicular to the bearers and fixed in position to the underside of the floor joists with either screws or staples.

When installing this product, I prefer to use a heavy duty staple with a large crown which gives an extremely secure fixing. Standard sizalation is inclined to tear around the fixings, however I have not found this to be a problem with Air-Cell. When installing the product, a 100 mm of the join should be left untapped for the release of any moisture.

When purchasing Air-Cell be sure that you are purchasing the real product, as there are cheaper alternatives that appear the same but do not comply with the Australian Standards with regards to flammability, insulation, mould resistance and vermin deterrents.

Strip footings for timber floors and earthen floors

A strip footing is made up of concrete with reinforcing rods of steel. The steel is positioned in the trench, and the concrete then poured into a trench in the ground. An engineer following the soil report determines the depth and width of the trench and the steel to be used. The concrete of the strip footings may protrude above the natural ground level or finish slightly below the natural ground level. When the concrete protrudes above the natural ground level formwork to support the concrete until it sets will be installed. When the strip footing is to have a timber floor installed within its bounds, the formwork will be designed to provide airflow beneath the floor for cross ventilation. Strip footings with concrete finishing below the ground surface will generally have bricks laid on top of the concrete to the desired final height. Again, when a timber floor is to be installed, ventilation gaps will be provided in the brickwork.

Strip footings will likely be required when an earthen floor is required. The concrete of the footing will normally protrude to the underside of the straw bales. The earthen floor would then be poured within the strip footing to the desired height. When earthen floors are used, significant care needs to be taken to prevent moisture penetration through the floor. Due consideration should be taken when investigating possible termite barriers. In heavy termite areas Kordon is laid under concrete slabs in the place of builders plastic. This provides both moisture and termite barriers. I can see no reason why this would not work equally well for an earthen floor, however you should contact your local pest controller regarding your particular application.

Concrete slab floor

As with all foundations, the specific design of a concrete slab for your property will be established by an engineer, and give due consideration to the findings of the soil report. A slab is normally laid on an excavated site; this is covered in Chapter 2, site preparation.

The trenches required for a concrete slab (beams)

A trench is dug around the outer perimeter of the house and often within the bounds of the house (referred to as edge beams). If you are using a contractor to lay the slab they will arrange for the appropriate trenches, if not you will need to refer to the engineers' details.

Building up the height of a concrete slab

Once the trenches are dug the area between the trenches needs to be flattened and often raised. This is achieved by installing crushed rock or packing sand (see Figure 3.11). This material must be well-compacted, as loose material will settle, leaving the slab above unsupported. Try to keep the required amount of packing to a minimum as the greater the depth of sand the greater the potential for settling, even when compaction has occurred. You can hire vibrator plates from almost any building hire company. Vibrating rollers would be difficult to get into the bounds of the house without collapsing the sides of trenches, whereas two people can lift a vibrator plate machine into the job.

The crushed rock has to be flat compacted and level. Any variance in the height of the crushed rock will be made up for in concrete. Crushed rock is significantly cheaper than concrete. The final level of the crushed rock will be determined by the specified thickness of the slab and the variance between the surface of the slab and the surrounding earth. Refer to the engineers' details and the approved plans to establish the required slab thickness. For residential construction it is normally 100 mm excluding the thickness of the beams.

Figure 3.11 Compacted crushed rock and formwork for a concrete slab

Formwork for the concrete slab

Once the crushed rock is in place, formwork is installed around the perimeter of the house to contain and set the height of the concrete slab. The top edge of the formwork will be set to match the required overall height of the finished concrete slab. A laser level is the simplest method of establishing this height, although a dumpy level will do just as well. You could use a water level, however this would be much more time consuming. A water level is a simple device comprised of a length of clear plastic tube almost full of water with the ends sealed closed. To use a water level to establish the required height of concrete boxing, stumps or anything else, hold the two ends of the tube together so that there is air at the end of each tube. Secure one end of the tube with the water line at the required height in the tube. By stretching the other end of the tube to another position, you will ascertain the level position by recording the level of water in the tube. Water levels are simple to make, accurate and very inexpensive. If you opt to make your own, it is best to colour the water with food colouring or similar, as this makes it much easier to see the water level.

Following the installation of the perimeter boxing or formwork, builder's plastic or other approved materials is laid in the building envelope to form a moisture barrier between the earth and concrete. The plastic is laid into the trenches and over the top edge of the boxing. All joints in the plastic are to be sealed with tape (see Figure 3.12).

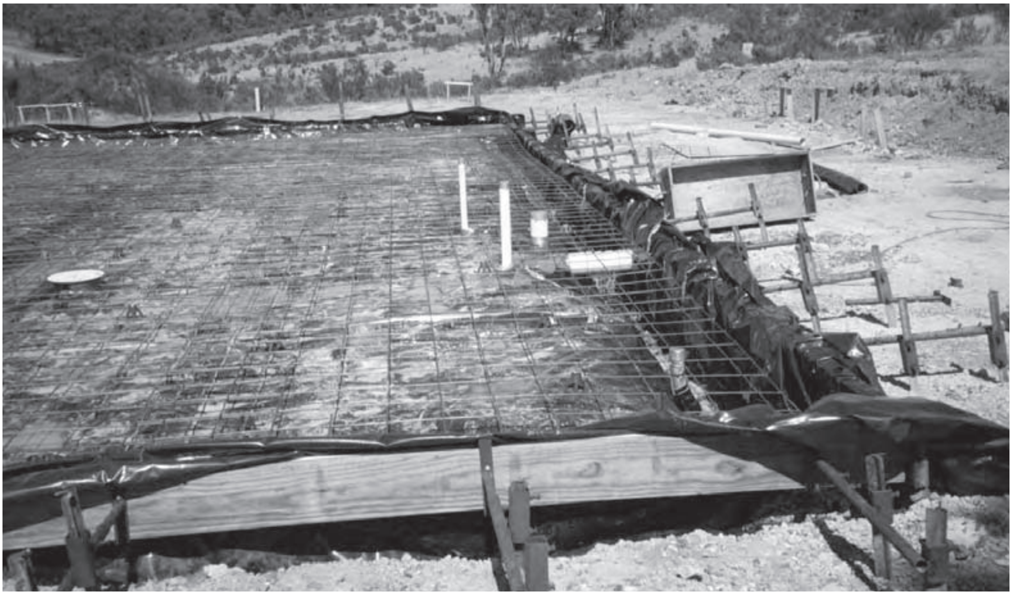


Figure 3.12 Plastic membrane and steel mesh supported on bar chairs for a concrete slab

While studying building techniques at the Royal Melbourne Institute of Technology in 1974, the subject of water penetration into concrete was studied in some detail. While it is the general view that the plastic forms a moisture barrier, the lecturers at the institute explained that it was not in fact the plastic that kept moisture out of the concrete slab. In actual fact the moisture barrier is created by the concrete resting on the plastic that has a glassy surface. As a consequence of this smooth surface the underside of the concrete was extremely smooth, as all the fine particles in the concrete settled against the plastic. It is actually the near glassy finish of the concrete that provides the moisture barrier. The engineer that we employ and I are both concerned at some of the problems that this same plastic can cause later in the life of the house. If, after the boxing is removed, the plastic is cut off at the surface of the ground the plastic can actually form a well around the slab. When the walls are wet from weather or watering, the water will run down the wall and can go between the concrete and the plastic. This can lead to the house sitting in a pool of water that the earth cannot draw away from the concrete floor.

Steel reinforcing for a concrete slab

Refer to your engineers' design to determine the steel required as reinforcing in your concrete slab. There will be steel placed in the bottom of the trenches that is to be kept away from the edges of the trenches. You will require steel mesh in the top layer of the concrete slab. This mesh is to be located approximately one-third down from the top of the slab. All steelwork is to be supported on bar chairs to keep it level with an even distance from the plastic lining.

Concrete slabs and heat control

As mentioned earlier in the chapter (see 'Thermal mass, is it for you or against you?') it is widely accepted that a concrete floor is better for heat control, however I have some reservations regarding this. My own two-storey straw bale house in Heathcote, Victoria, with its concrete floor and slate tiles downstairs is terrific in summer when the floor is cool, contributing to the low temperatures in the house on the hottest days, but it is equally as cool in winter. Had we taken advantage of the warmth from the northern winter sun, the cold floor problem would have been significantly reduced but this was not to be.

Our property has views over the McIvor Ranges to the south so we sacrificed the passive solar heat to take advantage of the views to the south. Our floor is quite cool, a direct consequence of the concrete sitting on the cool ground. To some degree, had foam insulation been installed around, if not beneath, the slab it would have reduced the cooling effect of the ground beneath the slab, but the mass of the floor is still significant in its own right.

Concrete floors, passive solar heating and thermal mass

If you have a large mass of material that is cool, such as a concrete floor, and you want to heat it, you must displace the coolness with the warmth. To achieve a neutral temperature takes a huge amount of energy. However, timber floors with appropriate insulation are more likely to gain a neutral temperature with much less heat generation as the heat is contained within the cocoon of the room without having to convert a cold mass first. The benefits of thermal mass can work against you.

The surface of the concrete slab was once viewed as a material to be covered with carpet or tiles of some sort but this is changing. I currently have a client building a house in one of Melbourne's outer suburbs using straw bale on a concrete slab. The surface of the slab has been ground back to expose the aggregate of the concrete and to give a very flat and smooth surface. They have then stained the concrete and sealed it. The effect is quite dramatic.

4

Straw bale walls

Longevity of straw bale houses

There is more than sufficient anecdotal evidence to refute any concerns regarding the longevity of straw bale houses. There is the ranch house near Hyannis, Nebraska, which has two of the oldest hay bale buildings that were built no later than 1914, but more likely nearer the turn of the century. It is reported that in 1997 Athena and Bill Steen uncovered some of the bales and found them to be in good condition. There is a load-bearing house known as the Martin Monhart House in Nebraska that was built in 1925. If you would like more details including good photographs, I would recommend that you purchase the book *The Beauty of Straw Bale Homes* by Athena and Bill Steen.

When I first announced to my friends and building colleagues that I was going to build a straw bale house I copped the traditional comment of what about the three little pigs, and then the more serious concerns regarding fire. We all know that the three little pigs are a fairy tale and we now know that the writers obviously had no understanding of construction. They caught the disease of thinking that the newest method of construction is obviously the best: a difficulty that we often face when approaching city building departments. I am pleased to say that this difficulty is now readily overcome.

Fire and straw bale buildings

Some time ago Bohdan Dorniak, an architect in South Australia, was having difficulty gaining permits for straw bale buildings in fire prone areas. As a consequence, Bohdan, with some generous support, had fire tests performed on rendered straw bale walls. Consequently, we now have scientific support of the construction of straw bale homes in bushfire prone areas. These tests are available at what I believe to be a modest fee of about $250 for people wanting to build in bushfire prone areas.

The one avoidable vulnerability of straw bale walls

Once the walls are in place and compressed they form an extremely strong and stable structure. The only concern that needs constant reference is its vulnerability to water. It is for this reason that special consideration be paid to the provision of roofing materials ideally with wide eaves, if not verandahs. I am also concerned about the treatment of penetrations through the bale walls of plumbing lines, as condensation on the pipes will most likely cause an increase in moisture content in the bales in the vicinity of the pipes. This issue is covered in Chapter 13, plumbing installations.

Straw bale construction: the basics

Straw bale houses are constructed in one of two methods or a combination of both: load bearing or infill construction.

Load bearing straw bale structures

With load bearing construction the weight of the roof and the ceiling is transferred through the bales of straw down to the foundations. The load bearing method is, in my opinion, the cheapest and easiest structure to build, and is an ideal method of building a simple single storey home.

Infill straw bale structures

The infill construction system has posts and beams that extend up to the top of the walls. The ceiling and roof are mounted on the upper beams or ring beam. Consequently the weight of the ceiling and roof is transferred through the posts and beams down to the foundations. Traditionally, infill buildings have had a timber or steel structure that is completely self-supporting. More often than not, there are 16 mm steel bracing rods fitted to the structure to provide the lateral stability to the building.

One of my owner-builders in Ringwood, Victoria, was required by his engineer to not only provide 16 mm steel bracing rods, but also large steel gussets at the junction of all his posts and beams. These gussets were triangular sections of steel approximately 6 mm thick and about 900 mm long down the diagonal.

Structural infill straw bale buildings

Our home in Heathcote is an infill two-storey building but does not have bracing of any sort to support the timber structure. The lateral stability of the building is provided by the straw bales only. We refer to this type of construction as ‘structural infill’ as the bales form an integral part of the structural integrity of the building as opposed to simply filling in the spaces between posts to stop the wind blowing through the house.

Two-storey straw bale buildings

Traditionally, two-storey buildings would be constructed by the infill method, with the upper flooring supported on timber beams that are in turn supported on posts.

There are reports of two-storey load bearing structures, however this method is in its infancy and, as yet, I have not had the opportunity to view the details of such structures.

Another alternative would be to construct the lower section of the house as infill and the walls of the upper floor as load bearing.

Posts, infill construction and timber floors on stumps

When constructing a straw bale house on stumps the load bearing method presents fewer issues, as this construction method spreads the load of the roof and ceiling much more evenly than infill. If the infill system is used, special attention will have to be given to the concentration of the load of the roof and ceiling down onto the floor. It will be necessary to install stumps directly below each of the posts. It may also be essential to increase the support under these stumps. These calculations would need to be done by an engineer.

What constitutes a good bale of straw

Straw bales do vary however the most common small bales in Australia are approximately 900 mm long, 450 mm wide and 350 mm high. If the length of the bale is twice that of the width it is easier to negotiate corners, as it will cause an even running bond. One of my owner-builders had purchased bales that were up to 1.2 metres long. When he handled the bales they tended to bow in the middle, often resulting in the bale popping and breaking out of the twine securing the bales. The bales need to be well compacted during the baling process, as the bales will form an integral part of the strength of the structure, regardless of whether the bales are load bearing or infill between posts.

Ideally the straw is baled early in the day when the straw has some moisture content. When the straw is baled in the heat of the day, the straw is drier and much more brittle. This leads to the straw breaking when folded into the baler rather than bending. As the bent straw contributes to the structural integrity of the bale, the resultant bale is significantly weaker, having many cracked or broken shafts of straw.

Testing bales for structural capacity

Compression of straw bale walls for infill construction

If you have done research on straw bale construction you may well have heard that the compression and structural capacity of a straw bale wall isn't of much consequence when building infill style construction. I disagree, as it is essential that the walls are able to withstand wind pressure and likely impact from lively teenagers, if nothing else.

There are two basic schools of thought regarding the carrying capacity of straw bale walls. The first is that the top boxing (a timber structure placed on top of the bales and tensioned with a similar bottom box below) should extend beyond the straw bales enabling the weight of the roof and ceiling to be transferred to the render on the faces of the wall. In this application the addition of bracing in infill wall construction appears to be normal. The other system is for the top boxing to be narrower than the width of the bales. In this application the render, while adding to the structural integrity of the wall, does not carry the weight of the structure above as in the first method. The actual weight of the roof and ceiling is transferred to the foundations through the straw rather than the render.

I have not personally been involved with the construction of walls with the wider top boxing, but have no difficulty in accepting the structural integrity of the system that is supported by years of testing. I have concentrated on working with the second alternative due to personal concerns over the previous method that I shall detail later in this chapter.

For and against relying on the render to carry roof load

When using the carrying capacity of the straw in the bales to carry the roof and ceiling load it is essential that appropriate compression of the walls be achieved. Once this level of compression is achieved, the straw bale wall will present mechanically as if it were a single block. In consultation with our engineers it was established that not only was the straw of the wall capable of supporting the roof and ceiling load when properly compressed, but also negated the need for additional metal or timber bracing in infill construction. Not only does this system hold weight by the recommendation of the engineer, but it has also been physically proven to work, as my home in Heathcote was built by this system.

The Heathcote house

The Heathcote house is as an example of not relying on render for carrying strength. We are in a high wind zone area with the peak of the roof approximately nine metres high, added to which are three-metre-wide verandahs that also catch the wind. The straw bale walls are over 4.0 metres to the underside of the rafters and have no additional bracing. The ring beam that supports the rafters is supported by 100 × 100 cypress pine posts 2.7 metres apart with nothing but the straw bales to hold them upright. I must stress that this is totally reliant on adequate compression of the bales to lock them together.

To achieve this level of compression we utilise flat filament polyester strapping with a breaking strain of 1000 kg. When using this strapping it is essential that the correct connector buckles are used, as the system is only as good as its weakest link. When we first started working with this strapping we were using a lower grade buckle, which was prone to collapsing under the strain of the strapping. The strapping is tensioned with a standard strapping tensioning tool available at around $120 (2005).

Compressed straw bale capability

Compressed straw bales are more than capable of carrying the roof load. The structural capacity of straw bale walls where the top boxing does not extend beyond the bales over the render is substantiated by the test results of research done at Sydney West University. The straw bales are more than capable of supporting the load of the roof in load bearing buildings, so it is unnecessary to extend the top boxing over the bales to transfer weight through the render. Extending the top boxing over the render does increase the carrying capacity of the wall, however I believe there are good reasons not to rely on the render for strength.

Relying on render

I believe there are reasons for concern regarding the reliance on render for strength in a straw bale wall. Over the years, I have had occasion to see first hand the maintenance, or lack of maintenance, to Australia's domestic buildings. We live a busy life in a hectic world, and are often griped by more pressing life issues than painting and maintaining our houses.

To build a structure that is reliant for strength on a skin of render, whose structural integrity is reliant on the owner's maintenance, does not appeal to me. In that the structural capacity of the straw bales alone are more than sufficient for most applications, I am yet to be convinced of either the need or wisdom in transferring any load to the skin of render over the straw bales.

Can any bales of straw be used to build a house?

I am often asked will any straw bales do the job? The answer is categorically NO! The bales must be dry with no sign of having been wet, and ideally tight. Look for dark stains on the straw as indication of them having been wet in the past. If you are reliant on the straw bales to carry the roof load or provide bracing for the lateral stability of the building, it is essential that the bales are able to carry the necessary load that will be placed on them. Even for infill walls where there is additional bracing the bales must be dry and tight. If you use bad bales in the wall you will have to work harder in preparation of the wall for rendering. There will be more trimming and more filling of gaps. It really is not worth compromising on quality. My house is over 20 squares, and used approximately 500 bales. In 2005 bales of straw were sold for around $5.50. If you were able to buy them from a farmer direct you might get them for $3.50. The percentage difference is significant, however it only equates to $1000 in total. Given what you are trying to achieve, you have to ask yourself, 'is this the place to try to save a dollar?'

Selecting straw bales

Straw baled early in the morning is stronger than that baled in the heat of the day. The old-time farmers will tell you that the best bales of straw are baled early in the morning up to about 10 am when there is some moisture in the straw from dew but the straw is still dry. Straw baled in the heat of the day will crack rather than bend when forced into the baler, thereby reducing the strength of the bale.

It is very easy to test a bale of straw for building purposes. First of all pick up the bale by one string. If the bale stays in tact continue the examination, if not, it is probably best to leave it for animals to bed on. Next you should check for any discoloration or blackening of the bale, as this would indicate that the bales have most likely been wet, which may promote the decomposition of the straw. Open up one of the bales to check for moisture in the centre of the bale and for any musty smells.

Proof of structural carrying capacity

Engineers and building surveyors may ask for proof of the bales carrying capacity. In rare instances I have had engineers and building surveyors request proof of the structural carrying capacity of the bales. While this can be measured utilising a moisture metre to ascertain what percentage of the weight is attributed to moisture, I believe that this is an unnecessary complication. When the walls are compressed with the polyester strapping the compression is such that any bales lacking in density will be compressed until their density is more than sufficient to carry the load. Obviously any bales that are clearly loosely packed would be eliminated prior to installing in the wall. The roof load will be significantly less than the compression applied to the wall with the strapping. With a compression factor of around 900 kg per 450 mm run around the bale wall, it is unlikely that any roof load would exceed this. This level of compression is equivalent to parking a small car on top of the wall every 450 mm around the wall in order to compress the bales.

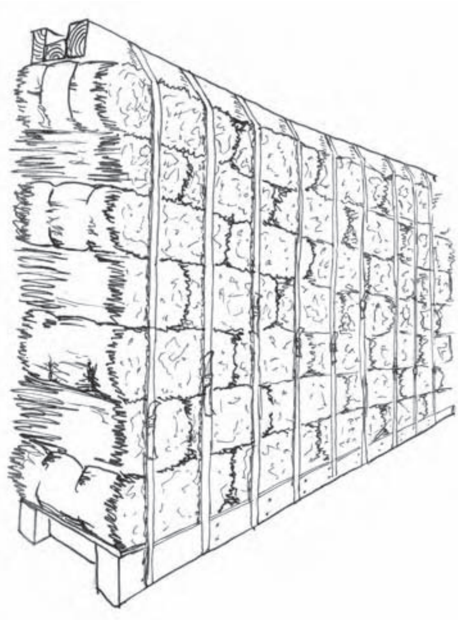


Figure 4.1 Basic straw bale wall construction

Straw bale walls to 2.7 metres high

You should be able to build a well-constructed wall of about 2.7 metres high without needing to hold it in place with temporary bracing. I would not recommend that you walk around on top of it although it has been done. Once all the bales are laid, normally seven or eight rows, a timber structure known as top boxing is placed on top of the wall. This applies to both load-bearing and structural infill structures. Regardless of the compression system, tension is applied to the top and bottom boxing in an attempt to draw them together thereby compressing the bales between them (see Figure 4.1).

Bottom boxing

Bottom boxing to raise bales up off the floor

As previously established, it is essential that the bales of straw be kept above the floor level to protect them from water. There are many methods of achieving this. You could create this as a raised-up edge beam when pouring the concrete slab, lay clay bricks on the floor or simply fix individual lengths of timber to the floor. The option we have chosen is to build a box section 90 mm high for the bales to sit on. This boxing configuration will allow installation of electrical and plumbing lines within it. The 90 mm height gives a good safe water barrier to the bales, and provides an excellent fixing point for skirting if it is required.

Making a timber bottom boxing 90 mm high

Construct the bottom bale boxing like a ladder with rungs. The side rails are from 90 × 35, as are the noggings between the side rails. The overall width of the bottom boxing is 450 mm. Fit the noggs, short for noggings, at 450 centres, on edge between the side rails which are also fixed on their edge. Additional noggs are to be fitted on flat at 1.8 metre centres. These noggs are to be fixed to the vertical noggs already in position (see Figure 4.2).

Polyester strapping

Position the flat polyester compression strapping prior to installing the bottom boxing. When using polyester strapping, cut pieces of the strapping approximately 1.5 metres long and position them on the floor at 450 crs. Tie a knot in each end of the strapping to prevent it from pulling out from under the bottom boxing during construction of the wall (see Figure 4.2). If you are using a physical termite barrier, such as Kordon, this to is to be installed prior to the installation of the bottom boxing. Position the bottom boxing over the polyester strapping in readiness for installation. Fit the bottom boxing level with the top outer edge of the floor. Fix the bottom boxing to the floor via the flat noggings. When fixing to a concrete floor, use three 75 mm masonry nails through each flat nogging. When fixing to timber floors with particleboard flooring, use three 100 mm nails through each nogging. The 100 mm nails are required to pass through the particleboard flooring into solid timber. Fixings into particleboard flooring are not deemed as structural connections.

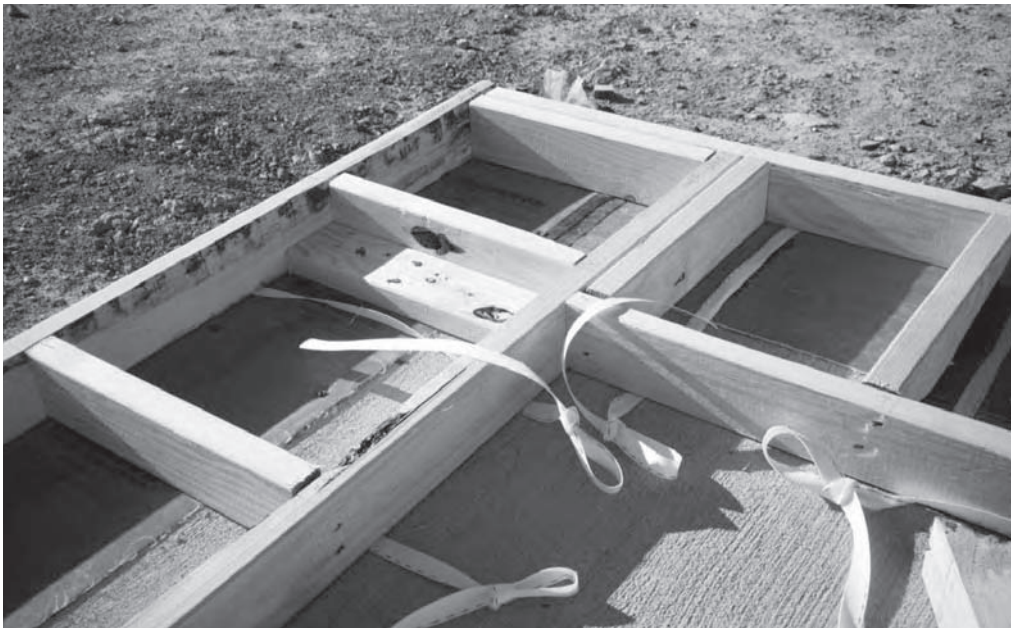


Figure 4.2 The bottom boxing to support a straw bale wall

Once the bottom boxing is fixed in place, have your electrician and plumber install any plumbing or electrical lines that are to be contained within the bottom boxing.

Supporting the straw bales

What prevents the straw bales being pressed into the bottom boxing? At the frame stage, as shown in Figure 4.2, the bottom boxing is unable to support the bales adequately, as the bales will be forced into the cavities of the boxing during compression. The additional support can take one of two forms. The cavity can be filled with crushed rock, or the surface of the boxing can be covered with structural ply.

Covering the bottom boxing with plywood

If covering the bottom boxing with ply it is advisable to fill the cavity with bulk insulation to reduce the risk of a thermal bridge. One concern that I have with ply is the risk of water pooling on the bottom boxing between the bales and the boxing in the case of rain. To reduce this risk, reduce the width of the bottom boxing to 410 mm. The bales would then over hang the bottom boxing so that water would be more likely to discharge cleanly from the face of the bales rather than penetrating the junction of the bales and boxing. The outer 20 mm or the bale that would overhang the boxing would have little if any structural implication, as this is the loosest area of straw in the bale.

Filling the bottom boxing with crushed rock

If you choose to fill the cavity with crushed rock it is imperative that there be no fine material in the crushed rock as there is in crushed rock used in driveways, for example. The fine material would enable moisture to travel through the material to the underside of the bales. I am not concerned about moisture from the ground penetrating the slab, as adequate barriers should have been provided beneath the slab. I am, however, concerned about moisture travelling from potential water spills in the house, for example, washing machine overflows or a burst dishwasher hose. For this reason it is a good idea to provide floor traps for water in the wet areas: these are also a legal requirement in some states. If using crushed rock it may be necessary for any electrical cables within the bottom boxing to be installed inside conduit to protect the cable from damage from the rock, particularly if the rock has sharp edges.

Avoid the use of plastic

It has been suggested that the crushed rock should be covered with plastic onto which the bales are laid. Cedar Rose, in her book *The Natural Plaster Book* (2003, p. 42), recommends that you avoid the installation of plastic against the bales. Plastic, rather than preventing water penetration into the bales, actually tends to do the opposite. As an experiment, place a straw bale on plastic under cover where no added moisture can get on the bales or plastic. Leave the bale to sit undisturbed for a week or two and then check the underside of the bale where it has been in contact with the plastic. You will find that the bottom of the bale is quite moist, if not wet, due to condensation between the plastic and the straw.

Knowing full well that moisture is the only enemy straw bales have, I would rather not risk introducing plastic and the resulting moisture to the bottom of my lovely dry straw bale walls. As plastic presents a very smooth surface that is quite slippery, I would be concerned about sideways slip of the wall at the junction of the bales and the plastic. If the plastic was to press into the crushed rock with the pressure of compression this would to some degree negate the slippage concern. However this would indicate that there are now dips and hollows in the surface of the plastic. If it were to rain and the water were to run down the bales and in on top of the boxing, these divots would become little reservoirs for water rather than flowing away, as is the case without the plastic.

Wall heights

Securing two-storey straw bale walls back to the infill structure

Wall heights up to three metres present few complications, beyond this lateral stabilising will need to be supplied. When constructing a two-storey house this stabilising can be as simple as tying the bales back to the upper floor joists. Drill holes in the upper floor joist through which you will feed polyester strapping. The strapping is to be fed through holes in the floor joists and then out through the straw bale wall. Thread a piece of twine into the hole of a single bale needle then push the needle through the straw to the outside of the building. Tie the twine to the polyester strapping and pull the strapping from the inside of the house to the outside. Repeat this procedure to feed the polyester strapping from the outside of the house back to the inside. This will form a loop of polyester strapping on the outside of the bale wall. Slip a piece of timber, ideally 35 × 35 approximately 400 mm long inside the loop of polyester strapping on the outside of the wall. Pull the excess strapping to the inside of the house so that the timber cleat is held firmly against the bales. With the strapping fed through the holes drilled in the floor joists, the tensioning tool can be used to tighten the strapping (see Figure 4.3).

Figure 4.3 The intermediate securing of straw bales to the upper floor joists to prevent the 4.2 metre wall from toppling over during construction

Sufficient tension is to be applied to the strapping to cause the timber cleat on the outside of the house to be embedded into the straw bales. It is essential that the strapping be fed through several of the deep floor joists. If the strapping were secured to a single floor joist the tension applied to the strapping would cause the floor joist to twist and bow out of its correct location.

Single-storey dwellings with walls over three metres high may need additional lateral stability. This will depend on the placement and frequency of internal walls. You will need to employ the services of an engineer that understands straw bale construction to design suitable stabilising for your house.

Laying the bales

How straw bales are made

It is useful to know how straw bales are made and why one side of the bale is thicker than the other. All bales have one cut face and one folded face. The folded face will have a fluffy appearance. When the bales are being formed the straw is picked up from the ground and fed up to what basically appears as a large fork, called a magpie. The magpie picks up a batch of loose straw and forces it down into a chamber causing one side of the straw to be folded back on itself. As the magpie retracts a ram pushes the straw forward, compacting it. While one side of the straw is folded, the other side is cut flat with knives giving it a relatively clean-cut surface. The folds of the straw are likely to run back into the bale for about 100 mm, which results in the folded or fluffy side of the bale being slightly thicker than the cut side. If you have ever stacked a pile of lever arch files you will have noticed that they tend to slide off one another. You will get the same effect if a system of alternate laying is not done.

Straw bale bulging

The most common cause of a straw bale wall bulging during compression is incorrect laying. Incorrectly laid bales are inclined to lean one way and bow in the middle during the compression process. It was recently suggested that the removal of 20 mm from the folded face of the bale was desirable prior to installation in the wall. If, however, this were done it may be more difficult to differentiate between the fluffy side of the bale and the cut side of the bale. This may lead to the bales being installed incorrectly thereby compromising the structural integrity of the wall. It would be much more likely that the wall would bulge and collapse during compression, or worse still, after completion. As the depth of the folded straw exceeds 20 mm, cutting this amount off would do little if anything to negate the variance in thickness in the bales.

Building a straw bale wall

Windows and doors

Provision for the installation of windows and doors needs to be made before laying any bales. Install any window or door bucks that extend to the floor prior to installing the straw bales. Mark the position of any windows that do not extend to the floor on the bottom boxing before laying any bales. Try to avoid vertical joints of bales lining up with the stile of window bucks that are resting on the bales, as there is a significant possibility that the buck sill will drop unevenly into the joint between the bales during compression. Position loose bales on top of the bottom boxing around the house to ascertain the ideal layout of the first row of bales relative to windows and doors.

Laying the first row of straw bales

Lay the first row of bales with the cut side facing the outside of the building. You will find this will work for you when it comes time to render the walls, and it sets you up for correct pinning of the straps to the bales, which I shall cover shortly. Start laying the bales at an external corner, a window or door buck. When laying bales up to a window or door buck, the bales are to be firm but not tight. If the bales are forced into position it will distort the buck and prevent the later installation of the window or door. Any small gaps between the bales will be filled at a later time

Laying the second row of straw bales

The second row of bales is to be laid with the fluffy side facing to the outside of the building. They are to be laid in a running bond so that there are no vertical joints in the first row of bales lining up with that of the second row of bales. Standard clay bricks are laid in running bond.

Laying bales around corners

When laying bales at the corners of the building do so in the same manner as normal building bricks, with the bale of every second row running around the corner. Tie the twine on the corner bales together in two places to ensure that they stay in the correct position, which will also add structural stability to the corner (see Figure 4.4).

Figure 4.4 The corner bales are secured by tying the bales together with twine in two places

If you want the corners of your house to be very neat it is best to fix two pieces of 240 × 45 timber together to form a corner piece the height of the wall. Nail braces onto the corner piece to hold it vertical at the corner of the building. This will control the positioning of the corner bales (see Figure 4.5). It is essential that the bales be placed one on top of the other in a vertical line. If not, the wall may bulge and burst out one side during compression. This is particularly important for load bearing walls, as the weight of the roof and ceiling is transferred through the walls and floor down to the foundations.

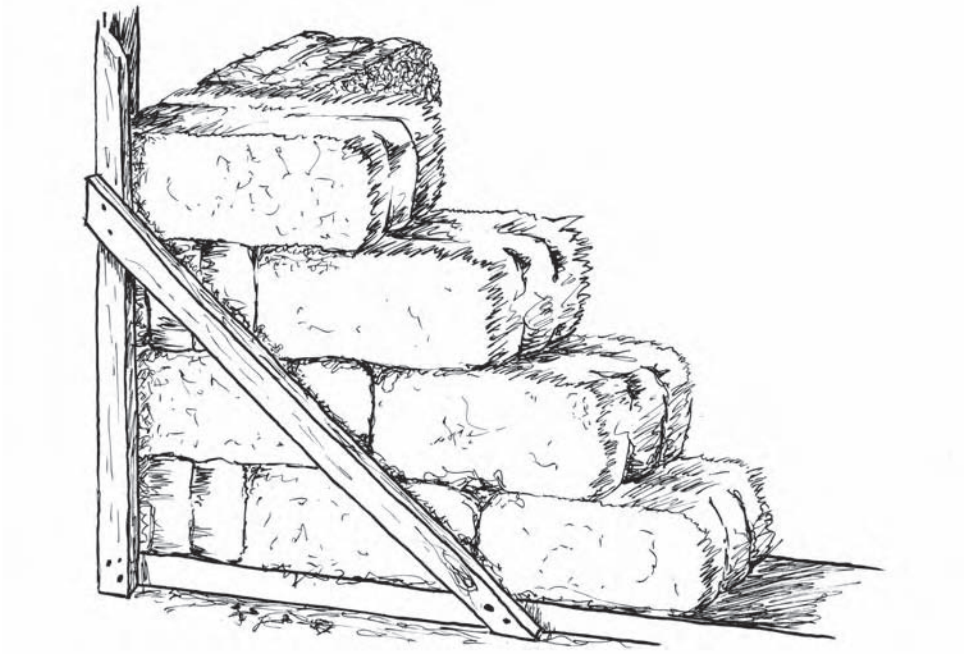


Figure 4.5 The use of a corner bale guide will help to keep the corner bales vertical and in line

Top bale boxing

Options for top boxing

The top bale boxing again varies between different builders. It is suggested in one book that steel be used, while another recommends that the top boxing be of timber and extend beyond the width of the bales. As previously mentioned, apart from my reservations regarding the reliance on render for support of the roof, if the job calls for this, then I do not have a problem with the use of top boxing that extends beyond the width of the walls. However I have more than a little difficulty with the concept of metal top boxing. For an owner-builder to assemble timber top boxing is simple, however this is not the case with metal. Apart from the cost and likely failure of the welds in this system I would rather not introduce more steel to the structure than necessary. I would expect building surveyors to demand that a certified welder carries out all structural steel fabrication, as it will form an integral part of the construction.

Preferred, proven and easy-to-build timber top boxing

For several years we have been using top boxing that is 180 mm wide, which roughly matches spacing of the twine around the bales, which vary from about 180 to 200 mm apart. Our top boxing is made up of three pieces of 90 × 45 pine, two pieces vertical nailed to the third piece which is horizontal, fitted flush with the underside of the vertical timbers (see Figure 4.6). The vertical timbers are nailed to the horizontal timber with 75 mm nails at approximately 200 mm centres. A spacer block of 90 × 45 approximately 100 mm long is fitted in the top of the bale boxing between the two vertical timbers to prevent the top of the boxing being squeezed together during compression. When building load-bearing walls, these blocks would be positioned at the junction of the rafters to the top boxing.

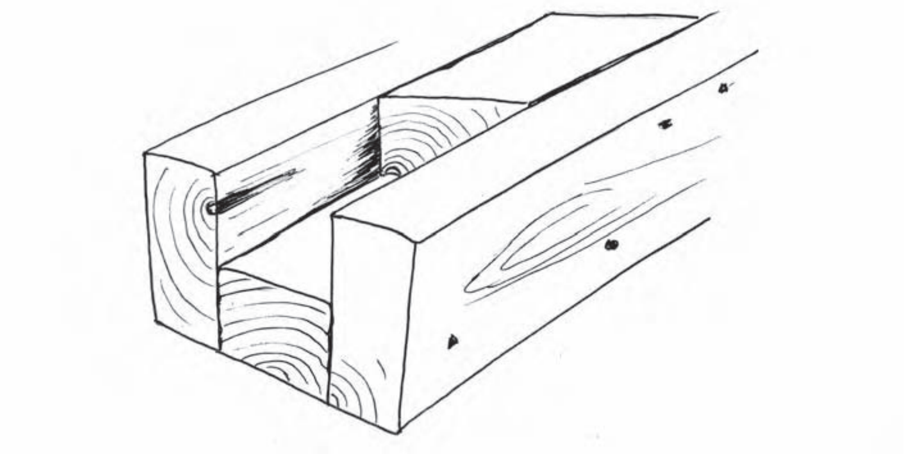


Figure 4.6 Top bale boxing is to be positioned centrally on top of the bale wall

By having the top boxing narrower than the bottom boxing, a triangulated pressure is brought to bear on the wall. This applies pressure to the sides of the wall in the upper region, adding greater strength and stability to the wall.

The top bale boxing is positioned in the middle of the bales on the top of the wall. Flat filament polyester straps are then fitted to encircle the top and bottom boxing and the bales contained within them. Pressure is then applied to the strapping with a tensioning tool. Not only is the wall compressed, but the top boxing will create a slight indent in the upperside of the top row of bales, adding greater stability to its position. This provides greater resistance to its dislodgment by lateral pressures from weather and when impact is brought to bear.

Compression of straw bale walls

Front-end loader

Front-end loader tractors have been used to apply pressure to the top boxing. The top boxing is then tied to the bottom boxing using wire.

Plastic and polypropylene strapping

Standard polypropylene and plastic strapping are, I believe, unsuitable for compression strapping as the manufacturers will not guarantee the strength of any strapping that has been tightened more than once. Ideal compression of the bales will occur over several days, which would not suit this product.

Threaded rod

One option for compression is to fix a threaded steel rod into the concrete. As the layers of bales are fed over the rod a female threaded connector nut is used to join another section of threaded rod to the previous to extend the threaded rod for additional layers. This process continues until all of the bales are in place. The top boxing is then fed over the threaded rod and bolted into position. As the nuts are tightened the bales between the top and bottom boxing are compressed.

Beware of the temptation to cut the excess threaded rod of with an angle grinder! Sparks and straw are not good companions as was discovered in Victoria not that long ago.

Conventional construction in cyclone areas often require steel rods from the foundation up to the roof, not dissimilar to that used in this compression system, so it would be fair to assume that the same requirements would apply to straw bale construction. The primary complaint about this method is that the bales have to be fed onto the steel as they are laid which I am told is frustrating and slow compared to external compression methods.

Fencing wire

Fencing wire combined with gripples, a mechanism for joining fencing wire, has been used quite successfully. Extreme care needs to be taken with this method. There are many farm-fencing contractors that have sustained a serious eye injury from fencing wire. With this method it is important to install a connector on either side of the wall, as once the wire is bent over the top boxing it will not slide to allow even tension on both sides of the wall. I have used gripples in farm fencing and have found them to be simple to use, however I have had more than a few fail.

Flat filament polyester

Flat filament polyester strapping is my preferred method of compression. The alternative that we recommend is the application of flat filament polyester strapping with a breaking strain of 1000 kg. This strapping is quite supple and tends to slide over the top boxing, however I still recommend that a connector buckle be installed on either side of the wall. While the strapping is more costly than fencing wire, the overall cost is the lowest of all methods as the heavy duty joining buckles are in the vicinity of 25 cents each as opposed to around $1.50 for wire connectors (2005).

Using flat filament polyester strapping

Prior to fitting the bottom boxing to the floor you will have positioned the strapping on the floor at 450 centres. Lay the straw bales as detailed previously, paying particular attention to alternating the direction of the cut side of the bales.

Position the top boxing on the top of the straw bale wall. To protect the top of the wall from unexpected rain, lay a section of builder's plastic approximately 1.8 metres wide over the top boxing. If you are particularly concerned about the possibility of bales getting wet from rain, additional plastic can be laid from the floor on one side of the wall to the other in a single piece, over the top of the compression strapping.

Position polyester strapping over the top of the 1–8 m wide plastic and top boxing down to the strapping fitted below the bottom boxing. Join the strap over the wall to the strap below the bottom boxing, ensuring that there are no twists in the strapping. The strapping has a red thread down one side of the strapping, so if you note its direction it will help you install it without twists. Allow approximately 400 mm of excess length on the strap at each side of the wall for the application of the tensioning machine. Pull the straps hand tight on one side of the wall. It will not be necessary to pull the straps up on both sides as the strap will slide over the top boxing at this point. Repeat this process until all the straps at the floor have an adjoining strap over the top of the wall. The straps over bales beneath windows should now be fitted and pulled up hand tight.

Straightening the straw bale wall

I use a large mallet to straighten the straw bale wall and realign the bales. Once the strapping is in place, and the straps are pulled up hand tight the wall will be straightened. Using a large wooden mallet known as a bale hammer, adjust the position of any bales that are out of alignment. I am not aware of anywhere that bale hammers can be purchased; however they are quite simple to make.

How to make a bale hammer

Take a piece of timber either 150 mm square or with 150 mm diameter, approximately 250 mm long, drill a hole large enough to insert an axe or mallet handle into it. Glue and screw the handle into the hole (see Figure 4.7). Timber this short and chunky is inclined to split, so fix a piece of the polyester strapping around each end of the mallet head to reduce the likelihood of the head splitting and breaking. It is best to make the head of the bale hammer as light as possible. As opposed to many hammers, it is not the weight of the hammer that will be doing the work, it is your strength in wielding it. The bulk of the head of the hammer is simply to prevent the hammer sinking into the bale rather than applying force to the bale resulting in its relocation.

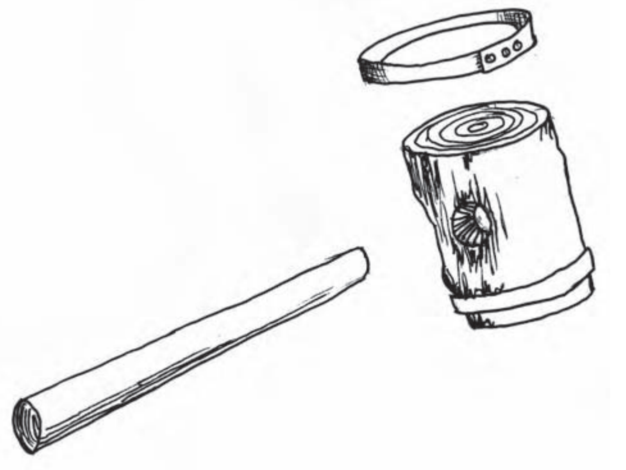


Figure 4.7 Bales protruding beyond the desired line of the wall are re-positioned using a bale hammer

Tensioning the polyester strapping

Once the bales are in place tighten the compression strapping with the tensioning tool until it is very tight. Watch the strapping where it goes through the buckle. If the strapping begins to change in texture or shape you have tightened it a little too much, but as long as it doesn't break this is not a problem. Progress around the complete house until all straps are tight. While it is not necessary, it is better to use a tensioning machine on each side of the wall, each operating in unison with the other, as this negates any possibility of uneven pressure on the top boxing. Repeat this process the next day, and again the following day.

Because the top and bottom boxing are basically rigid, the application of tension to the strapping will draw the top and bottom boxing together thereby compressing the bales of straw between the top and bottom boxing. This process is repeated over a three-day period to achieve maximum compression to stabilise the bales of straw. The pressure applied to the straw in this manner is greater than the weight of any load to be applied to the walls with the application of the roof and ceiling.

Once compressed over a three-day period, mechanically, the groups of bales that form the wall will have become one big building block. This building block has considerable resistance to lateral, vertical, and twisting pressure. It is for this reason there is no need to provide additional wall bracing in a well-constructed straw bale wall. When constructing a post and beam straw bale house using the structural infill system, it is essential that the completed straw bale walls be connected to the frame structure so as to transfer their resistant strength to the whole structure. This is a subject covered in detail in Chapter 8, roof framing. Once the walls are completed the construction of the roof and all other facets of the construction are very similar to standard building practices.

Pinning the straps

Following the complete compression process the polyester straps are to be pinned back to the straw. To make a reubin pin cut a piece of fencing wire approximately 600 mm long. Bend the pin into a ‘U’ shape. When initially bent the legs of the pin will tend to cross over. Bend these legs out so that the ends of the pin are separated (see Figure 4.8). Insert these pins into the straw with one leg on each side of the strapping thereby holding the strapping back against the bale. Insert one pin over each strap in every second bale up the wall. You should be able to insert the pin into the straw by hand, however it is sometimes necessary to use a hammer. If the outward pressure on the strapping is too great for the pin to hold against, you can insert a pair of pins together skewed against one another. Without the pins securing the strapping it is more difficult to cover the strapping when rendering.

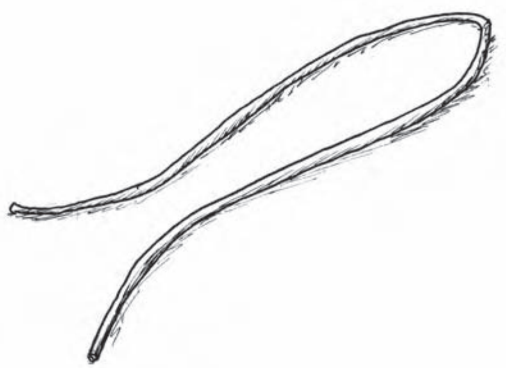


Figure 4.8 Wire pins are used to secure the compression strapping to the straw bales

Preparations for the installation of roof and ceiling timbers

Even a load of good firm bales will vary in density. This means that when the bales are compressed to the same tension, the overall height of the wall following compression will vary. After the third day of compression, the sections of the wall that are the highest can have more pressure put upon them to drop them further. Following the application of further compression to the high sections of the walls you must ensure that the top boxing presents as a flat and even line. Rarely is this the case, so you will have to pack up the low sections of the top boxing to enable the proper installation of the ceiling and roof members.

Preparation of top boxing in load bearing buildings

You will need to prepare the top boxing for the installation of roof and ceiling timbers in load bearing buildings. Find the point at which the distance from the top of the top bale boxing to the floor is the greatest. This height can be gained by extending a spirit level from the top of the bale boxing out over the floor and taking a measurement from the spirit level to the floor. Alternatively you could use a water level (refer to Chapter 2 for information on the construction of a water level). This is the height that the balance of the top boxing will need to be lifted to. Pack up the top bale boxing at the outer ends of each wall to this height. Install a string line from one packer to the other along the wall. Measure from the string line down to the top boxing to establish the thickness of packer required in any given position. Cut timber to pack the top boxing to the correct height. It is best that the complete length of the top boxing be at the correct height, however if the variance is within 3–5 mm you could simply pack the top boxing where the rafters and/or ceiling joists rest.

This is one process that should not be rushed. If the walls are not level the roof will not be level. If the roof is not level the fascia cannot be fitted correctly: fascia is the timber fixed to the ends of the rafters, onto which the guttering is secured. As such, if the fascia is not in the correct position the guttering cannot be fitted correctly. If the guttering is not fitted correctly it will hold water, rust out or overflow which will eventually cause it to break, as guttering is not designed to hold the weight of its water capacity for prolonged periods. I have seen straw bale houses where insufficient attention was given to this. At one house the fascia from both ends of the house dropped to its lowest peak right outside the front door – it is extremely inconvenient to have a down pipe down the middle of your door.

Trimming, shaping and notching straw bale walls

The bent straw on the face of every second row of bales contains a lot of loose straw. This loose straw does not provide a good foundation on which to apply render, and so it must be removed. Trimming the surface with a brush cutter or weed whacker does this well. The nylon cord of the trimmer does not hurt the polyester strapping, although on occasions it may tend to grab onto the strapping as it does when trimming strong grass.

Shaping the straw around windows

Before render is applied, you will need to shape the bales around the windows. You will need to know what shape you want the final wall to end up, as the straw has to emulate this shape. I prefer a clean crease from the window at a 45-degree angle from the corner of the window (see Figure 4.9).

If you insert a marker such as a pencil in the wall to give you guidance of where you need to trim the bales back to it will make the job much easier. First, with the trimmer, cut a groove in the bales from the corner of the window out to your marker (see Figure 4.10). Do this for all corners. Now trim the front corner of the bales around the window

back to the desired shape, blending them back to the initial groove you inserted from the corner of the window out to the marker. When trimming the edge of the bales in this manner it is quite easier to cut the twine on the bales so try to avoid striking them with the trimmer. If the bales are rounded right back to the twine securing the bale, the twine is likely to slide off the bale. To avoid this, leave 20–30 mm of untrimmed bale back to the twine. If necessary, pin the twine to the bale with the metal pins used for pinning the strapping.

Figure 4.9 The completed render around this window has relatively even 45-degree angles from the corners of the window

Figure 4.10 Markers are positioned in the straw bale wall as a guide for shaping the bales prior to rendering

Cutting a notching-out of straw bales

You will often have occasion to cut a piece out of a bale, as is the case when straw bales are fitted around posts in infill construction. It will often be necessary to cut a hole in a wall for plumbing and electrical work. For some time I was frustrated by the lack of equipment to perform such cuts, and the time wasted performing what should have been a simple process. Any number of people could tell me how to cut a bale to length but there didn't appear to be the equipment to cut notches and make holes.

I tried all sorts of equipment including a brush cutter, which did the job but was very slow and clumsy. On one occasion while my wife Jan was out for the day, I had a brain wave, and tried out some of Jan's good kitchen knives, much to her disgust. I discovered that the serrated carving knife with a sharp point did an excellent job. I did make recompense and replaced her knife with a new one of better quality. The serrations of the knife cut the straw rather than slide across it, as was the case with a plain knife. I had tried a hacksaw blade, but found that it grabbed onto the straw rather than cut it. This was not a serious problem with the serrated carving knife. I tried a knife with a similar serration that did not have a sharp point, but was unable to drive it into the bale. The same knife is ideal for cutting holes into existing straw bale walls.

The brand of knife we now use is 'F Dick'. There are two similar knives sold by this company, one with a straight blade that runs up through the handle and another with a forged blade. The knife with the forged blade is easily distinguished, as the metal of the blade, at the handle, bulges out to the width of the handle. I have tried both knives and have found that the cheaper knife is somewhat lacking in its staying ability. By the end of that house it is only good for cutting bread. The better knife has a much longer life, as the steel in it is of higher quality. I have now been supplying these knives to my owner-builders for some time, and have never had a complaint. At around $130 (2005) they represent a lot of money for a knife, however when compared to the cost of a good saw blade at around $200 they are quite reasonable. I am told that you can buy sharpening stones to suit them, however I am yet to be able to locate one.

Cutting a notch to accommodate a post

To cut a notch out of a bale, which is required when fitting bales around posts, simply drive the sharp point of the knife into the bale at the desired location and then with up and down motions, slice the straw at the required location. As the knife will not reach all the way through the bale, it will be necessary to turn the bale over and repeat the incision from the opposite side of the bale.

Cutting a hole in an existing wall

To cut a hole in an existing straw bale wall, simply push a single bale needle through the wall so that you can locate the point at which to cut on both sides of the wall. Insert the knife into the bales on both the inside and outside of the wall. The knife will reach more than half the depth of the bales. I recently had cause to insert a piece of 150 mm poly pipe through an existing straw bale wall for the plumber to feed a sewer line through. We knew the position of the hole on the inside of the house, so we inserted a single bale needle through the wall in what represented the centre of the required hole. This gave us an accurate position for the centre of the hole on the external side of the bale wall. The render was removed from the surface of the wall to allow the knife uninhibited access to the straw that needed to be cut. Incisions were made from both sides of the wall in the position that represented the external perimeter of the required hole.

Once the line of the external position of the hole was cut, we pulled the straw within that perimeter out with our hands. The plumber was helping with this operation. I was somewhat dismayed to find that he was putting his hand in the hole from the inside of the wall without my knowledge. Be careful to communicate if you have an assistant as I very nearly cut his hand with the knife. These knives are made for cutting flesh, so a cut from this knife is likely to result in a trip to the hospital.

Cutting special length bales

When you build your straw bale wall, the bales will be laid in running bond, just like normal brickwork. To achieve this every second row of bales will require a bale to be cut in half. This is a simple process using a tool called a bale needle. When cutting bales to a special length we use the double bale needle (see Figure 4.11).

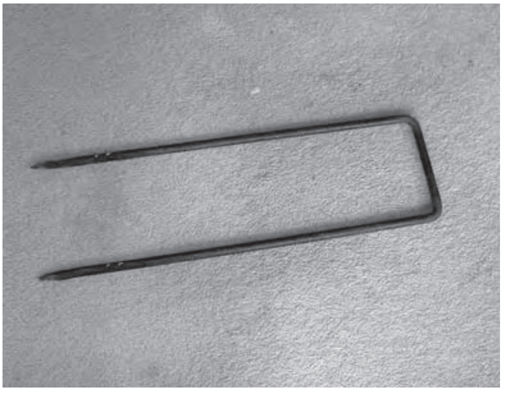


Figure 4.11 Double bale needle used for cutting special length bales

Figure 4.12 The single bale needle is used for feeding cables, etc. through a bale wall

There are many times that a single needle is required, for example, with the installation of electrical wiring. You will often need to secure bales to timberwork with the use of a single needle (see Figure 4.12). If you are working on an extremely tight budget it is possible to use the double needle in most instances that you would use a single needle, but if your finances can stretch the extra 30 odd dollars it is a worthwhile investment.

1. Rest the bale to be cut on two other bales

When cutting a bale, rest the bale to be cut up on two other bales. Ascertain the required length of the special bale, and insert the double bale needle into the bale at that position until the needle balances in the bale without inserting it beyond the holes into which the twine shall be threaded (see Figure 4.13).

Figure 4.13 The double bale needle is inserted into the straw leaving the eyes of the needle exposed

2. Leave the holes in the bale needle exposed

There are two holes just above each point of the needle. This is to enable two strings to be fed through the bale at both legs of the needle at the same time. The legs of the double bale needle are approximately the same width apart as the existing twine that secures the bale.

3. Thread twine into the bale needle

In the one leg of the needle, thread one piece of twine from left to right through the bottom hole of the needle and a second piece of twine through the top hole from right to left. Repeat this process for the other leg of the needle.

4. Use different coloured twine to reduce confusion when cutting bales

Many people find it less confusing to use different coloured twine. For example, if the twine on the bales you have purchased is black, you might choose to use yellow and pink twine for cutting the bales. The pink twine to go from left to right, and the yellow from right to left.

5. Push the threaded needle through the straw bale being cut

With the bale to be cut sitting on two spare bales, push the needle through the bale until the holes of the needle are fully exposed on the opposite side of the bale. If you position the two bales on the ground with a gap between them, you will be able to push the needle through the bale into clear space between the two supporting bales (see Figure 4.14).

Once the needle is driven through the bale you will have access to the two strings still threaded through the needle, now on the other side of the bale.

Figure 4.14 Twine is fed through the eyes of the needle for later tying of the new length bales

6. Unthread the twine from the needle, remove the needle from the bale

Turn the bale over, exposing the points of the needle, and unthread the pieces of twine from the needle. Be careful as you turn the bale, as the needle protruding through the bale can lead to a tear or two when it connects with your body inappropriately. Remove the needle and insert it into a spare bale for safety's sake.

Figure 4.15 The twine is tied around the new length bales

7. Tie the loose ends of the inserted twine to secure the new length half bales

Wrap each piece of twine around the bale and tie the ends of the common twine together. That is, join the pink twine on the left of the bale from the top of the bale to the pink twine on the left of the bale from the bottom of the bale. The twine needs to be tied tightly around the straw, as this will be all that holds your new length short bale together. Repeat the tying process for all four pieces of twine (see Figure 4.15).

8. Cut and remove the original twine around the bale

Once all four pieces of twine are securely tied, cut the original twine. It is best to cut the twine beside the original knot, then remove the twine by pulling the twine by the knot. If the twine is not cut at the knot, the knot is inclined to get stuck in the straw and be more difficult to remove. Once the original twines are removed you will be able to pull the bale into two pieces. Do not be concerned if there are some stalks of straw that need to be pulled out or cut to separate the two sections, as this is quite normal (see Figure 4.16).

Figure 4.16 The original ties on the bale are cut and the bale is separated into the two new lengths

Filling gaps and holes in the finished straw bale wall

When the bales of straw are laid together there are often gaps between the bales. These gaps, if unfilled, would break the insulation benefit of the straw bale wall, as heat and cold will travel quickly through these gaps unrestricted. Gaps between the bales seem to attract a greater amount of moisture than in the body of the wall. The processes of living inside the house generate moisture.

Condensation

Sleeping in a caravan on a frosty night demonstrates human production of condensation. If you have ever done this no doubt you will have noticed that the inside of the van is often wet from condensation. If you check the same van in the same environment but without people sleeping in it, there is a distinct lack of moisture on the walls and ceilings. Simply breathing will generate moisture. This moisture is passed through the straw bale walls and dispersed to the outside environment through the external render. When there are gaps behind the external render the moisture tends to gather in greater quantity in these areas. This is evidenced by dark marks on the external render caused by this concentration of moisture.

Wall check before rendering

After trimming, check all walls carefully for gaps between the bales. Fill these gaps with loose straw to within 100 mm of the surface of the wall. You will find it easier to get the straw packed in tightly if you bend the stalks of straw prior to inserting them into the wall. The bent stalks are then wedged into the space between the bales. The outer 100 mm or so is to be filled with cob. Cob is a mixture of mud and straw. Mix a batch of sticky render (see Chapter 11), having a good amount of clay for adhesion. This render should be about the consistency of cream. Mix this render through the straw. There should be sufficient render to coat the straw so that when it dries the straw will bind together. Push this into the outer section of the hole and smooth back into the straw, blending it into the straw to guarantee good adhesion.

Installation of structural posts and beams for infill construction

Posts for infill construction

The posts to support the beams of infill construction will be positioned so that they are either exposed or concealed within the straw bale walls. If the posts are exposed you will use mounting brackets to fix the post to the floor. There are many types of bracket, some are concealed within the post while others are mounted externally to the post. It may be possible to simply fix the post to the face of the bottom boxing. Consult with your engineer and/or building consultant to ascertain the most appropriate fixing system for your particular application.

Posts that are to be concealed within the walls are fitted within the bounds of the bottom boxing. Particularly with two-storey construction, the posts and beams would normally be fitted in line with the inside edge of the straw bale wall. Fitting them on the inside of the building reduces the span of the timber for floor joists, ceiling and roof. This in turn reduces the required load capacity for these materials, thereby reducing the timber sizes and cost. This is particularly appropriate when verandahs are being built, however it may be necessary to shift the beam to the outside line of the building if wide eaves are called for. The overhang capacity of the rafters will have a direct correlation with the eave of the building. If the rafter overhang first has to cover the bales and then provide an eave, the depth of the straw bale wall will reduce the actual eave over the bales. It is possible to add additional support to the ends of the rafters to increase the eave width, and details on this are covered in Chapter 8, Roof framing.

Installing structural posts for infill construction

Establishing the required height of the posts

Before installing the posts and beams, establish the height of the top of the posts, which will be the same as the ceiling height in the building. This detail will be included in the approved plans either on the sectional drawing or one of the elevation drawings. Cut all the posts to length. If the job calls for the beams to be checked into the posts, now is the time to make the checkouts in the posts. Measure the actual beams to be inserted into the checkout rather than to work with theoretical timber sizes. If the beam to be inserted is 45 mm thick, make a rip cut down the post 45 mm from the face of the post extending far enough down the post to accommodate the beam. It may be necessary to make a second cut from the other side of the post if the saw does not reach through the post.

Cutting a checkout in the post for the beam

Set your saw to a depth equal to the thickness of the beam. Make an incision across the face of the post so that the section of post to be removed to accommodate the beam is removed. It will be necessary to cut a piece out of the bottom of the post to allow the post to sit over the side rail of the bottom boxing (see Figure 4.17). Stand the first post in position with its face level with the face of the internal side rail of the bottom boxing.

