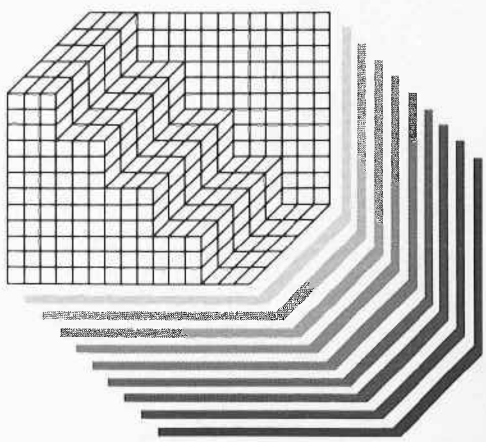
Patterns 10



Patterns 10

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Contents

Introduction

This tenth issue of Patterns is, so to speak, a Christmas Cracker – full of the unexpected and perhaps just a little bit unpredictable!

The bulk of our work over the past 15 years has been the engineering and design of projects to mostly conventional briefs, executed by large, multidisciplinary teams with engineering only a part of the whole process – albeit an important part. However, over the years there have been other, more unusual commissions, which because they were small, or singular or not actually constructed, have not yet made it into the records – but nevertheless are themselves interesting and were certainly absorbing at the time to those of us who were involved with them; some of the thoughts we had then subsequently arose in other more recent projects.

This issue is about twelve such projects – one for each day of Christmas.

Michael Dickson

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Christmas Decorations for Imagination Ltd, London

Project data

Client and Designers	Imagination Ltd
Structural Engineers	Buro Happold

November comes round again, the phone rings and Imagination Ltd is on the line. At this time of year that can only mean one thing – time to give structural advice for the Christmas decorations they have designed to adorn the outside of their offices for the festive season.

It all started back in 1986 with the banners – seven 8m high × 1m wide fabric banners printed with crackers, candles and puddings, and decorated with lights and tinsel which were required to hang perpendicular to the front wall of Imagination's old office building in Bedford Street, Covent Garden (Fig 1.1). The 200 year old front facade of this building is of natural stonework with a stone parapet at the top which was too delicate to carry the potential wind loads on the banners. An intricate temporary support system was designed to hang the banners over the parapet with loads counter-balanced by deadweight behind.

Fig 1.2 1987 – Seven decorated vertical ladders between windows

Fig 1.1 1986 – Seven 8m long printed banners adorning Bedford Street facade

The next year it was the ladders – seven 6m high scaffolding ladder beams placed vertically between the windows and decorated with a solid mass of Christmas trees, real fruit, and neon berries and bows (Fig 1.2). The dead weight when dry was significant enough, but the potential weight when wet and covered with snow was sufficient to make Imagination question the capacity of the facade to carry the loads. It had been envisaged that the ladders would sit on the stone cornice at first floor level, but because of other stone mouldings on the facade, would be fixed 300mm clear of the face and would therefore have loaded the delicate cornice near its edge. A special bracket fixed to the wall was designed to carry the load back to the wall/cornice intersection, the out of balance horizontal forces taken by the fixings which were bolts screwed into sockets inserted into the stonework. Additional restraint fixings were positioned further up the ladders to hold them back to the walls. Rigging wires were attached to the top anchors to prevent the ladders from falling should any of the support fixings fail.

The system was adapted in 1988 to support a circular truss ring which was to be decorated in a similar way. It was important that as many as possible of the original socket inserts were re-used to avoid peppering the facade with holes. Consequently, more of the load was carried by rigging wires than in the previous year because the support bracket positions did not all coincide with the necessary points of support of the ring, whereas rigging wires could move away from the perpendicular and still be effective.

And so to 1989 and 1990 and Imagination's new building in Store Street. The old soft brickwork facade of this building presented many of the previous problems. For 1989 the ring truss design was adapted for the new building except that this time all the load was carried by rigging wires fixed to anchor points between the windows (Fig 1.3). As the ring was quite flexible it was not possible to

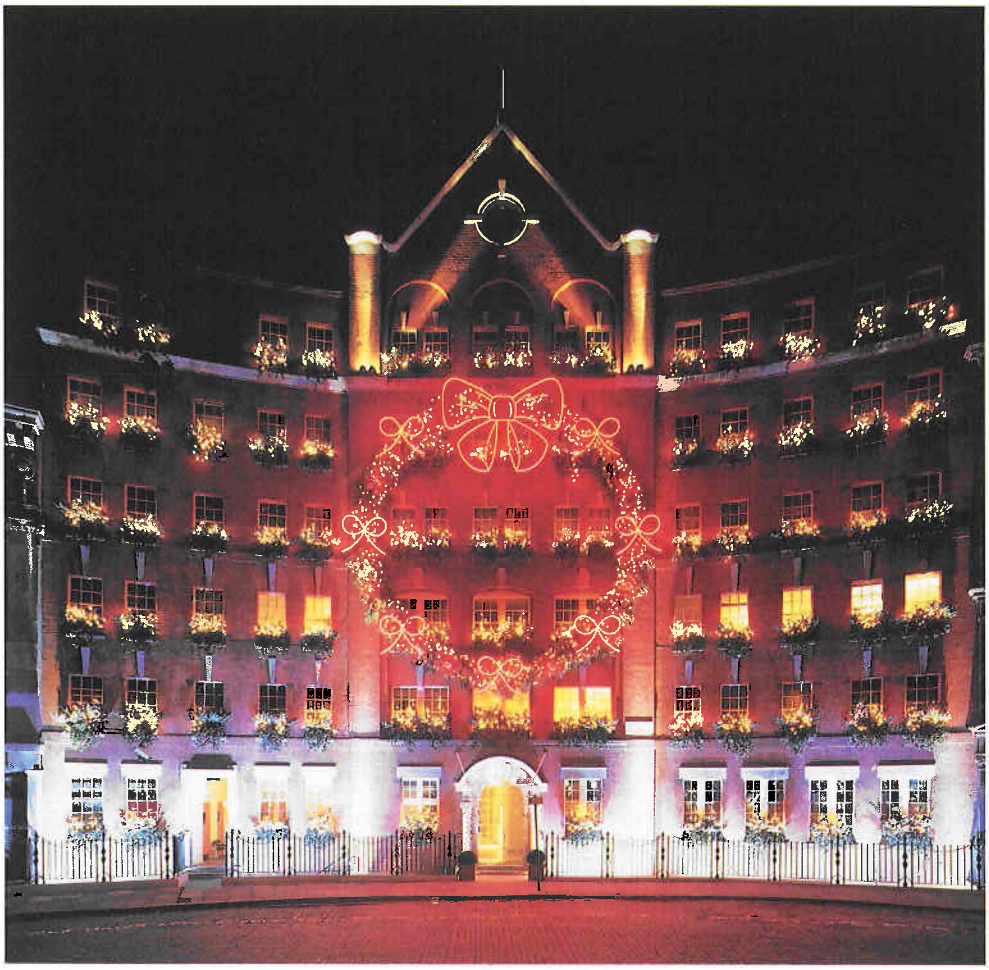

Fig 1.3 1989 – Decorated ring truss on facade of new Store Street headquarters

accurately determine the load at each fixing point of the rigging wires. The system was designed with an amount of redundancy so that failure of some of the fixings would not cause the ring to fall. As many of the anchor points as possible were positioned so that loading was in shear, the strength of the fixings in the soft brickwork being more certain in shear than in pull-out. In 1990 a 'swag' suspended between two ladders (Fig 1.4) was chosen for the festive decoration but the principles of construction and erection developed for the previous years were the same.

The new offices in Store Street have a unique fabric covered space separating the two original buildings (Ref.1.1). Into this space (Fig 1.5) a Christmas tree has been placed each year. The insertion of the tree is a feat of shoe-horning in itself, but the tree must also sit in the midspan of a floor only designed for a light live load. A special shoe has been designed to spread the load over a wide area and is skilfully disguised within the decorative base of the tree.

Each year the operation to erect the decorations takes place over a weekend, and involves a team of scaffolders, a team of riggers, a huge crane and cherry-picker, a team of electricians, a team to hang the decorations, not to mention a structural engineer and a very nervous Managing Director of Imagination, Gary Withers. It relies on the skill and commitment of all involved and the organisational skills of Imagination Ltd. Safety of the decorations is paramount and is checked by the structural engineer as the erection proceeds. Problems encountered are solved immediately because of time constraints, but the annual event is fun for all involved.

We await the design for this year's decorations with anticipation, wondering what Gary Withers has in store not only for the masses of Christmas shoppers who come to gaze but also for ourselves, who as his structural engineers have to be certain of the structural safety of the design and its implementation.

Glyn Trippick

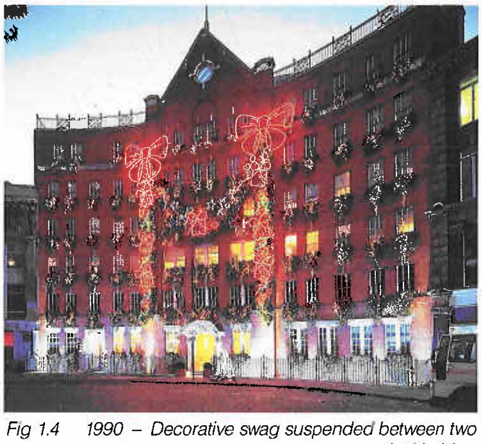

Fig 1.4 1990 – Decorative swag suspended between two vertical ladders

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Fig 1.5 Christmas tree in specially designed 'shoe' occupying fabric-covered space between Store Street buildings

The Lifting of the Calshot at Ocean Village, Southampton

Project data

Client	RAPD
Civil Engineers	Buro Happold
Contractor (civil)	Dean & Dyball
(marine)	Marintec
(lifting)	Sparrows
Project Value	£200,000 approx
Completion Date	Lift – 25 January 1989, Project finished March 1989

The Ocean Village development at Southampton has been fully described in an earlier issue of Patterns (Ref 2.1). In the initial stages of the scheme there was obviously a great need to concentrate on infrastructure, construction of the commercial buildings, and completion of the marina to get the project off the ground and quickly operational on a commercial footing. As the pressure eased however, the client, Rosehaugh Associated Ports Development (RAPD – a joint company between Shearwater Property Holdings Plc and Associated British Port Holdings Plc) was able to turn attention more to improving the quality of the environment on the project. The history of Southampton, and particularly the former Princess Alexandra dock, provided an obvious nautical theme to add the final finishing touches to the development. RAPD, in the person of their then Managing Director Ian Pearce, sought to make a somewhat grander statement than mere decoration with the flags, masts, anchors and buoys of everyday maritime memorabilia. The solution presented itself when the Calshot Spit lightship became available for sale, and was promptly purchased by RAPD from Trinity House.

The Calshot Spit, an iron-hulled vessel, was built by Thorneycroft in Southampton in 1914, and although there are no records to show where she was stationed prior to World War Two, she saw service between 1939 and 1951 in and around the Thames estuary. She was later stationed in the Solent, off Calshot Spit until the beginning of 1987, by which time she had become an unmanned lightship and all available space within her had been filled with expanded polystyrene foam.

The overall proposal was to refurbish the lightship and place it into a 'dry dock' final resting place on land, where she would become the focal point of the Ocean Village development (Fig 2.1 a,b). This fairly straightforward concept proved somewhat harder to bring to practical fruition. Many options were put forward, including a lift from water onto land from a barge-mounted crane; utilising the disused RORO ramps to haul the lightship onto land, either on a hovercushion or sled; or lifting it from the water using a land-based crane. Another idea advanced was to dismantle the ship and reassemble it on land with perhaps the hull being cut off at the water line so that no dry dock excavation would be needed for the boat itself.

Fig 2.1b Calshot in her final resting place

Fig 2.2 Purpose-built dock awaiting transfer of lightship

All these schemes presented both practical and financial problems and were debated at length. However, in late summer of 1988 a firm decision was taken to proceed, and the Calshot was removed from the marina and taken to Marintec's dry dock to be refurbished. It had been decided to lift the boat from the water into a cofferdam construction (Fig 2.2) located between Canute's Pavilion and the Savannah House office building by means of a land side crane. The space available for the cofferdam was small, and certain clearance criteria had to be maintained to conform to City of Southampton planning requirements. It was also necessary to divert utilities, including an HV electricity cable, in the vicinity of the cofferdam. Clearing the area for the lift further involved moving operational portakabins occupied by various marina activities, relocating electrical switchgear and overhead lines, and temporarily removing the marina pontoons in the vicinity of the project. The proposal was to instal the Calshot into its dry dock with its water line coincident with the ground line around it. To do this precisely within the space

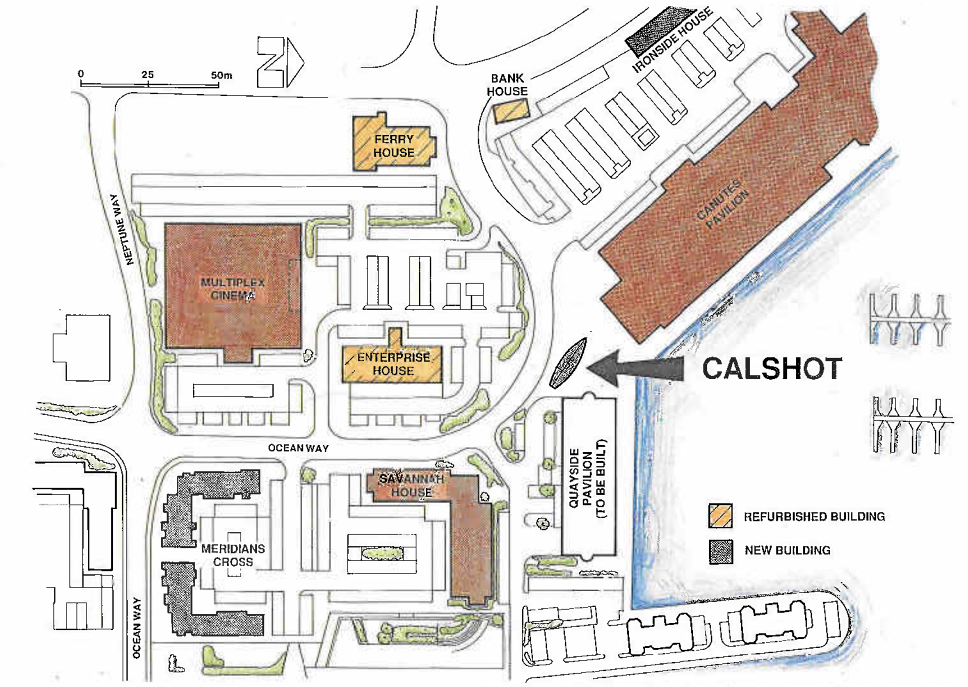

Fig 2.1a Location of Calshot within Ocean Village complex

constraints, the hull was surveyed and measured whilst the boat was being refurbished in dry dock (Fig 2.3 a,b).

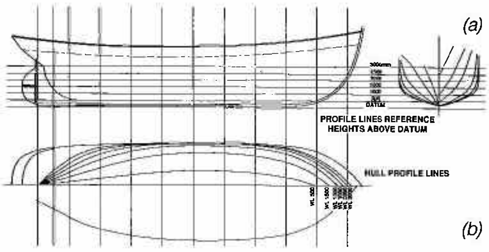

Fig 2.3 (a) Sections through hull of lightship
(b) Plan of lightship hull

Under the critical eye of Richard Free of RAPD, the refurbishment work and lifts were undertaken by Marintec represented by Bill Dunlop, with civil engineering works and site co-ordination carried out by Buro Happold, with Andrew Wood as Resident Engineer. The lifting operation was carried out using a Sparrows 1000t truck-mounted crane with superlift. This crane took almost two days to assemble, and to avoid additional loadings on to the old harbour walls, the areas under the crane feet were piled using four continuous flight auger piles.

As co-ordination of these various activities crystallised, RAPD decided to proceed with the lift at high tide on the morning of 25 January 1989. Watched by many guests and bystanders, together with local press and television, the exercise commenced at around 10.30am (Fig 2.4). Once clear of the water, the hull was hosed down, inspected and then positioned over the cofferdam. The moment of truth approached when we would know by the most empirically demanding test if the cofferdam construction was large enough to receive the vessel! (Fig 2.5) In the event they fitted hand in glove, and the relief that their co-ordination had been successful was very apparent in both marine and civil engineering groups. Apart from everyone's satisfaction on completing a rather unusual project, perhaps the most rewarding remark was overhead from a RAPD director who 'Wondered what all the fuss was about? It was easy wasn't it!?'

