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Design of the Atrium Roof for the Imagination Headquarters, London

Projet de la converture de l'atrium du siège principal d'Imagination, Londres

Entwurf der Atriumbedachung des Imagination Hauptsitzes, London

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SUMMARY

This renovation design has transformed the new West End headquarters of a design and communications company. The revitalised building, comprising two parallel blocks, linked together with multi-level walkways through a central H-shaped atrium, has attracted critical acclaim from both the lay public and designers, winning several awards. This atrium roof cover is tailored to suit the complicated geometry of the old buildings.

RÉSUMÉ

Dans le West End de Londres, ce programme de rénovation a transformé le nouveau siège principal d'une société spécialisée dans la communication. Le bâtiment, rajeuni, composé de deux blocs parallèles reliés sur plusieurs niveaux par des passerelles enjambant un atrium en forme de 'H' a reçu les louanges du public et du monde professionnel et a obtenu de nombreuses récompenses. La couverture du toit de l'atrium s'adapte à la géométrie compliquée de ces anciens bâtiments.

ZUSAMMENFASSUNG

Der Bericht beschreibt die Renovierung des neuen Hauptsitzes einer Design- und Kommunikationsfirma im Londoner West End. Das Projekt umfasst das Zusammenfügen von zwei bereits bestehenden parallelen Bürogebäuden unter Verwendung von Fussgängerpassagen auf verschiedenen Ebenen und einer Membrandachkonstruktion, welche der komplizierten Geometrie der alten Gebäude angepasst werden musste und zu einer hellen Atriumsatmosphäre beiträgt.

Introduction

The existing building of Staffordshire, a rather drab, Edwardian Ministry property, presented an imposing five storey brick facade in a slight crescent off Store Street. Six to eight metres behind, and linked by a brick-built toilet block, stood a second four storey block, reconstructed after the Second World War. The unused and extremely bleak brick faced gap between the buildings absorbed most of the lighting penetrating the space. Ron Herron of architects Herron Associates, put forward proposals to transform the building, including demolition of the connecting link between the blocks and replacing it with skeletal metal bridges. (Fig. 1) This would emphasise the narrow gap which he tentatively suggested could be covered with translucent fabric wrapped down the ends to create a unified atrium space. With the construction of ground floor and partial first floor slabs within the atrium, the basements of the two buildings could be combined to create a very large floor area for many of the client's technical functions, including some recording studios and video production units. With alterations to the drab interior, an eighty year old building could then adequately provide the flexible, open plan space required by a high tech company, whose image is of prime importance. The client was most enthusiastic, and Buro Happold was appointed structural, fire and services engineers for the project.

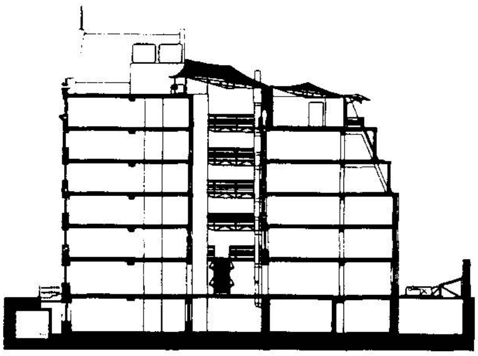

Figure 1 : Cross Section

Choice of Atrium Roof

Initially a glazed roof was considered to enclose the inner courtyard between the two buildings. However, not only was this an expensive solution requiring a substantial support structure, but the complicated geometry of the opening would have led to a very irregular structural layout. Use of a stressed fabric structure gave greater freedom to cover the space with the minimum of support structure necessary to accommodate the complicated geometry. Such a roof has a very low self-weight, the fabric weight of 1 kg/m^2 being only 5% that of glass. Typically such fabrics let in between 10% and 15% of visible light, sufficient to give a surprisingly strong light inside the atrium but also reflecting to the outside a sufficient part to avoid excessive heat gain.

The scheme which was developed provided a roof across the inner courtyard which continued over the roof slab of the rear building. This created a gallery space on the roof, thereby providing a useful and economical additional floor area. It was also planned to continue the roof down both ends of the newly created atrium to give an impression of a fabric wrapping to the building Christo-Style'.

Roof Structure and Detailing

Even with reasonable double curvature, for fabric to the stable under applied wind and snow loads it must be prestressed typically to 150 or 100 kg/m2. Under wind these stresses will increase to about 600 kg/m2, and must be resisted at the boundaries of the fabric. As it was felt that the existing structure would not be able to resist such a level of force between the buildings, a lattice strut supporting structure was developed across the building. A gutter and beam supported on columns divides the membrane on the line between atrium and gallery, and glazing on this line separates the stress (Fig.2). The lattice struts are also supported on this line and a second set of struts span over the gallery to the rear elevation. The whole roof is anchored in the transverse direction to the front block only (Fig.3).