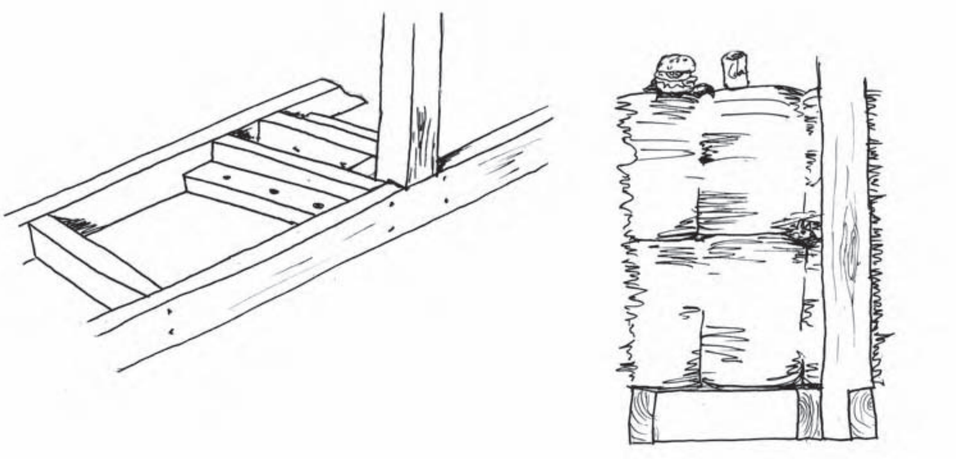


Figure 4.17 Connection of a structural infill post to the bottom boxing

Fixing temporary bracing to the post and securing the post to the floor

Fix temporary braces to the post so that it will stand securely in the vertical position. Fit vertical noggings against both sides of the post. Nail the noggings to the post and the bottom boxing. Fit a second nogging horizontally against the two noggings already fitted against the post. Insert three masonry nails through the horizontal noggings into the floor. You now need to fit a block against the post between the first and second noggings to add additional stability to the post. If you have chosen to use ply on the bottom boxing, this will also support the ply at the post (see Figure 4.17).

Fixing posts in position prior to installing bottom boxing

Some jobs require not only that the posts be fitted in the centre of the bottom boxing, but that the bottom boxing be built after the posts are in place. In this instance the posts will be fixed to the floor with metal angle iron brackets, the posts will then be braced in an upright position. The bottom boxing will then be built at some later stage in the construction. If ply is your chosen treatment of the bottom boxing, care needs to be taken to support the ply around the post (see Figure 4.18).

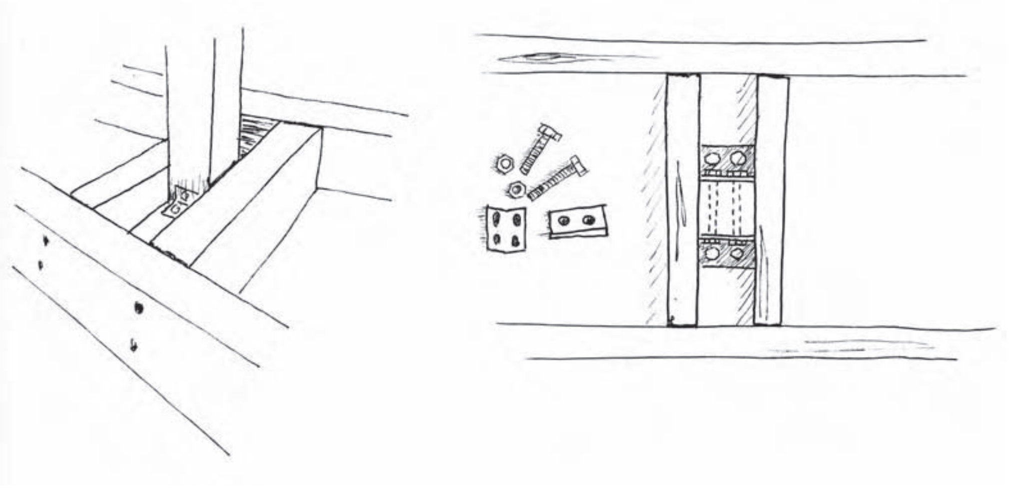


Figure 4.18 Infill post secured to the floor using metal brackets

Fixing the beam onto the post

Refer to the engineers' details for specific instruction on the installation of the beams. Depending on the particular application it may be that the beams are bolted to the face of the post, whereas in standard applications the beam is fixed into a checkout in the post. If there are no specific engineering details, refer to the approved plans, in particular the sectional drawings. If there are no specific instructions you can fairly safely assume that the beams are to be checked into the posts. Without exception, the beam should be bolted to the post with a minimum of two 10 mm bolts at each post. At the junction of two beams, the ends of both beams should have two bolts through them fixing them to the post.

Initially, the beams will be held to the posts using nails. When nailing the beam to the post, give consideration to where you will be drilling holes to take the bolts. When purchasing a drill bit for the job, ensure that the size of the drill bit matches the size of the bolts to be used. Furthermore, I would recommend that you purchase a drill bit capable of drilling both timber and steel, as it then matters little if you happen to strike a nail while drilling.

Bracing of infill walls

Unnecessary permanent bracing

Permanent bracing is unnecessary for structural infill straw bale buildings. In the past houses constructed by infill have required significant mechanical bracing to prevent the post and beam structure from collapsing. This is no longer necessary as the straw bale walls, when properly compressed, provide more than adequate bracing. Our home in Heathcote is in a high wind area. We have a roof that extends approximately nine metres into the air. Added to this are three-metre verandahs on all four sides. The roof is like a gigantic sail. If this house were a sailing boat it would probably win the America's Cup. On occasions, the wind is so severe that prior to fitting the roofing iron, the rafters would hum from the vibration of them shaking in the wind. On more than one occasion we had the opportunity to rebuild walls that had blown down during the night prior to compression. Our straw bale walls are over four metres high, and yet we have no additional bracing in any of them. There is no movement and no sign of cracking in any of the walls.

When additional bracing was required, the specifications for the bracing had to be established by an engineer, which adds more expense. A commonly used material for bracing infill straw bale houses is 16 mm steel rod. If this material is used, it is imperative that it be well covered, for as the sun hits the wall the metal can heat up and expand, causing cracking of the render. As often mentioned I have serious reservations about including steel in straw bale construction, particularly if it is unnecessary. In this instance it can be avoided, thereby saving considerable time and money without contributing to the ecological challenges of our world.

Eliminating the need for permanent bracing

By joining the straw bale wall to the substructure you eliminate the need for permanent bracing in infill construction. One of the criteria enabling elimination of bracing is the connection of the straw bale wall to the post and beam structure in such a way that they become as one. This process is very simple. Timber blocks normally about 190 × 45 are cut to size to fit between the rafters. These blocks are positioned on top of the top bale boxing between the rafters. They are then securely fixed to the rafters and the top bale boxing (see Figure 4.19).

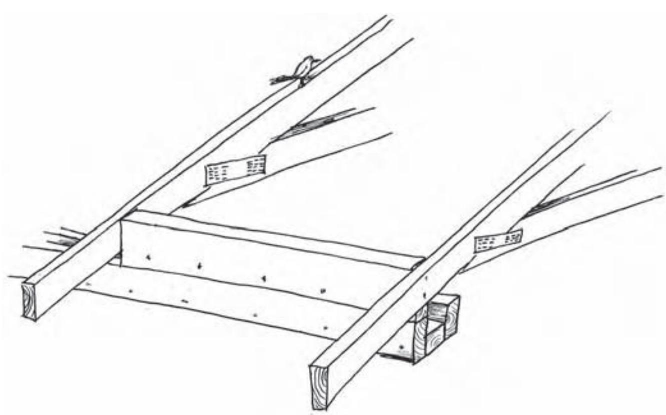


Figure 4.19 Securing the timber infill frame to the straw bale walls using 190 × 45 rafter blocks

Temporary bracing for infill construction

Once all the posts and beams are fixed in position it will be necessary to fix bracing to stabilise the structure until the bales are installed, compressed, and connected to the frame. As this bracing will stay in place until after the bales are installed, it is necessary that the bracing be fitted to the structure in a manner that allows the bales to be installed and compressed without needing to remove any bracing. Using 90 × 35 MGP10 pine as the bracing, fix it to the inside face of the beam and bottom boxing as detailed below (see Figure 4.20).

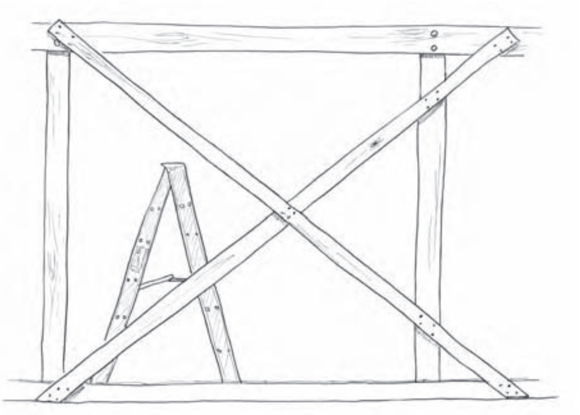


Figure 4.20 Temporary braces are used to stabilise the frame until after the straw bales are installed and connected to the frame

The timber used for temporary bracing will not go to waste, as it can be used in any number of applications within the house once the walls are completed and the bracing is removed.

Builder's responsibility and temporary bracing

It is the builder's responsibility to provided adequate temporary bracing during construction. I recently had occasion to visit the home of one of my owner-builders during construction. All the posts and beams were installed, as were the roof trusses, verandah posts and fascia. The home has a concrete slab floor and will have mud brick internal walls. The owner decided that it would be best to lay the mud bricks after the roof was on to avoid any possible water damage to the bricks.

I was somewhat dismayed to notice that the only bracing on the external walls was hoop iron that had stretched since installation and was now flapping in the wind. There were no internal walls to add stability to the structure, and no temporary bracing to compensate for them until their installation.

This building was in extreme danger of falling over in a strong wind. It is imperative that sufficient bracing be provided during construction. It is the builder's responsibility to provide adequate bracing. If you are the builder, and are not sure of what is deemed as adequate it is your responsibility to find out. Contact either your engineer or building consultant for this information.

Following this event, my engineer and I have had discussions as to how to prevent this risk in the future, and will consequently be providing detailed information on each job as to the requirements of temporary bracing for the house. I would strongly advise that you gain this type of information prior to starting construction. Fortunately we have not had occasion to try to claim against insurance for the collapse of a building with insufficient bracing. I would not be surprised if the insurance company refused to pay, and they would in my opinion have every right to reject the claim. Under all insurance policies, the policy holder has a duty of care to reduce the risk to the insurer. In this situation it is obvious that the owner who is the builder would not have taken appropriate measures to reduce the risk to the insurer.

Fixing to rendered straw bale walls

Fitting shelves to straw bale walls

To fit shelves or heavy objects to straw bale walls it will be necessary to fit wooden pegs into the wall prior to rendering. If the shelves are not aligned with the junction of the rows of bales you will need to make wooden peg to insert into the wall. You can make these pegs out of 42 × 19 or 42 × 35 pine. Cut the timber approximately 350 mm long and make a point on one end. It will add extra strength to the fixing if barbs are cut into the peg so that when inserted into the straw, the straw will be caught in the barbs cut into the peg. This decreases the possibility of the pegs slipping out of the wall (see Figure 4.21).

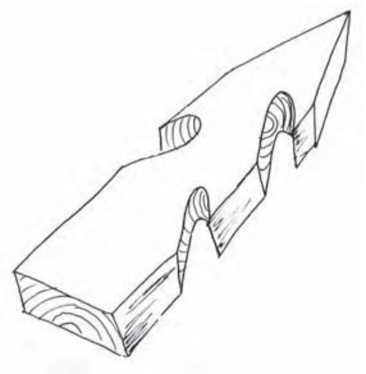


Figure 4.21 Barbed timber peg to be hammered into the straw bale wall

Fitting barbed pegs into the wall to support shelving

Hammering in the pegs

Hammer the pegs into the wall on a 5–10 degree downward angle so that when weight is applied to the end of the peg if it does drop slightly under the weight, it will still be above level. If the external end of the peg were to be lower than the point, the peg would be inclined to slip out of the wall.

When you have shelves that are to be fitted in line with the horizontal junction of the bales I suggest that you make spiked pegs, which are inserted between the bales. Cut pieces of 70 × 19 pine 400 mm long. Fix 75 mm nails through the timber so that the head of the nail is level with the surface of the timber, thereby causing approximately 50 mm of the sharp end of the nail to protrude from the other side of the timber. This is to be done to both sides of the timber so that nails protrude through both sides (see Figure 4.22).

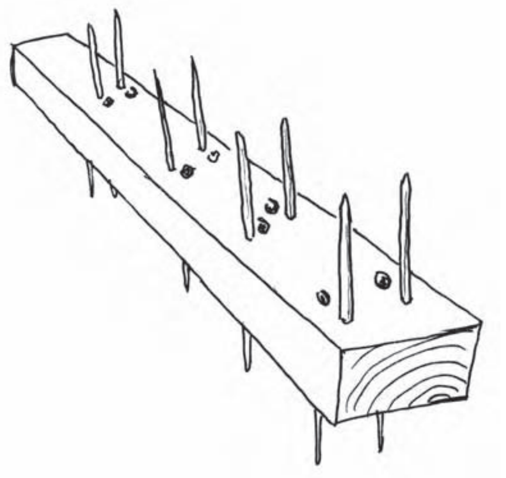


Figure 4.22 Spiked peg for installation between the rows of bales

Making sure your pegs are in line

The pegs must be in line to enable the installation of straight cut shelving.
When shelves are to be fitted to a straw bale wall it is best to have the section of wall adjoining the shelving as straight as possible. If the shelving is fitted against an uneven wall, the shelving will have to be cut to match the shape of the wall. The simplest way to do this is to ensure that all the pegs in the wall are not only in the same line vertically up

the wall, but also horizontally. That is, ensure that the external faces of all pegs are in a straight line to one another. To achieve this, hammer the first peg into the straw bale wall at a position relative to the end of the shelving to be fitted. Leave the top of the peg protruding from the wall approximately 30 mm. Now fit a peg for support of the other end of the shelving, also leaving it protruding approximately 30 mm. Attach a screw into the centre of each of these pegs and secure a string line tightly between the two pegs. The string line will give you both the horizontal and vertical position that the remaining pegs are to be fitted at.

Establishing the required height
When establishing the height the pegs are to be fitted at, the top of the peg is to be at a height representing the position of the underside of the shelving, as a timber rail will be fitted to the pegs onto which the shelving will be fixed.

Applying the first coat of render
Apply the first coat of render as per normal using the palm of the hand to force the render into the bales. When completed, the render around the pegs should be more in the bales than coated onto the face of the bales. When the first coat of render is completely dry, you will apply cob to the area around the peg. Cob is a mixture of straw with render, the same render that you would use for the first coat of render. Cob is a very 'strawy' mix, having much more straw than render, thereby giving it an extremely fibrous consistency.

Applying the cob
Wet the surface of the first coat of render prior to applying the cob. Apply the cob mix over the first coat of render around the pegs in a circular motion so that the pegs are encircled with the straw of the cob. When dry, this fibrous material will strengthen the surface of the wall at the peg, thereby reducing the possibility of the render cracking and allowing the peg to drop. The second coat of render should be applied to the wall so that the render is level with the surface of the pegs.

The second coat of render
Use a straight piece of timber as a screed from one peg to the next to ensure that the wall is straight. Remember, if the finished wall is not straight you are going to have to cut the shelving to the shape of the wall. Once completely dry, wet the wall with water and apply the final coat of render. This coat of render will cover the surface of the pegs to a depth of 5 to 10 mm.

Fitting a horizontal rail to the pegs to support the shelving
Once the rendering is complete, a horizontal rail is fitted to the wall using screws with sufficient length to pass through the rail and the render that covers the pegs, and penetrate the pegs by no less than 30 mm. When fitting the shelving to the rail on the wall do not hammer nails through the shelving into the rail, as this will break the seal between the render and the pegs, and generally weaken the render in the vicinity of the pegs. The shelving should be fitted either by screwing it to the rail or alternatively by using a nail gun. Don't use a framing gun, use either a fixing gun or brad nailer.

Fixing points for pictures

Small photos and pictures can be supported on a 20 or 30 mm nail hammered into the wall, or by using a standard picture hook with a nail that penetrates the wall by about 15 mm.

Lightweight pictures can be hung using masonry anchors. When choosing a masonry anchor avoid anchors that require a pin to be hammered into them such as nylon anchors, as the hammering process tends to weaken the surface of the render. Rather, choose anchors that have a screw inserted into them. These anchors are to be fitted by pre-drilling a hole in the render in much the same way as for concrete, however it will not be necessary to use a hammer drill. Use a slow setting on the drill when drilling the render, as when the drill bit breaks through the render into the straw, the straw can sometimes wrap around the drill bit. If this happens try to unwind the drill bit from the render. If you pull the drill bit straight out it will damage the rendered wall.

Support for heavy pictures

Heavier pictures and mirrors can be supported on a dowel inserted into the wall. The larger the dowel, the greater its holding capacity. Drill a hole in the wall the same size as the dowel to be fitted. Drill the hole on a 5–10 degree downward slope to allow the dowel to be inserted on a 5–10 degree downward slope. Cut the dowel approximately 350 mm long (250 mm if the bales are laid on edge) and sharpen one end of the dowel. It is best to sharpen it like a pencil rather than a wedge, as this will more easily be inserted into the wall without the peg running off to one side. If possible, push the peg through the hole into the straw bale using your hands.

If there is too much resistance, use a hammer or mallet with slow strokes with a tendency to follow through with the stroke of the hammer rather than to poke at the peg. The less vibration of the peg as it enters the wall the better. Once the dowel is flush with the surface of the wall, insert a screw into the centre of the dowel. If you were to try to hammer a nail into the peg, the peg would of course sink further into the wall. Once the dowel is inserted, inspect the junction of the peg and the wall. If the render does not fit tightly against the peg it may be appropriate to seal the peg into the wall to prevent air and moisture penetration around the peg.

5

Window and door openings

There are many variables to take into consideration when establishing the most appropriate construction system to be adopted for the installation of doors and windows. Structurally, the width and height of the windows and doors will have a bearing on the materials required. The more aesthetic considerations will concern the position of the windows and doors. Do the windows have straw bale wall below them? Will there be a window seat that you expect people will sit on? Will the window be positioned in the centre of the wall, or in line with the inside or outside of the wall? Will it be necessary to install straw bales above the window? What shape do you require the finished wall to be around the windows and doors?

Supporting the roof and ceiling over windows and doors

Windows and doors in straw bale houses of infill construction are simpler in the sense that a load-bearing frame already supports the roof and ceiling. Whereas straw bale houses of load bearing construction will require that the weight of the roof and ceiling is supported by some means. The top bale boxing used in the compression process has, with some limitations, the capacity to support roof and ceiling loads over window and door openings. The actual width of these openings can only be determined once the roof and ceiling construction design has been finalised.

In some instances windows and doors up to 1.9 metres wide can be installed without the need to increase the strength of the top bale boxing. Unless you are conversant with all the issues and options associated with roof and ceiling construction I would recommend that you employ a good building consultant or engineer to design your roof and ceiling. The design needs to not only to fulfil the structural requirements for the project, but also take into consideration your ability and budget. The roof design will have a large bearing on the width of the windows and doors that can be fitted without having to increase the strength of the top bale boxing. When using roof trusses, there is little that can be done to vary the load over the windows. However if the roof and ceiling are to be assembled piece by piece, known as stick framing, much can be done to reduce the load over these openings, thereby increasing the width capacity of the top bale boxing. It is not that the total weight of the roof and ceiling are necessarily reduced, but that the weight distribution is changed.

Window and door bucks

Windows and doors are generally fitted inside a timber frame that is fixed within the straw bale wall. These frames are known as bucks. Window and door bucks can be built by a variety of different methods, ranging from the construction of a frame that is then covered in plywood, to solid timber. It would generally appear that in Australia most people have chosen to use solid timber. It has been suggested that there are cost savings associated with the use of plywood, however my experience would not support this claim. Apart from the magic dollar, I have other reservations regarding the use of plywood. Plywood is manufactured with the use of a lot of adhesive, and while I am not paranoid about the release of fumes, neither do I invite it into my homes unnecessarily.

Much of the plywood is imported from Asia and is likely to contain timber from native forests rather than plantation-grown material. I personally will avoid the use of timber from old growth forests and rainforest. When designing the construction system and its components for any house, we go to a lot of trouble to avoid the use of steel, and timber from old growth or rainforests. I can see no valid reason to introduce a product that is likely to draw material from these sources, to say nothing of the energy used to produce and transport the plywood. The use of plantation pine, being a renewable resource, is ecologically responsible. Sadly, many owner-builders are more concerned with the saving a dollar rather than saving the environment. This is one time that everyone wins, for not only is plantation pine ecologically responsible, but it's cheaper than most other alternatives.

External doors

External doors can be hung on the posts between the floor and roof supports. They can be hinged to uprights that are fixed to the floor and to the top boxing or pitching beam. They will be fixed at the floor by nailing them to the bottom bale boxing. Alternatively, doors can be hung inside a simple door buck. It is also possible for the door to be hung inside a separate door jamb which is fitted into the door buck or between door posts that are secured to the floor and top boxing. If the door is to be hinged directly into the door buck or onto door posts the timber will need to be a stronger than 90 × 45 pine to provide a stable fixing point for the door. When the door is hinged directly to the door buck, the door buck effectively becomes a door jamb. I have used 90 × 75, 140 × 45, 190 × 45 as door bucks and door posts and found them all to be successful.

When deciding what size timber to use on your house you will have to give consideration to the height of the door posts, the position of the door, the weight that might be carried by the door posts and the final appearance that you are after. In some instances the door posts can be utilised as structural support for a pitching beam thereby reducing other timber requirements, consequently reducing the cost and the time taken to build the house. If you are unsure of what size timber and the most appropriate system to use speak with your building consultant. It should be noted that not all timber is appropriate for use when exposed to the weather, so ensure that the correct timber is used if the door posts or door buck are going to be exposed. If the door posts or door bucks are to eventually be painted you will extend their life by pre-painting the end grain of the stiles where they meet the floor.

Securing the door posts

Secure the door posts and bales together to reduce the cracking of render at the timber. It is important that straw bales be fixing to the door posts or door buck. If there is movement between the timber and the bales the render will crack at the junction of the bales to the timber. If this fixing is installed prior to compression of the bales the bales must be able to slide vertically down the timber to allow uninhibited compression. The primary aim of this fixing is to prevent independent lateral movement of the bales to the timber. The potential for vertical movement is negated during the compression process.

Using wire netting with door bucks

When a door buck is going to be encased in render a simple and yet effective method of preventing independent movement between the timber and the bales is to fix wire netting to the buck and across the internal and external faces of the bales adjoining the timber buck. The wire netting is to be pinned to the bales after the bales have been compressed and shaped with the trimmer. The netting should extend approximately 300 mm across both faces of the bales (see Figure 5.1). If it appears that the wire pins are not holding the netting securely against the bales it can be stitched to the bales. Stitching is the process of feeding twine through the bales from one side to the other, then tying the netting on opposing sides of the wall to each other. A single bale needle is used to feed the twine through the wall. Care must be taken when rendering over netting to ensure that the first coat of render penetrates through the netting into the straw beneath the wire netting. The application of netting to straw bale walls has been known to lead to delaminating of render from straw where the netting has prevented the render penetrating the straw.

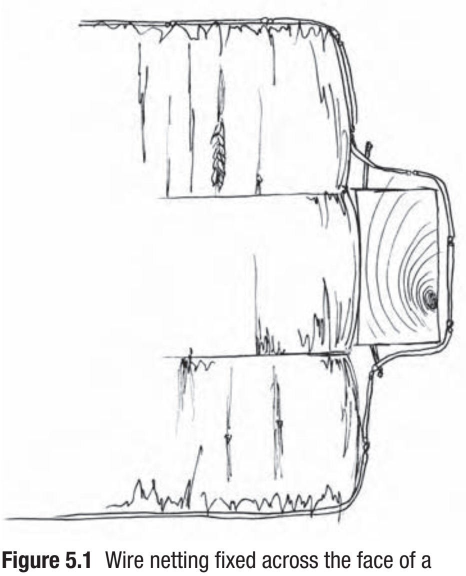


Figure 5.1 Wire netting fixed across the face of a door buck and straw bale wall

When the timber posts or door buck is to be exposed wire netting can be fixed to the back of the timber prior to laying the bales. Once the bales are laid, compressed and shaped, the wire is then pulled around the bales and pinned to both faces of the bales (see Figure 5.2).

This method does cause some frustration when the bales are being laid, and care must be taken when working around the wire to avoid injury.

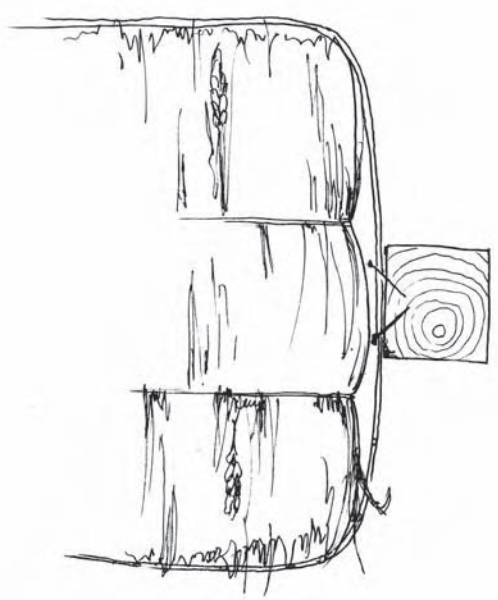


Figure 5.2 Wire netting fixed to the back of the door buck and over the straw bales

Timber ribs

Timber ribs can be placed on door bucks to stabilise the junction of the straw and the door buck. Lateral stability can be easily achieved when the door posts and bucks are built from timber with a depth of 140 mm or greater. This timber should be not less than 45 mm thick. A rib of timber 70 × 45 is to be fixed to the back of the door buck. As the bales of straw are laid against the door buck a groove is cut out of the end of the bales to neatly fit over the rib added to the back of the door buck (see Figure 5.3).

If the notches in the bales are tight over the rib of timber this will negate the likelihood of independent lateral movement between the timber and the bales. This system also adds strength to the door buck within the door jamb thereby reducing the possibility of the door jamb bowing under the weight of the door. The rib should be fixed to the door buck about every 300 mm with either nails through the door buck set on a slight skew to one another, or screwed through the rib into the door buck. If the door buck is to be stained it is best to use screws as they are less likely to mark the face of the door buck.

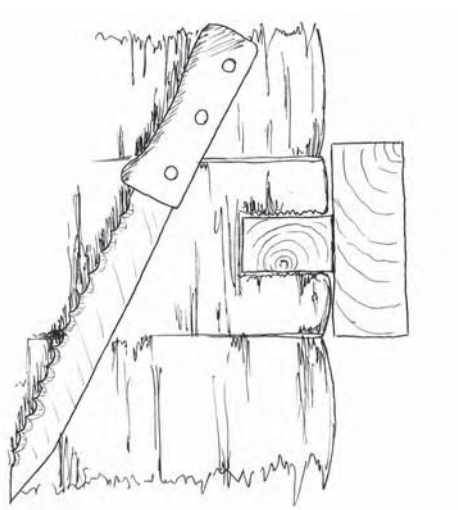


Figure 5.3 190 × 45 door buck with 70 × 45 stiffening and bale stabilising rib

Two-storey doors and windows

Door bucks that extend up two-storeys can provide a window frame to the upper floor. My home in Heathcote, Victoria, has walls upstairs 1.3 metres high. I ran the door buck from the floor all the way through to the top pitching beam, approximately 4.2 metres. Laminated glass was fitted between the two door posts above the upper floor level. This provides additional natural light to the stairwell. The space between the door posts between the door head and the window sill was filled with tightly packed straw contained by wire netting. This was then rendered and blended into the walls at either side of the door (see Figure 5.4).

Figure 5.4 Completed door and window buck made from 190 × 45 timber

Install temporary braces and spacers to door bucks

When installing door posts and door bucks it is important to fit braces and spacers between the posts to prevent the door posts being bowed in or twisted out of shape as the bales are laid. As a general guide, if the buck is greater than one metre high it will be necessary to fit the temporary spacer between the stiles to prevent the stiles bowing inward as the bales are laid. If in doubt, fit additional spacers. There is nothing more frustrating that having the wall complete with the first coat of render on, only to find that the window will not fit in the buck because it has been bowed in by over exuberant bale layers. Rather than to fix a single brace from one corner to the other it will be more effective if one brace is fixed from the top of one stile to the centre of the other stile. Then fix a brace from the bottom of the first stile to the centre of the second stile so that the braces form a 'V', fixed horizontally to the face of the door posts or door buck (see Figure 5.5).

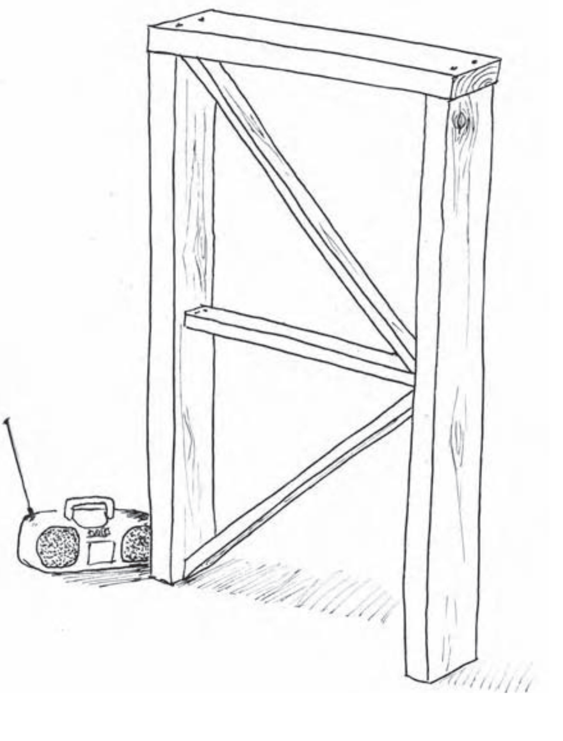


Figure 5.5 Door buck with braces fitted in a 'V' shape to hold the buck square

Configuration of window and door bucks

Calculating the internal dimensions of bucks

The bucks for windows and doors will need to be slightly larger than the actual window or door to be fitted into the buck.

- For the width of the window buck:
  Internal width of the window buck = External width of the window frame + 20 mm
- For the height of the window buck when the window sits on the floor:
  Internal height of the window buck = External height of the window frame + 20 mm.
- For the height of the window buck when the bottom of the window sits on top of straw bales:
  Internal height of the window buck = External height of the window frame + 40 mm.
- For the width of the door buck / door jamb for a **single** door hinged directly onto the door buck or posts:
  Internal width of the door buck = Overall width of the door + 5 mm.
- For the width of the door buck / door jamb for **double** doors hinged directly onto the door buck:
  Internal width of door buck = Overall width of both doors held together + 7 mm.

French doors

When fitting a pair of doors the doors will either be joined in one of two ways. One of the doors will have a mushroom stop fitted to it that the second door closes against it (see Figure 5.6). Alternatively, a rebate will be taken out of one side of each of the doors so that the doors join at the rebate, thereby providing resistance to airflow (see Figure 5.7). It is possible to simply fix a cover strap to the face of one of the doors rather than to use a mushroom stop, however the strength and security provided in this system is somewhat lacking. When a cover strap is fixed to the door the strength and consequential security provided is totally reliant on the strength of the glue and nails into the face of the door whereas the mushroom stop is moulded from a solid piece of timber.

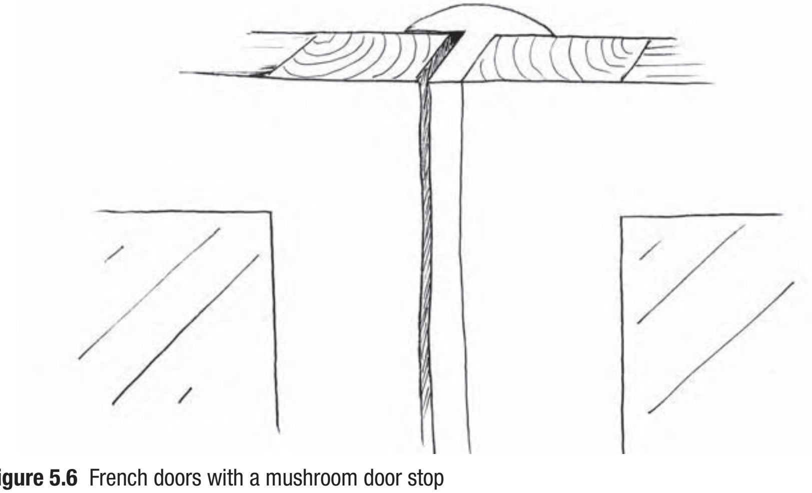


Figure 5.6 French doors with a mushroom door stop

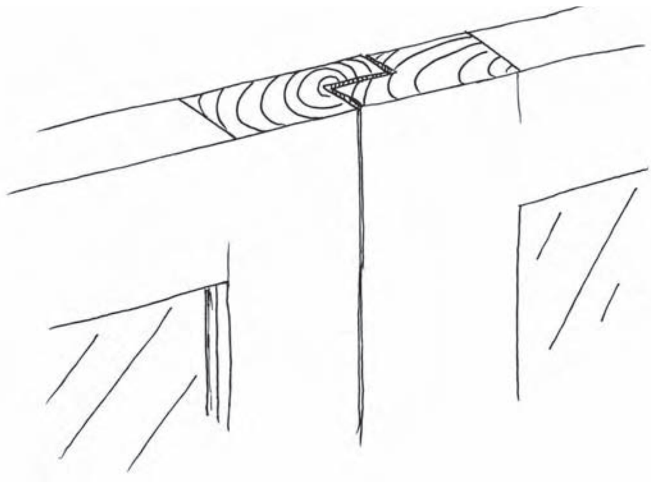


Figure 5.7 Rebated French doors

Without the rebate or mushroom stop, light would be seen through a crack between the doors that would create a draft resulting in significant heat loss in winter. While the mushroom stop and rebates help to reduce the airflow I have always found that fixing some kind of door seal down the junction is worthwhile.

If you have a pair of doors that have neither mushroom stops nor rebates, the simplest solution is to purchase mushroom stop material, which is available at most good timber yards. Fix the mushroom stop to the door with glue and nails prior to measuring the doors to calculate the door buck width.

Floor coverings and clearance

The floor coverings that the door will swing over will have a bearing on the clearance required under the door when it is finally hung. Obviously this will affect the overall height of the door buck. Door jambs for external doors may or may not have a timber sill. If the door jamb has a timber sill the door will have more than sufficient clearance to pass over any type of floor coverings however, if not, this will need to be taken into account. If you purchase an external door jamb without a sill you will most likely have to cut the bottom of the stiles (uprights) of the door jamb to the correct length.

- To calculate the width of the door buck into which a door jamb will be fitted:
  Internal width of door buck = External width of the door jamb + 20 mm.
- To calculate the height of a door buck into which a door jamb with a sill will be fitted:
  Internal height of the door buck = External height of the door jamb + 20 mm.
- To calculate the height of a door buck into which a door jamb without a sill will be fitted:
  Internal height of the door buck = External height of the door
  + Depth of floor coverings
  + Thickness of the door jamb head
  + 25 mm.

The calculations for the width between door posts that are fixed to the top boxing and the floor is the same calculation as that of the door buck.

To calculate the distance between door posts that are fixed to the top boxing and the floor when the door will be hinged directly onto posts.

- Calculation for the width between the door posts for a single door hinged directly onto the door posts:
  Space between the door posts = Overall width of the door + 5 mm.
- Calculation for the width of the door buck / door jamb for double doors hinged directly onto the door posts:
  Space between the door posts = Overall width of both doors held together + 7 mm.

Fixing the door head

Fix the door head between the door posts after the door is hung. Rather than set the height of the door head by a calculation you will find it easier to hang the door into the opening between the door posts. Set the door high enough off the floor to allow 5 mm clearance over and above the depth of floor coverings. If it is likely that stones may be carried in on shoes it may be appropriate to allow 10 mm clearance so that stones do not get wedged under the door, however this does increase air flow and associated cold drafts. Once the door is hung the door head can be fixed in position above the door with a gap of 2 mm between the top of the door and door head. Doors that are hinged directly onto door posts and door bucks will require door stops for the door to close against. The door stops should be glued into place as well as being nailed or screwed to the door jamb. The door stop needs to be well fixed, as this is the barrier to prevent easy access to the latch of the door lock. Without the door stop a credit card could easily be inserted between the latch and the door jamb, or the latch could be cut to gain access.

Simple window bucks

The simple window buck can be used for windows up to 900 mm wide that have straw bales fitted over the window. The simple window buck can also be used when windows are to be installed without bales of straw above the windows, and where the top bale boxing alone is capable of supporting the roof and ceiling. While it is possible to use this system for windows fitted at either face of the wall, in the situation where bales are required above the window it is simpler if the buck is fitted in the centre of the wall.

I will initially cover the assembly and installation of a simple window buck less than 900 mm with straw bales laid over the top of the window. Following this I will detail the different aspects of a wider window buck without bales laid above it.

Window bucks up to 900 mm wide with bales above

The simplest window buck can be made from 90 × 45 MGP10 pine. After calculating the required internal opening size for your buck cut two pieces of timber for the stiles (the vertical timbers) and four pieces for the head and sill of the buck. The head is the top of the buck while the sill is the base of the buck. Make a note when cutting the sill and head timber to allow for the thickness of the stiles of the buck when establishing the length of timber required after you have calculated the desired internal dimensions of the buck.

Nail the head and sill onto the stiles so that they cover the end grain of the stiles. This allows for any weight on the window buck to be cleanly transferred through the window buck. In this application the nails are simply there to hold the buck together rather than to be the primary structural component of the connection (see Figure 5.8).

Once the window buck is assembled, another piece of timber the same length as the head is to be nailed onto the head of the window buck. You will now have a rectangle with double thickness of timber at the head, or top of the window buck. A timber brace is to be fitted inside the window buck diagonally from one corner to the other to hold the buck square. If this is not done, it is likely that the window buck will be pushed out of square as the bales are laid around it, and then the window will not fit into the opening.

While it raises other issues regarding flashing, if you are going to lay bales over the top of the window buck, it is easier if the buck is centrally located in the wall. This will give you greater stability, as the bales are less likely to twist on top of the buck. When bales are laid over this style of window buck, the pressure during compression of the bales will be transferred to the ends of the bottom of the window buck, known as the sill. As previously detailed in Chapter 4 on straw bale walls, avoid the situation where the end of the buck sill is aligned with a vertical joint in the row of bales. If the end of the sill is aligned with the end of a bale, it is highly likely that the sill will compress into this area more than in the body of the bales (see Figure 5.8).

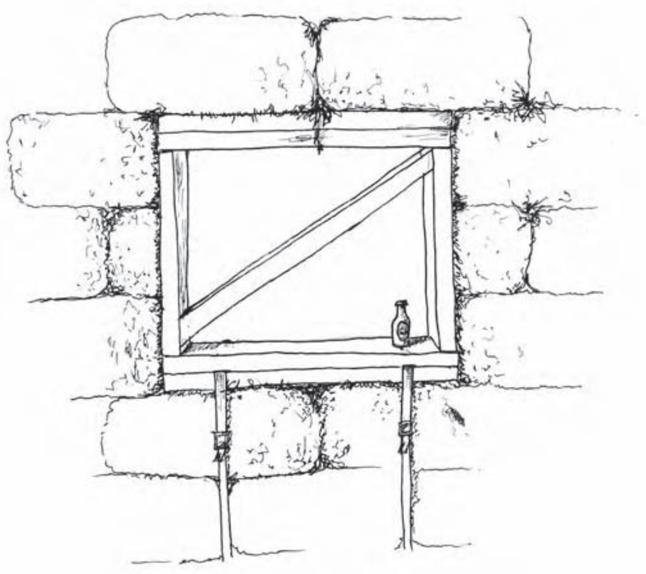


Figure 5.8 Small window buck with an internally fitted diagonal brace, installed into a straw bale wall

Fitting a simple window buck

Lay the bales on the bottom boxing as previously detailed until you have the required number of bales below the window. Position one of the pieces of timber for the sill on top of the bales. This timber is to be used to compress the bales below the window. If you need additional height to further elevate the bottom window, increase the depth of the compression timber. Lay the polyester strapping over the compression timber in the window opening and tighten the straps using the tensioning tool to compress the bales below. If possible, when tightening the straps, keep the compression timber horizontal and parallel to the bales. Use a spirit level during this process to monitor the horizontal status of the timber. While it is desirable, it is of no huge concern if the compression timber does not end up level. To overcome any variance, insert packers between the underside of the sill of the window buck and the compression timber to bring the sill timber into a level position. It is more important that the bales below the window are compressed than the compression timber held level. However, be vigilant to ensure that the timber is kept in the correct position horizontally on the bales as this is the foundation on which the buck will be fixed.

Fit the window buck on top of the compression timber, ensuring that the sill of the buck is level and the stiles are vertical relative to the face of the wall. It will be necessary to place temporary braces from the top of the window buck down to the floor or to pegs in the ground to hold the window buck in a vertical position while the bales are laid around it.

Check that the buck is plumb and level within the straw bale wall. Because diagonal bracing has been fitted to the face of the window buck, when the sill of the buck is level, the stiles of the buck should be vertical or plumb. Do not however take this for granted, check it. If this is not so it is likely that the diagonal brace is incorrectly positioned and should be altered before bales are laid around the buck.

When the window is eventually fitted, it is essential that support be provided below the line of the actual window to all vertical members of the window. Therefore it will be necessary to provide packers between the compression timber and the sill of the window buck to line up with the stiles of the actual window when eventually fitted. Apart from the stiles of the window which are at the outer line of the window, the mullions must also be supported. (The mullion is the vertical piece of timber within the body of the window that forms part of the fixed frame of the window.) Fit the required packers between the compression timber and the buck sill, fixing them in position to avoid dislodgment.

Window bucks greater than 900 mm wide without bales above the window where no lintel is required

The procedure for this window buck varies only slightly to that of the window buck up to 900 mm wide with bales above it. In this form of construction it will not be necessary to fit a second head on the top of the window buck, as the window head is not carrying the load of bales above it. There will be a gap between the underside of the bale boxing and the top of the window buck. This gap will allow the top boxing to drop without fouling on the window buck during compression of the wall.

The infill structure above the window

The bales are to be compressed over three days to gain maximum compression, following which the framing over the window will be completed. The framing over the window is referred to as a dropped rolled head. As the name implies, a dropped rolled head would normally have a rounded appearance over the window however it is possible to create quite a square look if so desired. Timber, known as a dropper, is to be fitted from the underside of the top bale boxing basically down to the top of the window buck. Measure the distance from the underside of the top bale boxing to the top of the window buck and deduct 10 mm for clearance. Depending on the desired shape of the render over the window it may be necessary to cut an angle onto the bottom front corner of the dropper. Nail the dropper to the underside of the top bale boxing, ensuring that the droppers are fitted vertical both ways. If the top bale boxing is slightly twisted, which is often the case, it will result in the dropper being tight to one side of the boxing and slightly open on the other. The droppers are to be fitted at 450 mm centres. Nail a nogging onto the underside of the top boxing between each of the droppers. Skew nail through the side of the dropper into the nogging (see Figure 5.9).

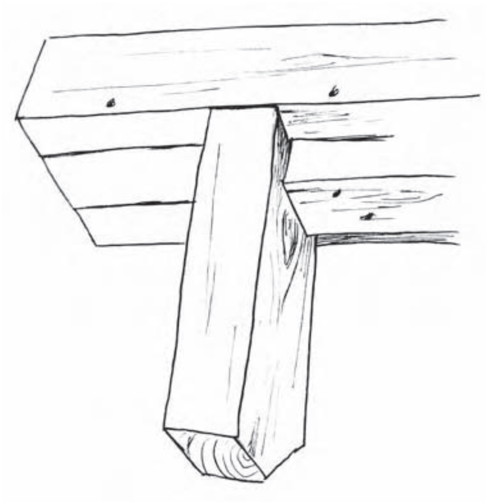


Figure 5.9 Droppers and nogging for dropped rolled head secured to the underside of top boxing

Fitting wire netting to emulate the finished wall shape required

Fix wire netting on the inside of the top boxing and feed it through the 10 mm gap between the droppers and the top of the window a buck. The render will eventually be added to the outside of this wire so it is essential that this wire replicate the final shape required over the window. Once this shape is attained, with the wire fed over the top of the window buck to the outside of the building, secure the netting in the correct position by stapling it to the droppers at the inside only (see Figure 5.10).

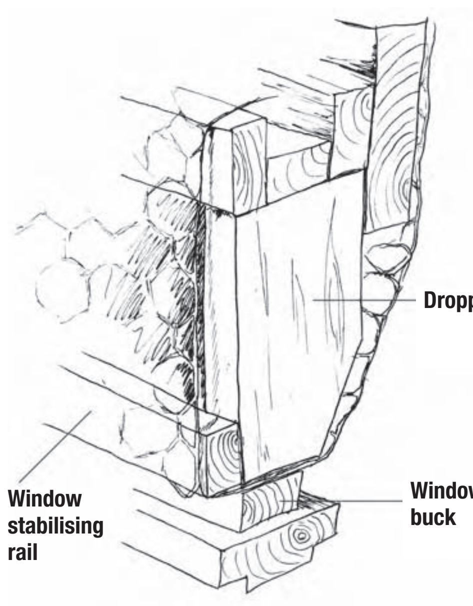


Figure 5.10 Dropped rolled head for infill construction

Fixing the window stabilising rail

Once the wire is fixed to the droppers, a window stabilising rail will be fixed to the outside of the droppers and secured to the top of the window buck. This rail will tie all the droppers together, increasing their strength, and will reduce, if not remove, the possibility of the window moving independently from the wall in the case of impact or strong winds. Lay the window stabilising rail on top of the wire netting, thereby resting on the top of the window buck, and against the outside edge of the droppers. When in position fix the window stabilising rail first to the droppers and then up through the head of the window buck into the stabilising rail.

Packing the cavity above the window with straw

Fill the cavity contained within the wire netting, including between the droppers, with tightly packed straw. It is important that the straw be tight to avoid heat loss through this area. Now fix the loose end of the wire netting to the outside edge of the top boxing. If you so desire, additional timber can be fitted to the droppers to assist in forming the final shape of the wall.

Allowing for the future installation of window dressings

If you require a greater vertical section above the window for the installation of window dressing, the clearance between the underside of the droppers and the top of the window buck can be increased to accommodate the insertion of additional timber.

Compression of bales beneath windows when the window is not centrally located

It is essential that the bales below a window be compressed by applying pressure to the centre of the bale. To apply pressure to one outer edge of the bale will cause the bale to twist and become unstable. In this application two compression timbers are fitted to the top of the bales. These timbers will require noggings between them to prevent them from being drawn to one another during compression (see Figure 5.11).

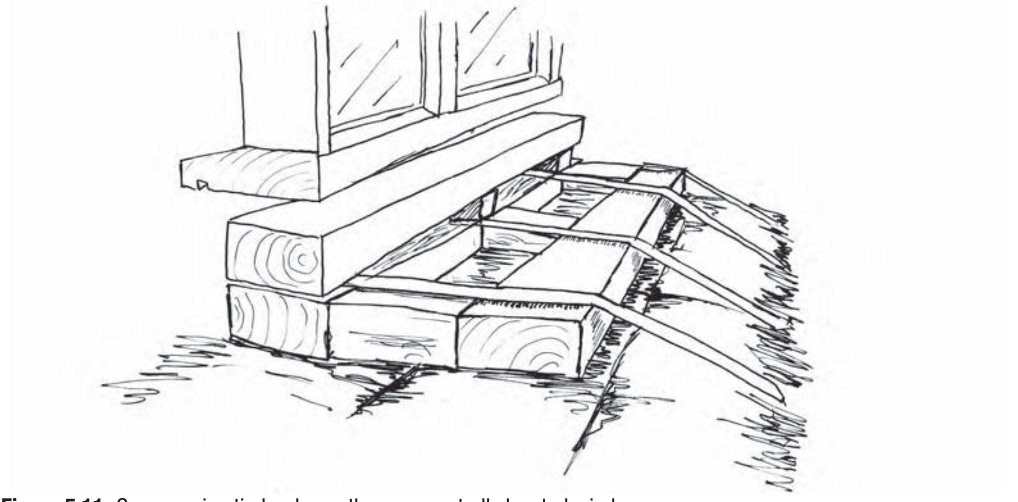


Figure 5.11 Compression timber beneath a non-centrally located window

Compression of bales beneath windows with a window seat

The depth of straw bale walls lends itself to the provision of window seats. Window seats have a certain charm about them. They inspire the imagination and conjure up pictures of reading while sipping hot chocolate as rain falls outside and the open fire crackles in the background. Anyway, enough of the romantic notions, how do you build one?

The process is very simple. First, as you are no doubt aware, earthen render, while being tough and aesthetically appealing, is no match for the constant banging of little feet swinging aimlessly in the breeze while sitting on a window seat. I suggest that window seats be covered in timber to overcome this problem. You will need a frame onto which the seat will be fixed, and to enable the compression of the bales below the window. Build bale boxing as per the construction of the bottom bale boxing but without the flat noggings. Fit the structural ply to the face of the bale boxing and then position this on top of the bales below the window with the ply against the straw bales. Wrap the polyester compression strapping around the bottom bale boxing and the window sill boxing, thereby encasing the bales, then compress the bales over three days as per normal. Once compression is complete, fit 70 × 35 timber vertically between the sill bale boxing and the bottom bale boxing. Fit these vertical timbers at 450 mm centres on both the inside and outside of the building. It will be necessary to trim the bales where the vertical timbers are to be fitted to allow the timber to be fitted flush with the face of the sill bale boxing and the bottom bale boxing.

Preparation of the timber-lined window seat

The window sill boxing is unlikely to be flat and level so you will need to fit packers to it to provide correct framing for support of the timber lining. To reduce movement at the junction of the seat timber and the window sill, it will be necessary to fit noggings along the length of the window. The noggings are to support both the inner edge of the window sill and the timber of the window seat (see Figure 5.12).

Trim the straw between the vertical timbers back approximately 20 mm below the line of the timber to allow sufficient depth for render to be applied to the straw and the timber lining to cover over the render. Ideally apply two coats of render to the straw prior to fitting the lining timber, as this will prevent airflow through the bales as well as create a barrier against vermin penetration. Note: the second coat of render should be no more than 10 mm thick, thereby reducing the likelihood of cracking.

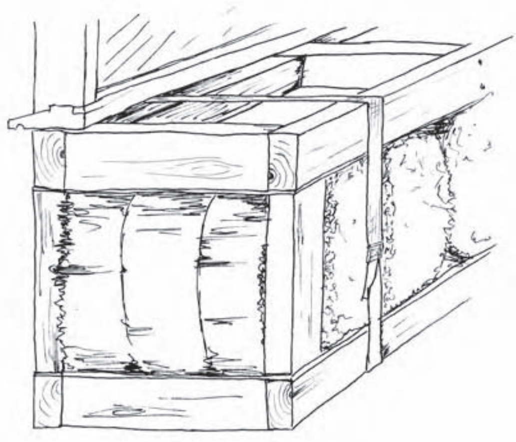


Figure 5.12 Timber framing for a timber-lined window seat

Cracking between render and timber

Without treatment the junction of render to timber will crack. This can be reduced, if not negated, by applying a mixture of glue and coarse sand to the timber surfaces. I have found that Bondcrete® and PVA wood glue both work well when mixed with the sand. If you are trying to avoid the use of commercial adhesives you could make up a cooked flour and water adhesive, however if this gets too wet during construction it is likely to come away from the timber. Apply the sand–glue mix to the surface of timber that is going to be covered with render, including the sides of the vertical timbers beneath the window seat.

Installing the window

The window can be installed before or after the first and second coat of render. Installing the window post render will reduce the risk of water leakage into the bales, as the bale envelope is sealed prior to the window installation. Following the installation of the window, the timber lining of the window seat can be installed. Ensure that the timber lining is secured to the noggings at the junction of the window. The flashing of a window sill is turned up the internal face of the window by approximately 10 mm. This prevents water from running inside the building, resulting in it being discharged to the outside of the building. There is an alternative to this type of flashing that is covered in detail in Chapter 10, installation of windows and doors. The timber lining of the window seat will cover the section of the flashing that is turned up on the inside of the window.

Fixing the window and door bucks to the infill frame

When fitting windows and doors into walls in a house of infill construction the window/door bucks will be fixed to the beam that supports the roof, known as the pitching beam, via the droppers. Droppers are positioned against the back of the pitching beam and against the underside of the top bale boxing. Fit a dropper every 450 mm along the pitching beam/top boxing. Nail the droppers in position by first nailing through the pitching beam into the dropper and then through the top bale boxing into the dropper. This not only securely fixes the droppers, but also secures the top boxing to the pitching beam thereby contributing to the connection of the straw bale walls to the infill frame (see Figure 5.13).

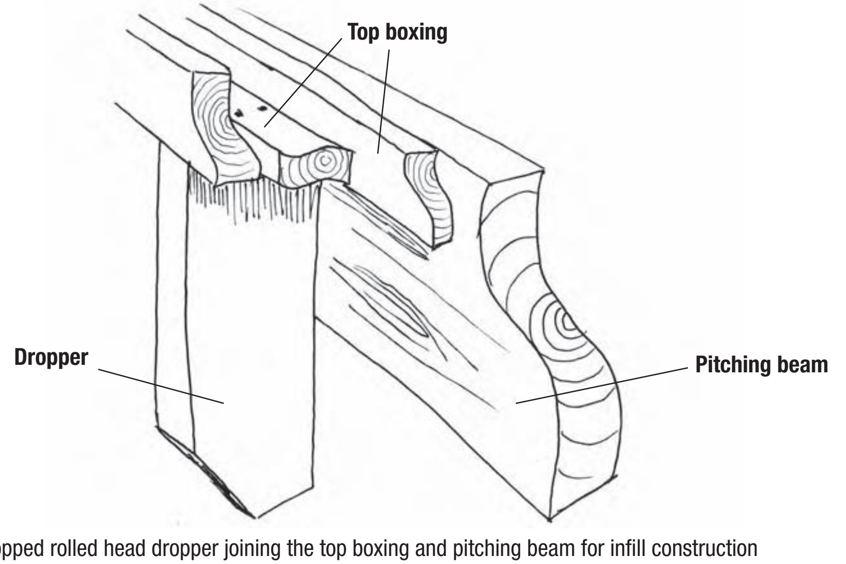


Figure 5.13 Dropped rolled head dropper joining the top boxing and pitching beam for infill construction

Space for wire netting

Allow space between the window buck and the droppers for the insertion of wire netting. Leave a 10 mm gap between the underside of the dropper and the top of the buck. This is to allow the wire netting to pass through the gap. If you require the pitching beam to be exposed, fix the wire netting to the back of the pitching beam. If the beam is to be concealed with render, fix the wire netting to the face of the pitching beam and then feed the netting through the gap between the droppers and the buck. If you insert a thin layer of straw between the wire netting and the pitching beam it will eliminate any cracking of the render at the junction of the pitching beam to the straw bales. Shape the wire to emulate the final shape of render that you require and then staple the wire to the droppers. The window stabilising bar can now be fitted on the outside of the droppers. Position the timber against the droppers while resting it on the wire that is laid over the buck. First nail the window stabilising rail to the droppers and then nail through the buck up into the stabilising rail. Tightly pack the cavity between the droppers and the wire netting with straw and then fix the loose end of the wire to the top boxing using heavy-duty staples. I use a staple gun with heavy staples, however you could use fencing staples if you are unable to access a staple gun.

Large window openings

Lintels supported on posts are needed for larger window openings with load bearing construction.

Openings greater than 1.8 metres for load bearing buildings

In the past it has been suggested that the use of windows greater than about 1.8 metres in load bearing straw bale buildings was unwise. There are two reasons for this. First there was concern that the render at the junction between the bales and the windows would crack as the bales continued to settle while the lintel over the window remained in a fixed position. Second, if a lintel were to be fitted to support the roof and ceiling over the windows at what height should it be fixed. It is impossible to accurately predict the compression that will be achieved as all bales vary, as does the compression of them. One of my owner-builders who built a house with load bearing walls has one window 3.0 metres wide and another 3.6 metres wide. The 3.6 metre window has a lintel spanning about 3.9 metres as the bales are curved from the wall into the window which is set on the outside of the building. The lintel and bale walls are carrying trusses that span about 8.2 metres with a 2-metre verandah also bearing weight onto the walls and lintel. The render around this window has now been in place for almost two years with no sign of cracking.

With the introduction of polyester strapping the rate of compression has been increased. This means that the bale walls carrying the roof load have been compressed beyond the weight that the roof and ceiling will place on them. As long as the load of the roof and ceiling is less than the pressure exerted through the compression process the wall will not compress any further. This, added to the lateral securing of the bales to the posts as previously mentioned in door bucks, means the junction of the bales to the timber posts are stable and will not crack. The only remaining hurdle is the ability to fix the lintel so that it lines up with the top bale boxing so that a constant ceiling and roof line can be gained.

Calculating the lintel height

To establish the likely height that the lintel is to be, calculate the overall height of the straw bale walls including the bottom and top bale boxing. Deduct 7 per cent for compression. It is likely to be less than this, however work with 7 per cent. This is the required height of the top of the lintel to the surface of the floor, which will result in the top boxing finishing higher than the lintel (see Figure 5.14).

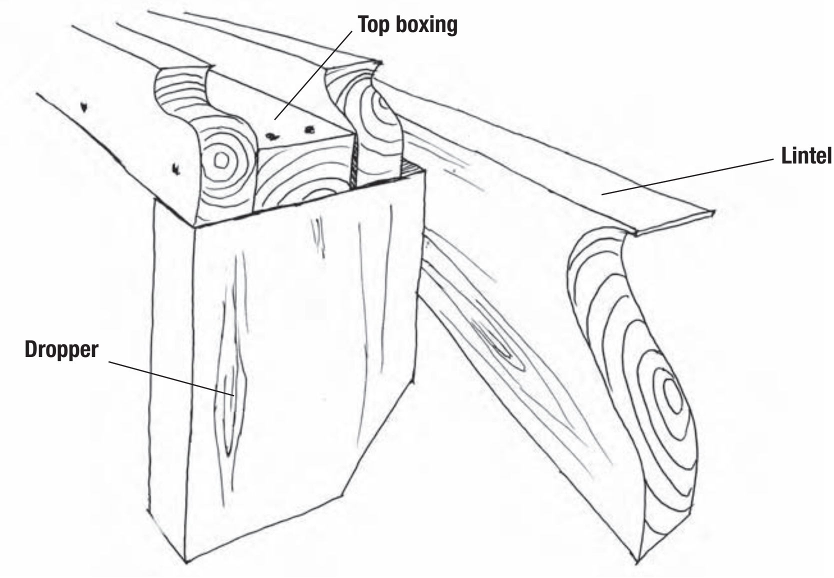


Figure 5.14 Dropped rolled head dropper joining the top boxing and window lintel for load bearing construction

Lintels supported on 100 × 100 posts

The lintel is supported on posts, normally 100 × 100. The lintel will either be checked into the post or bolted to the face of the post. There are a number of factors that will have a bearing on the construction system most appropriate for your house. I suggest that you initially discuss this with your building consultants; if it is beyond their capacity to determine the appropriate application you will need to refer this to your engineer. Fit the lintel to the post with them lying on the floor. Fit a piece of timber from one post to the other at the bottom of the posts so that the posts are fixed in a parallel position. With the posts, lintel and cross timber still laying flat on the floor ensure the structure sits in a square position by checking that the diagonal measurements are equal. Once the structure is sitting in a square position, fit a diagonal brace within the structure to prevent it from moving out of square.

The posts should not be greater than 140 mm deep. Fit a piece of timber horizontally between the posts halfway up the posts to prevent the posts being bowed inwards as the bales are laid. Stand the post and lintel up in the correct position and hold it in place with braces to the floor or pegs in the ground outside the building envelope. The lintel is positioned in the wall so that the inner edge of the top bale boxing when positioned on the bales will rest against the outer edge of the lintel. The edge of the lintel facing the outside of the building will normally be 135 mm from the inside face of the bales.

Fitting the window buck

Once the posts and lintel are in position you will need to build and position the window buck for the window. Determine the internal dimensions of the buck using the calculations previously detailed. If the opening is for a door it is best that 90 × 90 timber be used for the stiles of the buck, however in the case of a window 90 × 45 is sufficient. Having built the buck in accordance with the details aforementioned, stand it in position, which will most likely be at the external face of the wall. Nail timber cleats from the back of the stile of the buck to the face of the post supporting the lintel (see Figure 5.15). These trimmers are to be fitted every 600 mm up the stiles of the window buck. Following the installation of the bales and their compression, wire netting will be fixed to the back of the window buck over the trimmers and across the post and extended approximately 300 mm over the straw bales. Pin or stitch the wire to the bales as previously detailed. If you fit the wire netting in sections approximately 900 mm high it will be easier to pack the cavity with straw.