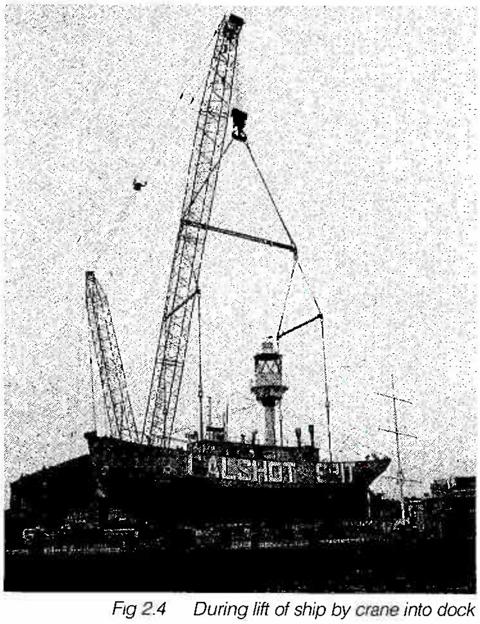

Fig 2.4 During lift of ship by crane into dock

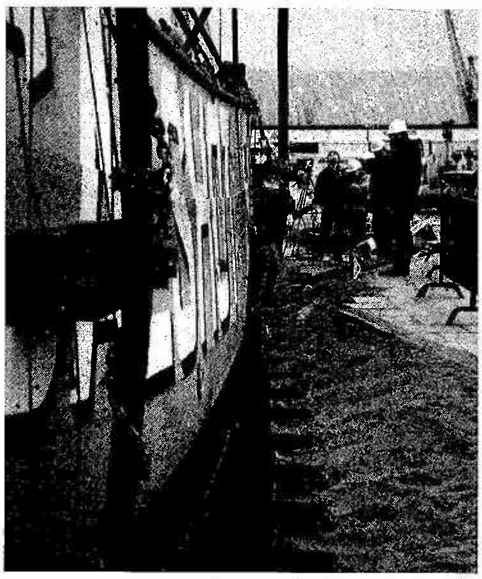

Fig 2.5 Tight fit of Calshot in dry dock

Lighting design was implemented to show the ship as it is, rather than to light it as a sculpture or monument (Fig 2.6). Four elements were chosen for emphasis – the light, bow, masts and interior.

No attempt was made to reproduce a true revolving lightship light as its proximity to shipping may cause confusion. Rather a single high wattage metal halide lamp was positioned in the lantern, with a diffusing translucent film applied to the inside of the glass lantern to reproduce the feel of the original light. Two floodlights placed at the bow created a graduated wash along either side of the ship, so giving the effect of bow spray and some impression of movement. The cabin, masts and ropes were lit by deck-mounted floods aimed at the leading edge, reinforcing the impression of forward movement. Tungsten lights used in the cabins created a diffuse glow through cabin windows, suggesting a warm, occupied interior.

In the days and weeks following, the cofferdam was filled with sand and gravel and hard landscaping around the boat was completed.

Since completion the Calshot has stood at the entrance to Ocean Village as a very prominent symbol of the development's maritime association.

Vincent Grant & Paul Ruffles

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2.1 MacDonald R, Grant V, Clark R and Moseley P. 'Ocean Village – Regeneration of Princess Alexandra Dock, Southampton' Patterns 3, pp 15–19 August 1988.

Illustration credits

2.1b, 2.4 P Carter

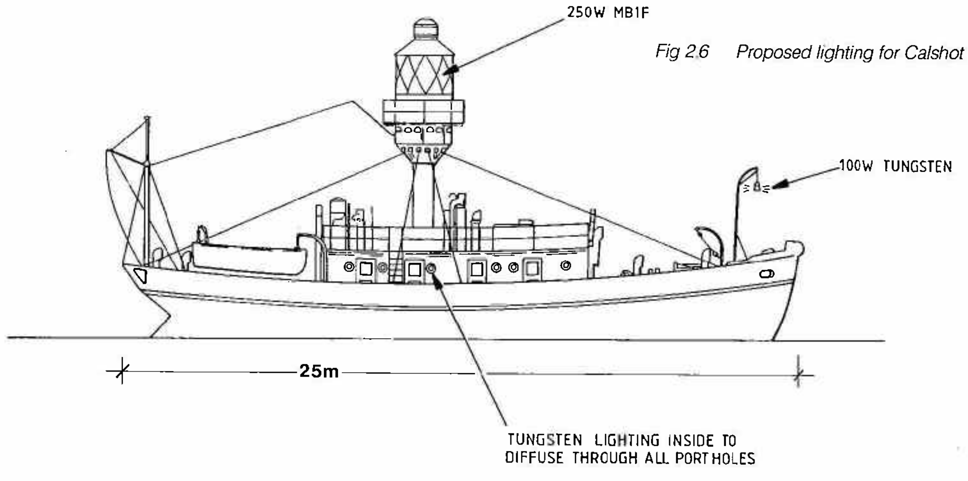

Fig 2.6 Proposed lighting for Calshot

Banners Launch BP Shares

Project data

Client	British Petroleum
Architect/Designer	Impact
Structural Engineers	Buro Happold
Contractors: Fabric	Landrell Fabric Engineering
Steelwork	SheetFabs
Project Value	£50,000
Completion Date	15 October 1987

In the autumn of 1987, Britannic House, central London headquarters building of British Petroleum, was used as a massive sign board in the much publicised launch of the BP share issue. An area of fabric, 100m by 35m emblazoned with company logo and emblem, was to be fixed to the face of the building to instantaneously reveal the share price on the moment of issue (Fig 3.1). The idea originated from Impact, an event and publicity company who, with only two months to spare, approached Buro Happold for a practical engineering solution, one which would not only work but which would be approved by BP safety assessors.

The original idea was to create a banner which, in a matter of seconds, could be unfurled down the face of the building, revealing the share price. In reality this was too risky. Running at such speeds any jam in the system would be catastrophic and there would be insufficient time for trial runs and snagging procedures. The final solution was to have a banner hung early on the launch morning from which six abseiling Marine commandos would release a series of covers over hidden numbers, so revealing the share price.

Britannic House, a 32 storey office block some 120m high, was well suited to the purpose. Glazing mullions, set at 4.7m centres down the face of the building provide continuous grooves to carry a window cleaning gantry. The banner was made up from seven separate strips of open weave fabric coated with PVC to minimise windage. Nylon wheels riveted at frequent intervals to the edges of the fabric held the banner in the mullion grooves.

During liaison with BP's own safety executive it was decided that a design wind speed of 20m/sec would be sufficient for the project, having only the remotest chance of occurring for the one night while the banners were in place. However, with this wind speed it was still important to check that the runners were capable of holding the fabric against the building. Simple scaffold tripods and tirfors were to be used to control descent of the banners which were fed into the mullion grooves from the top.

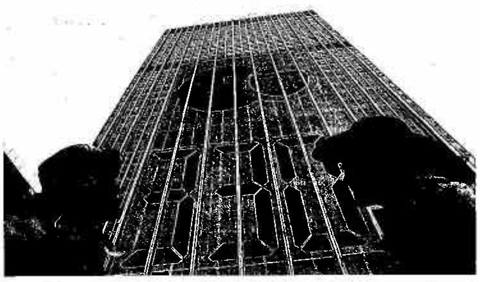

Fig 3.1 Banners unveiled on Britannic House elevation – Sunday Times November 1987

Attached to the bottom edge of each was a tubular truss which would add weight and keep the leading end of each banner stiff enough to move down freely (Fig 3.2). However, during a trial run, some wheel runners became jammed and broke, requiring speedy modifications to fix them more firmly to the fabric.

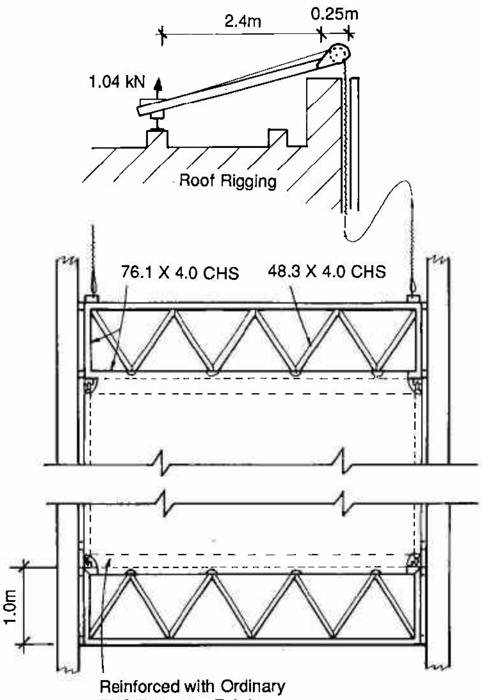

Fig 3.2 Detail of arrangement controlling descent of banners

Fabrication work was carried out by Landrell Fabric Engineering. The relevant parts of the BP emblem were hand painted onto each of the banner sections so that when hanging beside each other the whole picture was revealed. The share price was sewn on as a series of adjacent figure eights. Only on the night before the launch were the segments of each number removed to form the share price – very few people being privileged to this information, and only after close of the stock market.

Early in the morning of the launch the seven banners were lowered into position. With the nation's cameras poised, the six commandos abseiled down the face of the building pulling on the laced cord edges of fabric panels concealing the numbers (Fig 3.3). The fact that one man pulled the cord the wrong way tantalisingly partially hiding the price, momentarily ensured several extra

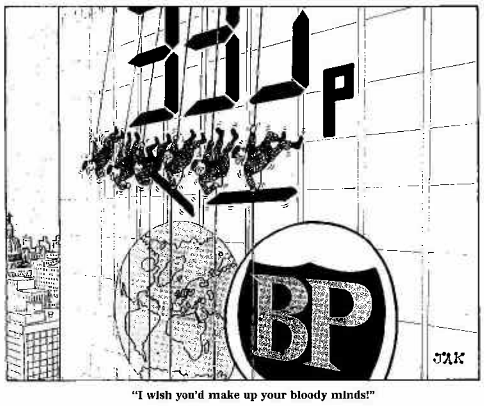

Fig 3.3 London Evening Standard cartoon – 22 October 1987

seconds of news coverage. The event was memorable and newsworthy – by definition therefore a success.

Throughout the day several of the team communicated with the Met Office checking that winds would stay below the 20m/sec threshold, beyond which the banners would have to be raised. News at mid afternoon was that rumours of high winds were false – the night would be calm. But this was 15 October 1987. By 2.00am the next day London would be experiencing the strongest winds for several centuries. At midnight the erection crew broke off a celebration party to lower the banners just as winds were becoming dangerous. Within two days the stock market had crashed and share prices plummeted. Clearly the 'impact' was far greater than expected!

Mike Cook and Ian Liddell

Community Building on Iona

Project data

Client	The Iona Community
Architect	Feilden Clegg Design
Structural Engineers	Buro Happold
Services Engineers	Buro Happold
Contractor	M. K. Macleod
Project Value	£1m
Completion Date	1988

The MacLeod Centre on the island of Iona off the north-west coast of Scotland takes its name from the Very Rev Lord MacLeod of Fuinary, who, in 1937 left the shipbuilding parish of Govan in Glasgow to found the Iona Community. His imaginative, romantic idea to rebuild the ruined living quarters of the medieval Benedictine Iona Abbey, lying on the site of the 6th century Columban Celtic community – using ministers as labourers for the craftsmen as part of a programme to train young clergymen for industrial areas – won him both admiration and hostility. The Iona Community, which used candles in its worship, there being no electricity on the island, and which worked in poor areas on the mainland, was described by its Scottish Presbyterian critics as 'half way to Rome and half way to Moscow'.

As the Iona Community steadily gained international recognition, its founder and leader became increasingly notorious at home. Dr MacLeod's theology was what he called a 'total gospel' – a unity of the spiritual and the material.

Fig 4.1 The new building and the Abbey looking towards Mull

As a Celtic mystic and poet, he crafted beautiful prayers which have proved to be an enduring gift to the church at large. His leadership of worship in Iona Abbey was peerless; yet these outstanding spiritual gifts were matched by deep pastoral concern for those who had lost their way in life, particularly young delinquents, and by a burning political concern for the underprivileged. He was 'green' long before the rest of us. He was warning us, decades before it happened, of the dangers of the worship of money and of consumerism.

The Macleod Centre (Fig 4.1), a new building replacing a number of prefabricated huts used by the Iona Community for nearly 40 years, and providing dormitory accommodation for 60 people, together with communal facilities, study rooms, and ancillary spaces was built as a result of an international design competition held in 1985. The winning Feilden Clegg/Buro Happold scheme was selected from nearly 200 entries.

The island of Iona is an international centre of pilgrimage due to the presence of the Abbey and its importance in the religious history of Scotland. The design of a building in this setting therefore posed particular problems. The solution was to produce a building which respected the vernacular traditions of the island, but which developed its own identity through carefully considered details, and the expression of internal and external communal spaces (Fig 4.2).

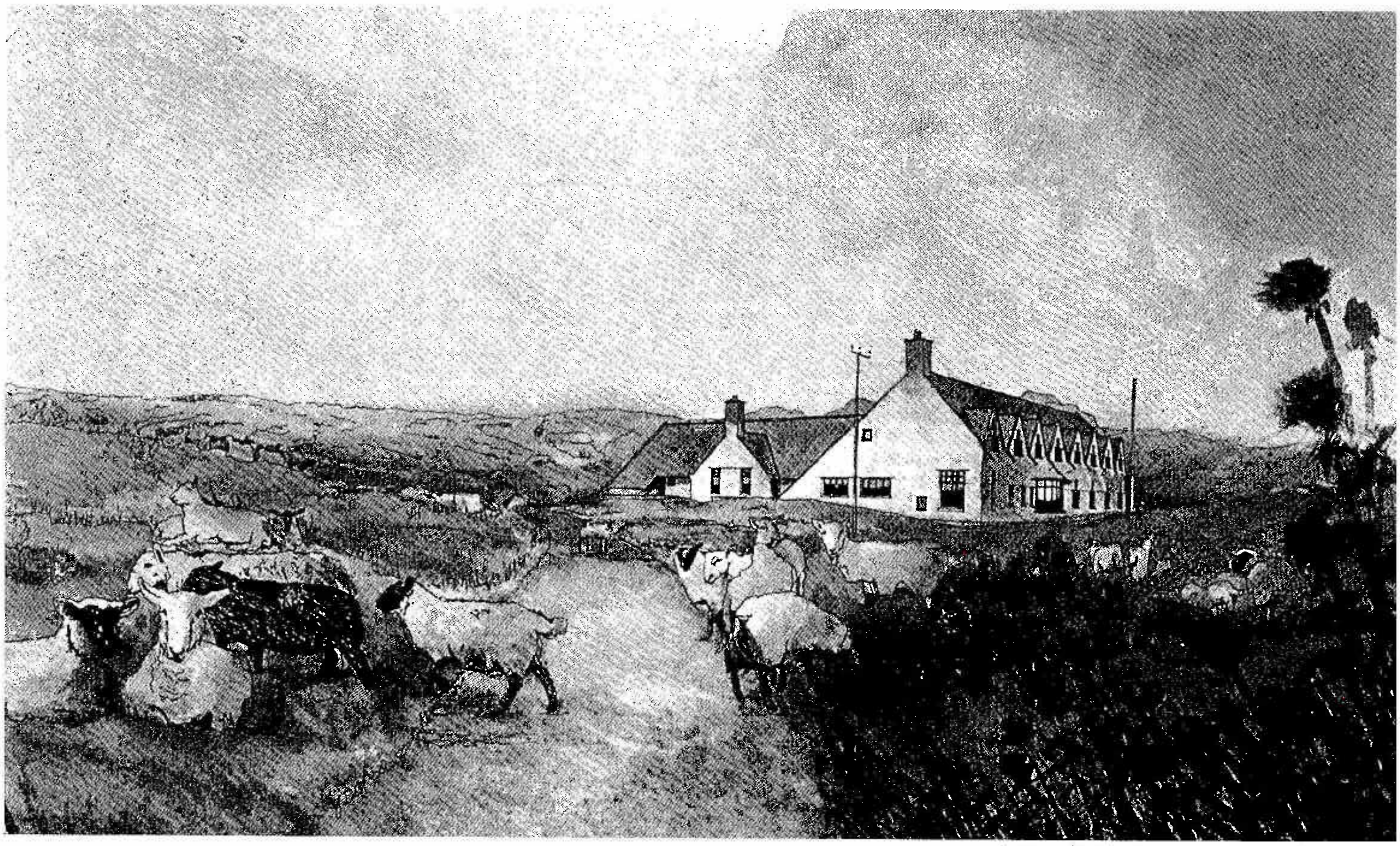

Fig 4.2 Architect's drawing of proposed developmen

It is perhaps appropriately founded on Precambrian rock of Torridonian age, some of the oldest rock formations in Britain. During design, consideration was given to prefabrication to ease construction problems and ensure quality. The final decision was to use materials manageable by hand on site and transportable across the narrow, twisting single-track road along the island. Traditional materials, concrete blocks, 'house floor' prestressed beams and filler blocks, timber and laminated timber were delivered to the island by traditional west coast 'puffer' which was beached by the island jetty to offload.

