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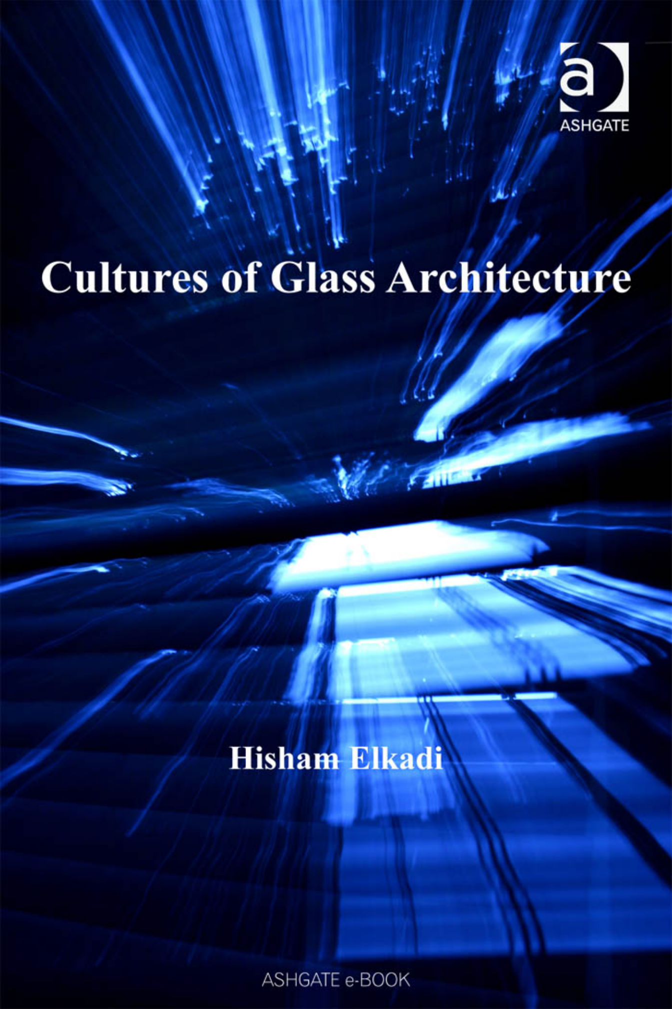

Cultures of Glass Architecture

Hisham Elkadi

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Preface

I have always been a great admirer of the ancient Egyptian glassmakers whose marvellous masterpieces cannot be matched by contemporary craftsmen, even with all the latter's technical progress. My admiration is also extended to the later Venetian masters whose followers decorated the windows of European cathedrals. In my first year of studying architecture and during my first visit to France, I was introduced to the wonderful world of glass architecture in Amiens Cathedral. The windows of the cathedral were fascinating. As I moved from the summer sunshine to the cooler dark interior, I was pleasantly welcomed by the coloured light of the rose window.

On my graduation in 1983 and as part of my national service, I was lucky enough to be given a job to design a hotel for the Navy in Alexandria. A glass façade was unimaginatively 'requested' by the commander-in-charge to reflect the new 'open and transparent' image of the Egyptian naval force at that time. I was studying, at the same time, for my master's degree in environmental science, where energy, ecology and sustainability were among the keywords in all learnt subjects. To my dismay, I had to observe in my project how an extensive glass façade could be badly applied in architecture to reflect false and distorted visual and cultural ideas in the city where marvellous glassworks were first introduced. On the other side of Alexandria, Snoheta's winning proposal for the Bibliothiqua Alexandrina was a sensitive application of glass on the southern Mediterranean coast; an elegant and contemporary use of glass that is both functional and aesthetically pleasing.

P.1 Aerial view of the Bibliothiqua Alexandrina, Egypt

During my early years as an architect, I also worked in a practice led by Professor Monir who gained his experience with SOM in New York. Professor Monir was captivated by the details of windows, particularly corner windows. The practice produced many buildings that were entirely evolved from the understanding of the role of daylighting and the positioning of windows. Some of our projects at that time were in the United Arab Emirates (UAE), where outside temperatures exceed 50ºC during the summer months. With the increasing wealth in UAE, the rulers of Abu Dhabi apparently decided that they wanted all buildings to be fully glazed and that all 'old-style' buildings that incorporated external shading devices and balconies should be demolished. Glass façades were their perception of development. Such an attitude continued to surprise many. Our work, however, continued to focus on producing appropriate and responsible architecture for this challenging climate. We were also challenged by the nature of glass itself – how a material with transparent, visual connections and spatial continuity can be applied in a society that observes strict privacy, secrecy and clear social hierarchy. Dealing with the consequences of our designs in Dubai and Abu Dhabi, we had to confront our professional ethics, as we were making buildings that required 24-hour air conditioning to meet the expected comfort levels. Following this experience it was no wonder that my choice for my PhD study in Liverpool was on the subject of the ecological principles of energy use in architecture.

In Liverpool, I lived in a flat overlooking the Catholic Cathedral, one of the iconic buildings in Liverpool. As I entered the cathedral, the colours of the glass windows in yet another religious building had less impact on me than those of Amiens Cathedral or Notre Dame. This was not simply because of the negative press that the cathedral had received at that time. Unlike some contemporary glass works, the coloured lights of the Gothic cathedrals seem to capture and accentuate the sense of place, outside as well as inside the buildings. Our experience with coloured or stained glass starts with our approach towards the cathedral and its relation within its context. Recently, I reminded myself of this concept through an entirely different experience during a visit to one of McCormic's churches near Letterkenny in rural Ireland.

P.2 The High Altar of Liverpool's Roman Catholic Cathedral

I was also fortunate to work with many people of different academic backgrounds who share an admiration of glass and light. Professor Michael Wigginton, Professor of Architecture at Plymouth University, is a passionate believer in this wonderful material and its role in architecture. We worked together in the early stages of his ambitious intelligent façade programme. While technical in nature, the project, which investigated the 'intelligent' façade in Europe, has emphasized for me the cultural dimensions of the technical fixes. These cultural dimensions not only affect users but also influence the culture of context as a whole. I have worked and lived in some troubled places, in Beirut and Belfast. In these tensioned societies, the interrelationship intensifies between the users and their surrounding urban environment. In such situations, the existence of glass, or the lack of it, would be our first impression of how safe a particular part of the city is. Glass

P.3 Domestic window typical of any area of conflict in Belfast

gives a sense of safety and confidence to a place while the lack of it takes the soul away from it. No other material has such instant visual impact. Its dynamic nature, the ability to present itself in myriad forms, in different colours, shades, textures, form and levels of transparency, all contribute to the fascination with using glass in architecture. Glass is made from solid opaque components yet can be transparent. It is formed from a liquid state but remains solid and brittle. It is an excellent electrical insulator but capable of transmitting electric current that can change its characteristics at a turn of a switch. While glass progressively softens as temperature rises, going through different phases of malleability, it can also be tough enough to be used in the heat shields of spacecraft. It is, however, the ambiguous interrelation with light that gives this material its mystery and its beauty. Glass used to be perceived in Europe's Middle Ages as a magic material through which light can pass without breaking it. Glass allows light to penetrate it but can also reflect light. It advances certain light waves while preventing others. With little modification of its form, glass can magically magnify objects or break the neutrality of light into its colourful components. With the aid of light, glass can obscure or reveal, distort or deceive almost instantly. The illusive nature of the material has not only captured the imagination of architects and artists, but also of writers, movie producers and directors, and has even been the precursor of religious tales.

The glass industry thrives in stable environments. Chapter 1 reviews the history of glassworking and shows how the glass industry flourished with trade across the harmonious material culture of the eastern Mediterranean. The turmoil of the third century AD led to a sharp decline in glassmaking, although the industry was kept alive through a strong protection of the trade by the glassmakers. The secrecy of its technological knowledge was kept by kings and monasteries and added to the mystery of this wonderful material. Gothic architecture exposed stained glass to the masses, with its glorious colours and immaculate manufacturing of windows. Liberalization and democratization of glass was therefore inevitable and took place during the seventeenth, eighteenth and nineteenth centuries, culminating in the great European exhibitions. The search for a liberal new Europe after World War I led to the adoption of glass for using daylight to illuminate the insides of buildings. Clarity and transparency were the new adopted values. The modern movement built on these ideals and the rise of glass façades appears to be unstoppable. The expansion of using glass in architecture was not, however, without setbacks. The calls for moral responsibilities towards the environment in the late twentieth century highlighted the disadvantages of glass façades.

Chapter 2 looks at the history of the troubled relationship between glass façades and the environment. The discussion inevitably leads to the investigation of concepts such as beauty, *techne*, ethics and aesthetics. Contemporary architects attempt to reconcile the relationship between glass and the natural environment by addressing all these concepts. Lessons learnt from vernacular architecture are used to go back to the real meaning of *techne*, where integral design of both aesthetics and building systems work in serving the users and reflecting their cultures.

The question of cultural identity is addressed in Chapter 3, which explores the relationship between personal and community identities and the role of glass façades in providing meaningful places in the built environment. As glass is the first building material to suffer from any disturbance in a built environment, it is necessary to examine the impact of glass façades in tensioned societies.

Chapter 4 investigates the tools for cultural representation in architecture. While glass reflects transparent and democratic ideology, it can also represent the economic might and the architecture of power. All these ambiguities of using glass façades on a macro scale invite us to learn more about how glass appearance can be transformed, not only by manipulation of light reflection and transmittance but also by varieties of applied films, coating materials and electric currents.

Chapter 5 reviews the various available types of glazing and their possible use in different environments. The new inventions in the glass industry in the last few decades have resulted in vast advances in new technologies and new types of glazing. Glass has become one of the most commonly used materials on earth and glass façades have become synonymous with urban development in many parts of the world. A crystal ball might have been a tool for looking into the future. We are living more and more in a virtual environment. The boundaries between reality and virtuality are becoming more and more illusive. In the near future, our virtual life might exceed the time we spend in the real world. Our built environment, as discussed in the last chapter, will soon be able to catch up with the technology. Once again, cities will be seen as the virtual machines, with glass playing a major role, in deriving the new spirit of the age.

Acknowledgements

> As for those learned scribes who lived after the reign of the gods ... their names shall endure forever, though they are gone and all their relatives are forgotten. They did not make for themselves pyramids of copper ... they were unable to have heirs to pronounce their names, but they made heirs for themselves in the writings and teachings that they created.
>
> An Egyptian Papyrus

This book would not have materialised without the cultural milieu that others provide. I am indebted to my family, to friends, to students, and to colleagues. They have continued to support me and give advice and guidance. The work of others who share my admiration of glass and who are committed to the quality of architecture enriches the material of this book. Above all my sincere thanks to my wife Rebecca and my children Hannah and Omar who, in numerous weekends and holidays, waited for their Daddy to finish his work. I am also very grateful to my parents, particularly my father who gave me inspiration and set an example of commitment to professional and academic life. I pay tribute to the wider fraternity of professionals and colleagues who directly or indirectly have developed the focus of this book through many discussions and arguments particularly to John Wiltshire and Michael Wigginton. My thanks are extended to my colleagues in Plymouth, Newcastle and Belfast, and to my former Ph.D. students. Special thanks to Nawal Al Hosany who has kindly helped with organisation of materials, references and images.

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For permission to publish material that has enriched the substance of certain themes, special thanks are due to Sawsan Saridar who significantly contributed to some of the textual materials in Chapter 5, Richard Hanley, editor of Journal of Urban Technology, for his help, and Michael Wigginton for his support during my early years in Plymouth.

I would also like to thank Jim and Myrtle Harisson for reading and commenting on early drafts of this book.

The collective arguments that flow from time to time through the pages of this book have vindicated my own convictions regarding not only the future role of glass in architecture but also the impact of its existence in our built environment on our understanding of visual culture. I am looking forward to building on this work in order to help those who seek peace and harmony as well as function and beauty in our built environment.

Hisham Elkadi

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Chapter 1

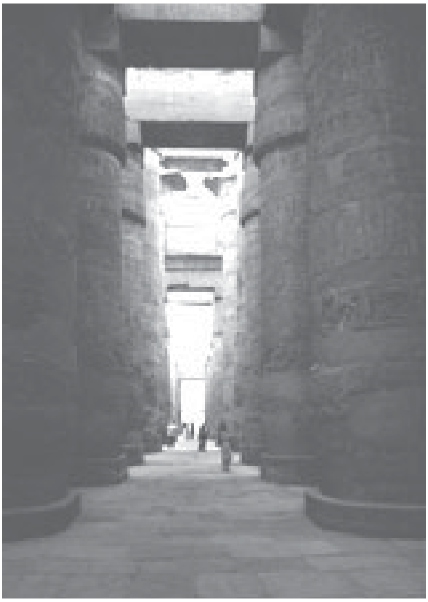
Glassworks: The History of Glass and its Architectural Identity

Introduction

Noever (1991: 8) argued that the Great Pyramid of Giza in Egypt (2723 BC) could be considered the ultimate expression of architecture because it manifests an idea in a functionally pure form (Figure 1.1). In the pyramid's case, a sandstone block provides an indication of the qualities of accuracy and geometric precision; it creates a form, serves a function and expresses an idea. The Pyramid of Cheops also has a definite identity with its place and its surroundings. These are the phenomena that give this piece of architecture its greatness. Both its unity with nature and the geometric precision of its cardinal axis help to create its uniqueness. The siting in relation to the Nile, the internal shafts meant to symbolize the passage of the soul to convene with the stars' eternal life, and the geometric reference to the life–death cycles of the east–west axis of the Nile are just three examples of the Great Pyramid's strong environmental links. What remains in our memories, however, is the strong visual representation of its façade. Façades, the architectural representations of cultures, are key ingredients in creating a visual identity of a place.

A façade is defined in the Oxford dictionary as 'the face of a building'. A

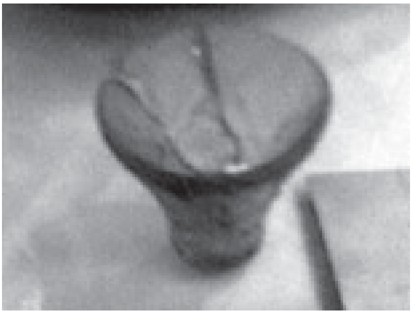
1.1 The Great Pyramid of Giza, Egypt (2723 BC)



1.2 A window in Karnak Temple, Luxor (1198 BC)

façade both obscures and protects a building's core. Openings and windows give a façade its distinctiveness. Windows preceded the development of glass by several centuries; they were part of the architectural aesthetics of buildings during the Fourth Dynasty in Egypt. An example can be seen in the openings in the pyramid of Dahshur (2723 BC). More elaborate windows were found in the temple of Ramses II in Medinet Habu (1198 BC) and in the Hypostyle Hall in Karnak (1198 BC) (Figure 1.2). These windows were used not only to provide lighting and ventilation but also as part of a deliberate playing with light and shadows to accentuate processions within the temples.

The Birth of Glass



1.3 Transparent goblets of crystal from Saqqara, Egypt (2000 BC)

From its discovery in the eastern Mediterranean in the middle of the thirteenth century BC, glass has basically been made of silicon dioxide (SiO_2 or silica), with soda added as a flux to facilitate the melting of the batch and lime as a stabilizer against the adverse effects of water. Unlike other materials which are formed through the melting of batches, glass retains the ambiguity of the random molecular structure of liquids rather than the crystallized structure of metals. It was not until the seventeenth century that the development of lead glass made a major step forward in the know-how of glassmaking. This invention was to enable the glazing of large windows (*de conjungendis et solidandis fenestris*), a technology that brought glass into the history of architecture. Examination of ancient pieces revealed that four main manufacturing methods were standard; rod and core forming, casting with open and closed moulds, free blowing, and blowing into moulds and forms. Colouring of glass, through the addition of metallic oxides, had already been perfected by ancient workers, most often using copper, manganese or cobalt.

The phenomenon of transparency has always captured the imagination of people. Sophisticated transparent goblets of rock crystal were found in Egypt as early as the First Dynasty in the tomb of Hamaka, Saqqara (Figure 1.3). Little is known about glassworking in its earliest period. The legend of the glass palace and Solomon's throne on reflective surfaces in the story of the Queen of Sheba is well known in the Jewish and Arabic traditions, but no evidence exists of whether the reflection quoted in the story was actually a result of a glass surface or of other crystalline rocks. The legend, however, is a further indication of early fascination with the phenomena of reflections and the transparency of materials, both of which capture human imagination. In the Bronze Age, the glass vessels of the prolific Egyptian industry are early examples that reflect sophistication. Factories located in Tel el Amarnah were productive well before 1450 BC. Some of the vessels found in the area have the cartouche of Thutmos III who ruled during that time. Other glass items were also found in other parts of the eastern Mediterranean including Syria, Cyprus and Southern Greece. While most of these products resemble Egyptian imports, there are many that reflect the uniqueness of their particular locales. It is believed that, because of the westward migration of some glass workers, glass artefacts started to appear in areas such as Yugoslavia and Southern Austria by the seventh century BC. By the fourth century BC, glass was widely manufactured in many parts of the eastern Mediterranean. Glass beads and glass vessels were also found in Iran, where a flourishing Persian glass industry produced cast and cut bowls in colourless or greenish glass. The Hellenistic period also witnessed surges in the glass industry in the major settlements around the eastern Mediterranean coast, including Alexandria, Sidon, and settlements on the Palestine and Syrian coasts, as well as in Greece and Italy. Alexander the Great founded the famous glassworks in Alexandria in 332 BC. Glass in this period represented an indication of the vast trade among different parts of the eastern Mediterranean and a proof of the flourishing common culture in this part of the world. Until this period, there is no evidence to suggest that glass was used in architecture and buildings. The mild climate of the eastern Mediterranean did not necessitate the use of material to protect the interiors either from excessive heat or extreme cold. Writers, however, hinted at the creation of artificial environments, but such environments (such as the gardens of Adonis) were limited to the protection of plants in the fifth century BC (Hix 1996).

At that time, glass was not thought to contribute to this idea of an artificial environment. Even during the first century, when practical measures were taken to create ‘greenhouses’ for plants, transparent stone (*lapis specularis* or mica) is thought to have been used. The discovery of how to blow glass in the first century BC was a major step forward. Wigginton (1996) considered this discovery to be the first important step in the development of glass in architecture. This major development probably took place in Sidon (Thorpe 1949). The trade was kept within Syrian families, who made use of the advantages of the Roman Empire to export their precious goods. The willingness of such families to migrate enabled the establishment of their industrial enclaves in many cities around the Mediterranean. One of the reasons for the scant documentation and description of glass technology at its early production was the strong protection by the producers and traders of their know-how. Later in Venice, protection was at royal and aristocratic level: the licence to allow a glassmaker to work on some important project abroad was often an item negotiated by a king himself.

Glass Cultures in the Eastern Mediterranean

The harmonious material culture continued in the eastern Mediterranean during the Roman period. The stability and the extent of the Empire encouraged the flourishing of arts and crafts and extended the glass industry's scale and horizon: Charleston referred to this period as a new age for glass (Charleston 1984: 22). The mould-blowing technique appeared in 25 AD and led to large-scale production of affordable glass vessels, and, by the mid-century, glass became a common material for tableware, beads and other uses. The phenomenon and the novelty of transparency were introduced to the common citizens of the Empire in 40 AD, with the manufacturing of colourless glass. In this period, glass was introduced to architecture. The first windowpanes were mounted in wooden or metal frames during the Augustan Age. They were used, for example, to glaze windows or screens at the Atreum Vestae, the sacred building of the six Vestal Virgins. The development of new building typology such as baths (with their need to retain heat) had also necessitated the use of glass during this time. Wigginton (1999) indicates that glass windows with pieces as large as 1 metre × 700 mm have been found in one of the baths in Pompeii. Other uses of glass were mainly in residential settings, especially in Pompeii and Herculaneum.

Coloured glass was also used for decoration in buildings on walls, floors and ceilings, both in private and public buildings. An early example from a Coptic Egypt setting is the upper part of a mosaic wall that has cut pieces of coloured glass with Christian motifs. This technique was mastered and used to embellish architecture during the Byzantine period. Small glass pieces for mosaic (tesserae) continued to be made in Rome and Alexandria to decorate walls, ceilings and floors in Byzantine churches. The second and third centuries AD witnessed a variety of experimentation and the production of different types of glass, including white opaque glass, the ornamentation of vessels and deliberately coloured glass pieces.

The turmoil and difficulties that faced the Romans in the third century AD affected the glass industry in two ways and (surprisingly) contributed positively to the use of glass in architecture. Firstly, the social transformation and the acceptance of Christianity as the imperial religion led to a dramatic shift towards simplification in the decoration of daily-use glass vessels and more focus on religious buildings. Secondly, the relative disintegration of the Empire led to an increase in the disparate regional and local styles of design.

The fall of the Roman Empire led to distinct glass practices in the north and south of Europe. Glassworks in Germany continued under the rule of the Franks. The most famous contribution was the development of the claw decoration technique, which was added to the already-developed cone beakers and drinking horns. While the Christian Church prohibited the use of glass chalices in AD 803, manufacturing of glass continued for day-to-day vessels. Development of techniques was, however, confined to architectural use. During this period, glassmakers were confined to monasteries, the new centres of wealth in northern Europe, and were encouraged to produce stained glass for the windows of their abbeys. Several monasteries' records from the ninth and tenth century refer to a 'Fra Vitrearius', who would be in charge of the monastery's glass. France was the main centre of production and there was a French connection with the monastic foundations at Monkwearmouth and Jarrow in Northumbria in the north-east of England. Excavations at Jarrow have yielded much information about the use of glass at this period (Figure 1.4). French glassmakers set up glasshouses in Northumbria in AD 676. The abbot of Jarrow continued, however, to ask for help with glassmaking from other sources – one was Archbishop Lullus of Mainz in the Rhineland (AD 758).

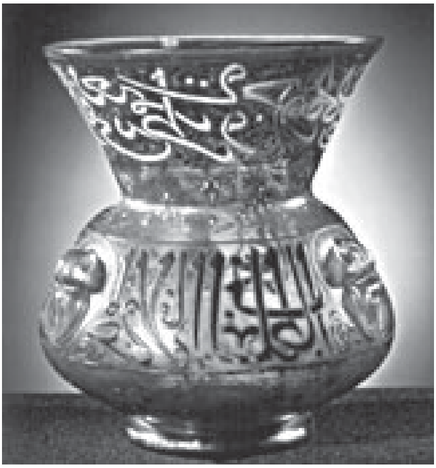
1.4 Excavations at Jarrow, Tyne and Wear (AD 676)

Further south, in Spain in the same period, the glass industry flourished in the advanced Moorish-Islamic culture. The technique of lustre painting, using metals dissolved in acid which were painted on cold glass and then fired, was developed in Egypt in the early Islamic period and became widespread in Spain. The most detailed description of glassmaking of this period was documented by Presbyter Theophilus around AD 1000. Theophilus wrote extensively on the making of glass in his time in his comprehensive technological manual entitled *Diversarum Artium Schedula*, which was first published by Leiste in 1781. According to Bontemps, who translated this treatise around 1843, Theophilus was a diligent German monk who, in his manuals, describes details of a set of state-of-the-art glass technologies or manufacturing processes. Bontemps' translation has not only provided us with the technical manual but has also given us an insight into the cultural aspects of glassmaking during this period. Theophilus' book, combined with a careful study of what is left of the great stained-glass windows in the European cathedrals, can help us in describing the state of the art of glass technology between the years 1100 and 1250 AD (Hawthorne and Smith 1979). Describing Theophilus' work environment, George Bontemps wrote of the monk:

> … after the matins and lauds and before going to his glassmaking workshop to produce, for the Glory of the Lord, for the wealth of the Monastery, for his Brothers in Christ and for the Holy Services, [he made] beautiful and delicate chalices with marvellous colours, often obtained by sheer chance, thanks to the alchemy and secret recipes of the ancient masters (Matteoli 1999).

In the fourth century, glass in architecture flourished in religious buildings in Rome. A good example is Constantine's Church of St Paul, built in AD 337, where coloured glass was used. The combination of strong Mediterranean sun and the coloured glass prompted the creation of a wonderful display of biblical stories within the churches. The experience of moving from the opaque exteriors and sunny Mediterranean streets to dark interiors with such colourful and richly informative windows must have been quite an experience in the fourth century. At this time, fine glassworks were also founded further north in Cologne, Germany. It is believed that migrants from Venice and the eastern Mediterranean had established themselves in Cologne, where they continued their trade during this period. It was there in Germany that the word *glesum*, meaning ‘transparent’, was first used, from which the word ‘glass’ came. The following 200 years saw a decline in glassmaking north of the Alps, while traditional locations of the industry (such as Palestine and Syria) continued to flourish, producing more highly distinctive and elegant pieces such as the collared flasks and decorated lamps being manufactured in Fayoum, Egypt.

The political unrest in Europe during the tenth century prevented further development of glassmaking. Centres of glassworks in Byzantine Europe continued to exist in Belgorod (near Kiev) and Corinth, established by Greeks emigrating from Egypt. Spain was, however, an exception: glassworks flourished, since imports from the eastern Mediterranean and Egypt provided both style and knowledge of technology after the Muslim invasion in the eighth century. Soon, local glass-blowers established themselves in Andalusia. Although the glass industry was stagnant until the thirteenth century, architectural glass largely improved with the adoption of the industry by the monasteries. The cylinder method of making glass for windows was in operation in the main centres of production in Burgundy, Lorraine and the Rhineland, and exported to other European countries, in particular to England. The cylinder technique enabled the production of relatively large flat glass panes. Church buildings were the first to be glazed. The techniques for making stained-glass windows for cathedrals and churches were also well established in Europe by the twelfth century. Good examples of this period include Augsburg Cathedral in AD 1065 and St. Denis (Paris) in the twelfth century. Stained-glass windows were also used in churches in the Central Balkans: a good example is the window in the dome of the Church of the Blessed Virgin in Serbia (AD 1190). During the twelfth century, glass techniques continued to be developed in Aleppo and Armenaz (Syria), as well as Al Fustat (Egypt) under the Mamluk rule. Despite such flourishing in production and trade, the use of glass in architecture was limited to lamps and other interior items. Glass windows were rarely used. Lamps for mosques were particularly popular in both Syria and Egypt during the twelfth century (Figure 1.5). An early use of glass windows was reported in the Ahmed Bin Toloun mosque (AD 868) and in houses such as the Palace of Bashtak in Cairo in 1334. The Mongol invasion of Persia and the Near East at the beginning of the fifteenth century brought a halt to the glass industry in Syria.