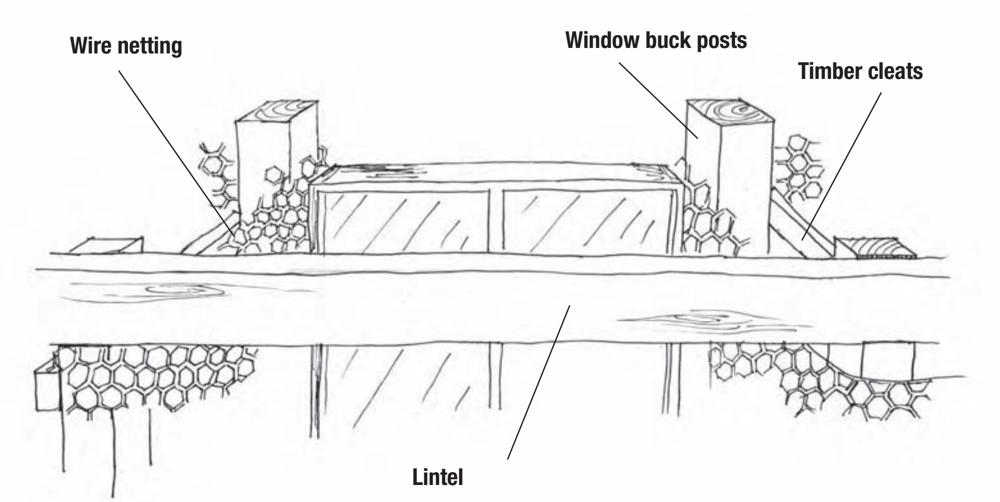


Figure 5.15 Wire netting over posts and frame of window buck for an externally located window with a pitching beam installed level with the internal wall

Installation of dropped rolled head droppers

Cut droppers 10 mm shorter than the distance from the underside of the top bale boxing down to the top of the window buck. Do not assume that all the droppers will be the same lengths. With the dropper held up to the bottom of the top bale boxing and against the outer face of the lintel, nail through the lintel into the dropper. It may make the job easier if you use a clamp to hold the dropper firmly against the lintel prior to nailing it. Now nail down through the top bale boxing into the top of the dropper. Complete this process for each dropper one at a time.

Once all the droppers are in position, fit the wire netting, as previously discussed, by first fitting the netting to the upper edge on the internal face of the lintel. Feed it between the droppers and the window buck, fit the window stabilising rail and then, after stuffing the cavity with straw, fix the wire netting to the external edge of the top bale boxing. Remember to lay straw between the wire netting and the internal face of the lintel.

Calculating the length of the lintel

The bottom bale boxing can be built before the post and lintels are stood up, which will make it easier to fix the bottom of the posts to the floor. If, however, this is a little confusing the bottom boxing can just as easily be built after the lintel and posts are sitting in position. Remember when establishing the length of lintel required to take into account the shape of the opening to the window. If the window is fitted level with the inside of the wall an allowance of 20 mm should be made to allow space for sealing the window to the posts when using foam and to allow space for adjusting the alignment of the window. When the lintel is fitted at the internal line of the wall, and the window is fitted level with the external face of the wall, which is more common, allowance needs to be made for shaping the wall back to the window.

Advising your engineer of lintel lengths required

It is important to advise your engineer of the actual lintel lengths required. In my home the rounding around the windows is significant and would require an additional 150 mm on each side of the window plus the thickness of the render which could be up to 40 mm thick. For a 3.6 m-wide window, I would have to calculate the size of a lintel to span just under 4.0 m wide. It is important that you supply these details to your engineer and building consultant otherwise it is likely that they will calculate timber sizes to span 3.7 m rather than the 4.0 m actually required. If this occurs there is a strong possibility that the dimensions of timber will be too small to carry the load. Furthermore, if this is not taken into consideration when creating a list of materials to be purchased you will more than likely end up with timber that is too short to span the distance required.

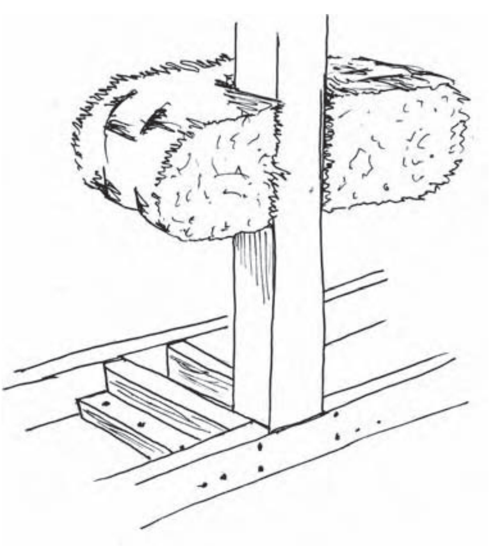


Figure 5.16 Securing of a load bearing post to the floor via bottom boxing

The bottom bale boxing is to be built so that it encompasses the post width. This will enable the post to finally be encased in the render (see Figure 5.16). Note that vertical noggings within the bottom boxing surround the post. Each post is secured to the vertical noggings within the bottom bale boxing. Horizontal noggings are fixed to the floor, vertical noggings are fixed to the horizontal noggins, and the post is fixed to the vertical noggings. This chain of fixings will provide a secure fastening of the posts to the floor. In certain wind zones it may be necessary to increase the connection to the floor. The engineer will clarify the requirements of your job when assessing the wind ratings in your area.

Installing the lintel

Once all the bales are laid, the top boxing will be positioned on top of the straw bale wall and the straw bale wall compressed. Ensure that there are no joins in your top boxing within the realm of the lintel. The top boxing is designed to give lateral stability to the lintel. The vertical surface of the lintel facing the outside of the building will have the top boxing sitting against it. The top boxing will sit higher than the top of the lintel.

Compress the bales of straw as discussed in Chapter 4. As the bales are compressed the top bale boxing will slide down the external face of the lintel. The bales are to be compressed over a three-day period. When the compression is complete the top boxing should rest slightly higher than the lintel. When compressing the bales, if tension is applied to the outside of the strapping more than the inside, the wall may tend to lean out. Monitor the position of the top boxing to the lintel during compression so that if it is moving away from the lintel you can apply more tension to the polyester strapping on the inside of the wall and see if they come back together. If the top boxing has separated slightly from the lintel this can be rectified by using clamps to pull the top boxing back to the lintel. It is not crucial that the top boxing rest against the lintel so if you are happy with the line of the wall and the position of the lintel leave it where it sits.

Solid timber bucks supporting bales over the opening

This is often required in a two-storey construction where bales that form the upper walls are to be supported over window openings. In some instances it may also be necessary for this construction to carry the upper floor joists that support the upstairs flooring.

The vertical supports or posts will be 290 × 45 timber with a rib on the back of them as detailed previously for bale stabilisation. Larger openings supporting floor joists as well as bales may require two 290 × 45 timbers nailed together with the rib then added to the

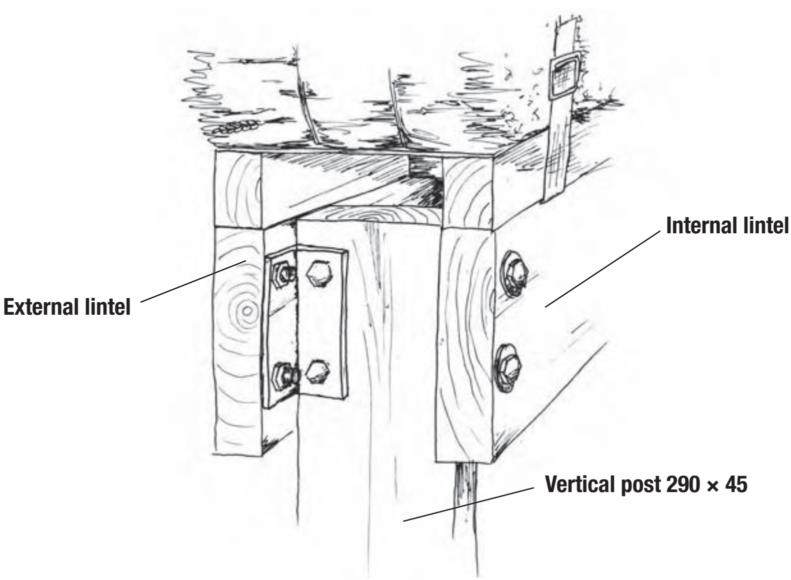


Figure 5.17 Double lintel fixed to 290 × 45 post to support straw bales over a wide opening

back of the pair of timbers. The horizontal timbers (lintels) spanning the opening will be fixed to both the internal and external faces of the 290 × 45 posts (see Figure 5.17). The lintels can initially be fitted to the posts with nails, however it will be necessary to use metal brackets to bolt the lintels to the posts. Your engineer will provide specifications for the timber dimensions, the configuration of the metal brackets and the required location of them. Once in place there will be a space of 290 mm between the two lintels. Blocks are to be fitted between the two lintels and flush with the top edge of the lintels at 450 centres along the lintels. The blocks are to be no less than 50 mm smaller in depth than the lintels. Droppers are then fixed to the side of the block to form the shape over the opening (see Figure 5.18).

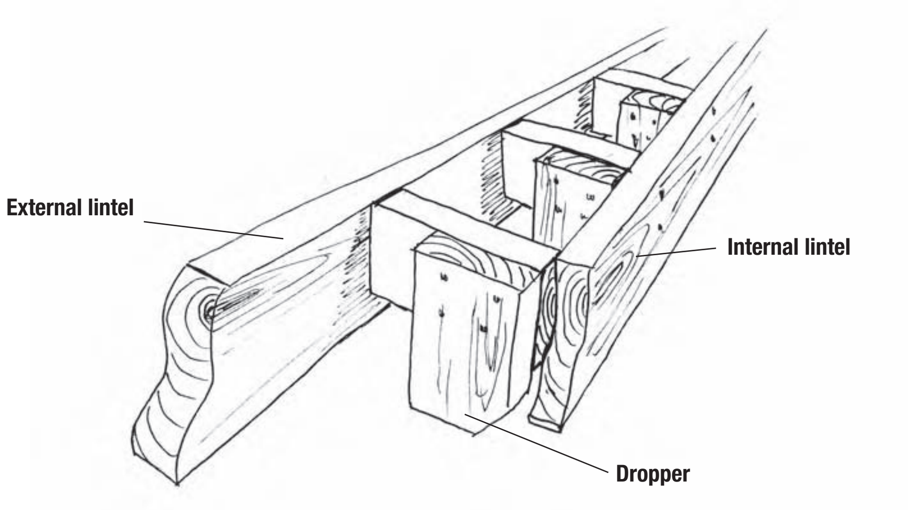


Figure 5.18 Noggings and droppers fixed to double lintels

Setting the height of the lintel

Set the height of the lintel to match compressed bale heights. If the lintels are supporting bales only, think carefully about the appropriate height for the underside of the lintel, taking into consideration the final shape required above the window. Part of this decision should account for the required position of window-dressings as it will be necessary to supply a fixing point for curtain tracks etc. if they are to be fitted against the window rather than on the internal face of the wall. Figure 5.10 shows a vertical timber above the window for installation of window dressings against the window. The height of lintels supporting upper floor joists will be determined by the ceiling height of the ground floor, as the underside of the upper floor joists function as the ceiling timbers of the ground floor.

The straw bales above the opening are supported on bottom bale boxing just the same as on the ground floor. When the lintels also support the upper floor joists the floor joists are fixed across and to both lintels. Flooring is fitted to the upper floor joists and the bottom bale boxing is fitted on top of the first floor flooring (see Figure 5.19). The bottom bale boxing for the first floor can either be skew nailed to the upper floor joists or nailed through flat noggings. If nailing through flat noggings, ensure that noggings are fitted into the boxing so that they end up directly above a floor joist.

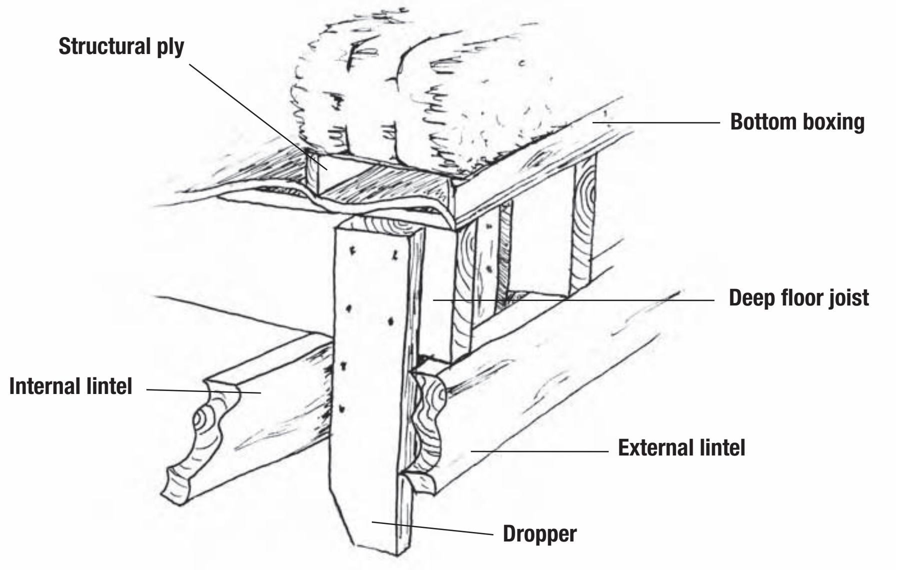


Figure 5.19 Upper floor joists and dropper rolled head droppers fixed to double joists to support straw bales and floor load over a wide opening

The droppers for the dropped rolled head are to be fixed against the internal lintel and into the blocks between the lintels. The height of the droppers will be established as previously detailed, as is the fitting of wire netting, straw, window stabilising rail and render.

Render over deep posts

Deep posts in our Heathcote house

Our home in Heathcote, Victoria, has a large sliding door from the lounge room out to a three-metre-wide verandah adjoining small garden wrapped around a 6 × 12 m lawn. Our bedroom has double doors into the lounge giving us a clear view from our bed through the glass door over the McIvor Ranges. Most mornings we sit in bed eating breakfast watching the kangaroos with their joeys as they graze in our front paddock or on the lawn. Lazy days are spent in front of the open fire watching the blue wrens frolicking on the lawn, or the magpies forming a circle warbling to their hearts content as if practising for a cathedral choir. Needless to say, the view through this window is the focal point of our home. We did not want a harsh window frame to interrupt the tranquillity of outside and felt that the only option was to have render gently rolled back from the window.

The timber posts supporting the lintel are 290 mm deep as they support an opening 3.3 m wide, and carry the upstairs floor and straw bales from the wall above. To achieve the desired shape around the doors it was necessary to create the shape using wire netting

Figure 5.20 Wire over 290 × 45 door buck stile to facilitate rounded render at the door opening

and straw. A 19 mm thick spacer was fixed to the post beside the door to lift the wire away from the post and allow the insertion of straw to begin the shaping of the curved form. The front corner of the post had to be trimmed to allow the wire to drop back far enough to create an even curve back into the wall (see Figure 5.20).

The double 290 × 45 posts were larger than actually necessary so there was no problem in cutting away the front section of this timber. Always check with your building consultant before cutting away any of the supporting posts for lintels. If there is insufficient tolerance in timber posts cutting them may result in a structure that does not conform to the building code. It would then be necessary to replace the timber. Unfortunately this problem is not normally discovered until the frame inspection. To replace posts supporting lintels when the rest of the structure is complete is a major job for a skilled tradesperson. I strongly suggest that all owner-builders seek professional advice before embarking on the rectification of a problem such as this. If it is not done in the correct order and method it could not only be very costly, but also life-threatening.

Forming the curve around the stiles

Wire netting was fixed to the 19 mm spacer beside the door. Loose straw was placed between the wire netting and the timber post as the wire was drawn back onto the straw bale wall thereby forming a gentle curve around the stiles of the window to match the shape of the dropped rolled head. The loose end of the wire netting was pinned back to the straw bale wall with wire pins. There was no need to apply the sand and glue mix to the post as the post was now covered with wire over straw. However the front edge of the window was treated with the sand and glue mix to ensure a good air seal and to reduce the likelihood of the render cracking at that junction.

Foam fill between the door frame and deep posts

Prior to rendering, the cavity between the door frame and the posts was filled with foam. When using foam it is important to overfill the cavity as the render will hold onto the cut face of the foam but not the smooth skin that the foam forms naturally. The excess foam was cut back level with the face of the window and then the render was applied. A render pump was used to apply the render, which assists its penetration into the straw beneath the wire, giving a strong bond of wire, straw and render around the door. It is important that render be worked well into bales and wire netting around all doors, as the vibration of the door's operation will break down unstable render in this area. The final result around the window is as gentle and unobtrusive as we had envisaged (see Figure 5.21).

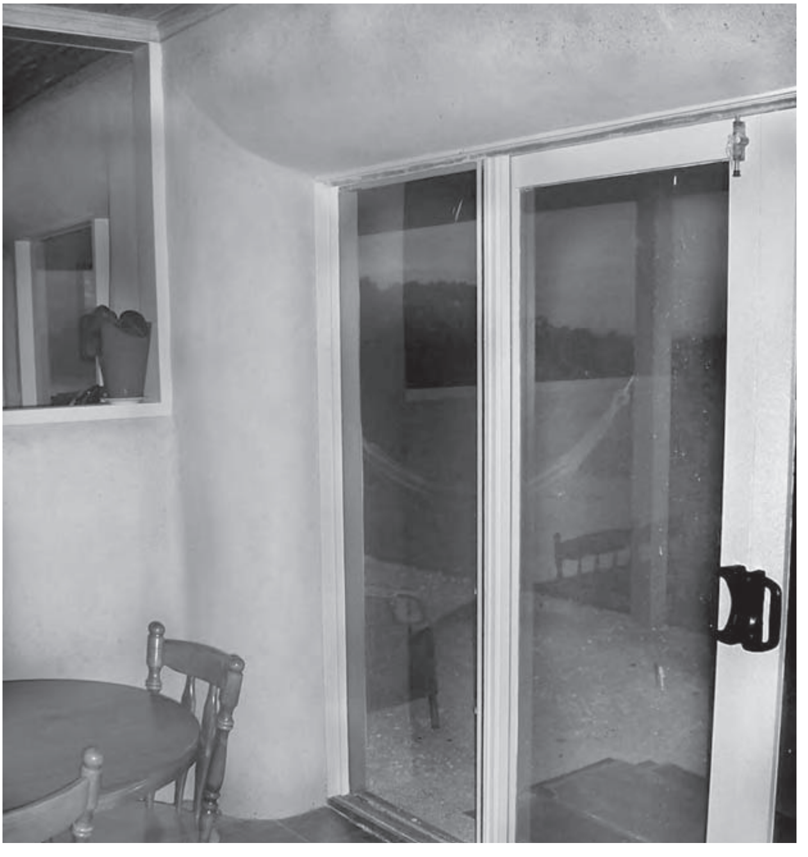


Figure 5.21 Completed render over the wire netting frame work at the stile of the door buck and door

Window openings with bales below and a lintel above

In this application posts will support the lintel in the same manner as previously discussed. Depending on the width of the lintel and the height of the bales below the window it is likely that the post size could be reduced as the bales will add lateral strength to the post. Ideally the straw bales will be laid in a continuous running bond pattern and will have a section cut out of the side of the bales to accommodate the post supporting the lintel. When posts greater than 120 mm deep are used, the bales will be laid between the posts. There are varying schools of thought regarding the compression of bales below windows. Some say that it is not necessary while others advise it. Personally, for the small amount of effort required, I believe it to be a good investment.

6

Timber framed walls

Components of a timber framed wall

Timber framed walls are made up of five components (see Figure 6.1):

1. The bottom wall plate – the horizontal piece of timber that is fixed to the floor
2. Studs – the vertical pieces of timber
3. The top wall plate – the horizontal pieces of timber at the top of the wall
4. Noggings – short pieces of timber fitted between the studs
5. Wall brace – either timber or metal. The wall brace is the material that reaches from the top plate down to the bottom plate and is fitted diagonally in the wall.

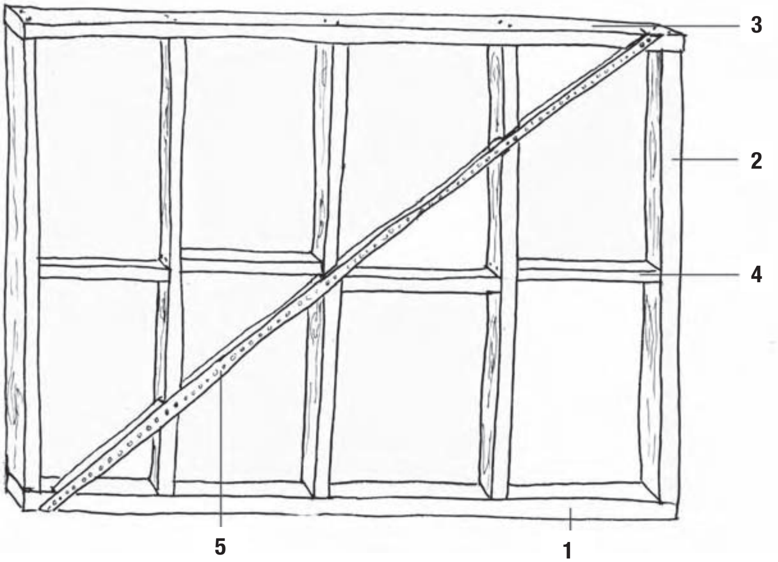


Figure 6.1 Simple timber framed wall

The carrying capacity of the wall is dependent on the dimensions of the studs and wall plates as well as the strength grade of the timber. Your engineer or building consultant can establish the timber specifications. The details of the timber to be used in the walls will be specified in the timber specifications that form part of your building permit.

Using non-structural timber legally

It is possible to use the new non-structural timber legally to reduce costs in a number of ways. Timber is graded relative to its load capacity. These days, most timber framed walls in Australia are built from Radiata Pine. The most common strength grading of radiata pine is MGP which stands for 'Machine Grade Pine.' What was previously referred to as F5 pine is now MGP10 and F7 is now often referred to as MGP12 pine The higher the reference numbers the greater the strength of the timber. When constructing your house, it is important that you use the correct grade of material as specified in the timber specification section of the building permit. The lowest grade of timber is non-structural. This timber can often be purchased at a significantly lower price than other grades of materials. The use of this material is not only financially beneficial but also ecologically responsible. MGP10 pine is the most popular material used in conventional building and so it stands to reason that the demands on this product are most likely the driving force behind the felling of pine plantations. The more non-structural material that can be used, the better use we are making of all the timber milled. If no one were to use the non-structural material it would have to be destroyed.

There are many applications in the construction of a house that do not require structural timber. When the roof of a house is built using roof trusses, all of the weight of the roof is transferred to the external walls. With this type of construction, any internal walls are basically installed as partitions and with some exceptions do not form a structural part of the construction, as they do not carry any load. In these situations the use of non-structural timber is appropriate. If you want to take advantage of the cost saving and ecological benefits of using non-structural timber, be sure to advise your engineer and/or building consultant. Standard practice is to specify stress-graded timber. If you do not advise them otherwise this is what will happen.

The process of constructing walls

The task of establishing wall lengths and their positions within a house can be very difficult if gone about in the wrong way. The excitement of the moment often overtakes owner-builders who set about building their first wall as soon as possible. Building walls as individual units is fraught with traps to catch the unsuspecting so PLEASE take note of this section. On more than one occasion owner-builders have built their walls one at a time and then found they simply do not fit together.

One of the processes in constructing timber framed walls is the marking of the wall plates to indicate the position the studs are to be fitted. The wall plates are the horizontal timbers at the top and bottom of a timber framed wall. This wall plate marking includes the studs at the sides of openings such as doors. To calculate the required width of the opening for a door you will need to know the width of the door to be fitted and the thickness of the material to be used for a door jamb. Timber framed walls to be clad in plasterboard or timber lining will normally have architraves fitted over the junction of the door jamb to the wall sheeting. Kram© walls (see page 120) will have render come up to the sides of the door jamb, thereby covering the junction of the door jamb to the frame. For conventional wall lining the door jamb would normally be 19 mm thick while for Kram walls it will be 35 or 45 mm thick. See Figure 6.2 for calculations of opening widths for doors and windows.

	Actual door width	for example, 820 mm
+	Thickness of door jamb × 2	for example, 38 mm
	Clearance between jamb and frame	for example, 20 mm
	Total opening width	878 mm
Rounded up to		880 mm

This calculation will need to be made for each door width in the house.

When building a timber frame to receive a window, the opening width is equal to the overall width of the window plus 20 mm to allow for manoeuvring of the window during installation.

Figure 6.2 Calculations to establish the opening size required for a door or a window in a wall frame

1. Mark the floor to show the wall positions

Mark on the floor of the house where the walls are to eventually stand. The most common timber width for timber framed walls is 90 mm so mark two lines on the floor of the house to indicate the outer edges of both sides of the wall. Measure from the outside of the floor to the required position on the floor for the wall and mark it with a carpenter's pencil. Put a mark on the floor representing each end of the wall. This mark should be made up of two arrows with the angular part of the arrows joining (see Figure 6.3).

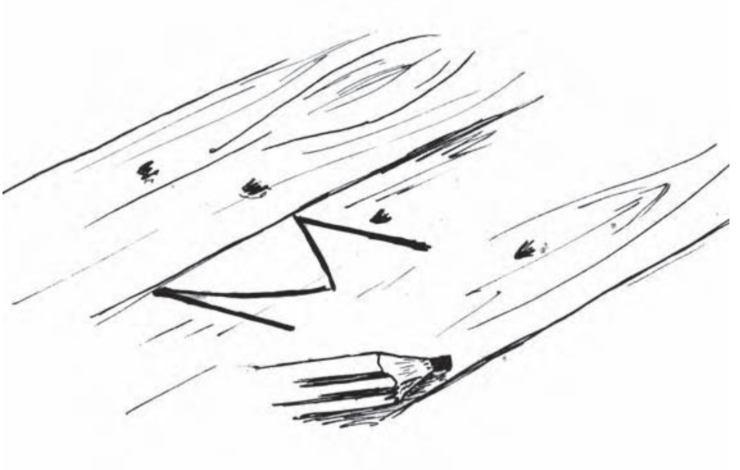


Figure 6.3 Pencil markings on the floor to indicate the position of the bottom of a timber framed wall

The peaks of the arrows drawn are to represent the outside face of the wall. A pair of arrows will represent each side of the wall, one at either end of the wall. These marks could be less than a metre apart or over 20 metres apart. The two arrows need to be joined by a straight line to represent the position of the wall in its entire length.

Marking the wall location
Mark straight lines on the floor to show the location of walls. This is best done using a chalk line, which can be purchased from any good hardware store. A chalk line is made up of a case, either plastic or metal, marking chalk and a string. The string is wound up inside the casing containing the marking chalk. As the string, or chalk line is pulled out of its carriage it is loaded with the chalk inside the unit. Extend sufficient string from the unit to reach from one mark to the other. If you are working alone, hammer a nail into one of the markings and loop the loose end of the string over the nail. Pull the string very tight between and over the markings. While holding the string taut, reach out along the chalk line towards the other with your other hand and take hold of the string. Lift the string off the surface of the floor in a vertical motion. When the string is let go it will spring back against the floor thereby dislodging the chalk onto the floor. It is important that the string be lifted vertically, as when it is lifted to one side it will mark the floor as an arc rather than a straight line. Mark the floor for the positions of ALL of the walls to be built in the house.

Mark the internal edge of the side rail of the bottom boxing on the floor, as the internal line of the outside wall. This will determine the length of the walls to be built within the house. The internal line for the bottom boxing will be 450 mm from the top outer edge of the floor, as the bottom boxing is 450 mm wide.

2. Cut the wall plates to match the markings on the floor
In this process the top and bottom wall plates will be cut to length and positioned on the floor one on top of the other. This will be done for all the walls of the house.

It is imperative that the walls are not bowed away from the lines marked on the floor once the walls are standing in position. Timber will often have a bow in it and so these bows and twists must be overcome. If the timber used as the bottom plate is bowed it is not too difficult to hold it straight once it has been forced into position, as it will have a number of nails through it into the floor. This is not the case for the top plate as it is in mid-air. The only means of holding it straight is to fit temporary braces from the top plate down to the floor holding it in the correct position. Consequently, it is wise to use the straightest timber available for top plates rather than bottom plates.

Refer to the material list
When the material list was prepared for material purchase, details of the position of various lengths of timber should have been recorded on a copy of the floor plan. Refer to this detail to determine what length timbers are to be positioned in what areas of the house for wall plates. Position the timber roughly into position on the floor emulating the details from the floor plate layout plan. It may be necessary to cut one end of the timber to ensure that it is square and free of cracks before positioning it on the floor. Start laying the wall plates from one side of the building. It is best to start on the side of the building with the greater number of walls. This will most likely be the area that includes the bathroom, toilet and laundry. All of the material for the top plates will be laid prior to cutting in the bottom plate timber.

Once all the walls are built and standing in position, you will have to ensure that the top of the wall is straight. If this is not done, you may well end up with a bow in the top of the wall, which would be unsightly to say the least. It is easy to hold bowed timber in a straight line when it is resting on the floor, as it will be nailed to the floor at regular intervals. It is not so easy to straighten timber two and a half metres in the air. For this reason, I recommend you cut the top wall plates into position before the bottom wall plates, as this process will result in the better timber being used at the top of the walls.

One by one choose the straightest timber for the wall concerned and position it between the lines designating the wall position. The end of the timber that is square and free of cracks will be positioned lengthwise, overhanging the chalk line representing the internal position of the outside wall (inside of the bottom bale boxing) by 120 mm. This will enable the top plate to be fixed to the internal face of the top boxing once the bale walls are built. If you have a timber floor use two 75 mm bullet head nails to skew nail the wall plate to the floor. Put one nail at each end of the wall plate. Standard bullet head nails are ideal as they will later be removed and it is unlikely that the head will pull off during removal. Next we need to cut the wall plate to the correct length.

Beneath the other end of the wall plate there will be a chalk line on the floor representing the position of the intersecting wall. Transfer a line from the floor to the top of the wall plate representing the position of the intersecting wall. Use a square to mark across the width of the wall plate and then cut the wall plate at the desired length. When cutting the top plates it is important that the top plates are only joined at the intersection of a right-angle wall (see Figure 6.4). Continue this process for all of the walls for the complete house. You will find it a lot simpler if you first fit all the walls at right angles to the external wall. When this is done the next wall that is parallel to the outside wall can be laid across the ends of the other wall plates that have already been cut to length.

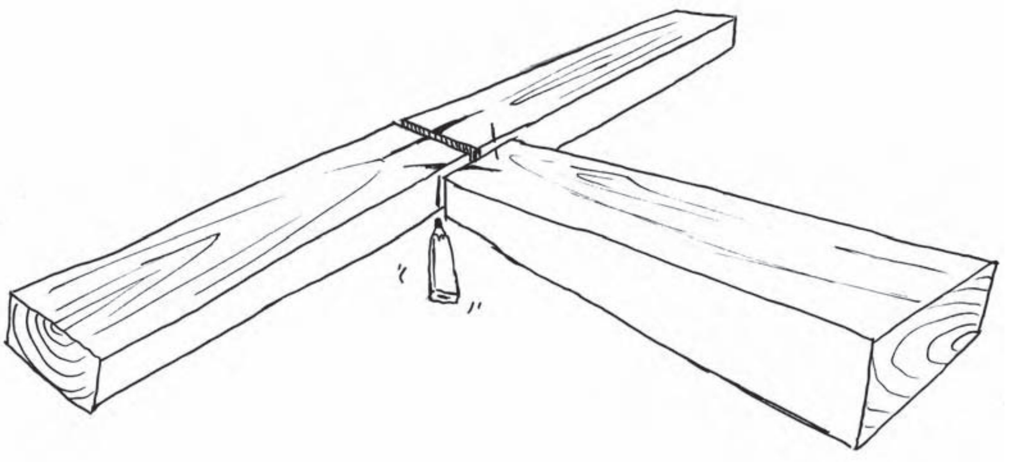


Figure 6.4 Marking the junction of three timber-framed walls

3. Marking the top wall plates

The walls will be assembled lying flat on the floor with the bottom plate close to its final fixed position. As I am sure you can imagine, this would be difficult to do with all the wall plates for the complete house still positioned on the floor so they must be removed. As the walls are built, you will bring each pair of wall plates back onto the floor for assembly. Prior to removing the wall plates from the floor, we need to mark them to assist in their correct relocation when they are brought back for assembly.

Mark the top of the top wall plates with direction arrows
Mark the top of the wall plate with the direction that the wall plate is facing. Some people will refer to the north and east while others might refer to the road and a tree. The term of reference is irrelevant, as long as it is consistent. Draw an arrow on the top of the wall plate and write a 'N' for north near the arrow, or 'E' for east. Mark the top of each wall plate in this manner (see Figure 6.5). Normally these marks would be made roughly in the centre of the wall plate, however if the wall plate is five or six metres long you may wish to put two marks on it. These marks can be done with pencil or a permanent marker, as you do not need fine detail for future reference.

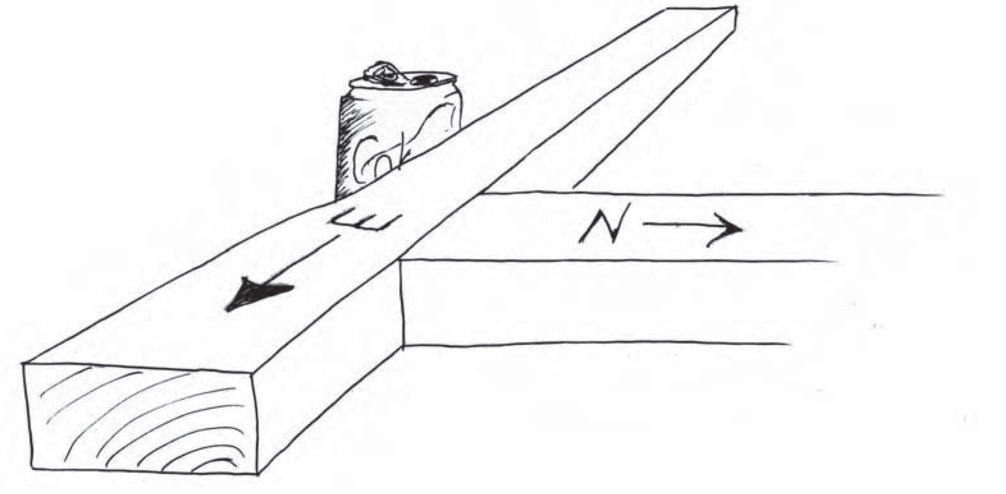


Figure 6.5 Markings to indicate the direction of timber framed walls

It is easy to identify the position of the walls on the surface of the floor as the floor is marked, however, when the walls are standing up in position there is nothing to show the position for the junction of the walls at the top plates. These required marks will take two forms.

Mark the wall junctions
Mark the wall junctions so that when you are joining the walls in the upright position it is easier. First, using a sharp carpenter's pencil draw a line up the side of the wall plate at the junction of the walls on both sides of each wall (see Figure 6.4). Next, hold a ruler or square on top of the top wall plate across the junction of the wall plates and draw a sharp line. If the junction has more than two plates intersecting, draw a line across each intersection. That is the completion of the relocation markings. Once the walls are assembled and in position it may be that the roof or ceiling may be fixed to the top of the walls. If this is the case it will be much easier to mark the position of them while the top plate is on the floor rather than two and a half metres or so in the air.

Mark the top wall plates with window and door positions

Now mark the top wall plates for the position of doors and windows. Most straw bale houses will have the windows fitted into a straw bale wall, however, occasionally it will be necessary to install them into a timber framed wall (see Figure 6.2 for calculations).

Make marks for the window and door openings on the side of the top wall plate, coming from the floor approximately halfway up the face of the timber. The studs at the sides of openings are normally 45 mm thick however it is possible to use 35 mm timber. Speak with your building consultant regarding the limitations and special requirements for installation of 35 mm timber at openings. When marking the studs at the sides of openings draw two lines 45 mm apart designating each side of the door or window stud. Write a 'D' between the two marks that are for doors and a 'W' between the lines for window openings. This will speed the process of construction when assembling the walls.

When the door is at the junction of the wall, think carefully about its final position. Do you want a section of wall behind the door back to the intersecting wall or do you want the door right against the wall? If it is to be right against the wall, will you have a piece of architrave between the door jamb and the intersecting wall or will you use smaller material? For many houses this has not been thought through, which is why you will find houses with 10 to 20 mm of plaster in the corner between the architrave and the adjoining wall. A gap like this is too big to leave raw and difficult to paint. Unless there is a specific reason to do otherwise, mark the position of the door stud nearest to any adjoining walls prior to its partnering stud. As detailed in the calculations above, mark the partnering opening stud with a gap of 880 mm or whatever is appropriate from the inside mark of the first stud. Once the position of both opening studs is marked on the wall plate, write the width of the opening on the upper side of the top plate in bold writing.

4. Cut in the bottom wall plates

Ensure that the joints in the top wall plates have corresponding joints in the bottom wall plates. When cutting in the bottom wall plates it is important that the joins in the bottom wall plates match the joins in the top wall plates. The bottom plates at the junction of the straw bale wall will be set in line with the internal chalk line for the external wall, which represents the inside of the bottom bale boxing. This will enable sections of wall to be built individually. Ideally the bottom wall plates will be made up of full-length timber matching the top wall plates, however it is possible to join them as the joints will be fully supported by the floor. If you are short on timber you can cut the bottom wall plates to the length of the wall less the opening between the studs at the door openings, however this does complicate things a little when fixing the walls to the floor later on.

Temporarily secure the plates together

Temporarily secure the bottom wall plates to the top of the top wall plates. As mentioned previously, it is important that the best timber is used for the top plates and the bowed timber used for the bottom plates. As each section of the bottom plate is cut and placed in position, use two 75 mm bullet head nails to skew nail the bottom plate onto the top plate leaving the head of the nail exposed for later removal. Continually check that the top plate is sitting in the correct position as you cut in the bottom plates. This is not an issue with timber floors, as the top plate is fixed temporarily to the floor. When cutting in the bottom wall plates watch out for the door stud markings. The bottom plate timber between the door studs will be removed once the walls are in position and nailed to the floor. Take note of the door stud markings when cutting in the bottom plates, as you can easily end up with a bottom plate below the door stud of as little as 45 mm (see Figure 6.6). It is not possible to nail through timber this short without it splitting, so this must be avoided. To overcome this, fit what is known as a 'long door stud', which is 45 mm longer than the standard stud length. This will allow the bottom of the stud to rest on the floor. The stud is then secured by nailing it back into the adjoining bottom wall plate (see Figure 6.7). The bottom wall plate will then be cut 45 mm short to accommodate the long door stud. The markings on the wall plates for long door studs will be marked 'DL' between the two marking lines.

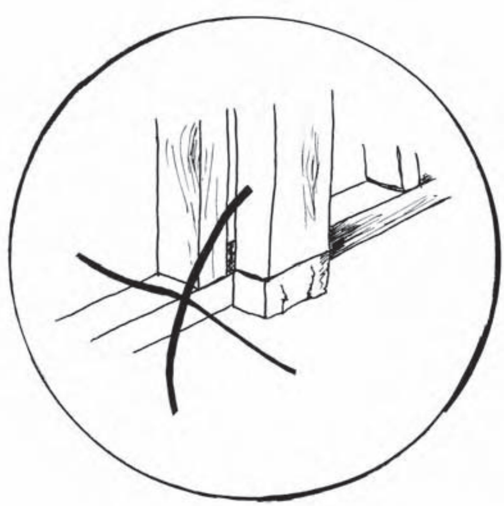


Figure 6.6 Incorrect installation of a short length of bottom wall plate beneath a door stud

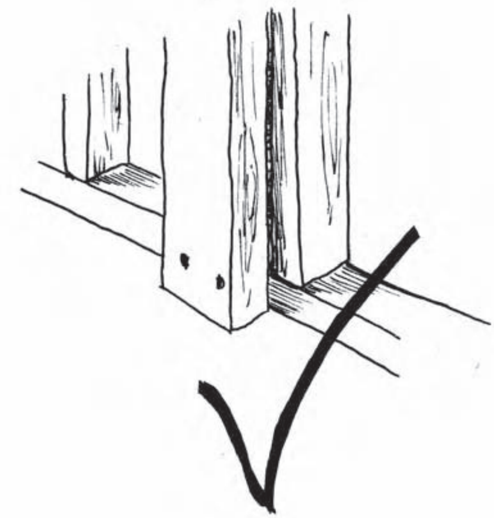


Figure 6.7 Installation of a door stud 45 mm longer than a standard stud to negate the need for a short section of bottom wall plate beneath the stud

Mark the sides of the bottom wall plates with direction arrows

As with the top plates, the bottom plates need to have directional arrows and markings written on them to assist in the relocation of the plates for wall assembly. These markings will be placed on the side of the bottom plates, which will enable you to differentiate between the top and bottom plates (see Figure 6.8). Once all the directional markings have been done, mark the junctions of the wall plates as you did for the top plates. The markings for the door and window openings on the top plates must be transferred to the sides of

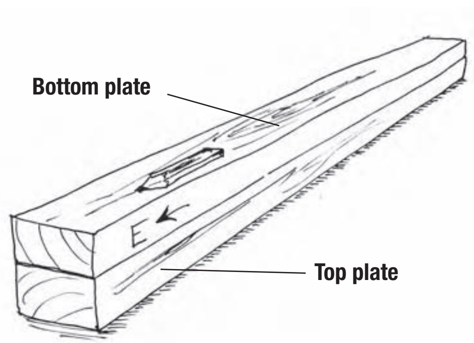


Figure 6.8 Marking the sides of the bottom wall plates to assist in the relocation of the wall onto the floor for assembly

the bottom plates. Place the marks on the upper half of the bottom plate. Again, write a 'D' between the two marks that are for doors and a 'W' between the lines for window openings.

Marking top and bottom wall plates for common and special load bearing studs

Provision for posts and special load bearing studs within a wall frame
On some occasions it is necessary to fit extra studs or even posts within a timber framed wall, normally to carry a concentration of load from the roof. Ask your engineer or building consultant if there are any special supports to be included in your walls. If so, now is the time to mark their position on both the top and bottom wall plates.

Marking the positions of common studs on the wall plates
All of the primary stud positions are now marked on the wall plates so all that is left to do is to mark the positions of the common studs. The common studs at the end of the walls adjoining a straw bale wall are to be kept in from the end of the wall plates to allow for the bales to overhang the bottom boxing. The first stud should be 10 mm in from the end of the bottom plate.

Stud marker gauge for marking common studs
The quickest and easiest way to mark the positions for the rest of the common studs is to make up a stud marker gauge (see Figure 6.9).

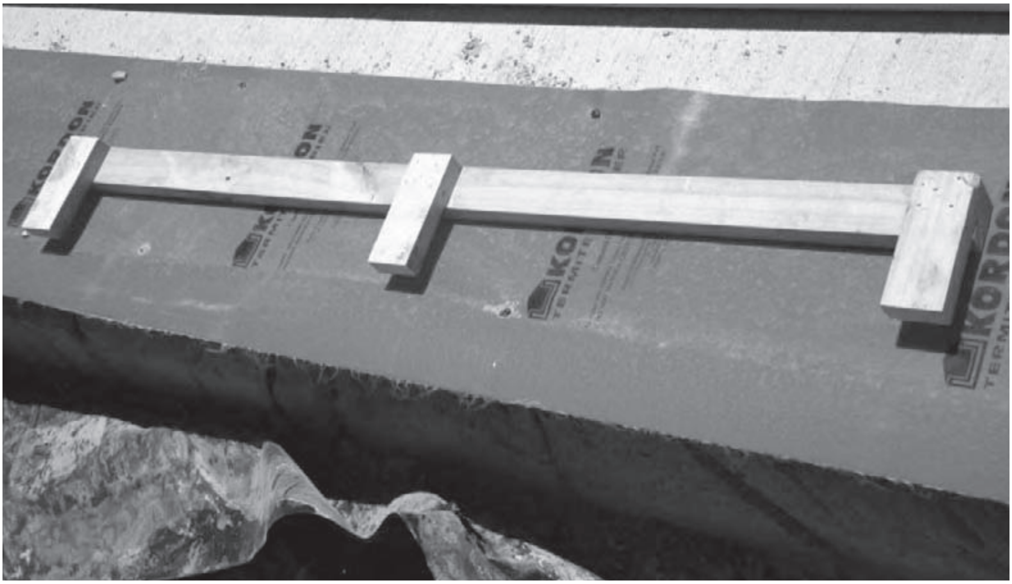


Figure 6.9 Gauge marker for marking the positions of common studs

The legs of the gauge will be the same width as the thickness of the common studs, normally 35 mm wide. The legs will be 90 mm long to enable you to mark the lower edge of the top plate. The distance between the legs of the gauge will correspond with the stud spacing specified in the timber specifications section of your building permit. The two common distances are 450 mm centres or 600 mm centres.

To use the gauge, rest its top rail on top of the bottom plate with the legs of the gauge hanging down across the edges of the top and bottom plate. Mark up each side of the legs with a pencil onto the top and bottom plates. Mark the lower edge of the top plate and the upper edge of the bottom plate. The distance between the legs of the gauge will be the same length that the noggings will later be cut to. It is best to start marking the common studs from one of the existing stud markings or from the junction of the walls. This will reduce the number of special noggings to be cut for the house. In most instances the space between the last two studs marked on the wall will be less than the distance between the markers on the gauge. Draw a squiggly line between these two stud markings on both the top and bottom plate to indicate that a special nogging will have to be cut for this space.

5. Count and cut the studs and noggings

Before counting the number of studs at openings, check the timber specification schedule on your building permit for any special size requirements for your house. If there are none you could safely assume that in Australia the studs at the sides of openings are 90 × 45. Windows will generally require a double stud or posts at each side of the opening, however this will vary with the width of the opening and the load onto the lintel spanning the opening. Check with your building consultant or engineer as to your specific requirements.

Counting studs from markings on the wall plates

First count the door studs and the long door studs. These can be identified by the 'D' and 'DL' markings on the sides of the plates. Next count the number of common studs. You can count the number of standard length noggings from the wall plates, however I would normally cut about the same number of noggings as common studs. Any additional noggings can easily be cut later on.

Establishing the required length of the studs

The length of the stud will be 90 mm less than the overall height of your wall. If roof trusses are being used, a further 20 mm will be deducted to allow for clearance from the top of the walls to the underside of the trusses, which must be clear of the walls. The timber specification section of your building permit will refer to the studs as, for example, 90 × 45 MGP10 pine @ 450 crs. To establish the length of the noggings, deduct the thickness of the common stud from the 450 mm. This will give you a standard nogging length of 415 mm.

Refer to your timber specification sheet to ensure that the timber you intend to cut for studs is correct. When purchasing timber for the noggings I suggest that you purchase this timber in the same lengths as the studs you are purchasing. This will enable you to sort through the timber and cut any bowed or twisted timber into noggings rather than to be forced to use them as studs. It should be noted however that it is not necessary to purchase stress graded timber for noggings. The savings in buying non-structural timber for the noggings over structural will be more than outweighed by the savings on purchasing extra studs to replace those that are too badly twisted to be used.

Assembling a timber framed wall

If walls are not built in the correct order it may not be possible to build all the walls up on the floor. Build the walls in the most congested area of the house first. Remember, when establishing which walls to build first, there needs to be sufficient vacant floor space for the wall to be assembled laying flat on the floor. Remove any wall plates from the floor that will obstruct the assembly of the first wall.

Ready for assembly

Position the top and bottom wall plates on the floor in readiness for assembly. Position them approximately the same distance apart as the length of the studs. With the wall facing the right direction as indicated by the arrow on the wall plates, position the bottom plate on its edge with the stud markings facing up and toward the top plate. When working on a timber floor, pin the bottom wall plate on its edge to the floor with two skew nails. The back edge of the wall plate is to be against the chalk line on the floor so that once the wall is fully assembled the top can simply be lifted up with the bottom plate sitting roughly in its final position.

Placing the studs

Place the studs on the floor correctly positioned at the wall plates ready for assembly. Lay them with one end sitting up on the bottom wall plate; one for each stud marking. Obviously, the door and window studs will be laid on top of the window and door markings. As you sit the timber down, look along the length of the timber to detect any bow in the depth of the timber, and sit it down with the bow facing up. Sideways bow is of little consequence, as this will be forced out of the timber when the noggings are fitted. If this is not done the wall is likely to end up with a wave in it.

Studs with shelving

When building the walls it is important that the studs in walls that are to have shelving or tiles fitted to them are as straight as possible. It is advisable to have a solid flat wall on which to fit tiles, and it much easier to fit the shelving to a straight wall than a wall that is in and out like a roller coaster.

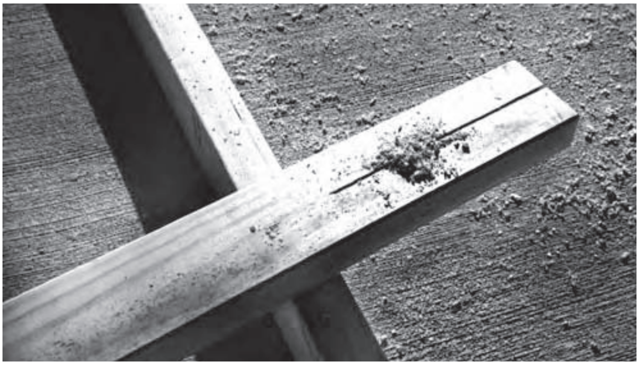


Figure 6.10 Rip cut in the end of a door opening stud in preparation for inserting a lintel

Lintels in timber framed walls over openings

When fitting a window or door into a timber framed wall, or the ground floor for a two-storey house, a lintel may have to be fitted to carry the weight of the structure above. Before these opening studs are fitted make a lengthwise cut into the end of the timber. This is known as ripping the timber. The thickness of the lintel will determine the position of the rip cut. If the lintel is 35 mm thick then the rip will be 35 mm into the stud from the face of the stud including the thickness of the blade (see Figure 6.10).

Walls that enclose a shower base

A precast shower base will be set approximately 15 mm into the wall so that the inside edge of the lip on the shower base is level with the face of the studs. Rip the bottom ends of the studs 20 mm from the face of the stud before they are fitted in the wall. When it comes time to fit the shower base the horizontal cuts can be made in the studs thereby removing the timber to allow the shower base to slip into position. Apart from ripping the studs, cut 30 mm off the bottom plate before the wall is assembled. This cut back should be deep enough to accommodate the shower base with about 15 mm spare so that the shower base can be manoeuvred into position. The shower base will be fitted on a cement based mortar mix which will spew out around the base, thus the reason for the 30 mm recess in the wall to accommodate the lip on the shower base, which is about 15 mm.

Nailing the wall together

You are now ready to start assembling the wall. All components of the wall are to be nailed with two 75 mm nails. Nail the studs to the bottom plate first and then to the top plate. If you are working on a concrete slab you may find it easier to nail the top and bottom of the end studs first and then fix the studs in between.

How to straighten and use twisted studs

It is not uncommon for timber to be twisted, however this does not affect the structural integrity of the timber so it can still be used. Ideally it should be cut into shorter lengths, such as noggings, but if it must be used as a stud there is a simple way to remove the twist during construction. Fix the bottom of the stud to the bottom wall plate. It is essential that the nails are into the centre of the stud and that the nails penetrate the bottom wall plate approximately 15–20 mm in from the edges of the wall plate. This will give good resistance to the twisting action that has to be applied to straighten the stud. If the nails are insufficient to hold against the twisting action you can fit a short block onto the top of the bottom wall plate and fix the stud back into the block as well as nailing through the wall plate. Screw a clamp to the top of the stud (see Figure 6.11). This will enable you to apply pressure to the clamp, using it as a lever to force the twist out of the timber which will then be fixed in the straight position by nailing through the top plate into the stud as detailed below (see Figure 6.12).

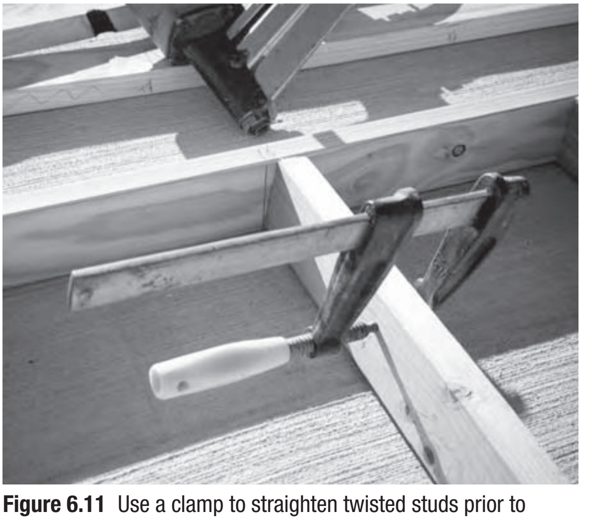


Figure 6.11 Use a clamp to straighten twisted studs prior to installation

Figure 6.12 Fixing a twisted stud into a timber framed wall using a clamp to hold the stud in the correct position

Nailing studs that are to carry a lintel

When nailing studs that are to carry a lintel, avoid nailing into the upper section of the stud that will soon be cut out to accommodate the lintel.

Fitting a door head in a timber framed wall

If the wall has a door in it you will now need to fit the door head and head trimmer. A door head is a piece of timber, normally 90 × 45, that will be fitted horizontally between the door studs onto which wall lining etc. will be fixed over the door. The head trimmer is a short piece of timber that is fitted vertically between the door head and the top plate. The length of the door head was written on the top plate earlier.

	The overall height of the door	for example,	2040
+	Thickness of door jamb (head piece)	for example.	19
	Thickness of floor coverings	for example,	10
	Clearance above and below the door	20	
	Total opening height	2089 rounded up to 2090	

This height is the height from the underside of the door head to the bottom of the bottom wall plate.

Figure 6.13 Calculations to establish the height of the frame door head

Mark the required height of the door head on the door studs and fix it in position, ensuring that it is square to the door studs.

Noggings in timber framed walls

The next task is to fit the noggings. Noggings are to be fixed in the wall at no greater than 1.35 metres from the top of the bottom plate. Walls higher than 2.7 metres will require two noggings. Once the walls are built inevitably you will end up climbing up the wall via the noggings so I suggest that the noggings be fitted 1.3 metres from the top plate. This will make it a little easier to get your leg up onto the nogging. Some people use a chalk line to mark the faces of the studs for the nogging position, whereas I find a nogging stick easier (see Figure 6.14).

Figure 6.14 Marking the studs for the location of noggings using a nog marking stick

The nogging marking stick is made from a piece of 42 × 19 pine with a nail or screw fixed into the stick the distance that the noggings are to be fitted from the underside of the bottom plate. Cut the stick approximately 100 mm longer than the required marking length so that a nail can be inserted without cracking the timber. To use the nogging marking stick, place the stick on top of a stud, and hook the nail of the stick over the bottom plate and draw a line on each stud at the top of the stick. When fitting the noggings they will be fitted alternatively, above and below the line. Do not fit the special length nogging at this time as this will be done once all the walls are standing up and fixed in their final positions.

Figure 6.15 Marking the stud with the depth of the lintel to be fitted

Lintels in timber framed walls

You will now fit the lintel. Lay the lintel over the top of the opening with its top edge in line with the underside of the top plate. Using a sharp pencil, mark the face of the studs at the sides of the opening and move the lintel out of the way (see Figure 6.15).

It is often necessary for the lintel to carry through to the next stud or to have double studs at the openings. Consult with your building consultant as to the requirements of your job and the most appropriate method of approaching this. You will now cut down into the face of the stud on the line to the depth of the rip that was previously cut into the end of the stud (see Figure 6.16). If you are using a circular saw be aware that the piece of timber to come out will probably jam the saw once the cut is complete.

Figure 6.16 Completed checkout in the stud ready for the installation of the lintel

Look along the lintel to determine any bow in the timber and then fit the lintel into the opening with any bow facing to the top of the wall. If the lintel is put in with the bow down, the lintel is likely to continue to bow down when load is put on it, resulting in a dip in the top of the wall. Ensure that the lintel fits snugly into the space and that it is not forcing the top plate away from the top of the studs. Fix the lintel in place using two 75 mm nails through the face of the lintel into the door or window studs. Fix the top plate to the lintel with 75 mm nails, at least one every 600 mm.

Braces for timber framed walls

The final stage in the construction of the wall is fit a wall brace. The wall brace is to be fitted as close as possible to a 45-degree angle up the wall. It is to be set into the face of the wall and be fixed onto the top and bottom plates. Metal angle braces have taken over from timber braces, as they are more cost effective and quicker to fit. Regardless of the material used, if the wall is to be lined with timber or plasterboard, it is important that the brace does not sit proud on the face of the wall, as this will result in a lump in the finished wall.

Ensuring that the wall is square first

Before fitting the brace, ensure that the wall is square. Measure from corner to corner diagonally across the face of the wall and then measure the opposite diagonal. Move the wall on the floor so that the measurements are the same, the wall will then be square, theoretically speaking.

Lay the wall brace on top of the wall and mark its position on the face of each stud to show you where to make the cuts into which it will be fitted. Use a circular saw to make incisions of the correct depth to take the brace. Lay the brace into the cut and fix the bottom of the brace to the bottom plate with connector nails. Tack the top of the brace in place but do not fix it permanently as it is likely that this will need to be changed. Stand the wall up with the bottom plate between the chalk lines marked on the floor but do not fix it to the floor. Use temporary braces to hold the wall up in position.

Fixing completed walls in the upright position

Fixing the top of adjoining walls together

When walls are stood up that are adjoining another wall, the top wall plates of the walls will be joined using a nail plate. A nail plate of about 100 × 50 mm would be appropriate. Ensure that the wall plates are tight down onto the studs at the junction of the walls at both the top and bottom wall plates. Hold the walls in position relative to the junction marks put on the walls earlier and then fix the nail plate across the junction of the two walls. Furthermore, fit two nails through the vertical face of the top wall plate into the adjoining wall (see Figure 6.17).

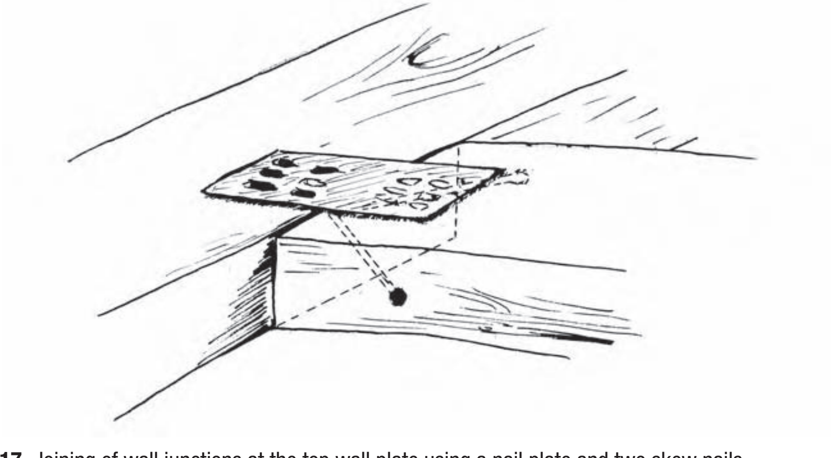


Figure 6.17 Joining of wall junctions at the top wall plate using a nail plate and two skew nails

As each wall is built the braces will be fitted into the wall in the opposite diagonal direction as the neighboring wall. So one wall will have the top end of the brace to the left and the next wall will have the top end of the brace to the right and so on. Walls that are equal to or greater in length than double the height of the wall are to have opposing braces in the wall unless a window or door opening prevents this.

Fixing the walls to the floor and fixing the wall braces

The walls will be fixed to a concrete slab using 75 mm masonry nails whereas the fixing into a timber floor with sheet flooring will be 90 mm nails. You are to fix one nail to the floor between each pair of studs, with an additional nail beside studs at wall openings such as doors and windows. Pay particular attention to the positions of the bottom plates on the floor before fixing them. Position the plate between the chalk lines and set the length by the chalk line for the side of the adjoining wall. Work from one end of the wall to the other, forcing the wall into alignment with the chalk line as you go. When fixing adjoining walls check that the pencil marks put on the plates when marking them are in the correct positions.

Complete the fixing of wall braces while ensuring the wall is plumb

Once all the walls are fixed to the floor you will secure the braces in the walls. Start with the external walls of the house. Using a spirit level held vertically against the corner stud of the adjoining wall, check that the wall is standing dead vertical. If the wall is not vertical, use the level at the other end of the same wall. If the readings at both ends of the wall indicate that the wall is not vertical disconnect the temporary fixing of the brace at the top of the wall and force the wall into a vertical position. This can be done using a long piece of timber as a lever against the top of the wall with its base seated against a bottom plate on the other side of the wall. Press down on the timber so that the its top slides down the stud. Now release the pressure from the timber and it will straighten, thereby pushing the top of the wall away (see Figure 6.18).

Figure 6.18 Force wall frames into a vertical position using 90 × 35 pine

When the wall appears to be vertical, check the other end of the wall. If there is a variance in the readings, and the level is not faulty, you can set the wall as an average between the two readings. Once the wall is vertical fix the brace to all the studs and the top plate. If the external wall of the house is a timber framed wall, set the position of the two end walls and then fix a string line along the outside of the wall as a guide to the positions of the intermediate wall, as the outside wall needs to be straight.

Removing a bow in the top wall plate between adjoining walls
Once all the wall braces are fixed, look along the top of the walls to see if any of the individual walls are bowed. The amount of bow that is acceptable at the top of the wall will depend on the wall lining and personal taste. If the wall needs to be straightened do so with the push brace as previously discussed, and then fix a temporary brace from the top of one of the studs at the centre of the bow to the floor or the bottom of another wall. A good rule of thumb is 'if in doubt, fix it'.

Cutting and installing special length noggings
Now that all the walls are fixed in their permanent position, the special length noggings can be cut and installed. At the wall junctions you will need to install two noggings or blocks in the wall running across the end of the adjoining wall. The stud of the adjoining wall is to then be fixed to these short noggings (see Figure 6.19).

