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ELECTRIC LIFT INSTALLATIONS IN STEEL FRAME BUILDINGS

INTERFACES

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FOREWORD

This publication has been developed jointly by The National Association of Lift Makers and The Steel Construction Institute. It results from a research programme into 'Interface Problems in Modern Commercial Building Design' carried out by the Steel Construction Review, and work aimed at standardising and improving lift installations in steel frame buildings carried out by the NALM Forum.

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British Steel plc

The Steel Construction Industry Federation

The National Association of Lift Makers

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Other publications in the *Interfaces* series, published by The Steel Construction Institute, are:

Curtain Wall Connections to Steel Frames

Connections Between Steel and Other Materials

CONTENTS

SUMMARY

Lift installations in steel frame buildings are conventionally supported either directly by the steel frame, or by concrete floors which in turn transmit the loading onto the frame. Whilst the frame and lift installation are separate and distinct packages, the detail of each can have a significant effect on the cost, buildability, programming and performance of the other.

This publication is the result of a joint initiative from the UK lift and steel industries. It continues a programme of research initiated by the Steel Construction Review and carried out by The Steel Construction Institute into building interfaces. It incorporates the studies on the interface requirements of standard lift installations, carried out by The National Association of Lift Makers (NALM) through the NALM Forum.

The publication provides an overview of standard electric lift installations of the type normally used in steel frame buildings. It appraises and recommends various methods of attaching guide rails, landing doors and other items of lift equipment to the building. The document also recommends acceptable guide rail spans for lifts of various speeds, deflection limits for guide rails and their supporting structure and design loads for structural elements supporting the lift installation. It provides a basis for standardising key design details, and where necessary will assist building designers to develop structural components and construction details in advance of a lift supplier being appointed.

The publication is written for use by architects, engineers, steelwork contractors, lift engineers, site managers, clients and developers.

Interfaces: Installation d'ascenseurs électriques dans les immeubles à ossature en acier

Résumé

Les installations d'ascenseurs, dans les immeubles à ossature métallique sont habituellement supportées soit directement par la charpente en acier, soit par les planchers en béton, qui transmettent alors les charges à l'ossature. Bien que l'ossature et les *installations de l'ascenseur soient deux choses séparées, elles peuvent toutefois s'influencer l'une l'autre et cette interaction peut avoir un effet significatif sur le coût de la construction globale.*

Cette publication est le fruit d'une collaboration entre les industries britanniques des ascenseurs et de l'acier. Cette collaboration poursuit le programme de recherche, réalisé à l'initiative du Steel Construction Review, par le Steel Construction Institute, et portant sur les "interfaces" dans les bâtiments. L'étude de l'interface entre charpente et ascenseur a été réalisée en collaboration avec le National Association of Lift Makers (NALM).

La publication donne une vue générale des installations d'ascenseurs électriques utilisées habituellement dans les bâtiments à ossature en acier. Elle recommande différentes techniques relatives aux attaches des rails, aux portes, etc., ainsi que les portées, déformations maximales et charges de dimensionnement recommandées, en fonction de la vitesse de l'ascenseur. Cette publication peut être considérée comme une base permettant une standardisation des détails constructifs. Elle peut servir de guide aux projeteurs pour le dimensionnement des composantes structurales et des détails d'assemblage, avant même qu'un fournisseur d'ascenseur ait été choisi.

La brochure est destinée aux architectes, ingénieurs, contractants ainsi qu'aux autres acteurs de la construction tels que clients, surveillants de chantier, etc.

Installationen für elektrisch betriebene Aufzüge in Stahlbauten

Zusammenfassung

Installationen für Aufzüge in Stahlbauten werden entweder direkt am Tragwerk oder an Betondecken befestigt, die die Belastung ins Tragwerk Weiterleiten. Während das Tragwerk und die Aufzug-Installationen deutich getrennte Gewerke darstellen, können sich die jeweiligen Details hinsichtlich Kosten, Ausführung, Bauablauf und Leistung gegenseitig stark beeinflussen.

Diese Veröffentlichning ist das Ergebnis einer gemeinsamen Initiative der englischen Aufzug- und

Stahlhersteller. Sie setzt ein von Steel Construction Review initiiertes und vom Steel Construction Institute ausgeführtes Forschungsprogramm fort. Sie beinhaltet Studien bezüglich der Anforderungen an Installationen von Standard-Aufzügen, die vom NALM-Forum (National Association of Lift Makers) erarbeitet wurden.

Die Veröffentliching verschafft einen Überblick bezüglich der Installationen für elektrische Aufzüge wie sie normalerweise in Stahlbauten verwendet werden. Sie beurteilt und empfiehlt verschiedene Befestigungsmethoden für Führungsschienen, Türen und andere Aufzugselemente an das Tragwerk. Empfohlen werden auch Spannweiten für Führungsschienen von Aufzügen verschiedener Geschwindigkeit, max. Durchbiegungen für Führungsschienen und Tragwerk und Lastannahmen für die Unterkonstruktion der Aufzug-Installationen. Die Publikation enthält Standard-Details und hilft dem Entwerfenden tragende Komponenten und Baudetails zu entwickeln bevor der Aufzug-Lieferant eingeschaltet wird.

Die Veröffentlichung wurde für Architekten, Ingenieure, Stahlbau-Firmen, Ingenieure für Fördertechnik, Bauleiter, Kunden und Entwickler geschrieben.

Interfases: Instalaciones de ascensores eléctricos en edificios con estructura de acero

Resumen

En los edificios con estructura metálica los ascensores se apoyan directamente sobre ella o sobre forjados de hormigón. Aunque la estructura y las instalaciones de los ascensores son sistemas distintos sus detalles respectivos pueden tener un efecto importante en el coste, facilidad de construcción, programación y funcionamiento del otro.

Esta publicación es el resultado de una iniciativa conjunta entre las industrias de ascensores y acero del Reino Unido, como prolongación de un programa de investigación sobre "Interfases en las construcción" iniciado por el Steel Construction Review y llevado a cabo por el Steel Construction Institute.

Incluye los estudios sobre requisitos para instalaciones tipificadas de ascensores realizado por la National Association of Lift Makers (NALM) en el marco del Forum NALM.

La publicación proporciona una visión global sobre las instalaciones de ascensores de tipo normal, que se utilizan en los edificios con estructura de acero. Considera y recomienda varios métodos de unión de carriles guía, puertas y otros temas relativos al equipamiento de elevadores en los edificios. El documento tembién recomienda vanos aceptables por los carriles guía según la velocidad de los ascensores, deformaciones límite para ellos y sus estructuras de apoyo y cargas de proyecto para elementos estructurales que sirvan de apoyo a las instalaciones del ascensor.

El informe suministra además una base para la tipificación de detalles clave en el proyecto lo que será de utilidad a los proyectistas para desarrollar componentes estructurales y detalles constructivos antes de la elección de un contratista de ascensores.

El informe se ha preparado para que sea útil a arquitectos, ingenieros, contratistas de estructuras metálicas, ingenieros de ascensores, ingenieros a pie de obra, clientes y promotores.

Anslutningar: Elektriska hiss-installationer i byggnader med stålstomme

Sammanfattning

Hissinstallationer i byggnader med stålstomme bärs antingen direkt av stålkonstruktionen eller av ett betongbjälklag som i sin tur överför lasterna till stålstommen. Då stommen och hissinstallationen ingår i separata entreprenader kan detaljutformningen av varje delentreprenad få betydande effekter på kostnad och utförande av den andra delentreprenaden.

Den här publikationen är resultatet av ett samarbete mellan Storbritanniens hiss- och stålindustrier. Det är en fortsättning på ett forskningsprogram initierat av Steel Construction Review och som utförs av Steel Construction Institute. Det innefattar resultatet från studien av anslutningar för normala hissinstallationer, genomförda av National

INTERFACES

Association of Lift Makers (NALM) genom NALM Forum.

Publikationen ger en översikt av vanliga hissinstallationer som normalt används i byggnader med stålstomme. Den bedömer och rekommenderar olika metoder för infästning av gejder, hissdörrar och annan hissutrustning till byggnaden. Dokumentet rekommenderar vidare acceptabla infästningsavstånd för gejder till hissar med olika hastighet, deformationsbegränsningar för gejder och dess bärande konstruktion samt dimensioneringslaster för element som ska bära hissinstallationen. Den ger en bas för utformning av typdetaljer, och där det är nödvädigt även hjälper konstruktören att utforma bärande komponenter och detaljer innan hissleverantören har utsetts.

Publikationen är skriven för arkitekter, konstruktörer, stålbyggare, hisskonstruktörer, projektledare och beställare.

INTRODUCTION

This publication is the third in the *Interfaces* series. The intention of the series is to review and rationalize the relationship between major building components and steel frames. Lift interfaces have an important influence on cost and speed of construction, and have not, until now, been the subject of detailed study.

Historically, many large buildings have incorporated massive concrete or masonry lift wells that often braced the structure. The walls of these wells were also used to support guide rails and other items of lift equipment. Many modern buildings, particularly those with steel frames, do not require such stabilising elements, and this inevitably leads to differences in the way in which lift installations are detailed.

This publication is primarily concerned with standard electric lift installations and is based on a thorough survey of modern lift technology, building codes and steelwork details.

The use of certain lift details and framing systems can reduce the cost of the lift package, but increase the cost of the steel frame. Similarly, poor or unsympathetic structural arrangements can impair the quality, and raise the cost, of the lift installation. The recommendations contained within this publication are intended to reduce the combined cost of the building structure and lift installation, whilst achieving high standards of lift performance and structural design.

During the preparation of this publication, a great deal of work has been done by the lift industry to standardise lift installation. This has involved all of the major lift suppliers in the UK, and has brought about harmonisation in five key areas:

1. Acceptable guide rail spans for lifts of various speeds, with particular regard to guide rails spanning between floor edges without intermediate supporting steelwork.

2. Steelwork arrangements for the support of lift landing doors.

3. Design loads for machine room slabs, lift pits and other structural elements.

4. Deflection limits on guide rails and their supporting structure.

5. Recommended methods of attachment of the lift installation to the steel frame or floor slabs.

These standardised approaches will assist steelwork designers to size and schedule the majority of steel frame elements before the lift supplier is commissioned, thereby rationalising the steelwork design and fabrication programme. This is likely to benefit the lift and steel industries, the construction industry and the client by assisting to achieve high quality buildings at lower cost.

This publication describes the components used in modern lift installations; and recommends specific details, structural arrangements and opening sizes. It should be used with manufacturers' instructions and in conjunction with British Standard 5655: *Lifts and Service Lifts* Part 5 (based upon ISO 4190), Parts 6 and 9. Regrettably, there is little other published information regarding lift interfaces in steel frame buildings.

1 DESIGN

1.1 Lift Anatomy

Lift installations are in principle very straightforward. Whilst there are a variety of approaches to configuring the components within lift installations, most are permutations of a basic theme. The major components in lift installations (illustrated in Figure 1.1) are as follows:

Lift well framing and slab openings

Floor openings around lift wells are framed by steel edge beams. In some buildings, normally where the well takes up one specially sized structural bay, these beams connect to corner columns. In many buildings however, there are no columns in the well, or columns are present only at particular corners of the well which lie on the main structural grid (Section 1.2); special consideration is required regarding methods of supporting lift equipment such as landing doors.

Where the walls around lift wells are constructed from dry lining systems, columns can be used to support beams, that in turn support lift landing doors. Where lift shafts are constructed from dry lining systems and columns are not present, lift landing doors are supported by secondary steelwork.

Where the walls around lift wells are constructed from masonry, doors can be fixed directly to the wall.

When several lifts are grouped together, they are separated by steelwork elements that divide the wells. This is known as 'dividing steelwork' and is not usually an element of primary structure, but is used to support guide rails.

Guide rails and guide rail fixings

Most lift installations have two sets of guide rails (Section 1.3), one set for the lift car and the other for the lift counterweight. Guide rails run vertically up the lift well and are fixed either to the steel frame, or to the floor edge using specially designed brackets.

Walls around lift wells

Walls around lift wells in steel frame buildings (Section 1.2) are usually constructed from light dry lining systems, or less frequently from masonry. They do not carry major structural loading, although they do resist local lateral loads (not associated with the lift installation) and have a fire resistant function.

KEY:

COMPONENTS
1. Lift shaft framing
2. Guide rails
3. Lift well walls
4. Landing doors
5. Door suport steelwork
6. Threshold
7. Machine room
8. Lift pit

INTERFACES
A Guide rail connections
B Door support steelwork connections
C Threshold connections

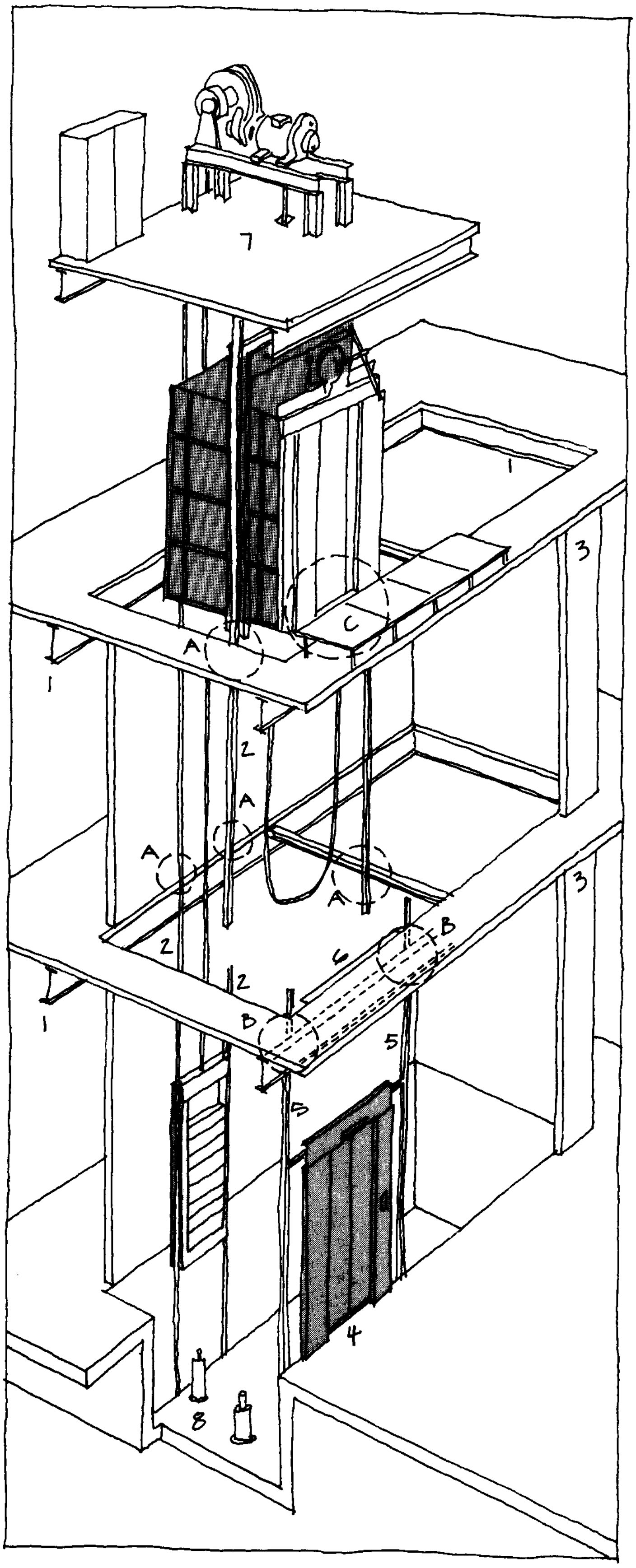


Figure 1.1 Electric lift installation, main components and interfaces

Doors, door frames, thresholds and architraves

Lift installations have two sets of doors. The inner set is integral with the lift car, and the other, the landing set, is located within the well. Both sets of doors are designed to operate simultaneously at any given landing.

It is usual for lift landing doors to be prefabricated into door units. These units include opening mechanisms (door operators) and running gear from which the doors are suspended. Door thresholds are generally designed and installed as separate items that incorporate running tracks to restrain the lower edge of the door. Architraves may or may not be fitted. Where they are fitted they are also installed as separate items, and tend to be custom-designed to suit individual architectural situations.

Top of well

Conventional electric lifts have the machine room located at the top of the lift well. The mechanical plant essentially comprises a hoisting machine with a traction sheave that revolves to wind the cables and thereby move the car.

It is usual to design the floor of the machine room with a raised area above the lift well. This provides vertical clearance and overrun space for the lift car, beyond the uppermost door openings. Details usually involve either a concrete upstand, or a series of steel piers.

There are three principle elements of steelwork at the top of the lift well: steel framing around the floor aperture, machine support steelwork (the steelwork supporting the raised floor area and the motor) and lifting beams.

Lift pit

The lift pit is an extension of the lift well below the lowest door opening. It may be below ground level or may extend into a storey of the building lower than the level of the lowest lift door opening. The pit contains buffers that dissipate forces from impacts of the car or counterweight. The floor of the pit also supports the guide rails. Peak guide rail loading occurs when safety gear is applied in order to stop the lift car.

Interfaces

Key interfaces are:

(a) Guide rail connections

In the majority of steel frame buildings, where the wall around the lift well is constructed from light dry lining systems or masonry, connections will be made into either the floor slab or structural steelwork. Guide rails may be connected directly to the building.

(b) Lift landing door support structures

As previously described, where the wall around the lift well is constructed from masonry, lift landing door frames can be fixed directly onto it. However, where the wall is constructed from light dry lining systems, additional secondary steelwork is required. This steelwork supports the door head mechanisms from which the doors are suspended (Section 1.4).

(c) Lift door thresholds

Door thresholds restrain the lower edge of lift doors. They are normally fixed to either the floor edge or to structural steelwork framing the slab opening. Details may take a variety of forms, and arrangements exist that can accommodate raised floors. Fire protection of the region beneath the top of the threshold and the slab often requires special consideration (Section 1.4).

