THE ARUP JOURNAL

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Contents

Front cover: Alex Beleschenko stained glass window at Stockley Park (Photo: Crispin Boyle)
Back cover: Glass atrium roof at Triton Court (Photo: Ove Arup & Partners)

Education and training in The Ove Arup Partnership

Joanna Kennedy

Introduction by Jack Zunz

The only real asset our firm has is its members. We want to attract men and women who share our aims and objectives. Our training schemes for graduates and technician engineers and our policy for continuing training and development are designed not only to assist in the attainment of appropriate professional qualifications but also to enable members of our firm to develop themselves to their fullest potential.

We are also making ever increasing efforts to provide satisfactory training and continuing education for the many non-technical people without whom we cannot function.

We must ensure that the people who join us have opportunities for education and training so that they can meet the challenge and changes in their profession. A professional qualification is only the end of the beginning. The following article describes some of the efforts the firm makes to help members to qualify and then to continue with their training and development. But ultimately each of us must realize that only by our own personal efforts and dedication will our firm continue to remain at the forefront of our technology.

Initial education and training

Graduate training

The initial education and training of graduates is a high priority. It is an investment for the future. In this area lead times are long! The recent appointments to the Partnership Board of some who were first recruited as graduates is the direct result of policy decisions taken over 20 years ago.

The firm has links with some potential employees from an early stage of their undergraduate courses, since it offers a number of sponsorships and bursaries at selected universities and polytechnics. Vacation work also makes a valuable contribution to early training and development.

Since the early 1960s the Partnership has recruited up to 86 graduates a year. In 1986 approximately 8% were women. The majority of graduates are from civil engineering degree courses. However, in recent years an increasing number have been taken on from the engineering science, mechanical, electrical and environmental engineering fields. This has been linked with the firm's expansion into multi-disciplinary work and advanced technology projects. Arup Associates also recruit a number of quantity surveying graduates and they take on several architectural students for their year out, as well as for their final professional practice year.

Most graduates start with the firm in September and after a two week residential Graduate Induction course in London, join their groups or offices in London, the Regions, Scotland or Hong Kong. The course is also attended by the graduate Arup Scholars from the Australian practice and a few graduates from the offices in Ireland.

Training for the first three or four years of graduates' careers is aimed at achieving technical and professional competence in their discipline or field, coupled with increasing responsibility for their own work and that of others. This initial training prepares engineering graduates for professional qualification as Chartered Engineers, gained through membership of one of the major professional engineering institutions. Training schemes for such membership have been approved and formally registered with the Institutions of Civil (ICE), Mechanical (IMechE) and Electrical Engineers (IEE) and the Chartered Institution of Building Services Engineers (CIBSE). Our training for quantity surveying graduates complies with the Royal Institution of Chartered Surveyors (RICS) training scheme and prepares them for membership of the Institution.

Architectural graduates apply to the RIBA for professional registration after their professional practice year.

These training schemes are a significant commitment to individuals as the firm agrees to provide them with the necessary breadth of design office and site work training. For civil engineers, site work is undertaken, either with the firm or on secondment to a contractor. Building services engineers undertake various external secondments for workshop, manufacturing and site-based training.

Since the 1960s the Partnership has provided Training under Agreement for nearly 800 graduates.

In addition, senior members of the firm are delegated to supervise and monitor the graduates' training. They are responsible for ensuring that appropriate training takes place and act as training mentors or tutors.

Draughtsman and technician training
At present the firm recruits up to 12 school leavers a year, boys and girls, to provide draughting and technician support roles in the civil, structural and building services disciplines. Trainees undertake three year training schemes, which include a variety of design office and site work, and keep a log of their activities. Senior draughtsmen, technicians or engineers supervise this training and monitor progress.

Trainees are also encouraged to study on a day-release basis for a Business and Technician Education Council (BTEC) National Certificate and then, if appropriate, Higher National Certificate. Our training scheme for civil engineers has been approved by the Society of Civil Engineering Technicians and prepares trainees under agreement for membership of the Society and the attainment of Technician Engineer or Engineering Technician status. A similar scheme for membership of CIBSE is under preparation.

Suitably qualified technicians are also encouraged to achieve membership of other professional societies and institutions such as the Highway and Traffic Technicians Association.

Trainees who have shown exceptional academic ability, and who have proved through their work that they are suitable, have been able to progress to degree courses particularly in the civil engineering and building services fields.