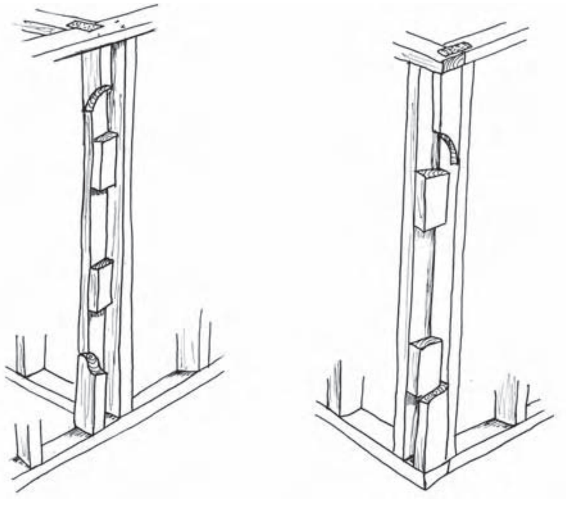


Figure 6.19 Fixing of wall junctions up the length of the stud

Noggings for walls with ceramic wall tiles
If you are fitting ceramic tiles in the shower recess you will need to fit additional noggings between the studs in this area. If you fit a nogging every 400 mm up the stud this will provide a good stable base for the tiles. Once the shower base is fitted a nogging will be fitted at the shower base approximately 5 mm above the lip of the shower.

It is also advisable to fit noggings to support toilet roll holders, towel rails and any mirrors or heavy pictures that are to be hung. Record the position of these noggings as inevitably you will have difficulty remembering where they are. The ideal position for a toilet roll holder is 300 mm forward of the front of the toilet bowl and 750 mm from the floor.

Wall lining options for timber framed walls

Noise and heat control with timber framed walls

It is not at all uncommon for the installation of sound batts in the walls of the master bedroom, or in walls between living areas and children's bedrooms.

The wall lining materials detailed below provide little resistance to noise travel apart from the Kram© walls, which I will explain shortly. The noise issue is of particular concern between toilets and bedrooms or where children's bedrooms share a wall with the parent's room. If these issues concern you and you are planning to use conventional wall linings there are solutions. Insulation batts for both noise and/or heat control can be fitted into the cavity of the timber framed wall. If you are trying to avoid the introduction of formaldehyde into your house you will need to investigate the use of sound and heat insulation batts further.

Lathe and plaster and Kram© walls are the only lining methods I am aware of that provide thermal mass within the house when timber framed walls are installed.

Kram© walls

When I first looked at straw bale construction the primary concern I had was the aesthetic match or mismatch of internal walls to the straw bale walls. In our home in Heathcote I have built what I call a Kram© wall, which finishes at about 150 mm thick. We were initially unsure of what to call this system of wall lining. On thinking through the total process of building the wall it became obvious as to what it should be called.

A Kram© wall is made up of a standard timber framed wall with wire netting fixed to both faces of the wall, with straw filling the cavity between the wire netting. Cramming the cavity between the wire netting with loose straw is, without question, the most tedious and time-consuming part of this process. In an attempt to identify the total wall system it was decided to name it a Kram© wall for obvious reasons.

When building Kram© walls, I use a pneumatic staple gun that fires staples with a 15 mm crown to fix the netting to the wall, however you could fix it with hand nailed staples. If you do not have a heavy gauge staple gun I would recommend that you try to hire one, as to fix the netting by hand will be very slow and frustrating. The wire netting used was 40 mm × 1.4 mm, which is good for all applications for wire netting in a straw bale house. The cavity between the two layers of netting is filled with loose straw, which is compacted firmly into the cavity using a piece of 42 × 19 timber approximately one metre long. The wire netting needs to be stretched tightly across the front of the timber so that you don't get big bulges in the wall as the straw is compacted in the wall. This is easily done using the tensioning tool and the polyester strapping.

Tensioning the wire netting prior to fixing it to the timber framed wall

Cut a piece of timber so that the length is equal to the width of the wire being fitted. A good size for the timber would be 70 × 45 or 90 × 45 pine as this is less likely to split. Hammer nails into the timber in a straight line in positions coinciding with the loops in the wire netting. Tie a length of strapping to the centre of the timber with the nails in it. Fix the wire netting at one end of the wall and extend it the length of the wall to be lined. Position the timber with the nails so that the nails loop through the wire netting. Do not loop it through the last loop of the netting as it will pull through the netting when tension is applied. The tensioning tool will be attached to the polyester strapping fixed to the tensioning timber and to another piece of strapping that is to be tied to the wall beyond the area to be lined. This strapping is then inserted into the tensioning tool and pressure is applied thereby tightening the wire across the wall (see Figure 6.20).

Figure 6.20 Tightening the wire netting across the face of the wall using the compression strap tensioning tool

I found that the wire netting 900 mm wide was ideal for our house, as the ceiling in the area with the Kram© walls is 2.65 metres high. Once the wire netting and straw is in place, the walls will be rendered in the same manner as the straw bale walls. This is not a process for the faint hearted; it is slow and tedious but it certainly has its advantages. The straw used will be from broken and cut bales so there is no additional cost for straw. The wire netting is less than half the cost of the plaster sheeting which is the next cheapest lining method. I am personally satisfied with the level of noise travel through the Kram© walls so there is no need to pay for sound deadening insulation. The thermal mass of the Kram© walls at approximately 30 mm of render on each side of the wall is a great benefit, particularly for homes that are able to take advantage of passive solar heating in winter.

If you want to increase the resistance to noise transfer through a Kram© wall, pack the straw into the wall as tight as possible. If you want to increase the thermal mass, the wall should not be packed too tightly, as a wall with lightly packed straw will permit the render to penetrate deep into the wall resulting in approximately 150 mm of render, thus increasing the thermal mass.

Timber panelling

Any of the wall linings from conventional building systems can be used to line the face of the timber framed walls. If you choose to use timber lining be aware that the cost will vary enormously between common and exotic timbers. If you opt for timber lining and want to keep the cost down I would recommend the use of a downgrade pine lining known as 'merch. pine lining'. I have used this on many occasions with great success. The difference between select grade and merch is that it will have more knot holes and may have some saw marks on one face of the timber. You will certainly discard more of this timber than the higher quality material, but it still works out much cheaper. You can glue or nail an offcut behind the knotholes so that the hole does not go through to the cavity of the wall. The smaller holes can be filled and are hardly noticeable. The material with the larger knotholes can be fitted inside cupboards and under stairs, generally in places where the knotholes will not be noticed.

Hessian and paper

In the past, timber framed walls have been lined with hessian (a coarsely woven fabric), onto which sheets of paper are glued like a huge papier mâché, using cooked flour glue. With this method it is quite simple, if not automatic, that the wall will have small undulations rather than to be dead flat, as with plasterboard. If you want to have a wall that blends a little more with the appearance of the straw bale wall this could be worth considering, although it will be quite time consuming.

Lathe and plaster

The old method of lathe and plaster will give a rendered finish to match the straw bale walls, however the cost of the timber lathe will be prohibitive unless you have access to waste material free of charge. With this method, strips of timber approximately 6 to 10 mm thick are nailed to the face of the wall. Lime render is then applied to the lathe in three separate layers, allowing the render to dry between each coat.

Plasterboard

There is also the conventional system of plasterboard that is used in the majority of brick veneer and weatherboard homes. This is without a doubt the quickest to apply and will result in a dead flat surface with sharp square corners. I have seen these walls where the paint has been applied using a sponge to give it a softer appearance so that it will blend in with the straw bale walls, but I think it is a lost cause. If plasterboard is to be used, I suggest that you take advantage of the flat surface that it creates rather than to try to disguise that which cannot be disguised.

Connection of timber framed walls to straw bale walls

Compression of the walls must be completed first

Compression of the straw bale wall must be completed prior to connecting it to a timber framed wall, otherwise the connection will actually fight against the compression process.

This will result in either the connection being broken or the reduction of the compression of the bales adjoining the fixing.

If the internal walls are to be Kram© walls, simply extend the wire netting that is attached to the face of the studs about 300 mm across the face of the straw bale wall. The wire netting is then pinned to the face of the bales. When the render is applied it is important that the render is worked well into the straw behind the wire netting to provide a solid connection between the walls.

Using a dowel for a timber frame/straw bale wall connection

Timber framed walls that are to be lined with material other than render will be joined to the straw bale wall by one of several methods. One method is to insert a 19 mm dowel through the stud into the bales. Drill a 19 mm hole just above the nogging through the stud and then drive a 19 mm piece of dowel through the hole into the bales behind it. The dowel should be approximately 350 mm long and have one end sharpened to pierce the straw bales. The end of the dowel must then be secured within the stud using either a screw or small nail.

Using polyester strapping for a timber frame/straw bale wall connection

Alternatively, you could use the polyester strapping to hold the bales to the timber wall. Using the single bale needle, thread a piece of twine through the hole drilled in the stud to the outside of the bale wall. Tie the twine to the loose end of the roll of polyester strapping and pull the strapping through the bales. Push the bale needle through the hole once again but this time thread the twine into the needle once the needle is protruding through the outside of the wall. Pull the needle back inside, thereby feeding the twine back through the hole to the inside of the house. Draw the polyester strapping back into the house, thereby creating a loop on the outside of the house.

Insert a piece of timber approximately 42 × 19, 300 mm long, into the loop of strapping on the outside of the wall. Wrap the strapping around the outside of the studs so that extends past three noggings. Join the strapping using a metal buckle (as with compressing the bales) and use the tensioning tool to tighten the strapping. Ensure that the buckle is positioned in the gap between two of the studs, as if it ends up against the face of the stud it will not be possible to fit the wall lining over it. The strapping should be tightened sufficiently to pull the timber on the outside of the wall into the bales until it is flush with the outside, however be careful not to tighten it to the point that it distorts the timber wall. If need be, a few blows with a hammer on the timber in the loop of the strapping will help bed it into the bales.

Using wire netting for a timber frame/straw bale connection

Another method is to fix wire netting approximately 700 mm wide to the back of the stud before the straw bales are laid. This wire netting will then be pinned to the face of the straw bale wall once the bales are installed and compressed. As with the Kram© wall method, it is important that the render be forced through the wire into the bales to provide a good connection. The only disadvantage with this method is that the wire tends to get in the way when laying the bales, however this is a small inconvenience compared to the benefit of what is undoubtedly the most secure of all options.

Using spiked timber pegs for a timber frame/straw bale connection

When assembling the straw bale wall, the timber spiked peg made from 90 × 19 timber approximately 400 mm long is inserted between every second layer of straw bales adjacent to the end of the timber framed wall. Once the straw bales are compressed, screws or nails are inserted through the stud against the straw into the end of the spiked pegs (see Figure 4.22 for details on a spiked peg). I would recommend that noggings between the last and second last stud be fixed at 600 mm centres to add stability to the end of the timber framed wall.

Final preparation of walls prior to lining

When installing the studs, you sighted down the length of the stud and fitted them into the wall with all of the bows in the timber in one direction. If that had not been done the next part of the operations would be significantly more difficult. When plaster or timber lining is fitted to the timber framed wall it is important that all of the studs are in line with one another so that you do not end up with a wavy wall. This is particularly important when fitting plasterboard, as it is quite supple and will easily bend around any high timber and bend into any troughs without difficulty.

The studs are joined to the top and bottom plates, which are now straight, so the greatest variation in the line of the studs is most likely halfway up the height of the wall.

Horizontal wall check

Check horizontally along the wall halfway up the height of the wall for any studs that are bowed out proud of the other studs in the wall. Use an electric planer to trim the high studs back into alignment. Any studs that are low will need a packer fitted to the face of the stud. Good building supply companies have precut masonite packers that are 3 mm thick specifically for this job.

If a stud is badly bowed making a cut in the hollow side of the stud can cripple it, thereby allowing it to be straightened. Make a cut in the hollow side of the stud and hammer a small wedge into the cut as you pull the stud into alignment. Once held in alignment, nail a cleat of stud material approximately one metre long to the side of the stud with the cut in the stud at the centre of the cleat. Check with your building consultant prior to crippling studs for details on how to maintain the structural integrity of the wall once the studs are crippled. If the stud is in a non-structural application, simply nail a piece of timber to each side of the stud to stabilise the cut.

If in doubt as to the implications of a non-structural stud in your wall, contact your building consultant. The other alternative is to simply remove and replace the stud.

7

Ceiling frame construction

The shape of your ceiling is limited only by your imagination, the experience and insight of your engineer or building consultant, and your physical capacity.

The most common ceiling is the flat ceiling, where the height of the ceiling is set by the height of the external walls. However, in a number of older homes false ceilings have been fitted below the original ceiling to reduce heating and cooling costs.

The cathedral ceiling is very popular, as it gives a feeling of space without dramatically increasing the cost of the construction. With a cathedral ceiling, the internal ceiling will normally follow the shape of the external roof with the highest point normally being below the peak of the roof, often in the centre of the house.

Our house in Heathcote has a barn style ceiling in the upstairs area. This ceiling is sloping and follows the roof line from the top of the walls up to a little over three metres high where it meets the flat ceiling covering the balance of the room. Rather than lose the lines of the roof behind dividing walls, we decided to extend the dividing walls 2.3 metres and leave the rooms open to the upper barn style ceiling. This means that the ceiling line is revealed throughout the upstairs area, giving it a free and spacious feel.

Components and method of stick construction for a flat ceiling

Stick construction is just as it sounds. The ceiling is built in position, one piece of timber at a time. The ceiling will be made up of ceiling joists and hanging beams. In some instances ceiling battens may be fitted to the ceiling joists, however this is unnecessary in most cases as the ceiling joists are generally held in an even plane to carry the ceiling lining. When roof trusses are used, it is normal to fit ceiling battens to the underside of the roof trusses.

The ceiling joist is fitted to the top of the walls, both internal and external. When fitting ceiling joists to a straw bale house of infill construction, the ceiling joists will be fitted to the beam around the perimeter of the building (the ring beam) and the internal walls. When a flat ceiling is required, the top of the internal walls must be level with the top of the external. It warrants mentioning that in this form of construction the internal walls supporting the ceiling joists are structural walls, so the use of non-structural timber in this construction would not be permissible.

When constructing a straw bale house where the walls are load bearing, the ceiling joist will be fixed to the top of the top bale boxing. Prior to fitting the ceiling joists, ensure that the top bale boxing has been packed up as necessary to provide a straight and level surface onto which the ceiling joists will be fixed. Refer to Chapter 4 on straw bale wall construction for details on how to straighten the top bale boxing.

Timber specifications for ceiling joists

Refer to the timber specification schedule on your approved plans for details on the timber specified for ceiling joists. The most common size and timber for ceiling joists in Australia is 90 × 35 MGP10 pine. However you will need to refer to the timber specification schedule included in your building permit to ascertain what is actually required for your house. It may be that there are different ceiling joists for different parts of the house. The timber specification sheet will have the material to be used, the dimensions of the material, its strength and the frequency of its installation. It will present something like this:

Ceiling joists   90 × 35 MGP10 pine @ 450 crs

If the ceiling joists vary in size for different areas of the house, the timber specification schedule will give details of the different sizes and hopefully clear details of their location within the house.

Fixing rafters to ceiling joists

Ceiling joists are to be positioned to enable the bottom of the rafters to be fixed to the side of the ceiling joist. It is important that the rafters are fixed to the side of the ceiling joists, as this provides the triangulated strength required for the support of the roof load. Consequently, the final position of the rafters will have to be marked on the top of the external timber prior to installing the ceiling joists. At this point it will be necessary to establish from the timber specification schedule the required spacing of the rafters, and the position of the first rafter, which is called the 'jack rafter'. This will be covered in the next chapter, on roof construction.

When a ceiling joist runs parallel to the outside wall onto which the lower end of the rafter is fitted, the first ceiling joist will be fitted between 450 and 600 mm from the inside of the external wall. Then trimmers, known as jack joists, are fitted from the outside of the wall to the ceiling joist (see Figure 7.1).

The process of installing ceiling joists

To begin fitting the ceiling joists, first locate the appropriate size and length material for each section of the house. Carry the timber around the outside of the house and stand it on its end against the outside wall of the house so that the other end of the ceiling joist protrudes above the top of the wall. Position them around the wall approximately

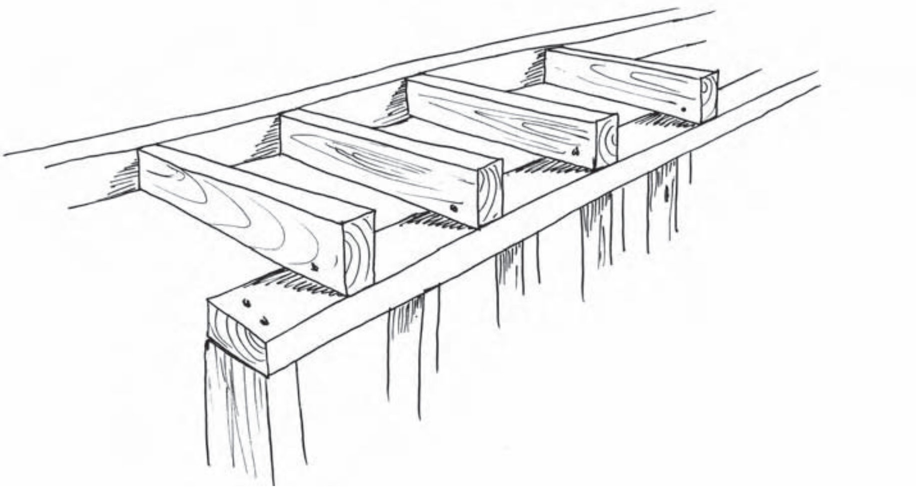


Figure 7.1 Installation of jack joists from the ceiling joist to the top of a parallel wall

adjacent to the position that they are to be fitted. The ceiling joists are now to be lifted into place on top of the walls. The law now requires that once your feet are over 2 metres from the ground, safety hand rails must be fitted. Consequently, you are no longer permitted to walk on top of the walls to pull up the ceiling joists, so this must be done from ladders or a scaffold. When you were marking the top plates of the walls you may have marked them for the position of the rafters, if so, lay the joists at the marks. If you have not yet marked the rafter positions, do so now. Refer to your timber specification schedule for details on the required spacings for the ceiling joists, which should be either the same as the rafters or half that of the rafters.

Bows in ceiling joist timber

As you pull the ceiling joists up onto the top of the wall, look along them to determine any bow in the timber. Lay the joists on top of the wall with all the bows in one direction, as this will speed up the installation process later on. Position the ceiling joist on the internal walls so that the internal end of the ceiling joist hangs past the wall by up to 100 mm.

Cutting the ceiling joists

Once all of the ceiling joists are laying on top of the walls, cut the outer end of the ceiling joist within 50 mm of the outer edge of its fixing point using a circular saw. Again this can be done either from a ladder or scaffold. If your external wall is a load bearing straw bale wall, ensure that you do not cut the compression strapping running over the top boxing.

Nailing the ceiling joists to the top of the walls

Once all of the ceiling joists are cut to length, they can be fitted. Remember to pick up the offcuts of the ceiling joists from the ground around the house before you proceed, as they are notorious for causing twisted ankles. The ceiling joists will be fitted using two skew nails through the side of the timber. The specifications for skew nailing are detailed in

Chapter 3, on timber floor construction. Fix the ceiling joist at the outer wall of the house first, ensuring that the ceiling joist is level with the outside of the timber it is being fitted to. This will mean that the ceiling joist may protrude past the internal wall by as much as 150 mm. Do this along one outside wall only, and then fix the other end of the ceiling joists at the internal wall. The ceiling joists can now be fitted to the opposite external wall in the same manner. When completed you will find that the internal end of the ceiling joist is against a ceiling joist that has already been fixed to the top of the internal wall. This will mean that it is not possible to fix the new ceiling joist with two skew nails, as the existing ceiling joist is in the way. In this instance, first fix the joist to the top plate with a skew nail, and then nail the new ceiling joist to the existing one using a 75 mm nail horizontally from the new joist to the original approximately 20 mm down from the top of the new joist.

Installation of hanging beams

The section drawing of the approved plans will show whether hanging beams are required, as will the timber specification schedule. Refer to the schedule for details on dimension and timber requirements. The hanging beam is positioned on top of and across the ceiling joists. Hanging beams are required when the width of the ceiling is greater than the capacity of the timber to carry the weight of the ceiling. When the hanging beam is fitted across a room from one internal wall to another, the hanging beam will be cut square at each end. When the hanging beam is fixed to an external wall from which the roof is pitched, it will have to be cut at an angle, otherwise the hanging beam will protrude above the roof line.

The traditional method of fitting hanging beams

The traditional method of fixing a hanging beam is to lay it across the ceiling joists in its vertical position. Using a sash clamp, hold the ceiling joists and hanging beam together and then skew nail the beam to the ceiling joist with a 75 mm nail through both sides of the hanger into the ceiling joist. You are required to fix the ceiling joists to the hanging beam using either metal joist straps or timber droppers. A metal joist strap or timber dropper is fixed to the side of the hanging beam in line with the junction of the ceiling joist to enable its fixing into the side of the ceiling joist (see Figure 7.2). The timber droppers could be made of 35 × 35 pine, however the metal joists straps are cheaper and easier to fit.

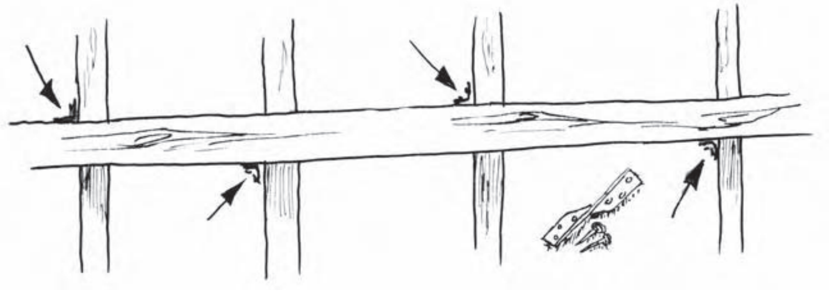


Figure 7.2 Plan view of joist straps at the junction of the hanger and ceiling joists

A quick and safe method of fitting hanging beams

Look along the hanging beam to establish the direction of any bow in the timber. Again, the timber is to be fitted with any bow up; otherwise you will end up with a dip in your ceiling. Draw an arrow on the beam indicating the top of the beam to save any confusion during installation. Lay the hanging beam on its side across the top of the ceiling joists. The beam will eventually be rolled up to its final vertical position, so ensure that the bottom of the beam is correctly positioned so that when rolled up to vertical, the bottom of the hanging beam is in the correct position.

Ensure the ceiling joists are straight and in the correct position

Before nailing the hanger to the ceiling joists, ensure that the ceiling joists are straight and that the distance between the ceiling joists complies with the requirements of the timber specification schedule. It will simplify the process of installation if you mark the beam with the positions of the ceiling joist prior to fixing them, rather than struggling with a tape measure at the same time as fixing. With the hanging beam laying on its side across the ceiling joists, fix a 75 mm nail through the side of the hanging beam at its bottom edge into the ceiling joist below. Make sure that the ceiling joist is hard up against the hanging beam, if not it may be necessary use a clamp to hold the two timbers together prior to nailing. The nail is to penetrate the hanging beam approximately 25 mm up from the bottom of the beam on an angle, so that the nail exits the other side of the beam just above the lower corner of the hanger (see Figure 7.3).

It is quite safe to walk on the hanging beam when nailing the hanger to the ceiling joists, as your weight is now distributed across all of the ceiling joists. This is one job that cannot be done from a ladder, as it requires your body weight to press the two timbers together. If you are unable to bring yourself to get up on the beam you could use a clamp on each joist but this would be quite slow. The beam is likely to be at least 190 mm wide, so there is plenty of room to crawl along if you would rather. Do not rely on any individual ceiling joist to carry your load though, as they are not yet stable as individual units.

When all the ceiling joists are fixed to the hanging beam, attach a clamp, ideally a sash clamp about 600 mm or longer, to the top edge of the hanging beam (see Figure 7.4).

Installing the joist straps

The joist straps are to be fitted to alternate sides of the hanging beam. Using one nail in the top of the joist strap, fix every second joist strap to the hanging beam in such a position that it will sit against the side of the ceiling joist once the hanging beam is stood up in its vertical position (see Figure 7.2).

Rolling the beam into position

Using the leverage provided by holding onto the outer end of the clamp, roll the hanging beam up to the vertical position (see Figure 7.4). Fix the joist strap to the ceiling joist with two clouts through the strap into the ceiling joist. Check to see that the ceiling joist has been held against the hanging beam prior to nailing the strap to the ceiling joist, if not, move onto another ceiling joist for the first fixing. Use a sash clamp to pull any ceiling joists back to the hanger if they have separated. Hammer a second clout through the strap into the hanging beam. The beam should now stand in the vertical position. If

Figure 7.3 Angle nailing of the hanger to the ceiling joists

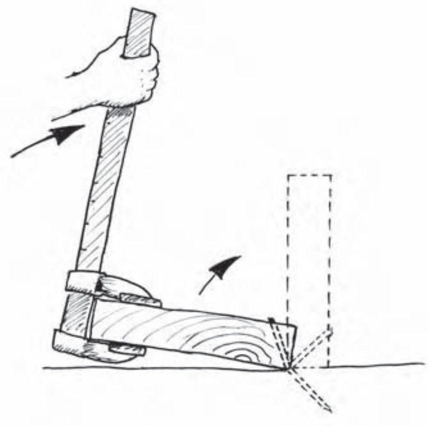


Figure 7.4 Raising the hanger to the vertical position on the ceiling joists

not, simply fix another of the straps adding additional stability to the beam. Complete the installation of the joist straps on each side of the beam fixing two clouts into the beam and the ceiling joist at each junction.

Supporting the upright beam on the wall

The ends of the hanging beam are to be supported onto the walls at each end with blocks to prevent the ceiling from bowing down. The hanger is to be supported on material the same depth as the ceiling joists. Where the hanger is to be supported on an internal wall fix a block of timber to the top plate, and then fix the hanger to the block, ensuring that the hanger is tight down on the block (see Figure 7.5). If the hanger is not directly over a stud, fit a block long enough to span over two studs. Where the end of the hanger has been cut back at an angle to allow for the fall in the roof, the hanger is to be seated on a jack joist, also referred to as a ceiling trimmer. The jack joist is fixed onto the top of the wall and butted against the face of the adjoining ceiling joist (see Figure 7.6).

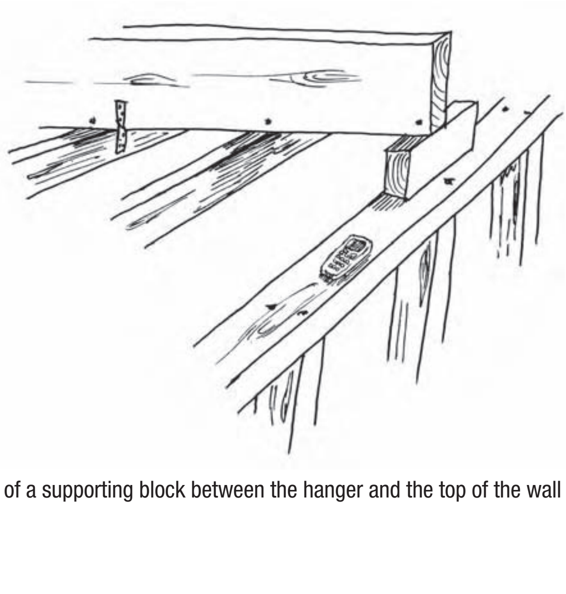


Figure 7.5 Installation of a supporting block between the hanger and the top of the wall

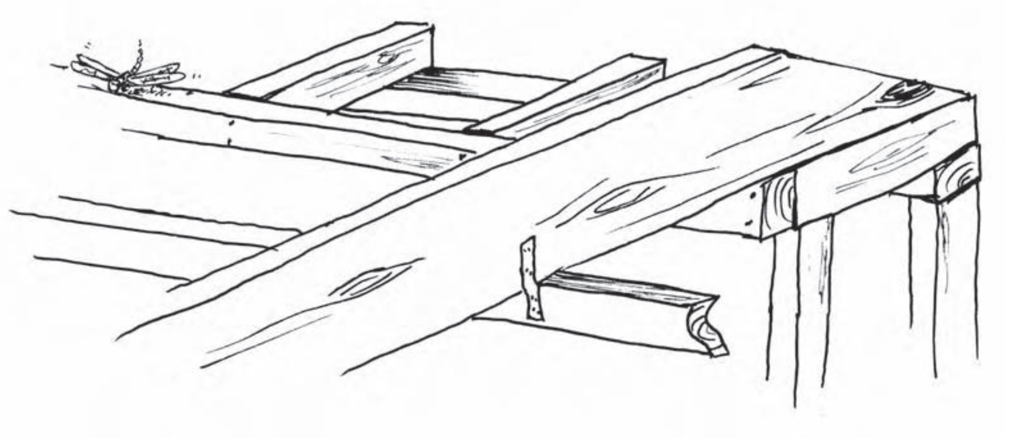


Figure 7.6 Installation of a hanger with an angle cut supported on a jack joist

Once the ceiling trimmer has been fitted under the hanger, the rest of the ceiling trimmers can be fitted, taking note of the marked position for the rafters as the rafters have to be fixed to the side of the trimmers.

Stick framing for a barn style ceiling

The majority of the ceiling in a barn style ceiling will be determined by the position of the rafters. The ceiling lining in the sloping section of the ceiling is fitted either directly onto the underside of the rafters or to ceiling battens which are fitted to the rafters. The flat section of the ceiling is established by fitting ceiling joists at the predetermined height horizontal to the floor. The ceiling joists are fixed to the rafters, normally using 12 or 13 mm bolts (see Figure 7.7).

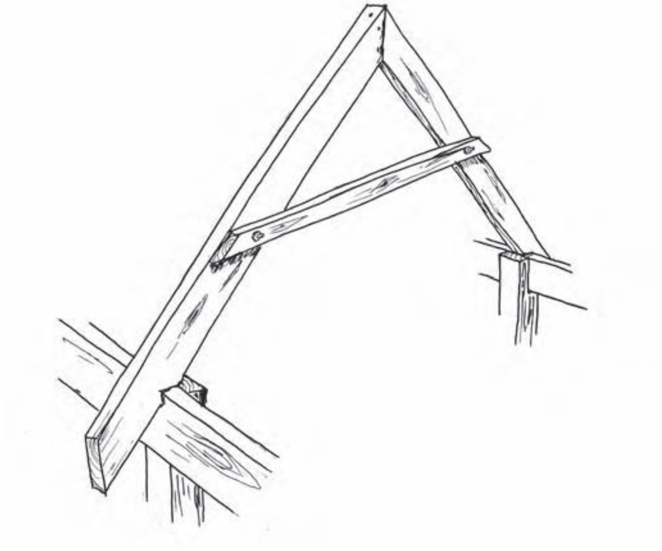


Figure 7.7 Collar tie bolted to the rafters to create a barn shaped ceiling

In this construction system it may be that the ceiling joists also add strength to the roof structure, so it is important that you follow the installation details on the ceiling joists accurately. I shall cover this subject in more detail in the next chapter, on roof construction.

The bottom cord of the roof truss serves as the ceiling joist

If your house has been designed to utilise roof trusses, the bottom cord of the roof truss serves as the ceiling joist. When roof trusses are used it is normal to fit ceiling battens below the trusses onto which the ceiling lining is fitted. It is common for the roof trusses to be fitted at 900 mm centres or 1.2 metre centres. The maximum spacing for ceiling supports for most ceilings is 600 mm. The installation of ceiling battens overcomes this issue. The ceiling battens are also useful for levelling the underside of the roof trusses to provide you with a flat, even surface for the installation of the ceiling. Roof trusses are generally designed to transfer the entire roof and ceiling load to the outside walls of the house. This means that the internal walls are non-structural so you should be able to utilise lower cost non-structural timber for their construction. In order that the weight is transferred to the outside walls, the finished height of the internal walls will be approximately 35 mm lower than that of the external walls. The installation of ceiling battens will take up the difference in the height of the walls for the installation of wall and ceiling lining.

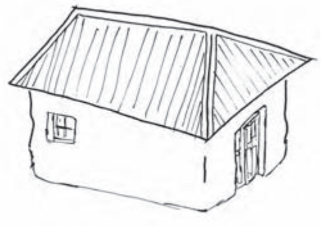
Details on the installation of the trusses will be covered in the next chapter, on roof construction.

8

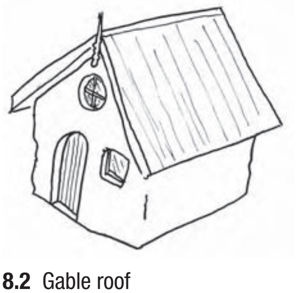
Roof frame

Roof shapes

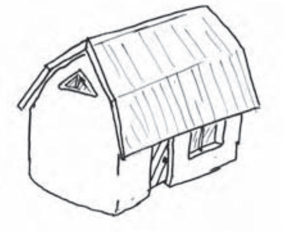
The main roof shapes would be the flat roof, dome roof, hip roof, gable roof and skillion roof. The surface of the hip roof slopes down to external walls at the end as well as the sides of the building (see Figure 8.1), whereas the gable roof will have a vertical wall that runs up to the underside of the rafters to the peak of the roof as an extension of the wall below (see Figure 8.2). Any building may have a combination of gables and hips, which are then referred to as a gable end or a hip end. The barn style roof has a gable roof, as it has a vertical wall extending the lower wall up to the underside of the rafters (see Figure 8.3). The distinctive thing about a barn style roof is the change of pitch of the rafter to give the broken line up the roof. The flat roof and dome roof are self-explanatory. The Dutch gable roof is shown in Figure 8.4. The skillion roof, also referred to as a shed roof, is a roof on one plane from the top to the bottom. It is basically like a flat roof only it has a steeper grade on it (see Figure 8.5).



8.1 Hip roof



8.2 Gable roof



8.3 Barn style roof

8.4 Dutch gable

8.5 Skillion or shed roof

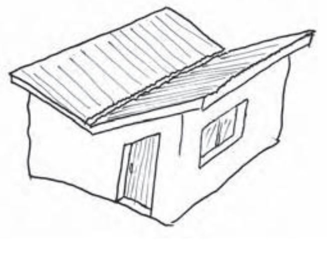
You can have any shape roof

The shape of the roof is limited only by your imagination and budget. I am yet to find a roof that cannot be built. In 1956 my father built a large house in Numurkah, Victoria. The carpenter told him that the roof could not be built, as there were offset angles combined with varying building widths. My father, being a man of solutions rather than problems, soon worked out an unconventional method of construction that has proven the test of time as it still stands strong today. The secret of success in roofing for owner-builders is to have a building consultant who is well versed in traditional roof construction but is also able to think laterally.

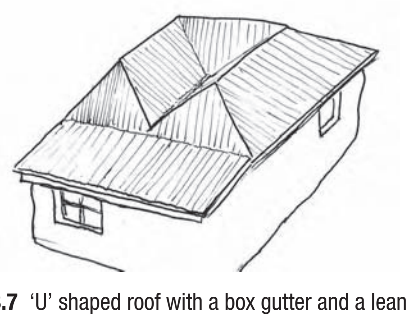
Roofs with box gutters

We have recently seen a renewed interest in the roof style shaped like a butterfly that was all the go in the sixties. This roof style has gable ends with the wall extending up to the underside of the rafters, however, rather than the roof to be lower at the outside walls, the roof is elevated at the external walls and lower at the junction of the two roof lines (see Figure 8.6). This can look quite striking on the right house, however considerable care must be taken to ensure that the box gutter at the junction of the two roofs is large enough to carry the largest of downpours of rain and hail. Hail and leaves play havoc with these roofs, as they interrupt the flow of water, which is then unable to be discharged from the roof. The consequences can be quite devastating as when this occurs the only route left for the water is to flow over the box gutter and into the house.

Many of the houses built at the turn of the century had a box gutter running down the centre of the building surrounded by traditional roofing with a high ridge in a 'U' shape around the box gutter (see Figure 8.7). In a high percentage of these houses a lean-to extension was added to the back of the house as the family's need for a larger house



8.6 Butterfly roof



8.7 'U' shaped roof with a box gutter and a lean-to extension arose with the arrival of more children (see Figure 8.7). This lean-to's roof, added onto the existing house, is referred to as a skillion roof.

The direction of forces applied by the roof load

The forces applied to buildings are classified as either live loads or dead loads. The dead load is the weight of the building itself while the live load includes all other weights and pressures applied to the building. The live loads would include things such as rain, snow, wind, earth tremors, furniture and people. The dead load is stagnant but cannot be ignored, as added pressure is bought to bear on the building by the live load, which compounds the effect of the dead load. The load applied to a building will ultimately be transferred to the foundation or ground beneath the building in one way or another. A well-built structure will pass the force applied by the total load on the house through the structure of the house to the ground without compromising the stability of the structure. If, however, the structure has insufficient strength to allow the load to be passed through it, both the load of the building and the load on the building will demolish it, ultimately transferring the force to the earth.

Roofs can cause walls to collapse

A badly constructed roof will cause the walls below to collapse. The roof is crucial, as the force applied to a badly constructed roof will quickly destroy the roof and walls below. When the load is applied to the roof, there is a natural tendency for the peak of the roof to drop, thereby forcing the bottom of the rafters to spread. If the top of the opposing rafters were not fixed together, they would slip past each other, resulting in the peak of the roof dropping. However, the rafters have to be joined for there to be strength in the roof. When the rafters are joined at the ridge but unsupported the transfer of the load will still be lateral, however it will be expressed by forcing the external walls outward, thereby causing them to collapse, as they are constructed to transfer weigh vertically to the foundation, not to resist lateral force and transfer the load to the foundation (see Figure 8.8). This must be kept in mind at all times when assembling the roof, for the weight of the timber alone is sufficient to spread the external walls.

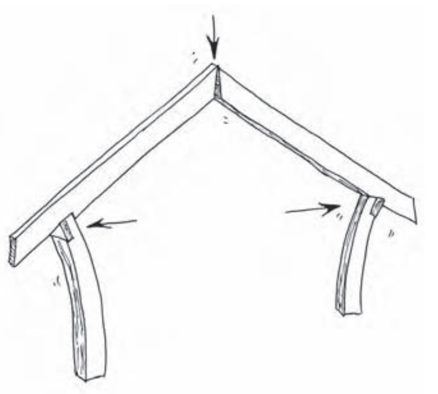


Figure 8.8 Roof loads on an incorrectly constructed roof will cause the walls to spread and the building to collapse

If the walls were built with a triangular strut or wall section extending out from the top of the wall onto the ground, the load would be transferred through the vertical wall and the angular strut to the earth (see Figure 8.9). You will often see walls like this in old churches.

Apart from providing the wall with external triangulated struts there are two ways to overcome the spreading expression of load transfer. By supporting the ridge beam the top

Figure 8.9 A church in Bendigo, Victoria, with buttresses that appear like wings along the outside of the walls to resist the outward pressure of the roof from spreading the walls

of the rafters are unable to drop, and so the load is transferred vertically into the outside wall and into the ridge beam, which transfers it to the post supporting the beam and down through the floor to the earth below (see Figure 8.10). Tying the bottom of the rafters together will negate the lateral pressure thereby preventing the destructive spreading motion (see Figure 8.11).

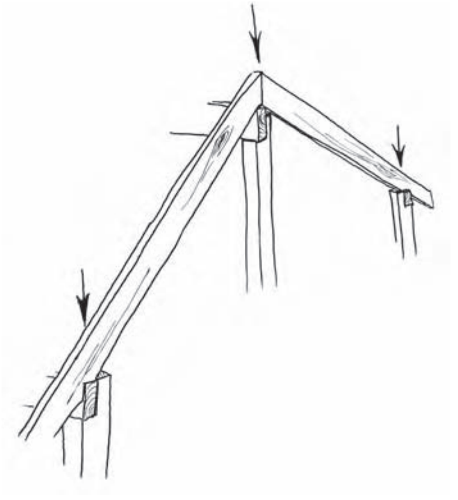


Figure 8.10 Rafters supported by a load bearing central ridge beam held up by posts, and by pitching beams on posts at the outside walls

Figure 8.11 Rafters supported only at the external walls with the addition of a ceiling joist to prevent spreading of the bottom of the rafters

Roof construction

There are two methods of constructing a roof on a straw bale house. The most common today uses prefabricated roof trusses. The other alternative and original method is what is known as stick framing, where the roof is constructed by cutting and assembling individual pieces of timber to form the roof. To some degree this is a dying art, with many of the newly trained carpenters having little knowledge or ability to perform this task. This was never more evident than in recent conversation with a building surveyor.

The building surveyor's story

This is a true story about a building inspector's reservations regarding building stick framed roofs. The pastor of the church we were attending at the time and personal friend had purchased a house that was short on a bedroom. Prior to purchasing the house we had discussions as to the cost of extending the house versus buying a bigger property and it was clear that to extend the house was the most cost effective alternative. The house was close to the church, and with the addition of a bedroom and ensuite, offered everything they needed. They decided on an appropriate design for the extension and I set about establishing an estimate for the cost of materials. To construct the roof and ceiling by stick frame method was the cheaper alternative without compromising the design. The plans were drawn up and submitted to the building surveyor for a building approval.

Not long after the plans were submitted, my friend rang me to say that the building surveyor was having difficulty approving the plans, because he was unsure of how the roof was going to be constructed as it was not a truss roof. Some time into the conversation the inspector inquired as to the age of the person building the roof. When he was told that I was about fifty years old he became a little more relaxed about the situation, stating that given my age it was likely that I might know how to build a stick frame roof.

Within the hour I had a phone call from the inspector asking how I would go about the construction of the roof. The primary concern he had was that there were several sections of the roof that had to be supported, but there was no wall below them on which to transfer the weight. I explained to him that I would use what is known as a barrap on each of the hips and possibly a scissors prop. He then felt even more comfortable with the project and agreed to issue the permit on the basis of the information supplied. While he at first appeared to be happy with the outcome of our conversation it was obvious he was still a little concerned, as his parting comment was that I should read the instructions on the box carefully before I fitted the barraps.

I think my response was something to the effect that if I had $10 for every barrap I had fitted Jan and I would have a lovely holiday. Anyway, all was well with the inspector and the building permit was issued the next day.

Once the walls and basic roof structure were assembled, it was time to measure and order the barraps. They were not available locally so we organised for them to be picked up in Melbourne. It wasn't until after the barraps were fitted when we were re-living the discussions with the building inspector that it dawned on us that in fact there were no instructions on the box. Obviously the manufacturers have more confidence in the ability of tradespeople than the inspectors. This is by no means a slight against the building inspector as he was merely responding to the situation with his understanding of the normal skill level of today's tradespeople.

Stick framing a roof is still a viable option

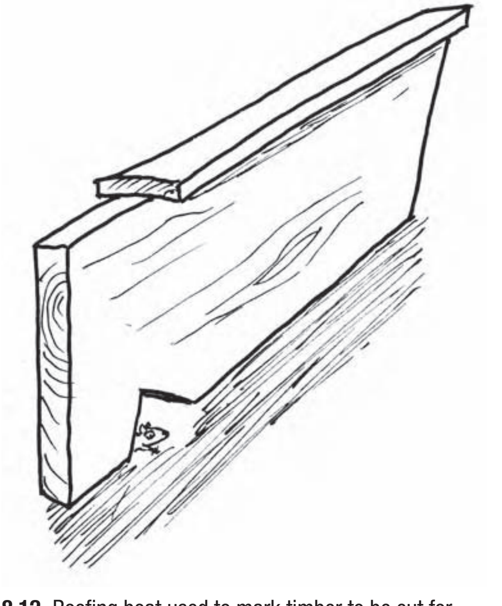
If you are considering stick framing of your roof do not be swayed by the public opinion that this is no longer realistic. All building is extremely rational. It is all about cause and effect. If weight is applied to the top of a roof it must be transferred to the foundations. It is simply a matter of having a consultant who understands the structural issues associated with general building and can advise you, and is available to answer your questions as you go about the process. Do not be daunted by the total job. The timber specification schedule will give you details of what size timber is to be used where and your consultant will help you work out the angles the timber is to be cut at, and how to fix it in place. The rest is simply one cut and one nail at a time. This reminds me of the old riddle, 'How do you eat an elephant?': the answer is simple – 'One mouthful at a time.' Although you might need a big freezer to keep it in until you get to the last mouthful, I guess your building consultant could be compared to a freezer, but I trust that you can find a consultant with a little personality and warmth rather than a cold fish, or elephant should I say.

Stick framed roofs

Template for cutting rafters

The template will give you a pattern for the top and bottom cuts required for rafters. When the rafters are supported at the top by a beam or wall, you may choose to rest the rafters on the beam with the rafters from opposite sides of the building fixed beside each other rather than butt join them together. If this is the case you will not need the pattern for the top cuts on the rafters, however, as you will soon discover, the angle of this cut is required to establish the bottom cuts or notch for the rafters.

The top of the rafter is to be cut at an angle that allows the rafter to sit evenly onto the face of the ridge beam. This cut is known as the plumb cut. At the bottom of the rafter a 'V' shaped cut will be made to allow the rafter to sit on the outside wall with the tail of the rafter overhanging the wall thereby creating an eave. The bottom cut on the rafter is known as the birdsmouth. Each rafter will have to be marked individually for these cuts so it is best to have a pattern for both cuts. The template for these cuts is known as a roofing boat (see Figure 8.12).



8.12 Roofing boat used to mark timber to be cut for rafters

The pitch of the roof will determine the angle of the plumb cut and birdsmouth.

The pitch of the roof will be expressed on your approved plans as degree. To prepare the roofing boat we will need to know the amount of rise in the roof for every horizontal metre. Let us use a 30-degree pitch as an example. At 30 degrees you will be able to walk on the roof when it is dry, if you are wearing Dunlop volley sneakers; at 33 degrees you will need a roof ladder. Please note: if you are on any roof you must have safety rails around the roof or wear a safety harness to comply with safety regulations.

A roof with a 30-degree pitch

A roof with a 30-degree pitch will have approximately 578 mm of rise for every metre of run, or to put it another way, 57.8 mm vertical lift (see 'B' on Figure 8.13) for every 100 mm of run (see 'A' on Figure 8.13) on the horizontal plane.

Making a roofing boat for a roof with a 30-degree pitch

The timber to make the roofing boat will be approximately 400 mm long, the depth of the rafters and approximately 20 mm thick. An offcut of sheet flooring is ideal. Line 'C' represents the top edge of the roofing boat. Line 'B' represents the plumb cut at the front of the roofing boat (see Figure 8.13).

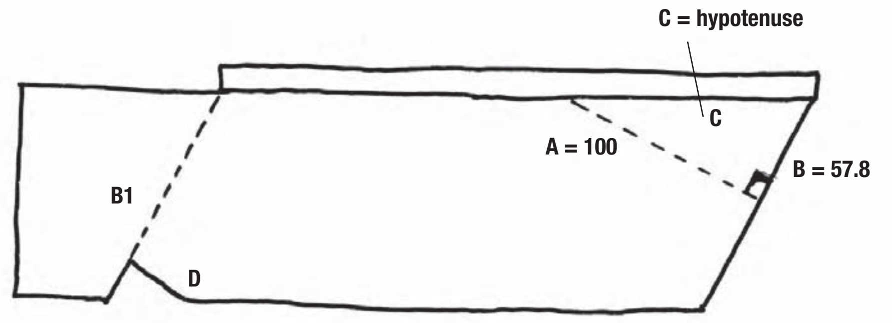


Figure 8.13 Transfer the calculated details to the roofing boat. B1= vertical birdsmouth line. D= Top plate horizontal birdsmouth

Once you have marked line 'B' on the roofing boat for the plumb cut, transpose this line to the other end of the boat, keeping it at least 30 mm from the end of the timber (see Line B1 in Figure 8.13).

The birdsmouth notch is to be not greater than one-third of the depth of the rafter. For example, rafters 150 mm deep would have birdsmouth notches of not greater than 50 mm. Establish the depth of the birdsmouth for your rafters and from this ascertain the depth of timber to be above the birdsmouth. From the top of the roofing boat, mark down line B to the depth equal to the timber to be left in the rafters above the birdsmouth. Mark the point that this depth meets line B1. From this point draw a line toward the front of the roofing boat at right angles to line B1 (see Figure 8.13 for line 'D'). This line represents the section of the rafter that sits on top of the external wall timber.

You now have all the relevant lines on the roofing boat, so carefully cut the plumb cut line and the birdsmouth notch. Measure the distance from the front of the roofing boat, that is, the top of the plumb cut, to line 'B1' where it intersects the top edge of the roofing boat. Cut a piece of timber, ideally flooring, 40–60 mm wide and 20 mm deep equal to the space between the plumb cut and the top of 'B1'. Fix this piece of timber to the top of the roofing boat with the end level with line 'B1' where it intersects the top of the roofing boat, allowing it to overhanging each side of the boat by equal amounts (see Figure 8.13). Further details on how to use the roofing boat are on page 148.

The support of rafters for a stick framed roof

Either your building consultant or engineer will have determined the timber requirements for your roof and they will be detailed in the timber specification schedule of your building permit. Ideally you will also have a detailed drawing of the positions that the rafters are to be fixed, and details of the angle cuts of the rafters.

Stick framed roofs will either have the rafters supported at each end of the rafter, or the rafter will be supported at the outside wall and be fixed to the side of a piece of timber at the peak of the roof called the ridge beam. Rafters supported at each end will rest on either a wall or a beam. More often than not, the rafter will be supported at the outside of the building by the external wall, however, when the building incorporates a verandah the rafter will be supported on a verandah beam supported by verandah posts (see Figure 8.14).

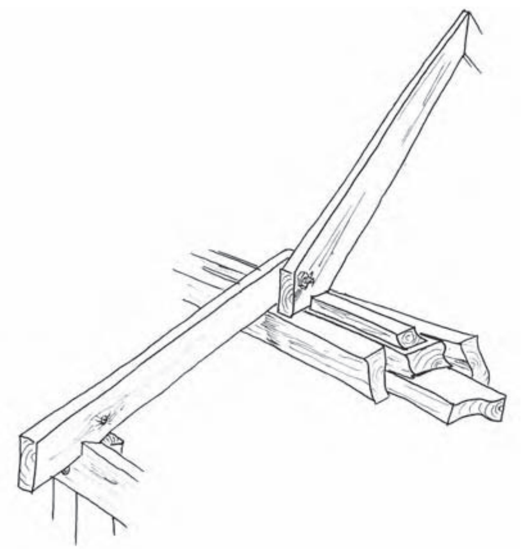


Figure 8.14 Installation of rafters for the main roof and the verandah, coupling them together at the top boxing

For a straw bale house the rafters will either be fitted to the ring beam fixed to the posts around the perimeter of the house, or to the top bale boxing after it has been leveled. Using a carpenter's pencil, mark the positions of the rafters on the top of the external walls as detailed on the roof layout drawing. If the house has a ceiling separate to the rafters, these positions will have already been established prior to the installation of the ceiling joists. In this case the rafters are to be fixed beside the ceiling joists.

Non-coupled roof

When a load bearing ridge beam is to support the rafters it will obviously be necessary to first fit the ridge beam. The size of the beam will be detailed in the timber specification schedule of your building permit. This beam may be supported on posts or be seated on walls. In most instances the beam will be supported on posts.

Once all the supporting posts are securely fixed in place the beam can be fitted to the top of the posts. It may be necessary to cut the beam into the side of the post, bolt it to the side of the post or fix it on top of the post using some kind of bracket or strapping. The specific details for your job should be included as detail drawings which will have been established by your construction designer and/or engineer, and will form part of your building permit. Obviously, you should refer to this information prior to cutting the post. If you are finding it difficult to decipher the specifications do not guess; contact your engineer or building consultant, as this is a crucial part of the structural integrity of the building. If it is done incorrectly you will be forced to pull it down and redo it, even if all the rafters are fitted above it.

The order of installation for a non-coupled roof

With a non-coupled roof the order of installation of the rafters is particularly important, as it is the rafters that will hold the shape and position of the external walls and the ridge beam. Start the process with the rafter at the centre of the ridge beam and work away from that. Complete the installation of each individual rafter before moving on to the next.

Measure the distance from the top outer corner of the external wall to the centre of the top of the ridge beam. This will be the length of the rafters from the birdsmouth notch to the plumb cut of the rafter. If the rafters are to be fitted side by side with the rafter from the opposite side of the building, additional length will be added to the rafter so that the bottom edge of the rafter will extend through to the top edge of its opposing rafter (see Figure 8.15). In some instances it is necessary to cut a birdsmouth notch at the top of the rafter where the rafter sits on the ridge beam.

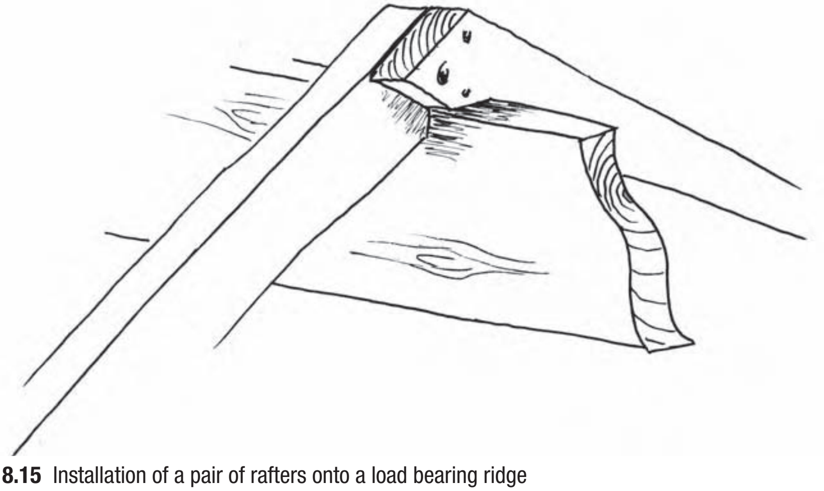


Figure 8.15 Installation of a pair of rafters onto a load bearing ridge

Installing rafters for a non-coupled roof

The bottom rafter is to be skew nailed with one nail from each side of the rafter into the timber at the external wall of the building. Now nail the rafter to the top of the ridge beam with two skew nails. When the rafters from either side of the building are fixed side by side to one another it is not normally necessary to cut a birdsmouth notch at the top end of the rafters, however you will need to check the installation details that form part of your building permit. As with floor joists and ceiling joists, the rafter from the opposing side of the building will have one skew nail into the ridge beam and a second into the partnering rafter from the other side of the building. Check the installation details regarding fixing these two timbers together, as in some instances you may be required to simply fix additional nails into the junction of the two rafters, however it may even be necessary to bolt them together.

When bolting timber together always ensure that the correct size drill bit is used relative to the size of the bolt specified. If the drilled hole is oversize the two timbers may slip back until the bolt takes up tension against the sides of the holes. This would likely cause the external walls to be bowed out. As long as the rafters are fixed well at the top and bottom it is OK to fix all of the rafters on one side of the building and then the other. Do not make the mistake of fixing all the rafters at the bottom on one side of the building and then fix the top at the ridge beam, as this is likely to either bow out the external wall or bow the ridge beam. This subject was dealt with earlier in this chapter regarding the direction of forces on a house resulting from roof loads.

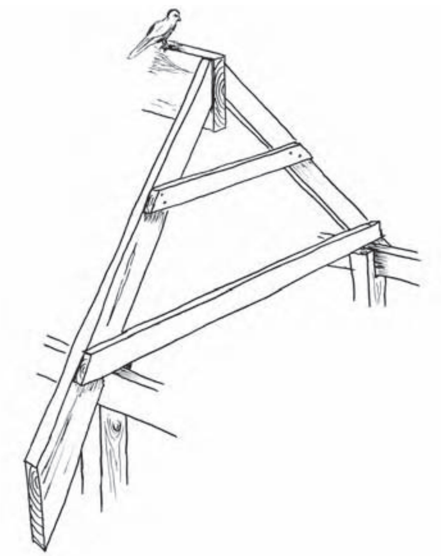


Figure 8.16 Coupled roof with collar tie, ceiling joist and non-load bearing ridge

Coupled roof

A coupled roof is a roof with horizontal members that prevent the bottom of the rafters from spreading (see Figure 8.11). With a coupled roof, the rafters are fixed to the vertical face of the ridge timber, which in this instance in non-structural to the extent that it does not carry the weight of the roof. The roof load is transferred through the complete structure onto the walls, which in turn transfers the load to the earth known as the foundation. Coupled roofs will generally have a second piece of timber parallel to the ceiling joist fixed to the rafters. This timber is known as a collar tie (see Figure 8.16).

If the rafter is capable of carrying the load applied to it for the area of its length from the ridge to the outside wall, the installation of the ceiling joist and collar tie is all that is needed to stabilise the roof. If, however, the rafters are not capable of spanning this distance, further support will be required.

Intermediate support of rafters in a coupled roof with walls below

The intermediate support of rafters in a coupled roof where there are walls below the roof onto which the roof load can be transferred is constructed through an underpurlin. This is a piece of timber that is fixed to the underside of the rafters within the centre third of the length of the rafter. Posts from the underpurlin down onto the top of the walls transfer the roof load onto the walls which transfer the load through the floor and stumps down to the foundation. These posts are known as struts (see Figure 8.17).

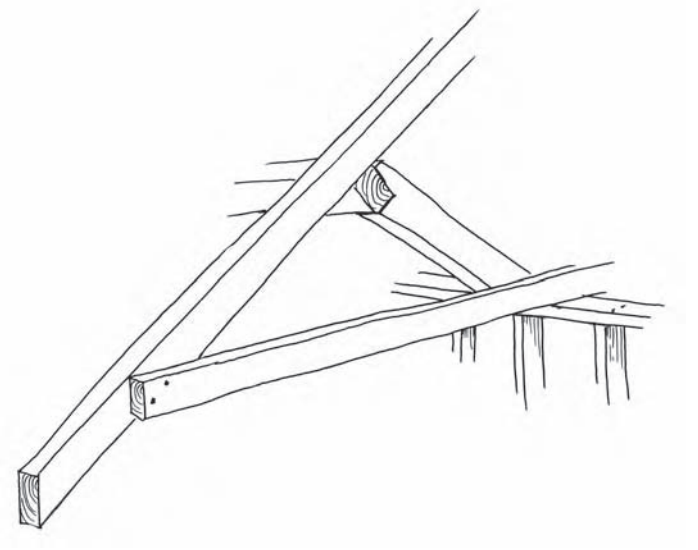


Figure 8.17 Installation of underpurlin and struts to provide mid-span support of rafters

There are several different struts that all have legal requirements for their installation. The perpendicular strut (see Figure 8.18) is to have a minimum bearing of 45 mm onto the underpurlin and is to be fixed at approximately 90 degrees to the rafters. The vertical strut (see Figure 8.19) is to have a minimum bearing onto the underside of the underpurlin of 38 mm.

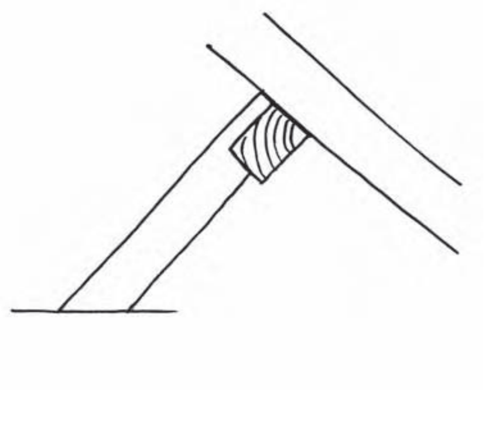


Figure 8.18 Perpendicular strut

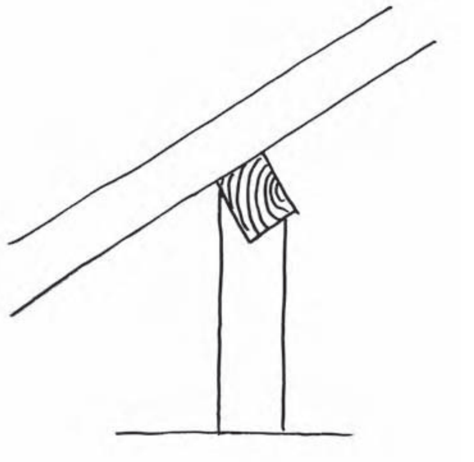


Figure 8.19 Vertical strut

Intermediate support of rafters where there are no walls below

There are three primary methods of supporting the roof where there are no walls below onto which struts can transfer the roof load from the underpurlins. The first is the tie-bolt system, otherwise referred to as a barrap truss. The principle behind the tie-bolt system is that if a fulcrum (a point on which a lever moves) is extended between a fixed immovable object (a steel bar or wire cable) and a bendable timber section (the underpurlin) the timber underpurlin will then be bowed up (see Figure 8.20).

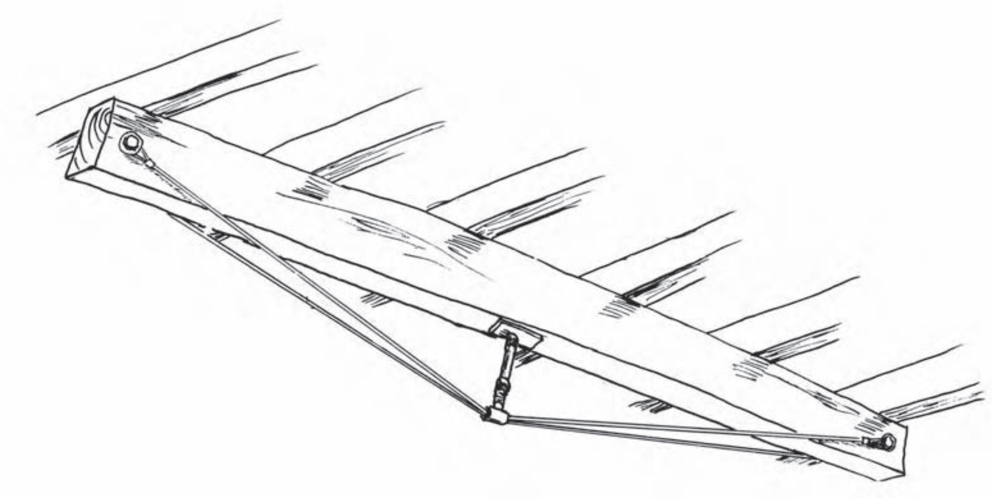


Figure 8.20 Tie-bolt or barrap truss

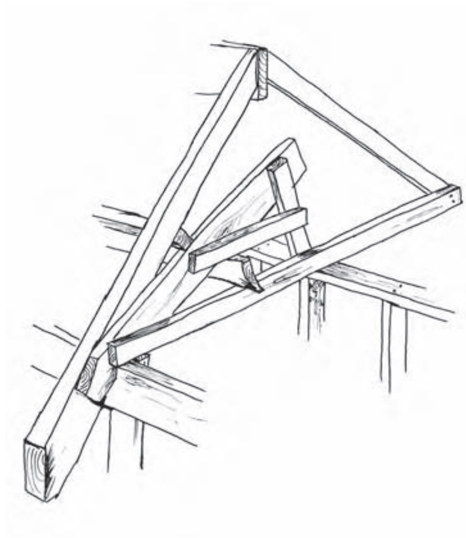
Tie-bolt or barrap truss support system

The original tie-bolt system was made up of a steel rod with thread on each end, a bracket for each end of the steel rod to connect to the ends of the underpurlin. An adjustable fulcrum was fixed to the underside of the underpurlin with the steel rod attached to the other end of the fulcrum. The most popular system is now supplied in a cardboard carton approximately 400 mm square and about 50 mm deep. Rather than a steel rod it now has two steel cables which are attached to each end of the underpurlin with about a 12 mm bolt and two large washers. The steel cables run through a sleeve on the top of the fulcrum.