The energy conscious building is well insulated and orientated to use passive solar gains (Fig 4.3). Only electrical power is readily available and this is of limited capacity. Consequently, water is heated 'off peak' and stored, and central heating is by an electric 'Night-stor' central unit feeding hot water to thermostatic valve controlled radiators. In the event of power failure, parts of the building can be heated by solid fuel and sections of the central heating can work by gravity feed. All lighting is low energy.

The project was concluded on time and within the original competition budget. The completed building (Figs 4.4, 4.5) is now used by the Iona Community as a centre of reconciliation for people of differing nationality and religious and ideological beliefs, and during the Community's jubilee celebrations in 1988 was officially dedicated to Dr Macleod by Mrs Leah Tutu, wife of the Archbishop of Cape Town.

Rod Macdonald (with thanks to Ron Ferguson and John Harvey, former leader and present leader of the Iona Community).

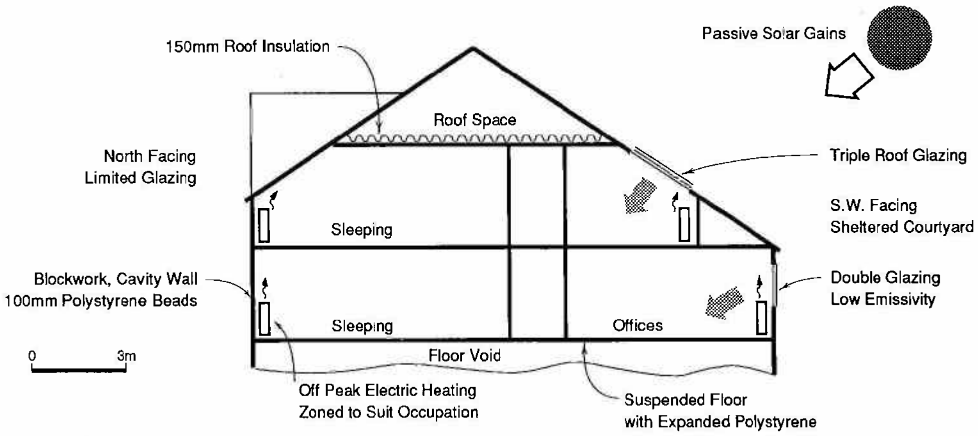

Fig 4.3 Environmental section through Macleod building

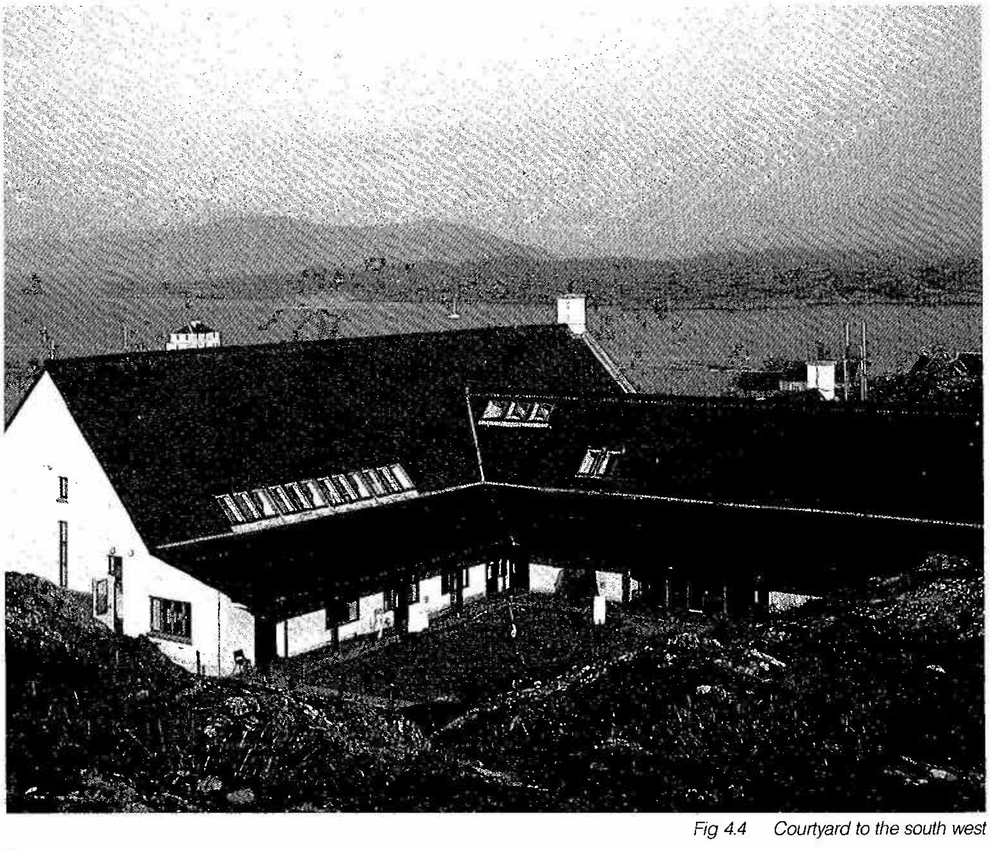

Fig 4.4 Courtyard to the south west

Fig 4.5 Interior of the main hall

TRAIL Computer Simulation

In 1983 the Freight Transport Association (FTA) published a guide for planners entitled 'Designing for Deliveries' (Ref 5.1) giving advice on requirements of delivery and service vehicles in terms of site parameters (road widths, minimum radii, service bays etc), turning manoeuvres and operating considerations. It also defined three standard design vehicles – the FTA rigid, articulated and drawbar types. Of particular use to the designer was an accompanying booklet of clear acetate sheet overlays. At both 1 : 200 and 1 : 500 scales these showed the swept paths for the FTA design vehicles during various manoeuvres including full lock U-turn, simple right turn and three-point turn (Fig 5.1). With these acetate sheets it was possible with careful application to check the layouts of junctions, service areas and the like for vehicle accessibility.

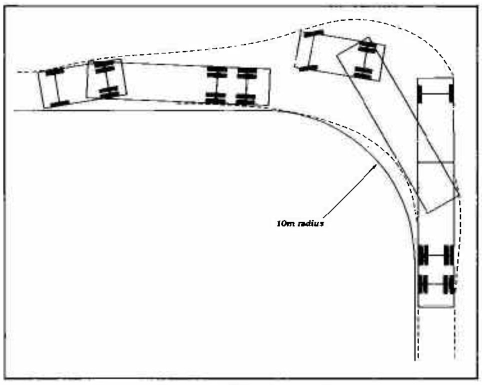

Fig 5.1 Typical FTA design vehicle manoeuvre sheet

Whilst the sheets indicate the more common turns, architectural and engineering designs often produce layouts requiring much more complicated manoeuvres. For example, an underground service area may have columns restricting simple turning movements. In these circumstances it was often necessary to compose a manoeuvre from a combination of sheets. It was with these situations in mind that John Morrison persuaded his son Clive to develop a computer simulation program. The resulting program, TRAIL, gave the operator the ability to theoretically 'drive' a vehicle of his choice (Ref 5.2).

To implement the program the operator is required to define a simple, co-ordinated layout of the area in which the manoeuvre is to take place. The vehicle type is then selected, positioned, and driven round the layout by a series of commands defining forward movement and angle of turn. The program calculates the position of the complete vehicle every 10cms of forward movement. The trial manoeuvres are revealed on the screen as a 'snails trail' of the vehicle's extremities so indicating its ability to manoeuvre around obstructions (Fig 5.2). The result

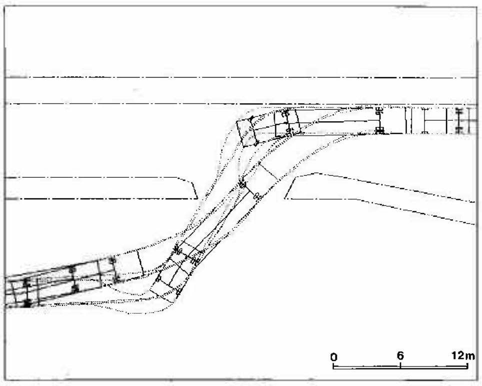

Fig 5.2 Snail's trail of vehicle's extremities during manoeuvre

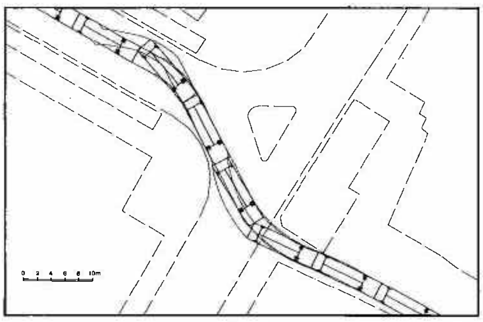

Fig 5.3 Computer plot of snail's trail

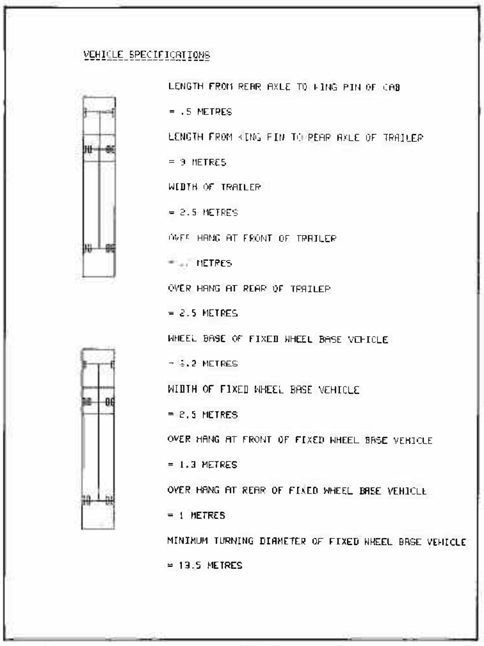

Fig 5.4 Specification for TRAIL vehicles based on FTA standards

can be output as a 'screen dump' or alternatively, the manoeuvre can be drawn at any scale on a plotter (Fig 5.3).

The program is based on slow moving vehicles manoeuvring through intricate procedures. There is an important restriction as it has been assumed that full lock from left to right can be achieved over a travel distance of two metres. In reality, it would be possible to turn the wheels whilst a vehicle is stationary, but this would lead to excessive tyre wear.

Default vehicle dimensions together with the manufacturer's specified turning circles can be modified by the user to suit any vehicle, even a fire engine or bus, and the program, calibrated against standard FTA manoeuvres, could be adopted for any other type of wheeled vehicle, such as aircraft, using the same principles (Fig 5.4).

Currently a new version is being developed using Micro Soft windows to enhance the user interface, and with a facility enabling transfer of Autocad-generated outlines into the program so that manoeuvres can be super-imposed on data generated during development of the project.

Clive Morrison and John Froud

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5.1 Freight Transport Assoc. 'Designing for Deliveries' 1983.

5.2 Morrison C. 'Trail Manual' 1989.

Rediscovering the City Walls and Gates of Riyadh, Saudi Arabia

Project data

Client	RDA
Architect	Beeah Consultants
Civil Engineers	Buro Happold
Civil and Structural Engineers	Buro Happold
Project Management	Buro Happold
Contractor	Dumez
Project Value	SR 7.25m
Completion Date	1992

Following Buro Happold's earlier work on the Diplomatic Club (Ref 6.1) the practice continued its association with the Riyadh authorities during design commissions for the Mosque and Justice Palace in the Kasr Al Hokm district of Riyadh, the oldest part of the city. This large scale development, whose construction continues today, is close by the Masmak fort, an important building in the history of Saudi Arabia. As part of the redevelopment of old Riyadh, the Riyadh Development Authority (RDA) wished to establish, record and, where possible, reconstruct the old city walls and gates which had long been lost in the rapid development of the city. In April 1985 Buro Happold (BH) again jointly with Beeah Consultants of Riyadh, were appointed to carry out the study and to evolve preliminary designs for this work.

The project was conceived as being in two parts, the first stage confirming the position of former city walls and gates, the research of appropriate construction methods, both traditional and modern, and the development of proposals to reconstruct elements of the walls and gates where possible, or to instal markers and other indications of its former location (Fig 6.1 a,b). The second stage was envisaged as the detail design and construction documentation to enable the reconstruction to proceed. For the initial research stage it was decided that Beeah would pursue the source material within Saudi Arabia itself interviewing local senior citizens, while BH investigated sources outside the Kingdom. Later in this initial stage Beeah would develop preliminary designs for the reconstruction and marking, with BH providing technical input on mud construction techniques, both traditional and more modern.

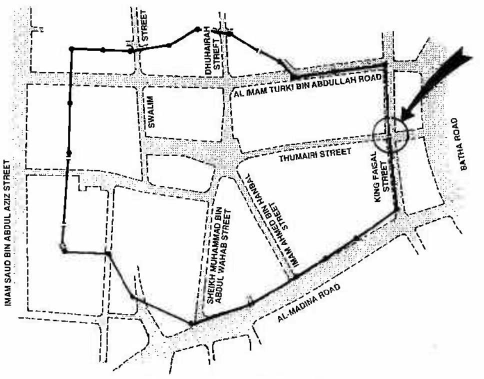
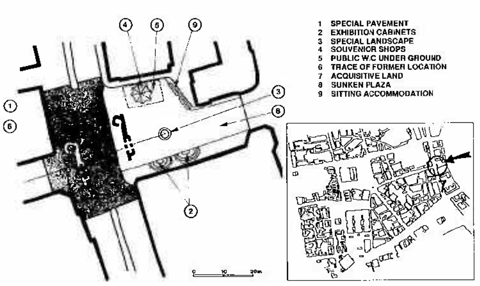


Fig 6.1 (a) Plan of city walls superimposed on present layout of Kasr Al Hokm district



(b) Detail of city wall and gate special exhibition area

It was quickly established that the principal sources of information outside Riyadh were now in the UK, with the greater part of the most valuable material concentrated in the Middle East Centre at St Anthony's College, Oxford. This post graduate college holds a prodigious amount of source information regarding the Middle East and Saudi Arabia in particular, being the recipient of many significant diaries, journals and exploration records made by Europeans into the Arabian peninsula. Work was greatly assisted by the active interest and participation of their librarian, Ms Gillian Grant.

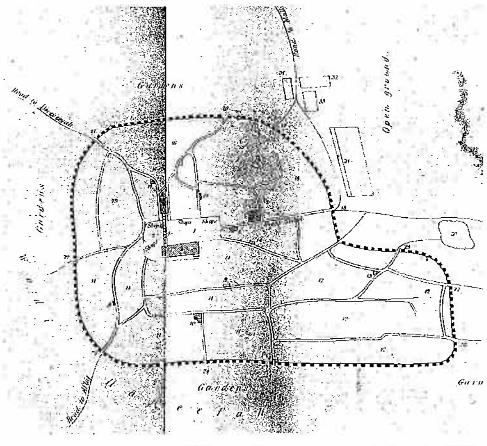
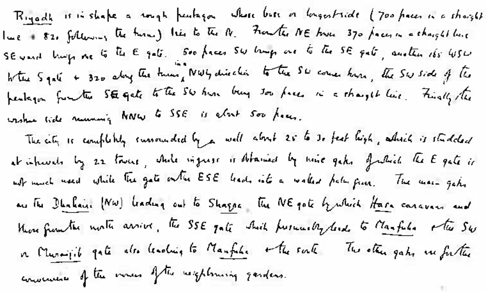


Fig 6.2 Palgrave's map of Riyadh, 1865



Riyadh is in shape a rough pentagon whose base or longest side (700 paces in a straight line & 820 following the turns) lies to the N. From the NE tower 370 paces in a straight line SEward brings one to the E gate. 500 paces SW brings one to the SE gate, another 165 WSW to the S gate & 320 along the turns in a NWly direction to the SW corner tower, the SW side of the pentagon from the SE gate to the SW tower being 300 paces in a straight line. Finally the western side running NNW to SSE is about 500 paces.

The city is completely surrounded by a wall about 25 to 30 feet high, which is studded at intervals by 22 towers, while ingress is obtained by nine gates of which the E gate is not much used while the gate on the ESE leads into a walled palm grove. The main gates are the Dhuhairi (NW) leading out to Shaqra, the NE gate by which Hasa caravans and those from the north arrive, the SSE gate which presumably leads to Manfuha & the SW or Muraijib gate also leading to Manfuha & the south. The other gates are for the convenience of the owners of the neighbouring gardens.

Fig 6.3 Reproduction of extracts from Philby's diaries

Early maps and journals indicated that general positions of walls and gates could be related to existing features and the present layout of the Kasr Al Hokm district (Fig 6.1a). Maps had been made by Palgrave in 1862/63 (Fig 6.2), and his account of his travels through central and eastern Arabia makes interesting reading (Ref 6.2). Later in 1917/18 St John Philby (father of Kim Philby) made extensive maps of Riyadh at that time as part of his diaries during his residency (Fig 6.3). This information was later contained in his book 'The Heart of Arabia' published in 1922, and again good correlation between the maps and the present layout was obtained (Fig 6.4).