Continuing training and development

In 1985 the Partnership Board agreed a policy of Continuing Training and Development (CTD) for all members of the firm. A working party has been examining how this can be achieved and how we can best target our resources. In the past, employees wanting training have usually been able to obtain it, but there is a clear need for the firm to encourage all members of staff to continue to develop their skills, not only for their own benefit, but also for the group they work in and for Arups as a whole. Only in this way can we continue to provide the best service competitively.

The Engineering Council in a recent report 'Call to Action' recommended that the engineering profession should introduce required updating for its members. Some professional bodies (eg RICS) do already make continuing education compulsory as a condition of maintaining membership. However, the best motivation is self-motivation and although a great deal is already being done, the present policy in Arups is to encourage people to take further advantage of the training and development opportunities that can be made available.

To ensure resources are well used, we are assessing skill needs and which activities can best, within the budget for CTD, meet those needs.

The activities include:

Further education
We support students on post-graduate courses and have established scholarships for further education and research.

External courses and conferences
A considerable proportion of our budget is spent on external courses and conferences. We are reviewing their effectiveness and an index by subject of suitable courses and conferences is being prepared.

Internal technical courses and seminars
These are arranged by different parts of the firm, some for particular groups or parts of the firm, others open to all. Better mechanisms for planning and putting on such courses, including the re-usability of course materials, are being looked at. Courses cover a wide variety of technical subjects, for example computing, fire engineering and acoustics.

Project management
In-house courses on managerial and personal skills are also held, for example project organization, presentation skills and effective writing. Further courses are being developed, in particular project management and negotiation skills.

In-house lectures
Lectures, given by visiting speakers or members of the firm, take place at lunch-time or in the evenings. Those arranged internally are an excellent way of using the firm's corporate knowledge and expertise as well as providing opportunities for younger engineers to make presentations.

Special topic selection
Individuals in a group are encouraged to select skills to develop from a 'menu' of needs.

Self-help groups/master classes
This activity is a new idea. Groups or classes will bring together engineers with the same interests (eg. fire engineering) under the chairmanship of a senior engineer or an expert in the field.

Secretarial development
Secretaries and other staff using word processors are trained in operating the hardware. A number of group secretaries have attended an in-house secretarial development course. Others have attended Industrial Society courses for senior secretaries, and for senior secretaries as administrators, as well as courses on time management for executive secretaries and also receptionists/telephonists. Follow up activities are planned.

Training for administrators and other non-technical staff
This area has not been given sufficient attention in the past and suitable training activities are under discussion.

Outside activities
Outside activities which act as a stimulus for CTD are to be encouraged, including involvement with professional bodies, technical writing, speaking at conferences/seminars and careers work.

On-the-job training
On-the-job training is an essential element of our CTD policy. New work often stimulates private study and research. Learning by example can be very effective. Responsibility encourages self-development. Broadening of experience is achieved by movement between jobs, groups, offices or overseas.

The international dimension

One of the great strengths of The Arup Partnerships is the fact that it is an international group of separate firms with a wealth of talent and experience, but joined together with a common name, shared ideals, great goodwill from personal contact, and a very real desire to see our standards perpetuated.

We now consist of some 13 major practices with a total of 40 separate offices in 22 countries. This presents us not only with a challenge, but also a unique opportunity for career development programmes which will allow us to share and expand our wide experiences, and to forge close personal contacts which will hold us together in the future.

Personal initiative and motivation are still the strongest catalysts, but there is also another. There is a career development panel of The Arup Partnerships which began meeting in 1981, specifically to see how our shared ideals could be exploited, and to encourage a worldwide approach to Continuing Education and Career Development. The panel has so far consisted of six representatives from offices in different parts of the world. John Nutt from Australia was the founding panel Chairman, but has now handed over to Richard Haryott from the UK, who is currently examining what the composition should be for the next year.

The panel meets every 18 months to exchange ideas, to review progress and to encourage new initiatives. The aims are set high — to create an environment where the rapport between leaders of the constituent parts can be handed on, where talents can be nurtured to the best interests of the whole, where opportunities can be made to extend people to a new level of achievement, and most importantly which encourages an inflow of talent into the practices.

So far the panel has concentrated on creating opportunities for an increasing exchange of talented staff between offices — never easy when those concerned are already busy at home — and in encouraging common attendance at in-house or other seminars and so on. Flowing from and in parallel with these wide initiatives, the level of awareness for the need to develop and train our talent is certainly increasing, and there is a willingness to provide an even greater resource.