1.5 An example of an enamelled glass mosque lamp (*c*. 1250)

Glass in Gothic Architecture

The Gothic style of architecture of the thirteenth century liberated walls from merely supporting the weight of the structure; instead they could be pierced to provide light to the formerly deep dark interiors. The walls of churches and cathedrals became narrators of biblical and local cultures. The development of stained-glass techniques has added another cultural dimension to the architecture of this period. Artists used thin layers of colour over a thicker layer of a clear glass. This technique led to a widespread use of leaded windows to demonstrate biblical and local stories. Other techniques such as 'grisaille' (clear glass panes painted with brownish-black enamels) were also used during this period. The architecture of cathedrals and churches reflected the cultural identities of local communities: their walls not only provided informative displays but also demonstrated local values as well as religious ones. Among the most celebrated examples of stained glass are the rose windows of Chartres (1194–1220), Notre Dame (1163–1250), Antwerp (1352) (Figure 1.6) and Canterbury (1175–84) Cathedrals, and the nave at St Denis (1231). The 'Five Sisters' at York Minister (1154–81) is an early example of stained glass in England.

1.6 Glass window, Antwerp Cathedral (1352)

The fall of the eastern Mediterranean glass industry in the early fifteenth century enabled the rise and dominance of glassworks in Venice in the fifteenth and sixteenth centuries. Many new glass technologies and arts were developed in Venice, such as crystalo, filigree glass, millefiori and calcedonio glass. Such advanced technology does not seem to find its way to the window glass industry. Glassmaking was later established in Antwerp, on which source the English glass industry relied. The glass technology in Antwerp at that time was well presented in its Town Hall (Figure 1.7). The façade shows large windows set in stone frames. It is to be noted that during this period most of the glass

1.7 Town Hall, Antwerp (Cornelis Floris, 1566)

windows in England were imported, mainly from Lorraine. It was not until 1572 that glassworking was revived in England by Jean Carré.

Another important development in the sixteenth century was the creation of botanic gardens in Europe. While collections of exotic plants were known in Europe, particularly in Venice and Salerno in the previous century, it was not until the sixteenth century that such collections received methodological protection through the development of botanic gardens, which were established in European universities such as Padua (1533), Pisa (1544), Bologna (1568), Leipzig (1580), Leyden (1587) and Paris (1597). While these wintering sheds were mostly made of masonry and wooden frames, the need for more control of environment and light led to advances in the use of glasshouses.

The seventeenth century witnessed an extensive use of glass in Europe. The political and philosophical environment of the seventeenth century (see Chapter 2) led to the abandonment of stained glass and more use of clear glass. The age of enlightenment and rationalism favoured clarity and quantity of light in architecture rather than the aura of mysticism introduced by stained glass, although wealthy bourgeois societies in Europe continued to value the latter. Remaining examples of seventeenth-century glass include the work of the Swiss artist Hieronymus Vischer and Richard Greenbury in Oxford under Royalist rule. The architecture of this century was also marked by ornamentation in the interior that requires maximum daylight through clear glass to depict the rich decoration. This can be seen in the work of Bernini and Wren.

The Democratization of Using Glass in Architecture

The seventeenth century was, however, marked by the democratization of the use of glass, with its use reaching different classes of societies. The relation between culture and environment also affected the details of the making of the window in Europe. The increasing appetite for light, using more uninterrupted sheets of glass, was restricted by the need to open the windows for ventilation. Though the extent of glass surfaces increased in the seventeenth and the beginning of the eighteenth century, the size of structures remained the same. During this period, the building of orangeries flourished throughout Europe. Olivier de Serres (the skilful French gardener from whose name the French word for glasshouses, *serres*, derives) described the Heidelberg garden designed by De Caus in 1620, with its openable skylights and removable glass walls. The first orangery in France was designed by Louis Le Veau in 1664, followed by another in Versailles by Jules Mansart in 1685. In England, John Gibson's 1691 book, *A Short Account of Several Gardens near London*, described several orangeries and greenhouses. The description of Brompton Park greenhouses in 1704 revealed the use of fronts of greenhouses that were all made of glass. It was in Holland that the greatest development of glasshouses from primitive winter sheds was apparent. Between 1700 and 1730, glass forcing frames surrounded the Leyden garden. Hix (1996) described this garden as an environmental machine at the end of the seventeenth century, when glasshouses were competing with the masonry-walled orangeries. The quest for light at this time also led to the innovation of sloping the glass to catch more sun. The large improvement in the glass industry during this period facilitated the shift towards glasshouses, and by the early eighteenth century, innovative glasshouses mainly included a large-scale south-facing glass façade. Plans of the Apothecaries' Garden at Chelsea in 1751 shows a large house with wings on both sides with glass roofs sloped at 45º. Glasshouses of this period were not only confined to nurturing plants but were also used as cultural spaces. Orangeries were used as seminar rooms and conference halls, as in the case of Leyden University. Louis XIV of France also laid out a ritual path for visitors which included the orangery. A network across Europe was soon established to exchange technical knowledge of glasshouses.

It was not until the further development of the cylinder method of glass production during the nineteenth century that it became possible to produce large uninterrupted sheets of glass. In England, the British industrialist Lucas Chance started sheet glass production in 1830. George Bontemps, who translated Theophilus' work and supplemented it with data and information drawing on his personal competence, was the French glass expert who advised Chance during this period. The new production methods coincided with an increased interest in glass buildings. A combination of interest in science, fascination with exotic plants and the beginnings of world travel meant that individuals and institutions were collecting animals, insects and plants from hotter and more humid environments, and this led to the enormous expansion of greenhouses in Europe. The new fashion brought together people from different classes of society, such as gardeners and aristocrats, scientists and men of rank and influence. This liberal attitude was also represented in liberated ideas as well as open spaces behind the glass façade. Gottfried Semper, who became part of the Crystal Palace circle in 1849, developed his theory of *Die vier Elemente der Baukunst*. In a fundamental break with the Vitruvian triad, *utilitas*, *firmitas* and *venustas*, Semper developed his four elements of architecture based on study of a Caribbean hut he saw in the Crystal Palace (Frampton 2002). An *enclosing membrane* was the fourth principle after a *hearth*, an *earthwork* and a *framework*. There was emphasis on the role of new materials in a building's envelope. Semper was, however, limited by his emphasis on historical references and symbolic conservation. In promoting the ethnographic origins of the manufacturing procedures by which the materials are made, rather than their specific nature, he marginalized the role of new 'processed' materials. It was left to his followers, in particular Otto Wagner, to pursue the technical and tectonic interpretation of Semper's theory and confirm the role of glass as the key material in an enclosing membrane.

The use of greenhouses expanded dramatically in the nineteenth century with the development of great exhibitions such as the Jardin des Plantes (1833) and the Palais de Machines (1889) in France, the Crystal Palace (1852) in England and the Munich Glass Palace (1834) in Germany. New structures also included grand private conservatories such as Syon House, Middlesex, designed by Charles Fowler in 1827, and the grand conservatory at Alton Towers, Staffordshire, by Robert Abraham in 1827. The rise of interest in greenhouses led to mass marketing (and even an advertising campaign in 1876), in parallel with the development of the iron industry in the late nineteenth century. The new iron and glass age also generated its own architecture out of the zeitgeist. New types of buildings were created and allowed for the design of large spaces to accommodate the masses in new liberated and well-lit spaces such as exhibition halls, railway stations and other public buildings. Glass emphasized the monumentality of these buildings and provided a unique identity and quality to these places. A new spirit in architecture was created.

Glass in the Modern Movement

1.8 Postsparkasse, Vienna (Otto Wagner, 1926)

After World War I, Europe was looking for a new beginning, not only in terms of new styles in architecture but also of new social settings, new ideas, new ideals – '*L'espirit nouveau*'. In Austria, the work of Otto Wagner is linked to the beginning of modernization as it coincides with the period of artistic renewal between 1890 and 1900. Wagner (1841–1918) proposed a novel architectural concept that took into account the cutting edge of technology and went beyond the mainstream styles of history. He was a co-founder of the Vienna Secession (1897–1917), an association formed by artists to break with academic art conventions. During this period, Wagner dominated the architecture scene in Vienna, pushing the transition from neo-Renaissance eclecticism towards the more rigorous but ornamental forms of Art Nouveau. His buildings were rimmed with steel, covered with ceramics and embellished with copper ornaments. While the Postparkasse (Figure 1.8) is Wagner's most famous building, his style is clearly demonstrated in many villas and town houses. The Ankerhaus (1893–95) is an early example of his work. The building shows the light metal structure and the extent of glass usage in the terraces of the ground floor and the mezzanine, in contrast to the heavy stone façade above. The best use of glass is, however, reserved for the covering of the main hall in the Postsparkasse, where Wagner used a system of construction that would allow narrow columns and tie beams of fluted metal to combine to create a thin curved layer of steel and glass. This innovative method allowed light to fill the main hall of the post office. The extensive use of glass in the lower parts of buildings was continued by Wagner's followers, Adolf Loos and Josef Hoffmann. Examples of their work include Loos Haus, built in 1912, and the Hoffmann House (1930–32).

The Italian futurists also spread the idea in the early twentieth century. A manifesto for the new modern city appeared in *Le Figaro* in 1909. Its author, Fillipo Marrinetti, called for complete detachment from the past, with total destruction of all 'old' libraries, galleries and palaces. Antonio Sant' Elia adopted these ideas in 1914 in his vision for the Citta Nuova, where gigantic machines, like buildings, are made of iron and glass. The term *L'espirit nouveau* was again used, this time for the name of the magazine in which Le Corbusier wrote his series of articles advocating his version of modern architecture. Le Corbusier (see Figure 1.9) was able to capture the imagination of architects in this period and crystallize idealistic entities as the 'new spirit'. Corbusier's City of Tomorrow provided more aesthetic analogies to Sant' Elia's Citta Nuova. Glass was again the tool in this description. Corbusier described his skyscrapers that 'raise immense geometrical façades all of glass, and in term reflected the blue glory of the sky ... immense but radiant prisms' (Le Corbusier 1987: 178). Europe was searching for a mechanism to achieve this new spirit after the failure of the social structure during the war years. Slogans of 'machinery' started to be echoed everywhere. Van Doesburg in 1931 even claimed that the machine was the creator of a new spirituality. This ideology continued to inspire modern architects such as Leo in the twentieth century (see Figure 1.10). Jencks (1997) explained that it was a combination of the need of machine efficiency and a fresh spirit and clarity in this new Europe that led on to the International style (Figures 1.11 and 1.12). In the same era, the technique of heat-strengthening glass was introduced. However, it was not until 1928 that glass was developed to be the material that is in use at present (Wigginton 1996). This provided the basis for all

1.9 Unite d'Habitation, Berlin (Le Corbusier, 1952)

1.10 DLGR, Berlin (Ludwig Leo, 1971)

1.11 Barcelona Pavilion, Spain (Mies van der Rohe, 1929)

1.12 Fagus building, Germany (Walter Gropius, 1928)

the developments in structural glazing which took place after World War II. High-quality glass, the product of new technologies, became a key material in the development of simple, modern and *good* architecture (Figure 1.13).

Glass architecture was poised to move into a new and larger role. The development of the curtain wall in the 1950s and 1960s dictated a different image from that of pre-war architecture. This was a result of the congruence of interest between commercial developers and commercial curtain wall installation contractors. The universal objective of these developers was the construction of buildings which maximized rental return against capital outlay. The brief for these buildings, a new typology (namely office buildings), was simple and straightforward. The production of maximum office floor area, flexibility for office use, greater window area and lowest possible cost were the main keywords. The rationalization of mechanical systems made interior planning more regimented and systematic. The distinctions between types of commercial buildings could be read only in the aesthetic interpretation of the façade, not in the articulation of plan and section. In his argument

1.13 Private house in Berlin (Wassili and Hans Luckhardt, 1928)

towards the importance of façades, Scruton (2002: 57) explained that the human world is governed by the principle of 'the priority of appearance'. The 'face' for a building seems therefore necessary to carry out the gestural messages in the urban environment. In this sense, the modern movement has abolished, largely through the use of repeated elements of glass panes, the very concept of the 'face' in building. Unlike many other materials, glass panes cannot be marked by life. Glass does not soften with age nor can we observe the movement of time through it. There was no more reference to orders; no biblical or local stories for visual consumption as in the Romanesque and Gothic periods; no relation to wealth of the sixteenth and early seventeenth centuries as at Hardwick Hall; no reference to the imperialism and collected natural treasures of the seventeenth- and eighteenth-century glasshouses; and no scientific evidence of development and excellence as in the great exhibition buildings of the nineteenth century.

Glass and the Rise of Green Architecture

The extensive use of glass with the rise of the modern movement in the mid-twentieth century has suffered a backlash in the second half of the century with the evolution of the world's environmental agenda in the 1960s. The environmental debate of the 1960s, while not having a direct impact on the construction industry, challenged the use of certain construction materials and techniques. A shift of ideological stands started to emerge among architects. Fully glazed façades started to be challenged, not on an aesthetic or social basis, but for environmental reasons. In the 1970s, major changes in the construction industry occurred as a result of the oil crisis in 1973. The crisis had accelerated the re-thinking of the extravagant use of natural resources, particularly energy, in the construction industry. Green architecture ideology emerged, questioning the morality of extensive use of glass, which at that time entailed expensive bills for heating and air-conditioning. The Green shift in architecture was expressed in low technological solutions. In this sense, Green architecture detached itself from the generally left-wing policies of Green parties and Green thinking, which advocated technical solutions as well as conservation policies. Glass architecture had fallen, therefore, out of the Green architecture agenda. Green architecture, with its flower-power analogy, has not lasted. In the 1970s, Green architecture basically referred to maintaining natural resources (Coomer and Howe 1979). In the early 1980s, sustainable development aimed to achieve lasting satisfaction of human needs and improvement of the quality of human life on one hand (Allen 1980) and maintenance of essential ecological processes and life-support systems on the other (IUCN *et al*. 1980). In the late 1980s, the approaches to sustainability emphasized social and economic aspects, which require elimination of poverty and deprivation, as well as the conservation and enhancement of the resources base. This was followed by the most common definition of sustainable development by the World Commission on Environment and Development (Brundtland 1987): 'the ability of humanity to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs'. The publication of the Brundtland report in 1987 has pushed the sustainability agenda, which has become the major motivation and the buzzword in the construction industry. Following the Earth Summit in the United Nations Conference on Environment and Development (UNCED) in Rio in 1992, 'sustainable development' has become the internationally accepted keyword for a political discourse committed to life, the conservation of natural resources and a sense of obligation to future generations. Sustainable development definitions have been broadened to include the ability of a society, ecosystem or other ongoing system to continue functioning into the indefinite future, without being forced into decline through exhaustion or overloading of the key resources on which that system depends (Haviland 1994).

The widely accepted definition of 'sustainable development' forced major re-definition of Green architecture. Despite the importance of architecture to the overall success of sustainable development, there is still no agreement on a definition that is applicable to architecture. Hagan (2001) described how the term 'sustainable architecture' has led to confusion and was open to contradictory interpretations. There was a widespread belief among architects that the UNCED definition, for example, does not specify the ethical roles of humans for their everlasting existence on the planet (Kim and Rigden 1998). The term 'sustainable architecture', used only to describe the movement associated with 'Green architecture' and passive means for environmentally conscious architectural design, has created ambivalence and confusion (Kremers 1995). Emphasis has shifted, therefore, in the 1990s towards more technical issues such as reducing energy consumption in the design, construction and maintenance of buildings. Glass façade technologies re-appeared as major tools in tackling environmental issues and energy efficiency models.

Very little attention was, however, paid to the social and economic aspects. Despite the wide acceptance of the UNCED's definition, 'sustainable development' also remains controversial because of the cultural differences and North–South divide (Strong 1990, Saunier 1999). Saunier identified four different movements of sustainable development: human development, nature conservation, natural resources management and environmental protection. There are, however, several pending issues related to the interests of different human groups. This includes the viewing of sustainable development as a process of reconciliation of human groups separated from one another by the different and conflicting demands they make on their shared surroundings. The disarray of sustainable development approaches in architecture is evident. The attempts to include ethical dimensions as well as technical dimensions are seen as contradictory to the profession of architecture itself (Levin 1995). This is despite the fact that human groups accept such values when they have conflicting demands on their shared surroundings. When human groups do not even have a shared context, conciliation for sustainable development becomes even more difficult. No material expresses such dilemma more than glass. The ambiguous role of glass throughout history has been a reflection of its own illusive nature. Glass has expressed its ‘art form’ as a wonderful material for the arts and has vastly improved its ‘core form’,[1] its static and mechanical functions. Contemporary architecture has, however, failed to provide glass with a cultural identity. The modern movement did not succeed in providing a third way capable of engendering a new cultural entity; a new style that reflected the principles of theorists such as Viollet-le-Duc. The essential role of new materials in realizing architecture and the true meaning of the word *techne* will be examined in Chapter 2.

1 The terms *kernform* and *kunstform* were first used by Botticher in 1844 to explain the two natures of construction (in Hermann 1984: 141).

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Chapter 2

Green Glass: Environmental Perspectives on Using Glass in Architecture

Glass Façades and the Environment: An Awkward History

The basic human need for protection from natural forces has been the main driver of the development of façade design. Since ancient times, the interrelationships between architecture and nature have always been debatable. As much as it was technologically feasible, early architecture did not develop physical barriers between man-made structures and their immediate contexts unless it was essential. Traditionally, local environmental factors influenced the shaping of building faces and restricted the role of the building envelope to mere functionality; that is, to secure and protect the indoor environment and its occupants. These local environmental factors were not limited to climatic ones as claimed by some (such as Lechner 1991) but also extended to include local materials and the relevant available construction technologies.

Stein and Reynolds (2000) identified two opposing concepts of design in traditional building envelopes; the open frame and the closed shell. The latter concept is mainly used in harsh environments where environmental conditions can be undesirable, especially if the climatic conditions are severe or where unwanted external influences such as noise or intrusive activities abound. Stein and Reynolds called this approach *barrier-dominated*, as building envelopes in this case act as shelters. In this typology, windows are no more than carefully selected punched holes, to make very limited contact with the outdoor environment. The open frame, on the other hand, is usually employed when external conditions are very close to the desired internal ones. An open structural frame provides the layout, with pieces of building envelope selectively added to modify only a few outdoor forces. The building envelope in this case acts more like a connector with the external environment. In contrast to the barrier-dominated approach, where no (or only minimal) contact between the external and the internal environments is required, the *connector-dominated* approach allows direct contact between the two environments. Glass technology is changing this rigid categorization, as transparency and protection are no longer at opposite ends of the scale.

Architects have always aimed to create alternative and hierarchical levels of interfaces with nature. This is evident through history, all the way from the work of Vitruvius to the neo-modernist architects who are pushing to new heights the potential of the modern school's principle of unimpeded flow of internal and external space.

It is within the principles of modernism (noble materials, technological advances, as well as the merging of indoor and outdoor spaces) that the extensive use of glass in architecture has mushroomed. Neo-modernists are still following this path but with more concern for environmental impact than their predecessors. There are, however, some contemporary voices that still claim the superiority of architecture over nature. In a recent publication, Julie Eizenberg, for example, highlighted the controlling aesthetics of modernism and its emphasis on indoor–outdoor connections; she continues to claim that architecture can 'give more value to outside space' (Richardson 2005).

2.1 An exaggerated example of the architectural concept of ascending to heaven: Hatchepsut Temple, Egypt (1520 BC)

Let us first examine the ambiguous relationships between building façades and nature throughout history. Vitruvius described this integrative relationship of façades with nature in the primitive hut analogy (Vitruvius 1960: 38), where metaphoric as well as physical processions between the insides and outsides of buildings were visible and instantaneous. This principle was not, of course, unique to primitive huts in earlier times. Throughout history, several design techniques were applied to link nature to structures. In the Pharaohs' temples, the ascending paths of earthly floors and the descending heavenly ceiling met in the sacred chamber. This architecture analogy is very well rooted in ancient Egyptian beliefs and culture. A series of gates and façades, rather than internal walls, provides a variety of thresholds within the temples leading towards the ultimate re-union of earth and heaven within a man-made structure (Figure 2.1). While the Pharaohs carefully considered and respected thresholds between earth and heaven, they never doubted the complete fusion of the two worlds. Their architecture reflected this religious and philosophical belief. Each façade in each building has a particular identity that is visibly demonstrated by a combination of hieroglyphics and graphical representations. Unfortunately, this was also used as a socially exclusive device. Façades were designed within the buildings as well as around the temple complex. Movements between the open courts and closed rooms in public spaces were, however, often mixed and well integrated.

Aristotle also examined the relation between nature and structures where nature represents an analogy. For Aristotle every part in the building composition (as in nature) is important to the whole in function as well as in composition. Unlike the Pharaohs who regarded façades as merely gateways or thresholds, a building façade for Aristotle became an integral part in the natural order. Beauty at that time was considered as synonymous with natural order. The understandings of early Greek philosophers were enhanced in the Renaissance period in Alberti's treatise *On The Art of Building*. Alberti, Palladio and other fifteenth- and sixteenth-century Italian architects based their elaborate systems of proportion on Pythagorean conceptions of musical harmony known to them through Plato's *Timaeus* and Ficino's commentary on the *Timaeus* (El-Hassan and Elkadi 2004). Alberti (1404–72) considered beauty to be 'a harmony of all the parts, in whatever subject it appears, fitted together with such proportion and connection that nothing could be added, diminished or altered but for the worse' (in Capon 1999: 8). Alberti found beauty in a kind of numerology that is derived from the observation of nature. Palladio also referred to beauty as a 'result from the beautiful form and from the correspondence of the whole to the parts, of the parts amongst themselves, and of these again to the whole' (in Landow 1994).

Followers of the Arcadian approach have since nurtured this direct link with nature, which values architecture that only follows natural laws and the unaltered characteristics of natural materials. Architects who promote this approach cannot, therefore, tolerate extensive use of glass in architecture because of its unnatural characteristics, its man-made nature, its smoothness, precision, and transparency. Stained glass continued, however, to be used during this period for its abilities to create a romantic aura within buildings and increase imagination.

With the era of enlightenment in the seventeenth century, nature ceased to be a model of cultural production in every sphere of human knowledge. Beauty was divorced from the study of morals and made into a separate discipline, 'the subject of aesthetics'. The disengagement of beauty from the divine orders in the age of enlightenment has liberated the arts and provided us with more exciting and energetic varieties that still explore the meanings and qualities of beauty. Neo-classicism, empiricism and rationalism replaced the Renaissance emphasis on the imagination, on invention and experimentation, and on mysticism. The enlightenment theorists put emphasis on order and reason, on restraint, on common sense, and on political, economic and philosophical conservatism. Gould (1998) defines such empirical beauty as rational and profane. Pruitt (1994) argues that beauty was firmly entrenched in neo-classicism and geometry, in probability and good taste and proportion. That was a Newtonian universe where all ran smoothly and dictatorially. Clear glass replaced the stained coloured glass. There was more need for daylighting to enhance the elaborate interior decorations. Clear glass was used to *enhance the beauty* of other elements rather than being a *beautiful* material itself. There was a large development of using glass in conservatories and glasshouses as confidence was built up for more interaction with nature, rather than just observing it. For the first time, there were attempts to modify and control climatic conditions by using large panes of glass. Theories were developed and conservatories were built to test those theories. The Palm House at Becton Park Gardens in Devon (Figure 2.2), for example, was erected to apply Loudon's theories of curvilinear hot houses in about

2.2 The Palm House, Bicton Park Gardens, Devon, UK (Loudon and Bailey, *c*. 1820)

1820[1] (Hix 1996: 40). The architecture of the bourgeoisie remained, however, in opposition to this development with its emphasis on decorated façades, and their architects continued to be inspired by the static balance of natural compositions. The nature of both the construction materials and the intellectual perception of space was not developed far enough to explore the rational of the dynamic and fluid characteristics of nature.

The Industrial Revolution and the extensive use of glass façades in exhibitions and other building types of the nineteenth century highlight the discussion among environmentalists on the role of aesthetics in architecture and whether beauty, for example, is an excess requirement. The environmental debate on the ethics of using glass varied widely between traditionalists like Ruskin, who rejected outright the extensive use of glass, and modernists like Viollet-le-Duc, who viewed iron and glass as the new-generation materials that would develop a suitable *future* architecture dress that (at the end) would provide a more efficient and modern discipline. The former spoke of beauty as both quality and feeling and considered glass as unnatural and environmentally harmful as it used large amounts of energy for its processes and for the operation of buildings. The latter shows the intention to separate culture from people and relate it to nature. Many architects who followed this 'future ideal' regarded beauty either as unacceptable excess (in contradiction to Ruskin who promoted the necessity of aesthetics in architecture) or in more rational terms. Viollet-le-Duc (1814–79) proposed the view that the beauty of a Gothic cathedral lay in the fact that its buttresses and vaulting clearly expressed a structural purpose (Capon 1999: 113). The word *aesthetic* was thus introduced by the German philosopher Baumgarten, as a reaction to the rational philosophy of Descartes and the mechanistic science of Newton. Baumgarten contended that it is a mistake to exclude sensations and perceptions from knowledge, and that those sensations and perceptions provide a conception of reality equally valid as Cartesian logic (Leath 1996). The philosophical debate of the nineteenth century did not lead to any conclusion on whether glass façades fall by default into the environmentalists' preference of pure function, regardless of their presumably faceless and culturally inept architecture, or whether they provide architecture that is sustainable both environmentally and aesthetically.