1.2 WELL DESIGN

Well sizes and tolerances

Reasonable tolerances for steel frames are given in the *National Structural Steelwork Specification for Building Construction (2nd Edition)*, published by BCSA/SCI. These are now widely accepted in the industry. The document covers both fabrication and erection. Those provisions which are most likely to apply to steelwork around lift openings are covered in Figures 1.2 to 1.4.

Tolerances in the steel frame are particularly significant if the lift car or counterweight guide rails are to be fixed to the frame.

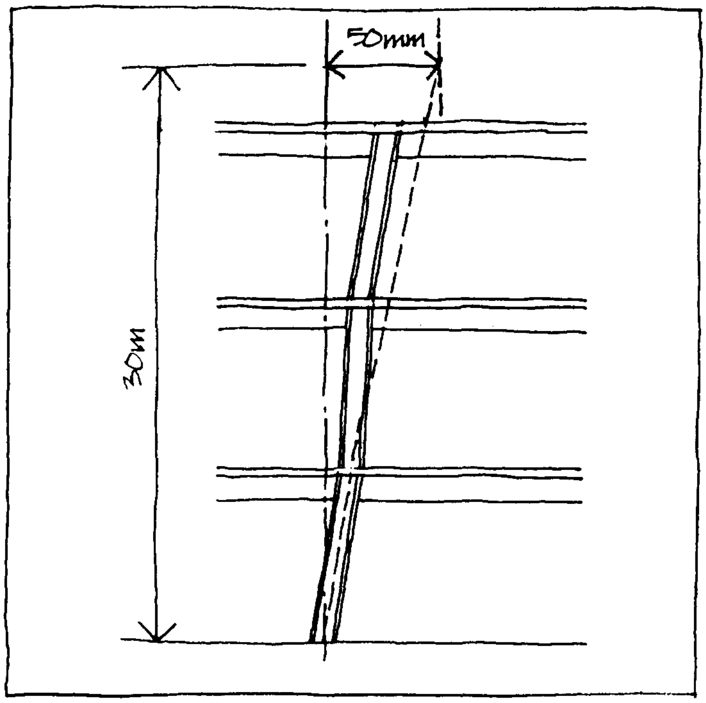


Figure 1.2 Columns should be within an envelope of 1 in 600 up to 30 m. Deviation on top relative to base should not exceed 50 mm above 30 m (NSSS Clause 9.5.4)

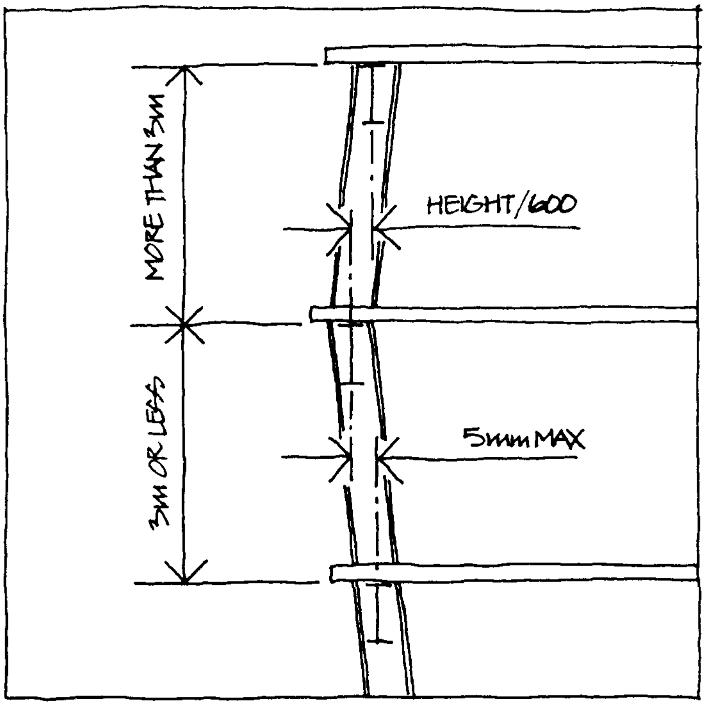


Figure 1.3 Beam and column alignment at adjacent floor levels (NSSS Clause 9.5.4)

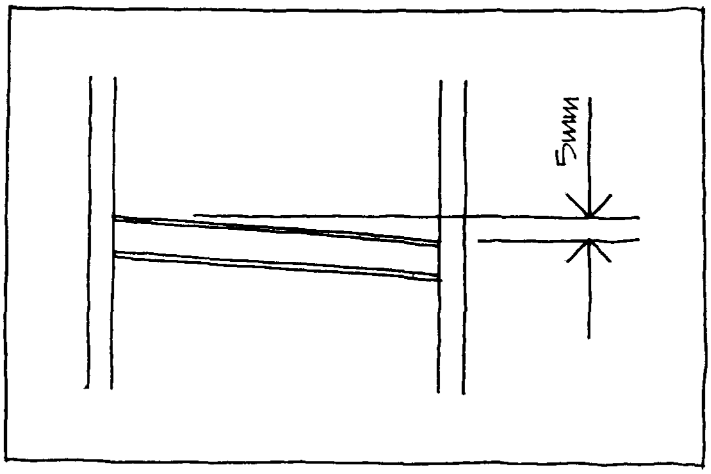


Figure 1.4 Individual beams should not be out of level by more than 5 mm (NSSS Clause 9.5.8)

Where fixing bracketry is to connect to the floor, or to the floor edge detail, tolerances of the concrete slab are most relevant (assuming the floor edge is set out correctly from grid lines, and not from the structural steelwork). Guidance on the range of deviations normally experienced in concrete construction can be found in BS 5606: 1990: *Guide to Accuracy in Building*, Table 1.1. Whilst no absolute data is given for floor edges, the standard suggests that stair wells and elements above foundations can normally be constructed to an accuracy of +/- 12 mm, with a risk of non-compliance of approximately 5%.

In principle, the plan dimensions of a lift well should be no more than the minimum needed to accommodate the lift equipment plus a practical construction tolerance, since unnecessarily generous well sizes reduce usable floor area.

There is a considerable body of anecdotal evidence to suggest that a significant number of buildings, both in concrete and steel, exceed the tolerances that have historically been set for the verticality of lift wells, without compromising the lift installation. It therefore appears reasonable to review these tolerances.

The National Structural Steelwork Specification (NSSS) sets out practical construction tolerances for steel frame buildings. These are slightly more generous than those that have historically been set for the verticality of lift wells.

Vertical lift well tolerances

It is important in order to achieve appropriate running clearances, door alignments and overall reliability of the lift installation, that lift wells are constructed to high standards of verticality.

The NSSS cites that columns may deviate from vertical by no more than 1/600 of their height or 5 mm per storey (whichever is greater), but by no more than 50 mm in total, irrespective of the height of the building (Figure 1.2, NSSS Clause 9.5.4, 2nd edition 1991). In order to harmonise tolerances for the steel frame and lift, these are the tolerances which should be adopted for verticality of the lift well. Adjustments designed into the connections between the guide-rails and well structure allow adjustments to be made to the verticality of the guide rails.

Horizontal lift well sizes and tolerances

An allowance is made for horizontal lift well tolerances which varies with the height of the well. Dimensions for this allowance are set out in BS 5655: Part 6 and vary from 25 to 50 mm. Standard lift well sizes for general purpose or intensive traffic lifts are set out in Table 1.1, together with their associated lift car sizes, and an allowance K, that should be added to the plan dimensions of the well to accommodate building tolerances. The value of K varies with well height. For instance, a single 1000 kg contract load lift of internal plan dimension 1600 × 1400 requires a well of 2400 + K × 2300 + K mm.

The size of multiple lift wells may be determined by simply taking the dimensions of a single lift installation + K, and adding the well width plus 200 mm for each additional lift in the well. Additional tolerances are not required. The size of a multiple lift well containing 3 lifts with plan dimensions 1600 wide by 1400 deep is therefore:

Width of single well is: 2400 + K mm
(from Table 1.1)

Width of multiple well is: (2400 + K) + 2×(2400 + 200)

= 7600 + K mm

DESIGN

Depth of multiple well is: 2300 + K mm
(from Table 1.1)

where K is the same as for the single lift well.

Tolerances for well wall positions should be +/- K/2 (Figure 1.5)

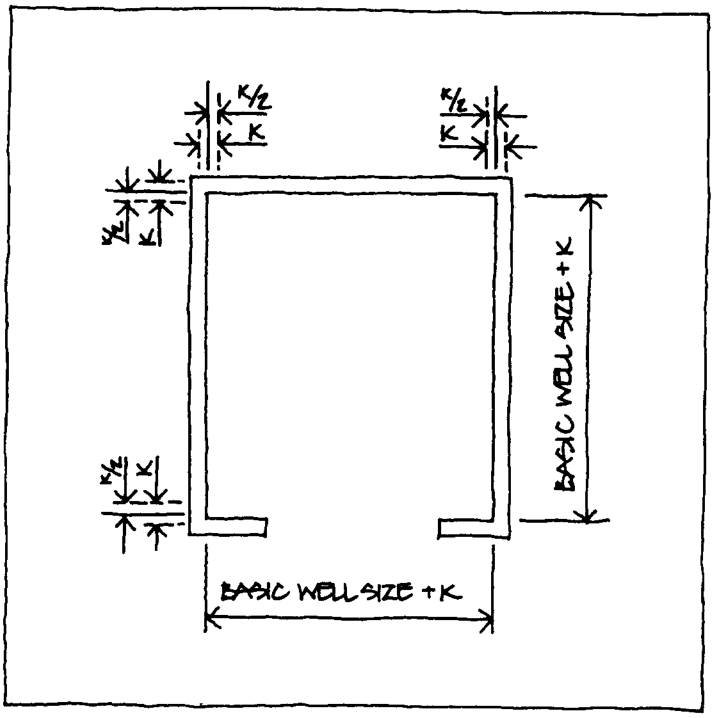


Figure 1.5 Horizontal lift well sizes and tolerances

Table 1.1 Well dimensions for general purpose or intensive traffic lift installations

Contract Load (Kg)	Persons	Car Internal Sizes			Recommended Well Sizes	
		Width	Depth	Height	Width	Depth
630	8	1100	1400	2200	1800+K	2100+K
800	10	1350	1400	2200	1900+K	2300+K
1000	13	1600	1400	2300	2400+K	2300+K
1250	16	1950	1400	2300	2600+K	2300+K
1600	21	1950	1750	2300	2600+K	2600+K
1800	24	2300	1600	2300	2900+K	2400+K

where K is:

25 mm for wells not exceeding 30 m

35 mm for wells over 30 m but not exceeding 60 m

50 mm for wells over 60 m but not exceeding 90 m

In the past, the sizes of lift wells have sometimes been specified as being the design dimension with tolerances of - 0, +X (where X is likely to be in the range 25 - 50 mm, refer to Table 1.1). Since constructors cannot work to - 0 tolerances, they have always aimed for the middle of the tolerance range, and have converted dimensions accordingly. The above method of calculating lift well sizes avoids this necessity. It is good practice for all dimensions to be specified in this form, both by the lift engineer and the constructor.

Setting out

Horizontal setting out

Lifts are usually installed relative to the well, but at the same time with reference to grid markings.

The tolerances suggested in Section 1.2 ensure that lift wells are constructed to reasonable standards of verticality. The lift contractor subsequently takes up any minor deviations by adjusting the position of guide rails at their fixings. Since there is a fixed relationship between the position of the lift doors and the guide rails, this procedure automatically determines the position of the lift entrance.

If, due to special lobby finishes, for example, it is imperative that lift equipment such as door entrance frames are installed to absolute dimensions, then this is entirely possible, but special provisions may be necessary. It is important to resolve a suitable design strategy as early as possible, and before the building structure is finalised.

It is normal practice for the general contractor to provide datum marks at the top and bottom of the lift well to be referred to when the lift equipment is installed. The optimum location for these markings is generally considered to be in front of the lift entrance, 1 metre from the floor edge. The lift engineer will make measurements between these to determine the theoretical position of equipment at intermediate floor levels.

Setting out markings may be on grid lines or may be calculated offsets from grid lines. Additional setting out points are often provided at intermediate floors, to check both the contractors' and the lift engineers' survey. This is recommended as good practice.

DESIGN

Vertical setting out

Vertical setting out is done by reference to datums set up by the general contractor at each storey, usually 1 m above finished floor level. These datums normally appear on columns within, or in the immediate vicinity of the lift well.

Vertical datums are particularly important where buildings have raised floors, but even in buildings with conventional floors they are a convenient method of taking into account floor finishes etc. when determining the height of thresholds, architraves, button boxes and alike.

Structural arrangement

The structural steel framing around lift wells is not significantly different from that around any other form of floor opening. In principle, all edges around the rectangular opening must be supported by floor beams. These can be either primary or trimmer beams, or a combination of both.

A specially sized structural bay is sometimes incorporated into the frame, sized to accommodate several lifts grouped into a multiple well (Figure 1.6). In this arrangement, the floor edge is bounded on all four sides by primary beams.

It is often not fully appreciated that there are advantages to locating lift wells away from columns, toward the centre of structural bays, or toward the centre of primary beams (Figure 1.7). Whilst lift wells in these locations may increase the number of trimming members that are required to support the slab opening, these locations present a number of advantages. Since there are no columns on the inside of the wall bounding the lift well, the floor edge does not necessarily project into the lift well.

Projecting floor edges have three disadvantages: they require haunching (refer sub-heading 'Floor edge details within lift wells'); lift services within the well have to be routed around projecting ledges; and space given over to ledges reduces usable floor area within the building.

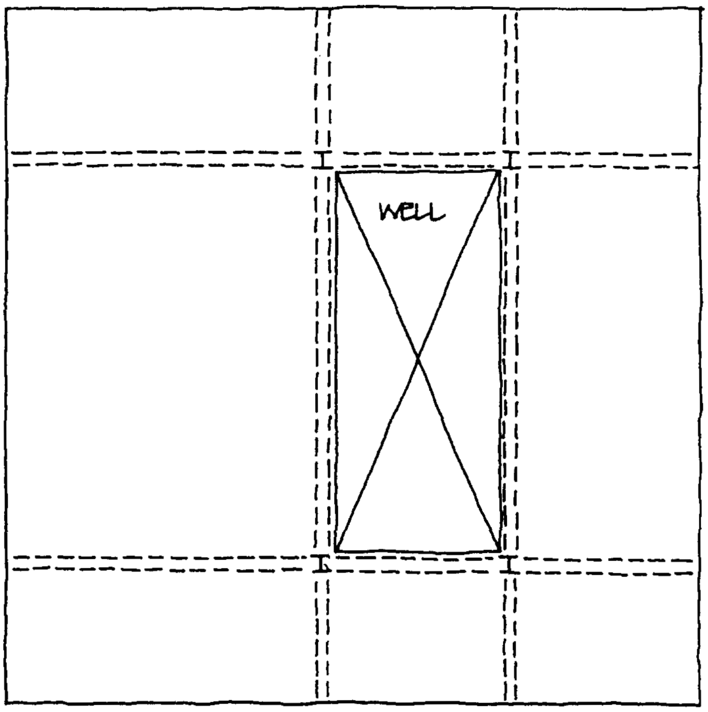


Figure 1.6 Horizontal framing schematic. Specially sized structural bay

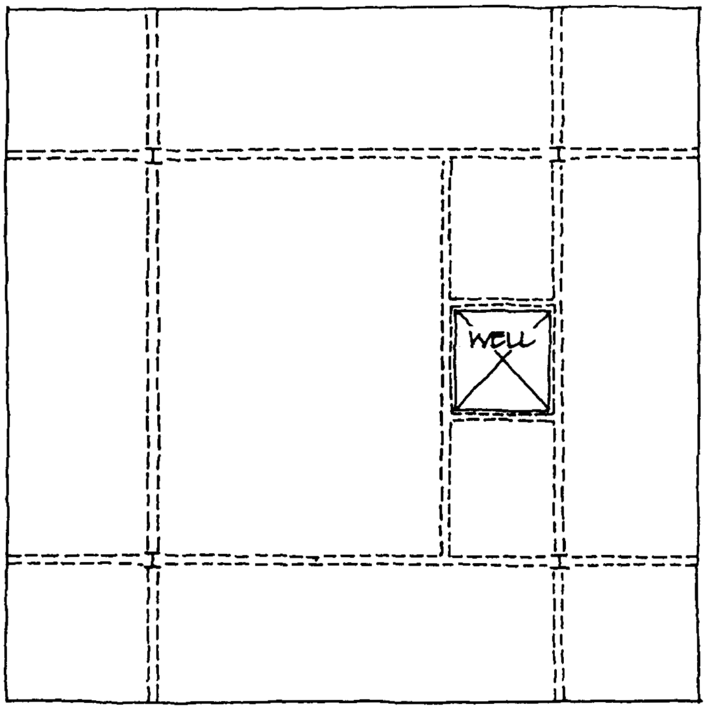


Figure 1.7 Horizontal framing schematic. Centrally located lift well

Where lift wells are built into a corner, or include several corners of a structural bay, they will contain a number of columns. Where two or more columns are available, bracing members are often introduced between columns, to provide lateral stability of the frame.

Where there are two or more lifts in a single well, they are separated by 'divider beams', which are not usually part of the main building structure.
A 200 mm zone is provided between wells to accommodate these beams.

DESIGN

Lift pit

The lift pit may be either a recess in the ground slab, or a dropped suspended floor. The pit has to be sufficiently deep to accommodate the floor depth of the lift car (plus the dimension of projecting equipment), together with an allowance for overrun of the car beyond the lowest floor level. It must also accommodate the buffers that dissipate impact forces of the car or counterweight.

The lift pit is normally of reinforced concrete construction, and designed to resist a variety of loads summarised in Section 1.5. These loads generally act either on the buffers or the floor of the pit beneath the guide rails. The pattern of loading when the pit is built into the ground is generally different from that when there is an accessible space beneath the pit, since this determines whether or not safety gear is fitted to the counterweight.