Conclusion

In British industry and commerce as a whole adult training is given a low priority. A recent MSC survey of the manufacturing industry indicated that a quarter of all businesses provided no training of any kind in the last year. Only 0.15% of private sector turnover is spent on training.

Arups' commitment to the education and training of its members has always exceeded the UK average. But constant improvement in this area is essential for any successful company, if it is to keep up to date technically and professionally and to provide the best service. As markets change and competition increases, it will also require improved management skills and more efficient methods of working to maintain our leading position. The development of a CTD policy for the Partnership has this as its aim.

Joanna Kennedy is a member of the Continuing Training and Development Working Party and acts as its Executive.

Stockley Park

Introduction

The Stockley Park Project is a large and complex development scheme in West London which has been under construction since 1985.

Based on the transformation of 350 acres of former gravel workings and rubbish tips into a major business park, the scheme includes the creation of 250 acres of landscaped parkland, lakes, playing fields, and an 18-hole golf-course with 90 acres of commercial development.

The project has involved extensive land reclamation and site planning to establish the infrastructure of a major public park and business community for high technology industries.

The development is seen as an important partnership between the public and private sectors. It involves the granting of planning permission for commercial development to the developer, Stockley plc, who in return provides extensive public open space facilities to the London Borough of Hillingdon. The project is jointly funded by Stockley plc and the Universities Superannuation Scheme.

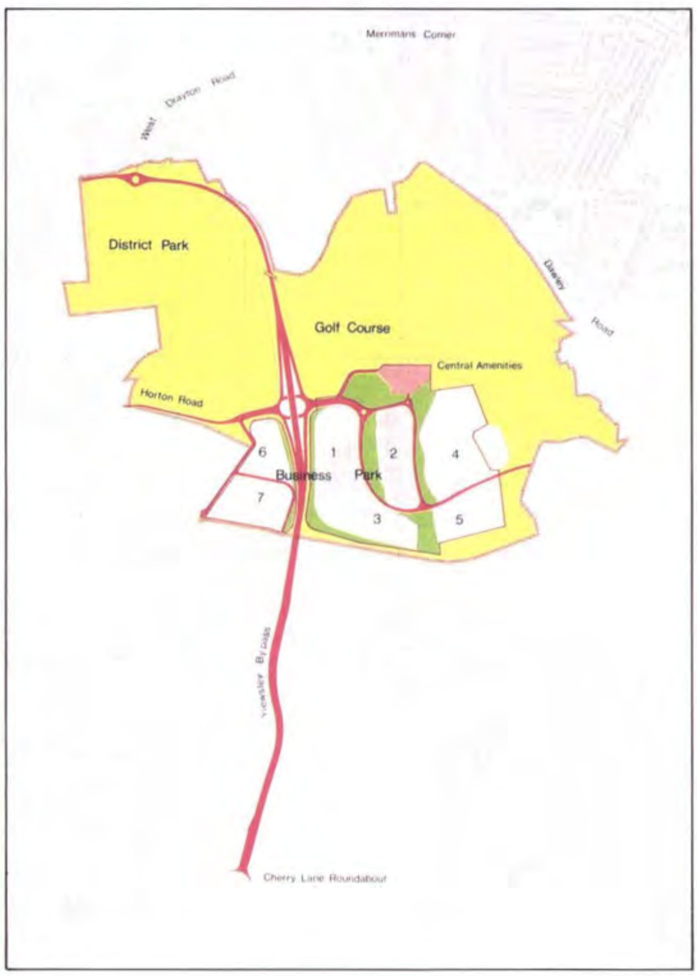
The site

Stockley Park occupies an extensive area in a central location within the London Borough of Hillingdon. The Park is strategically placed in relation to a large number of regional facilities which include Heathrow Airport, the M4, M40 and M25 motorways, the British Rail line to the West Country, two Underground lines, and numerous educational research and science facilities.

The single most significant factor influencing the development of the site was the landfill which covered nearly all of it at an average thickness of 10m. Gravel extraction and tipping commenced before the Second

The site in 1984

Location plan



Phase 1

World War and was only recently terminated in an area in the centre of the site. An extensive site investigation has been conducted by Ove Arup and Partners since the middle of 1981.