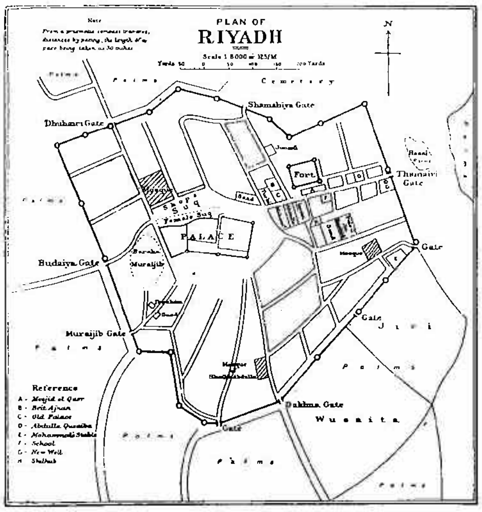


Fig 6.4 Philby's plan of Riyadh, 1922

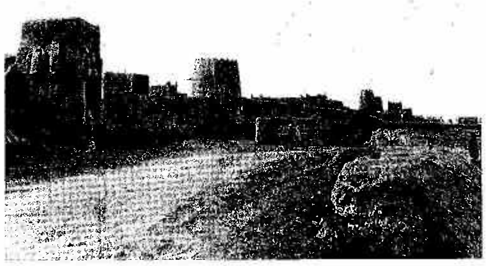


Fig 6.5 West wall of Riyadh during 1940's

Fig 6.6 Aerial photograph of Riyadh, 1967

Of equal importance to research was the great number of photographs of old Riyadh which were available from St Anthony's College. These included pictures by Philby and ARAMCO geologist, Steilike (Fig 6.5), and showed an old mud walled town very much in traditional Arab style, with towers and gates around its periphery. Very little development was seen beyond these boundaries, underlining the very rapid growth of greater Riyadh in the last sixty years (Fig 6.6). Other historical information described the making of mud structures both in the Arabian peninsula and elsewhere in the Middle East. The BRE Overseas Unit also provided much material regarding recent research on both mud and mud block construction, and the use of 'modern' additives such as glass fibre polymers and cement!

Using the old maps together with anecdotal evidence gathered by Beeah from senior residents in Riyadh, it was possible to establish with a fair degree of certainty the location of the old walls, towers and gates relative to the features of the Kasr Al Hokm district. Similarly the old photographs, together with other existing examples remaining in Arabia, allowed the method of construction of the walls, gates and towers to be accurately established.

A joint report was then prepared identifying certain gates for reconstruction and providing schematic proposals using basic mud construction techniques as far as possible, to construct replica sections of the wall, and reproduce towers and gates (Fig 6.7 a,b). At the same time a study was presented of the various construction techniques utilising mud construction methods, but incorporating wherever possible modern techniques, additives and construction practices (Fig 6.8). This also included proposals for design standards and loadings together with internal and external lighting.

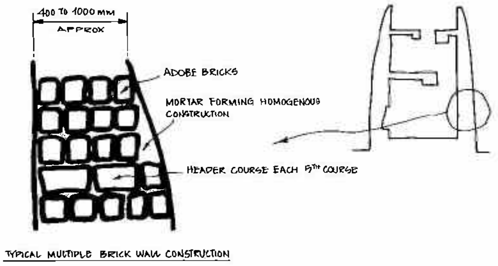


Fig 6.8 Typical sections through brick wall construction

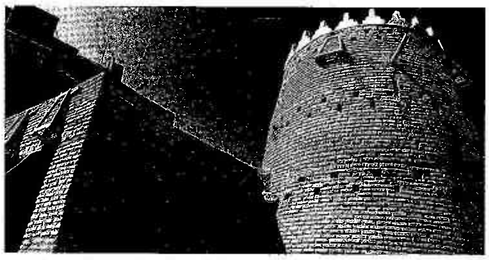


Fig 6.10 Replica Al Thumairi Gate and Tower Phase 8, Zone 8

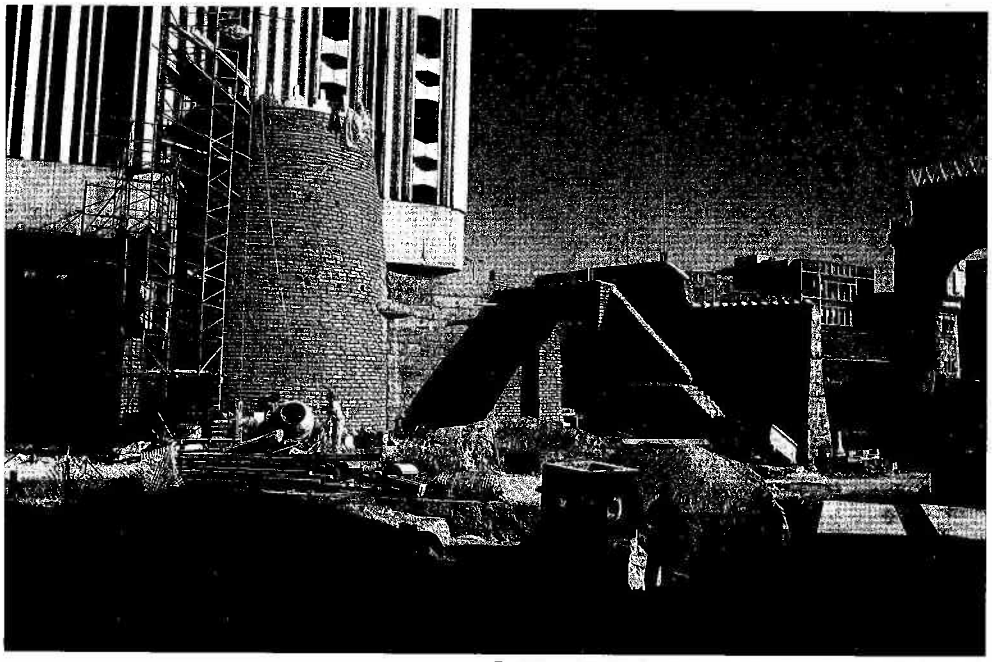


Fig 6.9 Replica Al Thumairi Gate and Tower: Phase 8, Zone 8

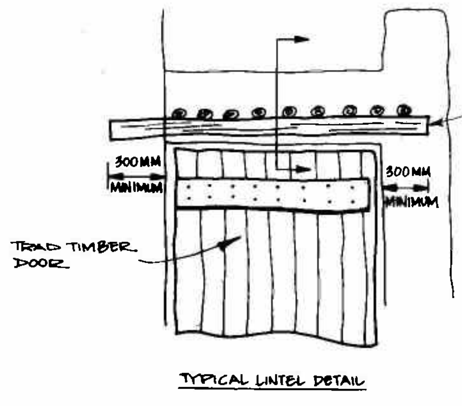
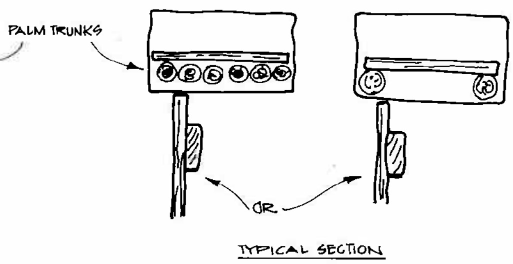


Fig 6.7 (a) Detail of typical lintel



(b) Section through lintel

Under the direction of Buro Happold acting as project managers for the RDA, construction work was commenced by Dumez in 1989 and now nears completion. Construction of the replica Al Thumairi Gate and Tower is shown on Figs 6.9 and 6.10, which illustrate the high standard of workmanship and authentic appearance being achieved.

Vincent Grant and Padraic Kelly

References

6.1 Ealey T, Grant V, Green M & McLaughlin T. 'Diplomatic Club, Riyadh' Patterns 1, pp20–24 October 1987.

6.2 Palgrave W.G., "Narrative of a year's journey through Central and Eastern Arabia. (1862–1863)" Macmillan. 1865.

The Commerzbank, Frankfurt – a proposal for a green headquarters tower building

Project data

Client	Commerzbank AG
Architect	Christoph Ingenhoven (with Prof F Otto as consultant)
Structural and Environmental Engineers	Buro Happold
Competition Date	July 1991

Design competitions are great thought stimulators, often resulting in much innovation and original work in building design and construction. A good example is Richard Rogers' Pompidou Centre – a building which set a precedent for 'high tech' building design. Those who have worked on competition designs and found their concept bordering on the radical or revolutionary, will know how exhilarating this can be. The feeling is balanced with realism when the concept has to be 'broken down' into standard components to which sound engineering principles must apply. Most engineers have this self-checking mechanism against stepping beyond bounds. If at the end of the analysis, the original concepts are still in place, then there is something worthwhile to work on. The proposal for the new headquarters building for the Commerzbank is just such a case.

During recent moves to upgrade the financial area of Frankfurt, the Commerzbank held a competition in 1991 between many of the world's great architects for a 'green' tower block to be built within a complex of existing buildings on a central site. Competitors included Pei, Skidmore Owings & Merrill and Foster Associates, to name just a few.

Judges were made up of other well known architects together with representatives from the bank and from the city of Frankfurt. The judging was interesting – apparently the architects voting for the entry by Christoph Ingenhoven, a brilliant young German architect with Buro Happold as environmental and structural engineers and Professor Frei Otto as consultant, and the city and bank representatives voting for the scheme by Foster Associates with engineers Ove Arup & Partners. The argument went on until the early hours of the morning and finally was resolved with design by Foster Associates being awarded first prize by one vote and that of Ingenhoven the second prize, with a unanimous recommendation by the whole jury that a second stage should be held where the two teams would present their designs so that a decision could be made on which design would be finally built.

Ingenhoven's entry was for a circular tower 44 storeys high, with a diameter of 42m and with a height aspect ratio of 10.5 (Fig 7.1 a,b). The concept allows for a central core with lifts and internal stairs and lenticular gardens at the four sides of the building (Fig 7.2). This leaves a cross shaped plan

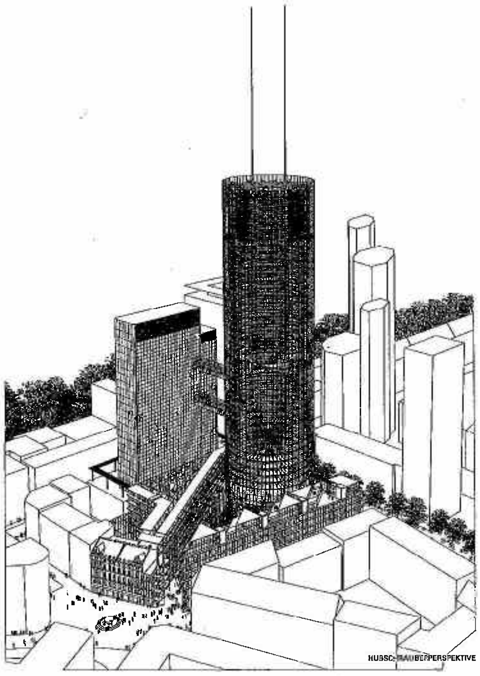


Fig 7.1 (b) Bird's eye view of new tower block adjacent to existing bank building
Abb 7.1 (b) Vogelperspektive des neuen Turms mit der Verbindung zum bestehenden Hochhaus

for the internal building which guarantees that all offices are less than 7m away from daylight (Fig 7.3) and natural ventilation from the internal gardens.

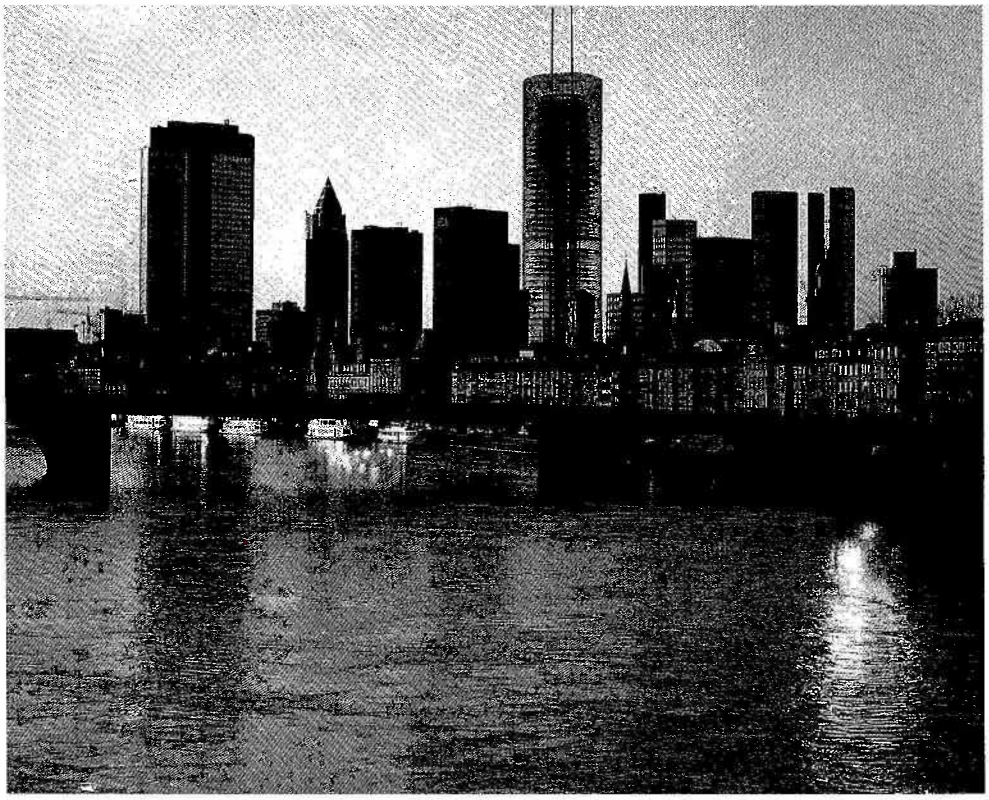


Fig 7.1 (a) Architect's image of tower block superimposed on Frankfurt landscape
Abb 7.1 (a) Einpassung des Hochhauses in die Stadtlandschaft Frankfurts (Fotomontage)

Fig 7.2 Plan showing equipment core, surrounded by offices and lenticular gardens
Abb 7.2 Grundriß mit Technikkern, umgeben von Büros und den linsenförmigen Gärten

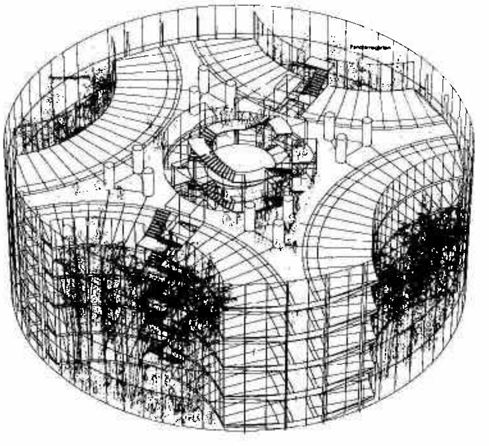


Fig 7.3 Isometric of part of tower showing central core and cross shaped plan of interior
Abb 7.3 Teil-Isometrie mit Kern und kreuzförmigem Grundriß

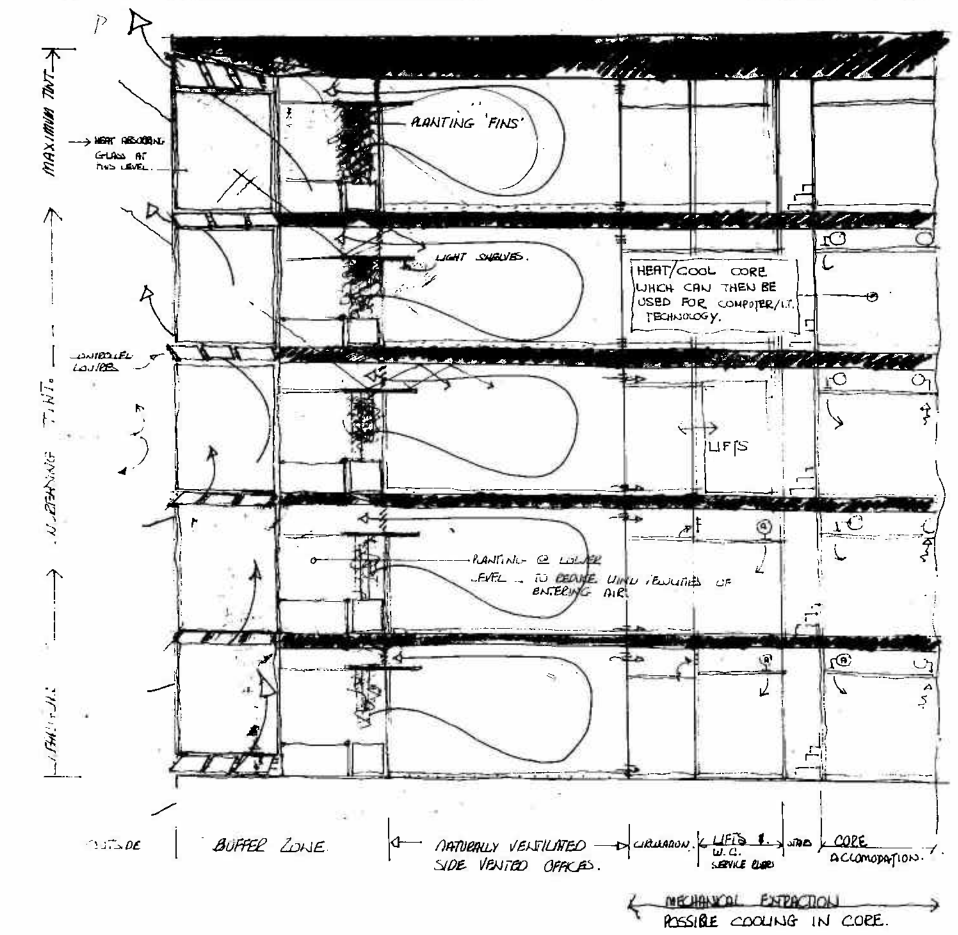


Fig 7.4 Environmental concept for tower block
Abb 7.4 Konzept für Klimatechnik und Beleuchtung des Turmes

With environmental engineering in building design predominantly based upon proven techniques, and experience of work and life, innovation applies the principles in a 'novel' or elegant way to enhance the environment of the building's users, contributing at the same time to an environmentally intelligent architectural form. The 'radical' starting point in the Frankfurt project was to strive to produce a naturally ventilated building depending on the stack effect for an element of forced ventilation. Normal natural ventilation criteria were stated, including maximum room depth, openable windows, stack and wind effects, the last being one of the first problems to be encountered. Wind forces at the top of a 44 storey building are significant. The solution was to put a shield around the building diverting the energy of the wind forces but yet allowing the outside fresh air to leak through into the buffer zone between the barrier and building, permitting the opening of office windows out into the space without disturbing effects.