Special connection brackets are required within the lift pit, and provision should be made for fixing these into the concrete (cast-in fixings or similar devices may be installed). Two sets of these connection brackets will normally be required, one set at the top of the pit around the floor edge, and a second set towards the bottom of the pit.
The vertical dimension between these should not exceed the design span of guide rails elsewhere in the well.

The lift pit should be constructed to similar internal dimensions and tolerances as the lift well. The size normally corresponds to either the dimensions between well walls, or those of the floor slab openings.

Machine room

There are three items of structural steelwork associated with lift machine rooms. These are:

(1) framing around the floor aperture,

(2) machine support steelwork supporting the raised floor of the machine room and the lift hoisting machine and

(3) a lifting beam, used to hoist and move lift equipment in the machine room.

Floor framing

The layout of steel framing around the lift well in the machine room is normally similar to that used at intermediate floors. This steelwork supports the machine room floor, which in turn receives loading imposed by the lift machinery (i.e. the static and dynamic loads of the suspended lift equipment, the contents of the lift and the mass of the motor). It is useful to make provision in the steel framing to attach the tackle used to hoist guide rails into position. Normally this will take the form of one framing ring or cleat on either side of the well.

Machine support steelwork

The top of the lift well normally has to be raised above the level of the surrounding floor, so that the lift has an amount of overrun space at the top of the well, beyond the uppermost floor. There are two forms of machine support arrangements: either steel piers can extend vertically from the columns within the lift well, and in turn support horizontal steelwork to provide a structure for the raised platform onto which the drive machinery is mounted, or the raised platform may be cast into the concrete floor slab (Figures 1.8 & 1.9).

Steel pier solutions are generally used where there are columns in the lift well. The columns are simply extended upward to form piers which in turn carry horizontal steelwork supporting the raised floor.

It is very important that the vertically cantilevered piers are sufficiently rigid not to deflect significantly when the floor slab receives loading from the lift motor. Lateral movement of the piers will compromise the ride quality and general operation of the lift.

Where concrete upstands are used with simple horizontal machine support members spanning between them, the steel members should be supplied by the lift contractor, together with any seating members that locate on top of the concrete upstand. The concrete upstand however should not be the lift contractor's responsibility.

KEY:

1. Machine support steelwork
2. Pier extending from column
3. Structural slab
4. Well
5. Hoisting mahine

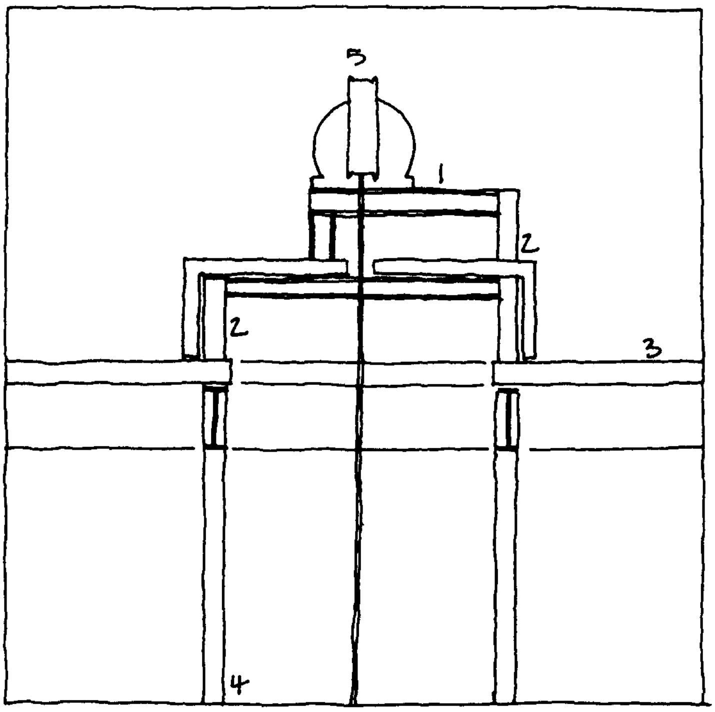


Figure 1.8 Machine support arrangement. Steel piers from columns

KEY:

1. Machine support steelwork
2. Raised concrete platform
3. Structural slab
4. Well
5. Hoisting machine

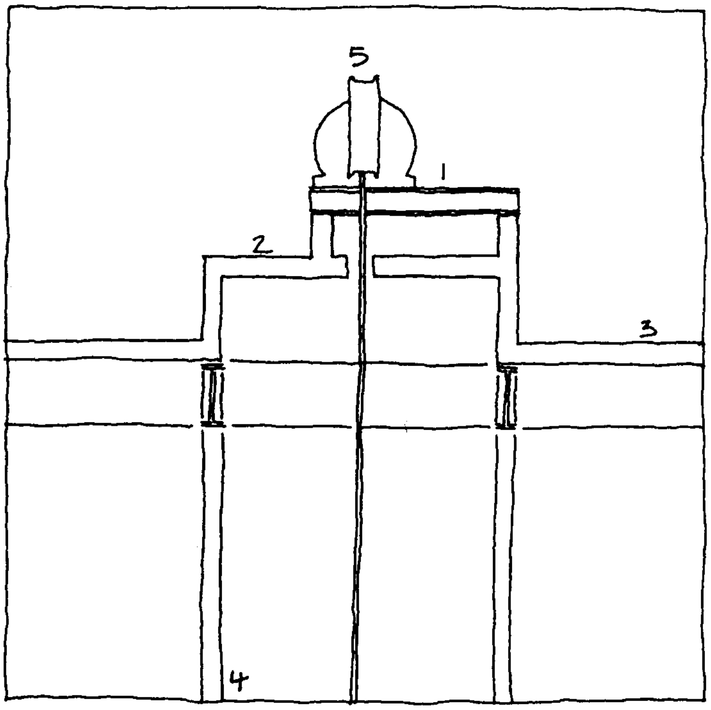


Figure 1.9 Machine support arrangement. Raised platform cast into concrete floor slab

Lifting beams

BS 5655: Part 6 requires provision of one or more steel beams, or other suitable members, at high level in the machine room. They are used for hoisting, installation and possible replacement of lift plant, and are usually centred on the lift well.

Walls

One of the most significant differences between the majority of lift installations in modern steel frame buildings, and their concrete equivalents, is the absence of the concrete well walls. In steel frame buildings these are usually replaced with lighter dry partitioning, erected after construction of the frame and floors, or on occasions by masonry walls.

Light lift well partitioning

Light lift well partitions are constructed using predominantly dry trades. They generally comprise a steel stud framework supporting multiple layers of plasterboard or similar fire-resistant boards. They are erected as a series of storey-height walls built off the floor slab, usually to the soffit of the floor above, or to the lower flange of the steelwork framing the floor opening.

Sophisticated designs permit all layers of the wall to be introduced from the outside of the well, thereby avoiding any need to provide work-platforms within the void (Figure 1.10).

It is common practice to erect three sides of the well wall early in the construction programme, leaving the side which is due to receive the lift doors open, but temporarily fenced.

This approach significantly reduces the amount of guarding required around the well, and can therefore reduce construction costs.

Masonry lift well walls

Masonry well walls are reliant upon wet trades, and have tended to be replaced by dry partitions. The majority of modern masonry lift wells in steel frame buildings are discontinuous between floors, i.e. are built off the slab edge. Owing to their relatively high mass, walls are often centred upon the steel framing around the floor opening, and finish at the soffit of the beam above. Where this occurs the beam itself must be fire protected (normally using dry lining or board based systems), to maintain the minimum fire resistance required of the well wall (Section 1.6).

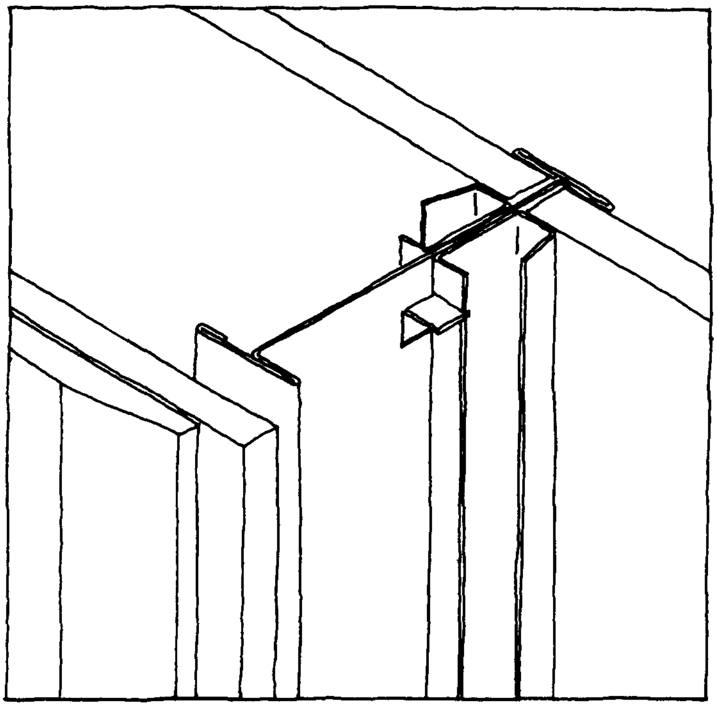


Figure 1.10 Light lift well wall system

Floor edge details within lift wells

It is preferable for the internal face of well walls to be flush, or very nearly flush, with the slab edge opening.

Where the floor edges extend into the lift well a significant distance, it is necessary to introduce haunching so that they cannot be used as walkways or footrests (Figure 1.11). This is an additional expense, and necessitates that services which would otherwise be fixed to the dry lining are routed around the floor edge and across the haunching. Whilst there is no definitive guidance as to the maximum ledge width that is acceptable without haunching, current practice is to haunch all ledges of 150 mm width or greater. Often lift contractors haunch both above and below the slab.

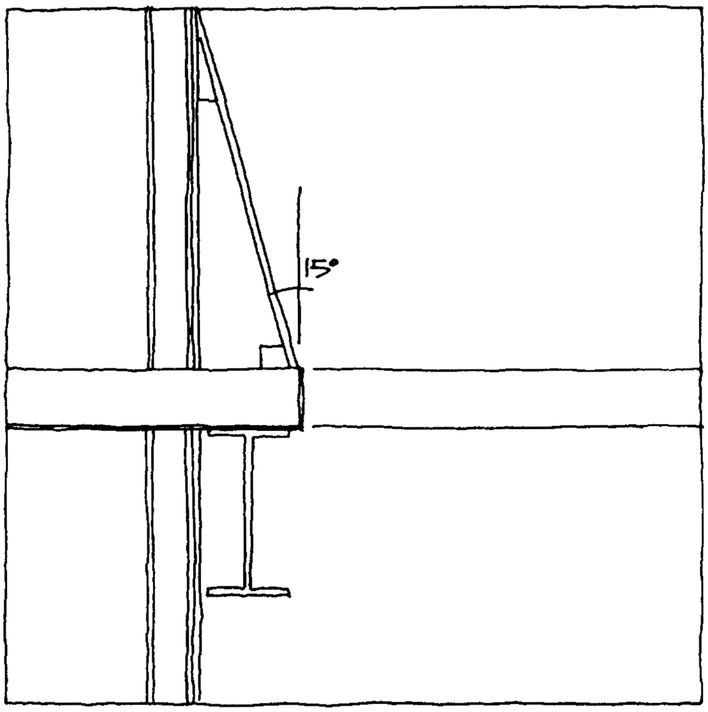


Figure 1.11 Haunching to projecting floor edges

Services in lift wells

All cabling and services associated with the lift installation have to be located in areas of the lift well where they do not interfere with the movement of the lift car, doors or counterweight. No other services are permitted in the lift shaft.

Wells with lightweight walls

Boxes behind call buttons and indicator panels on the outside of walls bounding the lift well are generally supported by one or more vertical studs, or special horizontal members running between studs in a similar fashion to that adopted in timber stud walls (see Figure 1.33).

As an alternative, it is standard practice in the United States and other parts of the world to use specially developed brackets to support service boxes (Figure 1.12). These are now available in Europe, and the more robust versions are suitable for heavy service conditions. Such boxes may be supplied by either the lift contractor or the dry lining contractor.

In walls constructed using dry lining systems, light conduits and cables can sometimes be fixed directly to the dry lining or to exposed steel studding on the inside face of the well.

Discuss me ...

Heavier cabling may require the provision of vertical cable trays, trunking or conduit spanning between floor edges. An edge detail that incorporates a 'T' bolt type fixing channel (see Section 2.1, 'Connections to slab edge') is a useful means of securing such devices.

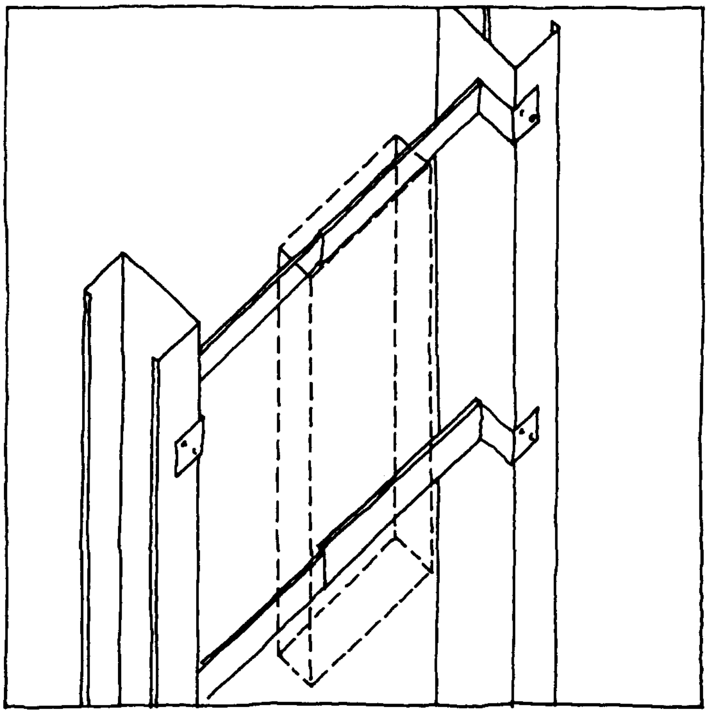


Figure 1.12 Box support brackets

Wells with masonry walls

Where lift wells are constructed from brick or blockwork, lift services can generally be fixed directly to the wall with conventional mechanical fixings.

1.3 GUIDE RAILS AND GUIDE RAIL FIXINGS

Guide rails

BS 5655: Part 9 gives guidance on guide rail specification, and sets out minimum performance standards. Guide rails are assembled end to end, and run continuously up lift wells.

Exceptional storey heights present particular difficulties, since the size of guide rails (and therefore their spanning ability) is constant throughout the lift well. Extreme spans frequently occur at ground floor level, where foyers and other exceptional accommodation demand increased floor to ceiling heights. Special guide rail support arrangements may therefore be necessary at these levels, such as the provision of backing arrangements or intermediate (mid-span) support.

Guide rails are located accurately end to end, using a key and a keyway detail, to prevent any relative lateral sideways movement between members. Connections between lengths of guide rail are made using a fishplate arrangement on the rear of the section (Figure 1.13).

Guide rail clips

Guide rails are attached to their fixings by clips (Figure 1.14). These clips allow the rail to slide vertically, whilst restraining the rail against lateral movement.

Guide rail brackets

It is very important that all connection brackets have sufficient horizontal adjustment to achieve optimum alignment of the guide rails, since this alignment has a significant effect upon the ride quality of the lift.

Guide rail brackets are not generally designed to sustain high vertical loads or significant bending moments at their connections. It is normal practice to ensure that vertical forces in the rail are reacted by the lift pit and not by the rail brackets themselves (Section 1.5).

The vertical position of the guide rail bracket may vary, since the guide rail has a linear section and the point of attachment is not generally crucial, provided that the spans of the guide rail do not materially exceed the design dimension. Fishplates, used to connect lengths of guide-rail together, must not clash with the fixing bracket. To avoid this, guide-rail sections can be supplied in special storey-height lengths, so that the fishplates always occur in a similar position relative to the fixing bracket; or alternatively special length rails can be installed periodically, to adjust the module of the fishplate centres.

Several types of guide rail bracket are in common use and selection will depend upon a variety of factors, including:

- The availability of suitable floor edges in the lift well.
- The size and location of steel framing members around the slab opening.
- Whether or not the steel members to which guide rails are to be fixed are fire protected, and if so the type of fire protection.
- The magnitude of lateral forces which the bracketry must transmit to the structure.