The Industrial Revolution, however, laid the basis for architecture that became obsessed with the potential of structural technology and industrial achievements (Kurtich and Eakin 1993). It was in this era of scientific discoveries and technological innovation that the erection of the three-dimensional impression seemed to entirely vanish, to be substituted by the interest in two-dimensional design (Zuker 1959). In this environment, Lucas Chance in 1830 produced large sheets of glass using for the first time in England the cylinder method of glass production. The invention of production methods for large sheets of glass, and subsequently its use

1 Richard Buckminster Fuller's scheme for a two-mile-diameter 'tensegrity dome' over Manhattan in the 1950s echoed Loudon's nineteenth-century vision of London's gardens covered with glass.

in architecture, marks one of the most important moments in the development of building façades, since glass thus provided architects with power to challenge and manipulate environmental forces. The need to create enclosure for shelter, protection and privacy did not conflict with the needs to transmit light, to provide illumination deep into the structure or to open up the envelope for views to the outside. The flatness of the century was reinforced by superficial use of iron and glass as building materials. Building façades were thus losing the inherited role of the light, which in antiquity had revealed the surface's plasticity or tactility. The emerging attitude had led to scenes of spatial impression. Public spaces were merely treated as lots of displays and places of utility accommodating the services across the urban core (Madanipour 2003). The two-dimension representation in architecture was used to accommodate and display nature in the form of exotic plants and animals rather than to interact with nature to reveal its own features. The role of windows, for example, to frame the natural beauty was still a well-accepted approach in architecture. This view has not changed since pre-Raphaelite Europe, when the architecture of the time emphasized the framing of natural beauty through windows.

Ethics and Aesthetics of the Twentieth Century

The twentieth-century ethos was to emphasize the relation of beauty to form, function, truth, will, context and meaning. For instance, Adelberto Libera related beauty to form. Quinlan Terry attached it to symmetry. Otto Wagner derived it from the adaptation to function. El Lissitsky associated it with politics, and Wright attached it to materials and the sympathetic coordination with nature, ground and the purpose of city and town (El-Hassan and Elkadi 2004). The improvement in glass technologies in the twentieth century has dramatically extended the power of architecture over nature and enabled architects to marginalize the role of environmental forces in determining the configuration of façades. The façade's role shifted from being a shield from, or interaction with, natural forces, to being a manipulator of those forces. The *glass culture* in architecture also marked a beginning of an era, a new social dimension to architecture. The essence of this new philosophy was set out clearly by Paul Scheerbart in 1914:

> We live for the most part in closed rooms. These form the environment from which our culture grows. Our culture is to a certain extent the product of our architecture. If we want our culture to rise to a higher level, we are obliged, for better or worse, to change our architecture. And this only becomes possible if we take away the closed character from the rooms in which we live. We can only do that by introducing glass in architecture.

He goes on to emphasize the relationship between architecture and culture by saying: 'the new environment, which we thus create, must bring us a new culture' (in Wigginton 1996: 52–3). Scheerbart, who inspired a new generation of European architects, believed that glass, particularly the coloured type, destroys hate, endures and brings a new era (Hix 1996: 217). Wright, Bruno Taut (1880–1938) and Le

Corbusier related beauty to purpose, function and utility. Wright saw beauty as 'integral … the form itself in orderly relationship with purpose and function'. Taut perhaps expressed the view most clearly when he wrote 'beauty originates from the direct relationship between building and purpose … everything that functions well looks well' (Capon 1999b: 46).

2.3 The Dominion Towers, Toronto (Mies van der Rohe, 1967)

The development of glass, iron and steel facilitated the implementation of such new architectural thinking. Entirely glazed façades sealed the mechanically controlled indoor environment. The building façade became an anonymous 'curtain wall' with surface continuity (Figure 2.3). The sealed envelopes with their rationalization of mechanical systems led to more regimented and systematic interiors. With the increasing demand for active control of the internal environment, the role of façades shifted away from just shielding inhabitants from the exterior environment. Building envelopes were expected to be waterproof and water-vapour-resistant, to provide thermal comfort and good interior light and air qualities, and to control the transmission of ambient noise and the fragile human 'comfort zone' inside. The façade's new function was to be an 'environmental modifier' – a function that was clearly predicted in Scheerbart's writings in 1914 where he suggested the applications of several glass skins to control thermal transmittance. Scheerbart also predicted the terracing solution in skyscrapers to allow in light.

In the mid-twentieth century, environmentally conscious researchers provided extensive studies of the thermal performance of windows and highlighted the role of the adjacent features and shading devices (Olgyay and Olgyay 1957; Olgyay 1963; Givoni 1998). Glass technology and glass treatments were at that time in their infancy and architectural trends of using, in most cases, single glass panes, continued. Such development led to a vast increase in the consumption of the world's energy resources. The 1973 energy crisis was the determining factor in the existence of this design movement. The notion of 'totally' sealed façades failed aesthetically and functionally. Their energy consumption was huge, and their occupants were not happy. Syndromes such as 'sick building syndrome' emerged and occupants requested more contact with the external environment and more control over their indoor environment. A new solution was required and hence a new attitude in façade design emerged. The energy and environmental crisis placed architects and engineers in a critical situation. The ancient conflict between natural forces and indoor comfort surfaced again, with calls to minimize the use of glass areas to reduce energy consumption. However, most architects and engineers were reluctant to abandon glass. Instead of giving up on glass, the construction industry came up with more efficient solutions, with glass material at the centre of this development. In 1981 Davis and Rogers described what was perceived then as a radical new proposal for the way to design building façades.

> We need to develop a new integrated window wall, where all these elements are one, where multiple performance is integrated in one single element. What is needed is an environmental diode, a progressive thermal and spectral switching device, a dynamic interactive multi-capability processor acting as a building skin … This environmental diode, a polyvalent wall as the envelope of a building, will remove the distinction between solid and transparent, as it will be capable of replacing both conditions and will dynamically regulate energy flow in either direction depending upon external and internal conditions, monitor and control light levels and constant ratios as necessary at all points in the envelope. The wall would be capable of energy transfer along its surface adding to or removing energy from building zones which are too hot or cold, trading energy surplus for energy need (Davies and Rogers 1981: 56).

The presented concept of Davies and Rogers has been labelled an 'intelligent façade' and became widely implemented. Hence, the building envelope is no longer perceived as a two-dimensional exterior surface; it becomes a 'transition space'. New agendas emerged in built environment research, motivated by enhanced information technology in the 1980s, a paradigm shift. Energy conservation was no longer the main priority. Energy efficiency had become the keyword. Rather than cutting back, the goal was to maintain the expected levels of service, for example, in terms of comfort or lighting, but to do so using more efficient systems and technologies. Global warming and the need to reduce carbon dioxide emissions, in the 1990s, promoted a new round of technical and scientific activities. Although the potential for nemesis in energy use and resources depletion was brought to light very clearly in 1972 in the Club of Rome's Report (Meadows 1972), sustainable development as a concept in the built environment did not flourish until the early 1990s. Building envelopes, mostly glazed, have turned into experimental grounds for the development of technical fixes that integrate different sustainability and energy efficiency measures.

Despite all the research and development, the urban environment with its complex matrix of buildings, activities, services, and transportation still consumes 75 per cent of the world's energy resources and produces the vast bulk of its pollution and climate-changing gases. Decisions made by architects have been more and more recognized to be crucial to the achievement of a sustainable future (Edwards 1999). Of greenhouse gas emissions, 40 to 50 per cent are produced by the built environment; 40 per cent of the total energy consumed in Europe is building-related and envelopes can be responsible for as much as 20 per cent of this total consumption (Elkadi 2000). Architects have finally come to terms with their crucial moral as well as ethical responsibilities towards the environment. Deterministic views of historicism on the understanding of beauty is, however, still rife. Vatimmo (1988) finds the past and memories the only way to define a criterion for the notion of 'beautiful'. Such a view still undermines, and provides grounds for the rejection of, extensive use of glass in architecture. As many contemporary arts stand outside a conservative definition of beauty, many of the new exciting environmental approaches in architecture stand outside the realm of the traditional understanding of 'vernacular architecture'.

Glass Façades in Contemporary Environmental Approaches

Contemporary architects, while mostly agreeing on the ethics of environmental design, vary in their assessment of the level of sustainability in their projects. In the 1980s, it was relatively easy not only to visualize the architects' environmental commitments in the design of façades but also to relate their designs to a range of environmental approaches from this period. It was possible, for example, to differentiate between those with a 'vernacular' agenda, such as the Vales who pursue an 'ecological' approach, those who seek 'technological' solutions such as Hopkins, or those who emphasize the importance of 'symbiotic' design such as Emilio Ambasz. Most of this earlier and rather simple categorization of environmental approaches has a direct relation to façade design in general and to the extent of glass usage and properties in particular. The plurality of environmental approaches currently employed in new buildings demonstrates the evolution of environmental design towards more complex and multi-faceted approaches, with socio-economic and political sustainability dimensions as well as ethical and resource-driven ones. The introduction of such new approaches, combined with vast technological advances in glass properties, has liberated glass from its condemned environmental status in the late nineteenth and early twentieth centuries. Neo-modernists have emerged to humanize modernism with their emphasis on environmental research and investigation, such as Pugh & Scarpa, Genik and Eizenberg (Richardson 2005). Extensive use of glass in a building façade is no more a reflection of the lack of commitment of the architect towards sustainable development. In many cases, a glass façade has been used to demonstrate intelligent, and not necessarily just technical, ways of optimizing resources and achieving ambitious sustainable building performance. The introduction and the continued evolution of what is referred to as 'intelligent' façades is one example.

The world 'intelligent' relates to the procession of intellectual faculties which provide a capacity for understanding. The term was first used to describe buildings at the beginning of the 1980s. The American term 'smart' has also been used to imply the same kind of abilities in materials, structures and buildings. The word 'intelligent' has been associated with building façades, and indicates the dynamic, almost living, capability of a façade to adapt to changing daily or seasonal conditions in order to achieve a reduction in the building's consumption of primary energy. According to Compagno (1999), the 'intelligent' expression with respect to façade indicates an ability to respond to changing environmental conditions, according to the time of day or year, in such a way as to reduce primary energy needs for heating, cooling and lighting, and thus make a contribution to environmental conservation. Wigginton and Harris (2002) expanded on Compagno's responsive active role of the intelligent façade to include the nature of its materials. They defined (*ibid*.: 44) the intelligent skin as 'an active manipulator of the external elements and responsive to internal conditions, with the ability to adjust itself automatically to provide optimum comfort by self-regulated amendments to the building fabric'. It is assumed that this is achieved with the minimum use of energy, and minimal reliance upon imports. The intelligent building fabric becomes a flexible, adaptive and dynamic membrane, rather than a statically inert envelope. Information is gathered through different sensors, and performance of façades is accordingly modified. Glass, with its advanced technology, including use of films, sensors, photovoltaic cells and other fixtures, was placed in the core of this vision. This was evident in Wigginton's earlier book on glass. In his *Glass in Architecture*, Wigginton (1996) set up rather deterministic criteria to achieve a 'smart', 'intelligent' or 'thinking' envelope. The selection of appropriate multi-state materials, which can perform in accordance with the needs both of the building as a whole and of its localized parts, was one of these criteria. The other items include a computer system and a control system that predict, analyse and respond, as well as a neural system, all of which feel and communicate and also think themselves. The centre role of glass in Wigginton's criteria is clearly defined and remained a major key material in the features that he later identified, with others, to distinguish an intelligent skin. In a survey that covered 22 case studies, Wigginton and Harris (2002) identified 12 different features that can determine the level of intelligence of a building and distinguish it from others. These features are:

- building management systems
- learning ability
- environmental data
- responsive artificial lighting
- daylight controllers
- sun controllers
- occupant control
- electricity generators
- ventilation controllers
- heating and ventilation controllers
- cooling devices
- double skin.

Compagno also highlighted the role of glass in achieving responsive façade design. He explained that an appropriate façade design for a building can be reached by using a combination of many criteria. The first main criterion is the number of glazed skins, single or multiple, incorporated in the façade design. Such emphasis on glazing requires accurate and well-measured design of shading devices. Compagno's second criterion is therefore the positioning of the solar control devices. A building façade is described, for example, as a single-skin façade with exterior or interior shading, or with integrated shading devices incorporated in the cavity between the panes.

Skelly was less industrious in his approach as he recognized the limitations of active control measures. Skelly (2000) identified the many variables to which an intelligent façade should respond. He divided these variables into three categories: weather, context and occupants. The dynamic nature of weather with its hourly differences would require a responsive envelope. While not referring to glass *per se*, there are very few alternatives to its capabilities of optical and thermal transformation. Skelly's other categories, context and occupants, followed the long tradition in environmental design of a passive view that focuses on differences in the microclimate between different sites and how obstructions imposed on one façade can be dramatically different from those imposed on another. Similarly, Skelly echoed the concerns about the occupants' role with emphasis on the differences of needs and preferences, depending on experience and various other psychological factors (Skelly 2000).

The Emergence of a Responsive Glass Façade

The liberation of environmental design from the confinement of both the vernacular and the resource-led technical approaches is now taking place. Glass, the *unnatural* material, is accepted as a key component in the sustainable development of façades and in improving the ecological performance of buildings. The understanding of nature as an interrelated complex network is nowadays mirrored in the environmental studies of glass façades. Stein and Reynolds (2000) extended the restricted description of the building envelope as being a set of two-dimensional exterior surfaces. More and more, façades are seen as an interface zone or a theatrical zone in which several natural players interact and influence each other. The authors compared a building façade to a transitional space, 'a theatre where the interaction between outdoor forces and indoor conditions can be experienced'. This transitional space is a place where people indoors experience something of what the outdoors is like at that moment, as well as where people outside get a glimpse of the functions within. The more suited the outdoors is to comfort, the more easily indoor activity can move into this transition space. The authors added that the building envelope has a fourth dimension, in that it changes with time. Seasonal changes have a marked effect on the transition space, and consequently have an effect on the environmental aspects of the indoor spaces. Glass permits the visibility of staging such dynamic performance and *beauty* is a possible product of a managed and well-executed performance. The display of the *physical* nature in this interplay will lead to and influence the transformation of the *cultural* construct of our built environment. The emerging new environmentally responsive glass façade is one in which the visible and invisible, nature and culture, chora[2] and form, female and male, natural and man-made, and

2 A chaotic mix of perceptions, feelings and needs.

design and technology come together in this theatrical zone of a building face. It is this merge between opposites that characterizes the development of an environmentally responsive architecture design, where design and technology are truly merged. In this sense, we are back to the true meanings of *techne* as described by Protagoras, meaning the complexity of craft, art or science. In other words, *techne* can be, with this description, a synonym for culture. Nussbaum explained the qualitative and plural nature of *techne* and described how the arts activities themselves constitute the end (Nessbaum 1989: 99). The technical qualities of glass façades, with their universality, precision, learnability and explanatory characteristics, should be considered means of achieving the aesthetic qualities of glass façades; neutrality, purity, dynamicity and transparency. The modern movement has only emphasized the measurable side of technology, following the Socratic interpretation. Exploitation of nature was therefore permitted and the negative environmental performance of early glass façades was accepted as a means to an efficient rather than true *techne* cultural end. The modern movement should not reflect the success or the failure of glass façades. The supremacy of man over nature as envisaged by Sant' Elia or Le Corbusier, for example, is not an acceptable model for the future. It is disheartening, therefore, to see some world politicians and decision makers still prepared to embrace such a narrow definition of technology with a belief of its triumph over nature. Technology should not be considered a solution but rather an instrument for reaching a more plural and complex cultural and sustainable end. Norberg-Schulz (1980) emphasized that consciousness of our urban environment must be viewed as being formed by nature. The aesthetics and technology of glass façades are increasingly merging to construct a more responsible step forward in the relationship between nature and architecture.

The Future of a Transparent Skin

The new cultural construct of the building façade has also been influenced by the 'organic analogy' of nature. Steadman explained 'organic analogy' in terms of metaphorical comparison of works of art with the phenomena of nature (Steadman 1975: 7). The simple metaphorical comparison of the skeleton with the supporting structural frame in a building takes on yet another dimension in contemporary façade design. A building skin is not just a reference to the anatomical analogy but also to the visual representation of its cultural aspects. Design, colour and materiality are important ingredients of the reference and metaphoric use of a *building's skin*. Ted Kruger (1994) described architecture as 'our collective epidermises' and buildings as 'our second skin'. Powler and Kelbaugh (1990) compared the envelope of a building with the skin of the human body, the 'building skin' being called upon to perform a multitude of simultaneous functions in a relatively thin dimension. These functions can be either to control heat transmission from the interior of the building or to present an aesthetic position. Powler and Kelbaugh (1990) have therefore expanded the role of building façade to 'communicate important cultural and social information such as sense of grandeur and permanence'. Harris, Elkadi and Wigginton (1998) have also emphasized the close relationships between buildings and epidermis, applying the biological metaphor of the human skin to achieve human comfort with particular reference to its abilities to learn and adapt – what they refer to as 'intelligent skin'. The technical emphasis of the analogy meant that almost all building examples picked by followers of this approach have glass façades. Glass is seen as the main ingredient of such intelligent systems. Alternatively, Tombazis (1996: 51) adopted a more ecological vision and explained that 'the more the design of buildings becomes bioclimatically conscious, the more the behaviour of these buildings tends to become skin-dominated'. The author continues by comparing the multi-layered building skin to the different layers of the skin of animals or human beings, which can serve more than one purpose at the same time, such as shading, movement of air, filtering of light, regulating the inner temperature, etc.

Designing and constructing a complex façade system that mimics skin should not be the aim of developing a sustainable architecture. Here, we need to differentiate between the natural products and the natural processes. The former would follow the organic approach in the work of, say, Eisemann and Ghuery, while the latter would emphasize the importance of simulating the natural processes and creating complex systems that can learn, grow, adapt and evolve. Calatrava demonstrates the difference, denying the following of the anatomical analogy of the animal skeleton while confirming his interest on how the structural forces work. Architects, therefore, should have the knowledge of how nature processes energy in order to optimize the façade design, to sacrifice the initial high investment of energy, the embedded energy, in order to build a more efficient and sustainable complex system. In other words, they must use entropy, as described by McHarg (1971: 53), to create more ordered and more complex processes that, in the end, minimize the use of operational energy (Elkadi 2000). One of the difficulties that limit the transformation in the design of contemporary façades is the emphasis on the static nature of products rather than the dynamic qualities of processes. A new technology of biomimesis that would produce artificial smart skins might indeed provide fundamental changes to the design of façades. However, what is more important is for architects themselves to create an architecture design that can dynamically interact with such systems. Otherwise, the revolution in envelope design might be just another cosmetic add-on in the façade construction industry. Hagan described the glass buildings of Mies van der Rohe (such as Lake Shore Drive Towers and the Seagram building) as being 'abstract, technologically driven and hyper-rational' (Hagan 2001: 60). Hagan expanded to derive a wider criticism of the modern movement, quoting comments by Le Corbusier and Gropius on the industrial nature of their architecture and their failure to reconcile with nature. It is difficult to see how contemporary Echo-Tech architects who heavily use glass in their architecture, such as Foster and Rodgers, can be spared from the same criticism. Rodgers, for example, relies on the advances in communication technology and automated industry (on the one hand) and increased ecological awareness (on the other) to derive novel solutions. The two sides of this equation are still not reconciled in his architecture. While the earlier is well mastered, the latter is only used for winning the political argument. There is still emphasis among architects of the Echo-Tech movement on natural products rather than ecological processes. But they need to understand the ecological processes that glass façades are capable of simulating, rather than just the industrial advances in the design and manufacturing of glass. Ecology and technology should be regarded as one, as described in the true definition of *techne*. There are still major deficiencies in the understanding of ecological processes and systems among architects. Responsive and responsible façades should also not be regressive. They can adopt the most advanced science and theories that imitate ecological processes and demonstrate cultural relevance. Such façades should detach themselves from consumerism and the ever-growing emphasis on fashion. In this sense, new developments in life cycle analysis and whole life costing become an essential integral part of the design of façades. As a result, glass as a façade material should be put under scrutiny, not only to test the sustainability of its initial energy investment or its immediate optical and thermal performance, but also to find the extent of its ability to simulate local ecological processes in order to justify the cultural 'morality' for using it extensively in building façades. Hagan (2001: 89) explained the dilemma that faces architects in considering what could be truly deemed a sustainable material. While, for example, vernacular architecture with natural low-tech technology consumes less energy, it requires more energy for its operation and maintenance. More energy-expensive advanced materials, as in the case of glass, can do more than pay back their environmental costs. Photovoltaic glass, for example, needs large energy investment in its production but will have minimum operational energy during its life and can itself produce clean energy. If properly designed, it can also export clean energy into the energy grid network. New accounting methods such as whole life costing and building life cycle, while useful, are not quite comprehensive and cannot lead to definite conclusions in justifying what can be considered a sustainable material. In fact, the use of the term 'sustainable material' is not useful at all. Processes in which 'a material' performs can decide whether such material is used responsibly or not. In this sense, we should also not divorce the passive ventilation, daylighting, heating and cooling techniques of traditional architecture from the more active means. In fact, it is our understanding of the natural ventilation and cooling techniques in the Austrian boxed windows (Figure 2.4) or the cooling techniques in Cairo houses of the eighteenth century (Figure 2.5) that have led to the development of what we now refer to as intelligent façades.

2.4 A traditional boxed window with several glass panes, Vienna

2.5 Mashrabeyah, Beit El Sehemi, Cairo (1796)

While there is a general agreement among architects to regard natural processes as models rather than imitating its products, there is no particular paradigm in architecture for doing so. Research in architecture continues to reside at the pre-paradigm stage. We need to look elsewhere, in other disciplines, to understand how natural processes rather than products can be understood. Van der Ryn identified four principles that explain the natural integral energy processes (Van der Ryn 1981). Recent glass technology seems to develop some of the features of those ecological principles. Van der Ryn explained how integral systems process energy through closed loops of multiple channels. It is only recently that the performance of façades has been seen within an ecological perspective. The identification of façades as theatrical zones allows the possible roles of different parts to be connected. Nowadays, we expect a responsive façade, besides its usual traditional functions, to optimize thermal performance, act as an effective filter of noise and pollution, maximize daylighting penetration, store meteorological and behavioural data, and in many cases produce energy through embedded solar cells. We also expect most of, if not all, these functions to be integrated. Currently, many of the façade subsystems remain isolated from each other. A disruption in one system (airflow mechanism in a double skin façade, for example) will not necessarily be compensated through another subsystem. With the increasing sophistication of building management systems combined with technical advances in glass façades, more and more systems can be integrated. An example can be seen in the field of HVAC[3] or solar energy production.

Van der Ryn described how the integral natural systems release energy in the system in small increments. The maximum power principles explained by Odum (1981) state that the system that gets the most energy and uses it most effectively survives in competition with other systems. In this sense, there is a need to design façades that will not just utilize minimum resources but, more importantly, reduce energy output. Advanced forms of glass might need large investments in energy for their production, but a properly designed façade would utilize their characteristics and improve the thermal performance of a building as a whole during its life cycle.

Integral natural systems also maintain a steady state through negative feedback and permeable boundaries. The thermal performance of a double skin provides a good example. A sealed double skin heats up the trapped air and can be used for heating the adjacent spaces in winter. During the summer, the allowed airflow from air inlets at the bottom of the façade flow upwards with the stack effect, sucking out hot air from the adjacent rooms and cooling them. This simple description of the dynamic thermal performance of a glazed double skin explains how the third principle can be applied in the case of building façades. The double-glazed skin has permeable boundaries with both the outside and the inside of a building. The skin, in this case, acts as a moderator of temperature in an attempt to maintain a steady state within the structure.

3 Heating, ventilating and air conditioning.

The fourth principle states that integral natural systems store information in a decentralized genetic memory. Van der Ryn (1981) used the jargon of electronics and circuit design to explain the relationship between pattern and information. He defined information as the pattern that organizes form; and the pattern, when transmitted, is information. Within an ecosystem, evolutionary information is contained in the DNA of energy cells, which is the code that determines the form and organization of the organism. The recent glazed façade technology with learning capabilities seems to be a step towards implementing this principle. A diversity of sensors and diodes allows the façade to store meteorological data, patterns of users' behaviour and other information in order to optimize its own performance. The next generation of glass façades should certainly benefit from the continuous observation of many façade performances in different parts of the world.

Glass had very shaky beginnings, in almost confrontational relationships with nature. Rejection of fully glazed façades by environmentalists and architects can not be accepted outright anymore. A deep understanding of aesthetics and beauty as well as of environmental principles reveals that glass façades can actually improve the environmental performance of the built environment. The negative view of an unnatural, energy-intensive and technologically driven glass façade is increasingly isolated. There are still, however, some concerns for environmental performance of glass in certain contexts; and improvements in the areas of thermal and light reflections and fire resistance, as well as new concepts of controls, need attention. Major criticism of glass façades is related to social and cultural dimensions rather than technical performance. The next chapter will discuss the question of identity and of how glass façades relate to the cultural profiles of its context.