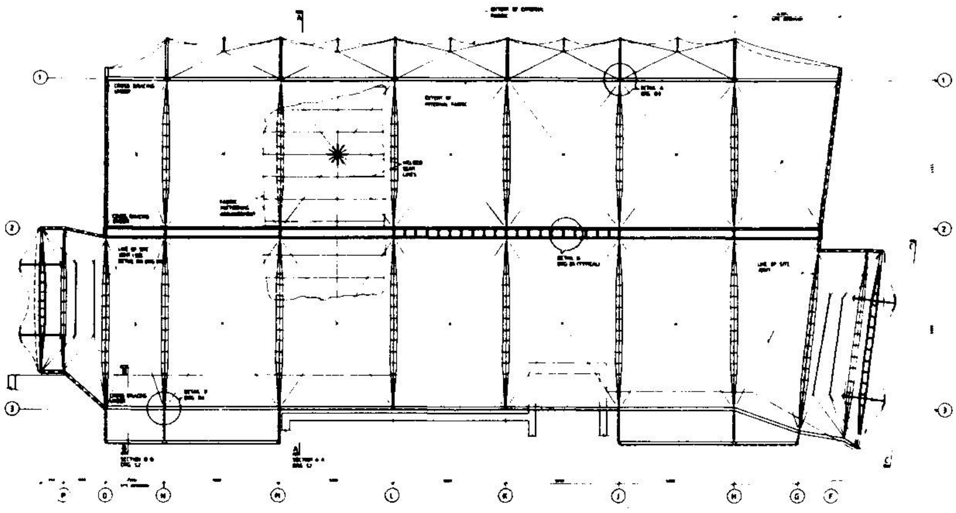

Figure 2 : Roof plan of Atrium

The fabric is supported by umbrellas on flying masts which stand on bridle cables running back to the ends of the struts. Generally there are single masts in each bay but at the ends the masts are in pairs to achieve the required shape and level of support to the membrane. At the ends of the atrium the fabric is attached to a triangular lattice truss designed to take the fabric forces in bending. Beyond the gallery the fabric oversails the glazed wall, creating a canopy. This narrow band of fabric is given shape by a series of flying struts which push the edge of the fabric down between cantilevering arms.

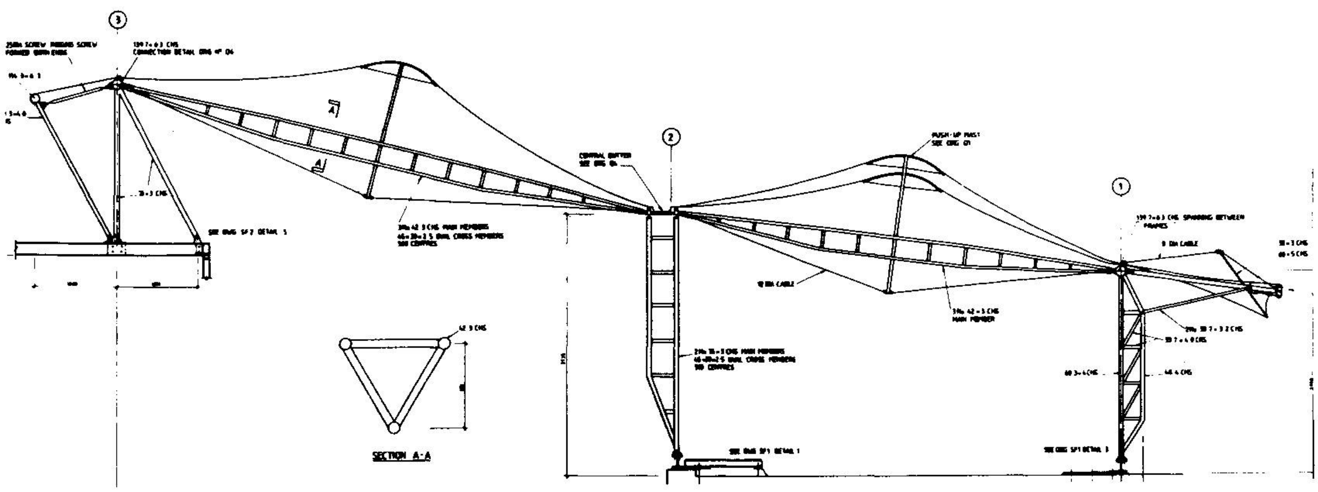

Figure 3 : Section through Atrium roof

Details had to be designed to enable the fabric to be prestressed, and had to include means of pulling or pushing the fabric into shape and maintaining it under load. Where it is attached to steel perimeter members the fabric passes over the structural tubes. Small steel tubes running inside pockets in the membrane are screwed down to small blocks on the side of the perimeter tubes, the screws providing adjustment at the edge to ensure a good fit of the fabric. Final tensioning of the fabric is applied by jacking up the flying masts, achieved by turning a threaded shaft which passes through the lower support point.