Furthermore, air movement up the buffer zone of the 44 storey block would be dramatic. To overcome this the building was layered in five-storey "blocks", limiting the stack effect to no more than five floors – giving fairly normal conditions for naturally ventilated offices off shared hallway spaces, and defining specific fire zones. Air in the buffer zone would then enter at the bottom of the five storey slice and leave at the top, inducing air movement in the surrounding offices. These five storey "block" elements provided the height for individual perimeter garden conservatories, bringing the changing seasons to office workers on the 40th floor of the building, and defined the separate communities of the floor, the block and the building.

Such a 'shroud' around the building presented the potential of a skin everchanging from transparent to opaque which would respond to the external environment – blocking out solar gain if not needed, opening up if beneficial for heat or light, and closing at night in the winter to help reduce heat loss (Fig 7.4). Thus standard proven principles were adopted in a unique building form. Into this 'shroud' was incorporated minimalist tie bracing against the high lateral winds on the tall building – exposing as a 'bone' the increasing magnitude of loadings requiring to be transferred downwards to the ground – from a facade clear of all bracing at the top five floors, to initially sparse ties, to denser flared bracing at the lower floors and finally into major cradle strut bracing supporting the whole external loadings on the tower to the ground (Fig 7.5). The major four sets of principal vertical load columns were revealed in the interior entrance halls of the building.

It is proposed that the system of louvres on both inner and outer skins would be controlled to allow night time cooling of the occupied spaces, thereby reducing the building's potential cooling demand. The exposed concrete ceiling of the offices provides thermal mass to absorb some of the daytime gains, this mass being selected to provide a time lag in the order of 10–12 hours allowing cooling by night air. In winter the enclosed gardens will act as solaria, collecting heat from the winter sun. This can be trapped and moved around the building to the cooler, north-facing zones and here the interaction of structure and environmental design is once again important. In order for the offices to benefit from the thermal mass of the

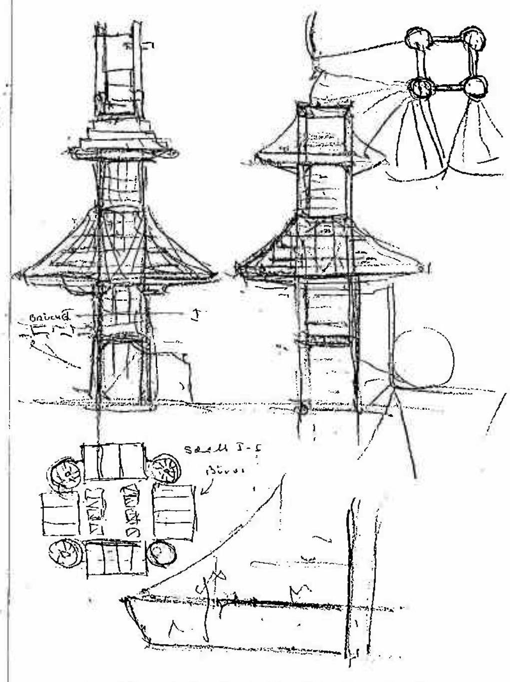


Fig 7.6 Professor Frei Otto's initial proposals for table structures
Abb 7.6 Professor Frei Ottos frühe Vorschläge für ein tischartiges Tragwerk

ceiling, no suspended ceilings are required and the mass of the structure of the floors has to be placed on the underside as is required in cantilevers with their bottom flanges in compression. Early in the design process Frei Otto had proposed that the principal structural components be formed from table structures (Fig 7.6, 7.7). This became adapted to the four principal sets of three vertical columns at the root of each cruciform arm which support the light but stiffer tapered cantilever slabs of each floor (Fig 7.8 a,b).

Again, a modern bank must have modern equipment. This equipment does not need contact with the outside world and is therefore placed in the core, where conditions are more appropriate. Efficiency of the building plan is thus increased, and the light raised floor supported on the 'cantilevered' floor structures provides an ample and accessible void for the network of communications and services required by a modern banking operation.

The relationship of the tower to the city is an important one. Car parking is only provided for visitors and a link to the U-Bahn is provided at the lowest level feeding up into a shopping galleria on the ground floor (Fig 7.9) which can provide coffee bars, newsagents, florists and small restaurants together with a pedestrian space for the many

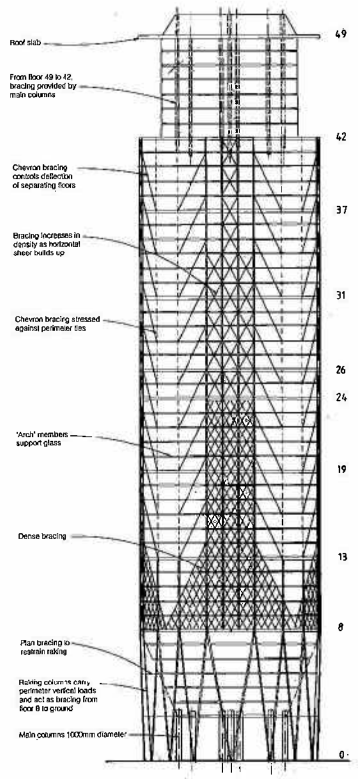


Fig 7.5 Bracing increasing from top to bottom of tower block
Abb 7.5 Die Windaussteifung nimmt zu von oben nach unten

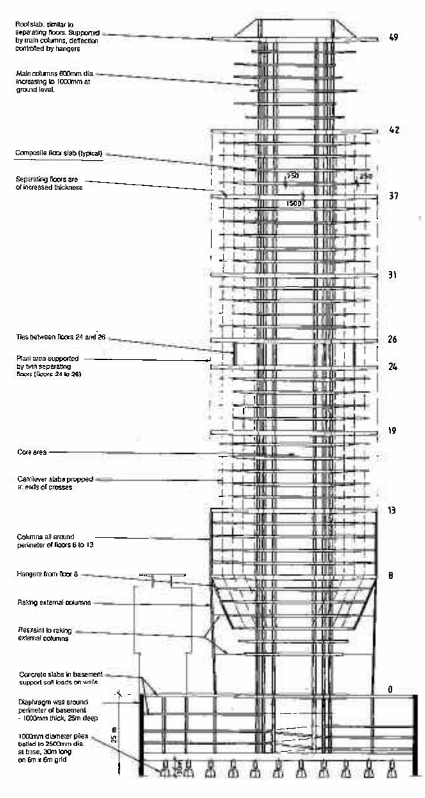


Fig 7.7 Section through tower showing "tables" and cantilevers of structure
Abb 7.7 Schnitt durch den Turm, der "Tische" und Kragarme zeigt

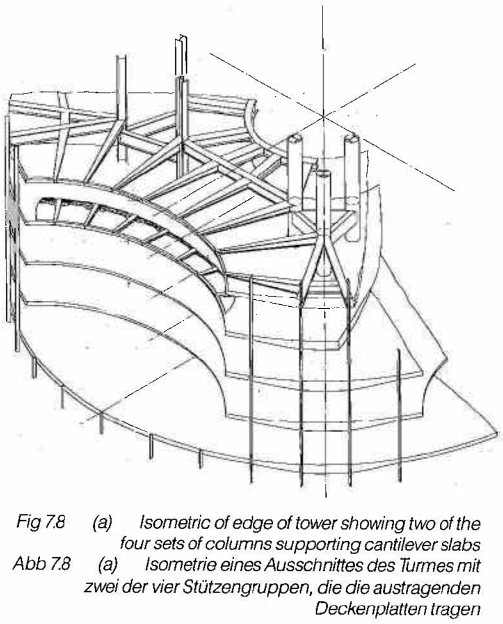


Fig 7.8 (a) Isometric of edge of tower showing two of the four sets of columns supporting cantilever slabs
Abb 7.8 (a) Isometrie eines Ausschnittes des Turmes mit zwei der vier Stützengruppen, die die austragenden Deckenplatten tragen

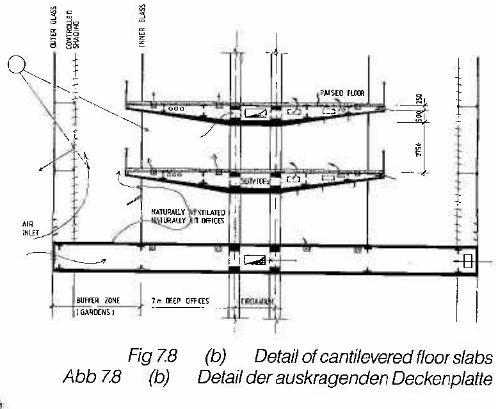


Fig 7.8 (b) Detail of cantilevered floor slabs
Abb 7.8 (b) Detail der auskragenden Deckenplatte

people who work in the area, and for whom present facilities are inadequate. This galleria links with the sculpture garden to use the space between the existing buildings and the tower block. It is itself an encouragement within the city plan for users and staff of the bank to adopt the more environmentally friendly course of travelling to work by public

Commerzbank, Frankfurt – Wettbewerb für ein grünes Hochhaus

Projektdaten

Bauherr	Commerzbank AG
Architekt	Christoph Ingenhoven (mit Prof. F. Otto als Berater)
Tragwerk und Haustechnik	Buro Happold
Wettbewerbsdatum	Juli 1991

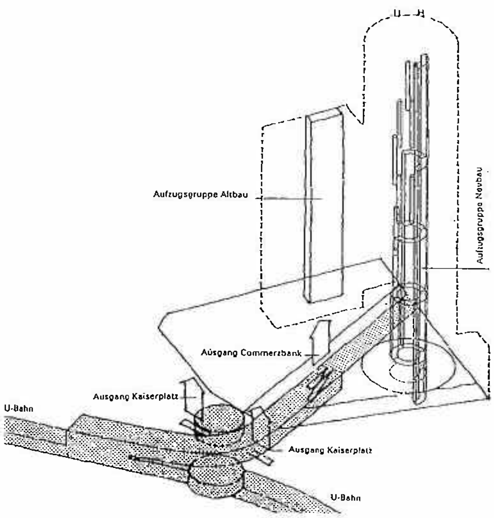


Fig 7.9 Link to U-Bahn and car parking at lowest level from shopping gallery on ground floor of tower
Abb 7.9 Verbindungen von der U-Bahn und den Parkebenen in den Untergeschoßen zur Einkaufsgalerie im Erdgeschoß des Turmes

transport – surely one of the main aims of a green building.

Perhaps one of the most intriguing aspects of this competition is that the engineers for both of the preliminary projects, Ove Arup and Partners in the case of Foster Associates and Buro Happold in the case of Ingenhoven, are both British consultants – albeit both are firms used to working in many cultures.

Für ihre neue Hauptverwaltung in Frankfurt lud die Commerzbank AG zu einem Wettbewerb ein. Unter den 12 eingeladenen Architekten waren große internationale Namen wie Pei, Skidmore Owings & Merrill und Foster. Buro Happold beriet den jungen deutschen Architekten Christoph Ingenhoven, vor allem auf den Gebieten Bauphysik, Haustechnik und Tragwerk. Die Commerzbank legte besonderen Wert auf den Nachweis von innovativen, energiesparenden Konzepten. In den Wettbewerbsbedingungen stand ausdrücklich: 'Die Verträglichkeit der Lösung mit der Umgebung hat gleichen Rang wie der Nutzwert'. Ingenhoven konnte Prof. Frei Otto als Berater, insbesondere auf dem Gebiet Ökologie, gewinnen (Abb 7.6). Gemeinsan entwickelte unser Team einen kreisrunden Turm mit einem Durchmesser von insgesamt 42m und 44 Stockwerken (Abb 7.1).

Untersuchungen zeigten, daß ein Bauwerk dieser Art in der Mitte von Frankfurt vor allem durch passive Energiesparmaßnahmen umweltfreundlich ausgelegt werden sollte. Durch die Kreisform wurde die Außenfläche auf ein Minimum reduziert. Doch innerhalb der kreisförmigen Außenhaut steht das eigentliche Gebäude mit einem aus der Keuzform entwickelten Grundriß (Abb 7.2). Die Außenhaut ist aus Glas, kann zur Durchlüftung mehr oder weniger geöffnet und je nach Jahreszeit beschattet werden. Die Belüftung der Büros erfolgt direkt über Fenster zu den Gärten, die sich jeweils über 5 Stockwerke zwischen Außenhaut und Innenhaut erstrecken Eine Vollklimatisierung des Gebäudes kann damit (Abb 7.4) entfallen.

Die Büros sind weniger als 7m tief; das erlaubt die natürliche Belüftung ebenso wie es ein Mindestmaß an Tageslicht garantiert. Die Begrenzung der Höhe der Gärten auf 5 Stockwerke erfolgte, weil gezeigt werden konnte, daß andernfalls die Aufstiegsgeschwindigkeit der Luft zu hoch würde, um die angrenzenden Büros über Fenster belüften zu können. Andererseits wäre die Luftgeschwindigkeit auch bei ca 160m Gesamthöhe nicht hoch genug, um diesen Effekt etwa zur Engergiegewinnung über eine Turbine wirkungsvoll ausnutzen zu können. Den Fenstern wurde zur natürlichen Belüftung und Beleuchtung der Vorrang vor Energiegewinnungsmaßnahmen in der Fassade eingeräumt; eine Nutzung der verbleibenden Flächen ist in der weiteren Bearbeitung zu überlegen.

Besondere Aufmerksamkeit wurde im Rahmen des Entwurfes der Anbindung an den öffentlichen Nahverkehr (Abb 7.9) sowie der internen Büroorganisation geschenkt. Die gelungene Lösung wurde von den Preisrichtern besonders hervorgehoben.

Das Preisgericht, zusammengesetzt aus Architekten, Vertretern der Commerzbank sowie Vertretern der Stadt Frankfurt, empfahl einstimmig, daß die Architekten Ingenhoven und Foster um eine Weiterbearbeitung in einer zweiten Phase gebeten werden sollen. Obwohl die Beauftragung der Commerzbank hierzu noch aussteht, arbeiten wir bereits daran.