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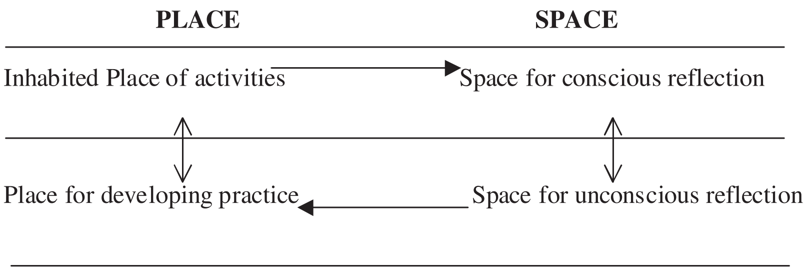
Chapter 3

Glazed Spaces: Constructing Place Identity

Glass, Place and Identity

The abstract and flat representation of public places at the end of the nineteenth century had gradually alienated large parts of the public from positive engagement with their urban environment. Contextually responsive surroundings as a source of delight were not valued and were sacrificed for more 'efficient' and industrially driven aesthetics. Glass as a façade material started to influence the reconstruction of the public place in the Western world. For centuries, tactile façades had given stability to city dwellers and conveyed desirable meaning to visitors but views were changing and the continuation of cultural identities was being questioned. It is difficult to examine the impact of the introduction of large glass façades on place making in the twentieth century without exploring the ambiguous relationship between place and identity. The relationship between cultural identity and place identity has always been seen in historical and visually identified cultural gestures. 'We would like to know not only where we are but also when we are and how now relates to time past and to come. Space and time together are two of the major dimensions within which we live' (Yuen 2003: 6). Lang (1987) also explained the urban experience in terms of sense of history and permanence. Through living in a historical town a person's sense of pride was also indicated by association, according to Lalli (1992), while Twigger-Ross and Uzzel (1996) linked the harmonious symbolic and physical qualities of the place with the inhabitants' values, suggesting that their positive self-esteem was enhanced by their visitors' positive feedback. Within the environmental psychological literatures the *place identifications* and the *place identity* have been elaborated; that is, the linking of place to individual identity (Twigger-Ross and Uzzel 1996). The relation between place and individual identities had been influenced by a number of authors such as Proshansky. Proshansky *et al*. (1983) proposed a new construct that compared place identity to social identity. Referring to the multitude of rules that shape the built environment's properties, Proshansky defined place identity as 'a substructure of self-identity that consists of … cognitions about the physical world in which the individual lives' (*ibid*.: 59). Building on empirical work, Korpela (1989) also conceived that place identity is part of the individual's ongoing processes of emotion and self-regulation that may involve their sense of self. A feeling of isolation, due to the personally uncontrollable changes in the physical environment, would lead to loss of reaction and discontinuity of involvement with the surrounding context. Similarly, there is a consensus that the contemporary phenomenon of *placelessness* or *rootlessness* results in negative consequences. In a place with no identified memory, such as a new locale or a landscape, a neutral environment can also create this feeling of placelessness. This was also confirmed by Relph's (1976) conclusion that the making of standardized landscape or placelessness produces a prospect in which loss of places simply do not matter. How then can a newly constructed glass façade influence either a new or heritage place? Would a glass façade be automatically associated with the former? Will it necessarily deconstruct the latter, the heritage place? What would be the role of glass in neutralizing a multi-cultural context? Would that necessarily be a positive development? Should architects encourage the development of multi-cultural contexts? It would be rather difficult to attempt to find answers to all these questions prior to fully understanding the concept of place. It is therefore necessary to debate the basis of developing meaningful place as it has a direct influence on people's identity and well-being.

Meaningful place is defined in this chapter as the sphere where conscious reflection takes place. Such a sphere should aim to enhance local experience and make local visual information (represented by the surrounding façades) explicit and understood by inhabitants as well as other users. In order to position our intention, it is important to demonstrate the dynamic nature of space–place relations; a space configured by nature that accommodates and evokes feelings and a place designed to accommodate certain human activities. There are continuous changes in architectural experience of *place* where practices are situated and *space* where local experience takes place (Figure 3.1). Any intervention, through addition of a built form or a change in façade materials in a space, leads to a creation of a place that will be gradually inhabited and transformed. A deliberately erroneous intervention might lead to a loss and discontinuity of local identity and an alienation of local cultures. Once local experience is lost, the place is likely to be reshaped, reconfigured and neutralized by a more powerful economic pressure. Examples can be seen in many European towns where local characteristics were lost during the Second World War (for example, Plymouth, Warsaw or Berlin) only to be replaced by standardized urban environments. Violich (1995) developed ten properties of *identity with place* from extensive field research in urban places of various scales and forms. His aim was to



3.1 The dynamic cycle of architectural space and place formation

create an awareness of the role of identity with place for the twenty-first century, and he investigated the role of natural open space for its potential in allowing social and cultural enrichment and in reinforcing community life, the principal source of what he called an environmental spirit. Violich's properties were mainly related to spatial and aspatial arrangement of places rather than to the impact that building surfaces had on defining a meaningful place. A deeper understanding of the phenomenon of 'façade aesthetics' can guide architects and urban designers towards better place-making processes in the built environment. It may be true that one has to choose between ethics and aesthetics, as described in the previous chapter, but whichever one chooses, the two issues cannot be separated and one will lead to the other.

Façades and Place Identity

3.2 Ronchamps, France (Le Corbusier, 1955)

A façade both obscures and protects a building's core. Openings and windows give a façade its distinctiveness. The design of openings, and in particular glass windows that admit light to the interior of a dark space, gives a clear visual character to a building's face and this, in turn, helps the building to influence the characteristics of a place. Glass is one, if not the most, valuable invented façade material in architecture. It gives great power and freedom to architects and we saw in the previous chapter that its sensitive use led to powerful buildings that were in harmony with their environment. Ronchamps, for example, designed by Le Corbusier in 1955 (Figure 3.2), shows empathetic use of glass in rural France. Far from a standardized landscape, the simple rough masonry walls faced with white-sprayed concrete are dotted with small dark openings that do not overwhelm the hilltop where the church is located. In contrast, the small glass windows provide a feast of coloured light in the interior. Glass, however, continues to allow architects to challenge and ignore the environmental characteristics of a place. The European exhibitions, at the end of the nineteenth century, introduced iconic buildings (such as the Crystal Palace in London and the Palais de Machines in Paris) that use excessive amounts of glass. The form and materials of these buildings served the projection of cultural and economic wealth rather than serving and reflecting the identities of the users. However, these buildings presented only 'temporary dominance' over their environment and they did not last, despite their initial powerful presence. Similarly, in the twentieth century, the glass façades of skyscrapers could be seen as an extreme and literal use of

3.3 Glazed skyscrapers as symbols of economic power, Shanghai

architecture operating on a level beyond function. The extensive use of glass in most of these buildings, with its negative environmental impacts, cannot be justified on a functional level. Skyscrapers that use excessive amounts of glass are symbolic projections of a culture's power and dominance where sensitivity to the environmental forces are ignored or marginalized. It is interesting to note how Toronto's Dominion Towers, for example, were initially intended to represent the power of the Commonwealth through concrete buildings until Mies van der Rohe appeared on the scene to represent the same ideas with iron and glass (Figure 2.3). Pawley (1988) regards the new skyscrapers in the East, a completely different cultural context from the West, as symbols of a transfer of economic supremacy from the declining West to the rising East. The race to build the world's tallest buildings is currently between competitors in China, Malaysia and Dubai (Figure 3.3). The sudden appearance of skyscrapers in the skyline of many cities is usually a sign of the morphing of the identity of the urban landscape. The glazed façade of skyscrapers expands the dimensions of those cities beyond their traditional boundaries.

3.4 Large glass windows identify Gothic architecture, Hereford Cathedral (1250)

While skyscrapers with their glass façades are considered symbols of power (economical or political rather than social), they do not in themselves provide any particular identity and bond with the places in which they are constructed. The hierarchy of spatial scale, for example, that creates a broader and more resourceful identity of place with a variety of visual experiences is rarely introduced in such development. Glass façades are usually identified with large spaces and rarely identified with intimate ones. Hierarchy in glass buildings can, however, be spatially achieved through manipulation of natural lighting. In the fourth century AD, glass in architecture flourished in Rome in religious buildings: we have already noted the example of Constantine's Church of St. Paul, built in AD 337. Gothic architecture, in the thirteenth and fourteenth centuries, liberated the walls to provide light to the deep dark interiors. The walls of churches and cathedrals became narrators of biblical and local cultures (Figure 3.4). This use of glass did not have any impact on the local identity of the places in which they were located because its impact could only be seen inside the cathedrals. The place identity was preserved and appropriate scale was used to provide adequate lighting to the interiors. The continuous change of lighting levels that accompany movement between spaces played a role in turning Gothic cathedrals from *places for practising religious functions* into *spaces for conscious reflection* in terms of human participation. The continuous change in lighting levels also promotes an unconscious reflection on the meanings beyond religious beliefs, turning Gothic cathedrals into cultural symbols for the wider community. This cycle has resulted in *changes in practice* as many Gothic cathedrals have changed their main role in the contemporary societies. This hierarchy of light and space is completely lost in, for example, office buildings where no transition and no connection with the building take place.

As previously explained in the work of Proshansky and Twigger-Ross and Uzzel, one's roots are deepest where the most habitual and intimate experiences take place. These experiences allow either (a) identity and connectedness with the built environment or (b) alienation to emerge from within us. Building façades of the place therefore contribute to the connection or alienation of users. An enriching sense of belonging and well-being could be cultivated in urban areas through familiarity with the surrounding façades. In a location of strong cultural built heritage, where building façades reflect the cultural and historic profile of a particular context, new fully glazed façades cannot be anything else except alien surfaces and could cause interruption and confusion to the users' visual experience. This view can explain the tension between the adoption of glass ideals of the modern movement among certain intellectual groups on one hand and the rejection of glass façades among the general public on the other. The sudden interruptions to place memories by the introduction of large-scale glass façades, despite the exciting ideology; fell foul of the public in most European contexts. It is only recently that appreciation of those ideas has started to gain momentum as architects begin to be more sensitive to contexts. The question remains of how to deal with similar contradictions when we are confronted with intervention, and increasingly controversial proposals, in cultural built heritage sites in many old cities. Many of the efforts that attempted to answer this question are made to enhance either the selection criteria or the system of value judgements. Others have tried to improve the decision-making process. The shift towards globalization of heritage in the latest UNESCO declaration on cultural diversity (2002) would take some of the crucial decisions away from the local population. Debates on identity in heritage policies have started to take precedence over the more deterministic economic models of the 1990s. In any case, introduction of glass in heritage sites still poses questions of perserving the integrity of old quarters in cities.

Apart from acting as neutral cultural surfaces in a specific cultural built heritage, glass façades tend to act as a dominant source of character for any urban context. It is difficult to think of subtle examples of glass façades that tend to create their own uniqueness rather than complement the uniqueness of a place. Glass façades reflect the signatures of the 'star quality' architects rather than the architecture of the ordinary described by Scruton (2002). Budd Schulberg defines 'star quality' as a mysterious amalgam of self-love, vivacity, style and sexual promise (in Rendell *et al*. 2000). Through repetition of elements on which windows are modelled, uniqueness becomes as economic and easy to achieve as repetition of a new, post-industrial paradigm (Slessor 2000). Glass façades can, however, be very useful in creating the new identities of new places. The Industrial Revolution, as explained in the previous chapter, gave rise to new types of building where liberal open spaces were formed. Glass played a major role in this era of enlightenment at the end of the nineteenth century. Railway stations, such as Barlow's 1865 St Pancras, Mead and White's 1905 Pennsylvania Station in New York and Stacchini's 1912 Art Nouveau Stazione Centrale in Milan (Figure 3.5), are good examples; and we have already noted the Crystal Palace in 1852 and Palais de Machines in 1889. Glass emphasized the monumentality of these buildings and provided unique identities and quality to these places. This quality is still being exploited now with new generations of office buildings and contemporary public places in many parts of the world. The regeneration of the Quayside in Newcastle upon Tyne is one good example. The Sage building by Foster has generated a very welcomed uniqueness to the development of the area. The Baltic and the excellent Wilkinson and Eyre Millennium Bridge have greatly contributed to the regeneration scheme, but Foster's building, whether we agree or not on its architectural appeal, also provides a dominant and exciting background to the Quayside development (Figure 3.6).

3.5 Stazione Centrale, Milan (Stacchini, 1912)

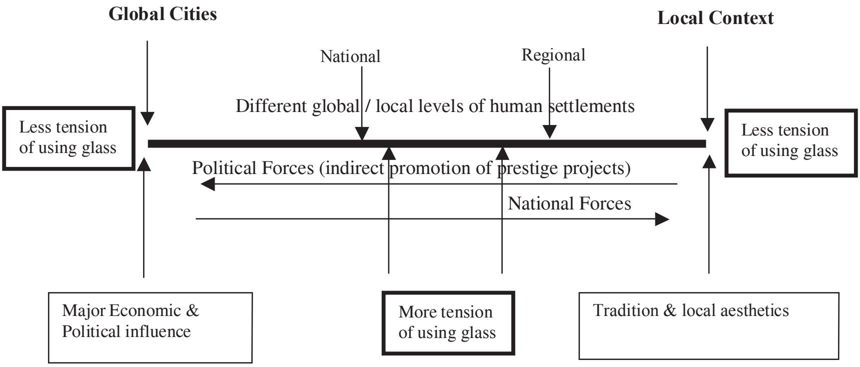
3.6 The development of Quayside, Gateshead–Newcastle (2004)

Violich (1996) emphasized the need to provide *common ground* for other identities for the making of a successful meaningful place. The physical built environment can provide a common platform for a shared identity and glass can play a positive role in this context. A glass façade has a neutral expression that can connect up a place's citizens from all cultural backgrounds into a healthy sense of belonging. It is to be noted here that architecture should not aim to reflect the heterogeneous make-up of our multi-cultural society. In fact this might lead to a loss of identity in specific locales, as previously identified in Chapter 2, as rooted in the environmental characteristics of the context. Glass façades should not be widely used to manifest multi-cultural identities but to act as neutral mediums, reflecting a variety of cultural expressions in order to enrich urban experience in a context to produce an overall unified cultural and environmental identity. Both inhabitants and frequent visitors may have tangible bonding with the place. This usually depends on their *experience and memory* of the spatial and aspatial elements of the place. Violich explained that the built environment could become a resource that brought people together into communities through a common commitment towards solving problems of the environment they share. Identity, in this sense, will evolve into a *collective expression* as individuals broaden their visual awareness and exchange with others their responses to visual experiences in their adopted place. It is not clear whether selection and details of façade materials have any impact on the visual culture and hence perception of different cultural groups in cities (Macphee 2002). It is unlikely that applications of glass façades would be any different from using any other construction material. Modernists, however, argue that the clarity of glass would be a reflection of a more cohesive community that interacts on clearer bases. There is also evidence from Northern Ireland, for example, that different socio-political groups have developed mental maps of towns and cities according to certain visual features and visual experiences of the surrounding built environment. Visual expression is anyway well understood in architecture. People have the ability to see beyond the form, shapes and measurements (Arnheim 1974). However, it is still not clear whether people can read what we earlier referred to as architectural gesture. People normally respond to an external façade in itself rather than thinking of it explicitly as a mere reflection of an architect's intention. People normally do not go beyond the appearance to think of the gestures, ideas or messages that a building façade might reveal. This might, however, not be applicable in a tensioned society. In situations where 'other' people are considered crucial or dangerous, individuals usually pay attention to the thoughts, feelings and gestures of those 'others'. Such weariness and alertness also apply to the relationship between people and their built environment.

In fact, glass façades are usually products of the pursuit of some sort of economic growth rather than cultural ones. Civic leaders often look to the 'big name' architects to install an instant element of prestige; provoking land value increases to attract inward investment (Hughes and Sadler 2000). The programme for the 'European Capital of Culture', which supposedly aimed to emphasize European and local culture(s) and enhance the dynamic of community-forming forces, led to the attraction of more international displays where glass usually plays a major role. The growing competitiveness of the cultural tourism market makes it difficult for the selected European cities to aim for the creation of meaningful local spaces. There is no clear evidence of whether the selected 'European Capitals of Culture' have formed community-led initiatives or have further alienated local cultures.

There is a distinction between identity of a place at a superficial level and at depth; this grows out of *sustained involvement of the users*. Glass buildings are usually public buildings with large turnovers of inhabitants and users. It is therefore difficult to identify the boundaries between the inside and the outside in glass buildings and they are sometimes criticized for being faceless and façade-less. It is in the façade that aesthetic effect is concentrated (Macphee 2002). Scruton (2002) claimed that Modernism abolished the very concept of the face in buildings and hence the building faces nothing, and smiles and nods at no one. In office buildings, for example, few users can become 'insiders' and develop a great degree of connectedness with the buildings that symbolize the firm for which they work. A large number of frequent users of more accessible public buildings, on the other hand, do develop a close sense of belonging with glass structure, where insiders and outsiders merge together and the feeling of belonging can be felt much more strongly than to opaque buildings.

As mentioned above, glass façades can provide a neutral setting to accommodate symbolic gestures for multi-cultural expressions and activities, thus providing a broader urban experience. In contrast to Violich's promotion of *dual and multiple identities* in contemporary places, this book argues against it. It is important to encourage dual and multiple cultural *expressions*, not *identities*, in common places. This is a clear benefit of using glass façades in our new common places – they present a terminus for a network of multiple cultural activities. Such common places are usually a result of strong economic pull. Nystrom and Fudge (1999) noted that the increasing de-differentiation of culture and economy aims to develop culture-led economic growth strategies. Figure 3.7 illustrates the different forces that affect the position of towns and cities on the local–global scale. At the global end of the scale, economic forces rule and glass façades are set to stage the multi-cultural expressions that reflect such forces.



3.7 The socio-political setting and global/local tension of using glass façades in place making

Getting to fully know a person is directly linked to creating a mental image of this person. This is only possible through accumulation of experiences with this person. Creating one clear mental image of a place is also a very good indicator of knowing place. This *one image of a place* is an amalgam of several mental images of different spatial and aspatial variables of the place, including time. It is this one image which gives a place its identity and implies its distinction from other places. Lynch (1960) identified identity within the realm of individuality and oneness. This one distinct image is composed of a well-fitted assembly of visual patterns, relevant associations and feelings, highlighted differences and unique qualities, together with history and substantive knowledge. Glass, with its transparency, has that quality in architecture which gives a building a probability of evoking a strong image, of what Lynch called *imageability*. Los Angeles is once again identified with a resurgence of modern buildings 70 years after Rudolph Schindler and Richard Neutra brought the international style from Vienna. The city has also witnessed a revival of restoration of modernist architecture such as Thornton Ladd's Hilltop and Neutra's Kaufmann House in Palm Springs. The new interest in Californian modernist houses is considered very 'hip', in sharp contrast to the destruction of Neutra's Maslon House in 2002. The new image attracts celebrities who are not only queuing to acquire and encompass the modernist ideals but also to engage with the design, such as Brad Pitt, a self-confessed architecture enthusiast (Richardson 2005). Away from iconic buildings, glass façades also contribute to the assembly and arrangement of visual patterns in urban settings through precision, transparency and reflective qualities, as well as highlighting the differences and unique qualities in a surrounding opaque context. While images of glass buildings might not be simply expressed as a face, the accumulation and the repetition of entities, as well as being intensely presented to the senses, do give a sense of one collective image, as is the case in Manhattan, Tokyo or Hong Kong. This probably explains Lynch's selection of part of Manhattan as an example of a highly imageable place (Lynch 1960). Unlike other opaque imageable places, such as Venice or Florence, glass façades have the advantage of providing images that are adaptable and changeable, images that can develop new groupings and new meanings as needs change.

The uncertainty of our rapid environmental change highlights the need to preserve places representative of the past as a part of today's urban fabric and daily life (Violich 1996). The *maintenance of the cultural built heritage* not only provides cultural continuity and hence stability, but also refers to successful environmental measures that have ensured the successful adaptation and performance of the building(s) in this particular place. Some of the contemporary glass façades provide a rather negative gesture in this sense. Glass is increasingly used to create buildings as abstract works of art that would upset Scheerbart's vision of an ideal glass future in architecture. Abel criticized the buildings of 'formal abstraction' as detrimental to the possibilities that advanced communication technologies offer for a cross-disciplinary approach to design (Abel 2000). Heritage of glass architecture is presented in greenhouses and grand private conservatories, such as Syon House, Middlesex (by Charles Fowler, 1827) and the Grand Conservatory at Alton Towers (by Robert Abraham, 1827) or the

Palm House at Bicton Park Gardens (see Figure 2.2), more than in any other glass building typologies. The heritage features of those buildings are not only limited to their imageability or the theoretical statements as those inspired by Loudon but also by their technical excellence. One of the most prominent examples of expressed structural ironwork in the nineteenth century is the Great Palm House at Schönbrunn Castle, Vienna (Figure 3.8). Franz von Sengenschmid designed the private conservatory, built in 1880, in collaboration with the structural engineer Sigmund Wagner. Once again, the separation between the walls and the façade of the building, as developed in the Gothic cathedrals, points to the partial autonomy of the façade as a symbol of cultural values (Leatherbarrow and Mostafavi 2002). The strong interaction between appropriate use of glass, climate, religion or culture and the public has given this type of architecture a special place in history, which remains a major architectural and cultural resource from which we can learn. Certain glass buildings have, on the other hand, developed glass walls rather than glass façades. The novelty of glass at that time, combined with technological advance, was the main driver towards the development of such buildings. Buildings such as Hardwick Hall (1590) and the extension of Hampton Court Palace (by Wren in 1689) do not entirely support the continuity of the culture and environmental identity of their places.

3.8 The Great Palm House, Schönbrunn Castle, Vienna (Franz von Sengenschmid, 1880)

A well-designed glass façade can provide a *spiritual link* between the man-made building's interior and nature. Such links have inspired architects throughout history. Davey explained the importance of understanding the complexities of buildings that can touch subtler and deeper levels of the psyche (Davey 2001). A good example of such buildings can be experienced in Ando's Church of Light in Osaka, the Roman Catholic Cathedral in Liverpool or the Pola Museum of Art in Japan, where the main glass wall has played a major role in the spirituality of the place. The mixture of light, colours and surfaces in glazed buildings was used to flatten the façades and to provide surface impressions (Figure 3.9). Sigfried Giedion compared the lighting quality achieved by Paxton in the Crystal Palace to the luminous spaces of Turner's paintings: 'Turner uses a humid atmosphere to dematerialize landscape and dissolve it into infinity. The Crystal Palace realizes

3.9 Lady Chapel, Hereford Cathedral (1250)

the same intention through the agency of transparent surfaces and iron structural members' (Giedion 1967). Efficient use and manipulation of daylighting through glass surfaces is crucial in these examples.

It is difficult to assess the extent of the positive or negative impacts of glass façades on the identity of place. The association with environmental forces that shape the place could determine the failure or success of glass façades in creating a meaningful place. Unfortunately, there are today other socio-economic and political factors that determine the shaping of place identity (Girouard 1985). Glass represents the 'high-tech' movement in architecture, the global neutral architecture of the international style and the liberal views of multi-cultural societies. The emerged new public 'place' is not necessarily globally welcomed. In capital cities ruled by the global economy, such place is not only welcomed but also preferred. In other more local settings, environmental identity rules and glass façades have to conform to natural and local forces. Towns and small cities search for their place on the local–global urban scale. There is a belief that architecture can upgrade, or degrade, the position on such a scale. Giovannini explained, with reference to the Guggenheim building in Bilbao, how an individual building could reshape the perception of an entire city (Giovannini 2000). Figure 3.7 shows that at the two ends of the scale there is little tension in using glass. At one end, in a global city, the use of glass façades is accepted as it provides a neutral platform for other multi-cultural expressions and activities. Repetitions of elements that constitute a glass façade also create a dynamic environment with unique qualities. Transparency is another welcomed contribution of glass façades in a global setting where the inside and outside of buildings merge. Direct and indirect promotion of 'prestige projects', which are often designed with metal and glass, find fertile grounds for their causes in global cities. Little tension can also be observed at the other end of the scale, at the local level, where glass façades are strongly opposed. Protection of cultural identity and local roots has the upper hand in shaping place at this level. The application of glass façades in urban fabrics in towns and cities between these two ends is more problematic and creates debate and tension. While economic and political forces tend to pull those towns and cities towards the global model, national forces and debates on protection of cultural identity, including environmental concerns, try to maintain or even push back towns towards more traditional settings. Glass was, remains and continues to be a fascinating material in shaping our built environment. With the vast improvement in glass technology, glass façades will continue to grow and influence the shape of our towns and smaller cities. Such developments can be successful only if their potentials and limitations are understood and their settings, in compliance with the environmental and socio-economic forces that shape such settings, are carefully selected.

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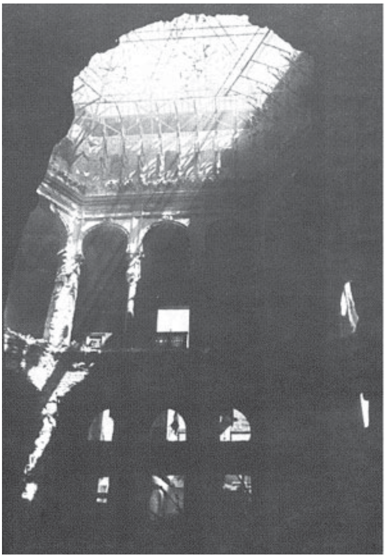
Chapter 4

Shattered Glass: Structures of Power

Cultural Built Heritage in Conflict Regions



4.1 Destruction of Sarajevo Library

The previous chapters showed that conflicts, value systems and culture definitions are inseparable from architectural aesthetics. Place identity stems from the cultural dialogue between the place users and their surrounding built environment. Multi-cultural living becomes the norm in many world cities, but the rise of ethno-nationalism poses a threat to cohabiting. The understanding of the gestural nature of our cultural built environment is necessary to avoid potential conflicts. The UNESCO declaration on cultural diversity (2002) indicated that one of the main causes of conflicts is the difference between the systems of values treasured by different groups or ethno-cultures. Friction may be filled with concrete ideological content and find its way into the minds of people, making them inclined to take this friction as a confrontation of cultural values and symbols. Architecture and artefacts of the cultural built *gestures*, as described by Ludwig Wittgenstein (in Ballantyne 2002: 10), are usually rightly perceived as strong historical evidence for the grievances of certain groups. Preservation or, in many cases, destruction and demolition of such symbols are attempts to delete such physical evidences. There are many global incidents where violence, for example in Bosnia, was deliberately targeting not only the people but also their cultural built heritage(s). Riedlmayer (1994) explained how the military violence in Bosnia aimed to deconstruct a heterogeneous and plural culture in order to destroy all records of coexistence (Figure 4.1). We should examine how building façades, in our case glass façades, transform our built environment and observe the diverse systems of values, and the relation of both to the quality of spatial and aspatial urban experience of different individuals.