The normally flexible fabric is stiffened to resist loads by virtue of the double curvature and prestress induced by the boundary and support conditions. To achieve this condition, the fabric has to be accurately tailored to the prestress geometry, determined by a computer form-finding process where stresses are specified in the membrane surface which then moves to its equilibrium position (Fig.4). The resulting numerical model is used for load analysis and finally to produce the cutting patterns to which each panel of cloth is tailored. This total process is carried out in-house using specially written software so allowing the designers total control of the fabric shape and detailing essential for such a complex roof.

Fabric was patterned with 1m wide cloths cut from a 2m wide roll to conform to the well developed curvature of the roof. Cross seams were introduced at the mast heads to create the required dome shaping in those areas. Stretch under load was measured by laboratory tests and fabric was consequently adapted by 0% in the warp and 2% in the fill direction to compensate.

During the design stage, consideration was given to using either PTFE-coated glass cloth, silicone-coated glass cloth or PVC-coated polyester for the atrium roof membrane. It was difficult at this stage to obtain approval for PTFE glass because of concern over possible production of toxic fumes during a fire. Such worries have since been dispelled and it would probably now be permissible to use this long lasting material. As an alternative, silicone-coated glass is difficult to obtain, consequently very expensive, and problems would have arisen in obtaining an adequate supply for the project. Consequently it was decided to use PVC-coated polyester fabric with fluoropolymer lacquer on the grounds of cost and expediency.

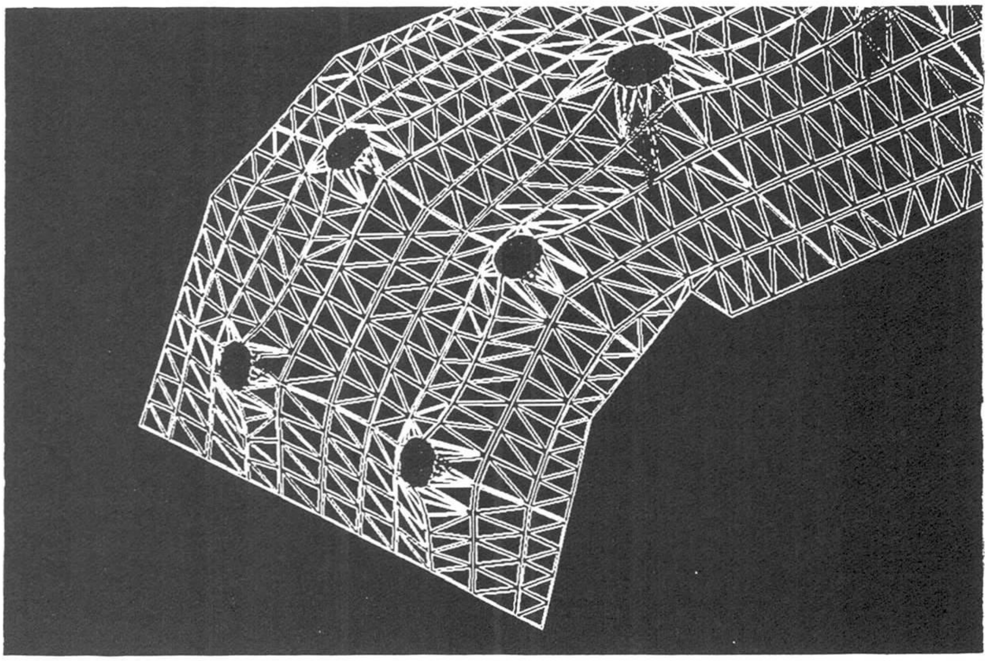

Figure 4 : Computer analysis of roof form

Fire Engineering Considerations

Buro Happold was also commissioned to carry out a fire appraisal of the spaces beneath the membrane roof of the atrium and roof gallery. A report was submitted to the local authority - London Borough of Camden - and its recommendations formed the basis for the fire strategy in these spaces.

The atrium was intended for transient use with a low fire load at least four storeys below the roof. It does not form part of ny fire escape route as the front an rear buildings both have their own independent means of escape. Furthermore, the buildings on either side are isolated by half hour fire glass in all windows and fire doors. In the event of an atrium fire, optical and smoke detectors will trigger an alarm and bring into action the smoke ventilation system. This comprises low level inlet panels which open automatically in the vertical side screens to the atrium, and high level louvres with extract fans.