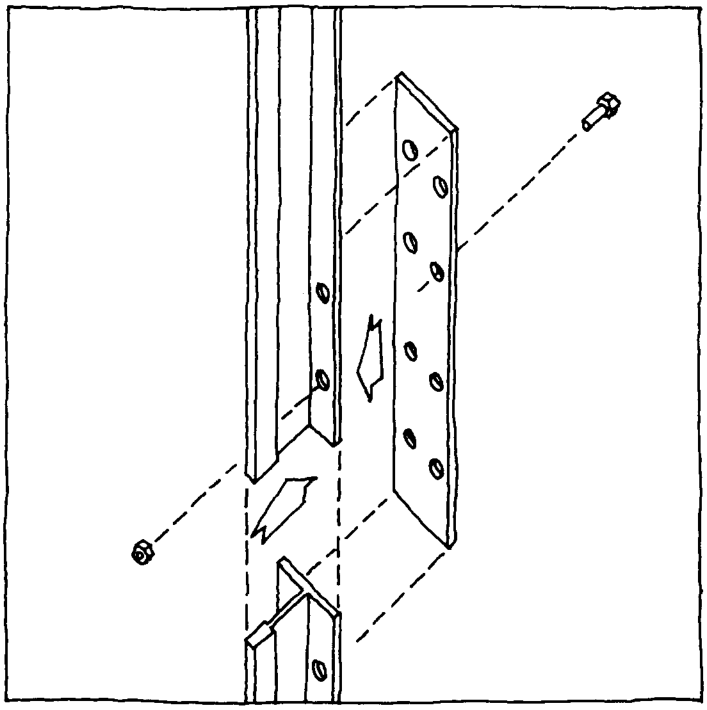


Figure 1.13 Guide rail fishplate

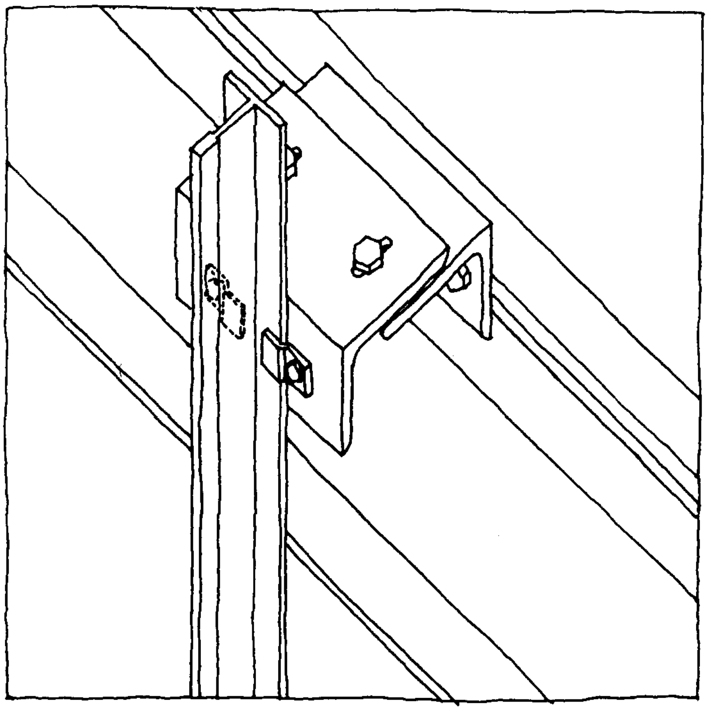


Figure 1.14 Guide rail clips

Deflections: guide rail and supporting structure

The loads that guide rails transmit to the building occur both through the normal running of the lift, and through emergency operation of the car safety gear. These forces can be calculated using the formulae given in Appendix A of BS 5655: Part 9. Typical forces imposed on guide rails and the supporting steelwork by heavy lift cars (Case 4, Section 1.5) are given in Table 1.2. These forces are generally of the order of 1 kN or less, and are far lower than the major forces, such as machine slab and lift pit loadings, referred to in Section 1.5.

Guide rail brackets are designed to support the lateral forces *Bx* and *By* (Figure 1.15). Guide rails can move vertically in their restraint brackets, however, there is typically up to a 3 kN frictional resistance (*Bz*) from the guide rail clips, and this has to be overcome before movement occurs. Guide rails normally rest on the floor of the lift pit and expand and contract up and down the well. This same mechanism accommodates building movements, such as floor beam deflections, or small amounts of elastic shortening of columns. Vertical forces arising from the application of safety gear are not resisted by the brackets but are transmitted to the lift pit. Guide rail brackets should not therefore impose significant bending moments on their supporting structures.

Concrete floors supported by steel frames normally have considerable in-plane stiffness, and it is generally advantageous to connect guide rails to them rather than to the steel structure, provided that a floor edge is present in the well and that the floor has sufficient depth and strength.

Where it is not possible to connect to the slab edge, and connection has to be made to structural steelwork, steel members should be designed to resist excessive lateral torsional bending or other deflections which might have an adverse effect upon the operation of the lift. Typical guide rail to steel connections include attachments to divider beams, edge beams on the facade of buildings (where there is no floor slab), and installations in buildings where the floor slab is not able to receive fixings.

Table 1.2 Forces imposed on guide rails and support brackets based upon heavy cars (Case 4, Table 1.3)

Rated Load (kg)	*Bx* (Newtons)	*By* (Newtons)	*Bz* (Newtons)
630	265	180	3000
800	450	220	3000
1000	650	300	3000
1250	950	350	3000
1600	1200	550	3000
1800	1400	750	3000

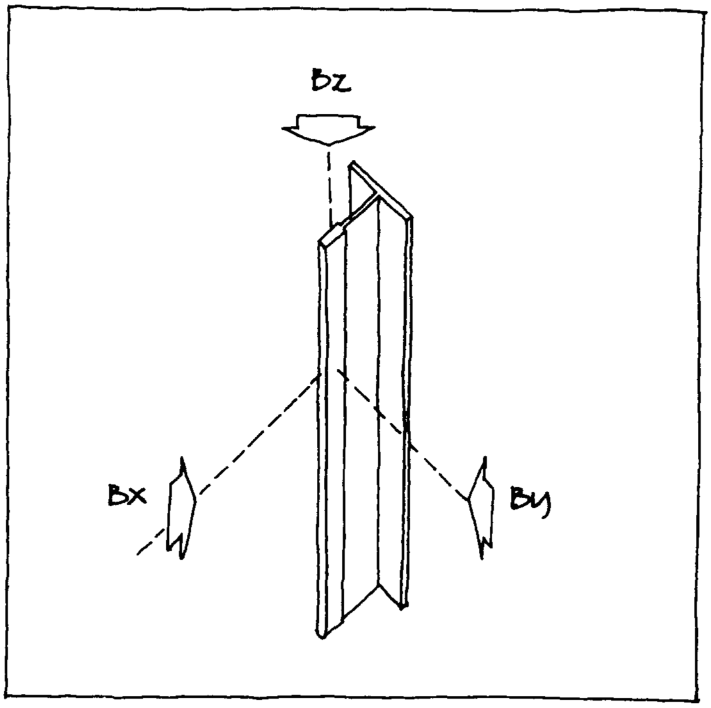


Figure 1.15 Forces on guide rails

BS 5655: Part 9 allows for guide rail deflections of 3 mm under the force *Bx* and 6 mm under the force *By*, together with a further 3 mm in the supporting structure. Smaller deflections are likely to be required where high standards of running comfort are demanded in medium speed lifts and above (i.e. where lift speeds exceed 1.0 m/sec). These lower deflections may typically be in the range 1 - 3 mm for guide rails, and 1.5 - 3 mm for the supporting structure.

In the case of the lower deflection figures, the total combined movement at the mid-span of the guide rails (where movement is usually greatest), is approximately 1.75 - 4.5 mm (Figure 1.16). This assumes that the mid-span loading is shared equally between two connections at adjacent floor levels, and the magnitude of their deflection is approximately one half of that which occurs when loading is applied directly at the connection.

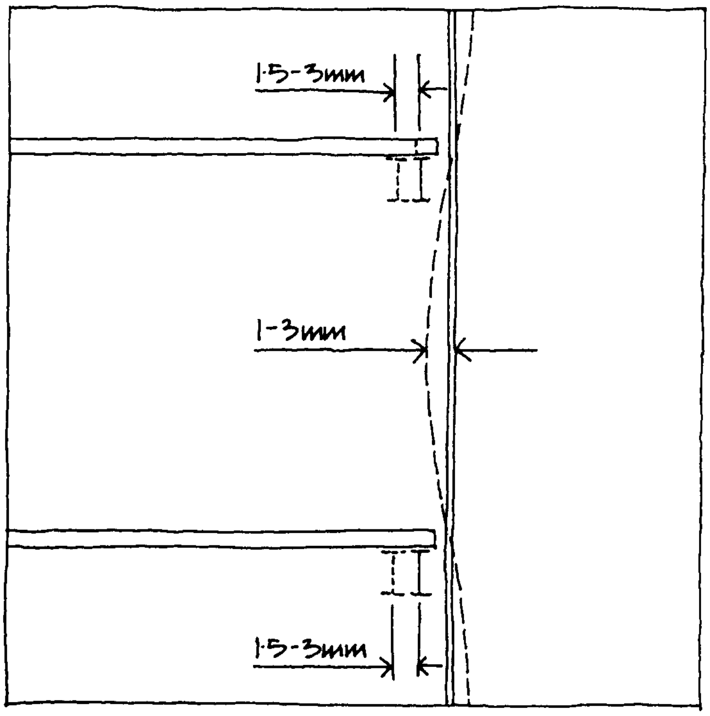


Figure 1.16 Improved deflection criteria for high standards of running comfort (medium speed lifts and above)

Where guide rails attach to the floor slab, deflections at the connection should be relatively small. Where guide rails attach to steelwork, deflection of the supporting structure should still be confined toward the lower end of the acceptable range (1.5 mm). The spans of steel members onto which lift car guide rails attach are normally realtively short i.e. the approximate depth of the lift well between point of lateral restraint (usually beam to beam connections). This assists in reducing deflections.

Guide rail selection depends upon such factors as floor span and running comfort. The smaller the acceptable guide rail deflections become, the larger is the required guide rail section. This has cost implications.

Guide rail spans

Where either steel or concrete frame buildings have a concrete wall around the lift well, guide rails are fixed to the concrete at relatively close centres (approximately 3 m). This has influenced the way in which guide rails have been supported in lift wells constructed without concrete walls. In such buildings, secondary steel components have been introduced in order to support guide rails between the floor edges. It is increasingly apparent however, that such supporting structures are not usually necessary, and where possible the practice is discouraged in favour of using heavier guide rails.

Intermediate guide rail support is not required for low and medium speed lifts (i.e. the majority of installations). It is realistic for the guide rails to span normal storey heights of 3 to 4.5 m without an adverse effect upon ride quality.

Guide rails for high speed lifts (where lift speed exceeds 2.5 m per second but is less than 5.0 m per second), can theoretically span 3.5 m without requiring intermediate support, however early consultation with the lift supplier recommended.

Express speed lifts (where lift speed exceeds 5.0 m per second) will usually require intermediate support, and special provisions may be necessary to ensure adequate standards of guide rail deflection and straightness. Such lifts are rare in the UK, since building heights rarely justify their use. Discussions should be held with lift manufacturers, early in the design programme, if these lifts are to be used.

1.4 DOORS, DOOR FRAMES, THRESHOLDS AND ARCHITRAVES

Door support

Light lift well partitions

There are three generic forms of support frameworks for landing doors:

- Beams spanning between columns to which lift landing doors attach (Figure 1.17).
- Light 'H' frames that fix to the floor edge and provide a horizontal member to receive the lift landing doors (Figure 1.18 and 1.19).
- Suspended arrangements where a horizontal door support member is fixed between two vertical members that project down from a floor beam (Figure 1.20).

All of these forms of door support provide a horizontal member onto which the lift landing doors can be attached. This member should be vertically in line with the floor edge, or slightly set back from the floor edge, away from the well, so that the lift doors can be packed off from the member at the point of connection (Figure 1.21).

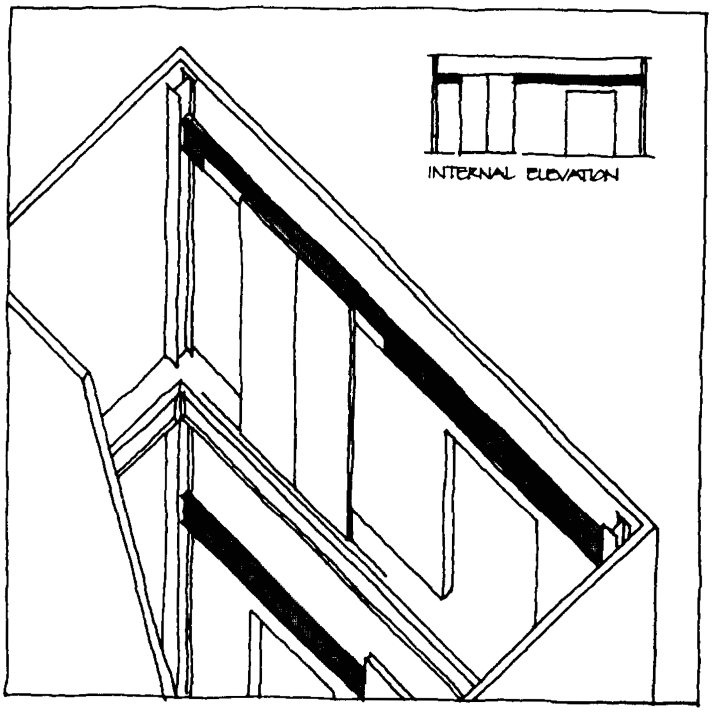


Figure 1.17 Beam type door support steelwork

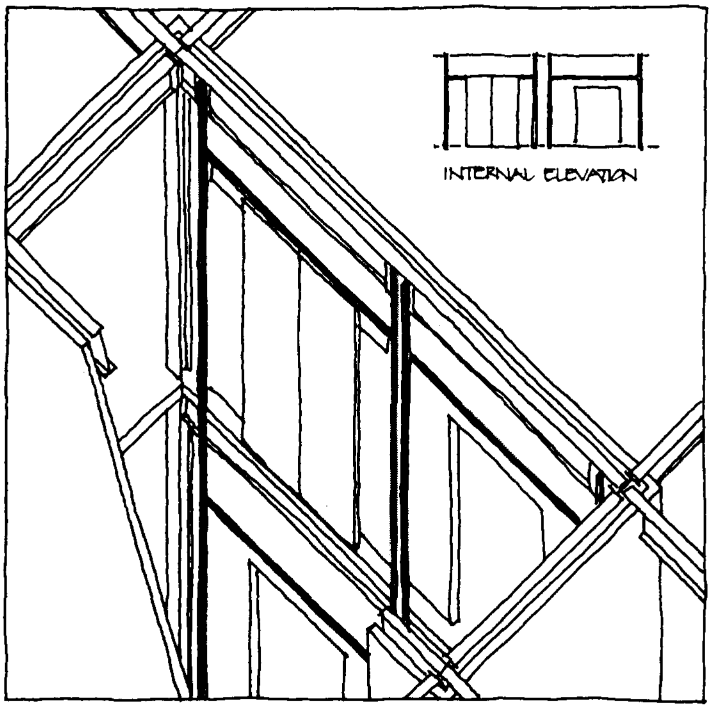


Figure 1.18 'H' frame door support (Type 1)

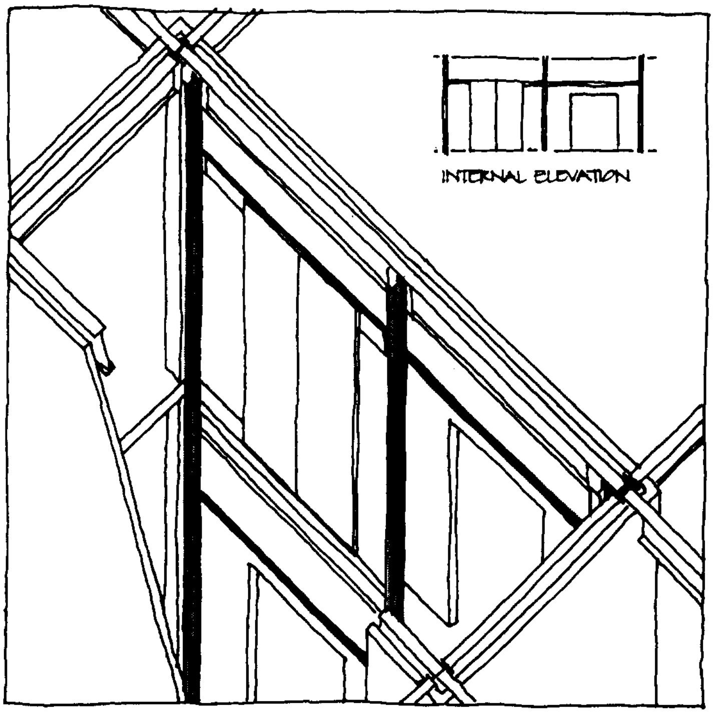


Figure 1.19 'H' frame door support (Type 2)

Where there are corner columns on the front wall of the lift well, a beam may be installed to span between these in order to support the landing doors. Such beams are however expensive, and their precise height may not be known at the time that the primary steelwork is designed and erected.
If columns are not present in the correct locations, and special columns have to be introduced to support the beam, this method of door support becomes particularly expensive.

Discuss me ...

Where storey heights are relatively low, and door heights are established, it is sometimes possible to use the floor edge beam to support the lift landing doors. This can be a highly effective and cost-efficient detail, however deflections in the edge beam resulting from live loadings must not cause excessive movement at the lower edge of the door, that might compromise door operation.