If we accept the assumption that architecture is a *built* gesture, then its configuration should be relevant to its context. There are meanings in the arrangement of building façades and in the places they frame for us (Ballantyne 2002). The aesthetics, a Greek word meaning perceptions and feelings, are the feelings that those buildings and their arrangements prompt us to have. Areas of glass façades, or the lack of them, act as visual indicators of the level of prosperity, safety and peace. One of the first things you notice in troubled cities is the significantly reduced surface of glass in building façades. The (re)introduction of glass features in cities like Beirut and Belfast indicated the confidence in lasting peace (Figure 4.2).

4.2 Re-introduction of glass façades in Belfast

Despite the positive gestures that glass and transparency bring to the urban environment, there is still antagonism against large-scale displays of glass in many such parts of the world. Such cultural rejection of glass is not, however, widespread. Interestingly, many of the most ‘private’ societies, such as those of the Gulf region, have welcomed the arrival of transparency in their cities and towns, as presented in many typologies including housing. Cultural values have major influence on whether glass façades are accepted or rejected in different locales. The ethics and aesthetics of erecting glass façades are interwined, not just for environmental reasons as explained in the previous chapter, but also for cultural reasons. The morality of architecture represented partially in the building façades is directly linked to such culturally instigated ethics.

Architecture and Representation of Cultural Values

The ever-evolving changes in definition and redefinition of the word ‘culture’ have not yet settled down to a single one. For the context of this chapter, I will adopt the descriptive definition of Eliot and expand on its interpretation. The descriptive definition of the word refers to ‘all the characteristic activities by a people’ (Eliot 1948). While this description is generally accepted in social sciences (Howells 2003), the interpretation of what ‘a people’ means can be divisive. It is not clear how Eliot defines ‘a people’. Is the term genetically prescribed or is ‘a people’ place-related? And what about the moral, religious or political orientations, which cannot be covered by Eliot’s definition? The argument will inevitably remind us of Heidegger’s connection with buildings and earth. Are those connections related to the place (*jus soli*) or defined by blood links (*jus sanguinis*), or both? The reader may be able to see the potential conflict in the argument. If architectural heritage is perceived to be an extension of a ‘blood line’, as evidence of one version of cultural ‘kinshipness’, tension will be created that will eventually undermine the positive role of the built environment in promoting a shared identity. Consequently, decisions for installation

4.3 Demonstration of power in the Olympia Stadium, Berlin (1936)

or conservation of certain architectural styles could lead to alienation of certain section(s) of a society. Buildings with glass façades defy this ideology. Compare this with the referendum on citizenship that Ireland held in June 2004, in which the constitution was amended to reverse the basis of Irish citizenship as being determined by one's place of birth (*jus soli*) to acquisition through parental bloodline (*jus sanguinis*). This emphasis on bloodline might seem inclusive by some while being seen as discriminatory and exclusive by others. Would alien glass buildings be allowed to contribute to a conservative setting? How does this idea of living with a inherited identity (*jus sanguinis*) conceal the emphasis on architectural identity, promoted by environmentalists, which is embedded in the soil (*jus soli*)? Does local identity only reflect buildings which are historically 'rooted' in its context or those which provide identity through, for example, the modern movement with its ethical agenda? The relationship or indeed tension between 'blood' and 'place' and of what constitutes culture is fundamental to our understanding of architecture and the role of glass façades in the cultural built environment in shaping the place identity. In fact, glass façades are not as passive as the above discussion suggests. Glass façades promote powerful socio-economic and political gestures. The question remains whether the justification of building glass façades is based on the interplay of culture, aesthetics and/or politics? History shows us many examples of strong links between architecture and politics (see, for example, Figure 4.3). Examples include the styles of different eras, the exclusion of fascist buildings, politicians' interest in architecture conservation, links between architectural achievement and political epochs, and so on. Occasionally, such links pose some serious moral questions. Heidegger's views on *building dwelling and thinking* (Guignon 1993) have several references to *people* but he in fact advocated the power of architecture in promoting certain ideologies. Leach (2002) explained how such references to people concealed a darker side of *domus* (house or home) and its relation to Nazi ideology. Vernacular architecture, while mostly described as 'the people's tradition', can also refer to a tradition of power. On the other hand, it is important to realize that not all glass buildings necessarily reflect strong, deep, powerful gestures in the built environment. There are also architectural values in arrangements of 'ordinary' glass structures.

While the people's traditions with their roots in vernacular architecture are well understood, the tradition of power is less so. Marcus (2004) identified six indicators for the architecture of power. These are:

- demonstrating might
- using existing superficial traditions

- destroying peoples' traditions (imposition of grid patterns, urban renewal, etc.)
- creating new traditions
- rejecting all traditions
- using selected traditions to suppress.

Glass and the Architecture of Power

4.4 The dome of the Reichstag, Berlin (Norman Foster, 1999)

Several major prestigious projects are now under construction in different parts of the world, from New York to Shanghai and from St Petersburg to Dubai. There is a common theme that appears to link these high-profile projects – an expression of power. This demonstration of might is not new in architectural scenes, but the new tools, the bold denial of all traditions and the current demonstration and revival of the *tradition of power* are. Throughout history, architecture was used to demonstrate power. Whether it was the form of the buildings, the scale, certain features or the materials used, architects have successfully reflected the desires of their powerful clients in different eras. The morality of preserving some of the symbols that reflect powerful gestures varies greatly. Transformation of many buildings, that were condemned for one reason or another, to reflect more politically correct approaches is usually acceptable. Glass is increasingly used to implement transformation concepts. Foster's attempt to replace the old dome of the Reichstag in Berlin that imitates a German soldier's helmet with a more contemporary glass dome is an interesting example (Figure 4.4). The transparency of the dome, while preserving the overall layout of the building has transformed the perceived role of the building as much as its visual characteristics. The reality, however, reflects the illusive nature of glass. Visitors to the Reichstag might be able to watch the parliamentary debates and observe democracy in action but they cannot listen or be listened to and are denied any real interaction; this is in contrast, for example, to the public gallery in the House of Commons in London. So while glass seemingly provides a wider transparency and a social transformation, it actually denies any real interaction. Apparently many members of the Reichstag have also complained about the distraction of the silent figures of visitors hovering around the glass roofs. In fact, the glass dome of the Reichstag has replaced one form of presentation of power with another illusive and more subtle one. The transparency of glass is used in this case to conceal the contemporary powers of the Reichstag; the dome is a reference to tradition in order to conceal tradition.

Glass is increasingly playing a similar role in concealing the powers of cities as presented in their office buildings. The increasingly transparent ground floors of business districts give false impressions of transparency and inclusiveness. Most of these buildings are in fact quite exclusive. The double and triple glazing or, in many cases, double skins are physical barriers that not only exclude unwelcomed environmental interference with business, but also exclude people. Glass design of business districts has developed empty transparent shells and mainly uses glass to deliver a 'slick image' rather than using its transparent qualities. According to Jencks (1985: 379), Philip Johnson has taken the Seagram curtain wall, played with its grammar, and produced an exaggerated version in the Pennzoil Place of Houston (1974). This late modern example did not necessarily use a more advanced technology but delivered a slicker version of an older glass façade technology. Exaggerated building skins introduced an extended aesthetic of the modern movement. The 'skin and bones' of Mies van der Rohe's international style were made more visually apparent. The Pompidou Centre in Paris, Lloyds of London and the Bank of Shanghai in Hong Kong were leading examples in the early 1980s. This approach, however, faded by the end of the century as the environmental agenda emphasized the role of the glazed skin while the structure elements were minimized and kept to the interiors. Despite changes in the façade technology at the end of the twentieth century, most glazed office buildings continued to compete in demonstrating power through their heights, forms and/or slickness. Emphasis on these qualities has ended up with many buildings looking alike. Instead of providing the immortality of the buildings' sponsors, glass structures have quickly disappeared from the collective heritage. It is precisely the above required qualities of glass façades that prevent a more interactive architecture that can make use of the full qualities of glass – its dynamic abilities to interact and transform.

Glass's Heritage of Power

The loss of the twin towers of the World Trade Center led to a shift in the understanding and appreciation of cultural built heritage, a shift in focus from people's traditions to more interest in the traditions of power. Emphasis has shifted from interest in local symbols to national and international ones. The WTC buildings demonstrated power and wealth in New York. The geometric street pattern underneath the towers was imposed on the old irregular street pattern and highlights the powerful forces that

4.5 Proposal for the replacement for the World Trade Center towers, New York (Daniel Libeskind)

shaped the city, showing the tension between the power of the city establishments and its older community. Glass towers were one of the tools that have graphically demonstrated power in American cities. This new tradition of demonstrating power has not faded but increased. Libeskind, with his new design for the WTC (Figure 4.5), conceals what he calls the Freedom Tower with ornamentation that is similar to that of the Statue of Liberty.[1] Libeskind attempts, according to Marcus (2004), not only to create a mental built heritage of the WTC but also to conceal its power base as office buildings. Ornamentation of glass façades is also common in different parts of the world to conceal their cultural significance. Extreme examples can be found in the Gulf region. Following clients' preferences in some cases and ambiguous building aesthetic codes in others, architects have introduced features that reflect local cultures. The results are a complete distortion of what glass is meant to achieve and how local culture is perceived.

4.6 Proposed scheme for the Mariinski II Opera House, St Petersburg (Perrault)

In another part of the globe, the proposal for the redevelopment of the Mariinski II Opera House in St Petersburg (Figure 4.6) presents another example of the ambiguous relationship between heritage and glass façades as promoted by the new powerful economic forces in Russia. It is interesting to note here the ambiguous attitude of different political regimes in Russia towards architecture. While the Soviet communist regime detested the bourgeoisie, it maintained the public buildings that represented it. Lenin and Stalin were fond of the social realism

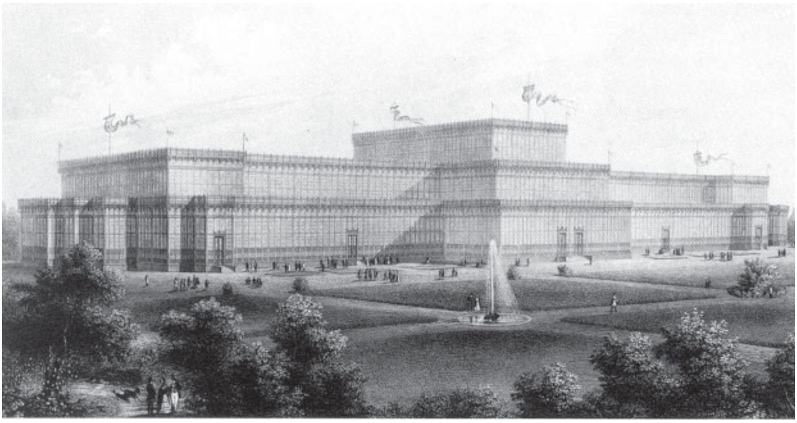
1 Daniel Libeskind was asked the following question in an interview: 'I believe that art as well as political power can completely ignore people. I would be interested to hear who you have in mind when you create a building. *For whom do you build?*' He replied: 'I have to say, I have thought about that. I think every building is addressed to someone who is not here. It is not addressed like a poem or a work of art. They are never done for the people in the exhibition going around and looking at the works. Look at those works: they are addressed to someone unborn. Every building that is good is not addressed to the public, that they walk around and find themselves to be comfortable. It is addressed to those who are unborn, in both senses: of the past and in the future. I think that is who they address and that is what makes them important. To that extent, every human being is really unborn. And if a building or a work of art is good, it might actually bring to life a dimension that was not there before, something that was not yet clear or not yet articulated, that was only potentially there. Good buildings do that all the time, good cities. People suddenly discover possibilities that they had other than before they were in those cities. They offer a different kind of freedom. That is who it is addressed to. It's never addressed to some politicians or some developer or some lobby groups, even if they are on your side.'

that embraced classicism, rather than supporting the constructivists. The current, more liberal, politicians, on the other hand, emphasize the importance of links to the distant, past but in many cases, such as in the case of the Mariinski II Opera House, reject the significance of its symbols and features as an integral part of the new economic driving forces. Perrault's glass extension of the Opera House that lies at the heart of the classical part of St Petersburg raised many questions and forced a formal debate in the city. Appropriateness of the introduction of large glass structure was seen as a sign of regeneration of the City's economy and would 'modernize' the city. Local Russian architects strongly rejected this and considered the proposal as a further proof of the decline of Russian values in face of the capitalists' economic market forces. But why do glass façades provide this link with economic power and why are they the expected contemporary image of corporation around the global? The following sections trace the development of these ideas.

In a traditional locale, a newly erected building with traditional features can rely on the notion of the *lifeword*; a term developed by Husserl to explain the interaction between individuals and society (Markus 1993). Despite the apparent deficiencies and waste in some cases from the contemporary construction point of view, the new building in a traditional setting might continue to receive contextual support, friendship and solidarity from the local residents. A rather dissimilar designed building might be treated differently. Since the beginning of the nineteenth century, newly designed buildings have related more to a power game. A building has a specific role that is brought (or bought) to play in a more structured system and with a given level of control of resources. A 'contemporary' designed building has therefore shaped the local environment, not only visually but also in terms of social practice and social relationships. A building can shape both the socially constituted power relations and the bond, which spring from the inner 'lifeword' (Markus 1993). Design of a façade, the face with which visual dialogue with the users takes place, has always struggled with the question of representation. Despite its importance to the whole society, the debate on visual representation in the built environment has been limited and left to architects, developers and the construction industry in general to decide. Two main approaches to design façades have occupied the architecture debate in the Western world since the nineteenth century (Leatherbarrow and Mostafavi 2002). The first is the visual representation of technological advances in the construction industry, representing visual reflections of systems of production. This mechanistic approach, which also forms the main ideology of the modern movement, is usually welcomed by the construction industry as it always endeavours to mimic the machine assembly which recently led to the rise of the façade industry. The second approach is the classic artistic approach of representing cultural values through recollection of pictorial images and styles. The development of free façades in the early twentieth century has deepened the debate of visual representation of cultural values. The motifs and celebration of visual culture of opacity was an accepted gesture with the technical necessity of structural capabilities of façades. Free façades have suddenly terminated the former marriage between structural elements and building skin. The opaque structural elements have given way to a more open and transparent façade. Just as the rising

4.7 Public Ledger newspaper building, Philadelphia PA (1867)

Gothic architecture of the twelfth century was adopted by the Christian church, free façades were also welcomed and adopted by the new symbols of power in northern Europe and North America for improving lighting and ventilation qualities in buildings. The new development opened a new chapter of representation of a non-traditional approach. It is important to note that no evolutionary process would take place without a host, a context that enables it. In this sense, a new rise in economic power was taking shape in Chicago at the end of the nineteenth century. The economic forces that produced an eagerness to sell and rent built-up spaces among the new firms resulted in little appetite for ornamentation (Figure 4.7). Meanwhile, the pace of development of steel components coincided with the new demand. A new method of architecture started to evolve; the frame construction. Clients were demanding new 'cathedrals' as symbols of power.[2] The pictures drawn by Claude Bragdon for the mediaeval and the future



4.8 Munich's glass Exhibition Hall (1853)

cathedrals are an example of this interplay between power and architecture in 1930. The new non-traditional method was gaining pace and creating its own tradition, and was claimed by powerful clients. There was an attempt to reject all other traditions.

2 '… an authority that carried spiritual resonances linked to the admired Gothic past, but which were also seen to be appropriate to spiritual and architectural needs of the beckoning century – all this in total accord with Viollet-le-Duc's insistence that "no one disputes the fact that an extensive knowledge of geometry is the groundwork of all architectural labors" ' (Whyte 1996: 13).

As explained in Chapter 1, the new iron and glass age generated its own architecture. Liberal open spaces were created by culturally and economically powerful clients to accommodate the masses, and glass was to play a crucial role in this enlightment era (see, for example, Figure 4.8). The separation mentioned earlier between figurative representation and mechanized repetition of elements and mass production led to the two separate approaches that were adopted by architects. Mies van der Rohe, for example, set up a new tradition that incorporated figurative representation of its time to produce architecture, using technology intertwined with its metaphysical and symbolic values. Mies van der Rohe's work is also based on the repetitive pattern of simple elements. The visual intentional representation stems from the collective impression of the primitive elements that appear to be unchangeable. The repetitive mechanized elements were not, however, completely separated from nature. Aalto referred to nature as the best standardization committee in the world. However, he addressed the criticism of Mies's approach by adding, 'But in nature, standardization is almost exclusively applied to the smallest possible unit, the cell. This results in millions of different combinations that never become schematic. The same path should be followed by standardization in architecture' (in Schildt 1986: 221). Jean Prouve tried, however, to move away from the anonymous representation of power with his involvement of his own design of the repetitive elements. In the Maison de Peuple in 1939, Jean Prouve was himself involved in the design of the panels which are used in the cladding. The 'personalized' cladding was described as 'self-supporting tectonic integrity'. Peter Rice and Norman Foster praised his efforts to combine technology and new aesthetics as one of the great pioneers of the time who showed how art and technology can be reunified (Sulzer 2002: 11). This and similar efforts were, however, limited and lacked the necessary economic support.

A good example of the dilemma of representation can also be seen in Kahn's work in the early twentieth century. Leatherbarrow and Mostafavi (2002) described Albert Kahn's conservative views of architecture and his rejection of the international style as a good example of an early vision of neo-conservatism. It is interesting to note that one of his famous works was for the Ford Motor Company, an advocate of such vision in the early twentieth century, despite his views of mass production and international production. Kahn's idea of separation between industrial buildings and architecture can therefore be seen as a recipe for a conservative vision of architecture, separating it from the global economy and technological development, and separating the social and economical drivers of society. Despite his views, Kahn presented the power of Ford Motors by using large façade windows. Kahn rejected, however, the idea that glass and steel would be adequate to several tasks and to accommodating and representing the full range of architectural concern (Leatherbarrow and Mostafavi 2002). Kahn separated 'the people's architecture' and 'the architecture of power' on the basis of typology, where iron and glass can only represent the latter.

Scenes on the other side of the Atlantic, in Northern Ireland, were very different. An interesting and powerful example of the importance of understanding the people's tradition and the tradition of power and their impacts on community relations can be found in the shirt industry's buildings in Northern Ireland. In 1871, the shirt factories started to scatter in both Protestant and Catholic areas outside the city walls. With the introduction of Tillie and Henderson's revolutionary combination of steam power to sewing and cutting machinery, factories started to adopt an assembly-line approach to shirt making. The changes brought fresh façade aesthetics to a conservative society and largely glazed façades were introduced, with interesting impacts on the divided communities.

Traditionally, the aesthetics of the façades of the shirt industry's buildings in Derry largely related to their locations and relations with the surrounding community within the city. The selection of architectural languages and locations of buildings of the flourishing shirt industry varied in the late nineteenth and early twentieth centuries. Within these buildings, we can distinguish three different categories, reflecting different approaches adopted by the architects, developers and owners. While some industrialists kept the community spirit of the traditional cottage industry and small enterprises by placing the factories within the community, others embraced the past by locating the factories around the religious symbols in the built environment. Others represented a more forward-looking and positive approach that emphasized the need for a liberation from the past by developing contemporary buildings with European-influenced architecture.

The first group of buildings represents the community-based industry. These are the buildings that truly reflect the state of the linen and shirt industry during the early twentieth century. These buildings, despite their disproportionate scale, were embedded within the residential areas, butting up against the terraces of houses and therefore often looking like bookends. Their façades tend to appear simple, with small openings, and not articulated. One example would be the Rosemount factory; however, the strongest example would be the factory on Bellevue Avenue occupied by Leinster Brothers and Staveacre during the 1920s and later by McArthur & Beattie & Co. Ltd after World War II (Figure 4.9).

4.9 Shirt factory located on Bellevue Avenue in Derry (*c.* 1900)

The second category represents the traditional façades of the late nineteenth century, largely in close proximity to religious symbols. The combination of unity and relevance to the church seems to have provided some sort of stability and security to certain groups of workers. These factories tended to have a more homogeneous population of workers. Unfortunately the same group of buildings are those that are reported as experiencing violent disturbances in the early part of

4.10 Welch Margetson factory, Horace Street, Derry (1872)

the twentieth century (Finlay 1993). Unlike the other two groups, this category of factory tended to have strong and decorative façade aesthetics. Examples include the McIntyre, Hogg, Marsh & Co. factory located next to the Presbyterian church on the Strand Road and the Welch Margetson factory located next to the Methodist Church on the Carlisle Road (Figure 4.10).

The third group is a positive example of Kahn's vision of industrial buildings. This category includes buildings that were progressive and reflect a forward-looking architectural language that liberates them and their users and workers from political and religious affiliation. An example of this is the early twentieth-century Wilkinson factory located on the Strand Road designed by R.E. Buchcanan in 1921 (Figure 4.11). The building reflects the state of the art at that time. Such buildings would have produced a sense of pride and would no doubt have helped to unite the workers. With strong classical references, the façade is composed of a combination of red brick and render with large glazed apertures repeated along the length of the building. Literature indicates that workers in Wilkinson's factory showed positive attitudes towards their neighbours. This was not only reflected in the increase in productivity but also in the low incidence of violence (Finlay 1993) among all categories.

There are indications that attitudes towards conservation of buildings in Derry are very much linked to either negative or positive memories. The developed culture of denial in the city of Derry has resulted in a lack of interest in the cultural built heritage. Accumulation of the widely reported incidents and events in the city, often situated on road intersections, has also led to the development of mental maps with

4.11 The Wilkinson factory, Strand Road, Derry (1921)

more subtle and softer invisible interfaces in the city. Unlike physical representations of history, mental memories are kept, and in many cases nurtured, as continuous forces that shape political and cultural attitudes. The built heritage and its political, social and/or religious symbols led to attempts to eradicate such memories. Peaceful or violent destruction targeted certain areas of the city, usually on the developed intersections. In a divisive environment, where understanding of the signifiers and the signified is so well comprehended, development of visual dialogue is essential for reconciliation. Understanding visual perceptions is a key towards the noble aim of building a 'united' visual culture. Cultural built heritage is an essential component of this visual dialogue. The aim should be to develop new and creative modes of mutual concern for the cultural built heritage on the basis of shared values. Such understanding of the common values of the cultural built heritage is under major threat.

The separation between people's architecture and power architecture, with their distinct façade representations, still exists on a geopolitical basis rather than a typological one. Such separation is more visible in both global cities and regional towns, as explained in the previous chapter. In the first instance, it appears that recent applications of the architecture of power, mostly represented by large-scale glass façades, tend to dominate in global locales, while people's traditions thrive in local towns. In fact, the manifestation of power is rather more complex. It is true that the contemporary representation of economic and political powers is reflected in large glass façades in global cities. It is, however, also true that older and more subtle presentation of power still exists through aesthetics in local towns.

General description does not necessarily reflect the complexity of human settlements. Iron and glass which represent the economic and political forces do not lead to tensions in such contexts, although there may well be frictions at the other end of the scale.

Chapter 5

Seeing Through Glass: A Technical Review

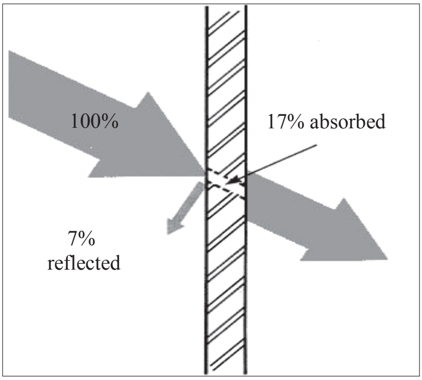
Introduction

The skin, independent of the building shell, is made up of three main groups of elements: the opaque elements, the transparent elements and the translucent elements (European Commission 1999). This traditional view of the characteristics of envelope materials is now questionable in the context of the speed of technical innovation in building materials, and in particular in glass. A glass pane, for example, can now be transformed into either a translucent or an opaque state by the manipulation of electric currents. New technology allows extensive use of glass as internal separators as much as in façades. This development is expected to receive a wider acceptance in public buildings where, in the light of the threat from terrorism, there is an increasing demand for surveillance, clear surfaces and visual inspection. The transparent components of the building envelope are usually the most interesting parts, due to their dynamic nature. They are more responsive to short- and long-term changes in interior and exterior conditions. They have more complex functions, allowing views and communication with the outside, providing heating through the controlled use of solar gains, and cooling by shading and ventilation. External shading, daylight enhancing devices and solar control blinds can play a significant role in filtering heat and light through a building's skin, particularly when used in combination with glazing selection and ventilated façade strategies that integrate natural processes.

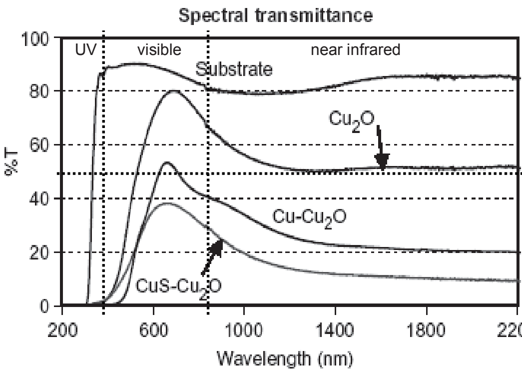
It is the transparent nature of glass that provides this material with its uniqueness. As glass is neither liquid nor solid,[1] because its molecules are motionless (like a solid) but random in configuration (like a liquid), glass exists in a solid yet transparent state. The interaction of light with the glass surface is at the core of understanding this wonderful material. Sunlight falling on a window is made up of visible light, near-infrared energy (heat) and ultraviolet light. Solar radiation that strikes the aperture glazing surface is either absorbed by the glass, reflected back to the

1 There is no clear answer to the question 'Is glass solid or liquid?'. In terms of molecular dynamics and thermodynamics it is possible to justify various different views that it is a highly viscous liquid, an amorphous solid, or simply that glass is another state of matter which is neither liquid nor solid. The difference is semantic. In terms of its material properties we can do little better (Neumann 2003).

outside or transmitted into the building (Figure 5.1). The nature of light and the variation in transmission and absorption experienced by different materials have resulted in the development of a variety of glass types that vary in performance and use. The selective transmission of ultraviolet, visible light and near-infrared wavebands determines both the visual characteristics and the performance of glass. In different locations with different environmental conditions, certain glass specifications are preferred. Such differences are not necessarily related to visual characteristics. The technical specifications can, however, determine the amount of light that is allowed to transmit through the glass façade. The technology to determine and control the selective transmittance has proved to be one of the most difficult tasks in the glazing industry. One of the main difficulties is the relationship between light transmittance and thermal characteristics. The more light transmittance the glass pane allows, the more thermal transfer it permits. Wigginton (1996) explained that methods used for decreasing the total radiation transmittance would undoubtedly entail reducing light transmittance and vice versa. Recently, technology became able to separate the two phenomena by manipulating the selection of wavelengths. Correa and Almanza (2004) showed the possibility of increasing admittance of visible daylight while preventing simultaneous heat transfer. The peak transmittance values for glazing with Cu_2O selective coatings, for example, lie within the visible spectrum, producing a window of high luminous transmittance. It is also possible to block 40–50 per cent of the infrared radiation with copper-based coatings, while blocking only 25–40 per cent of the visible radiation (75–60 per cent transmittance) (Figure 5.2). The relationship between visible transmittance and thermal transmittance is one of the main technological keys for developing a range of glazing systems. The following sections describe these two phenomena and how they influence the new technologies in glazing.