The ends of the cable are to be fitted approximately 150 mm from a strut at each end of the cable. The adjustable fulcrum is fixed to the underside of the underpurlin mid-span between two struts. It is unwise to order the barraps prior to construction of the roof, as they come in fixed lengths. When ordering them be sure to tell the supplier that the length you are giving them is the length between the two fixing points, not the length of the barrap, or you will be sent a barrap that is about 300 mm too short.

Timber scissor props

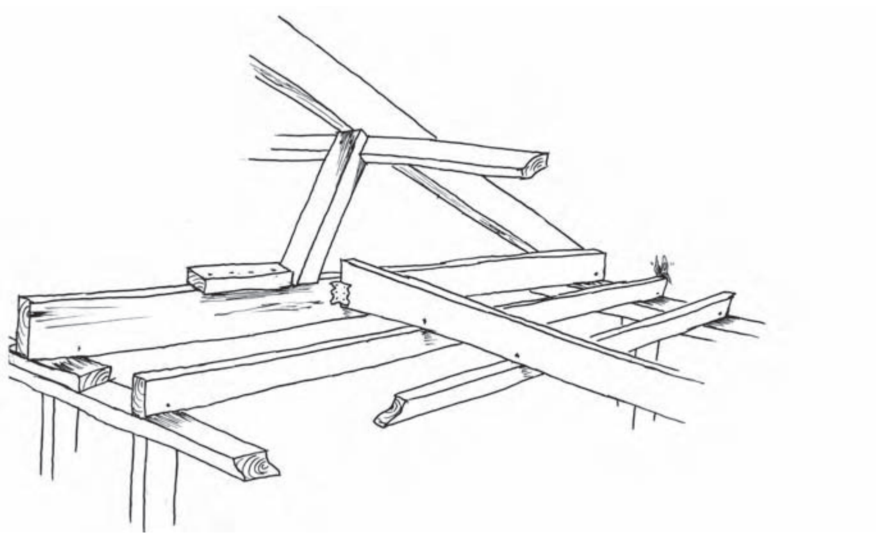
The second method of supporting the underpurlin where it is not possible to install a strut is to build a scissor prop. This is a combination of a beam which runs from the outside wall under the underpurlin extending into the house until it reaches a wall that the roof load can be transferred onto. The internal end of the beam will be elevated into the roof cavity and will be supported by a strut. Two additional pieces of timber are then fixed with bolts to either side of the scissor prop, running from the strut to the external end of the beam (see Figure 8.21). The size of the timber beam will vary with the length of the beam and the roof load to be carried by the beam. While it is theoretically possible to establish the length of the beam prior to construction, I would recommend that you check the length on site prior to purchasing the timber. Once you have measured the length of the beam, contact your engineer or building consultant to confirm that the size specified in the timber specification schedule is correct.



8.21 Scissor prop to support the underpurlin in the absence of a wall onto which a strut could be fitted

Strutting beam

The third and probably simplest method to support the underpurlin where there are no walls to support the struts is to install a strutting beam. The standard strutting beam will extend from the external wall to the nearest internal wall thereby travelling beneath the underpurlin. The strut is then fixed from the underpurlin down onto the strutting beam (see Figure 8.22). The strutting beam is to be fitted onto the walls with a minimum of 25 mm clearance from the underside of the strutting beam to the underside of the ceiling to allow space for any deflection of the beam when it is put under load. The strutting beam will go across the path of the hanging beam, which is then fixed to the strutting beam to support the ceiling joists rather than to run through to the wall at the opposite end of the room.

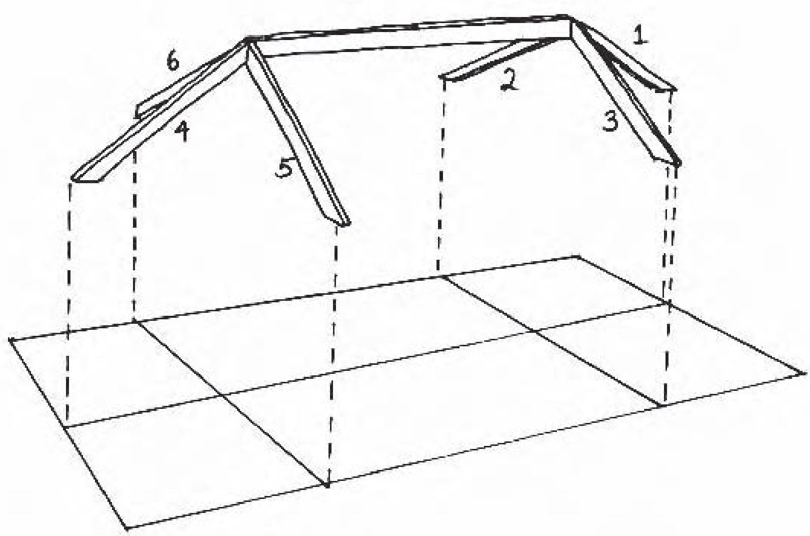


8.22 Strutting beam onto the top of two walls to support a hanging beam and strut to the underpurlin

There are a number of other strutting systems that can be used in the support of the roof, however, the struts detailed above should get you well on the way in your construction. If you are building a coupled roof system with underpurlins and struts, I suggest that you discuss this with your building consultant as they will be able to direct you further. Do not be overwhelmed by the process of fitting struts and underpurlins – it is straightforward and rational. All you are doing is providing a vehicle through which the roof load can be transferred to the walls, through the floor, and into the ground referred to as the foundation.

The process of constructing a coupled hip roof

We will assume that you have made your roofing boat as detailed above and that you have the appropriate timber for the rafters in front of you. Before anything can be done, you must first establish the required location of the rafters at the external wall. The primary rafters on a hip roof are the jack rafters. In a conventional rectangular roof there are six jack rafters, one at each end of the building, and a pair at either end of the ridge (see Figure 8.23).



8.23 Layout of jack rafters

Marking positions for jack rafters

You will need to mark the position where the bottom of the first rafters is to be fitted. The markings on the outside wall for the jack rafters are to be in the form of two parallel lines representing each side of the rafter, with a 'J' written between the lines. To state the obvious, if your rafters are 45 mm thick the lines will be 45 mm apart.

To establish the position for jack rafter 1, measure the width of the end wall of the house and divide this figure in half. This is the position of the centre of the jack rafter. Measure from the external corner of the house back along the side wall of the house the same distance that rafter 1 is from that corner to establish the position for rafter 2. Repeat this process for the other side of the house for rafter 3 to complete the marking of one end of the house. Repeat this process for the other end of the house to establish the positions for jack rafters 4, 5 and 6. In theory, if the house is a straight rectangle, the two end walls should be the same width, but check to make sure. If not, make the necessary adjustments to the calculations prior to marking the positions for rafters 4, 5 and 6.

Markings for rafters

The marks on the external wall for all rafters apart from the jack rafters are to be in the form of an arrow. The common rafters are the full length rafters that are fitted between the jack rafters. They are fixed to the ridge and the side walls. Refer to your timber specifications to ascertain the spacings for the rafters. Mark the external wall with the specified spacings, starting from jack rafter 2 towards jack rafter 6. Next mark the external wall for the rafters for the other side of the building starting from jack rafter 3 towards jack rafter 5. It is important that the rafters from each side of the building are in line with one another on either side of the ridge (see Figure 8.24).

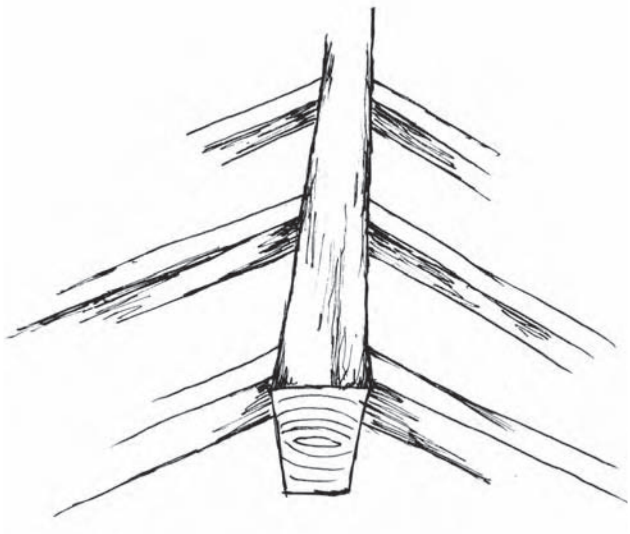


Figure 8.24 Pairs of rafters are to be fitted directly opposite one another at the ridge

The timber from the ridge down to the external corner of the building is called the hip. The top of the hip is fixed at the top junction of two jack rafters at the ridge. There are four hips in a rectangular building. The rafters from the outside wall to the hip are called creepers.

The creepers are to be fitted the same distance apart as the common rafters. The position of the creepers is to be related back to the jack rafters, so measure and mark the external wall from the jack rafter toward the external corner from all six jack rafters. This will mean that the creepers from each side of the hip should end up directly opposite each other.

Cutting and assembling the roof

First you will need to establish the length of the rafters. Measure from one side of the building to the other across the timber that the roof is to be mounted on. Check this measurement in several places to ensure that it is the same. If the variance is greater than 20 mm between two rafters, you are going to have to do a separate calculation for each pair of rafters. The pitch of the roof will determine the amount of rise in the roof compared to the run or distance across the ceiling. As previously detailed, when discussing the production of the roofing boat a 30-degree roof pitch will have a rise of near enough to 578 mm for every metre of run across the ceiling. Your building consultant will be able to look up a set of tables to calculate the length of your rafters, however I have provided a sample of the calculation below if you prefer to do it yourself.

Calculation to establish rafter length

Total width of the building across the timber the roof is to be fixed to, for example,	8.135 metres
Deduct the thickness of the ridge beam from the total width	0.035 metres
Sub-total	8.100 metres
Divide the sub-total by 2	= 4.050 metres
Multiply the answer by the rise per metre, for example,	× 0.578 metres
equals the total rise or height from the top of the walls to the underside of the rafter	2.341 metres
The rise squared, for example,	2.34 × 2.34 = 5.4756
+ the half span run squared, for example,	4.050 × 4.050 = 16.4025
Sub-total	= 21.8781
The rafter length = square root of the sub-total	= 4.678 metres

Figure 8.25 Calculation to establish rafter length

Cut only one pair of rafters initially

Once you have established the theoretical length of the rafters you should cut a pair of rafters and try them out before you cut the rest of your timber. Site along the rafter timber to check for any bow in the timber. As per normal the bow is to go up. Mark the top edge of the rafter with the calculated length, ensuring that the mark at the top of the rafter is near the end of the timber, to avoid wasting timber. You will now have two marks on the timber, one representing the top of the rafter at the plumb cut and the other at the top edge of the lower end of the rafter representing the *line* of the vertical cut for the birdsmouth. Use your roofing boat to mark the plumb cut at the top of the rafter and then slide the template down the rafter until the back end of the bar on the top of the roofing boat is level with the mark representing the extended line of the birdsmouth. Now scribe a line inside the birdsmouth notch of the roofing boat. Cut the plumb cut and the birdsmouth notch. Repeat this for a second rafter so that you have a pair of rafters.

Ideally you will have some kind of platform on the ceiling on which to stand, otherwise you will have to balance on the ceiling joists. Take a note from your calculations of the final height of ridge, which is at the centre of the roof. If the total rise is beyond your chest height you will have to utilise some form of scaffold to enable you to assemble the roof. You need be able to work on both ends of the ridge beam concurrently in order to locate the fixing position of the ridge and the rafters. Ideally you will have this scaffold for the total length of the ridge beam, or, at minimum, at each end of the ridge.

Check the angle of the cuts and length of the rafters

Lift the first two rafters up onto the ceiling in their approximate positions, with the tail or lower end of the rafter hanging over the outside wall with the birdsmouth checkout at the outside pitching timber. To test the length of the first rafters, you will need to have a block of timber the same thickness as the ridge so that it can be held between the rafters to check their cut relative to the ridge once they are fitted to the ridge. Nail the block to the plumb cut of one of the rafters, as it will be difficult to hold it in position while holding the ends of the rafters up. It is a lot easier if you have a second person to help with the next process, however it is possible to perform alone.

Lift the two rafters up into their respective positions with the birdsmouth checkout pulled firmly against the outside of timber at the external wall. Bring the two plumb cuts of the rafters together to check that the rafters meet the ridge without too much gap between the ridge and the rafters. If there is too much variation, first check that you have cut the rafters to the calculated length. While holding the rafters in position, measure the height of the underside of the rafter at its highest point to the underside of the ceiling joist, and check this height against the calculations. Next check that the calculations for the length of the timber are correct. If all of these measurements are correct it most likely that there is a discrepancy in the construction in the roofing boat, which will mean that the plumb cut will need to be adjusted. A 2–3 mm gap is not ideal, but particularly if it is at the top of the rafter to the ridge it is not too much of a concern. Before you make any adjustments to the rafters, check to see how they meet at the other end of the building.

Once any necessary adjustments are made to the rafters, check them in position again. If you are now happy with the way they meet and the height at which they meet, you can cut the balance of the common rafters. The common rafters are the rafters that have a square plumb cut, whereas the rafters that are fixed to the hip, known as creepers, will have a 45-degree angle cut on them so that they match the line of the hip. Spread the common rafters on top of the ceiling in their approximate positions.

Installing the ridge beam

For a gable roof the ridge beam will be the same length as the side wall of the house; for a hip roof, it is equal to the distance over the jack rafters, including the thickness of the jack rafters. Allow an additional 100 mm of length for the ridge, as it will be cut to the correct length just prior to fitting the final jack rafter.

Mark the ridge with the positions of the rafters

Before any rafters are fitted, it is best to mark the ridge to indicate the positions that the rafters are to be joined to the ridge. The ridge is to be fixed parallel to the external wall with the rafters running square from the external wall to the ridge. Consequently, the marks on the ridge are to be opposite the marks on the external wall. When the rafters are fixed to the ridge it is important that the top of the rafters are all at the same level. It is normal for the top of the rafters to be fitted level with the top of the ridge, however, if the ridge has a bow in it this could result in a hump up in the top of your ridge. Site along the ridge to see if it is bowed; if it is, use your chalk line to mark a straight line along each side of the ridge. In this instance, the rafters will be fitted with the top of the rafter level with the chalk line rather than the top of the ridge.

Joining the ridge beam

On many occasions the ridge will be made up of more than one piece of timber. To join the ridge timber, cut a 45-degree angle on the ends of the ridge timbers where they are to join. If at all possible, make the join in the ridge beam between rafters rather than have a rafter fixed over a joint. Before cutting the ridge beams, establish which piece of timber is

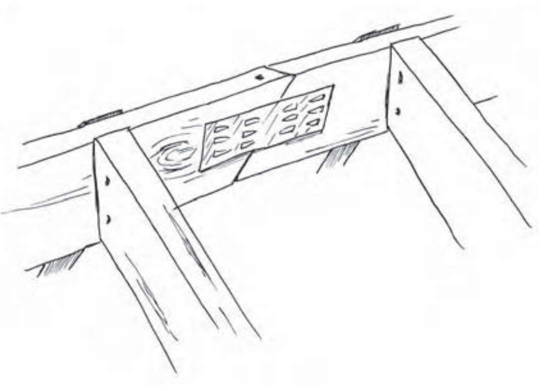


Figure 8.26 Joining of a ridge beam with 45-degree angle cuts and nail plates

to be installed first. This timber is to be cut with the long point closest to the ceiling so that when the joining timber is fitted it can simply rest on top of the first piece of ridge material (see Figure 8.26). The joint will eventually have a nail plate fitted to each side of the ridge to prevent the ridge timbers from parting.

If your roof is a hip roof, you will need to cut one end of the ridge square, and then mark the ridge from that point to the other end with positions that correspond to the marks on the external wall for the location of the rafters. This will enable you to easily fit rafters in the correct position with the rafters at right angles from the ridge and external wall.

The first rafters to be fixed will be the rafters at each end of the ridge, which are the jack rafters. While as a tradesman I am able to perform the next process alone, I would suggest that you get assistance unless you have significant experience and the roof is not out of your normal reach.

When it comes time to fit the rafters it will make it a lot easier if a nail has already been partly hammered into the top edge of the rafter so that it can simply be hammered in further to fix the rafter to the ridge. Hammer a 75 mm bullet head nail into the top edge of the rafter toward the plumb cut until the point of the nail is about to break through the face of the plumb cut. Once the rafter is in position against the ridge, this nail will be hammered into the ridge as the initial fixing of the rafter to the ridge.

Assembling the rafters and ridge beam

Positioning the ridge on top of the ceiling joists

Lay the ridge beam on top of the ceiling joists approximately in line with the position that it will eventually be fitted. The first rafters to be fitted shall be jack rafters 2 and 3. Have your assistant position themselves so that they can support the top end of the rafter roughly at the correct height. With your assistant supporting the top of the rafter at near to the correct height, fix the bottom end of the rafter to the external wall or beam. Ensure that the birdsmouth checkout is tight against the timber of the external wall and that the rafter is against the ceiling joist, if applicable. Using 75 mm nails, skew nail the rafter at the birdsmouth into the top of the wall, and make a second fixing horizontally into the ceiling joist. Repeat this process for the rafter on the opposite external wall. The person holding the top of the rafters should not place the top of the rafters together at this point, as this will cause the second rafter to slip away from the outside wall. Once the bottom of the second rafter has been securely fixed to the external wall as previously detailed, the two plumb cuts at the top of the two rafters can be sat together. At this point your assistant will no longer be carrying any weight, but merely steadying them in their upright positions.

Making the first connection of the rafters to the ridge beam

You will now make the first connection of the rafters to the ridge beam. Lift the square cut end of the ridge beam up to the underside of the two rafters at the junction of the rafters while the other end of the ridge rests on the ceiling joists. When the ridge is held just below the rafters, have your assistant lift and separate the two rafters to allow the ridge to be inserted between the rafters. It is easiest if they reach under the ridge beam to lift the rafters, as this eliminates the problem of having arms in the way of the ridge when it is being inserted between the rafters. As the ridge is held in place, allow the plumb cuts of the rafters to come to bear against the sides of the ridge. It is not essential that they be positioned perfectly adjacent at the ridge end; at this point near enough is good enough. Allow the tension between the rafters to wedge the ridge beam between them as you allow the rafters to drop in position. If the timber is dry, the friction between the plumb cuts of the rafters and the face of the ridge will be sufficient to hold the ridge in position. This, however, should not be taken for granted. A temporary fixing of the rafters to the ridge is required. The nails that were earlier hammed into the top of the rafters are now to be hammered into the ridge beam, while leaving a sufficient amount of the nail exposed to permit its later removal.

The carpenter who didn't tack the rafters to the ridge

This reminds me of a carpenter I once worked with who was a little lax when it came to safety. A man that it seemed would rather have a fight than breakfast any day. He was working on the frame of a house in the middle of winter. Not the choicest of jobs at that time of year. The site was wet and working in the mud was a constant battle. Leather boots were rejected in favour of rubber gumboots. The ceiling had been completed, the rafters cut and it was time to fit the ridge beam. This was back in the 1970s when the primary timber used in house frames was OBHW, which stands for ordinary building hardwood. To remove the somewhat exotic name, gum tree so green that the sap was still dripping out of it. The sap from this timber was so prevalent that our hands were constantly stained black, somewhat embarrassing when you were out at a good restaurant and put your hand out to receive change. Each night we would go home with our pants wet where we had been resting the timber against our clothes. Needless to say, it was extremely heavy.

The ridge beam was 200 × 38 mm and 6 metres long. The rafters were fixed at the external walls and resting together. He lifted the ridge beam up between the two rafters and allowed it to gain its bearing against the rafters. There was just one problem – there were no nails waiting in the top of the rafters. Rather than to go to the trouble of fitting the nails from scratch, he made the mistake of trusting that if it was sitting all right at the moment it would be fine. With his feet seated lengthways on the top edge of the ceiling joists, he lifted one foot to take a step back heading for the other end of the roof. Just at that very time, while effectively standing on one foot, the rain-drenched and waterlogged ridge slipped from between the rafters and came crashing down onto the ceiling joists below. It fell so cleanly that it remained in its vertical state until after it hit the ceiling joists, making a crushing blow to the rubber gumboot below it.

The colour of his face was indication enough that he was not enjoying the experience, and no doubt had the fleeting thought 'if only, if only I had nailed those rafters'. On inquiring as to his wellbeing, it was decided to help him down off the ceiling before investigating the damage. Once on the ground he slowly removed his gumboot, which now had a bright red sticky lining, and his blood drenched sock was carefully removed. He had been standing on the ceiling joist with his second toe sitting squarely on top of the joist. As the beam crashed down, the bottom edge of the beam struck him across and just below the top knuckle of the second toe. His big toe and third toe were bleeding, having been stripped of skin as they were forced down either side of the ceiling joist, but the second toe had worn the total impact. It was crushed beyond recognition, the only solution amputation. It saved about 30 seconds by not putting in the nails. A small price to pay for such a long time in recovery.

Back to fitting the jack rafters

Anyway, enough of the gory details and back to the process. Next you are to fit jack rafters 5 and 6. Follow the procedure detailed above for the installation of the rafters. Once fixed, you are again to lift the ridge beam to the underside of the rafters, separate the rafters and insert the ridge. This time ensure that the rafters are positioned perfectly in line with the positions previously marked on the ridge. Nail home (nail all the way) the nails in the rafters, securely fixing the rafters to the ridge beam. You will now have four rafters fixed to the ridge with two of the rafters only tacked to it, as they will need to be relocated. The weight of the ridge will be supported by the rafters, however the ridge will tend to want to lean to one end or the other as it does not yet have any lateral stability.

You will now fix jack rafter 4 to the ridge. In this instance, while your partner is stabilising the assembled roof structure, fix the top of the rafter to the square cut end of the ridge. Once the rafter is fixed at the ridge, the assembled section will be much more stable. Now fix the bottom of the rafter as previously detailed, ensuring that the birdsmouth is tight against the wall. Once the rafter is fixed at the ridge and the external wall, the structure will be stable and no longer need to be held in place.

Marking and cutting the ridge to its correct length

The other end of the ridge has not yet been cut to the exact length and so it will now be marked and cut. Pull the rafter up at the other end of the house and hold it in position

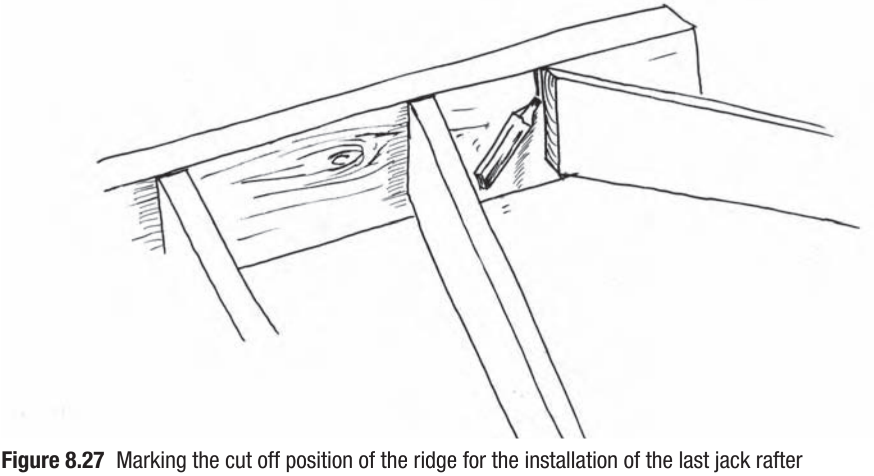


Figure 8.27 Marking the cut off position of the ridge for the installation of the last jack rafter

with the birdsmouth checkout firmly against the outer wall (see Figure 8.27). Scribe a line down the side of the ridge board at plumb cut of the rafter.

Take a measurement from one rafter to the other at the external wall, including the rafters. The length of the ridge beam is to be the same as that of the rafters at the external wall. If it is within 10 mm it is of little concern, more than this needs to be investigated further. If the scribed mark is in the correct position, cut the ridge board to length and fix the end rafter to the end of the ridge board. The first two rafters that were temporarily fixed to the ridge are now to be permanently fixed in position. One by one, remove the temporary nail from the rafter, and while holding the weight of the ridge and rafter, reposition the rafter so that it is adjacent to the end of the ridge and level with the top of the ridge or on the chalk line. Once in the correct position it can be fixed permanently to the ridge board.

The end rafters now securely brace the roof, so you can complete the installation of the common rafters. Refer to the details for installation of common rafters previously detailed.

Joining the ridge beam

When the ridge board is joined, the first section of ridge to be fitted will have a 45-degree angle cut with the point of the cut nearest the floor. Fit jack rafters 2 and 3 as detailed above, and then a pair of common rafters at the other end of that section of ridge. Now, fit jack rafter 1, which will stabilise that section of the roof. You are now to fit jack rafters 5 and 6 and lift the ridge into position between these rafters at one end while joining the angle cut end of the ridge to the first section of ridge fitted. Nail through top and bottom of the ridges to secure them together. Cut the ridge to length and fit jack rafter 4 as detailed previously.

Look along the top of the ridge to determine any bows sideways in the ridge board that need to be straightened. It may make it simpler if you fix a string line to the top of the ridge as this will allow you to refer to the straight line as the balance of the rafters is fitted.

In a perfect situation, the rafters will all be fixed to the top edge of a straight ridge board, and all the birdsmouth checkouts will be sitting firmly against the outer edge of the external walls all the way around the roof. As yet, after about 30 years in the trade, I am yet to see this happen. The most important thing is to keep the ridge board straight and the top of the rafters in line vertically, as this is the section of the roof where discrepancies will be most visible.

The birdsmouth checkout may have a gap between it and the external wall or you may even have to extend the birdsmouth so that the rafter can sit correctly at the ridge. Obviously there is a limit as to the tolerance in this, however there are many factors that need to be taken into consideration when establishing just how much variance there can be. As a general rule, a 10 mm gap between the back of the birdsmouth and the external face of the wall, or a need to extend the birdsmouth by 10 mm, is probably within the bounds of acceptable. If you are at all concerned it is better to contact your building consultant rather than to worry about whether you are doing the right thing.

Cutting and installing the hips

The next task is to fit the hips from the corner of the external walls up into the junction of the rafters to the end of the ridge. You will first need to establish the angle that the end of the hip has to be cut at so that it fits neatly into the junction of the rafters and the end of the ridge. To do this you will need a string line and a bevel. A bevel is a tool that has an adjustable blade that is held in position at virtually any angle by tightening a wing nut (see Figure 8.28).

Figure 8.28 Adjustable bevel

Hip cut angles

Use a string line and bevel to establish the required angle of the hip cuts. Fix a string line to the external corner of the outside wall. It is common for the birdsmouth checkout in the hip to be 50 mm deep. Consequently, if your hip is 200 mm deep, the position of the string line is relative to 150 mm down from the top of the hip. Measure 150 mm down from the top of the ridge and make a mark. Hold the end of the string line at this mark and then use a bevel in the corner to gain an angle from the end of the ridge to the string line, as this will be the angle that has to be cut on the end of the hip. The top of the hip is to fit into the corner created by the first rafter nailed at the end of the ridge, and the rafter fixed to the end of the ridge. To fit into this corner the top of the hip will have to have angles cut on it (see Figure 8.29).

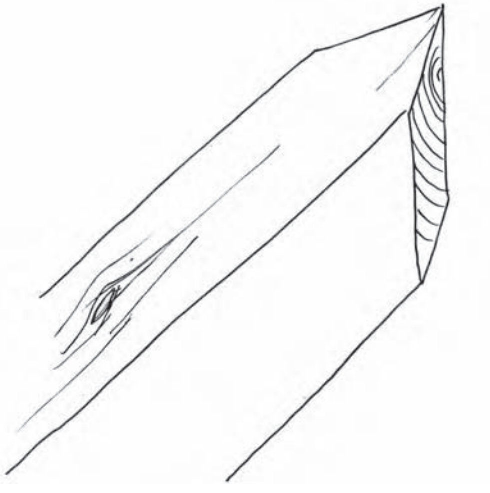


Figure 8.29 Double 45-degree angle cuts for the top of the hip beam

With the bevel fixed at the angle of the string line to the end of the ridge, draw a line on the end of the hip ensuring that any bow in the hip is up. If the hip is 35 mm thick, you are to draw a second line 35 mm from the first. Set the circular saw for a 45-degree undercut and cut along the line nearest the end of the timber. This cut should commence at the top edge of the hip. From the bottom edge of the hip, make a second 45-degree cut, thereby creating a point on the end of the hip which will fit into the corner of the two rafters.

Cutting the birdsmouth into the hip

Next you will cut the birdsmouth checkout in the other end of the hip. While in theory it is possible to establish the length of the hip mathematically, it is much simpler to measure it on site. Lift the hip into position with the lower end seated on the external corner of the external wall, with the plumb cut or top of the hip nestled between the top of the two rafters. The bottom edge of the plumb cut on the hip is to be held on the mark that was previously put on the end of the ridge, so that the bottom edge of the hip is in the same line that the string line was held in previously. Check that the top cut on the hip will allow the hip to fit snugly into the junction of the two rafters. While holding the hip in this position, the second person can mark the position for the birdsmouth checkout. This will be the junction of the bottom of the hip to the external wall. This can be done by measurement if you are working alone, but ensure that the tape measure is held tight as the sag in the tape measure over what could be five or more metres can cause the checkout to be cut in the wrong position.

Just as with the rafter birdsmouth, the back cut of the birdsmouth is the same angle as the plumb cut at the top of the hip, so you can again use the bevel to mark this. As previously mentioned it is common for the depth of the checkout to be 50 mm, so for this exercise you can mark from the bottom of the hip up 50 mm to the top of the birdsmouth checkout. From the 50 mm mark draw a straight line toward the top of the hip at right angles to the back cut of the birdsmouth checkout (see Figure 8.30).

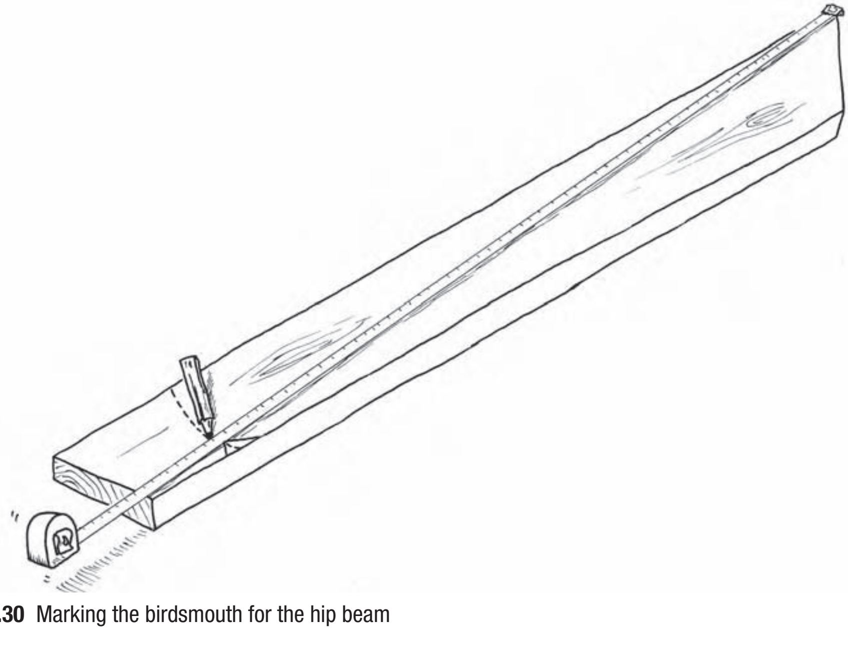


Figure 8.30 Marking the birdsmouth for the hip beam

Nailing the hip in position

Before fixing the hip in position, hold it in position to ensure that the birdsmouth checkout is allowing the hip to sit neatly on top of the external wall. If there is a gap between the back of the birdsmouth and the outside of the corner of the wall it will have little effect, as long as it is not more than 10 to 15 mm. Fix the top of the hip to the rafters and the end of the ridge, and then fix it at the birdsmouth checkout using two 75 mm skew nails into the top of the external wall. Repeat this process for each of the hips.

Cutting and fixing the creepers – the rafters fixed to the hips

The rafters that are fixed to the hips are called creepers. Creepers have a birdsmouth the same as the common rafters, however the top of the creeper, or plumb cut, will have a 45-degree undercut so that the face of the plumb cut will sit against the hip for fixing. Use the roofing boat to mark the face of the creeper, and then with the circular saw set for a 45 degree undercut, cut the plumb cut of the creeper. As you stand below the hip, the creepers to be fitted to the left of the hip will have a left-hand cut and those on the right will have a right-hand cut. As you look down on the top edge of a cut creeper, the left-hand creepers will have the long point at the left side of the creeper (see Figure 8.31).

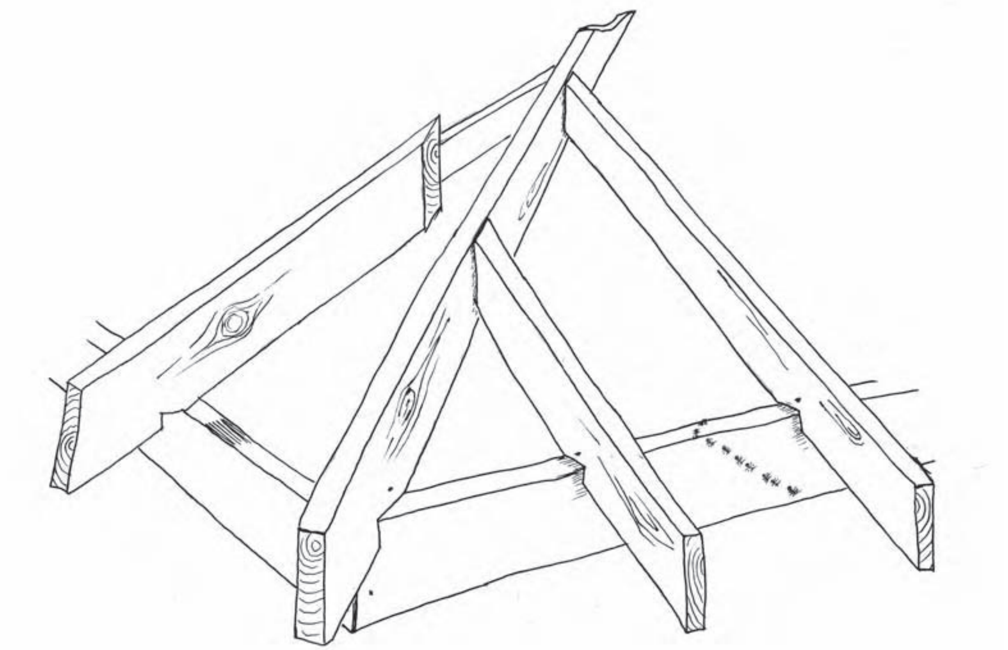


Figure 8.31 45-degree angle cut at the top of the creepers to enable fixing them to the face of the hip beam

The length of the creepers can either be established mathematically or by physically measuring them on the job. When measuring them on the job, ensure that the measurements are taken with the tape parallel to the common rafters. Your building consultant should be able to supply you with the details on the calculation for the length of the rafters. This is known as the shortenings of the creepers. It will be a figure that represents the reduction in the length of each of the creepers from the length of the common rafters. It is dependent on the required distance between the rafters and the roof pitch. Consequently there are too many variables for me to realistically include the calculations in this passage.

Bracing of gable roofs

If you are building a gable roof, the roof will have to be braced to prevent movement. The first rafters installed should have been at the end wall of the house. If the roof is two metres high, the base of the roof brace will run from the first rafters two metres back into the building thereby giving a brace at the optimum 45-degree angle.

Hold the ridge in a lengthwise position so that the rafters are vertically in line with the external wall relative to the fixing position of the bottom of the rafters.

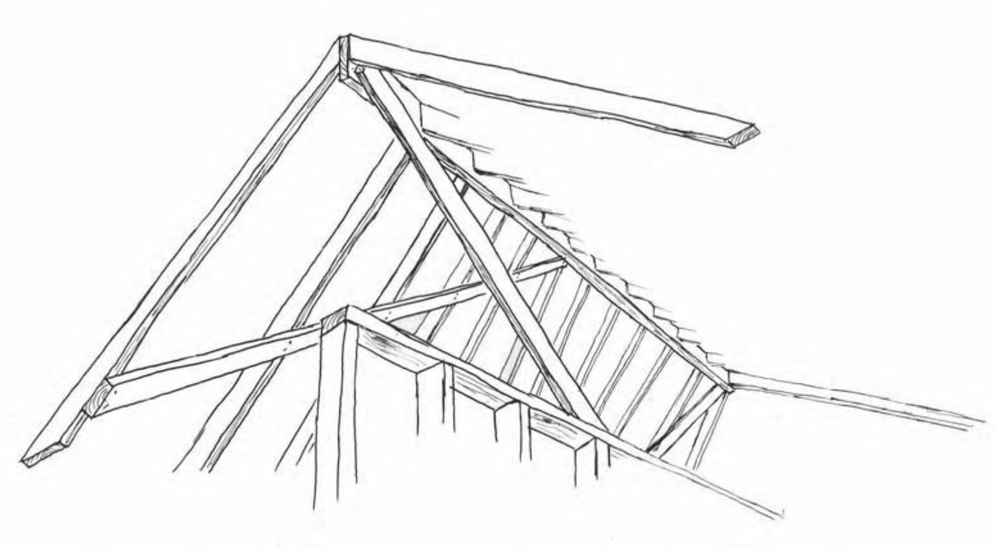


Figure 8.32 Two alternative methods of bracing a gable roof

Nail a brace from the side of the ridge beam back onto the internal wall at a 45-degree angle from the underside of the ridge beam. An alternative form of bracing is to fix the bracing to the underside of the rafters (see Figure 8.32).

Your roof will require additional work, however this will be covered for both hip and gable roofs later in this chapter.

Installation of collar ties

If the rafters are capable of carrying the roof load all that remains to be done is to fit collar ties to the rafters. The size of the collar tie can be determined by referring to the timber specification schedule which form part of your building permit. A collar tie is fitted parallel to the ceiling approximately halfway up the length of the rafters (see Figure 8.33). In most instances the collar ties will simply be nailed to the rafters, however it may

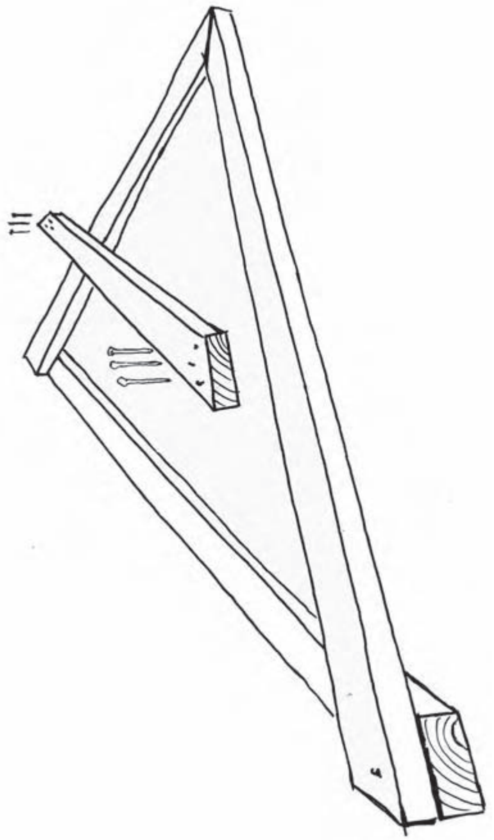


Figure 8.33 Installation of a collar tie to the sides of a pair of rafters in a coupled roof

be that your engineer requires that the collar ties be bolted to the rafters, as is the case with barn style roofs.

If you have an assistant, have them hold one end of the collar tie in position while you nail your end to the side of the rafter, and then have your assistant nail their end to the rafter. If you are working alone, hammer a 75 mm nail into the side of the rafter leaving the nail protruding from the timber as a support for the collar tie. Do this to all the rafters down one side of the construction. To fix the collar ties, simply rest the other end of the collar tie on the nail protruding from the rafter and fix your end of the collar tie. You can work your way along the building fixing one end of each collar ties and then nail the other end of each collar tie.

Collar ties/ceiling joists for barn style ceilings

When you require a barn style shape to your ceiling, the collar ties will double as a ceiling joist, so that the ceiling lining is fitted to the underside of the rafters for the first section of the ceiling and then to the underside of the collar tie (see Figure 8.33). When installing the collar ties for this application it is important that all the collar ties/ ceiling joists be in line with one another. The simplest method to achieve this is to fix a string line to the underside of the rafters in a position that represents the underside of the collar tie/ceiling joist. The collar ties will then be fitted relative to the string line. When using a string line as a guide for the installation of timber, always fit the timber slightly away from the string line. If the timber is resting against the string line it is difficult to judge whether the timber is in the correct position or whether it is actually pushing against the line which would, in turn, give incorrect guidance for the installation of the next collar tie.

Collar ties that also take the form of the ceiling joists contribute a more than significant part of the structural integrity of the roof, as they alone prevent the roof from dropping and prevent the external walls from being pushed out. There should be specific details in your building permit dealing with the installation of this timber. If you are unable to locate it or unclear as to the instructions do not proceed until the information is clarified either by your building consultant or engineer. It is normal for the collar ties/ ceiling joists to be both nailed and bolted to the rafters. When they are to be bolted, it is important that the correct size drill be used to drill the holes to take the bolts. If 12 mm bolts are specified then you will need to drill 12 mm holes. If you were to drill 13 mm holes, over time the timber will slide outward until the slack of the hole around the bolt is taken up. This is unlikely to happen immediately and will therefore more than likely cause problems with the cracking of render and ceiling lining as the rafters sag and force the external walls outward. It is unlikely that the building will collapse, however, the damage can be significant.

Additional anchorage of rafters due to updraft pressure

Depending on the pitch of the roof, the updraft pressure or vacuum exerted on a roof in what are loosely termed normal weather conditions can be in excess of 1 ton per square. It is essential that the roof be securely fastened to the walls below, particularly if metal roofing is used, as this has very little weight to counteract the uplift. Using prefabricated brackets, such as triple grips that are used to secure roof trusses to the walls, or alternatively by using metal hoop iron, will solve the issue.

Roof trusses

There are many companies that manufacturer roof trusses. If you take a copy of your plans to the truss manufacturer, they will design the roof trusses for your house taking into consideration the roof and ceiling load to be supported and the required shape of your roof. They will supply you with the structural details on the manufacture and carrying capacity of the trusses, which you will submit to the building surveyor when applying for your building permit.

I strongly recommend that you do not get the trusses delivered until all the walls are completed and you are completely ready to fit the trusses. The trusses are delivered on a crane truck, and if the truck is able to get next to the building they are more than happy to unload the trusses onto the top of your walls. This will save you a considerable amount of work and frustration. The strength of a truss is in its vertical position – when they are horizontal they are awkward and clumsy to handle. Manoeuvering them flat is a bit like trying to push a piece of string.

Follow the instructions supplied by the truss manufacturer

The roof truss manufacturer will supply you with installation instructions detailing the position each truss is to be fixed to the house and any roof bracing. Mark the top of the external walls with the positions that the trusses are to be fixed. It is much easier to position the truss on a mark than to try to manoeuver the truss while measuring where it is to be fixed. Along with the trusses you will receive any roof bracing required. This bracing is a metal brace known as speed bracing, which is fitted to the top of the roof trusses. You will also receive brackets to fix the trusses to the top of the external walls. You will fit a bracket on both sides of the roof truss at the junction of the external wall using the connector nails supplied.

The first truss to be stood up is the most difficult. Depending on the shape of the roof, it can often be some distance from the external wall at the end of the house. If at all possible, try to choose the truss that sits above an internal wall at about the centre of the truss so you have something to stand on while fixing the truss in place. It may be necessary to use ladders and/or a scaffold plank on top of the walls to get a stable footing to hold the truss vertical while a brace is fitted to it to hold it in place.

Fitting roof trusses

Stand the first truss up and hold it in place with a temporary brace from the top of the roof truss back to the outside wall. When satisfied with its location, fix it to the outside wall/beam (see Figure 8.34).

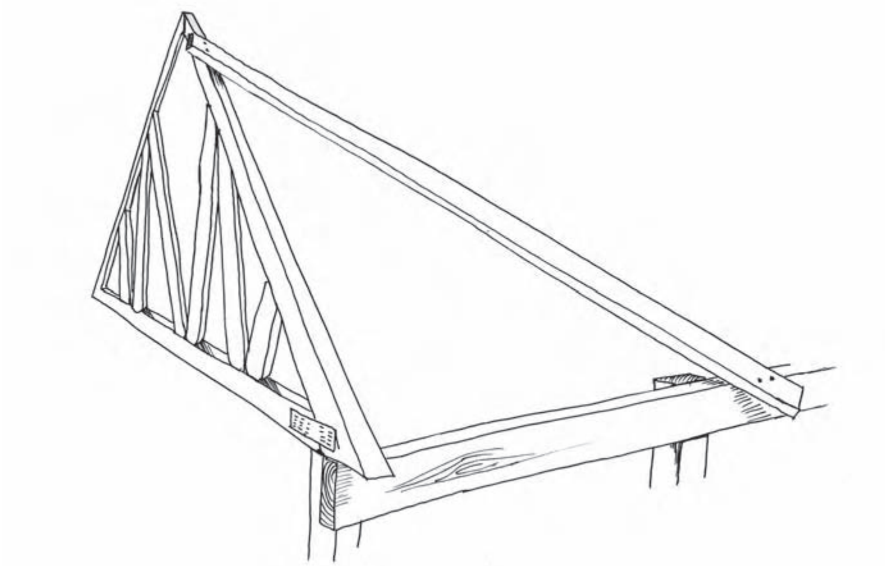


Figure 8.34 Initial securing of the first truss installed, using a temporary angle brace

Stand the second truss up in position, slipping it under the temporary brace. The second truss will now be fixed at the external walls and held vertical by nailing through the temporary brace into the top of the roof truss. Continue this process, adding additional temporary braces as required. Once all the trusses are fixed in position, fit timber inside the webbing of the truss the length of the house at the top and bottom of the truss, thereby fixing the distance between the trusses at the ceiling and the peak of the roof. Refer to your instruction details that are supplied with the trusses. If you have difficulty understanding the installation instructions, contact your truss supplier. On rare occasions you may be able to get a representative of the company to come on site and further explain the instructions, if not you are best to go to their office rather than to try to communicate over the phone. Alternatively, have your building consultant come on site to clarify the situation.

9

Roof battens, roof insulation and roof cladding

One of the major benefits of straw bale housing is the super insulation provided in the walls. However, the walls are only part of the overall heat efficiency of the house. As heat rises, the major area of heat loss is in the roof and ceiling. To gain the true benefit of the wall insulation it is important that sufficient insulation is first of all provided in the roof and ceiling. My house has bulk insulation between the ground floor and the first floor of R3.8. The 'R' value refers to the resistance of heat-transfer through a material (a higher R-value indicates more effective insulation). On top of the ceiling of the first floor I have bulk insulation of R3.8. I have fitted Air-Cell insulation (details below) under the roof battens and this is rated at R2.2. In addition to this we have timber ceilings in both the ground floor and the first floor, and particleboard flooring with industrial rubber underlay below the carpet which probably provides additional insulation of about R2 to R2.5. In total, between the ground floor, where we spend most of our time, and the roof above we have insulation of something like R11. Needless to say, this is not a difficult house to heat or keep cool.

Ceiling insulation

Ceiling insulation may be installed on top of a flat ceiling between the ceiling joists and/ or between the rafters. There are many different materials used for insulation – fibreglass, polyester, wool, seaweed, shredded paper, silver foil paper, wood shavings and straw to name a few. The application of the insulation will have some bearing on the insulation material to be installed, as will your budget. This is one time that the cost alone should not be the only consideration of the materials to be used.

Untreated waste wool product for insulation

I recently heard of a person using raw wool for insulation in the roof of their home. At face value this appears to be a great idea, as they had been able to purchase a waste product at a very low cost. However, the potential infestation of moths, mice and other little furry fellows is significant. I remember the disgust and disappointment on Jan's face the day she opened a plastic bag of wool that she had kept for spinning, only to see a mass of moths fly from the bag. One can only imagine how comfortable and inviting clean wool would be for mice. Treated against vermin, wool insulation is a great product, but without treatment I dare not contemplate it. When applying for a building permit you have to meet insulation requirements as specified by the building code. It would be unwise to make the assumption that the building inspector would accept your form of insulation if the R rating were unsubstantiated.

Wood shavings for insulation

I have boyhood memories of the demolition of an old cool room in my home town of Numurkah in Victoria. It was an old building with planks of timber nailed to each side of the timber framed wall. I remember asking my father where all the saw dust came from, as it was heaped up among the rubble. He explained to me that the saw dust was good to stop the heat from outside getting into the cool room where the butter was kept, and that the cavity of the timber framed wall had been filled with saw dust and wood shavings for this very purpose. This form of insulation was evidently quite common at the time of building the cool room. I imagine that this form of insulation would also provide significant acoustic benefits.

Roof insulation

In this section I will be speaking specifically about the insulation that is fixed above the rafters as opposed to insulation that is fitted between or below the rafters.

There are three reasons for the application of roof insulation: heat control, noise control and the control of condensation. Heat is transferred by conduction and radiation. The bulk insulation, such as fibreglass insulation, is specifically targeted at the heat transferred by conduction, as the small pockets of air trapped within the insulation reduces the free flow of heat from one area to the next. The radiant heat is reduced by the installation of reflective barriers such as sizalation; a foil product supplied in rolls approximately 1.35 metres wide and of varying lengths. When a roof is to be clad with roof tiles or shingles the sizalation is fitted directly to the top of the rafters below the roof battens. When roofing iron is used, the sizalation can be fitted either above or below the iron.

Air-Cell building insulation

One of my owner-builders introduced me to a product called Air-Cell, which combines both bulk and reflective barriers. Air-Cell is made up of what looks like a sheet of heavy bubble wrap sandwiched between two layers of sizalation. The sizalation provides the reflective barrier while the enclosed air pockets of the centre layer provide resistance to conductive heat transfer. I have found this product not only beneficial from an insulation perspective, but also because of the ease of installation. The R rating of Air-Cell varies with different installation methods. When fitted on top of the roof battens Air-Cell is rated at R2.5, whereas when installed on top of ceiling joists it is R3.0. I am told that it is capable of supporting a person when fitted correctly, however, I suggest that this is not something that should be tested for the sake of your own wellbeing. I do however acknowledge its strength, having once found myself in a predicament of its strength being all that prevented my acceleration towards the ground below.

In consideration of the need to supply as much insulation as possible to my roof I expected to install sizalation with a 50 mm fibreglass blanket on top of the sizalation. My property in Heathcote is extremely windy, the cause of much concern when contemplating the installation of sizalation with a fibreglass blanket on top of it. It would not be the first time I had been wrapped in an insulation blanket, but this history only served to motivate me to find an alternative.

Air-Cell does not tear or crack in the wind so it does provide some protection of exposed straw against rain when properly fitted.

There is always a delay in the supply of roofing iron and I was keen to have the bale walls covered. One solution was to fit sizalation onto the rafters and then fit the roof battens over the sizalation to prevent it being lifted from the roof in windy conditions, quite a common practice. I had little doubt that the windy conditions that prevail on our property would promptly shred standard sizalation. I had unsuccessfully tried to tear and puncture my sample of Air-Cell, so I decided to install it at Heathcote in the hope that it had sufficient resilience to withstand a few days of our wind until the roof could be fitted. As often happens, things did not go according to plan. The iron was delayed, and when it did arrive the wind came up preventing the installation of the iron. It was almost four weeks in the windiest conditions before all the iron was finally fitted and not one piece of the Air-Cell was damaged. When comparing the cost to other forms of insulation it is not cheap, however, if you are having your roof professionally fitted, the labour saving will more than compensate for any additional cost in materials. The only shortfall of Air-Cell over bulk insulation combined with sizalation is its apparent lack of noise control. When normal bulk insulation is fitted on top of sizalation and against the underside of the iron, the bulk insulation absorbs the impact of rain thereby reducing the resonance from the rain impact. Air-Cell does not achieve this.

Noise from rain

Many people enjoy the sound of rain on the roof, particularly after a long dry spell, however, it can be quite invasive. If you have experienced the noise generated by heavy rain on an iron roof you will no doubt be aware that it can be so loud as to prevent you from being able to hear another person speaking, or make conversation.

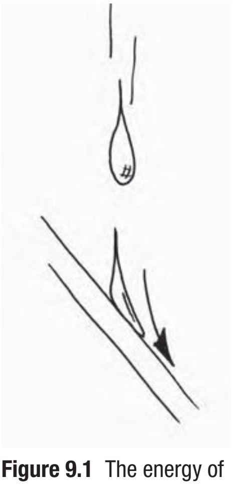


Figure 9.1 The energy of falling rain is diverted as it strikes a sloping roof

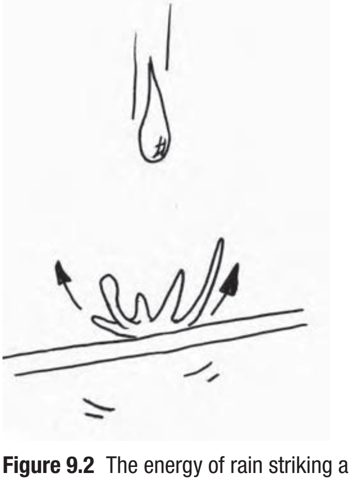


Figure 9.2 The energy of rain striking a flat roof is transferred to the roofing material, thereby resulting in increased noise

The lower the pitch of the roof the greater the noise generated by rain and hail. The noise is generated by the resonance from the impact onto the roof. When the roof has a steep pitch the impact of the rain and hail is deflected down the roof (see Figure 9.1), whereas rain falling onto a flat roof explodes on impact, creating significantly more noise (see Figure 9.2).

Reducing rain noise

Dramatic reduction in rain noise is achieved by installing a 50 mm blanket of bulk insulation directly beneath the iron roofing material. The installation of 50 mm fibreglass on top of a layer of sizalation, which is laid over the top of the roof battens, will eliminate much of the noise generated by hail and heavy rain on an iron roof. This works much the same way as a drummer who puts a wad of material inside his base drum to reduce the noise output. The resonance from the impact on the iron is reduced as the vibration is absorbed into the blanket of insulation held against the underside of the iron.

Roof condensation

The control of condensation is of particular concern for straw bale houses. I believe that condensation is the 'cancer' of straw bale houses as it often goes undetected until the full brunt of the situation is felt. When a pipe bursts or a roof leaks you will more often than not see the telltale signs of the water as it seeps out of a wall or runs down the face of the wall. These telltale signs can be quickly investigated and the source of the problem rectified. It may mean that some bales have to be replaced, but on many occasions even this is not necessary. When it comes to condensation there is no great flow of water to notify you of the problem. But mark my words, do not discount the outworking of this moisture penetration. It is equally damaging to the walls as gushing water.

Condensation that fell like rain

Roof condensation is a particular problem in central Victoria, as we have frequent and severe frosts. I have vivid memories of a run-down property that we purchased in Ravenswood, Victoria, a number of years ago. There was an old derelict brick building on the site that had had a makeshift semi-flat roof fitted to it and a new concrete floor. When we purchased the property we figured on using this shed as a temporary office until other arrangements could be made. We shifted into the property on a Friday and Saturday in the middle of July. We set up the desk and computer in this old building and, fortunately, covered them with plastic to keep the dust and any deposits from local bird residents off this new elite office area.

The following Monday, business had to go on and I had a list of phone calls to make. I was in the office by about 6 am and thought little of the damp surface on the plastic. By 9 am, sitting at the desk was paramount to standing under the shower. I found myself sitting at the desk with the large sheet of plastic that had previously been protecting the equipment from dust, now serving as a makeshift tent to turn away what seemed like a tropical downpour. The condensation was running on the underside of the iron, and seemed to take great pleasure in gathering momentum and building up the size of the droplets of water until they reached overload in my general vicinity, whereupon they dumped on me.

How condensation runs

The water from condensation will run until it hits an obstruction, and then fall. Condensation that forms below the iron will run down the underside of the iron until it strikes an obstacle such as a roof batten, or until the droplets gather together, thereby increasing their weight beyond their cohesive capacity whereupon they drop like rain. It was once considered that a roof with a pitch in excess of 22 degrees did not have a problem with condensation, however my experience proves this to be untrue. In Heathcote I have three-metre wide verandahs with a 25-degree pitch. The condensation is clearly evident, as are the lines on floor where the water drops from the roof battens. This is not an issue in this application, but it is if there is the remotest chance that the water will drop onto bale walls.

The solution for condensation

The solution for condensation is the installation of sizalation either above the roof battens or below the roof battens. Either application is acceptable, although I personally prefer to have it installed below the roof battens. When it is fitted on top of the battens it is essential that the material be tight enough to prevent pools of water forming behind the roof battens and yet it must not touch the underside of the iron between the battens. Whereas with the installation below the battens, while it is still essential that it be stretched out, there are no physical barriers behind which the water can gather until you get to the fascia or tilt batten. At this point you are past the danger point for the straw bale walls. The sizalation installed on top of the roof battens will have a number of penetrations through it where the roofing material is screwed to the sizalation and into the roof battens. When the sizalation is fitted below the battens it will only be penetrated by the fixings for the battens. Any water lying on the sizalation will tend to flow away from the highest point, which of course is at the rafters into which the battens are fixed.

Extent of the sizalation

Extend the sizalation beyond the external line of straw bale walls. If your house has verandahs and you do not wish to fit sizalation over the verandahs, ensure that the sizalation is extended beyond the external line of the straw bale wall. The water that comes from inside a roof is not always clean, so any discharge down the face of your wall may well stain the wall. If you extend the sizalation about 300 mm or more past the external wall line you should avoid this problem. To achieve this, fit a roof batten in line with the end of the outer edge of the sizalation. The sizalation can then be fixed up to the underside of the roof batten thereby providing another barrier for vermin entry into the roof cavity.

When choosing the appropriate sizalation for your house, avoid a decision based purely on price. Use a heavy weight sizalation or Air-Cell rather than a cheap lightweight material. Sizalation is there to protect your walls, so don't sell out for the initial savings, as it could be a very costly decision. Also consider the likelihood of birds damaging the sizalation. If this is likely it may direct you toward Air-Cell or you could protect the exposed area with bird wire.

Roof battens

Roof battens are fixed to the top of the rafters to carry the roofing material. The most common material for roof battens is timber, however the quantity of steel roof battens used is increasing. Ecologically, I would prefer to use plantation pine rather than steel. While I have not heard of it happening, I would not be at all surprised if in the future we see the use of recycled plastic in this application. The dimensions of the roof battens will be determined by the distance between the rafters, the distance between the battens and the roofing material to be fitted. The timber roof battens are generally secured with nails, with the larger battens being secured with 75 mm skew nails, whereas the metal roof battens are secured with screws. The distances between the battens are dependent on a number of things, however this information will be included in the timber specification schedule. If in doubt, contact your building consultant for specific instructions for your house.

Fascia board and tilt battens

The length of the rafters or roof trusses will vary, giving uneven line at their outer extremity. Consequently the outer end of the rafters will have to be cut so that they are all in line and plumb to enable the installation of fascia boards or tilt battens and spouting.

Installing fascia, or tilt battens and eave lining

Establish the width of the eave from your approved plan and mark the top edge of the rafter at each end of the wall with that position at each end of the wall. Fix a string line between the two marks. You can use either a level or a bevel to draw a vertical line from the string line down the face of the rafter. At this line the rafter will be cut off, and the fascia fitted to the cut end of the rafter. To use a level, simply hold the level against the string line in the vertical position and draw a line down the face of the rafter (see Figure 9.3). Using a bevel is less accurate but quicker. Set your bevel to the angle of the plumb cut on the roofing boat. Position the bevel against the string line and draw a line on the face of the rafter. In theory this line will be vertical, in practice it is unlikely but it’s normally close enough as long as the junction of the rafters and the fascia are concealed by eave lining.