Rüdiger Lutz, Tony McLaughlin, Michael Dickson & Ted Happold

Illustration credits

7.1, 7.2, 7.3, 7.7 & back cover Christoph Ingenhoven, 7.5 Prof F Otto, 7.4, 7.6 a & b Buro Happold

Landslips at Cannons Country Club, Bath

Project data

Client	Combe Grove Manor Hotel
Architect	Nicholas Eager
Landscape Architect	W Mount
Geotechnical Engineers	Buro Happold
Project Value	£120,000
Completion Date	Ongoing

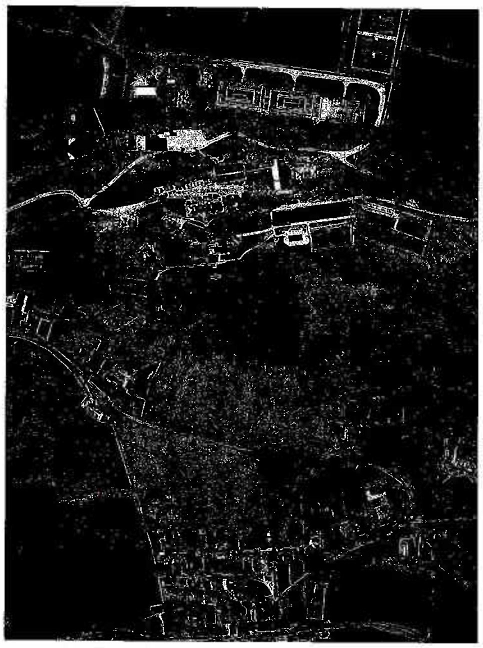


Fig 8.1 Aerial photograph of site before major slips occurred

Cannons Country Club, now known as the Combe Grove Manor Hotel, is an 18th Century country house located on a south west facing slope near Monkton Combe on the southern boundaries of the city of Bath (Figs 8.1, 8.2). The site has suffered a number of landslips since 1800, most recently causing problems for the country club in 1987/88, and various measures have been made to stabilise the slope. The earliest landslips in this area were recorded in 1800 by John Philips when William Smith, canal engineer and 'father of British geology', ordered the construction of a tunnel into the hillside to intercept the groundwater. The position of this tunnel however, remains unknown.

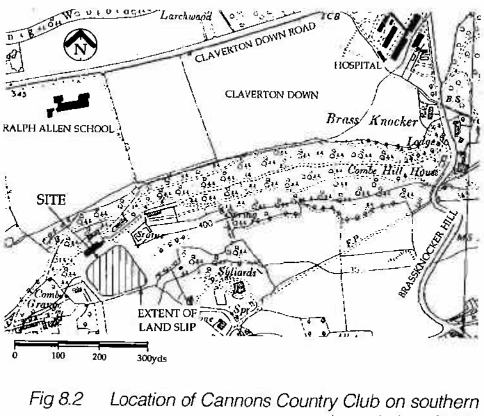


Fig 8.2 Location of Cannons Country Club on southern boundaries of Bath

Fig 8.3 Areas of landslip in front of hotel

Ground movements recurred in 1984 in the area of ground in front of the hotel. Four boreholes were drilled at that time in the unstable ground revealing movements at depths between 3.0m and 3.5m, and warning that movement was likely to continue if no remedial measures were taken. In fact the situation was worsened by the felling of trees to improve the view from the hotel.

In 1987 Geotechnical Engineering carried out a further site investigation for the redevelopment of the granary building within the grounds of the country club. Although this is outside the recently unstable area, clean polished planar discontinuities were noted, suggesting deep seated instability. Later that year it was discovered that the foul water drainage from the hotel and club was broken and leading into the top of the slope, with a consequent rapid deterioration of slope stability (Fig 8.3) as the water table rose. Buro Happold received instruction in March 1988 to investigate the causes of the landslip and propose methods to stabilise the slope. Due to the rate of deterioration a temporary foul water sewer was installed before any investigation or stabilisation works were undertaken.

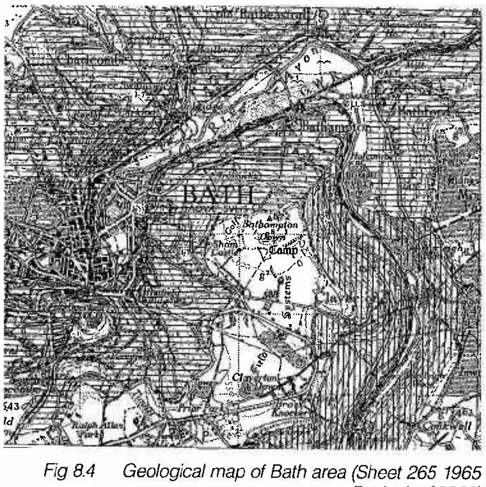


Fig 8.4 Geological map of Bath area (Sheet 265 1965 Scale 1 : 63360)

Investigation of ground conditions

The British Geological Survey map of the area indicates extensive landslips in Jurassic strata (Fig 8.4), including highly disturbed cambered slopes with bedrock geology consequently obscured by colluvium, a phenomenon common to many of the hills around Bath. A borehole nearby in Combe Down shows the succession to be:

Thickness:	Stratum:
7.6m	Great Oolite
46.3m	Fullers Earth
14.3m	Inferior Oolite
–	Midford Sands

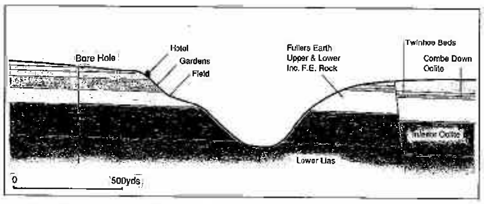


Fig 8.5 (a) Geological cross section through Monkton Combe valley

A geological section (Fig 8.5 a,b) constructed across the Monkton Combe valley indicates that the hotel is sited on the junction between the locally quarried Combe Down Oolite and the Fullers Earth Group, with this junction forming a natural spring line.

Five trial pits were dug and eight boreholes drilled during March 1988 by Soil Mechanics Ltd, to determine both the geology and slip location. Continuous U100 samples were taken in seven of the boreholes, which were extruded and split on site for description, and identification of shear zones. Disturbed samples were taken for classification testing. Drained shear box tests, ring shear classification and chemical tests were undertaken on samples close to the shear plane. Piezometers were then installed in each of the holes to monitor long term water levels.

The general sequence of strata encountered in the boreholes was:

Thickness:	Stratum:
	Topsoil
	Upper colluvium
1 – 4m	Lower colluvium
0 – 10m	Weathered Fullers Earth
–	Fullers Earth

The upper colluvium was generally firm orange brown clayey silt with frequent ooliths and gravel of Oolitic Limestone. The base of this material was frequently extremely soft, marking the zone of recent shearing. Beneath the upper colluvium there

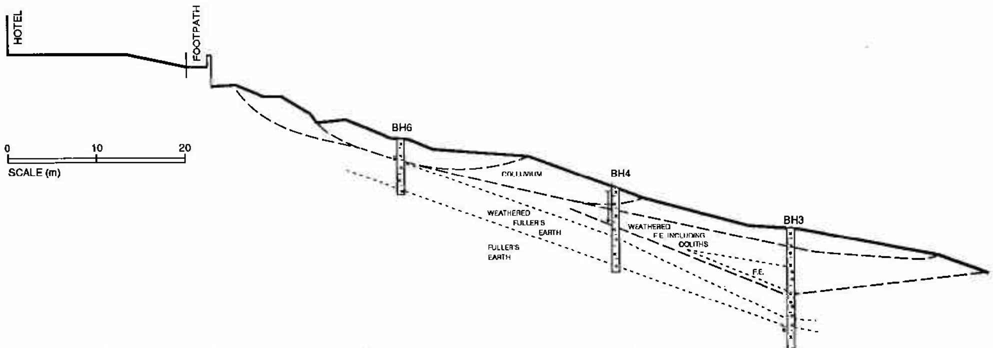


Fig 8.5 (b) Section through site showing boreholes and geology of slipped area

was often a layer of firm to stiff grey clayey silt (weathered Fullers Earth) containing occasional fragments of Oolitic Limestone. A substantial thickness of this material was present below the lower part of the slope, and several shear surfaces were identified within it. The total thickness of the colluvium varied from 1–4m near the top of the slope to a maximum of 13m at the base of the slope.

The top of the Fullers Earth was weathered to a firm to stiff clayey silt with orange brown mottling and laminae, and occasional lithorelics of mudstone. The Fullers Earth comprised stiff to very stiff dark grey clayey silt interbedded with weathered siltstones. From the laboratory testing and the detailed strata descriptions it was determined that the safe angle for the slope would be 13°, provided that the ground water level was reduced.

Remedial measures

During March 1988 the slope in front of the hotel was degrading sufficiently rapidly that it was agreed with the client for remedial work to commence before the investigations were complete. A new permanent sewer was constructed in a 'stable' part of the slope which allows sewers and manholes to move without breaking and consequent leakage. The active slip plane had been identified in the boreholes at depths of 1.8m to 3.8m and ground water had almost certainly risen due to the felling of trees and the effect of the broken sewer discharging into the slope.

The objectives of drainage would be to reduce the water levels within the slip material arising from seepage down the slope; discharge of surface water, land and foul drains into the slope; and infiltration during periods of heavy rainfall. Drains were installed at 10m centres to a depth of 3.5m consisting of DOT type 2 aggregate wrapped in terrain geotextile. A drain was installed behind the hotel across the car park, intercepting water flowing across the top of the Fullers Earth at the base of the Combe Down Oolite, and diverted around the slope (Fig 8.6). All drains were to be collected by a piped interceptor drain and water taken to a soakaway in the field below the hotel. The slope was regraded on completion to a maximum angle of 13°.

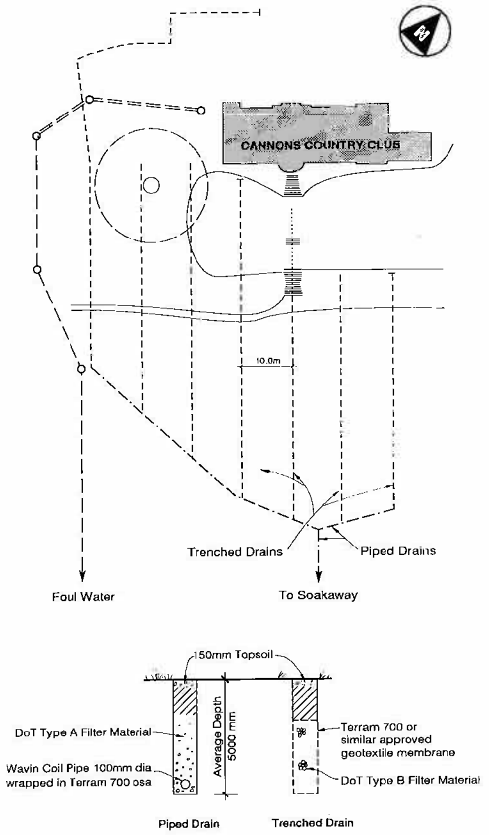


Fig 8.6 Plan of drainage installed in grounds with sections through drains and soakaways

Monitoring procedures

As the drainage installation proceeded, piezometers were monitored to ascertain the effect on water levels. Since March 1988 monitoring has continued with decreasing frequency. A system of peg lines was installed between stable end stations and monitoring carried out by sighting down the line. Piezometers are read at the same intervals.

When the site was first visited movement could be observed on a daily basis. Since the installation of the drainage there has been some creep movement which has amounted to a maximum offset of only 35mm downhill in eighteen months (Fig 8.7). The slope has now been relandscaped and although the edge of the slip is still visible, is regaining the appearance of mature gardens.

Isobel Lloyd

Fig 8.7 Recent photograph of relandscaped slip area showing minimal further displacement

Bus Shelters Given 'Street Cred'

Project data

Client	More O'Ferrall Adshel Ltd
Architect	Pentagram Design Ltd
Structural Engineers	Buro Happold
Completion Date	Spring 199[illegible]

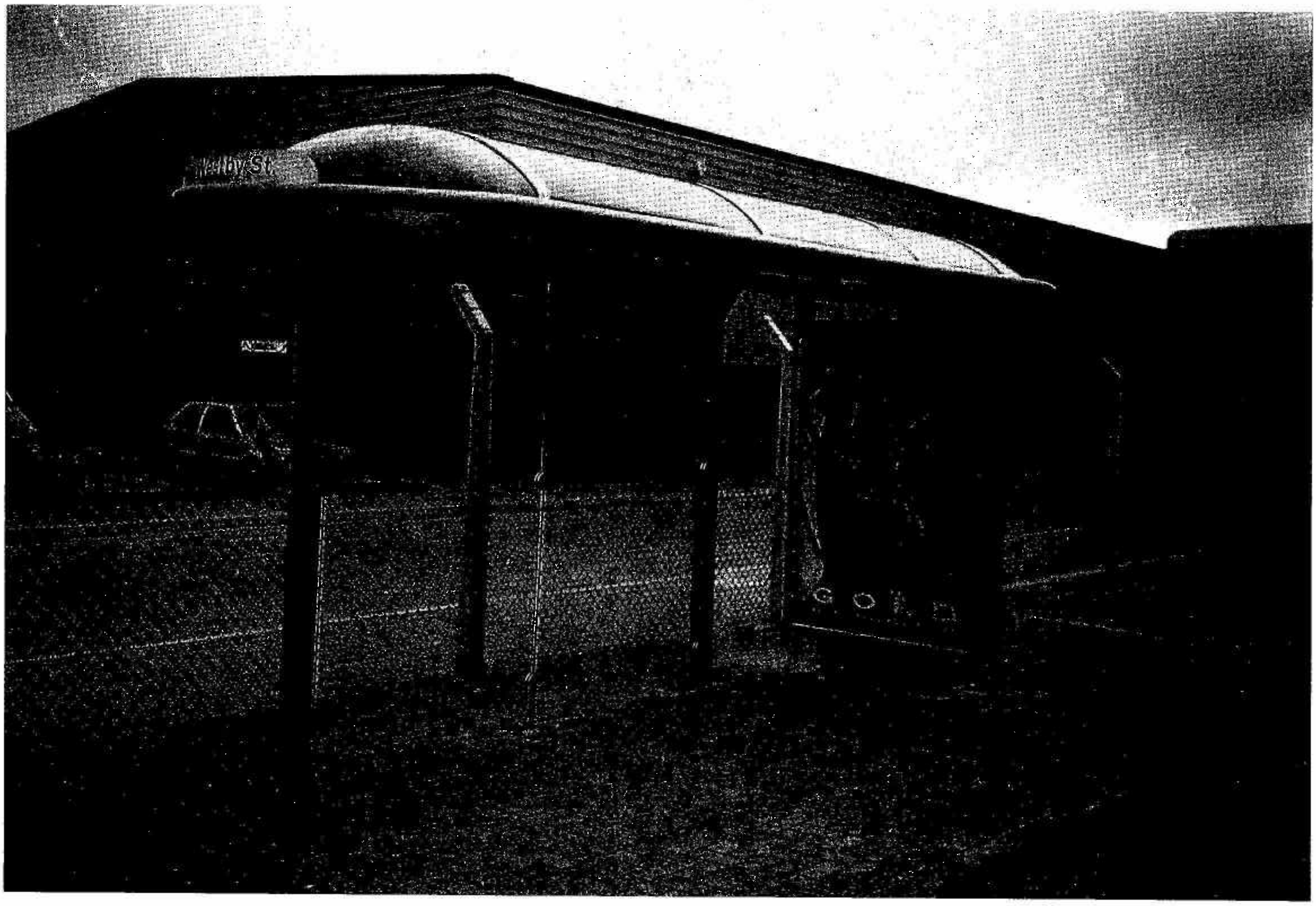


Fig 9.1 Bus shelter with 'aerofoil' roof

The French are coming! This was the message threatening to oust Adshel, Britain's leading bus shelter supplier, from its monopoly on this lucrative street furniture market. An invasion of the kerb sides of other large European cities by the modern French bus shelter prompted Adshel to turn to the design group Pentagram for the innovative design of a new generation of British bus shelters (Ref 9.1).

The client's brief required a shelter suitable for erection anywhere within the British Isles and capable of withstanding a basic wind speed of 54m/sec, and ground snow load of 100 kg/m^2. An additional 'vandal' load (two big lads hanging from the gutter!) incorporated by the designers led to the development of probably the most heavily engineered bus shelter available today. Pentagram's resulting design for a new bus shelter with roof based on the winged section of an aerofoil (Fig 9.1) and boasting integrated lighting, seating and electronic information display was to be thoroughly checked for structural integrity and given street credibility by Buro Happold acting as structural engineers for the project.

Three types of shelter, the cantilever, enclosed and matt types (supported at one end) were initially considered before a final design was chosen, but structural design of members for each was based on the cantilever type. Architectural emphasis was placed on restricting member sizes in proportion with the overall size of the structural frame but at the same time optimising the strength and serviceability of the frame under defined theoretical loads. Generally this was achieved with minor internal alterations to the architect's proposed overall section sizes. Great effort was made not to turn this bus shelter into a derivation of a wartime bomb shelter, as might have been the designer's tendency. The use of heavy duty UB and UC sections was to be avoided, but expensive aluminium extrusions were permitted only within the constraints of economic design.