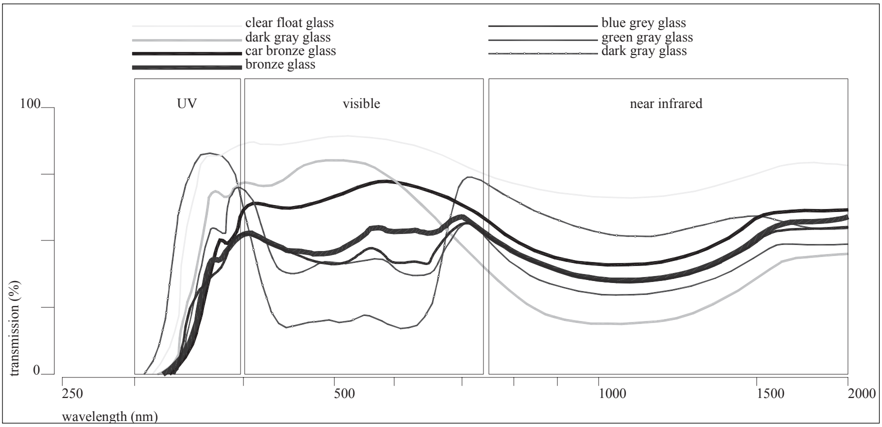
5.1 Sunlight striking a window can be transmitted, reflected or absorbed
Source: Saridar 2004



5.2 Characteristics of Cu2O selective coating glazing

Light Transmittance

Daylight performance in any urban context depends on a combination of direct sunlight, diffused skylight and the reflection of light from the façades and the ground. Glass façades influence many of these variables. This might explain the visual dominance of glass façades in many urban contexts. Daylight literatures have identified a number of technical variables that are related to the characteristics of space configuration that impact on the daylight performance. The physical configuration of the space is a morphological composition of vertical planes (the *frame*) and horizontal ones (the *floorscape*). The enclosure is consequently formed by the integration of these perpendicular planes (Baker *et al.* 1993). Three sets of variables can therefore influence the impact of lighting in shaping a place; the frame, the floorscape and the general detailing of the space configuration (Al-Maiyah and Elkadi 2006). Glass façades accentuate the influence of the frame in daylight performance within the place as it largely increases reflection. Wa-Gichia (1998) argued that the *reflectance of the opposing façades* and the *geometry of the sectional profiles* are among the main variables that affect daylight propagation and performance.



5.3 Spectral transmittance of six typical tinted glasses compared with clear glass
Source: Wigginton 1996

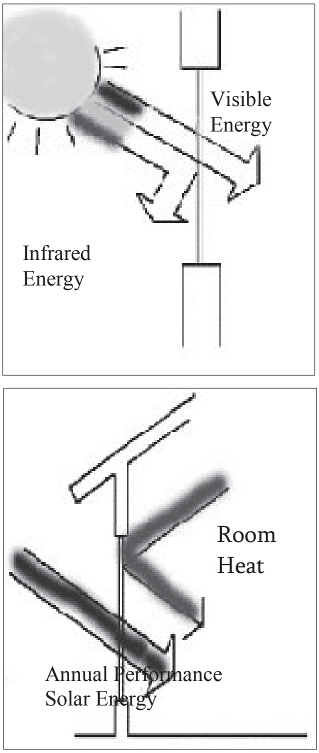
The transmittance of the reflected daylight differs from that of direct or diffused sunlight. Daylight travels in different wavelengths which can be explained under three groups; visible light transmittance, ultraviolet transmittance and infrared transmittance (Figure 5.3). The visible light transmittance factor (VLT) is the amount of the visible portion of incident radiation that penetrates a window, expressed as a percentage (Button and Pye 1993). A typical clear glass has a visible light transmittance of 60–80 per cent, between about 400 and 2500 nanometres. Glass with a high visible transmittance factor can introduce glare, as the window and the area immediately adjacent to it are far brighter than the surrounding areas. Design and placing of windows play a major role in reducing glare in these cases. Ultraviolet transmittance (UVT) indicates the percentage of incident ultraviolet radiation that passes through the glazing (Energy Source Builder 1994).

Infrared transmittance (IRT) measures the percentage of incident infrared radiation for wavelengths of 750 nanometres and upwards (Wigginton 1996). The range of selectivity of transmission between light and heat is limited by the fact that 53 per cent of the energy in solar radiation is in the visible spectrum (3 per cent ultraviolet and 44 per cent near-infrared). For energy saving and suitable solar filtering, the window material's transmittance should have the lowest value in the infrared spectrum and the highest value in the visible sector of the solar spectrum (Correa and Almanza 2004).

Thermal Transmittance

The thermal transmittance or *U-value* of a material is the time rate of heat flow per unit area under steady conditions from the fluid on the warm side of the barrier to the fluid on the cold side, per unit temperature difference between the two fluids (ASHRAE 1989). The direct relationship between visible light transmittance and thermal transmittance was taken for granted. As visible light transmittance increases, thermal transmittance is also expected to increase. In a northern European climate where light is greatly needed in winter time, admittance through large windows or clear glass also leads to an increase in loss of heat. Climates where the average outdoor temperature is consistently above or below the human 'comfort band' would benefit from a low U-value. The effort to reduce the U-value of glass while maintaining high visible light transmittance remains a challenge to the glass industry. All the four independent factors (identified by Givoni 1998) that influence U-value affect visible light transmittance. These factors include the existence and number of air spaces between glazing types, the properties and/or treatments of the glazing material and surfaces, the gas which fills the air spaces, and the materials and detailing of the window's frame. Mills (1996) found no direct relationship between the U-value and visible light transmittance. Mills discovered that visible transmittances may vary from roughly 0.2 to 0.8 over the entire range of insulating values. An appropriate glass technology can therefore be developed to reduce U-value while maximizing visibility; such development would end the technical and aesthetic dilemma of how façades can provide an effective shelter while still maintaining maximum contact with the outside.

The problem remains of how to make the properties of the glass window more dynamic. Glass façades should react to the dynamic environment of their settings. The continuous changes of climatic conditions and cloud cover pose a challenge to both architects and the glass industry. Visibility, while mostly welcomed from the inside, is not always required from outside buildings. Climatic conditions also vary during the year. While solar gains through a glass window in a northern European environment need to be minimized during the summer, they are very much welcomed during the cold months (Figure 5.4). Provision of maximum visibility with clear sky conditions can introduce glare to the outside as well as the inside of buildings, although it is desirable during gloomy sky conditions. Today, new technologies help to resolve the trade-off between glass façades and some of the environmental variables. Design solutions, such as the innovation of double and triple skins, also facilitate some reactionary measures to the dynamic characteristics of the natural environment.



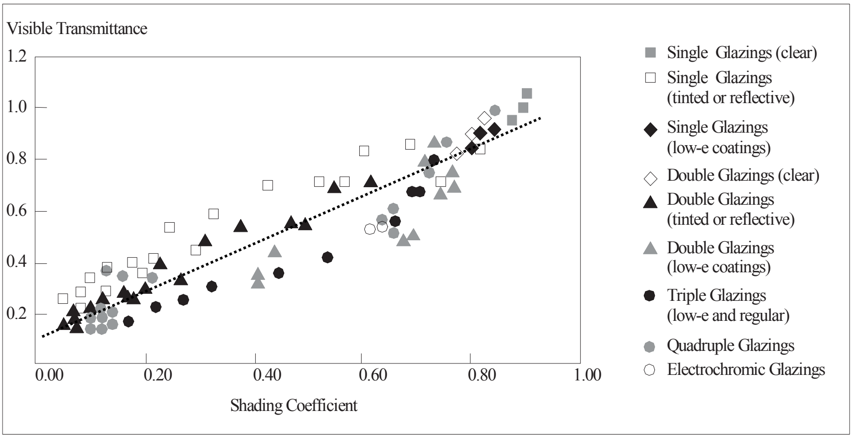
5.4 Performance of glazing material with visible lights and thermal transmittance

Measuring the Dynamic Performance of Glass

Many technical factors are currently being introduced to measure the advanced characteristics of glass materials. Multi-layered glass façades (which in many cases incorporate shading devices) are measured, for example, in terms of their shading coefficient, solar heat gain coefficient (SHGC) and light solar ratio (LSR). The reflectance of visible light can determine the visibility through a glass pane. Glass internal light reflectance and glass external light reflectance are also parameters to be considered, in addition to light transmittance, where the inward and outward views are imperative (Button and Pye 1993). This last characteristic can be measured by the visible light reflection coefficient.

Solar Heat Gain Coefficient (SHGC)

SHGC is gradually replacing the *shading coefficient* (SC) in glass window literature as the key solar parameter. It indicates how much solar heat is blocked by the window. SHGC differs from the shading coefficient (SC) as it expresses the amount of solar heat that penetrates the window compared with the amount that strikes the outside (Saridar 2004). In hot zones where comfort levels must usually be achieved through air conditioning, low SHGC values are desirable. Glass windows with high SHGC values, on the other hand, are desirable in buildings where passive solar heating is needed. *Solar coefficient* is another measure for the thermal efficiency of glass windows. The American Society of Heating and Refrigerating and Air-Conditioning Engineers (ASHRAE 1986) defined the shading coefficient (SC) as 'the ratio of solar heat gain through fenestration, with or without integral shading devices, to that occurring through unshaded 1/8 inch (3mm) thick clear double strength glass'. Figure 5.5 illustrates the variation in



5.5 Over a range of shading coefficient, windows vary considerably in their visible transmittance
Source: Mills 1996

visible transmittance and shading coefficients for various glazing products. This diagram shows a clear linear relationship between the two glazing properties. The shading coefficient correlates positively with visible transmittance, i.e. the integration of shading devices decreases the amount of light transmitted through glazing, and accordingly visible light transmittance decreases.

Ke Factor

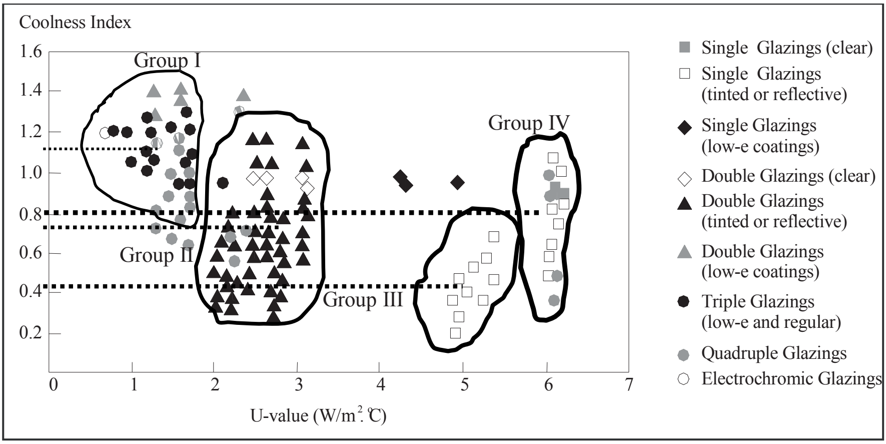
In 1986, Sweitzer and his colleagues from Laurence Berkley Laboratory suggested the *Ke factor* (Givoni 1998), which is also referred to as the coolness index (Button and Pye 1993) or efficacy factor. Ke is the ratio of visible light transmittance (VLT) to shading coefficient (SC); thus:

$$Ke = VLT / SC$$

This factor is one of the criteria that evaluate the window's performance. It is helpful in selecting glazing products for different climates, in terms of those that transmit more heat than light and those that transmit more light than heat. The higher the number, the better the glass filters heat from the sun's daylight (Givoni 1998; ESR 2000).

Light-to-Solar Ratio (LSR)

The Advanced Building Technologies and Practice Organization (2000) recommends LSR as a common measure of the performance of glazing units. This is the ratio of visible light transmission (VLT) divided by the solar heat gain coefficient (SHGC) for the glazing system. LSR is a similar measure to coolness factor, and is approximately



5.6 Over a range of U-value, windows vary considerably in their coolness index but can be organized in four main groups
Source: Saridar 2004

equal to 1.15*Ke since SHGC = 0.87*SC. High values of LSR are recommended in buildings where maximum daylighting is desirable with a minimal solar heat gain. The highest possible ratio is approximately 2.0. Clear glazing units have a value close to 1.0, while a good spectrally selective glazing system would have a value greater than 1.7.

Based on Mills's analysis (1996) of the relationship between visible transmittance and U-value (Figure 5.6), four groups of glass window can be distinguished (Saridar 2004). Group I includes electrochromic glazing, quadruple glazing, low-e (low-emissivity) triple glazing and low-e double glazing. This group is designed to control solar heat gain and provide good visible transmittance. These characteristics are suitable for hot and cold climates. At the other end, Group IV represents the clear, tinted or reflective single glazing types. These glass types have the same range of coolness index as other groups but their thermal transmittance is the highest and can reach as much as 6 m^2.°C/W. The U-values of clear, tinted or reflective double glazing, which constitute Group II, vary between 2 and 3 and have a wider range coolness index (between 0.2 and 1.2). Tinted glazing, of Group III, has a lower coolness index and U-value, depending on the tint colour but remaining relatively low.

Visible Light Reflectance

The visible light reflectance indicates the point at which glazing appears mirror-like, both inside and out (PG&E Energy Centre 1997). This factor measures the percentage of light reflected to that striking the glazing. The numbers are listed for inside, outside or both. While all smooth clear glass is naturally somewhat reflective, glazing treatments such as metallic coatings can increase visible reflectance. A higher visible reflectance represents a more mirror-like appearance. For a few years mirrored glass had aesthetic appeal in certain cultures. Mirrored glass façades were, however, quickly rejected. The visual opacity of buildings was against the best nature of glass itself, its transparency. The environmental impacts of mirrored glass were also negative, with increased light reflectance to the outside environment while providing a dark and gloomy atmosphere in the interiors.

The ability of glazing technology to manipulate the above factors led to development of a wide range of high-performance glazing systems. The aims are continuously shifting to provide evermore responsive and intelligent systems. This can be achieved through alteration of the properties and specifications of the glazing, and by adding learning capabilities to respond to the environmental conditions. Guzowski (2000) reviewed the advanced glass technology and divided them into three main approaches:

- glazing assemblies and glass technologies
- daylighting systems within the glazing cavity
- integrated glazing and shading systems.

Glazing Technologies

Over recent decades, a variety of glazing assemblies and glass technologies have been developed that use the characteristics of the glass as means of responding to environmental conditions. Research into and development of types of glazing have created a new generation of materials that offer improved window efficiency and performance. While this new generation of glazing materials has quickly gained acceptance in the marketplace, the research and development of even more efficient technologies continues. There are many types of glass that can be classified in terms of their applications (i.e. laminated, safety, solar absorbing, storm windows, spandrel glass, etc.). There are, however, nine basic types of glazing that are important for daylighting, solar heating and cooling applications because of their distinctly different behaviour in the three regions of the radiation spectrum (ultraviolet, visible and near-infrared) (Saridar 2004). These are:

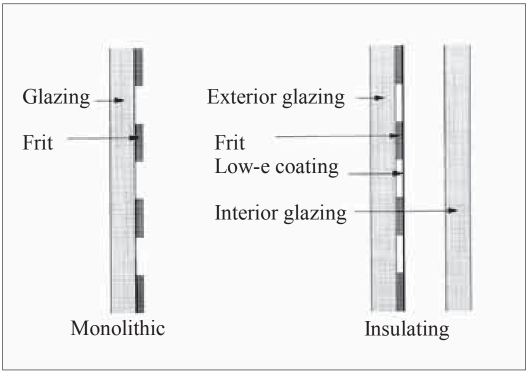
- clear
- fritted and laminated
- tinted
- reflective
- low emissivity (low-e)
- applied films
- spectrally selective
- switchable or ‘smart’
- photovoltaic.

Clear Glazing

Until recently, clear glass was the primary glazing material used in windows. Clear glass is generally durable and allows a high percentage of sunlight to enter buildings. A clear 'white' glass is achieved by chemical cleaning of the base materials. Impurities, mostly iron oxide (approximately 0.1 per cent), produce a faint green colour tint that can be seen on the edge of the pane. The reduction of iron oxide through chemical cleaning increases both the visible light and the heat transmittance. Clear glazing has, so far, the highest values for visible transmittance and shading coefficient, and the lowest values for coolness index. It is often the best choice in mild climates and where clear view and a maximum daylight penetration are recommended. On the other hand, clear glass absorbs most of the infrared radiation (longwave radiation) that causes the highest solar heat gain into the building, which then increases the cooling load in summer. However, such glass is the most suitable for solar heat collection in winter.

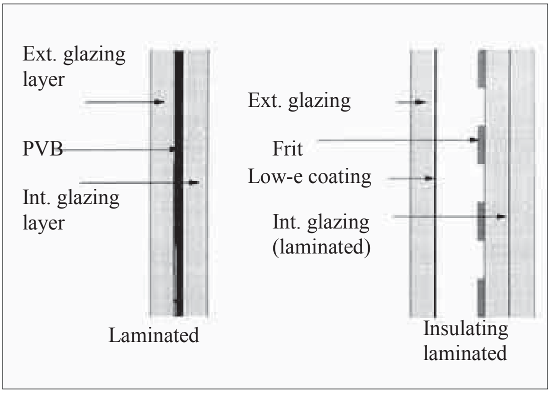
Fritted and Laminated Glazing

These types of system are important products in terms of shading sunlight, reducing thermal gains, responding to glare and providing privacy (Guzowski 2000). Fritted glass is manufactured by adding ground-glass particles (frit) which are oven-dried and fired onto the glass, creating integral shading through a translucent overlay. Standard or custom frit patterns can be applied to a variety of glazing assemblies, including additional selective films, insulation, air gaps and inert gas infills (Figure 5.7).



5.7 Multiple fritted glazing construction
Source: Saridar 2004

Frit glass offers no option to adjust or modify the daylighting for different uses or qualities of light. The advantages of this technology are the simplicity of an integrated shading device with low maintenance. The drawbacks are that it is static and cannot be altered to meet the changing daylight conditions or needs, to provide views, or to connect to the site. Potential glare at the window should also be considered, because the diffuse light captured on the surface of the frit can become a potential source of glare or a troubling light source within the room. In addition, fritted glazing by itself has no effect on the U-value of the window. Despite the relatively negative characteristics of fritted glazing, it is still used in architecture. A proposed development in Vancouver, Canada, highlights a positive aesthetic nature of this type of glazing. Wrapped in a skin of fritted glazing, the 52-storey tower appears to dematerialize as it rises. The effects of the subtle moiré patterns that reflect and refract light were tested using full-scale mock-ups in the architect's office. The top of the tower is eroded into an asymmetrical shard that seems to merge with and dissolve into the sky.



5.8 Laminated and insulating laminated glazing construction

Laminated glass consists of a tough plastic interlayer made of polyvinyl butyral (PVB) bonded between two panes of glass under heat and pressure. Once sealed together, the glass 'sandwich' behaves as a single unit and looks like normal glass. The PVB in laminated glass helps reduce solar energy transmittance to decrease cooling loads. Selective films, air gaps, tinting, infills and insulation allow reduced solar gains and provide shading within the glazing assemblies (Figure 5.8).

Tinted (or Heat-absorbing) Glazing

Tinting is the oldest of all the modern window technologies and, under favourable conditions, can reduce solar heat gain during the cooling season by 25–55 per cent. Tinted glazing, also known as heat-absorbing glazing, is where the basic clear glass formulation is modified by adding small amounts of additional materials into the mix.

5.9a Early use of green heat-absorbing glass at the Lever House building, New York (1951–52)

5.9b Early use of pink-grey glass at the Seagram building, New York (1954–58)

These additional materials are used to produce glasses that have different light and solar radiant heat transmission characteristics, coupled with different colours. These types of glass are rarely appropriate for daylighting purposes as they reduce light transmission and distort the colour of the view. They block heat transmission through bulk absorption in the glass itself. Unfortunately this also causes the glass temperature to rise, increasing the radiation coming off the window into the conditioned space.

Typical colours are green, bronze, grey and blue. Grey- and bronze-tinted windows reduce the penetration of both light and heat into buildings in equal amounts and are the most common tint colours used. The first tinted glasses used in buildings were green. Figure 5.9a shows the Lever House building in New York where green-tinted glazing was used for the first time (Wigginton 1996). The body-tinted green glass involves putting back the iron oxide that was removed in the first purification process to get 'clear white' glass. The addition of iron oxide, which is done in carefully defined quantities, is very good for absorbing photons towards the near-infrared and thus reduces the transmission of solar heat. After green glass came bronze glass, used for the first time at the Seagram building of 1954–58 (Figure 5.9b). The bronze tint is produced by the addition of selenium oxide to the glass mélange. These green and bronze tints were subsequently joined by the grey range. A variety of chemicals such as cobalt oxide, nickel oxide and selenium are added to the iron oxide to produce slightly different greys.

Blue-tinted glass is obtained by the addition of cobalt oxide. Blue- and green-tinted windows, compared to the other colour tints, offer greater penetration of visible light and slightly reduced heat transfer (Table 5.1).

Table 5.1 Light and thermal transmission of a variety of tinted glass

Glass type	Visible light transmittance	Infrared transmittance
6mm clear	0.82	0.70
6mm green	0.66	0.46
6mm blue	0.50	0.46
6mm grey	0.39	0.42
6mm bronze	0.46	0.46
6mm dark grey	0.18	0.58
10mm grey	0.23	0.25
10mm bronze	0.30	0.29

Source: CIBSE 1999

The tints used in this type of glazing have two additional thermal effects (Federal Energy Management Program 1998):

- longwave light transmission is reduced, resulting in an increased need for artificial lighting, and larger window areas to achieve the same level of daylight
- the psychological effect of looking at the world through brown, grey or green glass can be disturbing, and has been suggested as a contributory factor in building-related health problems.

Reflective Glazing

This form of glazing is created by depositing very fine semi-transparent coatings made of thin layers of metals or metallic oxides on the surface of the glass, producing a mirror-like appearance. This type of coating or ‘film’ is usually reflective in the infrared regions as well as the visible regions. They have a better shading coefficient than tinted glazing, which can reach as low as 0.11 (Energy Source Builder 1994), but light transmittance is very low. Reflective glazing typically blocks more light than heat but when applied to tinted or clear glass, it can also slow the transmission of heat. Developments in surface chemistry and coating technology have led to a wide range of coated glasses. The surface characteristics of glass can be modified to give a wide range of combinations of light and solar radiant heat transmission characteristics, including colour variety. Reflective coatings can be incorporated in multiple glazing and, in some cases, are applied as a minimum specification in combination with another glass as a sealed double-glazing unit.

Because reflective glazing reflects light along with solar infrared radiation, it should not be used in windows that are designed to collect daylight. It is, however, commonly applied in hot climates, where solar control is critical. The reduced cooling energy demands achieved may be offset by the need for additional electrical lighting.

Table 5.2 Visible light transmittance, infrared transmittance and shading coefficient of typical range of coated glazing types

Glass type	Visible light transmittance	Infrared transmittance	Shading coefficient
6mm silver	0.09	0.08	0.26
6mm bronze	0.09	0.06	0.27
6mm blue	0.18	0.15	0.28

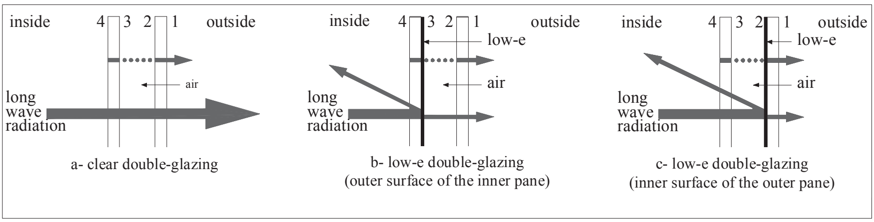
Source: CIBSE 1999

A new selectively reflecting glazing is available which reflects more of the shortwave infrared than visible light. Reflective glazing is more often used where it is more important to reduce solar heat gain than to maximize daylighting. Neither normal reflecting nor selectively reflecting glazing is appropriate in buildings where solar heating is desirable in the winter.

Low Emissivity (Low-e) Glazing

Introduced in 1989, low-e glazing has special coatings that reduce heat transfer through windows. The coatings are thin, almost invisible metal oxide or semi-conductor films that are placed directly on one or more surfaces of the glass or on plastic films between two or more panes. Low-e coatings are similar in behaviour to reflective coatings, but are selected for their low emission and reflection of longwave rather than shortwave heat. Low-e coatings are therefore also known to reduce the harmful ultraviolet rays which cause fading of interior finishes. Such coatings are defined as those which are predominantly transparent over the visible wavelength (300 to 700 nanometres) and reflective in the longwave infrared. The thermal properties of these glasses can be tailored to give good solar control. When applied inside a double-pane window, a low-e coating is either placed on the outer surface of the inner pane (surface 3 in Figure 5.10b) of the glass or on the inner surface of the outer pane (surface 2 in Figure 5.10c). When applied inside a double-pane window, the low-e coating is placed on the outer surface of the inner pane of glass to reflect heat back into the building space when heating is required. This same coating will slightly reduce heat gain during the hot season. Low-e coatings are used in double- and triple-glazed units, which may be filled with a low conductivity gas such as argon to achieve very high thermal resistance whilst preserving good levels of solar and visible light transmittance. Table 5.3 lists the properties of some low-e glazing assemblies (Hutchins 1997). There are two types of low-e coatings:

- multi-layer dielectric/metal/dielectric
- highly doped semi-conductor films.