The roof membrane itself does not support combustion, and when impinged on by flame does not drip. It is merely burnt and vaporised locally around the impinging flame, and is then self-extinguishing. If air temperatures in the atrium reach around 250°C it is anticipated that the PVC adhesion at welds would begin to reduce and seams would slide apart and open releasing the pre-stress, so improving ventilation of smoke. If temperatures then rise to much higher levels, and flames reach the membrane, local burning will take place and ventilation would be improved even further. With such a high level of ventilation assured, internal temperatures could not reach those more common in restricted compartment fires.

Whilst this type of membrane has been in use in structures worldwide for at least thirty years, it had not been used in such a way before in London or indeed anywhere in the UK. Despite the arguments of the fire report, Camden Building Control were not willing to set a precedent by making a favourable decision on the use of membrane for the atrium covering.

On application to the Department of the Environment for a determination there was no hesitation in accepting the use of the material for a roof. However, as no large scale tests are known to have been carried out to simulate the behaviour of vertical walls of fabric was not acceptable without demonstration. As there was insufficient time to conduct such tests, the intention to continue the roof membrane down on either side of the atrium to second floor level was deferred. As an alternative, the side walls are designed as more conventional fire panels supported on a steel grillage spanning between the two buildings.

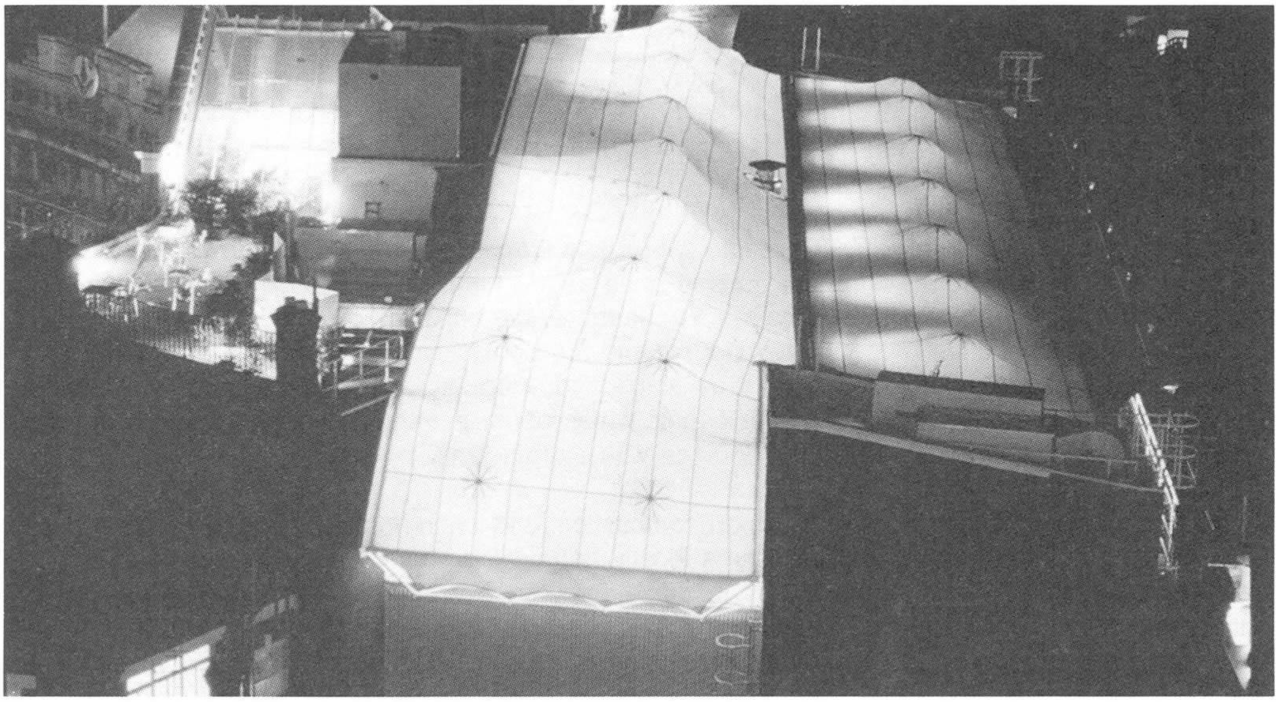

Figure 5 : Atrium at night

Conclusion

An extremely rigorous £5m refurbishment programme was thus completed in less than one year, with contractor R M Douglas Construction working on upper and lower floors simultaneously. In the words of the judges at the British Construction Industry Awards Staffordshire House (Fig. 5) is a 'landmark scheme to bring new lift to old buildings against which other refurbishment projects are likely to be judged for years to come'.