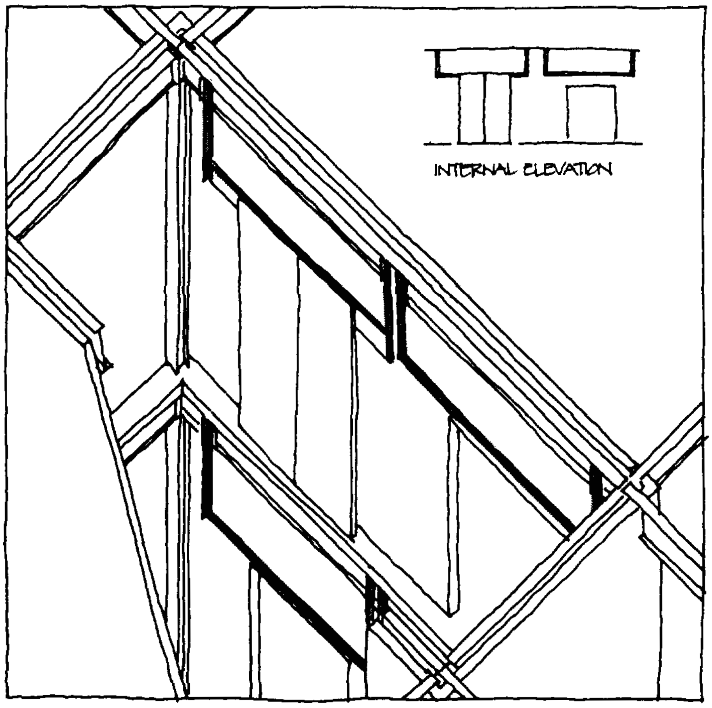
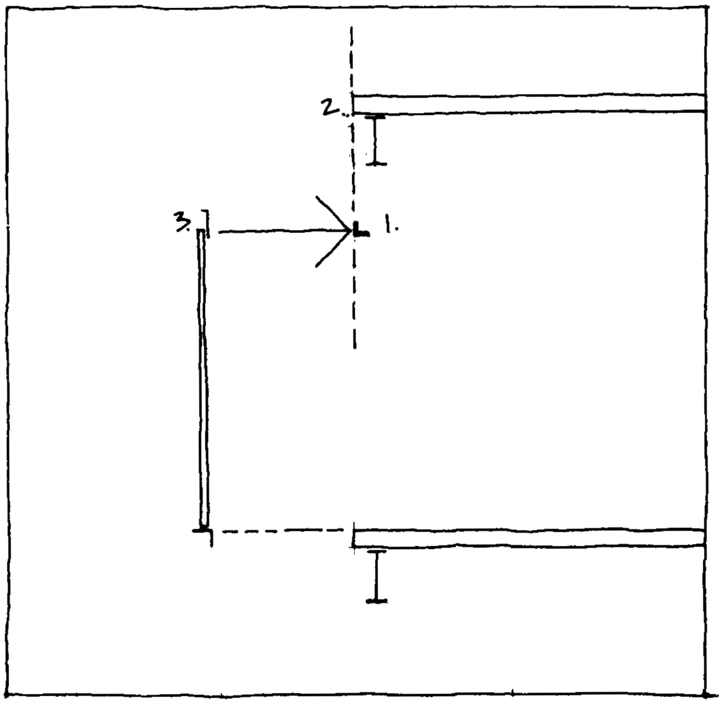


Figure 1.20 Suspended door support steelwork



KEY:

1. Landing door support member
2. Floor edge
3. Landing door unit

Figure 1.21 Vertical relationship of landing door support member and floor edge

Where there are no corner columns, 'H' frame or 'rugby goalpost' type arrangement (normally constructed from steel angles) are sometimes used to support the landing doors. Installation can be more complicated than alternative beam-type arrangements, since steel to concrete (or slab edge) connections are required.

There are two generic forms of 'H' frame:

(1) Types where each horizontal member is supported by two vertical members, the three members forming a unit (Figure 1.18).

(2) Types where horizontal members are supported by single vertical members located between sets of landing doors, and at the corners of the lift well either by columns or light vertical members similar to those between sets of landing doors (Figure 1.19).

The primary disadvantages of 'H' frames are that:

(a) They require a large number of connections.

(b) Movement joints are normally advisable at the top of vertical members so that structural loadings are not transmitted into the frame.

(c) They are usually a post-fix item, erected after completion of the main steelwork.

It is recommended that the bottom end of the vertical members in the 'H' frame should be fixed to the edge beam or floor edge, and the top end to the frame above, using a fishplate or similar detail incorporating slotted holes. These slotted holes will accommodate both building movements and tolerances. Fixings into the edge beam may be made to plates welded to edges of the flange, fabricated brackets, or brackets formed from cranked plate (Figures 1.22 & 1.23). Fixings into the floor edge may be made using cast-in fixings, including combined edge trims and channel details (Figure 1.24). Where the floor edge is relatively light it may be preferable to fix to the edge beam.

On occasions, 'H' frames have been formed by running continuous vertical rails up the lift well and fixing horizontal members at appropriate heights to support the doors. This practice is strongly discouraged for buildings of more than two or three stories, since building movements will cause the lift landing doors to move differently to the well wall. If this movement is more than a few millimetres, special details are likely to be required around door openings, and variations in the distance between the door head support rail and the threshold may become sufficient to compromise the operation of the landing doors.

Suspended door support arrangements offer a number of advantages over 'H' frames. The vertical members do not extend below the horizontal member and therefore do not compete for space with the lift landing doors, and relatively few connections are required. Since members in suspended support arrangements do not span between floor edges, there is no possibility of major vertical load transfer through the assembly, and building movements are not compounded i.e. vertical movements at the door support beam will be confined to those of the edge beam above. It is however, important to ensure that live deflections of the edge beam that would cause the lower edge of the door to move relative to the floor beneath, are not sufficient to compromise the operation of the door.

The connection to the edge beam in suspended arrangements must be a rigid moment design, often based upon a plate locally welded between the flanges of the edge beam (Figure 1.25). Vertical members must be sized to resist excessive deflection caused by lateral loading of the landing doors, or of the front wall of the lift shaft. It is essential that the landing doors are maintained at the correct distance from the doors on the lift car, so that the mechanisms that control the synchronised operation of the two sets of doors function correctly. Large unrestrained vertical cantilevers should be avoided, and horizontal deflections at the door support member should be minimal.

The suggested order of preference for door head support arrangements is:

(1) Existing edge beams if these are available at the correct height.

(2) Suspended arrangements where deflection criteria permit.

(3) Storey height 'H' frames.

(4) Door support beams spanning between columns.

Figure 1.22 Fixing for 'H' frame door support steelwork to structural steelwork (Type 1)

Figure 1.23 Fixing for 'H' frame door support steelwork to structural steelwork (Type 2)

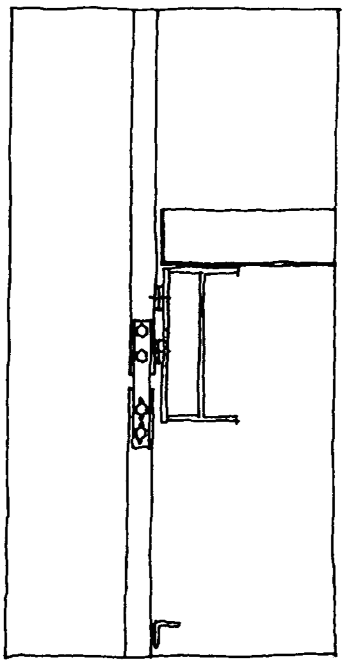


Figure 1.22

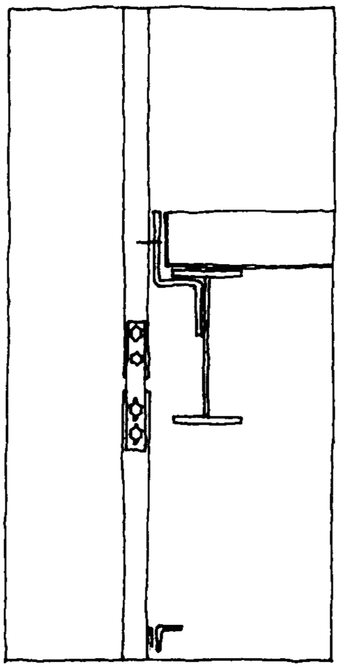


Figure 1.23

Figure 1.24 Fixing for 'H' frame door support steelwork to floor edge

Figure 1.25 Fixing for suspended door support steelwork

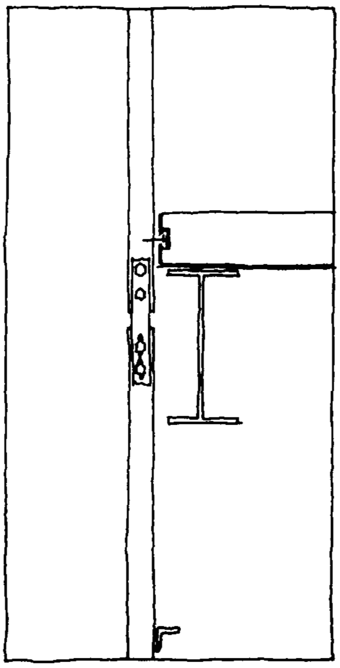


Figure 1.24

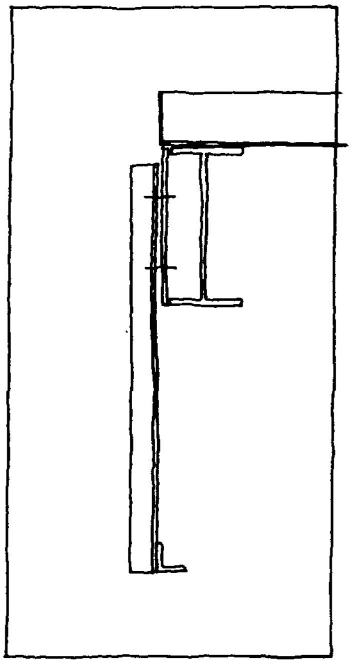


Figure 1.25

Masonry well walls

Where the wall around the lift well is constructed from brick or blockwork, it can normally support the door frame. Lift engineers prefer not to fix directly into the masonry, since problems of 'pull-out' of mechanical fasteners or anchors, combined with the need for on site drilling in order to use these devices. Thus lift installers favour specialised details such as cast inserts.

One approach is to use a precast lintel, with a fixing channel and extended end bearings, over the door head (Figure 1.26). Alternatively, a horizontal band of concrete may be cast in-situ above a concrete lintel, to incorporate a similar channel, secured by strap anchors. These details provide high levels of horizontal adjustment. Vertical adjustment is provided at the connection arrangement in the door unit.

The threshold is supported by a similar channel in the floor edge (ideally a combined edge trim and fixing channel detail, as can be used to attach guide rails, see Section 2.1, 'Connections to slab edge'), or by cast-in devices in the floor edge upstand (assuming a raised floor situation; refer to 'Threshold details' below).

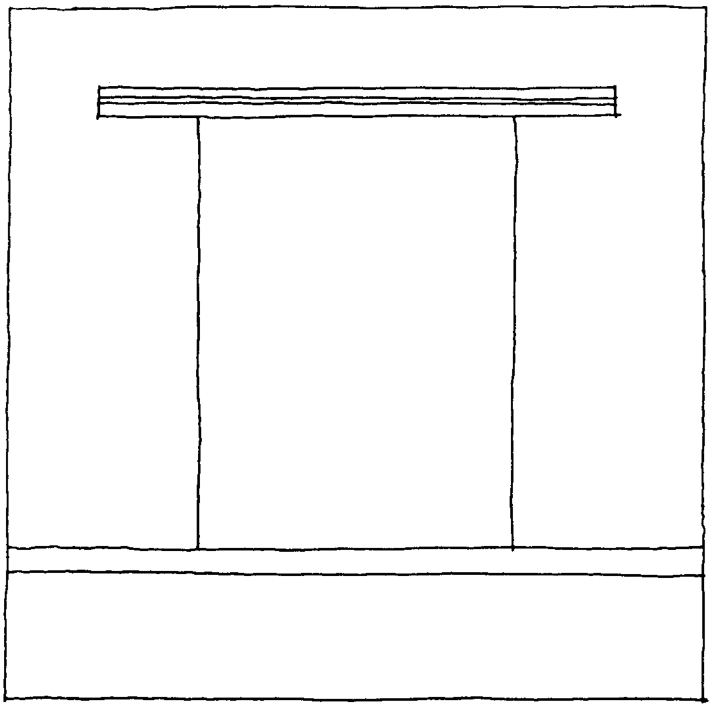


Figure 1.26 Door support, masonry shaft walls

Since the front wall of masonry lift wells is constructed prior to installation of the lift doors, sufficient tolerance has to be allowed in the size of openings to allow for inaccuracies in the position of the door openings relative to the guide rail positions. Door frames must be hung in the correct position relative to the guide rails.

Threshold details

Thresholds are normally supported on steel angles bolted to the floor edge, or to an upstand detail. Both vertical and horizontal tolerance is provided at the connections.

There are three common types of lift door threshold: non-raised floors where the threshold is fixed to the floor edge (Figure 1.27), raised floors where the threshold is fixed to a concrete upstand that forms a fire stop (Figure 1.28), and raised floors where the threshold is fixed to an adaptor plate and there is a separate fire stop (Figure 1.29).

Non-raised floor

In the majority of buildings without raised floors, the threshold is fixed to the floor edge using cast-in fixings; or where the slab edge is unable to receive fixings, may be supported on fabricated or cranked brackets similar to those sometimes used to support door frames.

Any gap between the threshold and the slab edge will be grouted, and in some designs (particularly those requiring high levels of fire resistance), the slab edge will be notched to receive grout. This method of grouting is an effective means of sealing the joint between the slab and the threshold.

Raised floor with concrete upstand as fire stop

Where there is a raised floor, one of the most effective ways of fire stopping the region between the lift threshold and the floor slab is to use a concrete upstand, cast on top of the floor slab. This is a difficult detail to programme since it requires two concreting operations. It does however afford reliable fire protection, and fixing channels can be cast into the well face of the upstand to support the lift threshold. Well walls are dressed around the concrete upstand.

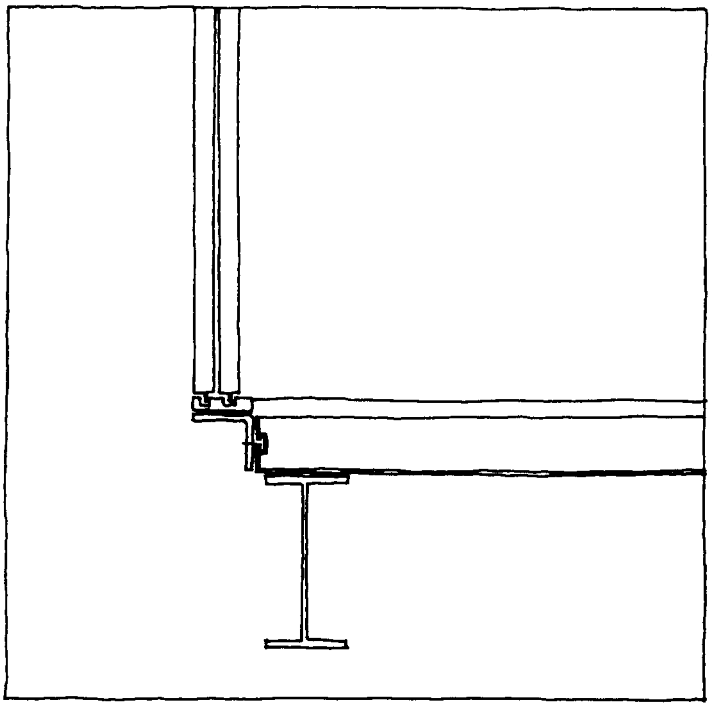


Figure 1.27 Lift threshold, non-raised floor

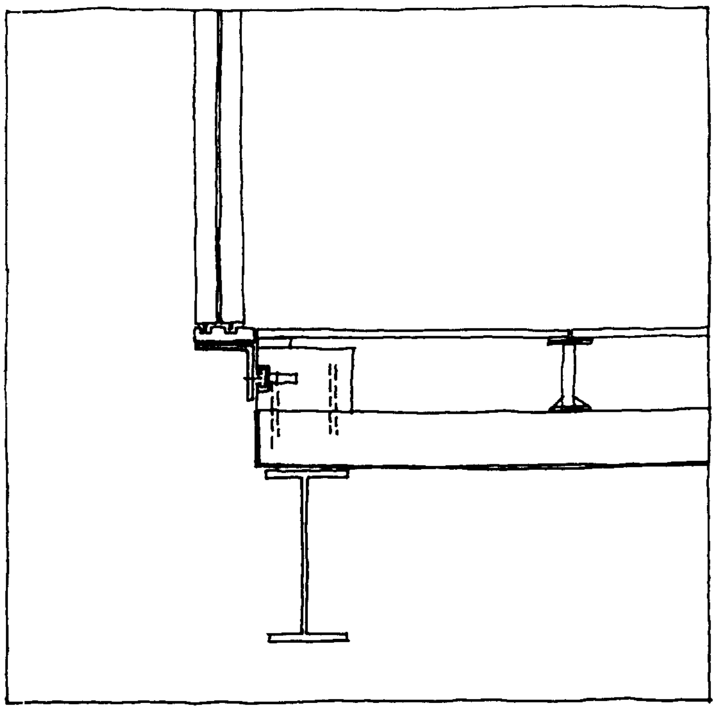


Figure 1.28 Lift threshold, raised floor with concrete upstand

Raised floor with adaptor plate and separate fire stop

An alternative detail to the concrete upstand is to use an adaptor plate effectively extending the threshold vertically through the depth of the raised floor. Where necessary, the ends of the threshold can be restrained against 'H' frame steelwork, to prevent excessive horizontal deflections. This adaptor plate is a specialised item and will normally be supplied by the lift contractor.

DESIGN

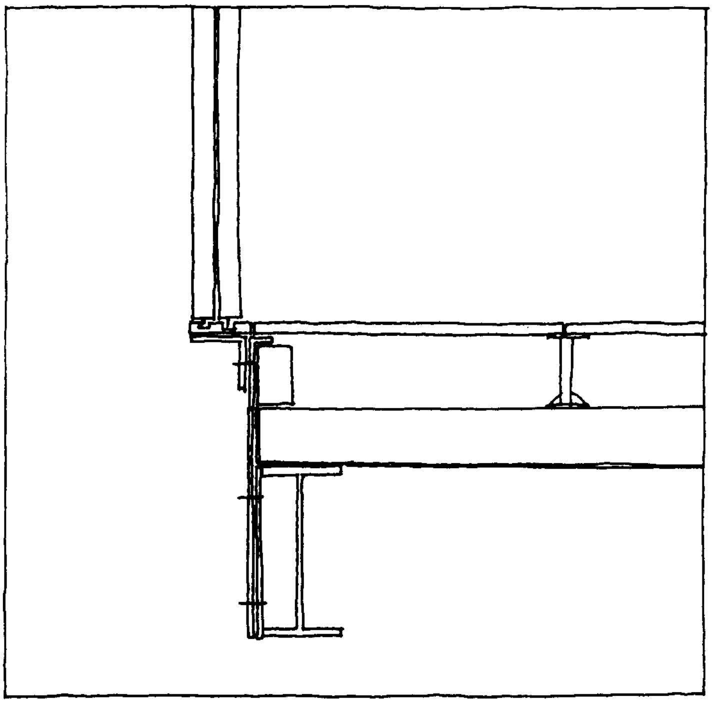


Figure 1.29 Lift threshold, raised floor with adapter plate

The adaptor plate may be cranked and fixed into the top of the floor slab, fixed to the slab edge, or bolted to the edge beam beneath.