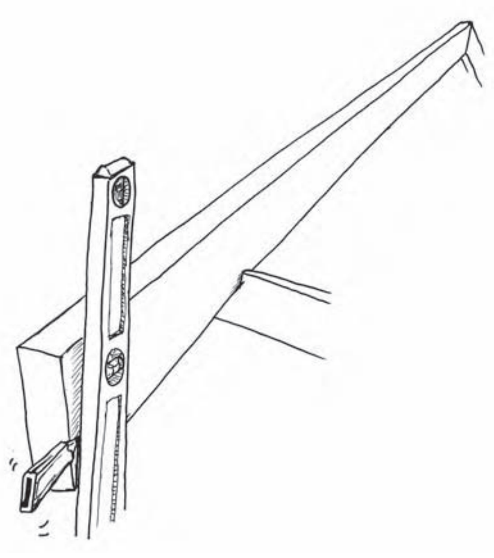


Figure 9.3 Marking the tail of a rafter to be cut in preparation for the installation of the fascia

The installation of fascia

Conventional fascia boards are approximately 180 × 35 mm and might be manufactured from treated pine or oregon. The board will normally have two grooves in the back of the board, however only one of these grooves will be utilised. When the fascia is fitted you will site along the fascia prior to installation and fit it with the bow up. Having the groove on both edges of the fascia allows you to do this and still have access to a groove at the bottom edge of the fascia for the installation of the eaves lining. When cement-sheet type eaves lining is used, the edge of the eaves lining is inserted into this groove.

The ends of the rafters are normally cut plumb and the fascia is attached to the plumb cut of the rafters. Any joins in the fascia are to be supported on timber, either by joining over the end of a rafter or by fitting a nogging between the rafters. Cut the ends of the fascia at 45-degrees so that the joint is overlapped (see Figure 9.4).

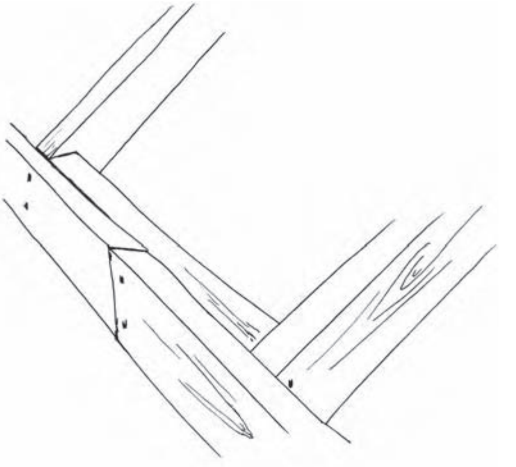


Figure 9.4 Joining fascia over a nogging between two rafters

Framing for eave lining

Additional framing timber is fixed to the rear of the fascia and back to the face of the wall. When constructing a straw bale house you may need to fit timber down from the rafters to support the wall end of the eave framing (see Figure 9.5). The horizontal timbers (soffit bearers) in the frame for the eave lining should be fitted at no greater than 600 mm centres, and should be positioned to suit the lengths of eave lining you have purchased, so that the ends of the sheets join on timber.

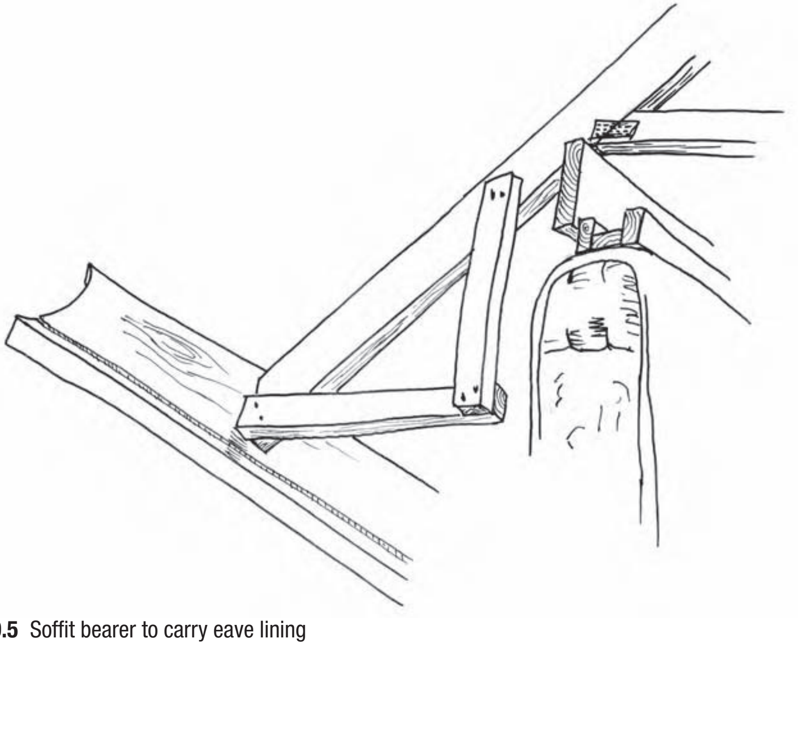


Figure 9.5 Soffit bearer to carry eave lining

Eave lining
To fit the eave lining, first insert the sheet into the groove in the back of the fascia, then swing the lining up against the framing timber and fix with soft sheet nails – a small flat head nail designed specifically for the job. You can use the 'H' section plastic joiners to join the sheets of eave lining, however I find it quicker and easier to use small timber cover straps that can be nailed on with a small nail gun if you have access to one.

Timber framing for eave lining
When constructing a straw bale house it is highly recommended that you have extra wide eaves or roof overhang. I have known of houses with eaves of 700 mm wide, however I would recommend 900 mm or, even better, verandahs. Depending on the dimensions of your rafters, they may or may not be capable of supporting eaves of 900 mm without aid. In this instance a horizontal section of timber will be fixed to the straw bale wall, either by using pegs or by tying the timber in place by threading twine through the wall and tying the twine on the opposite side of the wall. You will gain a much more secure fixing of this timber if you go to the trouble of checking the timber into the bales. Use your brush cutter/trimmer to make the check out in the wall to accommodate the timber, which should be fixed in place prior to any rendering. The soffit bearers will be cut to fit firmly between the back of the fascia and the horizontal timber fixed to the wall.

Tilt battens
One of the primary purposes of the fascia board is for the installation of spouting to carry the water from the roof. Spouting, sometimes referred to as guttering, is to be installed with the back of the spouting to be held in a vertical position. With a few exceptions, the upper edge of the spouting is flat and needs to be supported along its length with timber. This timber can take the form of fascia or a tilt batten. A tilt batten is a piece of timber cut along its length at an angle that enables it to be fixed to the rafters providing a vertical face at the extremity of the rafters onto which the spouting is fitted (see Figure 9.6).

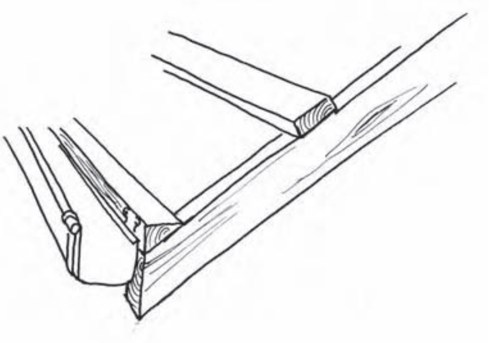


Figure 9.6 A tilt batten at the tail of the rafter as an alternative to fascia

Roof cladding

The most common forms of roofing systems include metal sheeting, roof tiles and shingles. There are many other forms of roof cladding such as thatched roofs and living roofs that will not be covered in this text. The material and shape of the roof cladding will determine the minimum grade that the roof can have. Metal roof cladding can generally be fitted at a much flatter grade than roofing tiles and shingles. Within metal roofing, the deeper the profiles, the flatter the grade that the material can be installed upon. Speak with your building consultant or engineer to ascertain the appropriate material and profile for your house design.

Roof material when harvesting the roof water

The first thing to consider when deciding on the roofing material is what is the likely use of water harvested from the roof. For example, if the water is for human consumption, would the water be suitable if harvested from a roof of timber shingles? Will the shingles taint the flavour of the water or introduce more dirt than an iron roof? Is your roof cladding likely to discharge chemicals into your water supply that might be detrimental to your health? By what means will the harvested water be transported to water storage areas?

PVC pipes considerations

PVC pipes to transport water to storage tanks are cheap and easy to fit, but is their use wise? I have heard mention of possible health risks in the use of PVC pipe, with it suggested that this product releases toxins that you would refuse to let your neighbour's barking dog consume. If this is true, what of all the houses with what is known as a sealed water system where the water lays in the pipes in the ground up to the height of the inlet to the tank. With a sealed system, water sits in the pipe line up to the level of the discharge pipe into the tank. Consequently the pipes at the house and under the ground are always full of water up to the level of the discharge outlet into the tank (see Figure 9.7).

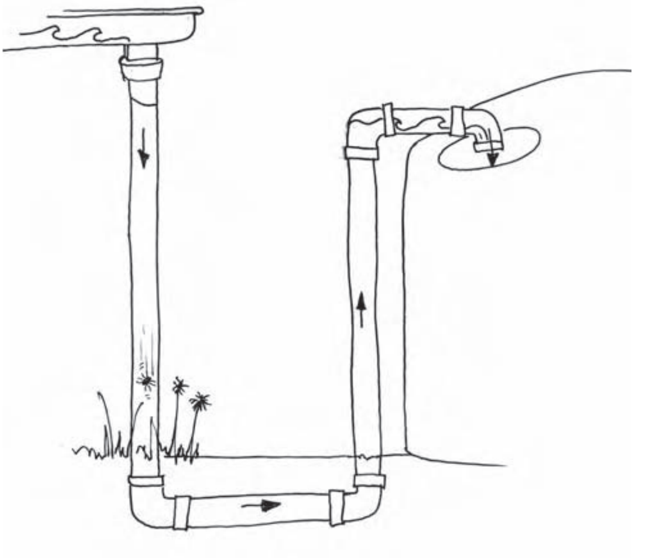


Figure 9.7 Sealed PVC water transport from the roof to a water tank

Variations in metal roof profiles

Metal roofing will vary in profile from one manufacturer to the next. Unless the supplier is simply a reseller, they will have their own equipment to roll the flat sheet that is supplied to them in coils into the shape that you purchase such as corrugated iron; commonly known as custom orb.

Roof shingles

Roof shingles may be in the form of a tar-based product, cement sheet, slate or timber. The most common timber shingles are made from western red cedar, however there are many examples of early buildings with shingles made from local hardwood (see Figure 9.8).

You will note that this property (see Figure 9.8) has at some point had corrugated iron fitted over the top of the timber shingles to provide a more watertight roof.

Figure 9.8 Derelict building in Malmsbury, Victoria, with Australian hardwood shingles

Flashing of roofs to straw bale walls

First and foremost I must remind you that the greatest enemy of straw is water. If you must have a straw bale wall down onto a lower roof area it must be well sealed and frequently inspected for any surface erosion from the impact of splashing water from the roof. The flashing detailed below has been designed specifically to reduce the splash back of a horizontal roof, while allowing some height in the flashing to further reduce the splashing up the wall (see Figure 9.9).

As previously mentioned in the section on noise from rain and hail on roofs, the greater the pitch of the roof the greater the diversion of the impact of the water as it strikes the surface of the roof. The steep grade of this flashing is designed to draw the splash of water at the impact of the rain on the face of the flashing down the flashing, rather than vertically up onto the face of the wall. This is not a flashing to solve all the problems of this application. Careful consideration of your application should be taken into account and the necessary adjustments and specifications as to installation on your property are a must. You will no doubt note that the drawing shows a section of cob over the face of the flashing. It would be possible to install wire netting in this application, however I prefer the installation of cob, as it can be moulded to the required shape without having to fight the bent shape of wire netting. The clay content of the cob holds well to the face of the metal flashing when it is coated with appropriate adhesive and coarse sand.

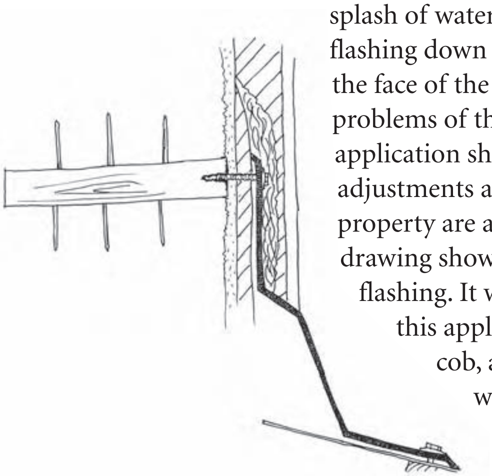


Figure 9.9 Roof flashing from a vertical straw bale wall to a sloping roof

10

Installation of windows and sliding doors

Components of a window

Figure 10.1 illustrates the main components of a window.

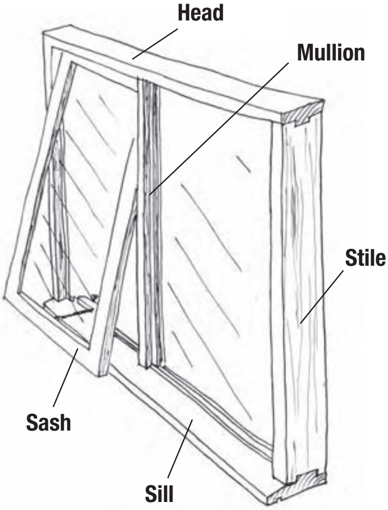


Figure 10.1 Awning window

Two sources of moisture penetration around windows

It is paramount when installing windows and external doors to give thorough consideration to the prevention of moisture into the walls about the windows. This moisture can enter in two forms, either as liquid or gas that condenses. In my opinion, the latter is the more dangerous of the two. Installing the windows in line with the external face of the wall will reduce the amount of horizontal or semi-horizontal render, which is the most vulnerable to degradation by the weather.

Preparation of windows and doors prior to rendering

To gain a better fixing of the render to the windows I recommend that all surfaces of the windows that are to be coated with render, whether aluminium or timber, be coated first with a mixture of coarse sand and adhesive. The type of adhesive might need to be varied in accordance with the surface on which it is applied, however I find that Bondcrete® is most often appropriate. When fixing to metal, construction adhesive would be a good alternative.

Fixing the window into a wall

In conventional construction, windows are fitted with four 75 mm nails through the stiles of the window (see Figure 10.2). In some instances it may be appropriate to add fixings to the head of the window, however under *no* circumstances should timber windows have fixings penetrating the window sill.

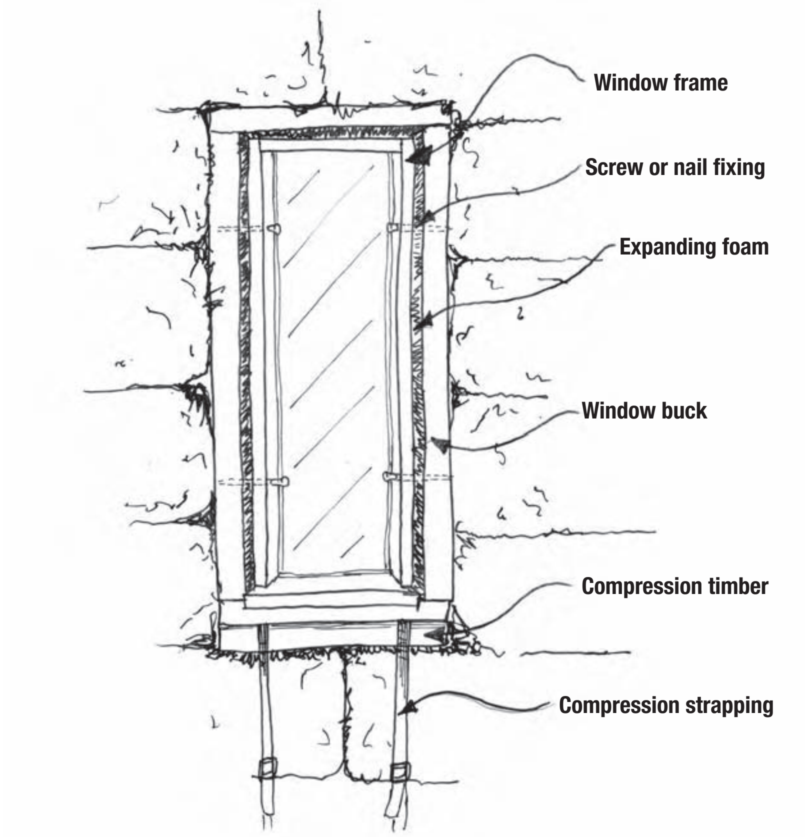


Figure 10.2 Fixing a window into a wall

Unless otherwise specified by your engineer, the same fixing method should be used in straw bale construction. If you choose to insert foam into the cavity between the window and the window buck this will add significant strength, as it not only bridges the gap, but forms a mechanical connection between the two surfaces. The installation of the foam shall be covered in more detail later in this chapter.

Protection of windows from render scratches

In conventional construction the plastic shrink wrap is often left intact until the house is completed, bar a few holes to allow the installation. This does not present a problem in standard construction however it is not advisable for straw bale construction. It is important in straw bale construction to gain a good joint between the render and the window, and this is not possible if the window is encased in plastic.

If render gets on the glass you will almost certainly end up with damaged glass. While it is likely that damage from the effects of lime might be able to be polished out, the deep scratches that you will get from the sand in the render cannot. There are two approaches to this: protect the glass; or fit the glass to the windows after the rendering is complete.

If you have chosen to install aluminium windows the option to install the glass after the render is of little benefit, as you will also have to protect the aluminium from damage.

There are many timber window companies that will fit the glass into the frames after they are installed, however this will increase the total cost of the windows.

A paint-on glass protection product

A recent edition of the members' magazine from the Master Builders Association had details on a product called Protect-A-Window. I have not yet had the opportunity to try the product on site but will do so as soon as possible. They send an installer to the building site once the windows have been installed and apply a removable film to the glass. In the case of aluminium windows the film is also applied to the aluminium but not the rubber seals. Once the house is completed, the film can be peeled off (see www.protectawindow.com.au).

Windows and condensation

Vapour entering the walls

We shall first of all deal with the issue of vapour entering the walls, which condenses, causing an increase in the moisture content of the walls. Regardless of the type of construction, this is a significant issue that needs to be dealt with. As we go about the normal process of life within our homes we are producing vapour which has to go somewhere. The gaps around the windows are one of the prime areas for this vapour to escape to the outside world. The normal installation of windows leaves a cavity of open air between the window and the frame of the building, which provides a path for the concentrated flow of the vapour to the outside. As the vapour hits the cold air in this cavity it condenses, causing water to lay on the base of the frame supporting the window.

The amount of vapour and climate

The amount of water that collects in this area is dependent on the climate. Areas that are exposed to severe frosts or extremely low temperatures are more susceptible to this problem. During my 30-plus years as a builder and carpenter I have, on many occasions, found window sills in the frame of houses that have deteriorated as a consequence of water laying in this area. A number of years ago I owned and operated a window replacement business in Melbourne; it was not at all uncommon to see the frame supporting a window rotted out when the flashing of the window was still intact. The fact that the window flashing was still intact would, in theory, mean that the rot had not been caused by water passing by the window to the frame, as the flashing prevents that. This is particularly so with older buildings, as they have much heavier metal flashing than that used today.

If this is a problem for conventional construction, how much more of a problem is it for straw bale construction?

Prevention of condensation around windows

The solution to preventing condensation around windows is to fill the cavity to reduce the potential marriage of the moist air and the cold air, which brings about all those little baby droplets of water. This can be done to some degree by installing bulk insulation, such as slivers of fibreglass insulation, however I would recommend the installation of a foam fill. There are numerous manufacturers of spray-in foam products, which are supplied in pressure cans and are available from most good hardware stores. You will be surprised how far a can of foam will go, but it still warrants checking up on the cost of different products. With most brands of foam, you will have greater growth if the area to be filled is dampened prior to the installation of the foam. It is also important that the can is warm in order to gain the potential yield from the can. Read the instructions prior to using the product, as incorrect use can reduce your yield by up to 50 per cent.

I have seen two different manufacturers with cans that yield very similar quantities of foam; one retailed at just over $5 while the competitor's product was over $20 (2005). Apart from the insulation benefit, foam has other attributes that I shall cover shortly.

Filling the cavities caused by the rounded end on the bales

If the foam is used to fill all cavities between the window frame and the window buck of a straw bale house, this will prevent the possibility of moist air condensing in this area. Needless to say, the connection of the straw to the outside of the window buck is the next most vulnerable place for this problem. The ends of a bale of straw are not perfectly flat, but to some degree rounded. As a consequence, the bale will be tight against the timber in the middle section of the bale, but it is likely to have a small gap at the upper and lower sections of the bale end. This can be easily overcome, either by trimming the end of the bale to allow the bale to partially encase the window buck where you have a centrally located buck that is narrower than the distance between the twine, or by filling the cavity. The cavity can be filled by forcing straw into it, and/or by filling with cob: a mixture of straw and wet clay. (Refer to the chapter on straw bale walls for further details on cob.)

Control of liquid water on or about the windows

House design to reduce water penetration at windows

The control of water should be the primary objective when installing windows and external doors in straw bale walls. Ideally a straw bale house would have verandahs protecting the walls from rain, however, this is not always practical and often does not meet the aesthetic design requirements. While it might not be possible to build with verandahs, I believe that it is inappropriate to build a straw bale house without significant roof overhang (known as eaves) to protect the walls. A common verandah width is 1.8 metres; I have heard it said that this will negate any issues with water around windows, however this is far from the truth. Even if the verandahs are three metres wide, this alone is insufficient to prevent water penetration about the windows. The building code requires that all windows be sealed against water penetration. Apart from water penetration as a consequence of rain, you must remember that at some stage in the future it is a possibility, however slim, that someone might actually wash the windows. This is not a common issue in our house, but it does happen. Normally just before we sell the property.

Understand the path that water travels

When considering your options for sealing the windows from water penetration you need to keep in mind the path that water is likely to take. Your prime objective is to keep water out of the building. If you are checking construction systems with conventional building you must understand all the relevant issues before adopting an application method from a different building system. Brick veneer houses have water discharged from window flashing into the cavity between the bricks and the timber frame. The timber frame is wrapped with builder's paper, a product not to be confused with sizalation. This prevents water discharged from the flashing entering the timber framing section of the wall. Furthermore, there are small holes in the bottom of the brickwork to allow any trapped water to escape and there is significant airflow between the timber frame and the brickwork to dry out any moisture present.

One of my owner-builders took note of the flashing of windows for a brick veneer and tried to apply the same method to his straw bale house. If he had chosen to emulate the flashing of windows on a weatherboard house he would have been OK: however the principles which apply to a brick veneer cannot be applied to a straw bale or weatherboard house.

The result of not understanding the path of the water

It was about three years ago that I received the call, as this owner-builder was having difficulty working out how to hold bales in position over a large window opening. He had not called with regards the control of water around the windows, only regarding the securing of about five rows of bales above a wide window. He had employed the services of other consultants but had been unable to resolve the problem. On inspection of the property, I was somewhat concerned to notice that he had installed heavy black builder's plastic on top of the bales beneath the window extending down the wall, covering one of the three bales beneath the window. It was proposed that wire netting would be laid over the plastic, which would prevent the render from sliding off the plastic. He had fitted aluminium flashing to the bottom of the window, which is the conventional form of flashing, however the flashing was resting on the black plastic. The render would be applied over the top of the plastic with the exposed end of the flashing being covered by the render, as he did not want to see a silver line of flashing beneath his window.

I could understand his motivation, as I too dislike the appearance of flashing against a beautiful natural rendered wall. The problem was that any water captured by the flashing would run down the flashing onto the black plastic, which would in turn run down the plastic onto the exposed straw bales below. It would take a considerable amount of water to reach the bales, as the render on top of the plastic would absorb the water, although it is possible. The initial problem would be that the render would become sodden and soft. The render would have been above the flashing and therefore against the underside of the window sill which would no doubt lead to the early demise of the window sill. All in all, this was not an ideal treatment of the window area. It was admirable that he had taken the time to investigate the installation of windows in conventional construction, but unfortunate that he did not understand all the implications of applying this method to straw bale construction.

Window flashing in conventional construction

In conventional construction builders are required to seal the bottom and sides of all windows to prevent water penetration. The conventional method of sealing is by using aluminium or plastic flashing. While in the window replacement business we developed a method to seal the windows without the use of such flashing down the sides of the windows. The conventional method of flashing the sides of the windows to be installed in a completed house would require the removal of the external cladding, as flashing has to be fixed not only to the window, but also the face of the house frame.

In many instances this cladding was in the form of brickwork, the removal of which was not financially viable, to say nothing of being extremely undesirable. The opening for the window in the timber frame of the house was always greater than the overall dimensions of the window to be installed, so we had little difficulty sealing this space with foam fill once the window was fixed in place. This achieved the same end results as the flashing with the added benefit of preventing heat loss and drafts around the window. In the majority of houses, if you hold your hand against the architraves around the window on a windy day you will actually feel the cold air forcing through the cavity between the window and the frame.

Conventional building flashing in straw bale construction

There are several conventional flashing products on the market. You can purchase rolls of black plastic flashing in various widths. This is the same product that is used between courses of bricks as a moisture barrier. There is also aluminium flashing which is silver, or a plastic flashing with a core of aluminium within it. This enables you to bend it to the required shape so it holds its position. With straight plastic flashing there is little you can do to alter the position that it naturally sits in.

The flashing is to be installed across the width of the window without joins, as joins would provide an avenue for water to bypass the flashing. The flashing is fixed to the internal face of the window with a turn up of approximately 10 mm (see Figure 10.3A). The side flashing will be fixed to the internal face of the window in the same manner as the sill and then brought through the cavity between the window and the window buck or frame to the external face of the buck (see Figure 10.3B). The lower end of this flashing is to be enveloped by the sill flashing so that any water captured by the side flashing is discharged into the sill flashing, which is in turn discharged out of the structure (see Figure 10.3C).

Discharge of water

When using conventional flashing its discharge point must be onto the external surface of the render, not beneath the render. This will allow any water to flow freely away from the

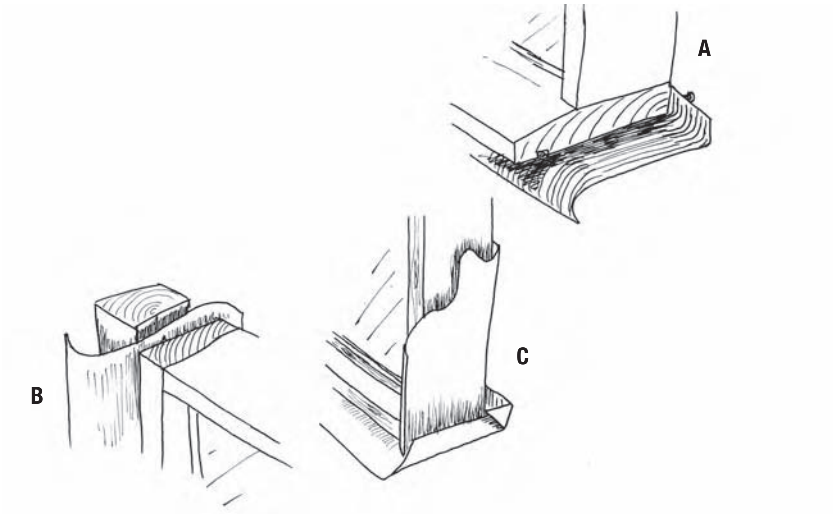


Figure 10.3 A side flashing for a timber window. Note that the sill flashing is to envelope the side flashing at their junction

window (see Figure 10.4). At the sides and top of the window it is important that the render form a good seal to the timber, as this too will inhibit water penetration. This can best be achieved by painting on a mixture of sand and adhesive to the surface of the window that will be covered with render. This might be as little as 10mm of the face of the window. I have found a mixture of Bondcrete® and coarse sand works well. It is ideal if this is applied to timber windows prior to painting them, however it will hold to painted surfaces. I have even found that it will hold to metal surfaces. Alternatively, use construction adhesive and sand.

Water can flow uphill

The window sill has a groove cut into its underside approximately 6 mm from the front edge of the window sill (see Figure 10.4). This is known as a drip line. This is to prevent water flowing back uphill under the window sill which would cause the window sill to rot out prematurely. Most people think that water doesn't flow uphill, but I assure you it does, as I will demonstrate shortly. For this reason, you should also ensure that the sill flashing is shaped to cause the water to discharge. If the end of the flashing is not turned down, the water may run back below the flashing, much the same way as it would the window. This method of flashing has some serious shortfalls as it leaves the cavity between the window and the window buck or frame open to condensation, which was covered earlier, and will definitely cause

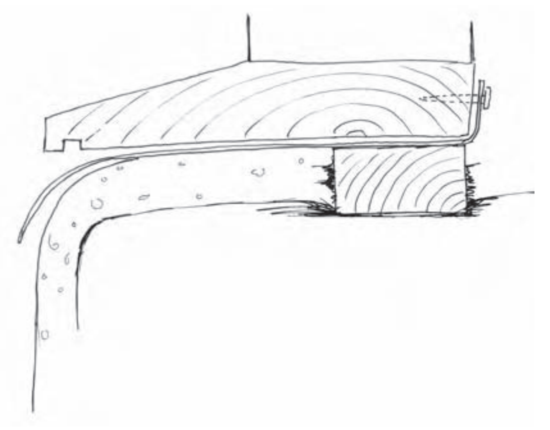


Figure 10.4 Sill flashing fixed to facilitate water discharge onto the external face of the rendered wall below the window

unwanted heat and airflow. Installing the flashing loosely could reduce the negatives, as bulk insulation could then be fitted between the flashing and the window buck. While this would reduce the problem I personally prefer to leave this application method to the brick veneers and weatherboard homes.

The water that flowed uphill

Back in the eighties, the owners of a house in Adelaide contacted me somewhat distressed as there was trickle of water running down the inside of their lounge room wall. Not a lot of water, but water just the same. It had not at this point done any notable damage, but obviously could not be left unchecked. The relative lounge room wall was virtually in the centre of the house, and as this was a new iron roof I was somewhat at a loss as to where the water could be coming from. I started my investigation at the water discharge point. I looked in the roof immediately above the point where the water was coming down the wall, but there was no water present, nor any sign of water having been in that area.

We determined that the problem only occurred after light rain, and that it was not until a good deal of time after the rain started that the trickle of water in the lounge room occurred. The fact that the problem only occurred during light rain gave direction, as this is a telltale sign of water flowing uphill by cohesion. The back section of this house had a reasonably flat roof, which could contribute to the problem, however this was nowhere near the point that the water was running down the wall. We set up a soaker hose (a type of garden sprinkler) on the roof to emulate the falling of gentle rain. We quickly discovered that the water was not discharging cleanly from the end of the iron into the gutter.

In one place only, the water was running under the edge of the iron and following the rib of the iron back into the roof cavity. It followed the iron slightly uphill for about two metres and then dropped down onto the sizalation. It gathered there until sufficient water was built up to reach a hole in the sizalation. From that hole it fell to the ceiling, which was about four metres from the trickle down the lounge room wall. Unfortunately, the water was dropping onto the ceiling at the junction of the cornice to the wall. The water then ran around between the wall sheeting and the cornice until it found a tiny hole in the cornice adhesive, which happened to be immediately above the trickle line on the lounge room wall.

I had been unable to see the water from within the roof cavity, as the ceiling sheets just happened to extend almost all the way through to the wall sheets thereby concealing the top of the cornice. The solution was simple. We bent the end of the iron down thereby increasing the pitch of the roof at its very end. The water would then discharge off the iron with greater speed. Furthermore, the increased angle at the end of the iron was too great for the water to flow back up. So you see, water really can flow uphill!

Installing timber architraves to seal the sides and top of timber windows

The sides and top of timber windows that are fitted at the external extremity of the wall can be sealed by fixing timber architraves to the face of the window which then extend across the face of the rendered wall (see Figure 10.5). This should be fixed in place after the second coat of render has been applied so that the straw below the timber architraves is completely sealed. Again the surface of the architrave should be treated with the glue and sand mix to reduce the likelihood of separation cracks between the timber and render. Apart from being unsightly, the separation cracks between the timber windows and render are likely to cause a thermal bridge in the walls, allowing heat transfer as well as the possibility of water penetration.

This system is similar to that of the window treatment of a weatherboard house with one variation. The horizontal architrave at the top of the window in a weatherboard has metal flashing fixed to and over the front edge of the architrave. The other end of the flashing is then tucked under the lower edge of the weatherboard above, giving it a total weather seal. This is not the case with straw bale construction. With straw bale construction the joint of the render to the top architrave will be relied upon to seal the junction. While I am confident about the stability achieved by the application of sand and glue at the junction of timber and render, it does have limitations. I feel that it would be irresponsible to suggest that this seal would be sufficient to turn away water if the seal were of a horizontal nature (see Figure 10.6). If, however, the render were to extend over the face of the architrave, this would dramatically increase the likelihood of success (see Figure 10.7).

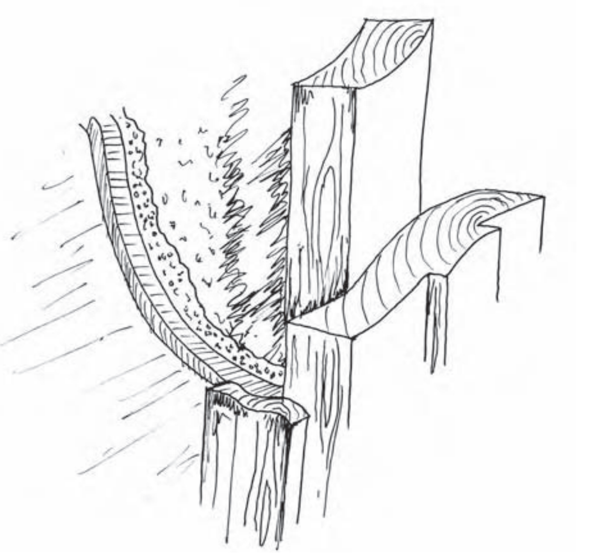


Figure 10.5 Architraves at the stile of the window to conceal the junction of the window and the render

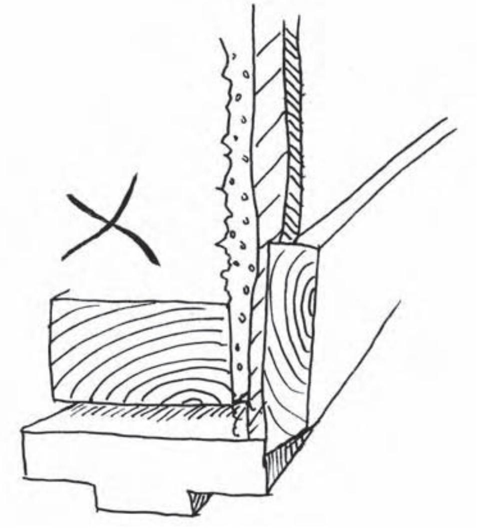


Figure 10.6 Render that finishes on the horizontal surface of a window head architrave is likely to result in deterioration of the render at that junction

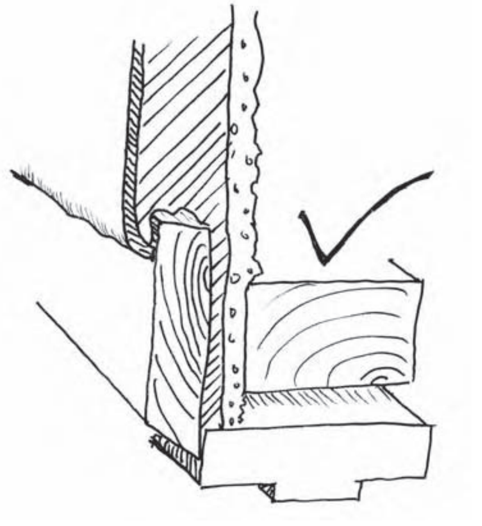


Figure 10.7 Render that finishes on the vertical face of the window head architrave will discharge water cleanly from the render

This flashing system is a dramatic improvement on the use of conventional flashing as it enables you to fill the cavity between the window and the window buck or frame. This can be done by inserting straw, cob, bulk insulation or foam into the cavity thereby reducing the likelihood of thermal bridges and condensation between the window and the window buck.

Foam fill sealing of windows

Following my experience with the use of foam to seal windows in existing houses I have no hesitation in putting up the use of foam to seal windows in straw bale houses as the best option.

As detailed in Chapter 5, the window buck should be built with an opening 40 mm greater in height than the overall height of the window. This will allow a 30 mm gap for the insertion of the compression strapping and two coats of render. The two coats of render will run from the inside to the outside of the wall beneath the window (see Figure 10.8) leaving 6–10 mm of space between the underside of the window and the surface of the render. This in itself provides an extremely good seal of water to the bales if for some unforeseen reason the window sealing did fail.

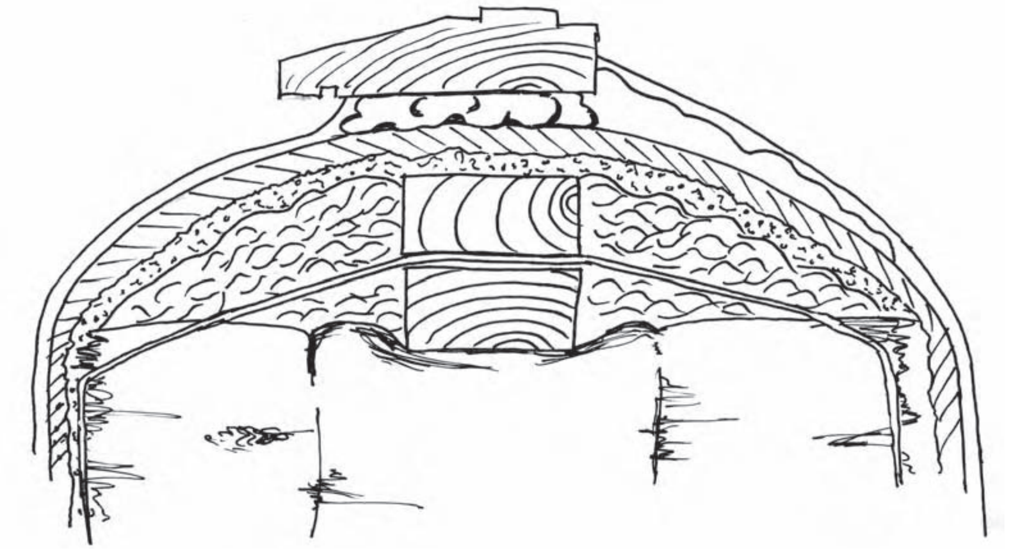


Figure 10.8 Expanding foam sealant in the installation of a window at its sill

Fit windows after the second coat of render

You will probably find it easier to install the window following the second coat of render, however this is of little consequence and entirely up to you. Might I add at this point, you will gain a better fixing of the render to the window buck if the timber is treated with the glue and sand mix. If after applying the first coat of render you are dissatisfied with the shape, you may wish to build up the shape of the window sill with cob prior to the second coat. This should not be done until the first coat of render is dry (see Chapter 11 on rendering).

Render process for windows
Apply additional render or cob after the window is installed prior to the final coat of render.

The final coat of render should be no more than 10 mm but ideally 5–6 mm. Given that you will not gain much in the way of shape around the windows from the final coat of render, any adjustments to shape should be made prior to the final coat. If you use cob to do this, it will hold its shape more easily than straight render, particularly if you need to add much depth to the area, as it is less likely to slump than straight render. Not only will you gain the shape you desire, but it will also add strength and stability to the general area.

You will not see the foam after the application of the final coat of render, as it too will be coated with 5–6 mm of render. It should be noted that the ideal installation of windows is at the external face of the wall, however this is one method that will work for central or internal mounted windows. Special monitoring of window sills is essential after the completion of the house when windows are not fitted level with the external face of the wall.

Installing aluminium windows

Aluminium windows can be purchased with or without reveals. The reveal is the piece of timber that you see from inside the house. The reveal is likely to be held to the window with staples through a fin which is part of the aluminium profile. The exact shape of the aluminium profile may vary a little, however the presence of this fin should be insisted upon. When rendering, the render is applied across the external face of the fin thereby providing a weather seal at the sides and top of the window (see Figure 10.9). The render at the top of the window should finish just proud of the top of the window so that water is discharged across the face of the window. Consequently, no water will be permitted to soak into the render, which may result in water gathering on top of the window in front of the top fin. Many aluminium windows have a plastic or nylon flashing strip at the base of the window which will also assist in discharge of water onto the face of the render.

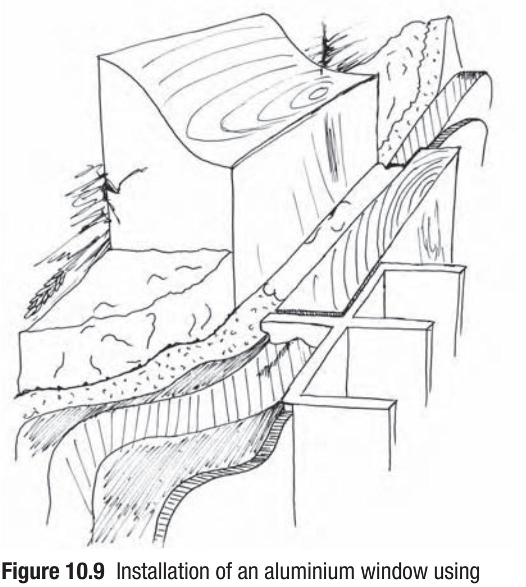


Figure 10.9 Installation of an aluminium window using expandable foam sealant

I would highly recommend the use of foam in these installations to increase the seal of the window to the reveal. The installation of the window should follow that detailed for the installation of timber windows with foam fill.

11

Render for straw bale walls

Earthen render

The basic ingredients of earthen render

The simplest earthen render would be made up of a mixture of clay and sand. There are a range of things that might be added to this for aesthetic appeal and function.

In our home in Heathcote the render for the internal walls is made up of clay, sand and chaff. We used white sand with white clay, so the chaff has given us a natural oatmeal appearance, which is very soft to the eye. It warrants mentioning at this point that earthen render is much more workable than cement render. To apply 10 mm of cement render is a challenge, as it is inclined to slump and come away from the wall. The application of 40 or 50 mm of earthen render is possible as it is less inclined to slump, as it is quite sticky. The application of render in multiple thin layers is preferable to the application of a thick layer, which is much more likely to crack as it dries. I shall cover this in more detail shortly.

The third and final coat of render at Heathcote is a mixture of white sand, white clay and a little lime. The lime was added to increase the render's resistance to the weather and to give us a whiter white on the outside walls, for the appearance we were after without having to go to the trouble of white washing.

There are numerous other additives that can be put into the render including linseed oil, cooked flour glue, cactus juice and cement to name but a few. The only one that I would definitely advise against would be the inclusion of cement. I would not personally consider render with the inclusion of any cement to be an earthen render. The inclusion of cooked flour glue and linseed oil is primarily to reduce dust at the surface of the wall, which I might add is not a problem in our home. While the inclusion of linseed oil can help with dust, if included in the wrong ratios it can cause delaminating of the third coat of render from the second. Therefore, I must emphasise that the only solution is: test, test, test and test before you even think about putting it on your walls.

What we are looking for in a good earthen render

Trial and error

Trial and error testing is essential when establishing a good earthen render recipe. The development of an earthen render is, to a large degree, a process of trial and error. No matter how good your theory, the proposed render must always be checked on the wall. If I am ever accused of nagging, this will be the subject. I cannot emphasise strongly enough that there is no other way to truly know if your render is going to work. It is devastating to work for days or even months applying render only to be told that it must be removed. It might seem like a waste of time to mix test renders, but it is the best time investment you will ever make. You don't have to mix a barrow full to test a recipe, simply use a jam tin or jar so that the quantities added to the test can be accurately measured for duplication when mixing for application to the wall.

The basic theory

The basic theory of mixing render is that if the render cracks you need to increase the amount of sand; if it crumbles, increase the clay content. You will also find that the inclusion of chaff, hair or other fibre will also help reduce cracking.

I recommend that you initially make up six test renders with small variations to what you suspect will be the correct recipe. Make sure that your tests are of similar consistency to that which will be applied to the wall. If the test is much drier it is likely to give you a false result. If you will use a render pump to apply the render the mix will be significantly wetter than if the render is applied by hand. We would all like to hit the perfect recipe first off but this is rarely the case, as there are so many variables. Before you start this process be prepared to test again and again. To simply choose the best of your first six tested recipes may not be an option. You might need to do another six and even more. Remember, it is the render that you are relying on to keep your bales dry and keep the weather outside. If you are willing to live with the effects of the weather inside, it is a lot easier to erect a tent than to build a straw bale house. There are no short cuts to producing a good render!

Test the render

When testing for the first coat of render, it is to be applied to naked bales of straw just as it will be to the wall. If the render is to be applied to the wall by hand you will wet the bales prior to spreading the render. If the render is to be applied with a pump you may not have to pre-wet the bales. The test recipe for the second coat of render will be applied over the approved first coat of render, and the third coat applied over the approved second coat of render. If this is not done you are likely to gain a false reading and end up with an unsatisfactory result. The first coat of render is to stick to the straw like poop to a nappy. This is the key into the straw; the bond that the rest of the render will rely on. When dry it is to be strong and not crumble, it will most likely crack, however this is of little concern, as the cracks will actually assist the adherence of the second coat of render.

You can use the same recipe for the second and third coats. Each test should include a section approximately 10 mm deep and another section 20–30 mm deep. I test this recipe with what I call a hose test, which is simply to squirt a jet of water at the area with a garden hose to monitor any surface erosion. When applied at 5–10 mm thickness it should dry without cracking and should be resistant to weather erosion.

An actual case of delamination of the top coat of render
I recently attended an owner-builder's property where the top coat of render had delaminated from the second coat of render. Furthermore, the second coat of render was failing under the pressure of weather exposure thereby exposing the first coat in some places. In the excitement of getting the bales sealed the frustrating process of testing renders was skipped for it was assumed that their theory was right, so why waste time. You can only imagine the disappointment when the render started to come away from the walls. The testing of the proposed render may well have eliminated this problem. Because the render was failing, it was not simply a matter of applying another coat over the top, for the strength and stability of the render is reliant on its adherence to the previous coat all the way back to the straw. As the saying goes, 'a chain is only as strong as its weakest link'. Fortunately the first coat was terrific so it was not quite as bad as it could have been.

I took the participants of a recent workshop to see this property and was somewhat surprised at their response. I was showing them the property to press home the point that it is essential to stick to the rules when doing the rendering or you will suffer the consequences. Several people expressed to me that this was one of the key things to give them confidence to build a straw bale home. They explained that in their mind one of their greatest concerns was whether they could get the render right. This house was the epitome of their fear and it would only take two or three days to fix. There were no walls to be pulled down and less than $1000 (2005) to rectify the problem. In their mind, if the worst that could happen could be overcome in a few days, then what was there left to worry about.

The use of your soil for an earthen render

The soil on your property will vary

Many straw bale houses are rendered using the soil from the property. This soil may have been recovered from the excavation of the building site, or even from digging a dam for water supply. The primary thing to understand about your soil is that it may well vary. The depth that the soil is below ground level and the locality on the property will both have a bearing on the material you have to work with. This is not a problem, but you will have to keep an eye on the results you are getting. While your tests may indicate that you have a render recipe that does not crack or fail, it is possible that this could change with unnoticeable variation in the material you put into the render. If you find that the render is beginning to show signs of cracking, it is not necessarily that the initial render recipe has not been followed or that it was wrong, but that the material used has changed.

Testing your soil for clay and sand content
When using the soil from your own property you will need to test it to ascertain the percentage of clay so that you have a starting point for the development of the ideal recipe. Once you have established the percentage of clay from sand, you will add washed sand to the soil to give you a ratio of about four parts sand to one part clay. This is a starting point

only, as the inclusion of silt and the variations in grain sizes of the sand in your soil will all have a bearing on the final mix. Avoid the inclusion of humus and obvious plant matter. To test your soil you will need a straight-sided clear glass or plastic container. A Fowlers bottling jar is ideal. These can still be purchased new, or alternatively, if you monitor the op shops (second-hand or goodwill stores) you will often be able to get them there.

Fill the jar with approximately 70 mm of your soil, which should represent no more than about half the height of the jar. Add clean water to this to about 20–30 mm down from the top of the jar. Shake the container vigorously until the soil is totally suspended in the water. Now let the container stand undisturbed to allow the material to settle in layers. The sand will be the heaviest material, which will settle on the bottom and the clay on the top.

If the soil does not have at least 15 per cent of clay it is unlikely that it will be of much value for an earthen render without the addition of clay. It is worth a try, but you will probably find that when dry it lacks strength and simply crumbles. If it is questionable do not persist, as it will only bring disappointment.

What to do with the soil on your property

The soil from your property that is useable will have clay in it, which when dry will form hard lumps. It is important that these lumps do not end up in the render as they will cause problems, not the least of which is difficulty in applying the render. The soil should first of all be sieved through wire mesh with no more than 6 mm aperture to remove the larger lumps and stones. This will still mean that you are likely to have lumps of clay of up to 6 mm diameter. If these lumps are fed into the render mix and are not completely saturated by water they will cause spotting in the wall.

A case study of using the soil from the site

One of my owner-builders was the first to discover this when he used the earth for his mix after sieving it through a 6 mm mesh. His ideal recipe showed no signs of cracking, however once on the wall it cracked. The test mix was made with fine soil excluding the 6 mm lumps of clay. When mixing the render a percentage of the clay in these lumps was released into the render which changed the percentage consistency of clay to sand, thereby causing the render to crack as the clay content was too high. When he was hard pressed for time he rushed the mix through the mixing process which meant that the lumps of clay were not broken down in the mix, thus, he had dark dots across the surface of the wall, most of which had little star-shaped cracks in them.

While the clay did not break down during mixing, it was eventually saturated by the wet render surrounding it, following which it cracked. In this instance it did not cause any major problems, as it was discovered in the second coat of render.

Crush the clay to dust

The solution to this is to feed the soil through a hammer mill to crush all the lumps of clay into dust, although this can only be done if the soil is dry. I have seen a straw bale builder feed the soil through a weed muncher, which worked very efficiently. More than a bit dusty but it worked. I am not sure of the life expectancy of the equipment in this application and I have strong suspicions that this just might be slightly outside of the usage covered by the manufacturer’s guarantee.

Saturate the clay to remove lumps

The other alternative is to dig a pit and soak the soil until the clay is totally saturated within the water mix. This does, of course, mean that you will have to use buckets to transport the wet mix to the mixer when mixing the final render recipe. If this approach is taken it is worth noting that Workcare recommendations stipulate that women lift no more than 16 kg while men should lift no more than 20 kg. This is probably a good guide for lifting what will be an awkward product to handle.

Another approach to producing consistent earthen render

As a conventional builder I was always concerned to have definite cause and effect results in construction. Without this it would be difficult to have confidence to provide a seven-year guarantee on the work performed. It was with this motivation that I set about reducing the variables in render, particularly variables that might occur after the initial decision on recipes was made. I believe that this is probably the prime reason why some builders still use cement render when there is such strong evidence against it.

The variables in an earthen render

The primary variable in mixing earthen render is the percentage of clay in the soil, with washed sand being added to the soil. Because the sand used is washed sand, the effect that it has on the soil of the render is predictable. I have felt for some time that if this variant factor were reduced, that being within the soil, we would have a much more predictable outcome. Consequently, we have approached the development of render from a slightly different angle.

The components forming the basic render are the same, clay plus sand, but we do not use the soil from the property. We purchase brickies sand or packing sand as the base of the render. This sand has a clay content that is removed from the washed sand. To this we add processed clay which can be purchased in 20 kg bags much the same as cement or lime. We have had a great deal of success with this approach for a number of reasons:

1. the amount of clay in the packing sand is much more consistent than that of the soil from a building site, as it is taken from deeper below the surface from quarries and is to some degree processed;
2. the powdered clay is totally consistent;
3. there are no lumps of clay to be broken down either mechanically or by saturation; and
4. the amount of water to be added to the mix is quite consistent.

For those of you that are particularly concerned with ecological consequences, this approach to producing render is not as ecologically sensitive as the use of soil from the site. The quantity of sand will be greater than when combined with the soil from the site, and it has to be processed and transported to the site. Furthermore, the clay is dried, crushed to powder form, bagged and then transported to the building site. This consumes more energy than using on-site soil, however this is a far cry from the energy used to create cement. Personally, while I am concerned about the ecological issues, I am also concerned about the energy exerted by my now 51-year-old body. I know full well that each human body can only withstand a certain amount of neglect and abuse, and evidence indicates that mine is by now well over its quota.

A starting point to develop the sand and powdered clay render

There is still no sure fire render recipe even with this approach, as the clay content of the brickies sand will vary from quarry to quarry so you will still have to make up test recipes. Start with three part sand to one part clay for the first coat and four part sand to one part clay for the second. If you want to add a little lime to the final coat replace about one-third of the clay with lime for the initial test. The introduction of lime is unnecessary in the first coat and is questionable in the second coat. If you are using polyester compression strapping, you should not include lime in any render that comes in direct contact with the strapping, as the strapping is vulnerable to high alkaline materials.

The sand represents the greater bulk of the material in the render, so you should vary the amount of clay for the alternative recipes rather than adjusting the sand content.

Mixing of earthen renders

I have seen people mix the render using a hoe in a pit or even their feet. This would no doubt be a lot of fun on a warm day, although with my family I doubt that much of the render would end up on the walls. I have found that a common cement mixer works well. If you are hiring a mixer it is best to get the larger mixer rather than a small one. This is not like mixing cement. When mixing cement if you add too much cement the primary outcome is a change in colour and an empty pocket. It would end up more brittle but when put into a path, the best place for concrete, it will have little or no effect, as it dries primarily by chemical reaction rather than evaporation. Cement will set under water, earthen render will not.

Consistency in adding materials

The materials added to an earthen render must be consistent. If the chosen recipe is not adhered to you will not be producing the desired recipe but a bastardisation of the recipe, which is likely to fail. It is not sufficient to add shovels full of the different material as this can give anything up to a 30 per cent variation in the mix. You need to take the same approach to earthen render as you do to making a cake. Too much flour and the cake will crack. Too much clay and the render will crack.

Using a bucket

Add material to the mixer via buckets to ensure you have a consistent render. Use a shovel to fill buckets much the same way as filling a cup measure with flour, as this will give you control over the contents of the render. When mixing in a cement mixer you will be able to gauge the viscosity of the mix by watching the paddles in the back of the mixer. Watch to see when the paddles separate from the mix. With render fed through the pump we normally find that it is best when the paddles break from the mix at about the one o’clock position.

Do earthen rendered straw bale walls breathe?

I have often heard that straw bale walls with earthen render breathe. This conjures up pictures of air flowing through the completed walls. This is one of the myths of straw bale construction as it is not actually referring to airflow through the walls but moisture transfer. Maybe this myth was started by someone that had slept in a straw bale building that had not been rendered. When we were building our house in Heathcote, we were living in a caravan on site. Not an ideal situation in the middle of winter. It brings a whole new understanding of condensation produced by human habitation.

Eventually we committed the cardinal sin and shifted into the house before it was finished. I was looking forward to a good night's sleep in what I believed would be a much warmer environment. If you have met me or seen my photo in the owner-builder magazine section titled 'Tips of the Trade', you will be aware that my forehead is much larger than that of many men, but similar to a lot. Hair is highly overrated, but extremely beneficial on occasions. We had one coat of render on the inside of the wall but had not yet rendered the outside. After struggling to sleep with a freezing head I eventually had to find a beanie to wear in bed. The airflow through the unrendered bale wall was remarkable. I am pleased to say that the completion of the second coat of render eliminated this problem and we now enjoy the benefits of a warm straw bale house with all three coats of render.

Moisture release

When people speak of the walls breathing they are actually referring to the capacity of the wall to absorb and release moisture. Earthen render is hydrophilic; that is, it will allow moisture to come and go. Consequently, the humidity produced in the house is able to travel through the wall without affecting the condition of the bales. There is little change in the moisture content of the bales in this process, as the moisture is travelling towards the drier air that is outside. When the humid air gets to the inside of the outside skin of render it is absorbed in to the hydrophilic external render which in turn releases it back into the atmosphere.

Chicken wire on straw bale houses

I would highly recommend that you add *The Natural Plaster Book*, by Cedar Rose Guelberth and Dan Chiras to your research library. This book delves into many issues associated with the rendering of straw bale walls and covers the use of wire netting under the sub-heading of 'Leave the chicken wire in the barn'.

Problems with chicken wire

The use of chicken wire is rejected as a process of benefit in straw bale construction. It can, in fact, contribute to the delaminating of the render from the straw bales. Please note, in speaking on this subject I am speaking only of the application of wire netting to bale walls, as we often use wire netting around window and door openings which is a completely different situation. Chicken wire and metal lath are often used on homes that are coated with cement stucco. For example, it is ideal if an owner wants a rendered finish over old weatherboards or cement sheeting, as this supplies a textured surface for the stucco to bond with. The surface of straw bales has more than enough texture and capacity to absorb render without the use of wire netting.

When applying render to a straw bale house it is essential to get a good bond to the wall. Even when we apply the render with the pressure pump we strongly recommend that the render be worked into the bales with a palm of the hand to ensure this bond. When wire is present it often prevents you from pushing the render into the bales as it is often held away from the bales as it covers dips.

I spoke recently with a straw bale builder who uses a cement lime render on all of his homes. He does not compress the bales, but he does apply wire netting to the face of the bales, which he says operates in his walls similar to steel mesh in concrete. I have no choice but to agree that this works, as he has been building in this way for about 10 years. Even given his success, I would still opt for avoiding the cement render and the wire netting.

If you have ever fitted chicken wire to a straw bale house you will be pleased to discover that not only is it unnecessary but detrimental to the house. The process called stitching is frustrating and time consuming. There is sufficient frustration and time absorbers in building without adding to them. This is a task we are all well rid of.

Earthen rendered walls that were growing

My son Brad was forced to render his house in winter, which is not ideal. The first coat of render was fine, as there was a spell of winter sun with a gentle breeze that dried it out nicely. The second coat of render on the outside of the house presented no problems, however the inside was a different story. It seemed to be taking forever to dry. He had a slow combustion heater inside the house, which warmed the area slightly, but there was little air movement compared to the first coat.

One evening I phoned to see how the family was coping, as they were living in a tent at the time, which was pretty gutsy considering the frosts that we get around here. On inquiring as to what he was up to he responded 'harvesting'. I was somewhat confused by his reply and inquired further as to what on earth he was harvesting at this time of year, as I knew he had not planted anything that I thought would require harvesting. His further response was 'the walls, we are harvesting the green shoots from the chaff that is growing on our walls'.

While the heater did little to dry the walls, it created a perfect environment for the seed from the chaff to germinate. They were cutting the now 50–70 mm long green shoots coming from the walls with a pair of scissors. They didn't want to pull them from the wall as they would damage the wall, apart from the fact that there were too many of them. With the onset of this crop they quickly decided not to do the final coat of render until the weather improved which made it all the more important not to damage the wall.

The various options were considered, one of which was to spray the walls with Roundup (a weed killer), however it was felt that the introduction of this into the home was not appropriate. Instead, we purchased a commercial gas blow heater and cooked the room up good and proper. The shoots soon shrivelled under the heat, although the house was more like a sauna than a house. The condensation ran down the windows like raging torrents but the end result was achieved. This was an expensive business as bottled gas does not come cheap, but it was at least a solution to what was a rather amusing situation. Mind you, I know many owner-builders who would have not been amused at all. Soon after the baking of the render they moved out of the tent, which only days after dropped its side walls as the material broke down, and they haven't looked back since.

Mixing of cob

Cob is a mixture of render and straw. The render used for the first coat is ideal, although it may be necessary for it to be somewhat more liquid as the clay mix should coat all of the straw. Cob can be mixed either in a barrow using your hands to work the render through the straw or in a cement mixer. While cob is predominantly straw, there must be sufficient render in the mix to facilitate adhesion to the wall and smoothing of the surface straw back onto the wall.

Alternatives to hand application of render

The time involved in hand rendering a straw bale house will always be the same. The only way to reduce the time spent in rendering is to change the approach, however this often comes down to budgetary issues.

Length of time rendering

It took four people more than three months to hand render one owner-builder's house. One of my owner-builders employed two people for more than three months to help him and his wife apply the render to their house in a suburb of Melbourne. There were no internal rendered walls, just the inside and outside of the external walls. I must admit however, it was a house of significant size, probably close to 30 squares downstairs, which is the area with the straw bale walls. He was somewhat amused at the speed of rendering when the render was applied to the wall with a render pump.

Contract render companies, all labour supplied

I recently spoke to a company that does contract rendering of straw bale houses about the cost of rendering. They informed me that when they supplied the scaffold, which is normally minimal, and the materials and labour to apply three coats of render, the final cost would be approximately $70 per square metre. My son's straw bale house in Heathcote, which cost less than $22,000 (2005) to build has about 226 square metres of straw bale walls. This does not take into consideration the internal walls of the house, which are also rendered, only the inside and outside of the external walls. At $70 per square metre the additional cost of having the render supplied and fitted would be $15,800 (2005) (it would have taken three days for my son and four helpers, with a render pump). If this fits into your budget it is a great way to go, however, for many people this is not a viable option as the funds are simply not available.

Hiring equipment for rendering

One option is to hire a render pump with a pump operator and supply the additional labour yourself. In 2003 we purchased a render pump from Italy which is hired out to owner-builders with one of our operators. This significantly reduces the cost of applying the render while overcoming the lengthy process of hand rendering. The owner-builders have their friends and family help on the day of the rendering, their task being simply to mix the render and wheelbarrow it to the pump. The pump operator then sprays the render onto the wall whereupon the owner-builder and his assistants simply spread it on the wall in the desired shape.

Depending on the efficiency of the mixers and render spreaders, most houses with upward of 400 bales can be rendered inside and out in a day. At a cost of $770 per day for the pump and operator, this is a sizable saving considering that the house can have all three coats applied over three days which would obviously be staggered to allow drying time between coats. The Melbourne house that took over three months to render would have been completed in six days using the same four people, plus my son Brad operating the render pump.