5.10 Transfer of heat through low-e double-glazing systems
Source: Saridar 2004
Note: The dots signify conduction.

Table 5.3 Optical and thermal performance of glazing units using low-emittance coatings

Glass type	Gas fill	Visible light transmittance	Infrared transmittance	U-value (W/m*.°C)
Single	–	0.90	0.86	6.4
Double-glazed unit (DGU)	air	0.81	0.76	2.9
DGU, low-e	air	0.74–0.78	0.62–0.71	1.8–2.2
DGU, low-e, porolytic heat mirror	argon	0.75	0.72	1.9
DGU, low-e, sputtered noble metal heat mirror	argon	0.75	0.58	1.1
DGU, low-e, sputtered noble metal heat mirror	xenon	0.76	0.58	0.9
DGU, low-e, sputtered solar control	argon	0.66	0.34	1.2
Triple-glazed unit, 2 low-e	argon	0.62–0.67	0.49–0.58	0.8–1.1
Triple-glazed unit, 2 low-e	krypton	0.63	0.55	0.7

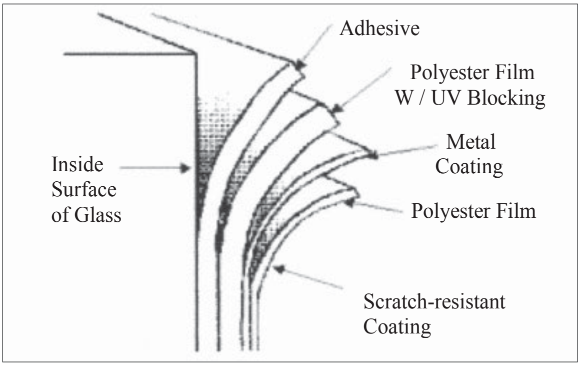
Source: Hutchins 1997
Note: * Low emissivity coating

Low-e films are applied in either soft or hard coats. Soft-coat low-e films have a limited shelf life. The multi-layer materials are more 'tuneable' while the doped materials tend to be more durable. When exposed to air and moisture, they are degraded and easily damaged. Therefore they are carefully applied by manufacturers in insulated multiple-pane windows. Hard-coat low-e coatings, on the other hand, are more durable and can be used in add-on applications. They are formed by a pyrolytic coating (often made of a metallic oxide) being baked on at a high temperature. The thickness of such a layer is about 1/10,000th of the diameter of a human hair. However, the energy performance of hard-coat, low-e films is slightly poorer than that of soft-coat films.

Applied Films

Glass films were first introduced in 1969 as a response to problems relating to excessive solar gains in homes and businesses. They are thin, transparent sheets that can be applied to the interior or exterior of glass surfaces to change the light-transmitting aesthetics, thermal, safety and security characteristics. Applied solar control films, also known as adhesive-backed films, are a common retrofit technology. They are available to give the same effects as the various forms of tinted glazing, reflective, absorbing and low-e types. The basic characteristics for all types of film today are that they are easy to apply, almost invisible and relatively cheap. They typically darken a window and give a mirror-like look to the glass, particularly the films that offer the highest degree of solar control. The most recent tests show that glass films produce good results in solar control, blocking up to 98 per cent of ultraviolet rays and 80 per cent of normal heat gain. In addition, if the film is applied properly it does not significantly reduce visibility through the glass. There is an expectation of further development with prediction of greater ultraviolet-blocking capabilities to protect ultraviolet-sensitive furnishings, as well as films which will be more durable and resistant.

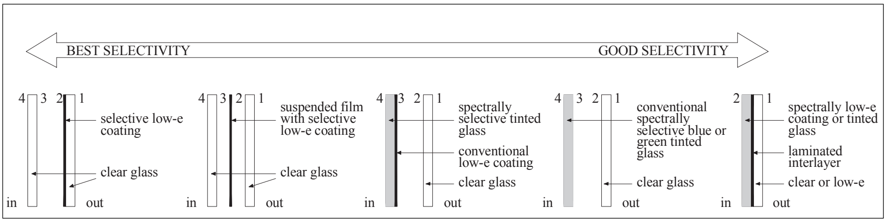
Window films are multi-layer assemblies of coatings and polyester films, as shown in Figure 5.11. These films are attached to the insides of existing single- or double-glazed windows by an adhesive backing. Typical films have a total thickness of 0.025 to 0.1 millimetres. Exterior grades are also available. They may give better thermal performance when applied to tinted glass or double-glazed units. Exterior application is also practical for inaccessible rooflights (Littlefair 1999).



5.11 Multi-layered film assembly
Source: Mills 1996

Spectrally Selective Glazing

Spectrally selective (optical) coatings are considered to be the next generation of low-e technologies. These coatings filter out from 40–70 per cent of the heat normally transmitted through clear glass, while allowing the full amount of light to be transmitted (DOE and NREL 1993). Spectrally selective glass is defined as ‘a window glass that permits some portions of the solar spectrum to enter a building while blocking others’ (Federal Energy Management Program 1998). This type of glass has been available since the 1980s. It is achieved through the use of thin film, noble metal low-e multi-layer coatings, which are commonly termed ‘cold mirrors’ or ‘cool daylighting glazing’ (Hutchins 1997). Spectrally selective coatings can be applied on various types of tinted glass, to produce ‘customized’ glazing systems capable of either increasing or decreasing solar gains according to the aesthetic and climatic effects desired (Figure 5.12).



5.12 Spectrally selective window assemblies
Source: DOE and NREL 1993

The energy performance of spectrally selective glass is illustrated by its ability to control solar heat gains in summer, to prevent loss of interior heat in winter, and to allow occupants to reduce electric lighting use by making maximum use of daylight. A report by the Federal Energy Management Program in 1998 showed that spectrally selective glazing significantly reduces building energy consumption and peak demand. DOE and NREL (1993) also claimed that simulations have shown that advanced glazing with spectrally selective coatings can reduce the electric space cooling requirements of new homes in hot climates by more than 40 per cent. Spectrally selective glazing is, however, not particularly suited to buildings in cool climates, because of the large reduction in winter solar heat gain.

Switchable or ‘Smart’ Glazing

Glazing materials that are responsive to hourly, daily and seasonal climatic changes are known as optical switching materials. These coatings can control the flow of light or heat in and out of a building window, thus performing an energy-management function. They inherently provide a change in the glazing optical properties under the influence of light, heat or an electrical field, or by a combination of these. Depending on the design, the coatings can control glare, modulate daylight transmittance, limit solar heat gain to reduce cooling loads and improve thermal comfort.

Switchable glazing, not yet available as a mature product form, changes its properties (such as shading coefficient and visible transmittance) in response to a signal. There are six categories, defined by the mechanisms that make them work:

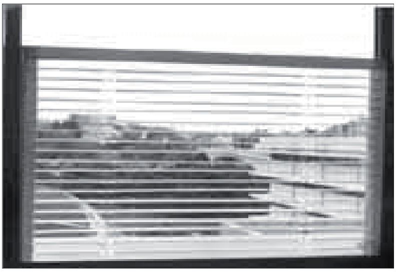
- angle-selective glazing
- liquid crystal assemblies
- the chromogenic phenomenon, which includes photochromic, thermochromic and electrochromic assemblies
- holographic diffractive films
- prismatic glazing
- photovoltaic glazing.

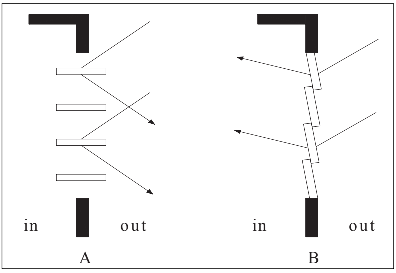
Angle-selective glazing These are used in window apertures to admit or reflect incident light depending on the angle of incidence. Generally it is desirable to reflect high-elevation light to avoid a high illuminance and glare level near the window, and to admit low-elevation light (which contains the view) and the useful daylight that penetrates deeply into a room (Reppel and Edmonds 1998). Daylight is reduced, but some winter solar gain may enter. This structure has a minimal effect on the ability to see through the glass from inside the building, as the angle at which radiation strikes the glass is different from the angle at which we look out.

Angular selective transmittance coatings are recent in their development. These coatings were first prepared at the University of Technology, Sydney. In principle, they are composed of a microscopic louvred grid structure created on a 0.28mm-thick polymer film by a process of photopolymerization, producing an oriented dendritic thin-film structure. The orientation of the dendrites can be controlled and varied by the deposition procedure. Evaporation, steered cathodic arc and sputtering techniques are being investigated (Hutchins 1997). Solar radiation is transmitted more easily when the radiation is incident in directions along the axes of the dendrites than when it is incident perpendicular to the columnar structure.

In Japan, Nippon Sheet Glass introduced its ‘Angle 21’ products using a polymer with an oriented column microstructure. This varies in its transmittance from specular transmittance to diffusing scattering, depending upon the angle of the light beam. The polymer molecules can be oriented so as to give an angular-dependent crystal structure, and this has been achieved for dispersed liquid crystal films; this opens up the possibility of switching the angles electrically, to produce molecular venetian blinds.

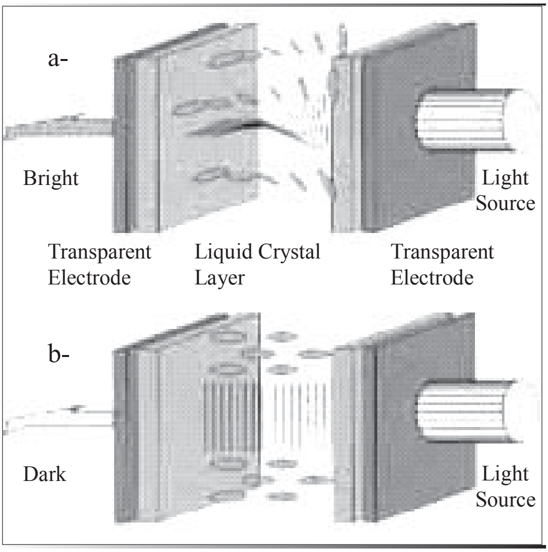
On the other hand, the angle-selective function can be obtained from the very high light-deflecting power of a laser-cut panel (LCP) (as illustrated in Figure 5.13) with LCPs in a louvre window (Reppel and Edmonds 1998). The panels may be used in windows as a moveable louvre system, to provide sunlight rejection (with the panels in the open louvre position) or as a light redirecting system (with the panels in the closed louvre position).





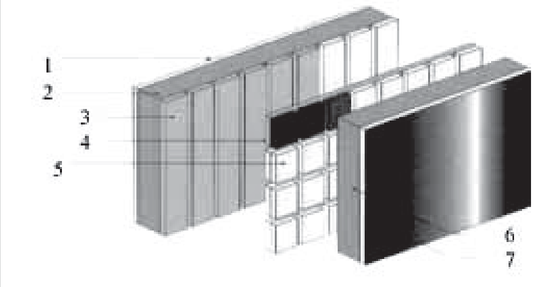
5.13 In louvre or venetian form, laser-cut panels may be adjusted to the open (summer) position to reject light or to the closed (winter) position to admit light
Source: QUT 2000

Liquid crystal assemblies These are based on laminated glass, with a minimum of two clear or coloured sheets of glass and a liquid crystal film, assembled between at least two plastic interlayers. Liquid crystals are based on the use of materials with a rod-like molecular structure which adjust the way light is transmitted depending on the alignment of the rods. Liquid crystal (LC) systems work on the principle that liquid crystal molecule chains can be influenced electrically to permit the transmission of polarized light. When the electric current is switched off, the glazing is a translucent milky white (see Figure 5.14b). When electric current is applied, it turns to a slightly hazy clear state (Figure 5.14a). In this state the system is able to transmit light, as long as the electrical field is maintained. Without any applied voltage, the molecules are randomly oriented and the incident light is scattered. To maintain a clear state the voltage has to be continuously applied. As there is little change in performance properties and because it requires constant energy to maintain its clear state, this liquid crystal window provides no energy-saving benefits.



5.14 The action of liquid crystal systems: (a) with applied voltage; (b) with no voltage

Liquid crystal systems are divided into two types: those which use polarizers and those which do not. The polarized LC systems tend to be optically inefficient, with a maximum light transmittance of 35 per cent (Wigginton 1996). The commonest type of liquid crystal system is the twisted 'nematic' (thread),



5.15 The twisted nematic liquid crystal construction
Note: 1 – polarizer, 2 – substrate, 3 – vertical electrode, 4 – horizontal electrode, 5 – colour filters, 6 – substrate, 7 – polarizer.

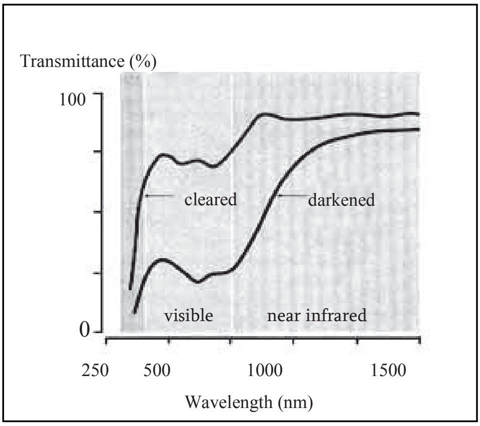
in which the polymers form chains that rotate between polarizing plates (Figure 5.15). The degree of rotation is controlled during manufacture. LC systems with no polarizers can transmit light much more effectively than polarized ones. Typical devices of non-polarizer systems are polymer-dispersed liquid crystal (PDLC), or 'nematic' curvilinear aligned phase crystal (NCAP). In the NCAP schemes, the liquid crystals are within an index-match polymer medium integrated between two sheets of indium tin oxide electrode film. When the current is switched off, the window is transformed into a translucent opal white surface; when on, the glazing is totally transparent because of the liquid crystal droplets' alignment with the electric field.

The main disadvantage, however, of LC layers is the fact that they are non-transparent when no voltage is applied across them. Therefore, continuous application of the electric field is required, which makes the system expensive. Referring to Hutchins (1997), 'liquid crystals do not appear promising candidates for use as energy-saving windows'. Relative to their later study, Hutchins *et al*. (2000) suggested that such a system might have effective application in glare control and privacy, as a substitute for conventional shading devices.

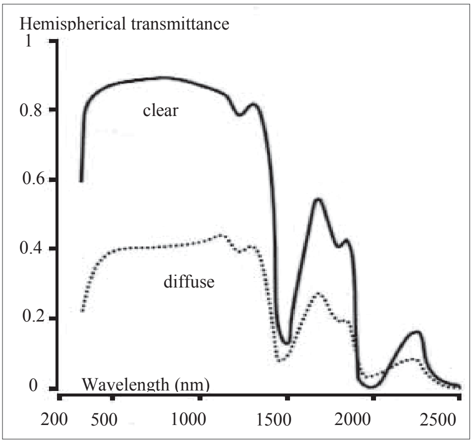
Chromogenic glazing assemblies Variable transmission has been the subject of a great deal of research, and the development of thin film coatings has permitted a wholly different category of materials to be created, resulting from the capacity of a film to carry an electric current. This work has been progressing for several decades, and chromogenics (the science of colour change in glasses) became in the 1990s a consolidated worldwide area for research and development.

Known as chromogenic glazing, these materials selectively control the spectral aspect of radiation. Chromogenic or optical switching windows enable windows to alter their transmittance in response to temperature (thermochromic) or light (photochromic) fluctuations, or in response to small electrical currents (electrochromic).

Photochromic materials change their properties in response to light; the light transmission decreases automatically in response to exposure to ultraviolet or shortwave visible light (Figure 5.16). Photochromism is one of the oldest switching ideas, and reference to it is reported as far back as the 1880s (Wigginton 1996; Hutchins *et al*., 2000). In 1937, the scientist R.H. Dalton noted a phenomenon relating to the already known behaviour of glass containing copper, i.e. that it turned red when heated. Dalton discovered that exposure of such glazing to shortwave ultraviolet radiation before reheating led to this colour change happening more quickly at a lower temperature. The process was patented in 1943.



5.16 Photochromic glass spectral transmission
Source: Wigginton 1996
Note: In this example, VLT is reduced by two-thirds.



5.17 Optical properties of a typical thermochromic glazing, 1mm thickness thermochromic material
Source: Wigginton 1996

The importance of photochromic glass is that the darkening phenomenon derives from the chemistry of the glass itself, rather than from a coating. The chemical structure of photochromic glazing consists of the removal of oxygen, the combination with hydrogen, or the lessening of the positive valency by adding electrons to a glass containing copper or silver halides. This technology has been used for years in sunglasses, and is apparently beneficial. Nevertheless, photochromism can operate inappropriately in a window, when the need for light in the interior is often independent of the brightness outside (Wigginton 1996). These glasses are suitable for glare control, but not so much for solar heat gain as they tend to reduce only the visible portion of the spectrum (Figure 5.17); when photochromic materials change their transmittance, the absorptivity is increased, causing the glass to absorb more heat. For example, a photochromic window may darken on a cold sunny day when more solar heat gain is desirable.

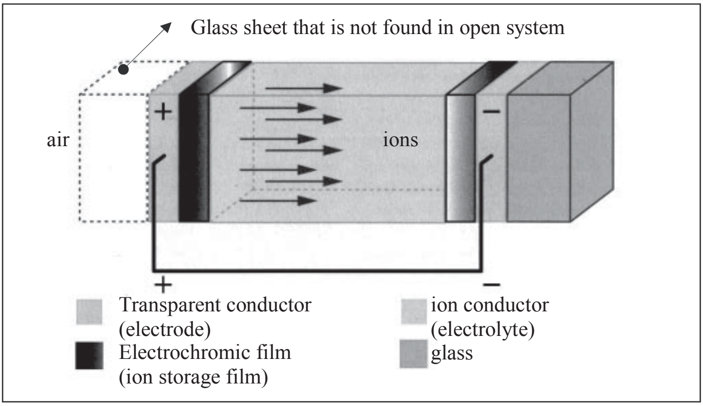
In *thermochromic* materials, temperature induces a phase alteration turned out by a chemical reaction. Thermochromic glazing mainly consists of liquid or gel polymers sandwiched between layers of glazing. With cooler temperatures, the polymers in the film elongate into diameters smaller than the light's wavelength, allowing light to pass freely through the film. However, when the film warms to about 24ºC, or to the programmed transition temperature, the polymer diameters become greater than the light's wavelength. As a result the molecules curl up, join together and reflect the light back.

Thermochromic windows are designed to block solar gain. A drawback to these systems is that they reduce the transmission of visible light. Typical visible transmission values lie between 0.8–0.9 and 0.1–0.5, and solar energy transmission values lie between 0.8–0.9 and 0.05–0.04 (Compagno 1999). Figure 5.17 shows the optical properties of a typical thermochromic glazing, where the thermochromic film is 1mm in thickness.

Elmahdy *et al.* (1988) state that the possibility of thermochromic liquids leaking from the glazing unit can affect the long-term stability of these materials.

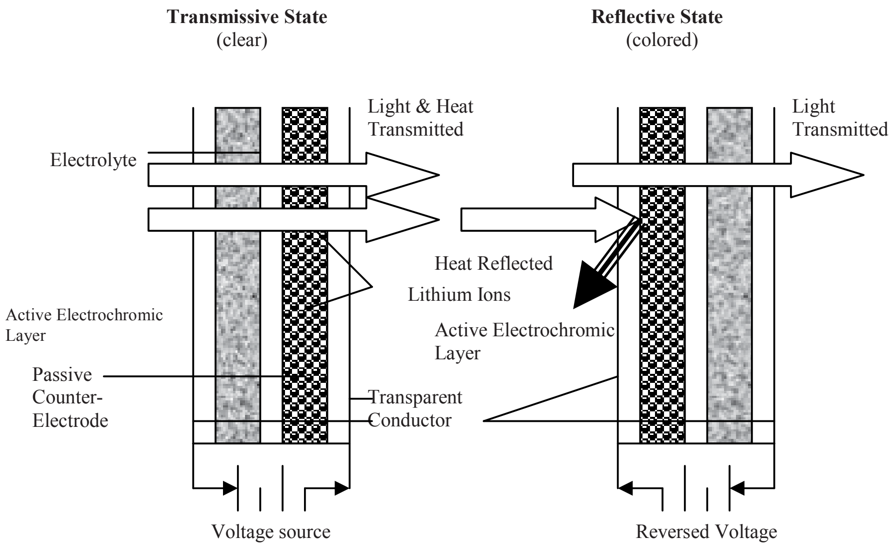
Again, as with photochromic materials, thermochromic glazing is not versatile in response. Daylight or view may have a higher priority for the occupant, at least temporarily, than any reduction in solar gain.

Electrochromic windows consist of two glass panes with several layers sandwiched in between. The system works by passing low-voltage electrical charges across a microscopically thin coating on the glass surface, activating an electrochromic layer which changes colour from clear to dark (Glassonweb 2003). Electrochromic glazing changes thermal and optical performance by the action of an electric field that runs on a very low voltage (1–3V), and changes back when the field is reversed. Pilkington has launched the first energy-saving window for buildings that can change colour on command. The new electrochromic glass product changes colour from clear to a pleasing blue as it is adjusted to control the amount of heat and light entering a room. The electric current can be activated manually or by sensors which react to light intensity to avoid overheating and reduce glare. If successful, this type of development would have a major impact on the design of façades. The role of external shades, for example, would be minimized. On the other hand, when there is little sunlight, the glass lightens and minimizes the need for artificial light. In winter, the coating on the glass ensures good heat insulation.



5.18 Schematic representation of multi-layer thin films that constitute the electrochromic devices
Source: Wigginton 1996
Note: The open system excludes the presence of an outer glass sheet where the transparent electrode is open to the air.

Electrochromic devices can be found in two forms, the open system and the closed system. These are presented in Figure 5.18 (Wigginton 1996). Electrochromic devices essentially consist of five thin film layers successively deposited on a transparent substrate (normally glass). Two transparent conducting thin films, commonly indium tin oxide (ITO) or fluorine-doped tin oxide (SNO_2F), serve as the electrical conductors. The active electrochromic thin film or ion storage film is separated from the counter electrode by a transparent ion-conducting layer (electrolyte). In the case of tungsten oxide (WO_3), under the condition that it is at a negative potential with respect to the counter-electrode, ions are transported from the counter-electrode through the electrolyte and inserted into the WO3 lattice (Figure 5.19). The system works by passing a low electrical voltage across microscopically thin coatings on the glass surface, activating a tungsten-bearing electrochromic layer which changes colour. The colour of individual windows can be controlled, or the total glazing in a building can be simultaneously altered by connecting it to the building's electrical management system.



5.19 Cross-section of prototype five-layer electrochromic coating, in clear and coloured states
Source: Mills 1996
Note: Layers not to scale.

Mills (1996) indicated that the electrochromic glazing developed by the Centre's Building Technologies Program permitted shading coefficients that could be adjusted from 0.98 to 0.36, with visible transmittances from 0.85 to 0.13. With such properties, Mills concluded that such windows freed designers from the historical rule of thumb that energy use eventually increases as a function of ratio of window area to wall area. His research shows that, even in very hot climates, energy use can decline steadily with increasing window area if electrochromics are used with daylighting controls, whereas conventional windows inevitably increase energy use as their size increases. Potential uses for electrochromic technology include privacy, daylighting control and solar control in windows and skylights, making traditional window shades and blinds obsolete. These are characteristics that were welcomed in the industry.

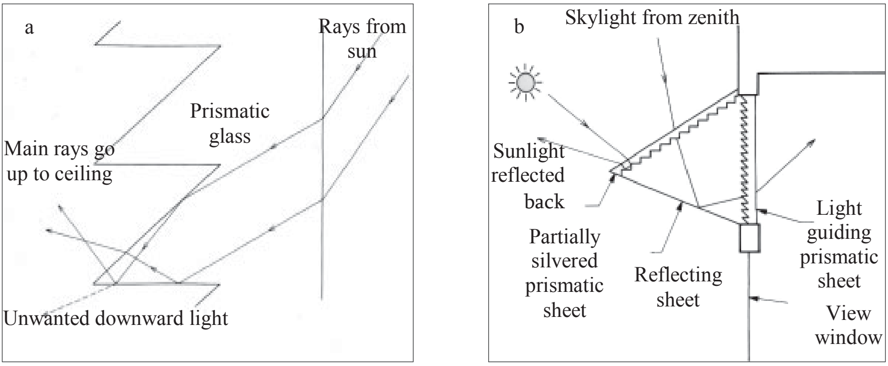
Another electrochromic technology is called suspended particle display (SPD). This involves the suspension of molecular particles in a solution between the plates of glass. In their natural state, the particles move randomly and collide, blocking the direct passage of light. While in an electric field, the particles align rapidly and the glazing becomes transparent. This type of switchable glazing can block up to about 90 per cent of light.

Holographic diffractive films These are two-dimensional or three-dimensional (volume holography) recordings of laser light patterns created on high-resolution photographic film, which is then laminated between two panes of glass. The diffraction lattice deflects light only from a predetermined angle of incidence, which means that the holograms can be electronically controlled to track the sun or the changing angle of light across the sky. In practice, this type of system produces good results for only a narrow range of solar incidence angles (Littlefair 1996). In side windows, holographic diffractive films act in the similar way to mirrored louvres, thus there is less solar glare control. Colour dispersion can be avoided by applying gratings of some different, special frequency (Littlefair 1996). Thus a clear view out is possible.