The primary advantage of this detail is that the front well wall construction can be extended to fire protect the zone between the lift threshold and the floor slab, or alternatively, fire stopping can be done within a general work package.

1.5 MAJOR LOADS AND FORCES

Load determinants

Lift installations generate a distinct set of loads which primarily act upon the structural frame and floor slabs, the lift pit and the machine room floor. These loads generally arise from four sources:

(1) The self weight of the lift and its mechanical systems.

(2) The dynamic loading induced by acceleration and deceleration of the lift, particularly when safety gear brings the lift car to an abrupt, controlled, halt.

(3) Impact of lift car or counterweight on the buffers.

(4) Installation of lift equipment.

Major loads are generally vertical and act on either the floor of the lift pit, or the floor of the machine room. Guide rails are required to resist any lateral motion of the lift car (Section 1.3), but this loading is relatively light and the designer will be primarily concerned with questions of stiffness rather than strength.

The magnitude of loads is primarily a product of the mass of the lift equipment, the lift size (and therefore its carrying capacity), and the acceleration and braking speeds of the lift car and counterweight.

The mass of lift cars varies significantly between installations. Lifts with a highly furnished interior will have a far greater self weight than basic designs, since finishes will be more massive and the car itself will be more heavily structured.

Table 1.3 schedules the weight of various lift car finishes in relation to car size.

Case 1 is a basic lift car, with laminate panels on the walls, integral light fitting in the ceiling, hand rail and carpeted floor.

Case 2 is lower medium range car, with handrail, half height mirror on the rear wall, stainless steel clad front wall and laminate sides, simple drop ceiling and carpeted floor.

Case 3 is an upper medium range car, with handrail, half height mirror on the rear wall, stainless steel clad front wall and laminate sides, simple drop ceiling and marble floor.

Case 4 is a top of range ornate car, with heavy handrail section, full height mirror on the rear wall, timber panels on the side walls, dropped ceiling with recessed light fittings and marble floor.

Table 1.3 Lift car finishes related to mass

Interior Spec.	Contract Load (kg) / Number of Persons					
	630/8	800/10	1000/13	1250/16	1600/21	1800/24
Case 1	115	130	140	160	180	215
Case 2	180	200	220	250	300	330
Case 3	260	320	360	400	520	590
Case 4	325	390	460	530	600	690

Lift pit loading

The lift pit should normally be designed to withstand the following loadings:

1. The downward force applied by the lift car guide rails to the floor of the lift pit, when safety gear is operated to halt the lift.

2. (a) The equivalent downward force which may be applied to the floor of the lift pit by the counterweight guide rails, if the counterweight is fitted with safety gear, *or*

   (b) The self weight of the counterweight guide rail when safety gear is not fitted to the counterweight.

3. The forces arising from the impact of the lift car or counterweight on the buffer arrangement at the bottom of the well.

The design requirements for the lift pit floor are dependent upon the relationship of the lift pit to other spaces in the building, and upon whether or not safety gear is fitted to the counterweight.

It is not usual to fit safety gear to counterweights when the lift pit is built into the ground, and so the lift pit is only required to support the self weight of the counterweight guide rails, and the loads associated with the lift car (Figure 1.30). Where however there is a usable space beneath the lift pit, one of two strategies may be adopted. Either safety

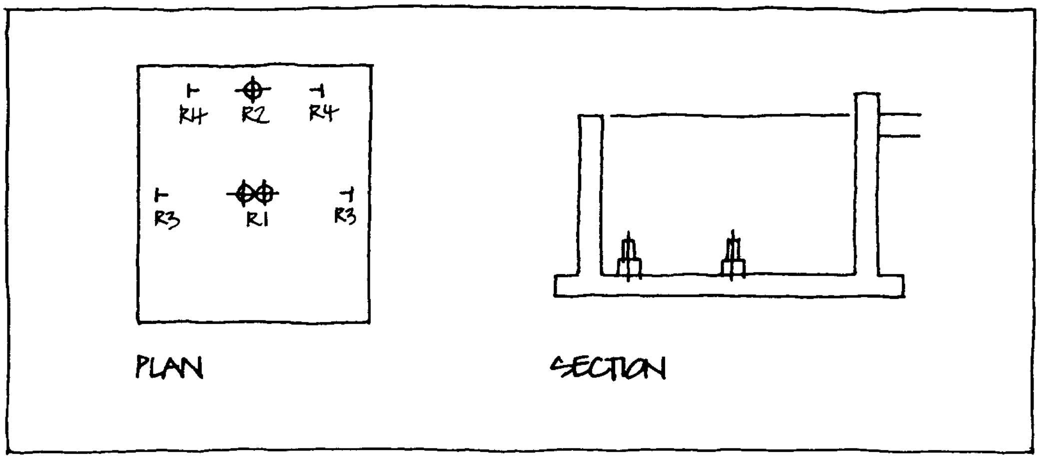


Figure 1.30 Lift pit built into ground

gear may be fitted and the lift pit floor required to resist the resulting vertical load on the guide rails (Figure 1.31), or a concrete pier may be constructed beneath the counterweight to transfer any impact loads down to the foundations (Figure 1.32). Clearly, this latter strategy may be realistically adopted only where the lift pit is located at, or close to, ground or basement level.

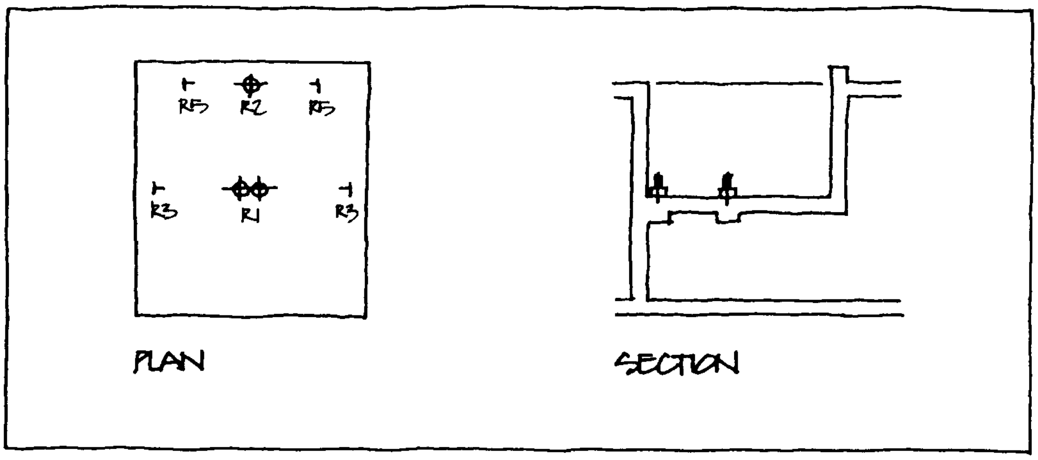


Figure 1.31 Habitable space beneath lift pit, safety gear fitted to counterweight

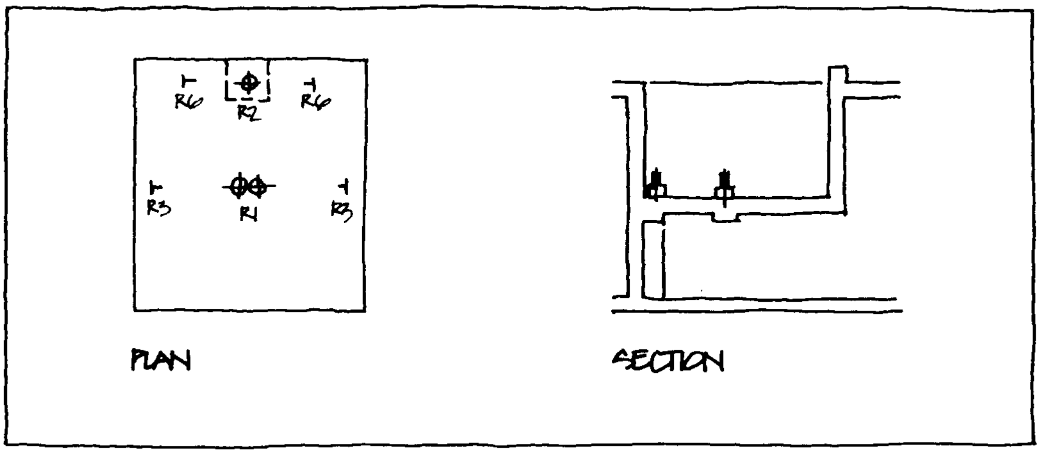


Figure 1.32 Habitable space beneath lift pit, safety gear not fitted to counterweight

Where safety gear is used, the force transmitted to the guide rails is dependent upon the speed of travel of the lift car. Standard reactions are assumed for lift car guide rails where lift speeds are up to and including 0.63 metres per second, and above 0.63 metres per second. Similarly, standard reactions are assumed for counterweight guide rails where lift speeds are up to and including 1 metre per second, and above 1 metre per second.

In addition to resisting loads transmitted by guide rails, the lift pit must also resist reasonable impact forces from the lift car or counterweight. Normally these will be applied through buffers located between each pair of guide rails. The criteria for assessing this loading is contained in BS 5655: Part 1.

Schedules of lift pit reactions (including those passed through the buffers to the lift floor) are given in Tables 1.4 and 1.5. Reactions cannot all occur simultaneously. Theoretically, the most adverse loading situation occurs when the lift car and counterweight are stopped at the same time either by safety gear, buffers or a combination of both. This could occur if the counterweight and lift car were disconnected.

The minimum design load for a lift pit floor is 5 kN/m^2.

Table 1.4 Maximum pit floor reactions: lift pit built into ground

Contract Load (kg)	Persons	Loaded Car Weight (kg) Case 4 Finishes, (Table 1.3)	Based on BS 5655 : Part 1		≤0.63m/s	> 0.63m/s	
			R1 (kN)	R2 (kN)	R3 (kN)	R3 (kN)	R4 (kN)
630	8	1900	76	64	55	27	5 (Due to mass of guide rail only. i.e. no safety gear)
800	10	2390	96	80	68	32	
1000	13	2960	119	99	82	38	
1250	16	3530	141	116	96	43	
1600	21	4400	176	144	118	52	
1800	24	5190	208	172	138	60	
2000	26	5770	231	191	152	66	

Notes: For location of reactions refer Figure 1.30.
Minimum design load for pit floor is 5 kN/m^2 (BS 5655: Part 6).

Machine slab loadings

Slab loadings, i.e. loads on the floor slab at the top of the lift well transmitted by the lift hoisting machine, may also be expressed as a product of the lift speed. The most convenient categorisation is for lifts with speeds up to and including 1.6 metre per second, and lifts with speeds above 1.6 metres per second. These figures correspond to the point of change from a geared hoisting machine to a gearless type as recommended in BS 5655: Part 6; the significance is that gearless machines impose heavier loads on the slab supporting the lift machine.

The total load on the slab is the dynamic loading from the lift, plus the static load of the fixed machinery mounted on the machine room slab, i.e:

2 × (mass of lift car + load carrying capacity of the lift, i.e. the contract load + mass of counterweight + mass of ropes and cables) + mass of machine, diverter wheel and support frames.

The resulting figure is termed the Equivalent Dead Load (EDL) acting on the machine room slab. Typical values are presented in Table 1.6.

Table 1.5 Maximum pit floor reactions: habitable space beneath lift pit

Contract Load (kg)	Persons	Loaded Car Weight (kg). Case 4 Finishes, Table 1.3	Based on BS 5655: Part 1		≤0.63m/s	> 0.63m/s	≤1m/s	> 1m/s	
							Safety gear fitted to counterweight		Safety gear not fitted to counterweight
			R1(kN)	R2(kN)	R3(kN)	R3(kN)	R5(kN)	R5(kN)	R6(kN)
630	8	1900	76	64	55	27	45	21	5 (Due to mass of guide rail only. i.e. no safety gear)
800	10	2390	96	80	68	32	55	25	
1000	13	2960	119	99	82	38	68	30	
1250	16	3530	141	116	96	43	78	34	
1600	21	4400	176	144	118	52	95	41	
1800	24	5190	208	172	138	60	113	48	
2000	26	5770	231	191	152	66	125	53	

Notes: For location of reactions refer Figures 1.31 and 1.32.
Minimum design load for pit floor is $5kN/m^2$ (BS 5655: Part 6).

Loads on Lifting Beams

Lifting beams should be designed in accordance with appropriate standards such as BS 5655 Part 6. Table 1.7 presents safe working loads for these beams in relation to lift speed and capacity.

Table 1.6 Machine slab loadings

Lift Speeds	Contract Load (kg)						
	630	800	1000	1250	1600	1800	2000
≤1.6m/s	85	105	130	155	185	220	245
>1.6m/s	135	154	184	210	250	326	375

Table 1.7 Loads on lifting beams

Lift Speeds	Contract Load (kg)						
	630	800	1000	1250	1600	1800	2000
≤1.6m/s	700	950	1000	1400	1450	2250	2350
>1.6m/s	2700	2700	3700	3700	3700	8200	8900

1.6 FIRE PROTECTION

Compartmentation

The Building Regulations require large buildings to be compartmented, for the purpose of preventing the spread of fire. Any lift well passing directly from one compartment to another will be required to maintain this compartmentation. Well walls must therefore be constructed to provide appropriate levels of fire resistance, and conform to the building regulations requirements for 'protected wells'.

Well walls, doors and fittings

The fire resistance of a protected well normally has to be maintained across the wall area, including push button and indicator boxes, landing entrances, and threshold upstands (usually within a raised floor). Where the lift is designed for fire fighting purposes, special requirements apply (refer to BS 5588: Part 5).

Most well wall constructions provide either 1, 1.5 or 2 hours fire resistance, together with high levels of sound insulation.

It is important to maintain the fire rating of the lift enclosure around the architrave and at the lift doors. Most proprietary head and jamb details will have been fire tested, and lift doors are constructed so that they can achieve the requisite periods of fire resistance.

Button and indicator boxes

It is necessary to maintain the fire resistance of the protected well at indicator and button boxes.

Recessed boxes in brick or blockwork enclosures should be fixed so that there is a sufficient thickness of masonry behind the box to maintain adequate fire protection (this might involve increasing the thickness of the front wall). Alternatively, boxes can be protected by layers of non-combustible protective materials on the well side.

Button and indicator boxes in dry lined walls require some means of support which is normally provided by additional studwork, the required design of which must be advised to the dry lining contractor prior to erection of the front wall. Again, openings at the rear of these boxes will require additional fire protection, a schematic for which is given in Figure 1.33. The depth of front well walls should be at least 90 mm, in order to accommodate boxes and fire protection details.

Structural steelwork

All structural steelwork within lift wells is required to meet the provisions of the Building Regulations as currently set out in *Approved Document B 1992*. The Approved Document sets out periods of fire resistance for structural elements, which are considered to satisfy the provisions of the regulations (refer Approved Document B 1992, Appendix A, Tables A1 and A2).

DESIGN

Non-structural steelwork

It is not usually necessary to fire-protect non-structural steelwork within the lift well, such as divider beams, guide rails, or door support steelwork.

There is clearly little gain in fire-protecting divider beams and guide rails, since these are purely associated with the lift installation, and do not contribute to the fire integrity of the building generally. The argument that door supports do not require fire protection appears to come from the requirement that well doors should resist the passage of fire from outside of the well inwards. Since there is unlikely to be sufficient heat developed on the outside of doors to distort the frame on the inside (and compromise the fire integrity of the protected well), fire protection is not normally required.

KEY:

1. Horizontal studs
2. Mineral wool insulation
3. Button or indicator box
4. Faceplate

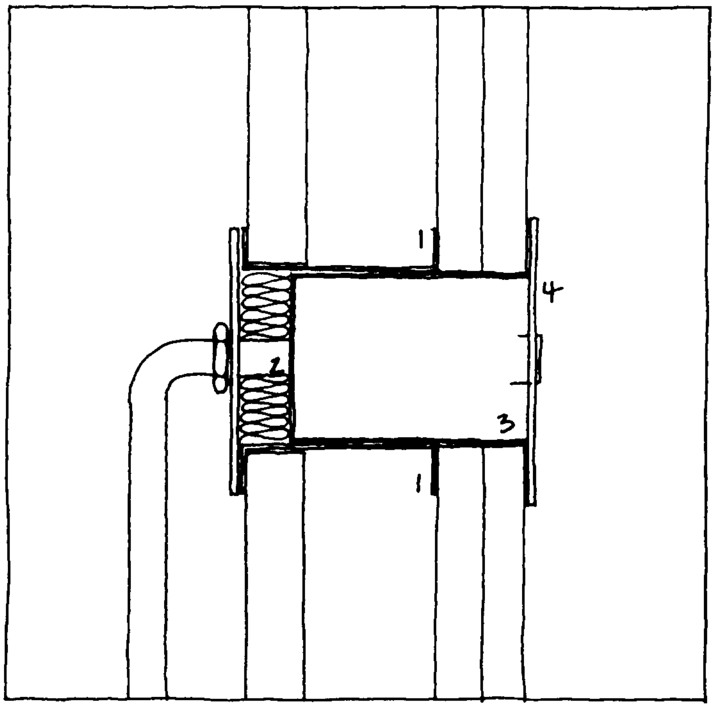


Figure 1.33 Button or indicator box in dry lined partition

Methods of fire protection

Various materials are used to fire protect structural steelwork; these include fire-resistant plasterboard, mineral fibre, vermiculite and lightweight cementitious materials. Mineral fibre, vermiculite and cementitious products are available in either board or spray forms. Expanded vermiculite is an excellent insulant but is relatively soft and so is usually mixed with cement products to improve its durability. Various proprietary fire protection systems are listed in *Fire Protection for Structural Steel Buildings, 2nd Edition,* published jointly by Association of Specialist Fire Protection Contractors and Manufacturers, The Steel Construction Institute, and the Fire Test Study Group.