Installation of earthen render

First or ‘discovery’ coat

The first coat of render is sometimes referred to as the ‘discovery’ coat because as it is a relatively thin layer of render it enhances the shape of the bales as they are in the wall. Render can be applied to the wall manually or with the use of a render pump. The first coat is to be applied to the surface of the straw bale wall so that all the straw is coated in render. This is not the coat of render to fill hollows or blend-in bumps. This first coat is often wetter than the second and third coats, as this makes it easier to force the render into the end fibres of the straw, which is the key to a stable and secure base. When applying by hand the mix, will be drier than pump application as the wetter the mix the more difficult it is to manage by hand.

Wetting the straw bale wall

As with rendering in conventional construction, the surface of the wall must first be wet with a spray of water, otherwise all the moisture will be sucked out of the render by the dry straw and delaminating will occur. When using a render pump, it is often unnecessary to spray the wall with water before the application of the render, as the render is generally much wetter than render applied by hand. Cement render applied to a dry brick wall will fall off the wall within an hour or two, if not in a few minutes, however the first coat of render on straw is unlikely to fall away until the additional weight of the following coats of render is applied. Don’t be fooled into thinking you can get away with it just because the first coat of render is staying on the wall. The first coat is the foundation for the rest of the render and no short cuts should be taken.

Force the first coat well into the straw

Apply the first coat of render to the wall, working it into the straw and going as deep as possible with the palm of your hand. It is essential that you wear rubber gloves for this process, not only to protect you from the drying effect of the render, but also to prevent the straw cutting your hands. Once the render has been worked into the straw, smooth it back over so that there are no deep finger lines in the render. While you are not to fill hollows in the wall with this coat, all the straw should be coated in render and the surface of the straw smoothed off as much as possible. When using a render pump to apply the render, the render hits the wall with some force, giving penetration into the surface of the bales. The render still has to be spread evenly on the surface of the bales, so why not make just a little extra effort and guarantee a solid fixing by forcing it further into the bales while you spread it.

Second coat (infill coat)

The first coat of render should be completely dry before applying the second coat. When dry, you will notice that the first coat of render has cracked, but do not be concerned. The cracks will actually help the second coat of render adhere to the first, as the render is keyed into the cracks. As long as the first coat is not crumbly, you are fine.

The second coat of render

Again, the surface of the wall is to be sprayed with water prior to the application of the second coat of render. Even when using the render pump, we still spray the wall prior to application of the second coat of render. When the wall is not wet prior to the application of the next coat of render, delaminating is likely (see Figure 11.1). This coat of render will be used to form the final shape that you want for your wall. While we call this the second coat, it might well be called the second coat with parts A, B, C, D, etc. as it is often necessary to apply additional layers to form the shape you desire. This shape can also be attained with the use of cob, which I shall discuss shortly.

Figure 11.1 Delaminating of the third coat of render due to incorrect preparation

The second coat of render will be applied with your hands, a trowel or a render pump. Once on the wall, the render will be smoothed out with a trowel. The longer the trowel, the flatter the surface you will achieve. If you are after an almost flat surface you might choose to use a screed across the wall. Screeds vary in length, but you will find a 1.2 metre screed is more than most people can handle. If using a screed it might be necessary to flatten the wall initially with a trowel and then go over it with the screed, adding more render in the hollows with your hands or a trowel.

Spreading the render on the wall

Once the render is on the wall, spread it initially with vertical strokes of the trowel. This action best enables you to apply pressure to the trowel, thereby forcing the render into the cracks and crevices of the first coat of render and driving air out. To flatten the wall, trowel the area horizontally, dragging render from high sections to the hollows in the wall. To remove render from high spots, hold the trowel at a greater angle off the wall as you run across the high area, as this will capture excess render in front of the trowel. When you come to a hollow section of the wall flatten the leading edge of the trowel back toward the face of the wall. This will allow the render gathered from the high sections to be discharged out the back of the trowel into the hollows of the wall. It is important at all times to keep pressure against the wall, as this forces air bubbles out of the render as well as giving a good connection of the new render to the existing wall.

Once you have trowelled the wall vertically, run the trowel across the wall horizontally. It will not be necessary to apply so much pressure to the wall this time, as the render should now be well and truly drawn to the wall. It will, however, be necessary to apply extra pressure if you wish to relocate render that is sitting high to the hollows in the wall. This operation will assist in flattening the wall and remove the trowel marks left by the vertical trowelling process. It may be necessary to repeat this process several times until you are satisfied with the end result. When the render begins to stick to the trowel it is time to leave it alone. Continuing at this point is likely to cause sections of the render to come away from the wall rather than to flatten it. If this happens it is not of major concern, just a little frustrating. Simply fill the hole left with fresh render and go onto the next section.

Filling deep hollows after applying the second coat

If deep hollows exist after the second coat of render it might be appropriate to fill them with cob, a mixture of straw and render. This mix is much more able to fill deep hollows and holes without slumping or coming away from the wall. Once the render on the wall has dried, wet the surface of the wall and apply the cob as required. Force the cob against the wall and smooth it out with long strokes of the palm of your hand. You can apply a thin coat of render over the cob to give a smoother finish, thus preventing the possibility of straw fibres penetrating the final coat of render. Allow this to dry completely before applying the final coat of render. While some builders apply the cob after the first coat of render I prefer to apply it over the second, as I am often able to fill hollows with the second coat, making cob unnecessary. As long as the cob is worked well into the previous coat of render, either application time is fine, it just comes down to personal preference.

Hatching the dry second coat

Hatching the surface of the second coat of render is the key for a successful final coat of render. The drying time for the second coat of render is dependent upon wind, air temperature and the thickness of the render. Earthen render does not set chemically like cement, it dries by evaporation. When the render is what is classified as ‘green’, that is, the render is firm to touch but not yet too hard to mark, you will need to hatch the surface of it. Score the face of the render with marks 1–3 mm deep to provide a key for the final coat of render to lock onto (see Figure 11.2). It is important not to do this too soon after rendering or the hatching will end up too deep. If the final coat of render is applied to a wall with deep hatching you can get discolouration of the final coat of render. Not everyone hatches the surface of the second coat of render, but if your render is of a good recipe, it will resist the penetration of moisture and the accompanying final coat of render. If cracks appear in the second coat of render it is again of little consequence, as the final coat will key into them. Any large cracks should be filled prior to the application of the final coat of render to avoid the risk of discolouration of the final coat.

Figure 11.2 Scoring (hatching) of the second coat of render provides a fixing key for the next coat of render

The third coat or finish coat

The third coat of render is the finishing coat, and should be applied with a depth of 5 mm to 10 mm to avoid shrinkage cracks. This final coat of render should only be applied after the second coat of render, and any cob applied to the second coat of render, are completely dry.

Applying the final coat of render

Wet down the surface of the wall to be rendered and then apply the render in the same manner as the second coat. While it is not essential, if you use a slightly shorter trowel than that used for the second coat of render you will find it easier to trowel the surface without leaving trowel marks. I would recommend that new trowels have the outer end of the trowels ground back with a gentle curve, as this too will help reduce the quantity of trowel marks left on the wall. As per the instructions for trowelling of the second coat, this coat should also be trowelled vertically and horizontally to gain an even surface. Once your render begins to firm up, use long sweeping motions with the trowel held almost flat against the wall and only minimal pressure to smooth out trowel marks.

Finishes of the final coat of render

A more weather-resistant surface

Just as with concrete, if you finish the surface of the wall with a metal trowel it will bind the surface of the render together giving it a more weather-resistant surface. As with concrete, this should be done when the render is quite firm. There is a point in the rendering of the final coat where it must be left alone as the render tends to stick to the trowel. After a while the render will dry that bit extra and yet still be workable at the surface. At this stage you will find that the trowel will again flow across the face of the new render.

If you require a trowelled surface but find it difficult to achieve without trowel marks, cut a piece of plastic into the shape of a disc and remove the trowel marks with the plastic. This is sometimes referred to as burnishing – a process also found in pottery production. The plastic in an ice-cream container works wonders. It can also be used to expose chaff or sand in the surface of the final coat as a feature.

Achieving a soft flowing appearance

If you want a softer appearance, work the surface of the wall with a damp sponge, which will also enable you to remove trowel marks. This should be done when the render is quite firm, rubbing in a small circular motion. If the sponge leaves circular marks in the render the render is most likely too wet. Wait until only the very surface of the wall is affected by the process. Do not render too big an area initially; wait until you establish the finish you are happy with and the timing of the process. Done properly, the end result is a soft, natural, almost cloud-like appearance sought after by many straw bale builders.

Earthen rendered walls may shed

We have found that earthen render walls, once completely dry, may go through a shedding process much the same as a new carpet. This is mostly apparent if the wall has been finished with a damp sponge, as this often increases the amount of sand that sits on the face of the wall. Rather than wait for the shedding process to be completed, it can be sped up in much the same way as using a rotary head vacuum cleaner on a new carpet. Rub the face of the wall with a dry sponge or your hand. If using your hand, it is best to wear a soft leather gardening glove, as the rendered surface will quickly wear away the skin from your hand. In most instances you will be left with a clean, dust-free wall, however, if you are still concerned with the dust I am told a mixture of 15 to 1 of Bondcrete® and water will solve the problem without altering the colour of the wall. This I cannot guarantee, as I have never had occasion to use it.

Cement render

When investigating the possible use of cement render to protect a straw bale dwelling there are a number issues to be taken into consideration. The supporters of cement render claim that it is more resistant to degradation and consequently is a better protection of the bales. It can easily be painted, which from their perspective increases the resistance to moisture penetration into the wall. I agree that cement render is less likely to break down when exposed to the elements than earthen render and it is easily painted, as is earthen render. At face value this presents a convincing argument for the use of cement render, however there are extenuating issues associated with straw bale construction that are not considered in this simplistic approach. There is always the exception, however, which I shall detail at the end of this section.

The characteristics of cement render

Cracks in the render are a concern for straw bale construction, as they provide an access point for water into the bales. In discussing render cracking we are not concerned with shallow surface cracks, called air checks, but we are concerned about potential cracks in the render that penetrate through the full depth of the render. On many occasions owner-builders send me plans and specifications that other draftsmen and engineers have prepared. Many of these have specified cement render and, without exception, have all called for expansion joints. While our engineers would not support the use of cement render on straw bale houses, they hold the position unequivocally that expansion joints would be essential in such a construction.

It is generally known and acknowledged by all tradespeople that cement is quite brittle. I agree that the use of expansion joints certainly does reduce the risk of cracking in the render, but it does not eliminate it. The mere fact that it is necessary to have expansion joints is confirmation of the fact that this type of render is prone to cracking. Some time back I viewed a property in Harcourt, Victoria, that had been rendered with a cement render. The general wall area did not appear to have cracks, however, this was not the case around the windows. Preventing water entry around windows is a challenge in itself, an issue covered in depth in Chapter 10, on the installation of windows. To add to this the problem of render cracking, in my opinion, would be undesirable to say the least.

It is necessary to lay plastic under a concrete slab to prevent moisture from travelling through the concrete and damaging floor coverings, etc. If this is the case for 100 mm plus of solid concrete, it is obvious that cement render will have the same moisture absorbent properties. If then, a cement render were used to eliminate moisture penetration it would be necessary to seal the surface of the render with something like a waterproof paint. It is quite easy to apply such a product, but is this desirable?

Moisture and condensation in conventional construction

The simple process of human habitation produces humidity in a house. As humans we produce a humid environment simply by breathing and giving off body heat, to say nothing of hot water usage, cooking and heating to name but a few activities. Conventional construction homes are now wrapped in builder's wrap rather than standard sizalation. While studying building construction at RMIT (Royal Melbourne Institute of

Technology) in 1973 the issue of condensation and sizalation was discussed at length. There were several houses in the western suburbs that had been wrapped in sizalation to control airflow, which would in theory reduce the energy consumption of the houses. Undoubtedly it did reduce energy consumption, however, that was not the end of the story.

When the houses were still quite new, about two or three years old from memory, it was discovered that there was serious deterioration of the bottom of the external wall timber framing. Condensation from humidity produced inside the houses had condensed against the sizalation and pooled on the bottom plate (the piece of timber that the uprights or studs are nailed to). The bottom plates and the lower section of the studs had rotted and had to be replaced. The roofs had to be supported and the plaster removed to facilitate the replacement of the affected timber framing. Humidity produced inside a house is going to go somewhere. In simplistic terms, warm air caries more moisture and will travel toward the cooler air. Since the discovery of the condensation problems caused by wrapping the house with sizalation, brick veneer and weatherboard houses are now wrapped in a product called builder’s wrap. Builder’s wrap is not a waterproof sheeting, as it is designed to allow limited airflow through the sheeting, thereby reducing the risk of condensation on the inside of the wrapping, which leads to timber deterioration. Obviously, this product is not suitable for installation in the roof where a nonporous membrane (sarking) is required.

Given that the only enemy of straw bale houses is water, I would not even consider trying to seal the outside walls. As the moist air travels towards the colder air outside, the moisture will be trapped within the straw bale wall, which is undesirable to say the least.

Cement stucco

Cement stucco is ideal to give a double fronted brick veneer a new lease of life. Many of the cream brick double-fronted homes of the fifties and sixties have been given a new lease of life with the application of cement-based render. Even weatherboard homes have had a render finish applied to them. Wire netting is stapled to the weatherboards and the cement render is applied over the weatherboards without the added cost of new foundations and brickwork. The wire netting is the key to hold the render to the house. The results can be striking.

Cement stucco has its place

Cement stucco has its place, but I do not believe that it is on a straw bale building. I recommend that you read an article by Gary Kruithof, ‘Moisture, materials and walls that breathe’ (*Owner-builder*, Issue 117 June/July 2003). Gary raises the issue of the natural moisture content of materials and appropriate considerations when combining different materials, as is the case in a straw bale wall with render. I have included an excerpt from the article below.

Typical equilibrium moisture content of different products.

Concrete	18–20 %
Wheat straw	7–9 %
Mud brick	4–6 %

(Note: the material in a mud brick is comparable to earthen render.)

I can't put it any better than this article does:

'If we put together two different building materials (like a render on a wall) we need to make sure their equilibrium moisture content is similar. If not, there will be a mismatch that can cause some interesting problems.

For example if we use a cement-based render on a mudbrick wall there will be a mismatch of moisture content … What happens next is that the mud slowly but constantly tries to soak moisture from the cement and eventually the bond between the two fails.'

Straw and cement render
The straw in a straw bale wall will suck in the moisture from a cement render. You don't have to be a rocket scientist to work out what will eventually happen when the straw absorbs this moisture.

The exception to the rule

I don't promote cement render, although there is always the exception to the rule. We recently had an open day at our home in Heathcote where we had in excess of 160 people attend. Throughout the day I answered many questions, most of which I have heard before, however there was one that caused me to dig a little deeper than normal, and caused me to re-evaluate my position on cement render.

One of the attendees explained that their property was in Tasmania overlooking the ocean. The property was subject to sea spray and wind which would often carry sand. They inquired as to whether earthen render would cope with these types of conditions. I have not had personal experience with such conditions myself, so the straight answer to the question was 'I don't really know.' The introduction of lime into the final coat of render may provide sufficient resistance, and certainly the application of lime putty to the final coat of render would dramatically increase its resistance. I was however, forced to give consideration to cement render in this particular application, as it would certainly provide greater resistance to the sand blasting it would be subjected to.

The longevity of the building

Focus your choice of building materials on the likely longevity of the building. When advising people on building straw bale homes, I am trying to direct them to construction methods that will last for many generations. I personally do not believe that cement render is the material to provide the longest life for a straw bale building, however, I have a relationship with a straw builder who has been building with cement render for about 10 years. As a professional builder, he has to provide a seven-year guarantee. Simply that he is still in business would indicate that he has not had an onslaught of warranty claims due to the cement render, otherwise he would have gone broke long ago.

I believe that under normal circumstances, a house with earthen render will outlive those with cement render, although in the Tasmanian example above, being near the sea, the earthen render may not stand up to the elements. I must concede that in this application a cement render may actually provide better protection for the straw bales. There is no way of knowing the difference in the life of an earthen-rendered building versus a cement-rendered building, or if in actual fact there is a difference. Even if an earthen-rendered building were to last 200 years compared to 100 years for cement render, in this instance 100 years would be a lot better than maybe 50 years with earthen render in the Tasmanian application. Please note that in this example I am not actually purporting the life expectance of either render system, but simply that sometimes it might be prudent to use cement render even when it is not the preferred option.

12

Electrical installations

Electrical cables can be installed into a straw bale wall by direct insertion into the straw or by fitting conduits into the bales into which the electrical cable is installed. When installing the cable directly into the straw bale it is essential that the cable be inserted well into the bale to prevent possible damage to the cable in the future. The strings on the bales are approximately 120 mm from the face of the bale. When fitting the cable directly into the bales, insert the cable a minimum of 75 mm into the bale. The render applied to the face of the bale will be a minimum of 20 mm thick but more likely at least 35 mm. This will mean the cable will be 95–110 mm below the final surface of the wall. The major cause of damage to electrical cables will come from hammering nails into the wall. It would be unlikely that anyone would hammer a 75 mm nail into a rendered wall, but if it were to occur even this would not cause any damage as the cabling is set into the wall beyond the nail's reach.

Inserting electrical cables into a straw bale wall

Bales of straw have one face with cut straw and the opposite with bent straw that has a fluffy appearance. When laid correctly every second row of bales will have a cut face and every other row will have a fluffy face. It is not too difficult to force the cable into the cut face of the bale, however the bent straw of the fluffy face resists the installation of the cable. Consequently it is necessary to cut the face of the bales into which the cable or conduit can be fitted. Remember that the strings of the bale are about 120 mm into the bale, so keep your cut less than 100 mm deep to avoid cutting the strings. If you do accidentally cut a string in the middle of the wall it is not a problem, however, if you cut multiple strings down the line of the cable it will weaken the wall. If there are heavy winds following the cutting of strings the wall may collapse.

When installing a cable into a straw bale wall, start the installation at the uppermost point by making a slit in the face of the bales into which the cable will be inserted. Force the cable into the slit just above the knife as you continue cutting with the knife (see Figure 12.1).

Figure 12.1 Cutting a slit in the straw into which the electrical cable is inserted

Using either your hands or a blunt piece of timber, force the cable or conduit into the cut in the face of the bales. Some people find it necessary to wear protective gloves as the straw is quite sharp and abrasive.

The installation of power outlets

Pegs to fix power outlets on to can vary in size and material, however they must be large enough to get two fixing screws into the timber through the back of the wall box. It is important that the wall box be held securely to prevent twisting during the render process (see Figure 12.2). Care must be taken when rendering around the electrical boxes, as they can easily be twisted.

Barbed timber pegs as fixing points for power outlets

The power outlet will be fixed to a timber peg that has been inserted into the straw bale wall. The timber peg, approximately 350 mm long, will have a point on one end and barbs cut into its sides. The barbs provide a stronger fixing into the wall, as the straw will lock back into the barb slits into the sides of the peg (see Figure 12.2). Note that the straw does not fold straight back into the barbs, this happens over a day or two as the straw relaxes after having been forced aside when the peg was driven into it.

Spiked timber pegs as a fixing point for power outlets

The spiked timber peg supplies a stronger fixing point in a straw bale wall. This peg is often recommended for the support of cabinets and shelving (see Figure 12.3).

Making and installing a spiked timber peg

Cut a piece of 70 × 19 pine or particleboard approximately 400 mm long, then put two rows of 75 mm nails through the timber approximately 50 mm apart. The head of the nail is to be flush with the timber so that 50 mm of nail is protruding through the opposite side of the timber. Repeat this process from the other side of the timber so that you have a piece of timber with sharp nails protruding from each side of the timber (see Figure 12.3).

When installing this type of blocking the nails are pressed into the lower layer of bales and the next row of bales are pressed down onto the nails protruding vertically from the fixing board. This system gives the greatest strength of fixing, however its placement in the wall is limited, as it has to be fitted between the rows of bales.

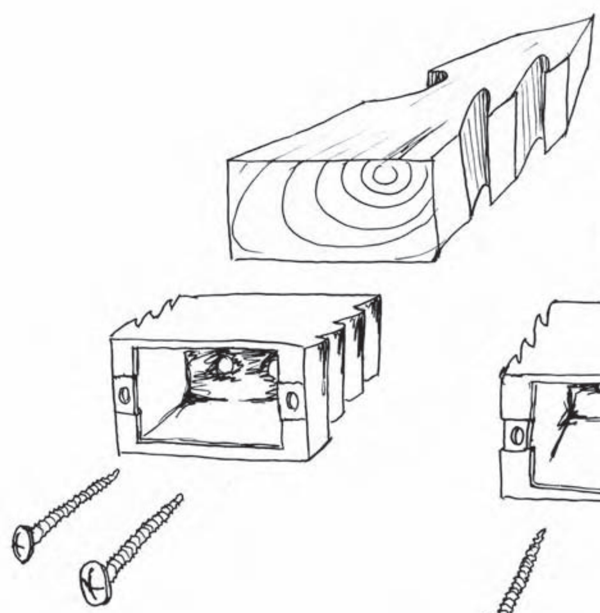


Figure 12.2 Barbed wooden peg to be hammered into the bale wall onto which the electric wall box is secured

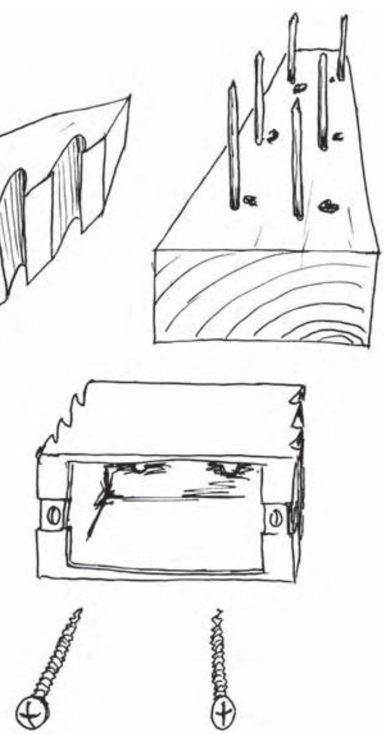


Figure 12.3 Spiked timber peg to be fitted between the rows of bales onto which the electrical wall box will be secured

Render and power outlets

Following the application of each coat of render, check that the electrical box is still level. Once the render has set it is not possible to adjust the position of the electrical wall box without removing the render. If this does occur the render has to be removed in layers so that the joint in the render is not in one line. The top coat of render will have to extend back about 200 mm from the outlet, the second coat 150 mm from the outlet and the first coat 100 mm from the outlet.

Figure 12.4 Screw the plastic electrical wall box to the timber peg

The face of the wall box is to be flush or buried in the render. On occasions we have found that the wall ends up thicker than expected, however this does not provide any difficulty as the render is stable around the box. You will simply replace the short screws provided with the box for longer fixings. The render will be approximately 30 mm deep while the wall box is 45 mm deep. Consequently it will be necessary to set the wall box 15 mm into the bales. Trim the face of the bales back and then hammer the peg into the desired depth. The trimming of the bales is to extend out 100 mm from the wall box in all directions to allow full strength of the render around the wall box.

Electrical wall mounting boxes fixed to timber pegs

When purchasing wall mounting boxes purchase those that have teeth protruding from the outside of the box. As with cement render, the teeth lock into the earthen render increasing the stability of the box in the wall. The electrical box will be secured to the timber peg in the wall using two round head screws (see Figure 12.4).

On one occasion we made the mistake of fitting an external power point directly onto the peg in the wall without the wall box. The lack of teeth on this type of power point resulted in a power point that was able to move within the surrounding render. This presented two problems. First, the power point was totally reliant on the strength of the peg in the wall, which would eventually pull out of the wall, as there was no mechanical connection to the render. There is significant pressure applied to the fixing when removing a tight plug from the outlet.

Second, the render was not sealed around the power point which would allow air and moisture penetration around the outlet. Apart from the obvious electrical problems associated with water penetration, this would lead to the breakdown of the straw surrounding the power point, and reduction of thermal resistance in that area of the wall. You can purchase waterproof covers to go over standard power points and switches. This would be a better option for external fittings, as they are mounted on the wall box thereby providing a much stronger connection to the wall.

Strengthening the junction of the render and wall mounting box

The greater the strength of the render around the power outlet and the connection of the render to the outlet, the better. I previously suggested that the junction of render to timber would benefit from a coating of sand and glue to the timber. The same applies for power outlets.

Applying a mixture of sand glue

Applying a mixture of coarse sand and adhesive to the outside of the mounting box where the render will contact the mounting box will dramatically increase the strength of the junction of the render to the wall mounting box. You could use construction adhesive or Bondcrete®, however I doubt that a cooked-flour based adhesive is going to hold onto the nonporous surface of the wall box.

The coating of sand on the wall box will provide a key for the render to lock into and add to the security of the wall box in the wall. Earthen render alone, while being quite strong, is not capable of withstanding too much abuse. For this reason, we apply a strong cob around the power outlet to increase its strength. Apply the first coat of render ensuring that the mix is worked well into the straw rather than to coat the surface of the straw. Use the palm of your hand to force the render up into the straw. The straw is quite sharp so you will probably need to wear rubber gloves during this process.

Using cob to increase strength around the electrical box

When the first coat of render is completely dry, apply cob to the area around the electrical wall mount box to increase the strength of the render. For details on cob, see Chapter 11. Wet the surface of the first coat of render and then apply the cob mix to the bales around the outlet in a circular motion so the outlet is encircled with the straw of the cob. It is important that there are no air gaps between the outside of the wall box and the cob.

Build the cob up around the wall box to within 10 mm of the face of the box. The build up should ramp back down across the wall for approximately 150 mm out from the wall box. When dry this fibrous material will strengthen the surface of the wall around the outlet much the same way as fibreglass fibre strengthens the hull of a boat. Not only will the wall be stronger in this area, but also the adhesive sand mix applied to the sides of the wall box will provide a good bond to the strengthened wall.

The hole in the rear of the box where the cables enter the box should be sealed with silicone to prevent air flow and moisture penetration.

Electrical outlets in rendered timber framed walls

It is possible to have a rendered finish on timber framed walls. Timber framed walls to be rendered are referred to as Kram© walls, which are made up of a timber frame, wire netting fixed to the faces of the timber framing and straw tightly packed into the cavity between the wire netting. When installing electrical outlets in Kram© walls it is essential that the electrical connections be kept clear of any straw which could cause a fire. Standard metal wall mounting plates are used in this application with the addition of a shroud insert. These shrouds are available from any good electrician's supply store. They are made from light plastic and simply fit into the metal bracket. A hole is cut into the back of the shroud through which the cable is inserted. The metal bracket is to be installed in the same way as for standard plaster-lined timber frame walls. Ensure that the wire netting overlaps the metal bracket, but does not protrude past the opening in the metal bracket, as this is difficult to cut after rendering without damaging the render.

Screwing the outlet fixing screws

Screw the outlet fixing screws into the metal bracket prior to rendering. The first time we used this method of installation we covered the screw holes in the metal brackets with small pieces of electrical tape. This was laborious and frustrating, particularly when some of the tape came off the brackets during the rendering. A better alternative is to fit the screws that come with the electrical outlets into the holes. This keeps the render out of the thread of the bracket and makes it easier to locate the edge of the bracket post-rendering.

Protect the ends of electrical cables

Before rendering, the wire protruding from the shroud and metal bracket is to be curled up and positioned within the shroud. If you wrap electrical tape around the curled up cable it will not only keep the cable clean, but will also protect any markings the electrician has put on the cables. Electricians are likely to charge more for the work if they constantly have to trace wires because their markings have been removed. Apart from this, it is much nicer for them to work with clean cables than cables coated in render. Look after your tradespeople and they are more likely to look after you.

Applying render at the power outlet in a Kram© wall

The render is to be applied over the top of the bracket and worked well into the wall around the outside of the shroud. It is not necessary to coat the shroud with the sand and glue mix, although if you are so inclined it will make for a better job. The first coat of render will fill the wire of the Kram© wall adding little depth around the electrical outlet. The second coat of render is to be approximately 10 mm thick, covering the surface of the metal bracket.

Compress the render around and over the metal mounting bracket

When the render is very firm but not yet dry, use your finger to compact the render around the outlet. This will force air out of the render and increase its density and strength. Following the compaction of the render, use a knife or small tool to cut away any render that overhangs the internal cavity of the shroud. Also trim the render back from the screw that is in place so that there is 2–3 mm of clearance around the screw.

Trowelling the face of the wall

When applying the third coat of render it is important to draw a trowel across the face of the power outlet to ensure that the final surface of the area is flat. If this is not done there will be gaps between the wall and the fitting. This is unprofessional, unsightly and if the gap is too great, may not pass the electrical inspection. Again, when the render is firm but not completely dry, compact the render around and over the metal mounting bracket and trim the render back as previously detailed (see Figure 12.5).

Always keep a bucket of render for touching up blemishes that are not noticed until after the rendering is completed. This will ensure that the render matches the rest of the wall for colour and consistency when dry. Do not dispose of the extra render until all work in the room has been completed. Following the compaction of the render it may be necessary to add a little of the extra render to the area while the render is still wet, in order to provide a flat surface.

Figure 12.5 Render over a metal mounting plate with a plastic shroud at its rear

Once the third and final coat of render is completely dry the electrician can fit the outlets. If, during this process, the render around the outlet is damaged, the wall can be repaired with a little of the render kept in reserve. Simply soak some of the render until it becomes moist and pliable. Depending on the amount of damage to the wall, you will probably need to have the render the consistency of toothpaste (very gritty toothpaste). Before attempting to repair walls around electrical outlets, turn off the main power supply at the meter box to prevent possible electrocution. In Australia all new homes must have earth leakage protection on the power supply to the house. This would shut the power off if water got into a power outlet. These safety devices are to save your life in the advent of an accident – to rely on them as a normal operation I suggest is foolhardy.

Use a wet cloth to moisten the surface of the render to be repaired and the surrounding area, and then apply the repair as necessary. The surface of the area to be repaired should begin to soften as a consequence of the wet cloth being applied to it. Work the new render well into the damaged area and then blend it into the wall. Apply pressure to the render in its application to eliminate the possibility of air pockets between the repair and the original wall. If you have kept spare render from the original mix to use in the repair, it will obviously blend well with the render previously applied to the wall. As opposed to cement render, earthen render will not crack at the junction of the repair to the original render if performed correctly.

The only reason cracking will occur with earthen render is if the wall being repaired is too dry when the repair is applied. If the damage to the wall is deeper than the top coat of render it may be necessary to remove more of the top coat of render to give access to the wall to repair the lower coat of render. Once the second coat of render is repaired and dried, the top coat of render can then be repaired. It is important that the join in the render penetrate only a single depth of render. The joint of the renders should be staggered.

Electrical outlets at the base of straw bale walls

Electrical cables can be fitted inside the bottom boxing that is fitted to the floor.

A standard wall box for electrical installations can be screwed to the face of the bottom boxing. The cable will then be fed through the bottom boxing and into the rear of the wall box. The bottom boxing is 90 mm deep so when fixing the wall box to it position it so that the top edge of the wall box is about 20 mm above the top of the bottom boxing to allow extra clearance from the bottom of the power outlet to the floor. If you require the outlets to be higher still you will need to revert to the method detailed above for fixing power outlets to straw bale walls.

Wiring to the meter box or switchboard

With conventional construction, such as brick veneer and weatherboard homes, it is possible to insert additional wires into the back of the switchboard by running the new cables inside the cavity of the timber frame. This is not the case with straw bale construction. I would strongly suggest that you have your electrician fit the cables from the switchboard to the roof cavity inside an oversized conduit. This will enable the insertion of additional cables in the future if the need arises.

13

Plumbing installations

The primary enemy is moisture

First and foremost it needs to be understood that the primary enemy to straw bale houses is moisture. It is imperative that not only are there no leaking pipes within straw bale walls, but also that there is no avenue for the introduction of water to those walls.

You will need to impress on your plumbers that there can be long-term and very expensive consequences when water is allowed to penetrate the straw in a straw bale house. There is nothing too complicated in the elimination of this potential problem, it is simply common sense. Extra care needs to be taken to ensure that water does not penetrate straw bale walls during construction, and that there is no risk of water penetration during standard maintenance in years to come. This applies to all pipe work and roofing on a straw bale house.

A comparison of water

In a brick veneer or weatherboard house the small amount of water that might penetrate the wall cavity while changing a washer in a shower recess is of little concern, however, this could become a major issue in a straw bale house. When installing water lines for water under pressure, the plumber, before leaving the job, will pressure test all pipes to ensure that there are no leaks. However, during the process of the installation a few spills here and there are of little consequence, as they will dry leaving little or no sign of the occurrence. This is not the case with a straw bale house. Every time water is introduced to a straw bale wall, the risk of straw degradation is increased. The problem with this is that no one can tell what is happening inside the wall to ascertain whether the wall can tolerate more moisture.

Dealing with wet bales in the wall

On several occasions while building straw bale houses the straw bales have got wet, but have dried out without any difficulties. However I must confess that when monitoring the drying process I have been known to remove the wet bales and replace them rather than take the risk of them not drying out. The drying process can be monitored while the bales remain unrendered, but only if you have been made aware that they got wet in the first place. If you approach your plumbers aggressively about this issue they are much less likely to tell you if bales do get wet during their installation. It is best that you have an open relationship with them rather than to have the expense and heartbreak associated with replacing the wall in the future.

Changing tap washers

One of the major entry points for water into the walls in the future is when changing tap washers. Most showers have a hot and cold tap and a shower rose. The tap is made up of the handle, which is fitted to what is known as the spindle. The spindle is screwed into the fitting in the wall known as a breach. When a tap washer is replaced, the spindle is removed from the breach and the washer inserted into the rear of the spindle. To change a tap washer the water is turned off at the main tap near the street, or alternatively, when using water from a tank, the tap at the pump or the pump itself will be turned off. If this is done while the tap is turned off, the tap will need to be turned on to release the pressure that still exists in the water lines, otherwise water will spray out over the room as the spindle is removed. Even though the pressure has been removed, water will still remain at the spindle in the breach. Almost without exception, as the spindle is removed water will flow out of the breach with some of the water penetrating the wall.

Fill and seal gaps between the wall lining and the plumbing fittings

This can be easily overcome by sealing around the breach to the surface of the wall. Silicone for bathroom applications is the most appropriate product for this. While the spindle is in place, fill the cavity between the breach and the wall, taking care not to allow the silicone to cover the junction of the spindle and the breach. Once the silicone is dry, remove the spindle from the breach to ensure that the spindle can be removed without compromising the seal of the silicone to the breach. The washers that are supplied with some tap fittings are not of the highest quality and so it may be a good idea to get your plumber to replace them with good quality washers. A longer-term alternative would be to purchase tapware that has ceramic discs rather than standard washers, as these will operate for an extremely long time without maintenance.

Condensation moisture and straw bale walls

Condensation is like a slow death cancer to a straw bale house. In many ways, the moisture from condensation is worse than water from an individual spill, as perpetual introduction of moisture into the wall gives the wall little chance of discharging the moisture and drying out. The moisture from condensation around pipes will cause the straw around the pipes to decompose and disintegrate. It may take three or four years, but it will happen.

To prevent condensation from pipes, all pipes must be fed through the straw bale wall within an insulated sleeve. This will prevent condensation between the bales and the surface of the pipe. While it is possible to insert the sleeves following the construction of the walls, it is much easier to fit them during the construction of the wall. Your plumber will be able to provide you with the details of where pipes will penetrate straw bale walls. In single-storey house construction there are very few wall penetrations required, as most will go through the floor.

Feeding pipes through a sleeve

When installing 100 mm pipe it could be fed through 150 mm PVC and insulated between the sleeve and pipe. Allow sufficient length for the sleeve to reach from one side of the bale wall to the other with approximately 20 mm additional length at either end. This will enable the application of the first and second coat of render to finish roughly level with the face of the sleeve. The cavity between the 100 mm and 150 mm pipe could be filled with spray-in foam (see Figure 13.1). This will secure the pipe in position while providing an insulation barrier between the pipes and thereby eliminate condensation. If you are avoiding the use of foam the cavity could be filled with wadding, however be sure to seal the ends well with the render to avoid vermin penetration. If the space between the pipes is not filled appropriately it will also form a bridge for heat transfer from the inside to the outside the building. Needless to say, a 50 mm pipe could be fed through 100 mm sleeve and so on.

Figure 13.1 100 mm sewer pipe through 150 mm pipe with expanding foam sealant

Water feed lines can be sleeved with Aeroflex foam rubber inserted into 38 mm PVC pipe (see Figure 13.2).

Figure 13.2 Copper pipe covered with black foam in a PVC pipe

Fire is a major concern during construction

Whilst a completed straw bale house has a high level of fire resistance, the risk of fire during construction is significantly higher than when building a brick veneer house. Straw in itself is extremely flammable. In fact, I believe it is just as flammable as paper and paper is the very thing that most people use to light a fire.

We all acknowledge that paper is flammable, and that the finer the paper the greater the flammability. Take a page from the phone book for example. This would ignite very easily and would be totally consumed in a very short time. However, if you were to try to burn a complete phone book it would be difficult. The outside would first burn a little and then char. The only way to get it to burn properly would be to continue prodding it to let the flames grasp at a few pages at a time. Actually it is not that you are letting the flames get to the pages, but rather you are allowing the oxygen to get to the pages. The reason the phone book will not readily burn is because there is a lack of oxygen between the pages, and oxygen is a necessary component for fire. Tightly packed bales of straw are to fire just as a phone book is to fire. The material is extremely flammable, but the presentation of straw in the form of a bale starves the fire of the necessary oxygen.

Bales of straw do not self-combust like hay

There have been more fires of straw bale homes than any of us would like. To my knowledge there has never been a fire from self-combustion. This is an issue for hay bales that are baled green – another story in itself. I do not know of any fire in a straw bale house that has not been caused by man.

A fire extinguisher could save the day

We could speak of the house that was burnt to the ground when a spark from an angle grinder set an unrendered straw bale wall on fire. Or the fire that started in loose straw on the ground and got into the building before it could be stopped. As a CFA member (Country Fire Authority) explained to me, it doesn't take much to stop a fire on the face of straw bales if you get to it in the first few seconds. Once it is feeding on the loose straw ends protruding from the bales on the whole face of a wall it is a totally different thing. A 9-litre fire extinguisher is a fast answer to an immediate risk. At around $200 it is a small price to pay for at least some peace of mind. I insist that all tradespeople working with equipment that produces sparks or has flames, such as welding equipment, keep the fire extinguisher next to them at all times. A tradesperson deserves some space and privacy in which to do their work, however this is one occasion that I check up on them. If they are doing work that has a fire risk without the fire extinguisher close at hand, I politely bring it to them.

Installation of toilet cisterns

When investigating toilet pans and cisterns for straw bale construction the method of installation of the cistern is the primary issue. Toilet pans have either an ‘S’ trap or a ‘P’ trap. This refers to the shape of the discharge pipe from the toilet pan. The ‘S’ trap forms an S from the toilet bowl thereby allowing the waste to travel vertically through the floor of the building. The ‘P’ trap obviously has a P shape from the toilet bowel and allows the waste to travel horizontally through the wall of the building. Wherever possible I would suggest that you use an ‘S’ trap toilet pan, as this negates the issues associated with pipes penetrating straw bale walls.

There are two basic styles of toilet pans and cisterns, the split system and the coupled system. The most common and cheaper range of toilet pan and cistern is the split system. These rely on the wall behind the toilet to support the cistern. You will see this type of unit in most of the project homes or spec homes. The early versions of this type of cistern had the pipe between the cistern and the toilet pan exposed, however, most these days have a shroud covering the pipe, filling in the space between the pan and the cistern.

Installation cisterns that are screwed to the wall

If you are going to use this type of toilet pan and cistern it will be necessary for you to provide timber for the cistern to be screwed into. The timber is normally set at 750 mm from the floor, however the specific details for your unit will be on the installation instructions. If the wall behind the toilet is a straw bale wall you will need to provide timber for this fixing that is supported both vertically and horizontally. If there are timber walls on either side of the toilet you can simply fit a piece of timber, ideally 140 × 45 between the two walls. You will not want this timber to be exposed once the render is completed, so you will need to trim back the bales where the timber is to be fixed so that the face of the timber is level with the face of the bales once it is fitted.

When straw bale walls are on either side of the toilet fit two legs to the cross rail so that the weight of the cistern with its water is transferred to the floor. These too will need to be set back into the wall. In this application it will be necessary for the top rail to be fixed back to the wall to prevent the cistern moving forward when full of water. This can be achieved by fixing wire netting over the fixing rail and extending approximately 300 mm out each side of the rail onto the straw bale wall. The wire is then stitched back to the wall and the render applied over the wire and the fixing rail. In this method, the strength of the render to the wall is relied on to hold the cistern fixing rail in place.

Another, and probably easier, method would be to use bale twine to tie the fixing rail back to the bales. At each end of the cistern fixing rail, use your single bale needle to thread bale twine through the straw bale wall behind the cistern, one above and one below the rail, thus forming a loop over the fixing rail. On the outside of the wall, pull the two ends of the twine together and tie them together holding the fixing rail firmly in position.

Self-supporting toilet cisterns

The second, but more expensive, option is the coupled toilet pan and cistern. If you are careful with your purchasing they will be a bit less than double the cost of the cheaper option. The advantage with the coupled system is that the weight of the cistern and its water is transferred directly onto the toilet pan so there is no need to provide fixing timber in the wall behind the toilet. Some units still require that the cistern be held back to the wall to prevent the cistern leaning forward. Check this prior to purchase, as it is much better to find a unit that does not require any fixing of the cistern to the wall.

Generally speaking this type of unit conceals the plumbing behind and within the toilet pan and the pan is designed so the 'S' or 'P' shape at the rear of the pan is concealed within its own construction. It is only in recent years that I have opted for the coupled toilet pan and cistern, primarily to avoid fixing the cistern to the wall. However I would now find it difficult to return to the cheaper option if for no other reason than the aesthetic appeal of the coupled system.

Showers and baths against straw bale walls

If at all possible avoid the installation of showers and baths against straw bale walls as it presents a number of challenges, particularly if it is essential that the plumbing lines are within the straw bale walls.

Our home in Heathcote has a spa bath with a shower over the bath against a straw bale wall on one side, with a Kram© wall on the other side. The water supply and shower rose are fitted to the Kram© wall which eliminated some of the challenge. The water supply pipes were encased in foam prior to the installation of the straw around them. This negates the potential for condensation within the wall. Rather than use ceramic tiles in our bathroom we opted for mini-orb. This is a form of corrugated iron, however the corrugations are only about 10 mm deep. Not only has it given us the look we wanted, but has proven to be incredibly functional. The cleaning of grout between the tiles is all but a distant memory. A memory I am sure Jan has no desire to rekindle.

Moisture protection for wet areas

For moisture protection, I would recommend that a timber frame and/or sheeting be installed between wet areas and straw bales. This should be done, however, after the straw bales have had at least two coats of render, to protect the bales from vermin entry. Earthen render will also assist in the dispersion of any airborne moisture that might get into the cavity between the lining and the bales. At Heathcote, the bathroom concerned was on the ground floor where the ring beam supporting the upper floor joists was exposed. Sheet flooring was fitted between the timber beam at the ceiling and the side rail of the bottom boxing. This provided a good water barrier and stable base onto which the mini-orb could be fitted.

When installing ceramic tiles it will be necessary to supply a more rigid surface on which to apply the tiles. This can best be done by building a timber framed wall as is done in conventional building (see Chapter 6, on timber framed walls). This timber framed wall would then be covered with Villaboard or something similar. Personally I prefer to line wet area walls with Villaboard rather than plaster, as I believe that this provides a better base with a longer life expectancy. Villaboard is a sheeting product that resembles cement sheet in appearance. It can be cut with a scorer or a cement sheet cutter. It has a recessed edge to allow joining tape and compound to be applied to the joint without bulging out the joint, which would be a problem when tiles are applied.

It is inappropriate to glue tiles or fix any material directly to the straw bale wall for showers or baths as a barrier for the water must be provided.

Installation of a preformed shower base

Preformed shower bases might be manufactured from fibreglass, plastic, metal or polymarble. The polymarble bases seem to be the most popular as they are strong with a good surface for cleaning. A precast shower base will have a lip on the upper edge of the shower base. The wall sheeting is to pass over this lip onto the shelf below it, thus preventing water from flowing off the sheeting over the edge of the shower base. Consequently the shower base must be installed so that the inside edge of the lip on the shower base is level with the outside face of the timber framing to permit the sheeting to drop uninhibited down onto the shelf below the lip.

When using mini-orb to line the shower, the mini-orb should be fitted to the shower recess prior to lining the other side of the walls. Once the mini-orb is fitted, silicone seal the sheeting to the shower base by applying silicone to the back of the sheeting down into the shower base. Alternatively, silicone can be applied to the junction of the iron to the shower base on the face of the sheeting, however this is much more likely to attract grime in the future. If someone stands or sits on the outlet for the shower and the water rises to above the edge of the shower base, and the sealant is not in place, the water will flow over the back edge of the shower base and onto the floor. This will damage floor coverings in the adjoining areas, and will eventually cause the timber framing to rot and need replacing.

Fixing metal flashing around a shower enclosure

If the shower is in a corner you must fix a metal flashing in the corner at the junction of the two walls down into the shower base over the lip of the base prior to installing the sheeting. The sheeting must then be sealed to this flashing and to the shower base where the sheeting meets the shelf below the lip of the base. Fit the sheeting with a 3–4 mm gap between the surface of the shower base and the bottom of the wall sheeting. This will enable you to seal the sheeting to the base by using silicone in the gap, preventing water flow over the lip of the shower base. The tiles will cover not only the gap between the sheeting and the base, but also the silicone sealant.

Installing the shower base on a bed of mortar

The shower base will be laid on a mortar mix. This is a mixture of sand and cement, similar to that used when laying bricks. This will enable the shower base to be positioned level regardless of the floor it is to be fitted on. Furthermore, the mortar mix will provide even support to the underside of the shower base reducing the possibility of the base cracking while in use. It is a lot easier if two people can work together to lay the shower base onto the mortar mix.

Use a level to check that the base is sitting level. Twist and wriggle the shower base down into the mortar applying pressure to any area that is high in order to cause it to sit level on the floor. When it is sitting level, check that it is set far enough into the walls so that the inside of the lip of the shower base is level with the face of the timber frame of the wall. As a final safety check, pour a cup of water into the shower base to ensure that the water flows to the drain hole. If not, continue to work at adjusting the horizontal position of the base until it drains. Allow 24 hours for the cement mortar under the shower base to set before you apply any pressure to the base. The installation of additional timber to support wall sheeting is covered in Chapter 6, on timber framed walls.

Silicone: uses, limitations and installation

Silicone has revolutionised building. You just have to look at the Opera House in Sydney, Australia, and note that silicone is holding the huge windows in place. When two non-porous surfaces are to be joined together to eliminate water penetration, silicone is in its element. Since the advent of silicone, plumbers no longer have to solder joints on guttering or beat lead into shape as caps over the junctions of different shaped iron. Not only does silicone prevent water penetration, but it is now made in colours to blend in with the material you are working with.

It is less effective when applied to timber and semi-porous material, as it tends to come away from their surfaces. The application of silicone to earthen render would be somewhat questionable for a couple of reasons.

First of all, silicone is used primarily to prevent water penetration so it could be reasonably assumed that its application would be in an area prone to water flow or at minimum splashing. This is not a situation that earthen render should be exposed to. Second, silicone is designed primarily to be applied to and seal non-porous materials. Earthen render, on the other hand, is porous and functions best when this porosity is utilised rather than prevented.

Getting a smooth surface on silicone

One of the challenges when applying silicone is to avoid a final surface that is rough. When the silicone is initially dispensed from the cartridge it has a convex shape, however, in most applications it is preferred that the final shape be concave. This is normally achieved by running your finger across the surface of the silicone to smear and blend it together over the materials being joined by it.

The owner-builder with lumpy silicone

This reminds me of one of my owner-builders who was sealing the tiles over a vanity unit to the laminate top on the vanity unit. When I turned up the task had just been completed. Silicone was spread up the face of the tiles by about 20 mm and across the vanity top by about the same. Anyone that has ever lived with silicone will know that while it is great to seal such surfaces, it will always attract dust and grime and should therefore be kept as small as possible.

I gently inquired as to what he was trying to achieve and if he was concerned about the width of the silicone now smeared over both surfaces. I did not raise the issue that apart from being smeared about, the surface of the silicone was quite rough where his finger had dragged across its surface. He explained to me that he had tried to make it smaller and smooth but that it just wasn't working. Rather than to get frustrated with the process where he probably felt it would go from bad to worse, he decided that he would trim the edges of the silicone with a knife once it was set. While this seemed like a logical solution I assure you it will not give the desired result. We scraped off the silicone that fortunately was not fully cured and proceeded to start again.

Applying silicone

Ensure that the surfaces to be sealed are clean and dry. Pour a small amount of dishwashing liquid into a small glass or a lid. Later on you will need to dip your finger in the solution, so ensure that the container allows you to do this. The hole in the end of the silicone nozzle is quite small. If the diameter of this hole is smaller than the gap you want to fill, shorten the nozzle a little at a time until the hole in the nozzle roughly matches the gap to be filled. Cut the nozzle on a slight angle so that when the nozzle is held against the surface to be sealed it will force the silicone down into the gap and slide along the surface smoothly giving an even flow of silicone without bumps and ridges. Once you have put the silicone on the surface to be sealed dip your finger into the detergent and run your finger across the surface of the silicone to press it into position and smooth it out. Only very light pressure needs to be applied, otherwise the silicone will spread out too wide over the surfaces being sealed.

14

Installation of internal doors

Pre-hung door jambs

Door jambs with hinges and latches already fitted

For about 30 years you have been able to purchase pre-hung doors and door jambs. A pre-hung door jamb has the hinges and door latch fitted to the door and the door jamb. It is simply a matter of cutting the length of the door jamb to suit your job, nailing them together and fixing them into the wall. If you are purchasing new doors and door jambs I strongly recommend that you investigate pre-hung options further. The additional cost of a pre-hung product over and above the cost of the door and the door jamb is little more than the price you will pay for the hinges and the door latch, which are obviously included in the deal. If you are using second-hand doors and/or door jambs thicker than standard door jambs, you can still gain the benefit of this system by fitting the hinges to the door jamb and door prior to its assembly and installation. I shall go through this process in detail shortly.

The split system

Split door jambs that are fully assembled with architraves, hinges and latches have been around for 20 or so years. The door and door jamb are pre-hinged and latched as detailed above, however, this system includes the architraves which are already fitted to the door jamb. The door jamb is split down the middle, so that it can be inserted from each side of the wall with the architrave then fitting snugly against the face of the wall. The door stop conceals the gap between the two halves of the door jamb. If your walls are thicker than the standard walls for which this system is designed, this can easily be overcome by fitting a wider door stop to conceal a wider gap between the two door jambs.

Standard door jambs

The details below for hanging doors are for the use of standard timber. If you have purchased a set of door jambs that do not have the hinges attached you will find that there is a checkout in one end of the door head into which the top of the door jamb stile will be fixed. You are to install the stile that is to have the hinges fitted to it into the checkout in the door head. It may be necessary to trim off some or all of the excess timber beyond the checkout for the door head to be able to fit inside the framed opening for the door. The calculation below does not take into consideration the depth of the checkout in the door head. If you are using a door head with a checkout, the measurement of the depth of the checkout is to be added to the length of the door jamb stile on the hinge side of the door jamb.

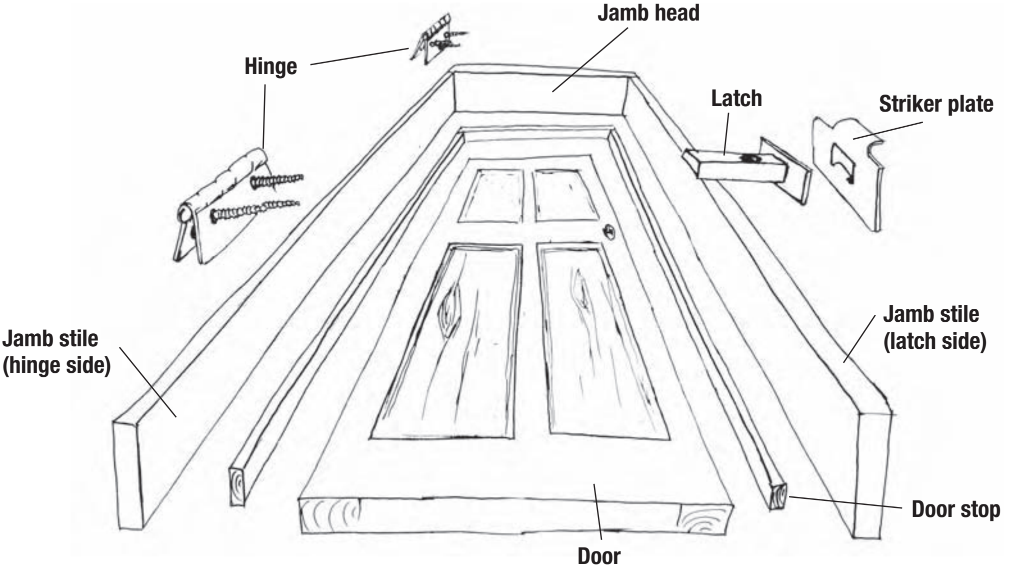


Figure 14.1 The components of a door jamb

The installation of doors in standard door jambs

Determine the required height and width of your door jamb components.

Height

	Measure the height of your door
+	The thickness of any floor coverings to be installed
+	10 mm for clearance below the door
+	2 mm clearance between the top of the door and the underside of the door jamb
=	Actual length of the stile of the door jamb

Width

	Measure the overall width of the top of the door
+	The total thickness of both door stiles
+	4 mm for clearance on either side of the door
=	Actual length of the door head

NOTE: Before cutting the door stiles, check that the floor is level at the positions that the base of the door jamb stiles will be sited. If there is a variance you are to add the measured variance to the length of the relevant door jamb stile. (If you subtract the variance, the other side of the door is likely to scrape against the floor.)

Cut the stiles or uprights of the door jamb to the calculated height. Cut the door head or horizontal section of the door jamb to the calculated height.

Positioning the hinges on the door

Traditionally the top of the top hinge is set 150 mm from the top of the door and the bottom of the bottom hinge is 200 mm from the bottom of the door, although this is not a requirement. The pre-hung doors have both the top and bottom hinges about 150 mm from the edge.

The correct direction of the hinge on the door

Establish the correct side of the door that the knuckle of the hinge (the side with the pin in it) is to protrude from. Mark on the door the position for the top edge of the top hinge. Position the hinge on the edge of the door at that position and scribe a line around the hinge to indicate the position of the checkout to house the hinge. The hinge is to finish in the door with its surface level with the surface of the door. Repeat the process for the bottom hinge.

Cutting the hinge checkout

Cut a section of timber out of the side of the door into which the hinge will be fitted. This cavity is referred to as the hinge checkout. The next step is to check out the side of the door within the lines marked on the edge of the door to enable the hinge to be fitted with its surface level with the surface of the door. This can be done using either a chisel or router set to the correct depth. When using a router you will still need to use a chisel to clean up the edges of the cut and square up the corners of the checkout. Ensure that your chisel is very sharp, otherwise it will tear the timber rather than cut it. Use light blows with the hammer on the chisel initially until you get the feel of how the timber is going to respond, otherwise you are likely to split the timber.

Using a router

Use a router to remove the majority of the timber from the checkout. First, set the depth of the router to the thickness of the hinge. Ensure that the door is held firmly on its edge so that it will not fall as you work on it. Start the cut at the centre of the checkout nearest the edge of the door. As you gain control of the router, continue to move toward the lines drawn on the door. Run the cutter of the router along the inside of the line to remove most of the timber within the checkout. Go only as close to the line as you are comfortable. A little extra timber to be removed with the chisel is of little consequence compared to patching or replacing a damaged door.

Finish with a chisel

Hold the chisel vertically to trim the sides of the checkout so that the hinge will fit neatly into it. Hold the chisel with the chamfered edge toward the centre of the checkout, as this will enable a vertical cut around the checkout. Be gentle as you do this, particularly when working parallel with the edge of the door as it is prone to split if the hinge is relatively close to the edge of the door.

Removing all of the timber with a chisel

If you are removing all of the checkout with a chisel you will need to put depth-guiding cuts into the edge of the door. Working from the end of the door toward the centre of the door, hold your chisel at about 45 degrees to the door with the chamfered edge of the chisel toward the door. Hammer the chisel into the door until you are close to the depth required for the checkout. The material within the checkout will now be removed. Hold the chisel with the chamfered edge of the chisel toward the door (see Figure 14.2). Work in the opposite direction to where the depth cuts were inserted (that is, from the centre of the door toward the end). It is important that you watch the progress of the point of the chisel rather than the head of the chisel where you hit it with the hammer. Hold the hammer near the head of the hammer, as this will make it easier to strike the head of the chisel without looking at the chisel, as you need to be watching the progress of the point of the chisel into the door.

Figure 14.2 Make a checkout in the side of the door for the hinge

It is not necessary to remove the full depth of material in one run across the checkout. The flatter you hold the chisel the shallower the cut. When the chamfered back of the chisel is against the working surface you will find it much easier to control the depth of the cut. Using light blows on the chisel remove the majority of the material within the checkout. It is likely that you will now be left with a slightly uneven surface within the checkout, and that there will still be material in the corners at the edge of the checkout.

Clean up the checkout

Clean up the checkout so that the hinge fits neatly into the cavity created. If you are simply cleaning up the material left by the router you will simply progress around the checkout with light taps with the hammer holding the chisel as detailed above.

To flatten up the surface and clean up the edges you may need to turn your chisel over and hold the blade of the chisel flat on the working surface with the chamfer facing up. Using two hands – one to push the chisel and the other to steady and guide it – flatten the surface and clean up the edges of the checkout. It is important that the movement of the chisel be controlled in this process otherwise you are likely to remove the timber parallel to the edge of the door. It may be helpful to use a slightly sideways movement, giving the chisel a slicing motion. Repeat this process for the bottom hinge.

Fitting loose pin hinges

Ideally you will have purchased loose pin hinges. You will notice that one end of the pin has a head on it to prevent the pin working its way out of the bottom of the hinge. Hold the hinge in position in the checkout with the top of the hinge toward the top of the door. The screws should be at least 20 mm long, however I prefer 30 mm. When the screw is fitted in the hinge it should not protrude beyond the face of the hinge. Screw the screws into the door through the hinge, ensuring that the screw is centred in the hole of the hinge (see Figure 14.3). It may be helpful to use a nail to create an indentation in the centre of the hole in the hinge prior to screwing in the screw. Without this the screw has tendency to move off centre as it is fitted.

Figure 14.3 Fit the hinge to the door

Marking the door jamb

Mark the door jamb with the required position of the checkouts to house the hinges. Lay the door flat on a workbench or on the floor with the knuckle of the hinge down. Lay the stile of the door jamb that is to have the hinges fitted to it next to the door. Position the stile parallel to the door with the top of the stile approximately 2 mm beyond the top of the door. This will give you 2 mm of clearance above the door to the door jamb once the unit is installed. Lay the hinges, which are now screwed to the door, out onto the stile of the door jamb. Adjust the position of the stile so that the hinges are in the correct position on the stile ensuring that the 2 mm variance to the top of the door is maintained. Using a sharp pencil, scribe around the hinge (see Figure 14.4). Depending on your confidence, you can either repeat this process for the bottom hinge or wait until the top hinge is fitted and then mark the position for the bottom hinge, which will ensure that the position marked for the bottom hinge is correct.

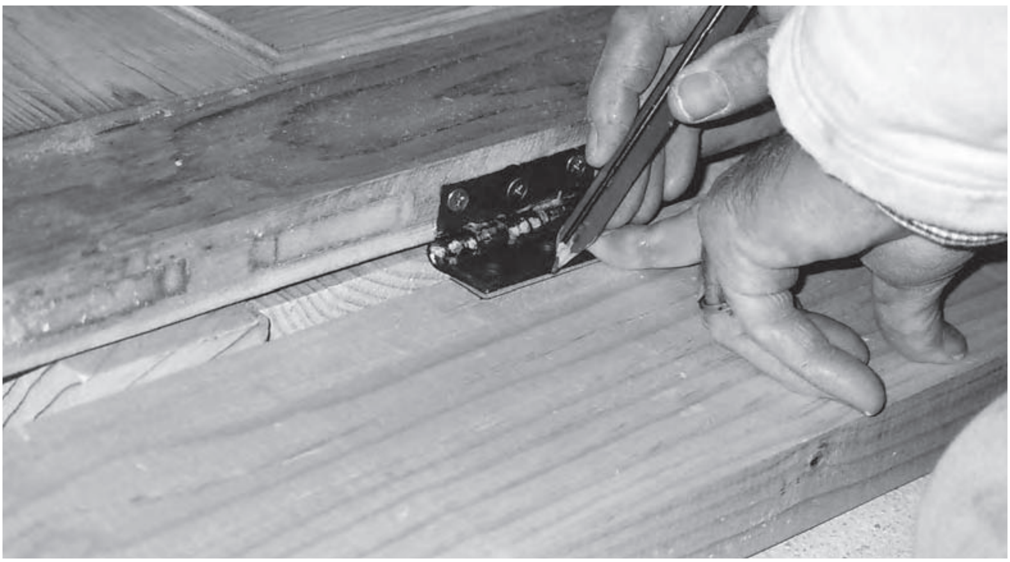


Figure 14.4 With the hinge fixed to the door, mark the door jamb stile

Making the stile hinge checkout

Figure 14.5 Use a router to remove the bulk of the timber from the hinge checkout

Use a router to remove the bulk of the hinge checkout (see Figure 14.5). It is important that the stile be held firmly to avoid accidents and errors in cutting. If you are working on a table I suggest you use a clamp to hold it in place. It is best to put a scrap piece of timber between the stile and the clamp to avoid marking the surface of the door jamb stile. As with the checkout in the side of the door, clean out excess material from the checkout in the stile to allow the hinge to be fitted. Holding the chisel vertically with the bevelled face of the chisel facing toward the checkout, cut along the line marking the required position of the hinge (see Figure 14.6). With the bevelled face of the chisel flat against the timber, remove the balance of the material in the area of the checkout back to the cut made with the vertical chisel (see Figure 14.7).