Prismatic glazing The principle underlying prismatic glazing is the alteration of incoming daylight by means of refraction and reflection. Typically, prismatic glazing comprises glass sheets that are flat on one side and faceted on the other in the form of long parallel prisms. The prismatic sheet controls light and heat by reflecting the energy, instead of absorbing it. Prismatic systems can be utilized to redirect diffused light from near the sky zenith towards the back of the room, which would otherwise receive no direct skylight.

There are two primary types of prismatic glazing: sunlight-directing prisms and sunlight-excluding prisms. *Sunlight-directing prisms* work on the same principles as a mirror. Figure 5.20a shows typical ray paths through a schematic prismatic sheet. Usually, the prismatic panel is installed inside a double-glazed unit and located in a clerestory-type system, since refraction distorts and obscures the view to the outside. According to Ruck (1989), this arrangement offers transmission efficiency of 50–70 per cent, depending on the solar altitude. For energy efficiency and occupants' comfort, the glazing needs to be adjusted seasonally to optimize deep daylighting onto the ceiling surface by controlling the direction of reflection.

Sunlight-excluding prisms feature in a system where the aim is to reject direct sunlight while admitting skylight from near the zenith (Figure 5.20b). The tilted



5.20 Prismatic glazing systems: (a) sunlight-directing, (b) sunlight-excluding
Source: Littlefair 1996

prismatic sheet has one face of each prism silvered, so that light from the areas of sky where the sun is will be reflected back outside. Diffuse light from higher altitudes is admitted and refracted onto the ceiling by the inner, vertically fixed prismatic sheet. This system allows glare-free lighting into the depth of the room, and is particularly useful where visual display units are used.

Photovoltaic Glass

This is a special glass with integrated solar cells to convert solar energy into electricity. The solar cells are embedded between two glass panes and a special resin fills the gap between the panes, securely wrapping the solar cells on all sides. Each individual cell has two electrical connections, which are linked to other cells in the module to form a system which generates a direct electrical current. Layers with photovoltaic modules enable the active use of solar radiation by turning it into electrical energy; they can also represent a form of passive solar protection. The most well-known photovoltaic products are silicon solar cells, available in three types: monocrystalline, poly- or multi-crystalline, and amorphous (i.e. non-crystalline). Silicon cells were used in 1991 in Aachen by the architect Georg Feinhals for the renovation of the glass façade of the Stawag administration building. Special light-scattering and insulating glass elements were developed in order to meet the needs of both lighting and insulation, as well as to meet the desire to maintain and exploit the corporate image as protected through the façade.

The monocrystalline solar cells are opaque, blue, or dark grey to black, and they have a high efficiency (14–16 per cent) (Compagno 1999). The poly-crystalline solar cells are mostly blue or opaque. Crystalline solar cells are produced as 0.4mm-thick disks, in sizes from 10 × 10cm to 15 × 15cm. These disks are then put together to form modules and embedded with resin in the cavity of a laminated glass unit. According to composition, the result can be either a transparent, translucent or non-transparent module. Light transmission through transparent and translucent modules can be set from 4 per cent to 30 per cent according to the choice of spacing.

Daylighting Systems within the Glazing Cavity

While the preceding section focused on the characteristics of the glass itself, this section focuses on the opportunities of the glazing cavity to accommodate additional levels of daylighting response. The glazing cavity can range from a narrow slot between the glass panes to a large three-dimensional volume. The way in which this space may be used may range from the modest insertion of diffusers, shading and insulation, to a more elaborate integration of daylighting and passive solar systems.

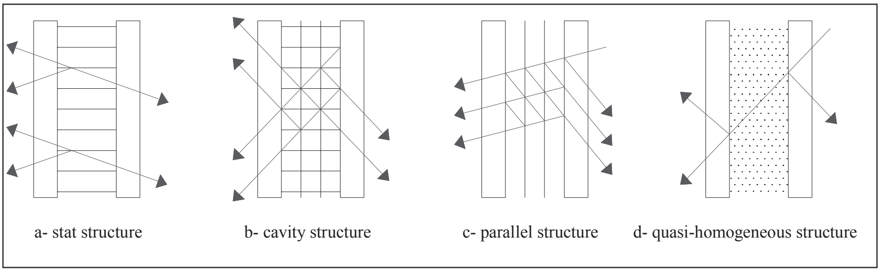
Inert Gas Fills

Traditionally, the space between glazings was filled with air. Air is a very good insulator, as long as it is still. Wide gaps (more than 12.5mm) tend to increase natural convection (heat transfer from moving air). Thus, the further decreasing of the heat transfer between two layers of glass requires the use of a gas with a thermal conductivity lower than that of air. Manufacturers have introduced the use of argon and krypton or xenon gas fills, with measurable improvement in thermal performance. Argon is inexpensive, non-toxic, non-reactive, clear and odourless. The optimal spacing for an argon-filled unit is the same as for air, about 11–13mm. Krypton has better thermal performance, but is more expensive to produce. Krypton is particularly useful when the space between glazing must be thinner than normally desired, for example 6mm. The optimum gap width for krypton is 9mm. A mixture of krypton and argon gases is also used as a compromise between thermal performance and cost.

Transparent Insulation Material (TIM) Fills

These are an additional way to reduce heat losses. The advantage of TIM over traditional insulation lies in their high transmission of incident light and near-infrared radiation. Various transparent and translucent materials can be used for transparent insulation, such as glass, acrylic glass (PMMA), polycarbonate (PC) and quartz foam, in varying thickness and structures. To protect them from the effects of weather and mechanical stress, these layers are sandwiched between two panes of glass.

A division into generic types of geometric media in the structure simplifies their classification. The first group consists of a build-up of several layers, arranged behind one another parallel to the glass surfaces and enclosing separate air spaces. This type of TIM fill is known as ‘parallel plate structure’ and comprises stretched films. Figure 5.21 shows Wigginton’s (1996) generic typing of TIM fills. Type



5.21 Transparent insulation material fills: generic types
Source: Wigginton 1996

(a) has the advantage of lower optical losses, as the incoming beams are reflected several times from the parallel surfaces and transmitted in a forward direction. This opens up the possibility of increasing levels of natural daylight at the back of deep rooms. Type (b) has cavity or capillary structures that are made up of many small plastic or glass tubes. The plastic tubes, of acrylic (PMMA) or polycarbonate (PC), have a diameter of 1–4mm, depending on whether light-scattering properties or higher radiation transmission are desired. Type (c) entails higher reflection losses, an effect which can be partly reduced by the use of anti-reflection coatings. The fill comprises structures arranged perpendicular to the exterior surface, such as louvres (or parallel slats), honeycombs and capillaries, which divide the cavity into small air cells. Type (d) consists of quasi-homogeneous structures, such as aerogels and xerogels, which have microscopic cavity structures. An aerogel is a highly porous filigree structure of 2–5 per cent silicate and 95–98 per cent air, interspaced. Dawson (1995: 21) describes the benefits of this technology thus:

> The advantage of aerogel as both insulator and translucent screen lies in its cellular structure. Its pores' dimensions are smaller than the wavelength of solar radiation, and too small to allow the free movement of air molecules which transmit heat … regardless of season and climate, an even temperature can be maintained across the interior of the room.

This group has high radiation transmission and thermal insulation properties with a fairly high daylight transmittance of 45 per cent (Guzowski 2000). Xerogel is very similar to aerogel, but cheaper because it needs no special drying process during manufacture. As its structure is less homogeneous and the air spaces are larger, xerogel has better radiation transmission but worse thermal insulation properties than aerogel.

Shading Devices

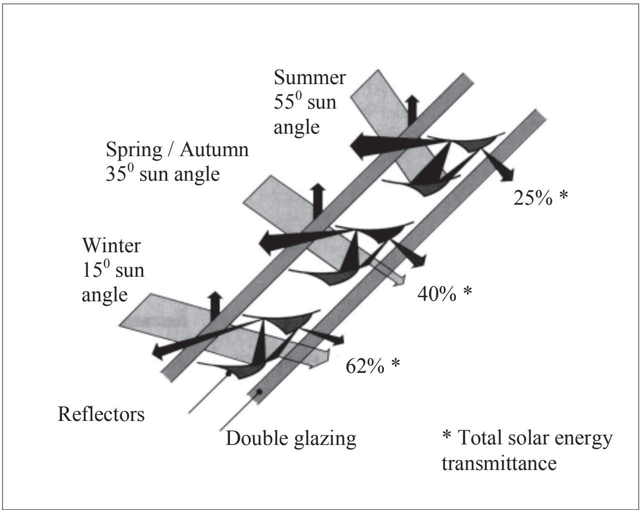
As glazing technologies have evolved during the past decades, so have shading devices. The integration of external and internal shading systems with new glazing assemblies expands the opportunities for daylighting inside the building envelope. Shading usually consists of micro venetian blinds, which can be operated by magnets or a small electric motor.

Mid-pane Blinds

These have several advantages. They provide better protection from the sun's heat, as the heat that is absorbed by the blind is more likely to be emitted to the outside. They do not take up space inside the building, and can be less obstructive to occupants (Littlefair 1999). Difficulty of access, cleaning and maintenance are the main disadvantage of such a system. Only tilting the blind's slats can affect the view out or reduce daylight on bright days. Roller and pleated blinds can also be installed inside double glazing.

Mid-pane Fixed Reflective Louvres

Fixed louvre systems have curved slat profiles, and they are installed inside double glazing to cut maintenance. Figure 5.22 shows a proprietary system with seasonally varying shading performance. In summer, sunlight is reflected back, but in spring, autumn and winter it is admitted and redirected. Inevitably, slat design is a compromise between view, daylight admission and glare.



5.22 Cross-section through curved slat louvre system
Source: Littlefair 1999

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Chapter 6

A Glazed Future: Rethinking Identity

Glass and Modernization

The construction of glass façades and concepts of modernization are still strongly linked in many cultures around the world. Environmentalists, conservationists and traditionalists have been criticizing such links since the beginning of major usage of glass panes in buildings. This perception of modernization has certainly intensified since the advance of the modern movement in the beginning of the twentieth century. In Chapter 1 we discussed the role of leading architects in the early twentieth century, such as Sant' Elia and Otto Wagner, in seeding and promoting futuristic architecture or *modern* architecture based on glass and steel that has no particular links to the socio-economic context. Norberg-Schulz also indicated that 'socio-economic conditions are like a picture frame; they offer a certain space for life to take place, but do not determine its existential meanings' (Norberg-Schulz 1980: 60). In many ways, these views were largely adopted throughout the twentieth century. At the start of the twenty-first century, architecture is facing different challenges that need new concepts to address not only its relations with nature (as described in Chapter 2) but also the questions of global versus local architecture, with the attendant political, socio-economic and cultural complexities (as discussed in Chapter 3). There are also issues related to the emergence of virtual environments as alternative ways of living and the impact of the reality/virtuality on identity and citizenship. The earlier discussion in Chapter 2 suggests that glass façades are partly a product of socio-economic and political forces and that our contemporary construction industry is completely bound up with socio-economic and political conditions. Hagan (2001) compared the façade design to textile art: as we dressed ourselves in textiles, she argued, so we dressed our shelters with them too. Fashion design can indeed be seen within socio-economic contexts. However, just as there was debate at the beginning of the twentieth century, many architecture theoreticians deny the assumption that architecture is the production of the interplay of socio-economic variables and emphasize the need for this link to be readdressed in the twenty-first century. We need to look into the debate over whether consciousness structures the world or the world structures consciousness. The argument shows an intention to separate culture from people. Leach (2002) has criticized the very notion of 'place' and has argued that human beings have the capacity for accommodating and adopting the new worlds offered by new technologies. In this sense, computers and mobile phones have transferred the idea of physical space to encompass a real experience of virtual place. Describing the age of the megalopolis, Lyotard explained that even the concept of 'dwelling' is marked by a form of passage rather than place occupancy (Lyotard 1988).

Hagan (2001) expressed the role of materials in what she called the etherealization of culture. Hagan explained that emphasis on the fourth dimension, a result of the pervasive electronic mediation, led to killing present time by isolating it from its here and now. Hagan argued that the cyberdream and material reality are at present very far away from each other. In fact, this might not be quite true. New technologies in glass, for example, are capable of transforming our communication with buildings in a 'higher' order. The ambiguity of the material tests the ontological order and our direct sensory experience of the world. Progressive cities with futuristic agendas that witnessed major development in the last few years, such as Shanghai, Dubai and Singapore, appear to be suitable contexts for testing these ideas.

Dubai: Regional Authenticity or Positive Trend towards a Future without Identity?

While many cities in the Western world are experiencing difficulties since the recession of the 1990s, other cities in the East are thriving. The crises in European cities are not only limited to the manufacturing industry but also extend to whole swathes of the producer services (Hall 1995). Efforts to transform some European and, in particular, British cities to cultural, educational or entertainment industries (such as Newcastle, Glasgow or Liverpool) have had different levels of success. Newcastle provides a good example of a successful regeneration effort. The city's Quayside (on both the Newcastle and the Gateshead sides of the river Tyne) has been renovated and transformed through a series of prestige projects. The extensive use of glass has added sparkling effects to the area and developed a sense of renewal and renovation. The new Millennium Bridge has linked development on both sides of the Tyne. Following a long tradition of bridge building in Newcastle, the Millennium Bridge has visually united the new development with the old visual identity across the Tyne (Figure 3.6).

The thriving glass façade installations in Dubai, with its peculiar socio-economic and political profiles, make the city an interesting example for exploring questions of identity and authenticity. Until the early 1970s, Dubai was largely a small town hardly noticeable in the architecture world. Since the surges of oil prices in the late 1970s, Dubai has been transformed into an experimental ground for architecture. Figure 6.1 shows one aspect of that transformation. Recently Dubai is increasingly perceived as a successful venture and an interesting model of efficient management that steers successful urban development. This has, however, been tainted with criticism on the grounds of superficiality, fragmentation and loss of identity.

6.1 The Dubai skyline is almost permanently dotted with construction cranes

It is not uncommon for a visitor to Dubai to get engaged in a debate on the authenticity of new development in the city. Positive feelings about the city, generation rather than regeneration, the speed of development and the scale of investment are almost always met by scepticism about relevance, sustainability and, most certainly, authenticity. The local population, the other forgotten factor in the context, is normally either completely ignored or marginalized in this debate. The local population represents a fraction of the total population of the city. Dubai is claimed by more foreigners than its indigenous population. It is the '*wanderers*', the contemporary 'gypsies of the world' who claim the city. We can argue whether or not the wanderers constitute the contemporary model of living, with their skewed and obscured sense of home – *domus*. Dubai represents an extreme case, with less than 20 per cent of its population being truly 'local'. How can developers maintain a distinguished local identity with such a skewed population pattern? The governing and management bodies of the city have realized that local authenticity is, in fact, a myth in Dubai. In its initial attempt to present a logo of mingling the past with contemporary living, Dubai has previously under-represented the future living it intends to produce. The city politicians and developers, in most cases under the same governing body, moved from references to elusive historical relevance to focus on a more futuristic approach for the development of the city. Cities in the region have struggled with reflecting their past, or the lack of it, in the architecture of their built environment. In an attempt to create contemporary cities, glass façades seem to provide the ultimate solution. The Hong Kong model of the early 1980s was praised in the region as a successful corporate image that defies historical roots and should be imitated. The cultural profile of the local population maintained, however, a separate identity with mediocre architectural styles that attempt to make some historical gestures using combinations of stone and concrete. Neither of these approaches is authentic. Dubai, with its interesting corporate-style management, has opted for a fourth dimension where all materials are relevant in a dominant glass environment. Dubai is creating an environment that is neither real nor virtual. The city is selling the future cyberdream whose possibility was denied by Hagan. The city, in this context, can be seen as an experiment in the evolution cycle of human settlements. Many ingredients have provided Dubai with a unique opportunity to create such an identity-less place. The relatively sudden influx of investment and abundance of resources and cheap labour in a raw but well-managed context, all contribute to this unique experiment that is increasingly being taken seriously globally. The full potential of such a model might, however, be lost if the boundaries of this experiment are not realized. The success or failure of Dubai should not be debated on the basis of its proclaimed regional authenticity or its relevance to its socio-political context. Dubai should be seen as a concept; an action research with a set of hypotheses that continue to be shifted and modified. In order to argue our case, we have to shed more light on the contemporary understanding of the transformation of what we call 'place'.

Domus and 'Place' in Dubai

The traditional forces that shaped other cities are much less relevant in Dubai. Transport, rivers or proximity to raw materials do not constitute any of the major factors that are developing the city. Unlike many cities in Europe, Dubai does not have an industrial base, very little historic base and no major raw material base. Unlike the perception of being an oil-rich emirate, Dubai actually has very limited oil. Such traditional forces therefore have been replaced by new factors such as globalization, instant information and also '*disneyfication*'. It is the latter that has actually regenerated Dubai. The recent development in the city can be compared to the creation of cities and towns that were generated by North America's nineteenth-century gold rushes.

With the disappearance of boundaries between nations and the continuous shrinkage of distances, the understanding of nations, homeland and home as fiction will be clearer. It is precisely these words that contain a potential for violence. Dubai should represent itself away from such words. Emphasis should be upon universalizing the city, where differences becomes irrelevant. The promotion of current planning practices where the city is divided into bits, sections, neighbourhood and community-based centres should be abandoned. It is with such structures that differences appear and intolerances, sectarian and political divides flourish.

The new development in the city is based on perceptions rather than realities. The city is interestingly run as a major economic venture, owned and promoted by five major companies. The promotion seems to be based around a model of coping with globalization through provision of high-level services and information infrastructures that are made possible through cheap labour from the Asian subcontinent. The five companies, with rigorous systems of control, have successfully exploited major recent political and economic incidents. Such incidents are not always benign but were fully transformed into opportunities in the city. These include, among other less respectable events, the move of Arab investors away from the American and European investment market after 9/11 as well as provision of migration opportunities through lavish investment from the subcontinent.

Architectural approaches that are grounded on Heidegger's notion of place and its authenticity are not relevant for Dubai. Fredric Jameson (1998) has argued that authenticity is prone to collapse into its opposite. Dubai has followed trends in the West to regenerate city centres through schemes to search for authentic local experiences and made-up heritage attractions. The result is a confused mix of visual experience in the city centre. In Dubai, attempts to provide authentic gestures are in themselves somewhat representative of the inauthenticity of Disneyland (Figure 6.2). Dubai does not have to deal with the dilemma of what constitutes an authentic architectural tradition, as discussed in Chapter 2. The question of whether the immediate or the distant past presents such tradition is simply not applicable. It is interesting to note that such questions might actually be more relevant to the 'unreal' Disneyland than to Dubai itself. Dubai is complicit with a broader deception. Rather than playing on the false symbolic nature of 'future living with local roots', Dubai should declare itself unreal in opposition to the real world outside. By positing itself as 'unauthentic', Dubai can really pose an authority of hyperreality to the world outside. The new model requires a more imaginative urban visual environment that can mainly be represented by the urban fabric. Glass façades, as well as glass sculptures and entities in public places such as the proposed metro, are perceived to provide a further step in this direction.

6.2 Burj El Arab, Dubai (2000)

Dubai has successfully promoted itself as a city of opportunity. By eliminating problems such as overcrowding, disease, social disorder, conflicts over land or lack of infrastructure, the city has emerged as an alternative model to urban living in the twenty-first century.

Such achievements did not come without very high economic and social price tags. While problems (such as dissatisfaction with the physical environment, anxiety about failing infrastructure or fear and alienation) might not be expected in the city, others (such as divisions and diminishing sense of locality) are of concern. The fear and alienation that are experienced by inhabitants in other major cities do not seem to pose problems in Dubai. CCTV systems are common in indoor and outdoor shopping malls, in housing areas and other public places. In fact, the crime rate is very low to justify such intrusion on privacy in an ultra-conservative society that is exposed to an unprecedentedly transparent urban model. The applied social structure in Dubai means that the highly selected foreign workers who comprise the bulk of the population (more than 75 per cent) are unlikely to become engaged in the serious crimes that endanger public safety. Interestingly, while CCTV systems are sharply resented by the local population, transparency of their own glazed urban environment, including housing blocks, is welcomed.

Conflicts in cities that arise from dissatisfaction with the physical environment are also not applicable in Dubai. The expansion of the city southward as well as expansions to the west and even into the Gulf (for example, the Palm project), combined with the monopoly of the five major construction companies, means that no spaces are contested.

6.3 Artist's impression of Dubai's proposed train station

The vast expansion in the city in the last ten years has led to fear of division due to mobility. Unlike Western cities, division is not based on the degree of mobility among older populations and young couples, or on environmental concerns (for example, the impact of polluted city centres). The fear of expansion in Dubai is over the socio-economic division involving the imported cheap labour. This fear led to an ambitious programme of a monorail public transport network to serve the city, a futuristic vision with fully glazed, elevated terminals (Figure 6.3).

6.4 General view of Dubai, where isolated glass towers pierce the skyline

Such growing divisions in the city remain a major threat to its harmony. Dubai is socially fragmented. The labour market is divided between highly paid managers and professionals and the low-paid labourers. Unfortunately, the division in some cases is also expressed on racial and gender lines. Such division provides the basis on which contemporary Dubai is built. The Gulf States were able to position themselves between the masked European liberal attitude towards immigrants and the economic needs of the populations of many Asian and African regions. The city and its architecture emerged to reflect such a position; it perceived and visually expressed opportunities that are restricted by invisible socio-economic barriers. By the time the workers comprehend the limitations in realizing, but not eliminating, their dreams, they are replaced by a new wave of dreamers and fortune seekers. The city is, therefore, and in many ways creates, a hyperspace, a wonderland that people experience with no real contribution to it or exploitation of it. The tool that is fuelling this hyperspace phenomenon is, as David Harvey described, contemporary planning; aesthetics rather than ethics, with glass in the forefront of the new city fabric (Figure 6.4).

The diminishing sense of locality and identity is presented, in literature that describes Dubai's experience, as a problem and remains as a concern to Western visitors and professionals of the built environment. In reality, the glazed urban living does not raise any anxiety among either the local or foreign population. There are several reasons for such attitudes but the over-arching reason is an economic one. Unlike many Western cities, benefits from the presence of foreign workers are very visible and explicit. Globalization of the city is seen as a positive development towards a perceived prosperous identity-less future. Difficulties that arise from the temporary nature of these waves of inward migration are controlled through strict immigration policies.

It is not until recently that the rulers of this small emirate have realized that generation of knowledge through creativity and innovation, matched by rigorous systems of management control, can be the key to the development of the city in the twenty-first century. Despite the boom in investment in the construction industry, Dubai has failed to make creativity a central issue of any plan for its sustainability in the next 50 years (Figure 6.5). The success of great European cities in the nineteenth century was due to the creativity of scientists, planners and engineers. Landry and Bianchini (1995) explained that such achievements were not merely physical and that psychological and social dimensions were also integrated ingredients that led to the early success. While we realize the important role of users and participants in the regeneration process, planners and other built environment professionals still put emphasis on the physical dimension. In fact, focus on the physical dimension should be shifted. We know that erecting a series of gated cities will not lead to improved security and enhance a sense of place and mutual responsibilities in communities and neighbourhoods.

6.5 'Disneyfication' of Dubai, using some historic gestures

The development of glass has no doubt influenced the direction of progress in architecture. This influence is likely to increase in the future. After more than 3000 years of development, we have just started to use its truly illusive visual and physical nature in architecture. Since its discovery in the thirteenth century BC in the eastern Mediterranean region, fascination with glass has been mainly for its transparent qualities. While completely sheltered from natural elements, glass still allowed us to continue observing our 'real' outside environment. Glass panes separated, while visually connecting, the 'inside' and the 'outside' of our real world. As the volume of our virtual world increased at the expense of the real world, glass evolved and renewed itself to serve the new era. In doing so, glass turned to reflect its illusive self. The Queen of Sheba pulled up her robe from the glass floor of Solomon's palace, thinking that it was a lagoon. Similarly, we can now look through glass to observe other dimensions of virtual reality. Architecture, with the assistance of glass, will move to uncover new virtual worlds. Our windows will allow us to observe different worlds. This will not come without a price. What are now perceived as collective identities might soon be issues of the past. Our desperate attempt to preserve cultural identities, whether on national, regional or local bases, may disappear altogether. Glass has diluted such identities since we were separated from our own natural environment while still allowing ourselves to observe it. We even pursued a dream of capturing our natural environment and imprisoned it under glass envelopes in the greenhouses and great exhibition halls of the eighteenth and nineteenth centuries. We were further alienated when the modern movement used glass as a synonym for a new spirit in Western societies. All these attempts have actually taken us further and further away from our identities and realities. The contemporary effort to reconcile glass with environment is not a step backward towards regaining our environmental roots but rather a further development, or regression for many, towards virtuality. A cutting-edge intelligent façade with its glazing features is creating a buffer, a theatrical zone, where we ought to believe that nature is manipulated for our own comfort. Soon, visual manipulation, digital transformation and animated images will also be developed in this zone. Glass technology is developing fast to capture and display animated images on façades. The sensors embedded in glass façades already have learning capabilities for recording, analysing and reacting to climatic data or users' behaviour. It is not difficult to see how animated and reactionary glass façades will soon be developed to entertain us in a new virtual world. Glass will continue to reflect a peaceful and prosperous context. In a more and more polarized world, glazed façades will flourish where clarity and transparency become the required or the pretended values of a society. Tension, whether political or economic, would hinder glass development in the same way as the third-century turmoil of the Roman Empire did. The development of glass might not be everybody's taste as it would express and even encourage a 'harmonious' material culture – a culture that is moving steadily towards virtuality at the expense of reality. In all cases, glass technology will continue to improve and will have a larger share as an architectural material in the future of the construction industry. Scheerbart argued in 1914 that our culture grows in the closed rooms that we build and that the only way to raise our aspirations is to change the architecture of those rooms through extensive use of glass. His aim would be to use glass to create architecture without buildings; an ultimate desire of *techne* where aesthetics and function merge together. We are on the threshold of creating the architecture of mental images. We might like to argue about the higher levels of culture but glass is changing our architecture and hence our lives and will continue to do so.

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