The proposed hollow section extruded side column consists of an internally closed semi-circle providing torsional resistance, and an open box section with cover plate giving access to the electrical equipment housed within. The closed semi-circular part of the column section is also used as a water drainage route to the ground. A specially extruded roof edge channel member supporting the curved glass roof panels acts as a gutter, having a slight slope to drain water towards the columns. The full

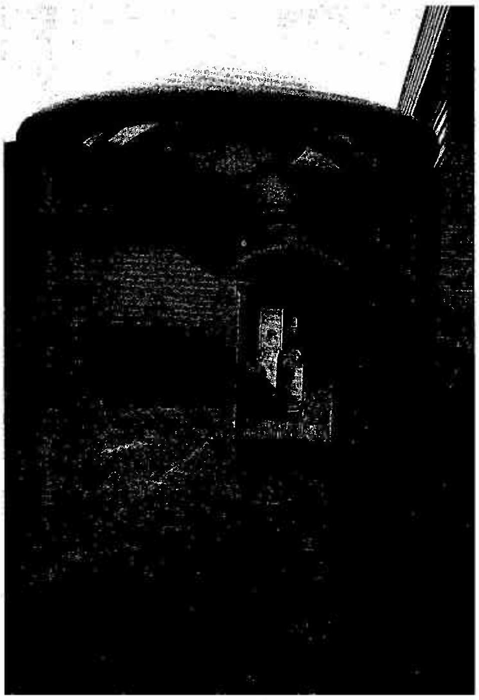


Fig 9.2 Glass roof panels fixed to columns and supported by two curved cantilever members

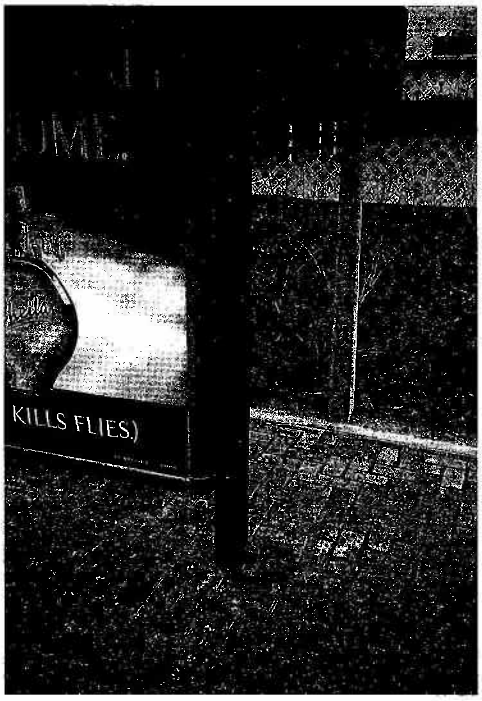


Fig 9.4 (a) L-shaped spigot member at base of column

assembly of glass roof panels and edge channel is fixed to the column tops at one side and supported by two curved cantilever members at the other (Fig 9.2). An optional cantilevered seat or perch can be mounted on the columns to accommodate up to seven people with an additional provision of two people on knees when the bus is late and the standing gets tough! (Fig 9.3.)

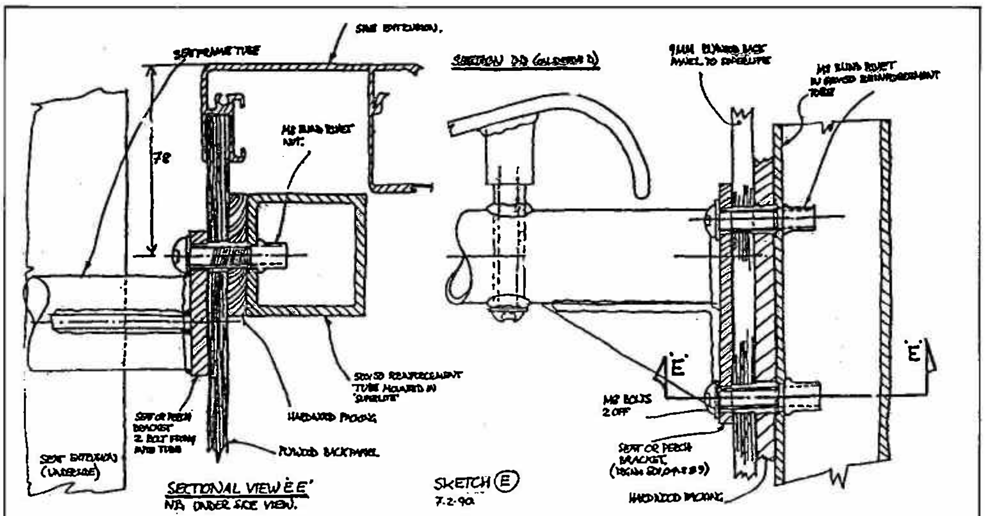
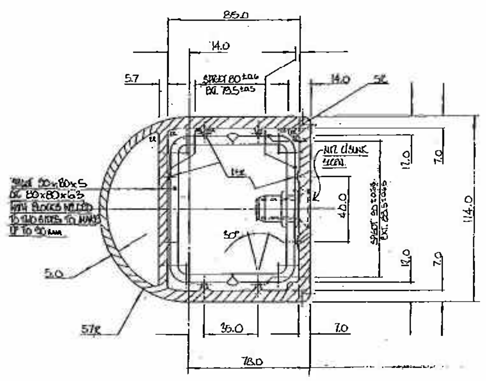


Fig 9.3 Typical seat or perch fixing to superlite panels between columns



(b) Typical section through column and base spigot

Fig 9.5 Finished shelter complete with advertising panels

Overturning is resisted by provision of an L-shaped spigot member at the base of the columns and by mass concrete foundations (Fig 9.4 a,b). In restricted city centres, where depth of foundations is limited by underground cables, the overall capacity of the frame is reduced. Foundations are designed to suit the local, normal load conditions with the slight risk of occasional high winds. Stability of the aluminium frame itself is achieved with fully welded aesthetically pleasing joints but at the expense of reducing the load bearing capacity of the sections due to the heat affected zone, HAZ.

This small interesting structure emphasises not only the importance of structural member design but that of section geometry. Such shelters are currently being provided and maintained free of charge for London Transport and other regional transport authorities by suppliers who in turn retain 100% advertising rights. So why not splash out on a bottle of Sheila, pay for your bus shelters and also kill flies!!? (Fig 9.5).

Morteza Mohammadi

Reference

9.1 Glancey J. 'Bus shelters given street credibility to beat French threat' The Independent 31 May 1990.

The Hyperion Airship at EuroDisneyland, Paris

Project data

Client	EuroDisneyland
Architect	EuroDisneyland
Structural Engineers	Buro Happold
Services Engineers	Buro Happold
Contractor	Koit Hi-Tex GmbH
Project Value	£750,000
Completion Date	April 1992

Much of the early work on the structural properties of fabric was carried out in the 1910's during the development of pressure airships so it is not surprising that, as specialists in fabric engineering, Buro Happold is sometimes asked to work on the modern airship form. One such project the practice was involved in was a design study for the German Navy who wished to assess the performance of an airship as a radar platform travelling at 100mph with a payload of 20 tons. With a design pressure of 2,000 pascals it was proposed as a pressurised hull with an internal structure of Kevlar ropes with helium lifting gas contained in separate gas ballonets. The system of construction was similar in weight to that of a single skin gas filled airship but had many advantages in terms of safety, strength and maintenance.

Recently Buro Happold was asked to assist Euro Disneyland, the new Paris-based Disneyland, with the construction of a fantasy airship, the Hyperion, envisaged as a futuristic design from late Victorian time. The 30m long airship is to be hung in the entrance to the Videopolis in Discoveryland, the front half projecting outside, and so subject to wind and snow loads (Fig 10.1). An internal aluminium structure bolted back to the entrance holds the ship in this position, with fabric appearing to bulge through the net from the pressure structure. Design of the structure comprised a pressurised fabric underneath a net of ropes (Fig 10.2). It was essential that the external fabric was fire resistant to M1 grade, which required the use of a glass base cloth fabric. As this material is very inelastic, great care had to be taken in patterning to achieve the bulges. Eventually a suitable silicone coated glass fibre fabric was found which could be pigmented to the specified colours. Restraining ropes also had to be inelastic, only Kevlar or steel wire would suffice. A wire rope covered with nylon and looking similar to hemp rope was selected for the net.

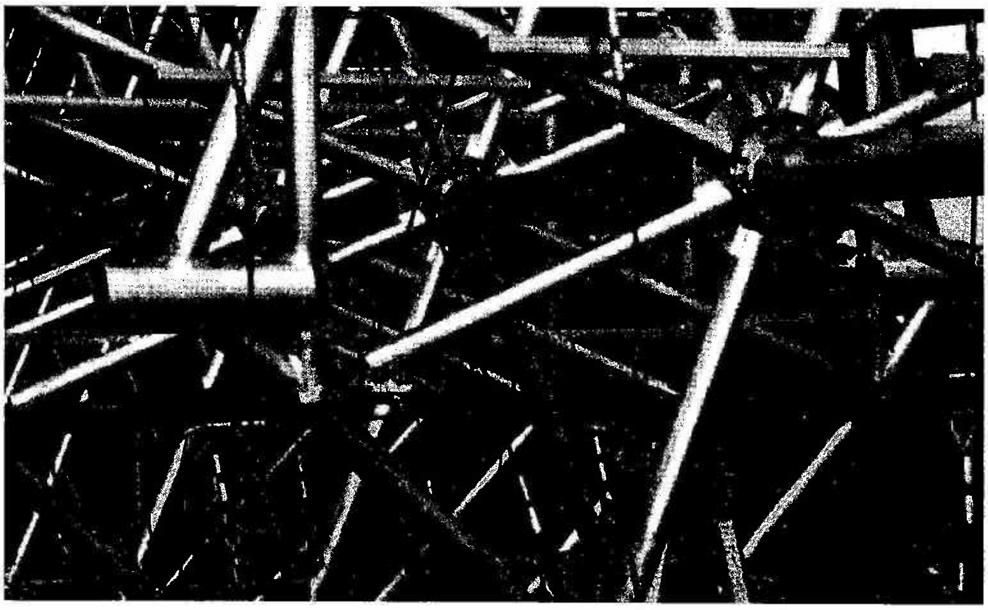


Fig 10.2 Internal aluminium framework of airship

During pressurisation of the structure with air bags supported on the aluminium frame, it was necessary to obtain higher pressures at the top of the hull in order to model the effects of a true airship (Fig 10.3). Consequently the hull lifts from the stiffening frame below, thus inducing tension in the rope net and tie down ropes. It was necessary to calculate the geometry of all components to ensure that the correct appearance was achieved. This was carried out using software developed for tensile analysis but, because of the conflict between fabric and rope net, proved to be an extremely time consuming process. Many new pieces of software had to be written in the course of design development.

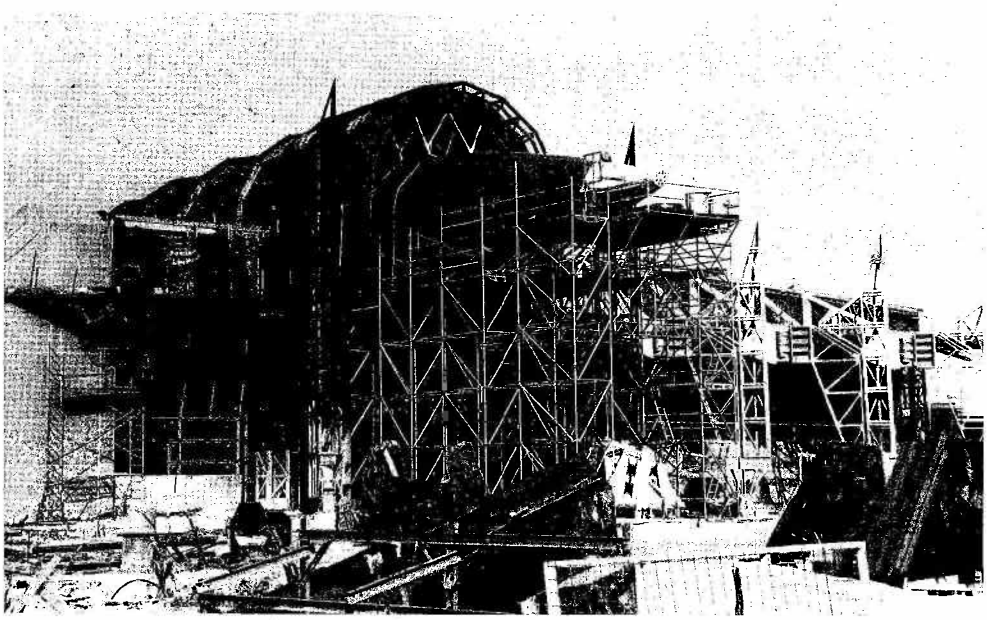


Fig 10.1 Airship during construction in position at entrance to Videopolis, at Discoveryland

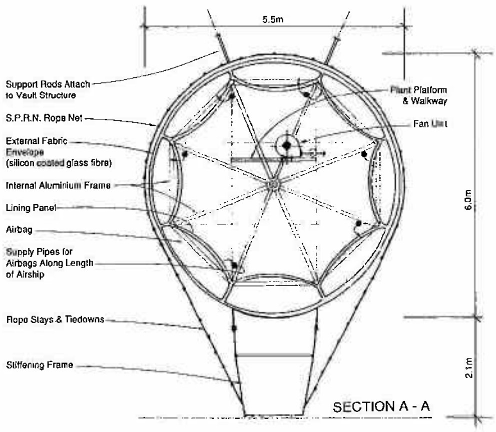


Fig 10.3 Cross section showing pressurisation of hull of airship

Three pairs of centrifugal fans were installed inside the airship to inflate the air bags within each of the three pressure zones and then maintain them at design pressures over a wide range of air flows. Each pair of fans was connected in parallel to a common header and controlled to operate as either run or standby, alternating duties on a weekly programme. Particular care was taken when selecting the fans, as once inflated, they were required to continue running at 'no flow' to ensure that any leaking bags would remain inflated unless a major failure occurred. Speed controllers were specified to allow fine tuning of the fan performance.

Durapipe plastic 'air-line' pipe was used to connect pairs of fans to the air bags. Pipework was sized to give minimal pressure drop between fan and final connector, but to provide a relatively high pressure drop through the final connection so rendering the system self-balancing. A second connection was made to each air bag from which a pressure tapping was taken to monitor the condition of the bag (Fig 10.4). As each bag must be maintained at its design pressure, within upper and lower limits, pressure conditions in each bag must be monitored and referenced to atmospheric. Excessive deviation is detected by the scanning pressure sensor, and an alarm raised on the control panel. The system also monitors the status of the fans via pressure differential switches and similarly raises an alarm on fault.

Two independent electrical supplies are provided to the airship – one from the normal site distribution system and one from emergency generators. All fans, control and alarm modules are connected to the emergency supply ensuring that pressure is maintained during a mains failure. Distribution and control equipment is housed in a purpose-built panel which was carefully detailed because of space restrictions.

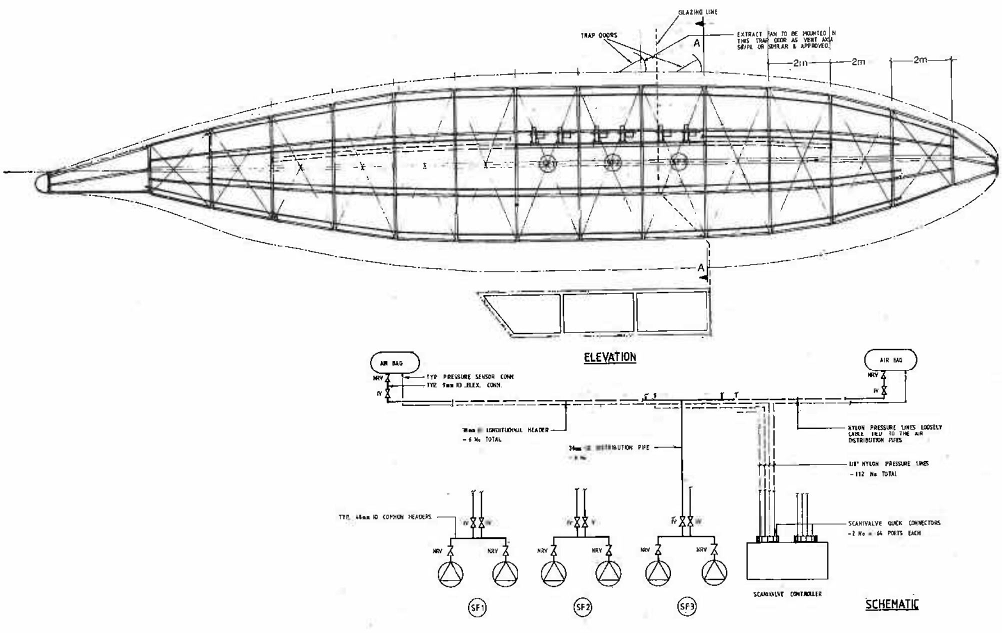


Fig 10.4 Inflation system for airship

In addition to normal working lighting in the airship, display lights are located on the nose and fins and are controlled by a flasher unit operating continuously during public opening hours. A further one hundred display lights are installed in the gondola suspended below the airship (Fig 10.5), together with a number of animated Disney characters who wave to the crowd below. Although the gondola and associated displays were not part of this contract, provision had to be made for supplying the necessary power and control signalling from the facilities management system in the building above, through the airship to the gondola below. Suitable cable routes were cleverly designed as an integral part of the access ladder construction.