Figure 14.6 Chisel held vertically to cut the clean edge of the hinge checkout

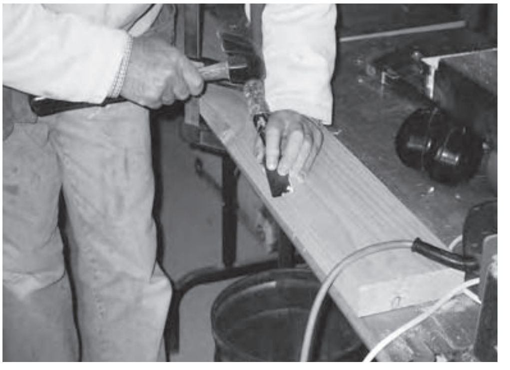


Figure 14.7 Clean up the checkout for the hinge using a sharp chisel

Assemble the door jamb

You will now nail the door jamb together. Hold the end of the door head level with the outer edge of the door stile and nail the door head to the stile using 3 nails skewed against one another (see Figure 14.8). The size of the nails will vary relative to the thickness of the door jamb material. If you are using standard 19 mm door jamb material you will use 50 mm nails. Figure 14.8 shows the assembly of a 45 mm thick door jamb which is joined using 75 mm nails.

Figure 14.8 Fix the head of the door jamb to the stiles

The principles of fitting a door jamb

Once fitted, the door jamb must be held securely in place, otherwise the impact of the door closing against the door stops will dislodge any faulty fixings and cause the door to jam within the door jamb and/or scrape on the floor. When the door opening was built, it should have been made wider than the total width of the door jamb to allow manoeuvring of the door jamb into the correct position. The gap between the back of the door jamb and the frame must be filled, particularly where the nails are fitted through the door jamb into the frame. This can either be done by inserting packers of the appropriate thickness or by filling the cavity with expanding foam after the door jamb is installed. Personally I prefer to use the foam, as this not only increases the mechanical fixing of the door jamb within the opening, but eliminates air flow around the door jamb. If you are rendering up to the door jamb it gives a good base for the render.

Fixing the door jamb in position

Locating the door jamb in the wall

Use a spirit level to correctly locate the door jamb in the wall, establish whether the hinge side of the framed opening into which the door jamb is to be installed is vertical. If the top of the opening is leaning out you will need to fit a packer to the top of the opening onto which the door jamb can be fixed. If the top of the opening is leaning in slightly you can proceed without a packer. Stand the assembled door jamb into the framed opening with the hinge side of the door jamb against the frame.

Securing the door jamb

Ideally the nails that are to hold the door jamb in place will be within the area covered by the door stop once it is fitted. When installing a door jamb into a wall with plasterboard or another wall lining, the face of the door jamb should be close to level with the face of the wall on both sides of the wall. If you are going to render the wall after the door jamb is in place, you will locate it centrally in the wall. Using a hand nail, fix the top of the door jamb adjacent to the hinge checkout leaving the head of the nail protruding so that it can be removed if adjustments need to be made.

Ensuring that the door jamb is vertical

Use a spirit level to position the bottom of the door jamb so that it is vertical to the first fixing at the top hinge in both directions (see Figure 14.9). If you are using a nail gun and foam filling between the jamb and the frame, you can hold the door jamb away from the frame the appropriate amount and shoot a nail through the jamb into the frame (see Figure 14.9). The nail will hold the door jamb firm enough until the foam is later installed. If you are using packers rather than the foam, or a hammer rather than a nail gun, the packers should be held in position and the vertical of the stile checked to that

Figure 14.9 Fix the bottom of the jamb stile to the frame

packer prior to fixing. Once correct, the fixing should pierce the packers so they will not fall from the correct position.

Installing the door at the hinge side of the door jamb

You should now have the hinge side of the door jamb fixed in position at the top and bottom hinges. You will now screw the door to the door jamb stile. Position the door at the side of the door jamb in its open position. You will need to lift the bottom of the door off the floor to bring the hinge on the door in line with the checkout for the hinge on the door jamb. Lay a piece of timber on the floor for the door to rest on, to help lift the door into position. If the timber is not the correct thickness you can lay a second piece of timber down to use as a lever, like a seesaw, which will enable you to raise or lower the door as needed.

Using loose pin hinges

When using loose pin hinges, simply hold the door in position with the half of the hinge fixed to the door aligned with its partner that is fixed to the door jamb. Insert the pin into the hinge, thereby re-joining the hinge and securing the door to the door jamb.

When using fixed pin hinges

Screw the top hinge which is fixed to the door onto the door jamb in the checkout previously prepared. Insert only one screw and ensure that the screw is centred within the hole of the hinge. Remove the packer used to hold the door up into position. This will allow the hinge at the bottom of the door to be manoeuvred into alignment with the bottom checkout in the door jamb. Screw the bottom hinge to the door jamb with one screw.

Fixing the latch side of the door jamb into the frame

With the latch side of the door jamb sitting in its theoretically correct position, close the door and check that the margin between the door and the door head is even. If the margin is uneven you can lift the stile of the door jamb to make the margin even. If it is necessary to lift the stile, place a temporary packer beneath the stile to hold the stile at the correct height before you progress to the next step. Ensure that the door jamb stile on the latch side of the door is sitting vertically, then check that the side of the door and the door jamb are parallel (see Figure 14.10).

Figure 14.10 Check that the door and stile are parallel

Door and door jamb stile out of alignment

There are two possible causes for the door and the door jamb stile not being parallel. Either the door is twisted or one or both of the jamb stiles are not vertical. In an ideal world the door and the door stiles will be perfectly in line in every direction, however we do not live in a perfect world. The tolerance for this being out of line is in your hands. To a large degree this is an aesthetic decision, as long as the door does not swing open or closed on its own or drag on the floor. There is a certain amount of flexibility within the door which is capable of absorbing 5 mm of variance, so the rectification process I am about to go through is only relative to variances greater than 5 mm.

When the door and jamb stile are not parallel, first check that the latch side of the door jamb is held in the correct position. Now look across the face of the two door stiles to see if they are parallel to one another. If the door is not twisted and the two stiles are not parallel it will always cause the door to be out of line with the latch jamb stile. If they are not parallel, place a spirit level on the side of the hinged jamb stile to see that it is vertical. If it is out of plumb it may be necessary to remove one of the fixing nails and adjust the position of the stile, but first ensure that the proposed adjustment is going to help the situation and not hinder it. It is best to keep the hinged jamb stile vertical in both directions otherwise the door will swing open or closed on its own and it is likely to scrape on the floor. If the door stiles are parallel the only possible cause is that the door is twisted. Depending on the degree of variation you have two options: work with the door as it is and try to conceal the variance, or try to straighten the door. First we will look at how to absorb some of the variance.

As previously mentioned it is best to leave the hinges vertical, however, small adjustments can be made at the hinges. Establish just how much twist you are trying to compensate for, as you can only conceal about 5 mm in any particular position. The first 5 mm will be absorbed by the flexibility of the door. By moving the latch side of the jamb stile out of vertical you can, at a push, absorb 10 mm of the variance. Keep the centre of the door jamb stile in the correct position and pivot the stile out on the top and in on the bottom until the stile lines up to within 5 mm of the line of the door.

Fixing the latch side door jamb stile in position

Once the stile is in the correct position and the margin between the top of the door and the head are parallel, fix the stile approximately 100 mm down from the head in a position that will be concealed by the door stop. Again, if you are using foam to fill the gap between the door jamb and the frame you will not need to fit packers. If you are not using foam, packers of the correct depth must be inserted between the door jamb and the frame. Leave the head of the nail protruding until you are satisfied with the complete installation of the door and jamb, as this will enable easy removal for any necessary adjustments. Hold the bottom of the door stile in position while keeping the margin between the door and the door stile even. Nail the stile in position, leaving the head of the nail protruding. Check that the door is within 5 mm of parallel to the door jamb. With the door in the closed position, look at the margin between the door jamb and the door midway between the fixing points on each stile. You will now fix each stile at the centre point between the two initial fixings, ensuring that the gap between the door and the door jamb is even. Do this on the hinge and latch side of the door jamb. As previously detailed, use packers and/or nails to hold the door jamb parallel to the door, leaving the head of the nail protruding. Now make another fixing between each of these nails so that you have five nails through each door jamb stile into the frame.

NOTE: Be careful not to nail through the door jamb in the position that the door latch is to be fitted, as this will prevent you from drilling the hole for the latch. Keep the nails in line with the position that the door stop is to be fitted.

Installing the door latch and door furniture (handles)

If you have purchased a pre-hung door and door jamb the hole in the door for the latch and door furniture will have already been drilled. The latch will be in the door and the striker already fitted to the door jamb. There are two types of latches – the most common is the style with a backplate that is set into the door and fixed in position with two screws. The alternative, which is used by the companies that manufacture the pre-hung door systems, has no backplate, as it is driven into the side of the door. It has ribs on the side of the assembly that secure it into the door. These latches are available at good building supply companies. They are not something that you are likely to find at the corner hardware store.

If you have your own doors you will have to drill the appropriate holes to take the latch and the door furniture. The manufacturer's installation instructions will contain a template for marking the positions that the holes are to be drilled and will specify the hole sizes. You will hold the template in position on the door, and hammer a small nail into the door through the template to mark the centre positions for drilling the holes. First drill the hole or holes in the face of the door for the installation of the door furniture. Next drill the hole for the latch.

Drilling the hole for the door latch

Particularly when drilling the hole for the latch, it is important that the hole is square to the door both vertically and horizontally. This is most important if you have a 32 mm thick door, which is quite common with the older doors, as there is not much margin between the hole and the side of the door if you are off square horizontally. You may be able to find a guiding jig that will hold the drill square to the door at the larger hardware stores, and this would overcome the potential problem. Alternatively, I recommend that you use a spade bit for drilling the hole for the latch (see Figure 14.11).

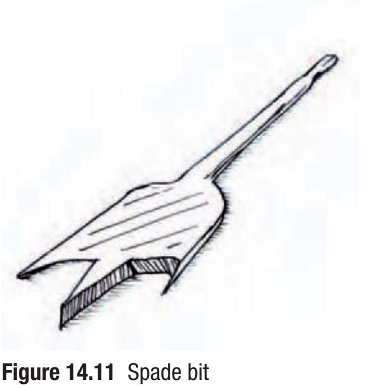


Figure 14.11 Spade bit

As you can see in Figure 14.11 the spade bit is flat and has three points protruding at the cutting edge of the bit. The centre point is obviously to be located at the centre point of the hole which will drop into the nail hole in the door left from marking the installation templates details. The two outer points are the initial cutting edges.

Drilling the door to house the door latch

It is important that the door is held in a fixed position before you start to drill the hole for the latch. If the door moves during this process there is a distinct possibility that the drill will come out the side of the door, which is likely to render the door useless. Brace your body and arms together so that you have control over the direction of the drilling.

Position the point of the drill in the hole marking the centre of the hole. Hold the drill as close as you can to square on the door both vertically and horizontally. Start the drill slowly, applying the minimum of pressure against the door so that the two external cutting edges of the drill bit mark the surface with a fine line. You will notice that the marks from the cutting points do not create a complete circle as the drill is unlikely to be perfectly square to the door initially.

Raise or lower the drill so that the cutting points create a perfect circle on the surface of the door. When the cutters are creating the perfect circle you can move the drill forward. Ensure that the width of the circular mark on the door surface is even, as you will now gauge the square position of the drill to the door by the depth of the cutting points on the drill into the door. Once you have the drill running square, continue to drill into the door until the drill breaks through into the hole drilled into the face of the door earlier on.

If you have chosen to use the latches with the backplate it is best that you use a router to make the checkout in the side of the door into which the backplate will be recessed. Follow the same procedure as that described above for the checkout for hinges, however, extra care must be taken when cleaning up the sides of the checkout, particularly with 32 mm thick doors, as it very easy to break away the timber at the sides of the latch. Once all the holes are drilled fit the door furniture as per the manufacturer's instructions. You will now fit the striker plate onto the door jamb into which the latch from the door will fit. Hold the striker plate against the door over the latch to ascertain the position that the front of the door meets the striker plate. If you want, you could mark this position on the latch.

Installing the striker plate onto the stile of the door jamb

Positioning the striker plate on the door jamb

Mark the door jamb with the position that the latch strikes the door jamb as this will determine the position that the striker plate is to be fitted so that the latch finishes vertically in the centre of the striker plate. Hold the striker plate upside down against the door jamb with the mark placed on the striker plate level with the face of the door jamb. The hole in the striker plate should be lined up with the tongue of the latch, to enable the latch to slip into the striker plate with clearance above and below the latch. Scribe a line around the perimeter of the striker plate to indicate the area to be checked out to house the striker plate. Scribe another line around the opening of the striker plate to indicate the position for the hole to be drilled to receive the latch tongue. Mark the position of the screws through the holes in the striker plate.

Choose a drill bit to drill the hole in the centre marking of the striker plate. A 22 mm drill is likely to be suitable, but be careful not to remove any timber near the screw hole markings as this will weaken the fixing of the striker plate. Sit the striker plate in position the correct way up so you can see that it is able to be lined up with the original markings with the bent section of the striker plate inserted into the hole. If necessary, extend the hole with a sharp chisel to allow the striker plate to sit in the correct position. You will now checkout the marked area for the striker plate with a router and/or chisel as previously detailed.

Fix the striker plate in position
Check that the door jamb is still parallel with the door, particularly around the striker plate, as it may have moved during the installation of the striker plate. If not, make the necessary adjustments. The nails that are protruding from the door jamb can now be hammered flush with the surface of the door jamb. It is not necessary to punch them if they are going to be concealed beneath the door stops, however, any nails outside of that region should be punched in readiness for the insertion of an appropriate coloured wood filler.

Installing door stops

Cut the door stops to the correct length
Cut the top door stop to fit snugly between the stiles of the door jamb. The two door stops to be fixed to the jamb stiles are to fit between the underside of the top door stop and the floor.

Installing the door stop to the head of the door jamb
Standing inside the room, close the door and see how the door sits in the door jamb. Is it even with the face of the door jamb? At the top of the door it is likely to be set back behind the face of the door jamb or protrude past it. Measure the variance from the face of the door to the face of the door jamb. When the door stop is fitted it is to have a margin of about 1 mm between the door stop and the door at the hinge side of the door. This is necessary to allow the sweeping action of the back corner of the door to clear the door stop when the door is closed. Hold the door stop in position basically against the face of the door, allowing the clearance gap of about 1 mm between the door and the door stop at the hinge side of the door. Nail the stop within 30 mm of the end of the door stop at the hinge end of the stop.

Ideally, the other end of the door stop is to be fixed in a position that allows the top of the door to be flush with the face of the door jamb. If you have a small variance of a couple of millimetres it is unlikely that this will be noticed once all is completed. Nail the latch end of the door stop in position. Close the door to ensure that there is not too much pressure on the door latch thereby preventing easy operation of the door handle, and that the door is not binding or catching on the hinge end of the door stop. If it is OK, nail the door stop in two other places, giving four evenly spaced fixings in the top door stop.

Installing the door stop on the hinge side of the door jamb
Now fix the door stop on the hinge side of the door. Position the door stop parallel to the door with the top of the new door stop in line with the top door stop already fitted. Nail the top of the door stop about 30 mm down from the door head. Set the door stop parallel with the door leaving a gap of about 1 mm between the door and the door stop and fix the door stop in seven evenly spaced positions down the door stop.

Installing the door stop on the latch side of the door jamb
Last, but not least, is the door stop on the latch side of the door. If there is any bow in the timber used as a door stop, it is to be fitted with the hollow facing the door. Again, close the door and fix the top of the new door stop about 30 mm down from the top with the new door stop lined up with the door stop fixed to the door head. If the door has to be

held out at the bottom to cause it to be flush with the face of the door jamb you will have to hold pressure against the door with the door stop. It would be helpful to have someone on the other side of the door to guide you, otherwise it will be done by measurements. Either way, this nail should be left with its head protruding so that it can be removed and repositioned if necessary.

With the door in the correct position fix the door stop to the door jamb approximately 30 mm up from the floor. Close the door to ensure that the latch and door furniture works appropriately. If not, you may have to ease the tension of the door stop to the door. If it is OK proceed to fix the door stop adjacent to the latch. At this point the door stop is to be slightly off the door by no more than 1 mm. This will allow the door to spring closed and be held firmly in position without straining the latch and yet preventing the door from rattling in the wind. Now make another two fixings between the existing nails, creating a straight line from the top and bottom of the door to the centre.

Punching in the nails

When satisfied with the operation of the door, punch the nails to enable the later installation of wood filler over the nails. It not a bad idea to putty the nails once the job is complete, as this prevents the possibility of moisture in the air getting to the heads of the nails, causing rust that will leave black marks on your timber. This is more of an issue with timber that is to be stained than that to be painted. If you are using hammer-in nails it is worth considering using galvanised nails rather than plain steel nails as this negates the issue.

Foam fill in place of solid spacers

If you have chosen to use foam as a packer and fixing for your door jambs, complete the hanging of all the doors and then install the foam. If you are rendering up to the door jambs it is best to overfill the cavity with foam so that it exudes out the front of the cavity. Once dry this excess is easily cut off using a knife or sharp chisel. Cut it back so that it is flush or slightly below flush with the face of the door jamb. The open texture of the foam when cut dry is ideal for the application of render.

15

Purchasing of building materials

Terminology to be used when purchasing materials

My father worked in management within the timber industry for a number of years. Every day he would have people claim to be builders or tradesmen in an attempt to purchase their materials at a reduced rate. He said that it was not that hard to pick the genuine from the counterfeit and it had nothing to do with their clothes, a common misconception. He would supply people dressed to the nines with trade or builders discounts, so what made the distinction clear? It was their terminology when ordering materials.

Beware of American terminology

Beware of using American terminology, gained by watching television. I will use a common timber size of 90 × 45, which, in the days before the introduction of metric measurements, was referred to as 4 × 2. Some people would ask for a piece on 2 × 4, which is the American system. In Australia we always refer to the largest dimension of the timber first. In America the smaller dimension of timber is referred to first. Too much television may cost you a lot of money if you take that terminology with you to the timber yard.

The people with the correct timber description might ask for 90 × 45 and specify that the timber they required is radiata pine but not give details of the required grade of timber. They might also ask for 10 pieces 3.6 metres long, whereas a tradesperson would request 10 at 3.6 with no mention of metres.

The tradeperson's note pad

A clever owner-builder will arrive at the supplier with a block of timber with the details of his or her requirements, as this is common practice for tradespeople who tend to grab anything for a shopping list. It will more often have something resembling:

90 × 45 pine 3.6 long, 4 of; or
3.6 long 90 × 45 pine, × 4

Where as the tradesperson will record the information as:

90 × 45 MGP10 4/3.6; or alternatively
90 × 45 4/3.6

and he or she will tell the attendant what type material is required.

The '4' is obviously the number of pieces required.
The '/' is referred to as at.
The '3.6' refers to the length of the timber required.

When ordering windows the height of the window is always mentioned before the width. When ordering doors it is assumed that the doors will be 2040 high unless you specify otherwise. The other standard height for doors is 2340 – this is 2.34 metres, not centimetres, as that would be a door with a height approximately the same width as your thumb.

Centimetres don't exist in the building industry

One of the most common errors in terminology is the use of centimetres. Within the building industry you need to understand that centimetres do not exist. The use of centimetres will only bring confusion. As a simple example, if you order timber with centimetres in mind it will have no bearing on the supplier, as they do not give reference to centimetres. If you order particleboard sheeting cut to size at 90 × 240 you would be expecting a piece of material a little wider than a standard door and as high as the ceiling in a project built home. What you are likely to be supplied is a piece of particleboard close to the length of your hand and less than half its width. The centimetre measurements equates to 900 mm or 0.90 of a metre × 2400 mm or 2.4 metres, however, the supplier is more than likely to consider them as millimetres for they only refer to millimetres and metres. When interpreted in terms of millimetres it equates to 90 mm × 240 mm.

Second-hand timber

When timber is used in a structural application it must be understood that the use of second-hand timber is a privilege, not a right. I am sure that many readers will, at this point, have feelings of dismay and may even wish to reject this statement but I assure you it is true and I shall explain why. The building code requires that timber used to carry load in the construction of a house, or any other building for that matter, must have the capacity to carry the load. If you check the timber specification schedule on your approved building permit it will have details of various grades of timber which might present as MGP with a number following for pine, or 'F' with a number following for other materials. These terms refer to the measurable strength of the material that is to be supplied.

In the seventies and eighties, trained people visually graded a high percentage of the timber. They understood that density of the timber and the direction of the grain in the timber reflected a particular strength in the material. They would then grade the timber with the appropriate 'F' value to reflect that strength. Today, the majority of timber is graded electronically. When you purchase pine you will often see a line of paint on one side of the timber which can be quite annoying if you wanted to expose that face of the timber. It might be black in one place and then change to green. This paint is put on the surface of the timber by the electronic grading machine to signify the strength of the timber in its entirety. If a single piece of timber has a variety of strengths within its length the whole stick of timber is downgraded to the lowest strength factor. The black paint indicates MGP10 and the green paint indicates a strength value of MGP12. The letters MGP stand for machine grade pine and is consequently only used in reference to radiata pine, while the 'F' is used for all other timber. Before the inception of the MGP coding, pine, too, was referred to as an 'F' value although most assistants in timber supply companies will now become confused if you refer to pine with an 'F' value, as they were not around at that time.

The building inspector's responsibility

It is the inspector's job to ensure that the material used to build the structure meets the requirements specified on the approved plans. When second-hand material is used, it is rare to find such a stress grade marking on the material. Without this marking, on what basis does the inspector determine that the material is capable of carrying the load? In most instances the inspector's training will not include a university degree as an engineer or training for the grading of timber, so to approve unmarked material would be irresponsible. Just because a piece of timber looks strong does not actually mean that it is strong.

Physical grading drawbacks

There were a number of problems with physical grading of timber prior to the introduction of electronic grading. In the early to mid 1970s the majority of house frames were built out of green gum tree, referred to by the tradies as OB, its official term being OBHW, which stands for ordinary builders hardwood. We would organise the construction so that the fascia was fitted prior to completing the roof, as this meant we could use the timber for the house as scaffold planks. This was common practice, however the sub-contractors approached it with due caution at the time, for there was a very real possibility that timber might break beneath your feet uncharacteristically. At that time it was not infrequent for timber to crack across the grain like a carrot. On inspection of the break it became apparent that something had chewed through the grain creating a weakness in the timber that could not be viewed from the surface. This was blamed on a particular type of beetle. It wasn't that the timber would break immediately – pressure had to be applied to it, as one of the sub-contractors found out.

One of the carpenters had set up a scaffold approximately 1.2 metres from the ground and, knowing the problem with the timber, walked over all the scaffold planks before he continued his work. He was using a circular saw to cut the ends off the rafters in readiness for the fascia when one of the planks broke. As he fell the circular saw, still going, dropped across his thigh and did serious damage. The electronic grading systems used today are much more likely to pick up weaknesses in timber from a beetle or any other cause, but much of the second-hand timber has not been graded in this way.

Appropriate use of non-structural timber

There are many instances in which the use of non-structural timber can be used, such as in partition walls that carry no roof or ceiling load. But make sure that it is specified as non-structural within the timber specification schedule otherwise the building inspector will almost certainly demand that the material used meet the specifications of the schedule.

Consult with your building surveyor/inspector

Talk to your building surveyor/inspector before using non-structural timber. If you want to use material that is not stress graded you will need to form an understanding relationship with your building inspector. Do not try to bully them, as anyone in the trade will testify that this approach will only cause them to demonstrate to you that they have the power to make things difficult for you. Speak to the building surveyor and ideally the inspector employed by them before you lodge your plans with them for a building permit. If they are unwilling to work with the material you want to use, try another building surveyor. Once the building permit has been issued it is probably too late for this type of discussion.

Purchase of recycled windows and doors

When considering the purchase of second-hand doors and windows you should be aware of the immense amount of time that it takes to get them back to a good condition. Timber stripped with caustic must first of all be washed down with vinegar to neutralise the caustic before painting, otherwise the paint may peel, or the caustic may bleed through the paint, discolouring the painted surface. Then they must be sanded and have any filler that the caustic doesn't remove scraped from them. Our doors had to be patched, undercoated, patched again, undercoated again and then have two coats of enamel paint. We had originally thought that we might stain the doors, however it is impossible to see the timber below the paint so it is potluck as to what you get. Our doors had very light and very dark timber, which was not conducive to stain.

Second-hand doors

Before purchasing second-hand doors, you should look across the face of the door to check for any twisting. This is particularly important if purchasing a pair of doors that are to be fitted together. If the twist on a pair of doors is opposing you will have serious difficulty fitting the doors, as you can easily have a total twist of 30 mm in a pair of doors. When purchasing second-hand doors it is best to have them stripped of their paint, if at all possible. If you purchase the doors from a reputable supplier they will replace any doors that are not structurally stable, which will become evident once the door is stripped.

Last year I purchased doors from a Melbourne company who stripped the doors in a caustic bath. When I went to pick the doors up the stile of one of the doors had a bow in it about 70 mm deep. The door stile had had numerous types of door furniture fitted to it during its life. Repairs had been done in that area, however, when immersed in the caustic bath the repairs had let go and the door became badly bowed. I approached the supplier who did not hesitate to offer to replace the door. I then had to choose another door, which again had to be stripped. While it was frustrating to have to go back to Melbourne from Heathcote to pick up the extra door, this was a small price to pay compared to installing a faulty door which would inevitably fail.

Recycled windows

If you are purchasing second-hand windows avoid windows with broken glass. To replace a single pane of glass can cost almost as much as the window you are purchasing. Also check that any weights for the window are supplied with it and that winders and catches are included in the price. Some double hung windows are fitted with a spring-loaded system to support open windows. These mechanisms are known as spirals and are now available in good building supply stores.

Checking timber windows for dry rot

The primary position for degradation of windows and doors is where two pieces of timber join. It is at these joints that the water is most likely to penetrate the timber and cause it to rot. It is not always possible to see if the timber is rotten in these areas, as the paint may well disguise the problem. If you push a key or small screwdriver against the timber in the vicinity of the joints you will quickly discover if any rot exists. Be sure to check the timber up to 50 mm around the junction as some windows have been repaired with fibreglass or builder's bogg, which would cover the problem at the theoretical joint position.

Avoid windows that have dry rot repairs

In the past I have been asked by customers to postpone the inevitable replacement of windows that were rotten at the junction of timber on the window sashes. It is possible to gain three or four years by using builder's bogg but that is all. To save the window for the time being, the rotten timber is cut out using a knife or sharp chisel. The rotten area needs to be cut out so that solid timber is exposed. You then fix several screws into both the vertical and horizontal pieces of timber, with the ends of the screws from each piece of timber overlapping. The cavity left by the removal of the timber is then replaced with builder's bogg, a fibreglass product. Once cleaned up, sanded and painted the window is likely to operate for several years. It is not that the person is trying to cover up the problem with the window, rather they just want a bit of extra time out of it until they can afford to replace it. When purchasing windows you need to be sure that you don't accidentally get a window that has only one or two year's life left in it.

Windows must comply with the building code

Windows installed in a new house must comply with the building code. You need to keep in mind that the building code specifies the glass that is to be in windows and doors, and this must be adhered to. We now live in a world where safety is a major focus of the authorities. There are regulations controlling the height you are allowed to be on a scaffold without handrails. You are forced to lay sheet flooring on the floor of first floor buildings before you are permitted to continue building above that level. You must have handrails around the roof frame or use safety harnesses. This attitude of protecting the foolhardy from him- or herself also extends to the glazing of windows.

I have no doubt that as you run around unreservedly in your birthday suit in the bathroom the risk of cutting off bits that are not to be removed is very high. One could only assume that many people have been maimed by such indiscriminate accidents, for while it was once necessary to have safety glass in windows over baths and showers, you are now required to have safety glass in any windows within reach of baths and showers. The chances of purchasing second-hand bathroom windows with safety glass would probably be somewhat similar to winning tattslotto. So unless you are planning on re-glazing the windows for the bathroom, don't bother buying second-hand windows for that area.

The story behind the current glass requirements in doors

In the sixties you did not have to have safety glass in any doors. I remember as a child that we had sand-blasted glass doors in our house in Numurkah. I recollect that the door at the end of the hallway had a koala sitting in a tree. This was in about 1960 so ensuites were not yet in vogue. One of the members of our family, who shall remain anonymous to all but the immediate family, had a significant call of nature in the middle of the night. There was evidently a high level of motivation to make it to the toilet at the other end of the house as quickly as possible. Unbeknown to this person, someone had shut the glass door on the end of the hallway that led to the toilet – the glass door with the koala sitting in the tree.

This particular night it was as black as the inside of a black cow on a stormy night. The person in question knew the path well and in the rush of the moment chose not to turn on any lights as this might have disturbed others in the middle of the night. The concern regarding others was somewhat overridden as the whole family was woken to the crashing sound of breaking glass. A team of rescuers soon arrived at the scene only to find that the koala and his habitat had been annihilated, but there was no sign of the culprit. I am sure that it was luck, but the culprit would claim good form, for the foot was lifted just at the right moment to clear the bottom rail of the door.

One can only assume that great speed and commitment to continue to the end cause was what saved the person from serious harm. For the penetration and destruction of the koala and his habitat brought nary a scratch from falling glass.

Glass requirements for glass doors

In the seventies the glass requirement for doors was upgraded to safety glass in all doors that did not have a horizontal rail. You are now required to have safety glass in all doors. Probably a good idea.

Glass requirements for full-height windows

Full-height windows previously had 3 mm glass in all areas, whereas now you are required to have 5 mm glass in the bottom panes. I am reminded of an incident that occurred in the tri-level house we built in Boronia. The stumps to the ground floor were over 3 metres high at the back of the house, and supported a two-storey construction above it. The formal lounge had a straw ceiling with walls lined with pine log offcuts and upstairs there were views over the city. The lights twinkled as we sat high above all obstructions. We had full-height windows filling three-quarters of the width of the wall.

Again it was the sound of crashing glass as it passed by the window below that drew our attention to the incident. On arriving up two sets of stairs in no time flat, we were greeted by a somewhat sheepish look from one of our children who now had a complexion somewhat similar to a white sheet. We had always said that skateboards should not be used in the house, but obviously this must have been an exception to the rule, for perched, balancing on the window sill halfway between inside and a 6 metre drop outside was the brightly coloured skateboard. I am not sure if the extra 2 mm of thickness in the glass would have stopped the skateboard, but it would certainly be a step in the right direction.

From the evidence above I would tend to agree that the upgrade on glazing requirements for doors and full height windows is appropriate, but I can't help wondering if the new requirements for bathroom windows are doing little more than to increase the cost of housing. None the less, this is now law and must be abided by.

16

Mice

It is generally acknowledged that mice cannot live in rendered straw bale walls, however there is always the exception to the rule, and so I feel this needs some clarification.

The mice that didn't know

The mice that didn't know they could not live in the walls of a straw bale house were found at a property with a two-storey infill straw bale house. In the quietness of the evening the owners could hear the mice in the ceiling of the ground floor. There are most frequently mice in the straw bale walls prior to render, but in most cases they are encased in the walls without a water supply and die.

When rendering the house in question there was little attention paid to the straw exposed between the ends of the deep floor joists for the upstairs rooms that also formed the ceiling frame for the ground floor. The straw was exposed while the first coat of render was applied, but it was not worked into the straw as was the case for the walls. The ceiling lining was installed prior to the second coat to enable a build up of the render at the ceiling to overcome the need for a cornice. Obviously the third coat was also restricted to the walls and not to the straw exposed between the floor joists.

The mice were able to get through this badly applied first coat of render between the floor joists with considerable ease, and continued to do so. This meant they had access to the complete ceiling cavity between the upper floor and the lower ceiling. After about 12 weeks there was no evidence that the mice were going to die out but more likely, mice being the amorous creatures that they are, that the numbers would increase. I am sure by now you ask the same question that we did; how are they surviving without water?

How did the mice survive without water?

The hot and cold water pipes for the kitchen passed from one side of the house to the other through the ceiling cavity. The only explanation for their water supply was that they were most likely getting the little bit of condensation off the cold water pipes in the ceiling. This small water supply would have no doubt controlled the population, however it appears to have been more than sufficient for the support of the resident mice.

The mice's healthy eating kept them alive

We contacted our pest controller and decided that it would be necessary to lay baits for these fury little fellows. We cut five holes in the upstairs floor, being careful not to lose the pieces of floor removed as they would be needed later on to patch the floor. Baits were placed in the ceiling cavity and the waiting game began. Another three weeks passed and there didn't seem to be any change. The mice were not interested in our baits, no matter what type we put in. We had not understood that mice are health freaks, choosing only the supply of wholegrain wheat rather than food with all kinds of additives. Maybe there is a lesson to be learnt from them.

A green drink brought the demise of the mice

We knew that there was a shortage of liquid in their living environment and deduced that if we could acquire liquid bait they would be more likely to take that. We again contacted the pest controller who was able to acquire a liquid bait which when diluted with water had a strange resemblance to green cordial. It was only a couple of days after laying the liquid bait that there was serious evidence that the mice had consumed this lovely green cordial. This was not a time for warm cosy rooms, for to close the windows intensified the evidence of their demise. Fortunately they are only little, so the smell only lasted a few days. A few days that we will never forget!

17

How to build your own staircase

I have no doubt that you have seen a huge variety of staircases, including straight stairs and spiral staircases. The staircase mentioned in *Fiddler on the Roof* is a favourite, and an expression of many people's attitudes towards stairs as they can add a lot to the aesthetic appeal and flavour of a house. However, I think that to have one going up and another coming down just for show is a little over the top. The simplest staircase to build and install is a straight run of stairs from one floor to the next (see Figure 17.1).

It is often not possible to fit a straight run of stairs into a house, so landings are used to join shorter straight sections of stairs. The landings might be in the form of a flat platform or may have triangular shaped stairs within them. The options are limitless in the design and materials uses to build staircases, however there are legal requirements that must be adhered to.

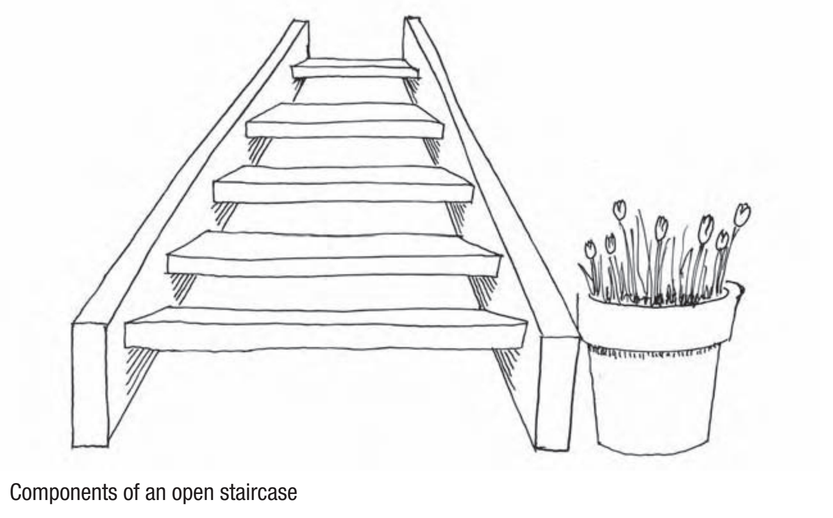


Figure 17.1 Components of an open staircase

In this passage we will only deal with the construction of straight runs of stairs. Once you have the theory behind the construction of straight sections of stairs you will be able to adapt this to many applications including external stairs. The introduction of landings to join different runs of straight stairs can simply be built as platforms supported on posts or short walls.

Legal requirements of staircases

The minimum depth of the tread (the horizontal section of the stair) is 240 mm.

The maximum rise from one tread to the next is 190 mm. This is measured from the top of one tread to the top of the next tread.

External stairs must be constructed of timber approved for external use, such as treated pine and many of the hardwoods.

The tread width and the rise should be consistent throughout the flight of stairs. Variance, particularly in the rise, is likely to cause people to trip when using the stairs.

The specifications of timber to be used in staircase is unlikely to be included in the timber specification schedule so I suggest you consult your building consultant with details on the width and height of your proposed stairway so that the correct timber dimensions might be established. It is not necessary to close in the rise of the stairs, although in some instances this will assist in the structural support of the treads.

Make allowances for stair installation at the frame stage

It is important that correct calculations be made prior to framing the upstairs floor, and most certainly prior to lining any walls or ceiling in or about the stairwell.

The staircase that didn't fit

A couple of years ago I was called to the home of an owner-builder who was having difficulty sorting out his stairs and stairwell. The stairwell ran from the lounge room to a second living room upstairs. The owner-builder was concerned that he didn't seem to have enough space to fit in his stairs, and he was right. The stairwell needed to be extended approximately 300 mm to achieve the required minimum ceiling height. This meant that one of the upper floor joists had to be removed to lengthen the stairwell.

The cutting of electrical cables

At frame stage this would be a relatively simple adjustment, but in the excitement of the moment the owner had fitted a beautiful timber ceiling. Part of the ceiling had to be removed. We all know that timber removed will rarely go back into position like it was originally. I suspect that this is another one of Murphy's laws. There were electric cables in the vicinity, so great lengths were taken to count them to see that all were accounted for prior to cutting the ceiling. You guessed it, within seconds of starting the cut there was a bright flash and the smell of smoke. Thank God for safety cut-out switches or it could have been very serious. An electrician had to be called in to repair the damage. More money and more delays.

The timber panelling had to be removed

At first glance it appeared that all that had to be done was to cut back the ceiling, re-framing the upper floor joists and refitting the ceiling. But there was more. The owner was fabricating his own stairs to save money: a common practice for owner-builders. He had already fitted the stringer of the stairs and brackets to the stringers in their theoretical position to take the treads. It was when fitting the brackets that he realised he had a problem. The stringers and brackets had to be removed and refitted in a lower position. Unfortunately he had already fitted his beautiful timber panelling complete with dado mould to the wall of the stairwell. The timber panelling had to be completely removed, but this time there was no saving it, for it was now too short.

A day was lost waiting for the electrician, and it could have been a lot longer. Four days were lost altering the ceiling height of the stairwell, and another to fit the new wall panelling on the walls. The stair stringer had to be replaced, as did all the panelling for the walls. There was significant financial loss in the whole process, but that was the lesser of the cost. The highest cost was emotionally. The disappointment and frustration at having to destroy his pride and joy took a heavy toll. It is sometimes difficult to look past a problem that is so daunting; this can often bring the job to a sudden halt.

The theory behind the construction of straight stairs

1. Establish the total height the stairs are to traverse

This is equal to the distance from the surface of the finished floor at the bottom of the stairs, to the surface of the floor at the top of the stairs. Divide the height by 190 mm, which is the maximum rise permissible. Round the answer up to the next full number. This will be the number of risers required in the staircase.

For example:

2.6 metres high that is,	2600 mm
Divided by the maximum rise	190 mm = 13.8
Rounded up to the next full number	= 14 risers

2. Establish the actual rise of each step

Divide the total height by the 14 risers

For example	Total height 2600 mm
Quantity of risers	14 = 186 mm

3. Establish the length required in the stairwell

An ideal width for the tread is 280 mm however you may not have the total length required of the stairwell to accommodate this. The quantity of treads is one less than the quantity of risers, so in this example it will be 13. To establish the total required length to accommodate a 280 mm tread, multiply the tread width by the number of treads.

For example	Proposed tread depth 280 mm
Quantity of treads	× 13
Required length of stairwell	= 3640 mm or 3.64 metres

4. Establish the depth of the treads for a predetermined stairwell length

Let's assume that you only have 3.2 metres available for the stairwell. To calculate the tread depth, divide the 3.2 metres or 3200 mm by the quantity of treads.

For example	Available space for stairwell = 3200 mm
Divided by the quantity of treads	13 = Tread depth of 246 mm

When constructing the stairs, allow the tread to overhang the line of the riser by 10 mm (see Figure 17.2). This will give you more comfort in walking up the stairs and increase the tread size by 10 mm.

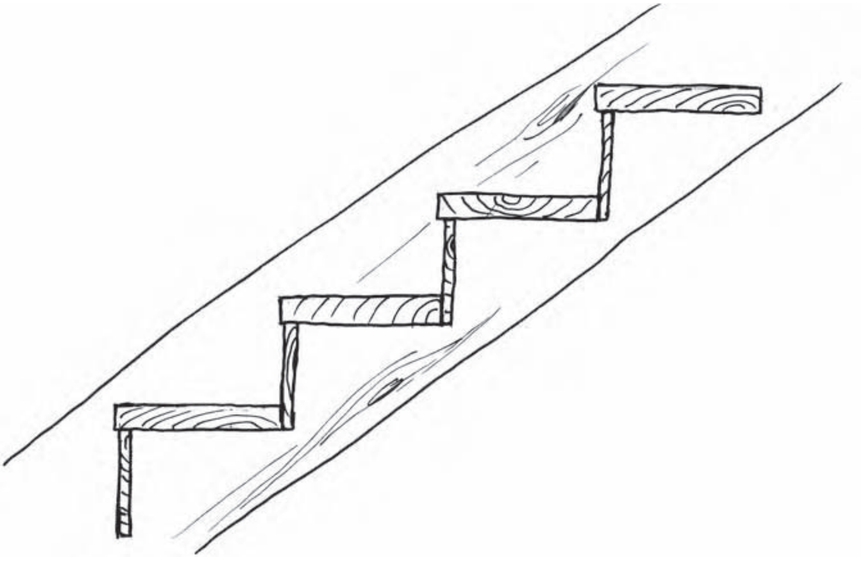


Figure 17.2 Sectional view of a staircase with the tread overhanging the riser by 10 mm

Staircases have traditionally been built by making a checkout in the stringer (the angle piece of the stair) into which the treads are fitted. The treads are then wedged into position with small wedges being hammered into position below the tread within the checkout (see Figure 17.3).

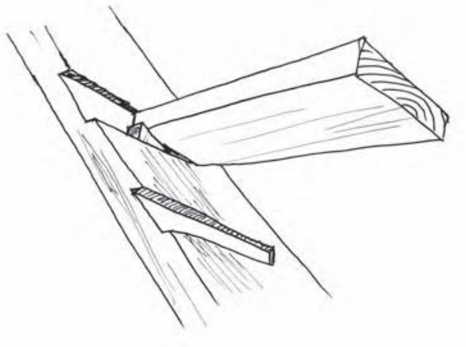


Figure 17.3 Installation of a tread into the checkout in the stringer with the use of a wedge

The use of brackets or mounting blocks to support the treads

You will find it much easier to assemble your stairs by fitting mounting blocks to the stringers. The treads are then fixed in place by nailing through the stringers into the ends of the treads and by fixing the tread to the mounting blocks, usually with screws through the mounting blocks into the underside of

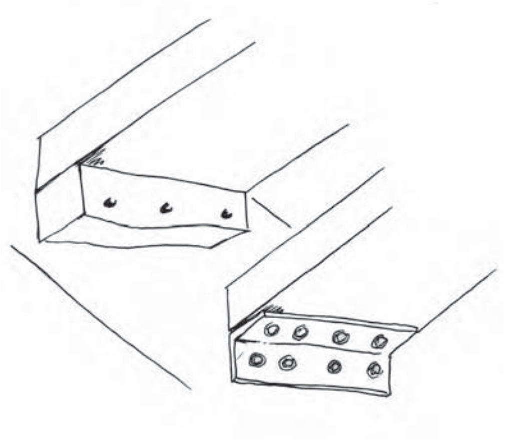


Figure 17.4 Metal and timber mounting blocks fixed to the stringer to support the treads

the tread (see Figure 17.4). The mounting block might be made from 35 × 35 pine, or, particularly in the case of external stairs, you would be advised to use the metal angle brackets now available at good hardware stores specifically for the purpose.

Once you have established the rise and depth of the treads, you can mark the stringers with the positions that the treads are to be fitted. Ideally you will use a roofing square (see Figure 17.5) which will sit flat on the timber stringer, or you could replace it with a square cut piece of timber. I shall detail that approach shortly.

As per normal, the stringer is to be installed with the bow up. Site along the stringer and mark it with an arrow to avoid any confusion.

Building a staircase

Mark the stringer

Mark the stringer with the required position of the front of the tread by drawing a line parallel with the top edge of the stringer approximately 20 mm from the edge.

Mark the location of the tread

Using a large square, mark the stringer with the location of the tread. If the rise is 190 mm and the run or tread depth excluding the overhang of the tread across the riser is 246 mm, you will locate 190 mm on one arm of the square and 246 mm on the other. Hold the square against the stringer with the 190 mm mark on the square and the 246 mm mark on the square in line with the mark drawn on the stringer (see Figure 17.5). Scribe a line against the square to record the position of the square. Move the square up the stringer so that the measurement representing the tread (246 mm) meets the line drawn along the length of the stringer at the same point that the mark

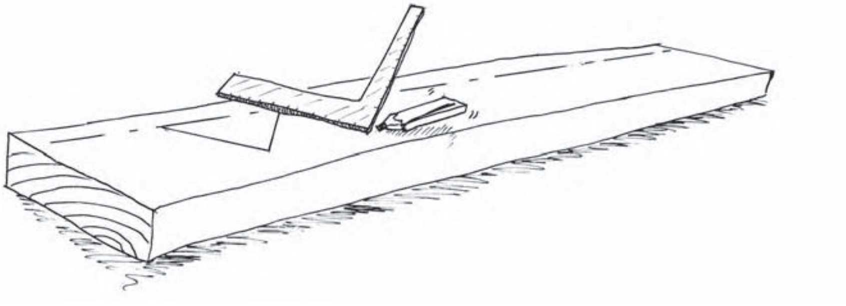


Figure 17.5 Marking the stringer with the tread positions

representing the riser position was previously drawn. Continue this process until you have the correct number of treads and risers represented on the stringer.

The bottom mark should be that of a tread. This is the line that the bottom of the stringer is to be cut at as this will give you a cut that will sit flat on the floor at the bottom of the stairs. The top cut is to be cut vertical in line with the final riser marking BUT do not cut it all the way through, as you will need a checkout to sit over the top of the upper floor to support the top of the stair case. Draw a second line approximately 20 mm beyond the line of the top riser. The checkout will be cut so that as the staircase sits on the upper floor the distance from the top of the upper floor to the top of the first tread down the staircase is equal to all the other risers (see Figure 17.6).

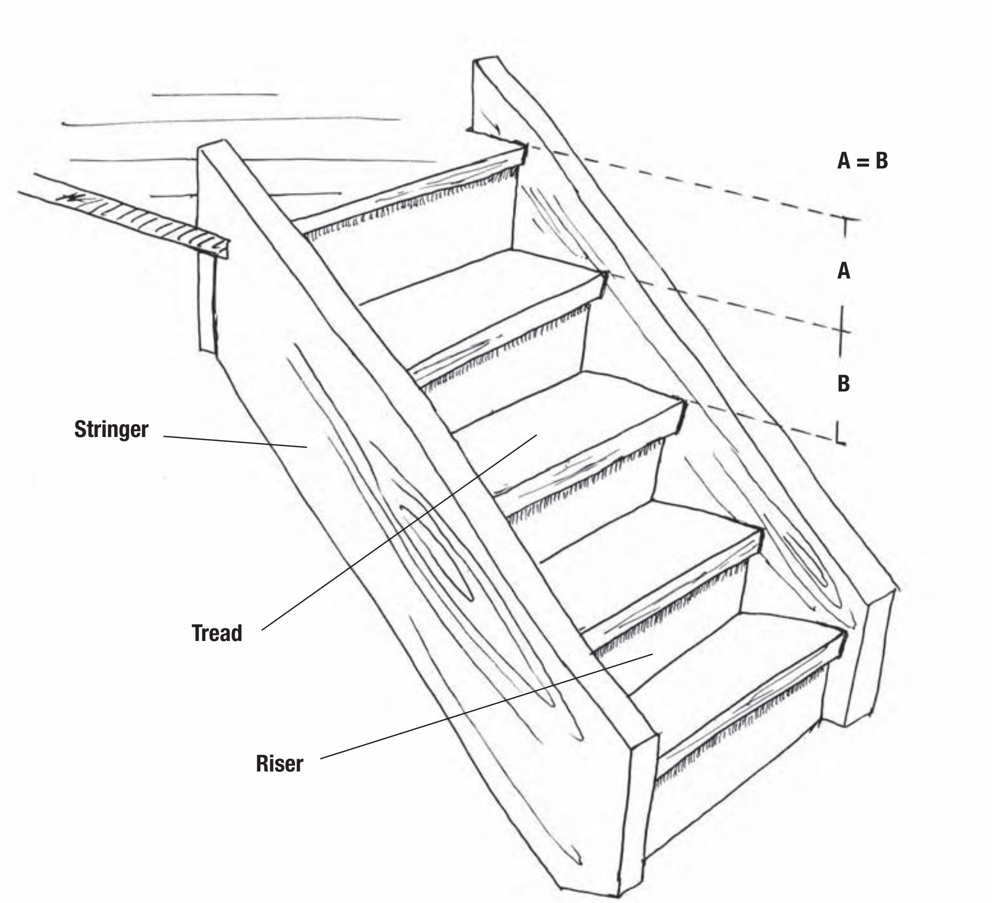


Figure 17.6 All risers of a staircase are to be equal

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Conclusion

I recently had occasion to speak at length with a potential owner-builder. She is a single mum with a deep desire to improve her lot. Finances are tight and experience non-existent. She has shared her dream to build a straw bale house with her family and friends and most have tried to discourage her, saying it will be too hard. She knows one couple that are currently building their own straw bale home who have encouraged her to pursue her goal. She has attended one of my workshops and her faith in her ability has grown. She is rational and able to lift a bale of straw. She is short on friends that believe in her, but her fellow workshop attendees have offered to help her. She has the desire and a heart to carry her to the end. An end that will see her and her children in their own home. The first for three generations. No longer locked into the financial battle of paying ever-increasing rent and fuel costs. She is a woman with success in her heart and victory in her eyes. You too will bear the brunt of jokes about the three little pigs and the big bad wolf. Dare to be different. Dare to defeat discouragement and put-downs. Dare to rise above the emotional pressure of building your own home. In the end, the people that said it could never be done will admire your vision and guts. There are people that will help. People to talk you through your lack of knowledge. People to lend a hand when stuff's too heavy. You are not alone. Reach out to your dream and grasp it. Live your dream. Build your own straw bale home. May your building be joyous and fulfilling as you give birth to your dream.

Appendix: Metric/imperial conversion

Length

Metric to imperial

1 millimetre	= 0.001 metres
1 centimetre	= 0.3937 inches
	= 10 millimetres
	= 0.01 metres
1 metre	= 3.281 feet
	= 1000 millimetres
	= 100 centimetres

Imperial to metric

1 inch	= 25.4 millimetres
	= 2.54 centimetres
1 foot	= 30.48 centimetres
	= 0.3048 metre
	= 12 inches
1 yard	= 0.9144 metre
	= 3 feet

Area

Metric to imperial

1 square centimetre	= 0.155 sq inch
	= 100 sq millimetres
1 square metre	= 1.196 sq yards
	= 10 000 sq centimetres
1 hectare	= 2.471 acres
	= 10 000 sq metres
1 square kilometre	= 247.1 acres
	= 1 000 000 sq metres

Imperial to metric

1 square inch	= 6.452 sq centimetres
	= 1/144 sq foot
1 square foot	= 929 sq centimetres
	= 0.0929 sq metre
1 square yard	= 0.8361 sq metres
	= 9 sq feet
1 acre	= 0.4047 hectare
	= 4046.87 sq metres
	= 4860 sq yards

Glossary

Ant cap Metal hat fixed on top of a stump to help prevent termite passage

Auger A drilling implement shaped like a corkscrew

Bale mallet Large wooden mallet for relocating straw bales in a wall

Barrap A roof support system utilising metal cables and adjustable fulcrum

Bearers Timber fitted on top of stumps that support the floor joist

Birdsmouth Triangular checkout in the bottom of a rafter which sits over the outside wall

Bottom boxing Timber structure at the bottom of a straw bale wall on which the straw bales are laid

Bottom plate Timber at the base of a timber framed wall

Buckle Coupling for compression strapping

Cement render Paste materials often consisting of 1 part cement, 1 part lime, 6 parts washed sand. Also referred to as stucco

Centres A measurement from the centre of one piece of timber to the centre of a parallel piece of timber. Equivalent to common edge

Chalk line A marking system with a string line held in a holder with chalk inside it. The chalk is loaded onto the string and when flicked against a surface the chalk marks the material, leaving a straight line marked

Checked into… To fix a piece of timber into another with its face level with the face of the original piece of timber

Checkout To remove a straight-edged section from timber

Chippy Nickname for a carpenter

Cob A sticky, fibrous mixture of straw and earthen render

Collar tie A piece of timber in a roof fixed horizontally between the ceiling joist and roof peak

Common edge A measurement from the edge of one piece of timber to the edge of a parallel piece of timber. Equivalent to the centres measurement

Compression strapping Polyester strapping encircling the bottom boxing, straw bales and top boxing. The shortening of the strapping causes the compression of the straw bales

Cripple To cut part way through a piece of bowed timber to facilitate its straightening

Cutting (excavation) To excavate land, normally with a view to create a flat section on which to build a home

Door buck A frame fixed into a straw bale wall into which a door is fitted

Door chair rail The central horizontal section of a door

Door head (door frame, door fix) The top horizontal section of the door opening of a timber framed wall or door jamb into which the door is hung

Door post A vertical post adjoining a door

Door sill The bottom horizontal section of a door

Door stile The vertical timber of a door

Door stop Timber within a door jamb that the door closes against

Dumpy level A mechanical piece of equipment used for measuring land gradient

Earthen render A paste made up of sand and clay used to seal straw bale walls

Eave The section of the roof that extends beyond the outside wall

Fascia Timber fixed to the outer ends of rafters, onto which guttering is secured

First fix The carpentry to build the frame of a house

Floor clamps Clamps also referred to as floor dogs, used to clamp flooring together

Floor joist Horizontal sections of timber fixed to the bearers onto which the flooring is fixed

Framing Carpentry work on the timber frame of a house, also referred to as first fix

Framing gun A nail gun which fires 75 mm nails, used to assemble the frame of a house

F7 A rating of timber strength

Fulcrum The point of rest on which a lever turns or is supported

Gang nail Metal plate with spikes protruding used to join two pieces of timber

Gripple A mechanism used to join fencing wire

Hanging beam A timber beam fixed above and to ceiling joists to support the ceiling joists

Head door, head window The top section of a door or window

Hip truss A manufactured truss running from the external corner of a building at a 45-degree angle to the centreline of the building

Hurdle A structure on which the location of a building's foundations are recorded as a term of reference during construction (a horizontal piece of timber fixed to two uprights)

Infill A straw bale building system where straw bales are used to fill the spaces between a self-supporting structure

Jack joist Short sections of timber fixed to the outside wall running parallel to the ceiling joists, and to the first ceiling joist, onto which the ceiling is fixed (also referred to as ceiling trimmers)

Jack rafter The first full rafters to be fitted at each end of a roof

Joist strap Upright timber or metal straps fixed at the junction of the ceiling joist and hanging beam

KDHW Kiln dried hardwood
Kordon A physical and chemical barrier to termites
Laser level A piece of equipment with a laser, used for measuring land gradient
Latch A spring-loaded door lock system that can be opened by turning a door knob or key
Lath A small, flat section of timber fixed to a timber-framed wall, onto which plaster is spread to create a flat wall surface
Level A nickname for a spirit level
Lime putty A paste made up of hydrated lime and washed sand used to seal straw bale walls
Lintel A horizontal beam fitted within a wall to support a load over an opening
Load bearing A straw bale building system where the weight of the roof and/or upper floor joists of two-storey construction is supported by the straw bales
Lock-up Carpentry work resulting in the house being securely locked
Metal wall brace A length of angle iron fixed into a timber framed wall to hold it square and upright
MGP Machine Grade Pine (a measurement of the strength of pine)
Mullion Vertical piece of timber fixed within a window
Nail plate *see* gang nail
Noggings Short horizontal piece of timber fixed between studs in a timber framed wall (can be abbreviated to noggs)
OBHW Ordinary building hardwood
Packers Thin pieces of timber used to build up the depth or thickness of timber
Plane Method of reducing the size of timber, which results in a smooth surface
Plumb bob Implement consisting of a weight and a piece of string; used to find a vertical line
Plumb cut A vertical cut on a piece of timber, most often on a rafter
R value A measure of resistance of insulation to heat transfer; the higher the R value, the more effective the insulation
Rafter Material supporting roof cladding
Render Paste material used for sealing straw bales. *See also* cement render, stucco, lime putty and earthen render
Reveal Timber fixed to the inside of an aluminium window
Ring beam Beam around the perimeter of an infill straw bale building which supports the upper floor joists and/or the roof
Rip To make a cut along the length of timber (normally along the grain)
Riser The vertical part of a staircase, which may be filled with timber or left open
Second fix The carpentry work that results in a house being able to be locked
Sheet flooring Pieces of flat flooring material approximately 3600 x 900 mm, normally made of ply or particleboard
Sill The bottom horizontal section of a window or door
Sizalation Sheeting fixed beneath roof cladding and above the rafters to prevent condensed water falling on the ceiling
Sole plate Timber or concrete support for stumps
Spacings The gap between two parallel materials

Sparky Nickname for an electrician
Spirit level A tool used to establish vertical and horizontal positions
Stile The vertical section of a door or external vertical parts of a window; the frame into which a window or day is to be fitted including a window or door buck
Stucco *see* cement render
Striker plate Metal plate fixed to a door jamb. The door latch passes over its face and then protrudes into it and holds the door in the closed position
Stringer The angled section of a staircase
Strip flooring Narrow pieces of timber fixed to the floor joists
Strip footing A combination of concrete and steel within a trench in the ground designed to support a building
Structural infill A straw bale building system where the roof and/or upper floor joists are supported on a frame, which is fixed to and held upright by the compacted straw bales
Stud Vertical timber within a timber framed wall
Stump Timber, concrete or metal pile used to support a house
Stump pin A metal pin protruding from the top of a concrete stump
Subbies Nickname for sub-contractors
Sub-floor bracing Angle bracing fixed to stumps
Thermal mass A body of matter capable of absorbing and retaining heat
Top boxing Timber structure fitted to the top of a straw bale wall
Top plate Horizontal piece of timber at the top of a timber framed wall
Tradies Nickname for tradespeople
Tread The horizontal section of a staircase
Trusses Prefabricated roof structures
Vibrating plate Hand-operated machine for the compaction of sand and crushed rock
Villaboard Cement-sheet type product with a rebate at the edge of the sheets that enables joining compound to be fitted, giving a flat, patched surface. Ideal for use in wet areas, particularly as a support of ceramic tiles, etc.
Wall plate Horizontal piece of timber at the top or bottom of a timber framed wall
Water level A piece of equipment utilising the properties of water to determine multiple locations that are at the same level as one another
Wall brace Diagonal piece of material to hold a timber-framed wall square and vertical
Window buck A frame fixed within a straw bale wall into which a window is fitted.
Window flashing Plastic and/or aluminum sheeting fitted to windows to prevent the penetration of water on or about windows (also used around external doors jambs)

Anvill

Do you still have questions?

After the initial excitement wears off, many potential owner-builders begin to doubt their ability. This is the time when most of my clients first contact me. Their questions vary, but inevitably sound something like 'I have no building experience. Can I really build my own straw bale home?'

My answer is categorically yes, as long as you are physically fit and you are a rational human being. Every challenge you will face, I can solve for you. All the daunting questions you have, I can answer. All the hurdles presented by the authorities, I can help you jump. Having been in the building industry for over 30 years, I have yet to be asked a question that I, or one of my associates, couldn't answer.

I'm sure you have seen those television shows that tell one horror story after another of unreliable and dishonest builders and owner-builders who are out of their depth. I have rescued many an owner-builder and I would like to help you before your niggling worries become a nightmare.

Our workshops and one-on-one consulting services will, without exception, save you time and money; much more than you will invest with me. Several months ago, for example, I spent four hours reviewing and adjusting a house construction design at a cost to the owner-builder of $360. This resulted in a saving of well over $3000. More importantly, the owners now enjoy peace of mind, knowing that they have an experienced eye and a sympathetic ear to help them through any challenges beyond their ability.

I can also introduce you to my son, Brad, who can save you thousands of dollars by supplying hard-to-find, low-cost new building material and straw bale building tools. Hiring him to apply the render to your straw bale walls using his render pump will save you months of work.

Take a quick look below for some other services that we can help you with, and be sure to visit our website at: www.anvill.com.au.

I can be contacted initially by email on: questions@anvill.com.au or via our informational website: www.anvill.com.au.

I look forward to hearing from you

Brian Hodge

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TRAINING CONSULTANTS FOR STRAW BALE CONSTRUCTION

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Provide the core theory and practice for owners building with straw bale

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Render your house in one-tenth of the time

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Introduces you to draftsmen that are passionate about straw bale

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Engineering certification of our construction designs achieve trouble-free building permits

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Fire ratings documentation

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