The relationship of fire-protection and steelwork details must be carefully considered. For instance, steelwork connection details based upon plates welded between the extreme edges of the flanges of steel beams (Section 2.1, 'Connections to structural steelwork'), may be difficult to reconcile with board based systems, due to the geometries involved. Connections that are intended to be adjusted and aligned at the point of attachment to the structural steelwork (Section 2.2, 'Connections to structural steelwork'), can also be problematic when used in conjunction with board based fire-protection since access is restricted.

Sprayed fire-protection systems pose other considerations: it should not be necessary to remove sprayed fire protection in order to install or adjust connection brackets, so appropriate outstand or channel fixing arrangements are advisable (Sections 2.1 and 2.2, 'Connections to structural steelwork'). It must also be possible to spray behind plates welded between flanges and any similar features, fixing channels may require masking and the depth of the channel should not be so shallow that it is lost within the depth of the fire spray.

Programming of fire protection

Fire protection should be applied to structural steelwork prior to lifts being installed. Where guide rails attach to steelwork, it should not be necessary to remove fire protection in order to carry out the installation. This means that either the base part of the bracket must be installed ahead of the fire protection, or channels must be provided to receive post-fixed brackets (Section 2.1, 'Connections to structural steelwork').

Sprayed fire protection should not be applied or made good after the installation of the lift, since overspray or airborne material can damage lift machinery. Board-based products tend therefore to be preferred, but the choice is usually determined by cost and construction criteria.

Fire engineering

Current Building Regulations permit 'fire engineering' techniques to be used to prove the safety of structures in the event of fire. These techniques normally involve simulating, testing or numerical analysis of the effects of fire, and consequently it is often possible to demonstrate that lower levels of fire protection than those cited in the building regulations are adequate in particular circumstances.

In a lift well, for instance, where the well and entrance doors have high levels of fire resistance, and where there is little combustible material, fire engineering techniques may be used to demonstrate that it is not necessary to fire-protect steelwork or alternatively to justify reduced fire protection. In general, the potential for fires within lift wells is relatively small, since there is little combustible material.

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2 CONNECTIONS

Provision must be made for fixing door support steelwork, lift thresholds, guide rails and dividing steelwork.

Door support steelwork and lift thresholds are discussed in Section 1.4. Connections for these elements should normally follow the design principles set out in the text, and will reflect individual building requirements. Connections for guide rails and dividing steelwork can be rather more standardised, and the following presents detailed guidance on their design.

Counterweight guide rails in standard lift installations are usually connected to the floor edge, or to structural steelwork at the rear of the lift well.

INTERFACES

Lift car guide rails are fixed to either the floor slab, or steelwork, at the flank walls of the lift well; or to dividing steelwork between lifts in multiple wells.

The position of these connections will vary between lift manufacturers, and therefore where precise information on the location of fixing brackets is not available at the time of design, some adjustment must be allowed. Figure 2.1 sets out the minimum adjustment that should normally be provided.

Where short lengths of channel fixings are used (as opposed to continuous combined edge trim/fixing channel details) the level of adjustment will determine the length of the fixing channels.

KEY:

A. 0.5 × car depth + 250

B. 0.5 × width

C. +/- 150

D. +/- 75

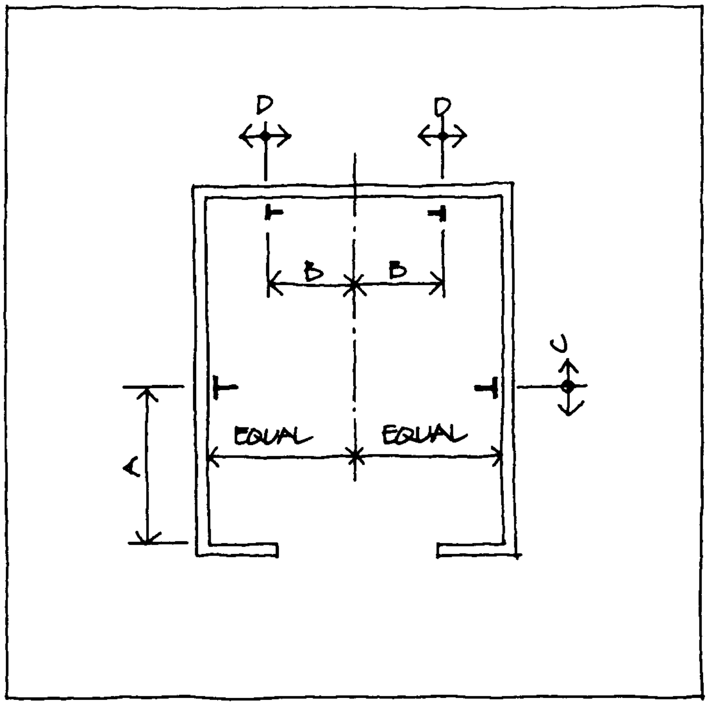

Figure 2.1 Variability in guide rail positions

Where guide rail support brackets are to be bolted to pre-drilled holes in the steelwork, similar levels of adjustment have to be provided. This can be done either using slotted holes in the brackets, or by providing a combination of slotted holes and a range of bolt down positions in the structural or dividing steelwork (Figure 2.2). Bolt hole diameters are normally 16 mm.

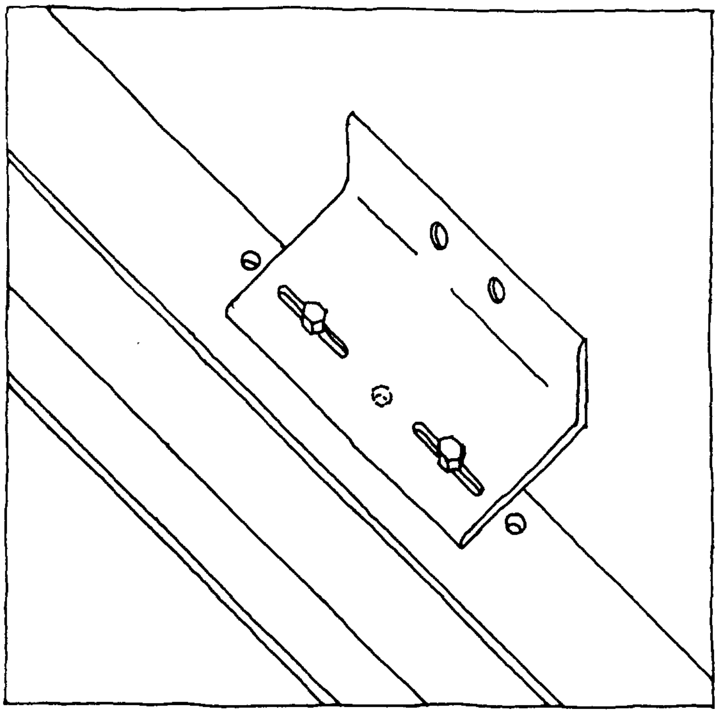

Figure 2.2 Bracket adjustment by slots and multiple holes

2.1 CONNECTIONS BETWEEN GUIDE RAILS AND STRUCTURAL ELEMENTS

Connections to the slab edge

Guide rail connections may be either cast or drilled into slab edges, however drilled-in connections are generally not recommended since these may clash with reinforcement, require special programming considerations and are time consuming. Cast-in fixings are preferred, and a variety of types are in use.

Standard edge channel detail

An established approach is to bolt short lengths of channel section to the inside face of the edge trim prior to concreting (Figure 2.3). These are fitted with strap anchors and polystyrene channel fill. When the slab is cast, the position of channel sections is evident from the bolt heads on the outside of the edge trim. Connections are made by cutting out the trim in front of the channel so that 'tee bolts' may be inserted. Lift installers tend to find such cutting out difficult and time consuming.

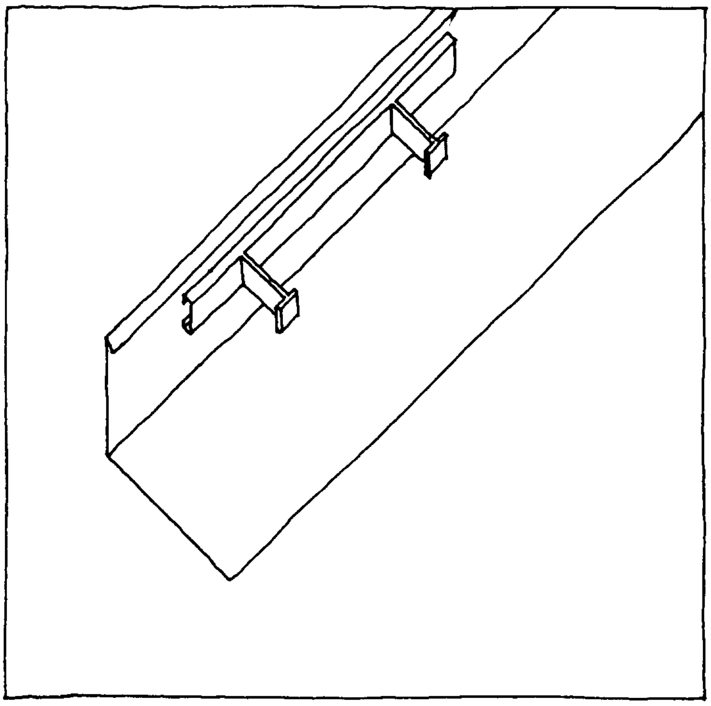

Figure 2.3 Standard edge channel detail

Combined edge trim and channel detail

An alternative method of fixing to slab edges is to use proprietary edge trims which incorporate fixing channels in the profile (Figure 2.4). The component cost may be greater than the system outlined in the previous section, but there are various advantages:

- Guide rail fixings may be made at any point along the length of the channel, thus enabling their precise location to be determined after construction of the slab edge (guide rail positions are not standard between manufacturers).
- The channel is available to receive cable trays and other elements.
- If the floor edge is sufficiently robust, the channel may be used on the front wall to provide connection points for door frames.
- Connections cannot be sited in the wrong position or orientation, as can occur with standard edge channel details. The likelihood of delays caused by remedial action is therefore minimised.
- Total cost may be less due to installation efficiencies.

Guide rails are usually attached to floor edges using bracketry of the type illustrated in Figure 2.5.

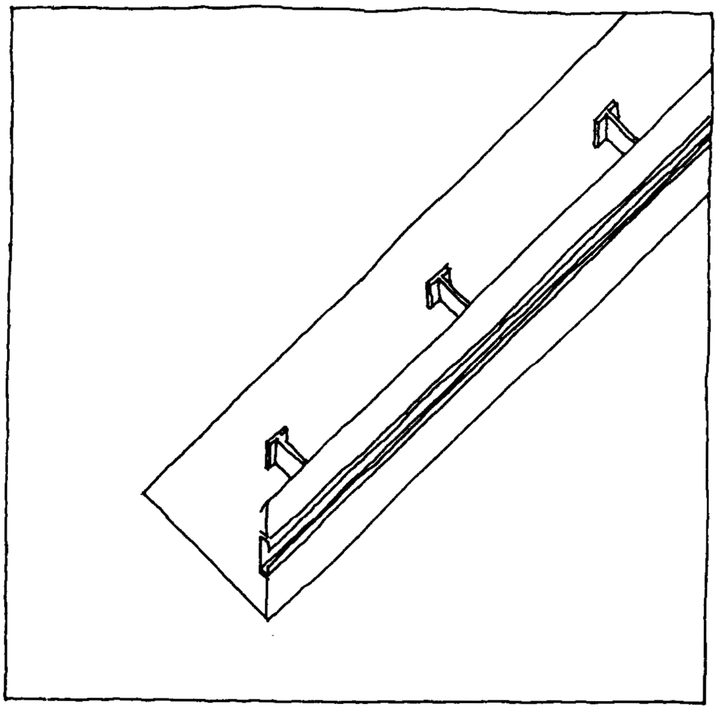

Figure 2.4 Combined edge trim and channel detail

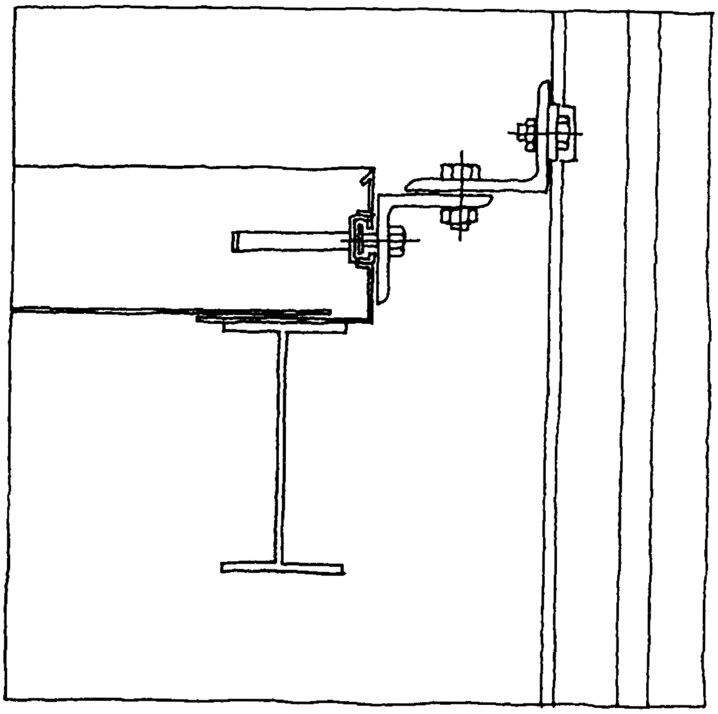

Figure 2.5 Guide rail connection to slab edge

Connections to structural steelwork

Welded or bolted brackets

Fabricated steel brackets, designed to receive guide rail connections, may be welded or bolted to edge beams. Where the edge beam is some distance from the slab edge, the bracket must be located on a spacing element (such as a channel section) to bring the face of the insert close to the slab edge.

It is not necessary to fire-protect brackets. However, bracket bases or spacing elements should be in place prior to the edge beams being fire-protected, so that the material can be dressed around them. If fire protection has to be removed in order to fix the brackets to the beams, it will be necessary to arrange remedial work to reinstate the lost material. This causes unnecessary cost and programming difficulties, and the application of sprayed fire protection can damage lift machinery (Section 1.6).

There are a variety of types of welded bracket; the two most common are outstand types, often designed around channel or angle sections (Figure 2.6), and full height plates that are welded between the chords of the framing members (Figure 2.7).

When brackets are bolted to the steelwork, slotted or oversized holes should be incorporated to provide tolerances in the fixing position. Similar slotted holes can also be provided at the point of support of the guide rail brackets, to compliment the 'fine' adjustment designed into the bracket for final alignment of the rail. Most guide rail brackets will be fully adjustable in the horizontal plane.

Outstand brackets are generally best designed so that the top of the bracket is immediately beneath the soffit of the floor. If the bracket is located some distance beneath the soffit of the floor slab, it is then necessary to dress fire protection into the zone beneath the soffit and the top of the bracket. Since space is inevitably restricted, this is a difficult operation.

Where the steel framing around the well does not support a floor slab, and is not fire protected, as may occur where the lift well is outside of the main building envelope, or where one wall of the well is a facade wall, it is usually possible to adopt

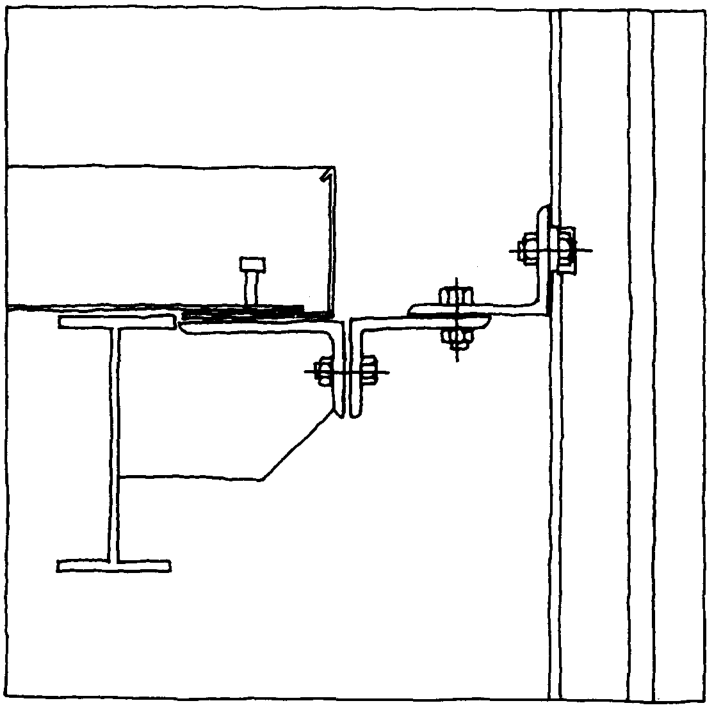

Figure 2.6 Guide rail connection to edge beam based upon outstand angle

Horizontal adjustment (Parallel and perpendicular to beam) by slotted holes in angle brackets.

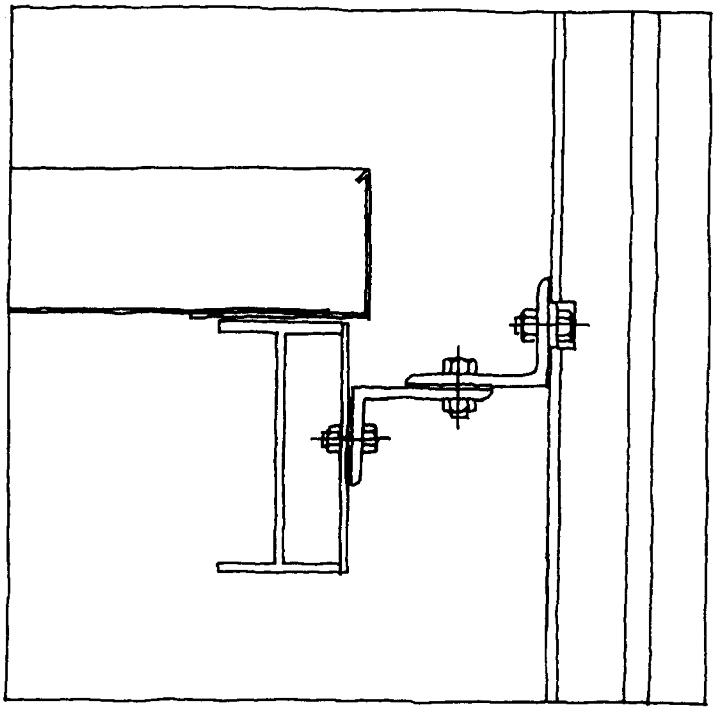

Figure 2.7 Guide rail connection to edge beam based upon welded plate

Horizontal adjustment (parallel and perpendicalr to beam) by slotted holes in angle brackets.

relatively simple connection brackets fixed to the top flange of the horizontal steel beams. These may comprise one extended angle section. This angle has slotted holes for horizontal adjustment perpendicular to the axis of the beam at the connection to the flange, and slotted holes for adjustment parallel to the axis of the beam at the connection to the guide-rail (Figure 2.8).