The Hyperion project was put out to tender in 1991 and the contract was awarded to a German company, Koit Hi-Tex, who specialise in fabric structures. Completion is anticipated during April 1992, on schedule for the spring time launch of Euro Disneyland.

Ian Liddell, Simon Wright & Ken Carmichael

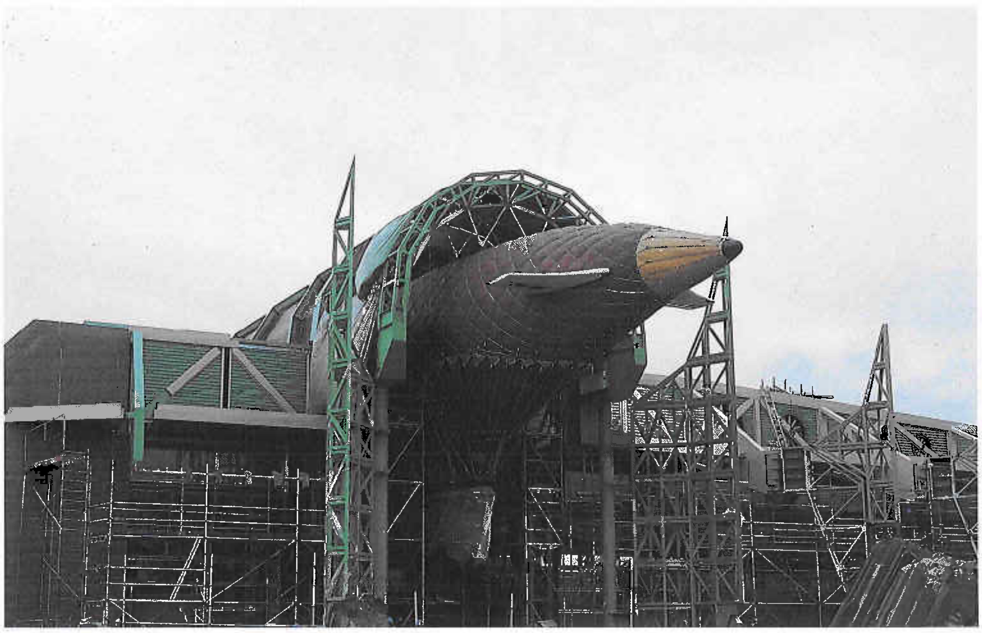


Fig 10.5 Completed airship with gondola below

The Heart Tent – An Artform in Glass

Project data

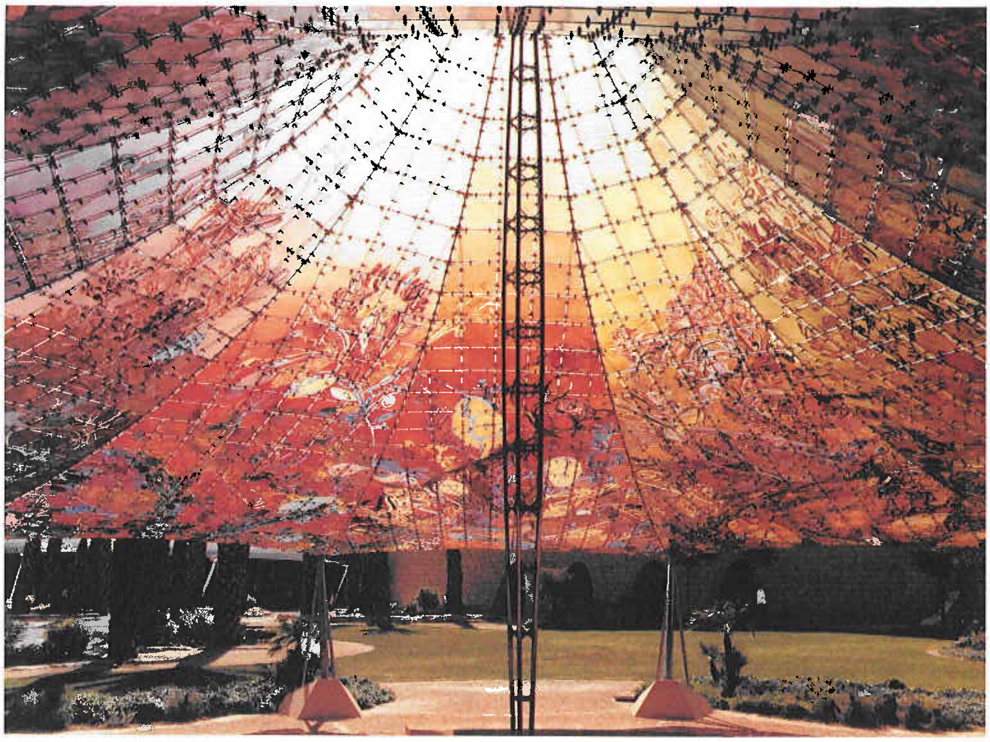
Architects	OHO Joint Venture (Omrania-Happold-Frei Otto)
Main Contractor	Han Yang
Specialist Cable Constructor	Stromeyer Ingenieurbau GmbH
Artistic Glazing	Franz Meyer & Co GmbH Munich in co-operation with Bettina Otto
Completion Date	April 1986

Towaiq Palace is undoubtedly the most significant and expressive building on the recently developed Arriyadh Diplomatic Quarter (Fig 11.1). The Palace was conceived as a primary meeting, entertainment and social centre and offers the wide range of facilities necessary to cater for the diverse interests of the cosmopolitan diplomatic community, whilst remaining sympathetic to the traditions and customs of the Saudi Kingdom.

Location on a promontory overlooking the picturesque Wadi Hanifa the external elevations of the Palace have been designed to harmonise with the rocky plateau landscape. The curvilinear plan form of the Arriyadh limestone Palace Walls skilfully divides the 75,000m^2 site into an inner lush oasis like garden, where lawns and plants flourish under the cover of 100 palm trees (Ref 11.1).

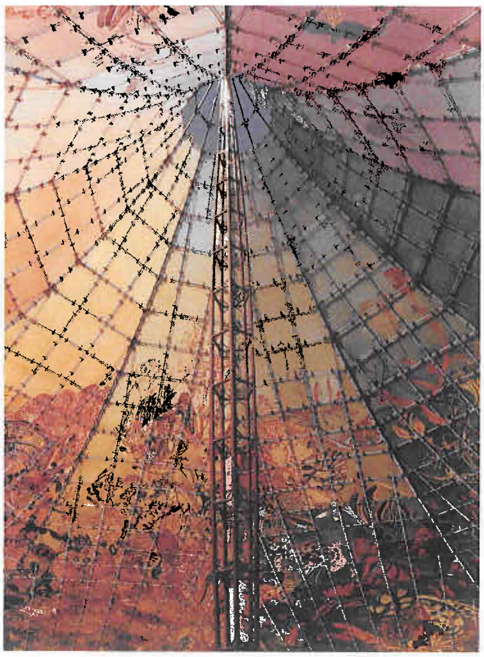
At the centre of this exotic inner garden lies the Heart Tent, constructed from over 2000 individually painted and artistically decorated glass tiles. The Heart Tent acts as the focal point of the inner garden and during the day provides a luxurious exquisite artwork under which the visitor can take a respite from the harsh rays of the Saudi sun (Fig 11.2).

Structurally the Heart Tent is comprised of a regular conical 326mm mesh cable net suspended from a 7.3m high central lattice mast and ten 2.3m perimeter stayed tubular masts, achieving an overall diameter of 17.0m (Fig 11.3).



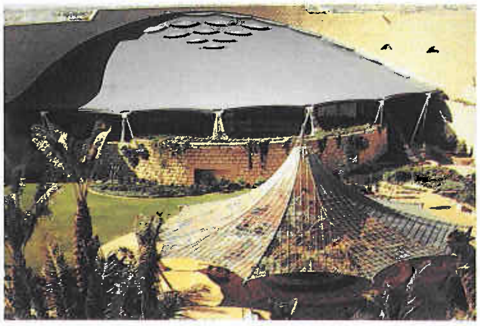
11.2 Artistic glazing within canopy of tent

Fig 11.1 Heart Tent at centre of inner gardens

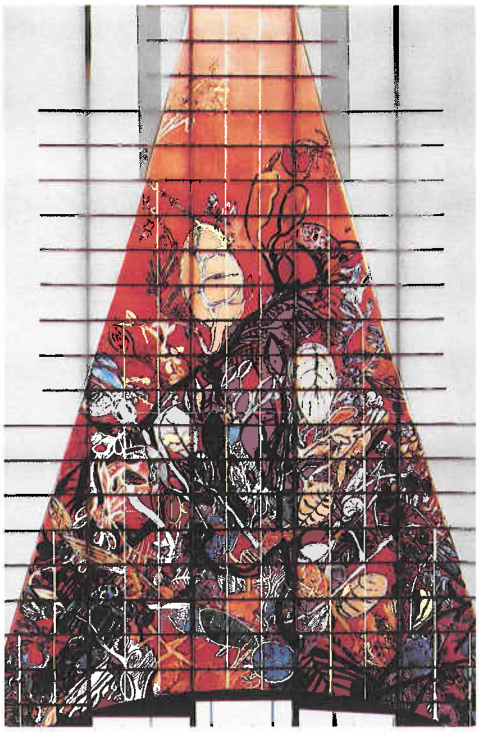


11.3 Cable net suspended from central mast and supporting tile canopy

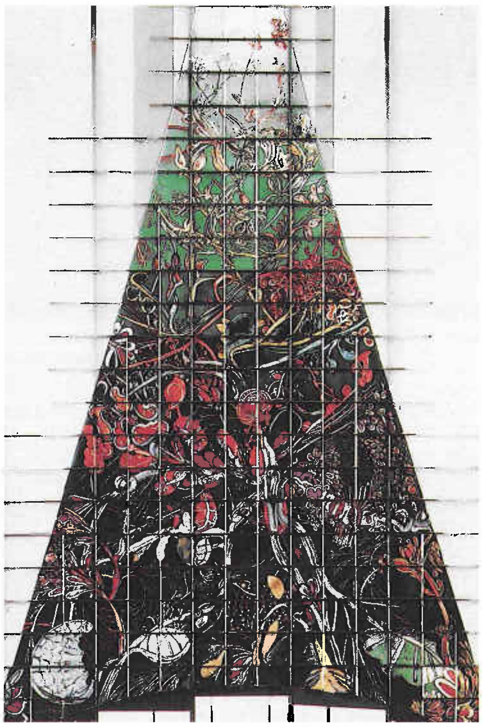
Pairs of 6mm diameter strand were selected for the net cables while 19mm diameter wire rope was chosen for the ridge and boundary cables. All structural components are of stainless steel. The central mast, consisting of five curved stainless bars and welded lattice bracing, sits on a spherical bearing amid a reflective pool of still water. The outer mast tripods are of tubular compression members and solid tie bars supported on exposed aggregate precast concrete pedestals, all anchored to a reinforced concrete substructure. The reactions from the perimeter masts are resisted by radial ground beams which meet at the central mast support base.



11.7 Completed tent within Palace garden



11.5 Tiles of one canopy segment



11.6 Tiles of one canopy segment

The canopy is made up of over 2,000 8m thick tiles of float glass. The geometric form requires that the glass tiles are either square or rhombic in shape, and exact dimensions were derived from the computer calculated cable net cutting patterns. The glass tiles are supported on the cable strand pairs using specially designed stainless steel clips with lead inserts at the glass contact points.

The tile artwork was conceived by the artist, Bettina Otto and features a floral theme based on images of foliage and blossoms. In full respect of Islamic artistic principles, life forms are not depicted. The background colours of the ten segments are in graduated warm spectrum hues with the densest colours used in the southern aspect (Fig 11.4).

The artistic glazing was realised in the studios of Franz Meyer & Co GmbH in Munich. Each glass tile was individually hand painted by the artist and her team of assistants. To ensure durable and permanent pigmentation, ceramic melting colours were used which were then fused by firing at 625°C–700°C. In this way, the glass is also partly toughened. After firing, each completed $^{1}/_{10}$ segment was assembled in a viewing window, and colour and quality reviewed by the artist. A photographic record was taken of each of the 2,000 tiles so that replacements could be supplied should the need ever arise (Fig 11.5, 11.6).

11.4 Graduated colours of ten segments of canopy

The Heart Tent, erected in April 1986, is believed to be the first ever example of a steel cable net to be covered with decorative artistic glazing (Fig 11.7).

Eddie Pugh

References

11.1 Ealey T, Grant V, Green M & McLaughlin T, 'Diplomatic Club, Riyadh' Patterns 1, pp20–24 October 1987.

Journey to the South Pole

Project data

Client Roger Mear
Structural Engineers Buro Happold
Project Value £1200
Completion Date 1985

In 1983 Buro Happold were asked by mountaineer Roger Mear to design a camping tent for the 'In the Footsteps of Scott' journey he and Robert Swan were planning to make to the South Pole. The existing British Antarctic Survey tents were steep pyramids with six straight wooden poles, each weighing around 70lbs. Any lightweight climbing tents then available were not large enough for their purpose, and were not considered strong enough to withstand the snow drifts and catabatic winds. The chosen tent had to be capable of rapid folding and erection even in severe blizzard conditions. During the expedition equipment would be carried on 8ft long sledges, so that a tent folded into a long bundle would be suitable.

Fig 12.1 Prototype under test in the 24' diameter open jet wind tunnel at Farnborough

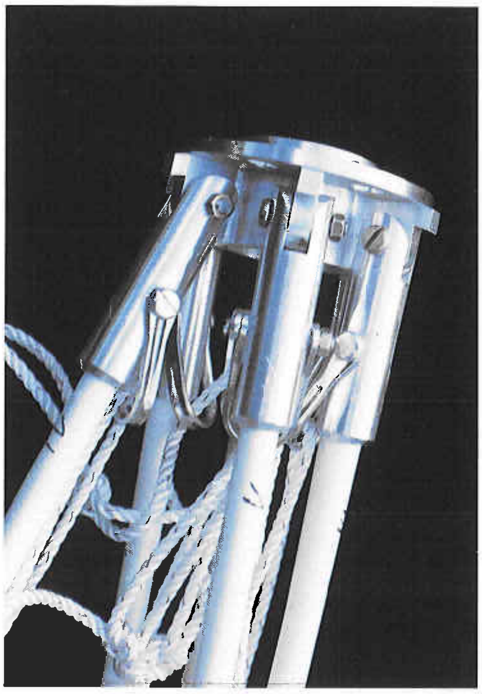


Fig 12.2 Collapsed hardware of tent

Fig 12.3 Trial erection of tent in front of the Royal Crescent, Bath

An umbrella tent with six radial spokes consisting of 10mm glassfibre rods hinged together at the top was proposed (Fig 12.1). The tent fabric was to be of Goretex, a fabric allowing water vapour to pass through from the inside, and consisting of a nylon outer layer with a PTFE skin bonded to the underside, and a lighter nylon inner layer. Unusually, watertightness was not a problem in this project, since all water was in the form of ice. However, durability of the tent was paramount since if it became damaged it would be life-threatening. Consequently fabric was reinforced with thin Kevlar tapes. Patterning of stressed fabric ensured the glassfibre rods were held sprung into a curve, with tapes looped around the glassfibre rods. End fittings for the rods were machined from high strength aluminium. Rods were retained by a spiral pin so that in the event of damage a rod could be removed and replaced.

The crown joint of the frame consisted of a ring with six radial plates, machined from solid high strength aluminium to guarantee strength, and which provided a hole up the middle for ventilation (Fig 12.2). The tent, lined with lightweight nylon, had a PU-coated nylon ground sheet permanently attached to the lining with zip joints enabling ice and other waste products to be shaken out. The lining itself was permanently attached to the poles. In stressing the tent it was necessary to tension the corner points of the fabric down to the ends of the rod so pushing the rods out into the curve of the fabric (Fig 12.3). The corners of the tent were then pulled out and pressed into the snow. Additional tie downs were installed to snow anchors, skis stuck into the snow, sledges or other secure objects available at the time. During striking of the tent, rods were released at the bottom point and the centre of the ground sheet was pulled up by a cord through the hole in the top joint (Fig 12.4).

The original 3.6m wide hexagonal ground plan of the tent required 2.6m long rods – a design considered by the explorers to be too bulky and larger than really necessary. Consequently, a scaled down version 2.5m across was designed.

Fig 12.4 Roger Mear holding the folded tent

Fig 12.5 Tent in use during expedition

Fig 12.6 Folded tent being transported by sledge

One of these tents was used by the three walkers for their 70-day expedition (Figs 12.5, 12.6). The polar journey ended in disaster and confusion however, when their support ship "Southern Quest" sank crushed by the pack ice, at the same time as the walkers reached their destination in January 1986. They became stranded at the Pole, to the irritation of the Americans at the Polar Research Station, who disapproved of such ventures.

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