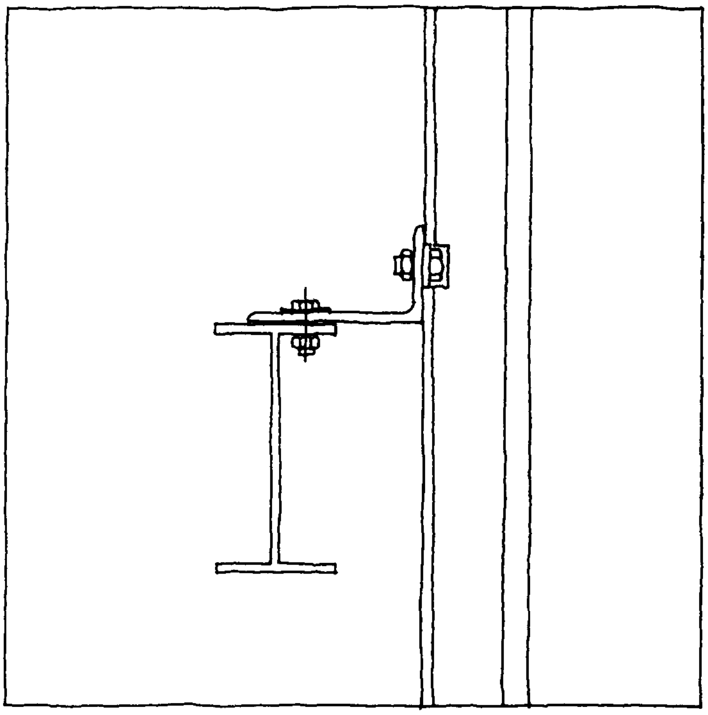

Figure 2.8 Guide rail connection to non-fire protected edge beam without floor slab

Limited horizontal adjustment by oversized holes. Greater horizontal adjustment possible parallel to beam using slotted holes or slotted holes and multiple bolt down positions.

Fixing channels

It is possible to connect lift guide brackets to steel framing using channels fixed to the webs of the framing members.

Since structural steelwork is usually fire-protected (Section 1.6), it is generally necessary to dress the insulating material around the fixing channels. Channels will normally be filled with polystyrene and suitably shielded. Care must be taken that the channel is not lost within the depth of the fire protection, which will normally be in the range 15 - 35 mm thick.

Channels may be either welded or bolted in place, although welding is generally the preferred solution.

Connections to dividing steelwork

Since it is not usually necessary to fire-protect divider beams, guide rail connections can be bolted either directly to the beams or fixing channels, or can be welded in place. Connections can be made either to the web, or to top or bottom flanges (Figures 2.9 & 2.10). Connections to flanges are often based on saddle plates. Where bolted connections are used, it is normal to provide pre-drilled holes.

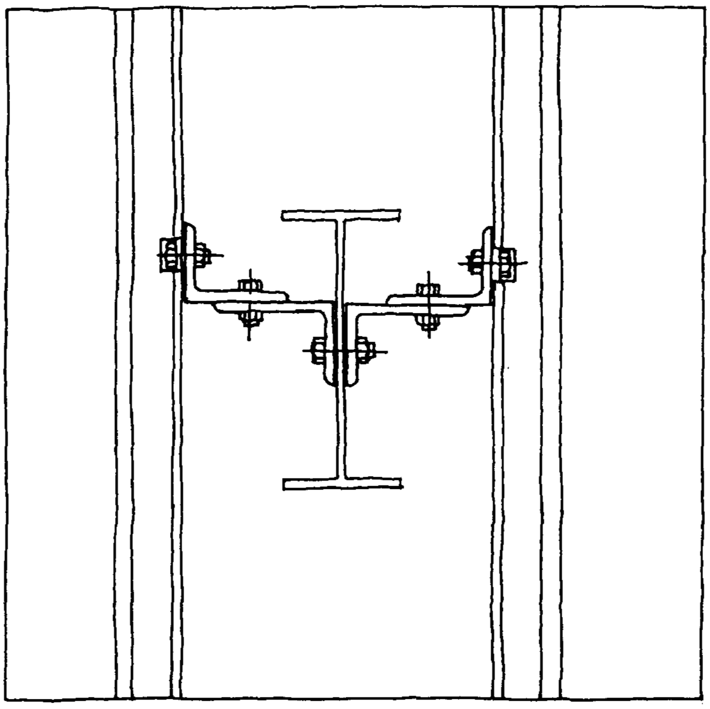

Figure 2.9 Guide rail connection to web of divider beam

Horizontal adjustment by slotted holes in angle bracket fixings to beam web (parallel to beam), and angle bracket to angle bracket fixings (perpendicular to beam).

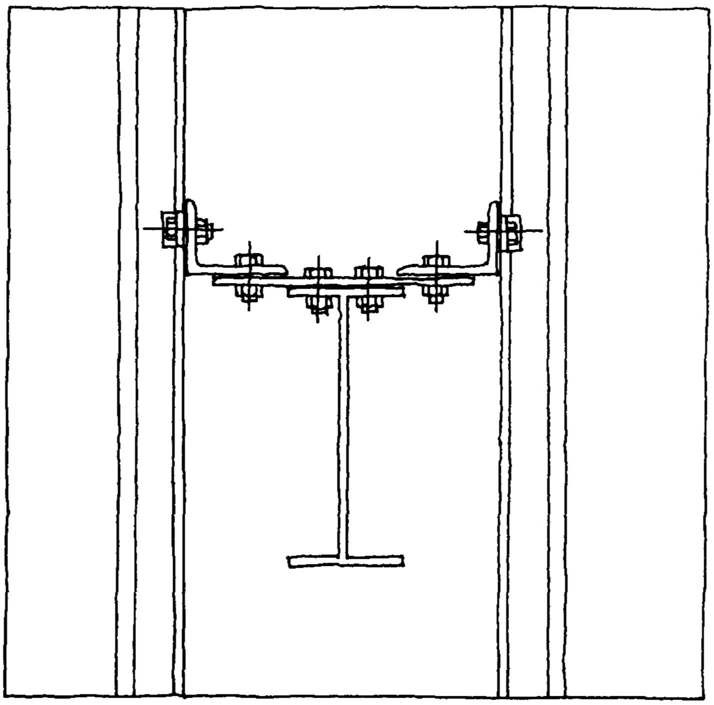

Figure 2.10 Guide rail connection to flange of divider beam

Horizontal adjustment by slotted holes in saddle plate (parallel to beam), and at angle bracket to saddle plate fixing (perpendicular to beam).

2.2 CONNECTIONS BETWEEN WELL-DIVIDING STEELWORK AND STRUCTURAL ELEMENTS

The following summarises the most common types of connection used to attach well-dividing steelwork to structural elements:

Connections to slab edge

Where well-dividing steelwork is connected to the floor slab, the connections will be similar to those used for connections between guide rails and the slab, described in Section 2.1, ('Connections to slab edge'). Again, drilled-in connections are generally not recommended, since these may clash with the reinforcement, require special programming considerations and are time consuming. Cast-in fixings are preferred (Figure 2.11).

Channel type connections, whether based on sections of channel bolted to the edge trim, or combined edge trim and channel details, are able to take up dimensional variations in the horizontal plane, and normally therefore allow considerable tolerance in the position of the divider beam. Where these details are used, it is important to ensure that the connection can provide adequate restraint to prevent the ends of the divider beam fixings sliding in the channel under horizontal loading from the lift guide rail.

Connections to structural steelwork

Divider beams may be erected with the steel framing, and connected using standard beam-to-beam details (end plates, fin plates or cleats). Where these members connect to structural steelwork, the connection will be fire-protected. However, since divider beams are not load carrying, the beam itself will not be fire-protected.

Alternatively, divider beams may be bolted in place after the framing members have been fire-protected. This will require the provision of channel type connectors on the web of the edge beam (Figure 2.12), or bolt-down details projecting from the fire protection (Figures 2.13 & 2.14), similar to those used for guide rail connections.

Details should include horizontal adjustment to take up building tolerances, but this should be capable of being adequately secured against movement in the direction of the adjustment under loading from the lift guide rail.

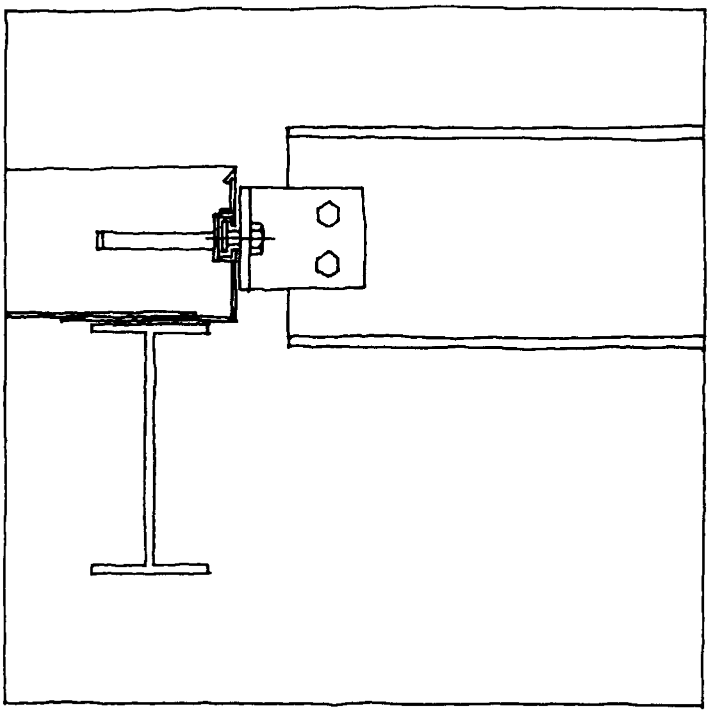

Figure 2.11 Divider beam connection to slab edge

Horizontal adjustment at channel fixing and by slotted holes at one divider beam to cleat fixing.

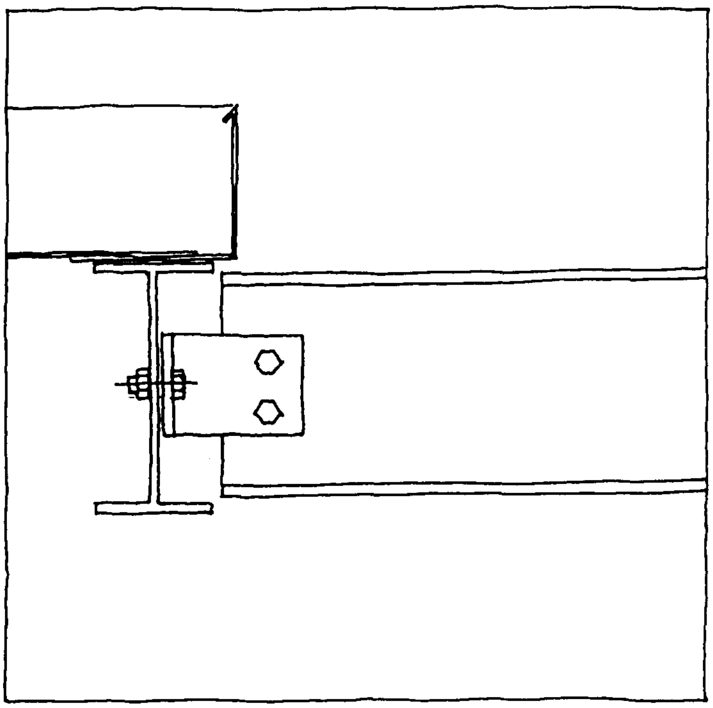

Figure 2.12 Divider beam connection to edge beam based upon web mounted fixing channel

Horizontal adjustment by slotted hole in cleat at fixing to beam and by slotted holes at one divider beam to cleat fixing.

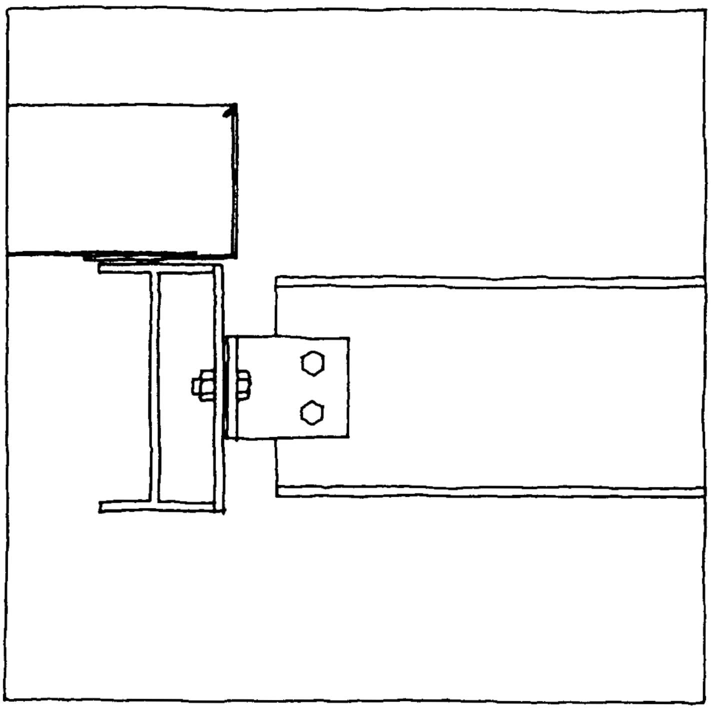

Figure 2.13 Divider beam connection to edge beam based upon welded plate

Horizontal adjustment by slotted hole(s) in cleat at fixed to beam.

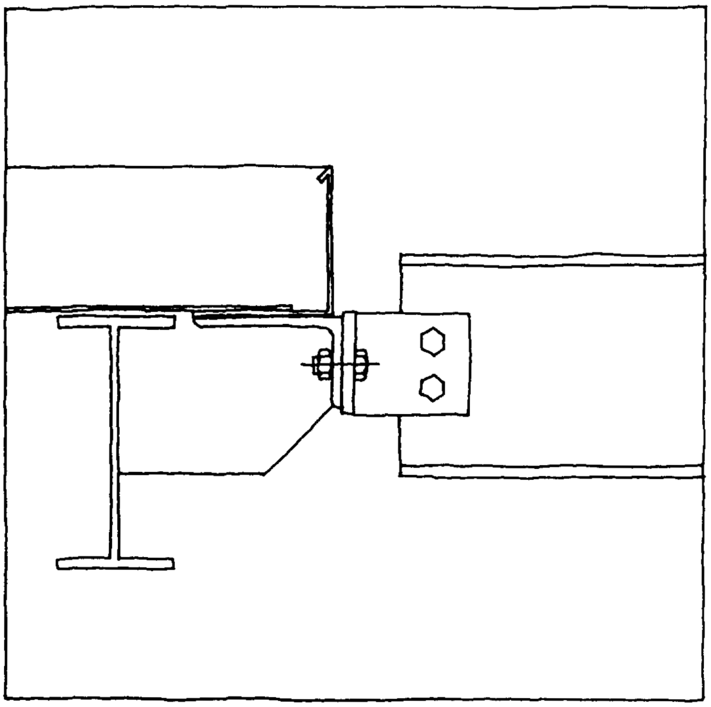

Figure 2.14 Divider beam connection to edge beam based upon outstand angle

Horizontal adjustment by slotted hole(s) in cleat at fixing to beam.

GLOSSARY OF TERMS

Architrave	Optional lining to the reveal around lift landing doors.
Contract load	Load carrying capacity of a lift installation.
Counterweight	Fabricated steel frame containing ballast to act against the mass of the lift car.
Dividing steelwork	Beams spanning the lift well (front to back), used to provide fixings for guide rails in multiple wells.
Dividing screen	A continuous mesh screen used to separate adjacent lift wells in multiple wells.
Floor edge trim	The steel pour stop installed to the edge of concrete floors cast on steel floor decks.
Guide rails	The steel 'T' sections used to restrain the lift car and counterweight in the correct running position.
'H' frames	Steel frames (usually fabricated from steel angles) used to support the lift landing doors.
Headroom	The vertical height allowed to accommodate the lift overrun and height of the machinery, measured from the highest landing floor level served by the lift.
Hoisting machine	Plant consisting of motor, brakes, traction sheaving and possibly a gearbox, used to drive the lift car and counterweight via suspended ropes.
Internal car size	The size of the lift car at floor level.

Landing furniture	Collective term for call-buttons, indicator panels, fire switches etc.
Lifting beams	Steel beams at high level in the machine room used to install and remove lift equipment.
Lift well	The vertical zone occupied by one lift.
Machine above	Installations where the hoisting machine is situated at the top of the lift well.
Machine below	Installations where the hoisting machine is situated at the bottom of the lift well.
Multiple lift well	A lift well containing more than one well.
Pit depth	The finished vertical depth of the lift pit measured from the bottom floor level served by the lift.
Suspended door	Door support steelwork cantilevered down from a Steelwork edge beam above the lift doors.
Threshold	The sill used to restrain the lift landing doors.
Traction sheaving	The wheel-type component attached to the hoisting machine that winds the ropes used to suspend the lift car and counterweight.