Bounded by the Grand Union Canal to the south, and a mix of industrial uses, housing and open space, the setting was a rather uninspiring one. However, its potential landscaping and movement links to regional amenities will provide attractive features for the project.

Immediately to the south of the canal is a gravel crushing plant that generates noise and some air pollution. Major earth mounding and screen planting will separate the development from this industrial operation and a helicopter maintenance depot. Elsewhere along the canal the quality of the environment varies from picturesque views of wooded banks and charming humpbacked bridges to rundown warehouse buildings behind chain link fences.

The eastern site boundary is bordered by some non-conforming uses that, in the longer term, will make way for developed green belt. The majority of the eastern boundary is defined by Dawley Road and the 'Dawley Wall' which is the only remaining element of the 18th century Dawley Estate. This brick wall will remain and is required to be reinstated to create a screening element to the open space.

The northern boundary abuts existing housing and skirts an equestrian facility on Goulds Green Road. This road, which is a cul-de-sac, will remain as a significant minor route along the periphery of the site. The western section of the site is separated by the Yiewsley By-pass, which is under construction.

The Master Plan

The generating forces that shaped the Master Plan for Stockley Park stemmed from an analysis of the planning context and local site conditions, development objectives and extensive market research.

The primary site planning decision was to locate the new business park in the south while reinforcing the green belt in the north. This not only enhanced part of the site for public use, but also created an appropriate separation between the new development and the surrounding housing.

The second strategic planning decision was to transfer the landfill from the business park to the green belt in the north. This required the use of structural fill to create safe, stable building sites and to avoid the necessity of providing piled foundations and ventilated undercroft space normally required when building on polluted sites. Landfill was partially left in place in defined car parking zones. This reduced the civil engineering costs and at the same time established limits to the building sites. Clay was used in zones where ponds or other features were required. The strategy of this operation, including the technique for the control and disposal of methane gas and polluted groundwater, is described in a report entitled 'Outline design for site reclamation', jointly prepared by Arup Associates, Ove Arup and Partners and Grontmij NV in December 1984, which subsequently formed the basis of a paper published by Thomas Telford Ltd. in 1986, entitled 'Buildings on marginal and derelict land'. Approximately three million cubic metres of landfill material was moved from the business park creating a new landform to accommodate open space uses within the green belt.

The planning concept for the business park was to create a series of flexible development sites related to public open space that linked the green belt on the north to the Grand Union Canal on the south.

The site plan has buildings grouped around a loop road, reinforced by landscaping, lakes and a necklace of lime trees. These trees have been planted to give a defined structure to the landscape, to reflect the loop road and create a frontage to the large building sites. Conceived as a device for controlling the building line and providing visual continuity in the development, they extend through the green belt and link into the future Phases 2 and 3.

Traffic

Considerable research into anticipated traffic generation for Stockley Park has been undertaken jointly by Ove Arup and Partners and the London Borough of Hillingdon. On the basis of an average of 32.5m^2 gross building area per car, the business park could generate a need for 4,300 parking spaces.

The Yiewsley By-pass, with its interchange at Horton Road, will serve the traffic access needs of the site. The interchange has been designed as a rotary system with the through traffic being carried overhead on a viaduct. The By-pass will consist of a dual carriageway system from the Cherry Lane roundabout near the M4 motorway junction up to the site interchange where it will reduce to a 10m wide two-way road for its remaining length.

Access from the interchange into the eastern side of the site is by a dual carriageway roundabout. The local road system within the Business Park consists of a two-way loop, 7.3m wide, serving all the building sites.

Phases 1, 2 and 3

Road network

Photographs show the new landscapes and buildings at Stockley Park and model of the Centre. The stained glass window is in the A1.3 building and was designed by Alex Beleschenko.

Landscaping

The development has provided a major opportunity to create a landscape plan at a grand scale and to regenerate a wasteland into viable and useful public open space. Arup Associates as Master Planners are working with Bernard Ede Associates and Charles Funke Landscape Consultants, as well as Grontmij NV Reclamation Consultants and Robert Trent-Jones Golf-course Architect, to produce a co-ordinated plan for the total site. The site has developed into three defined zones:

(1) The 'naturalistic' golf-course and informal public open space areas.

(2) The 'geometric' forms of the district park and playing fields.

(3) The contrasting 'linear and cellular' forms of the business park.

The green belt is created into a broad dome-like landform which assists the requirements of leachate control. The business park lies in the low section of the site and incorporates shallow valleys that contain attenuation ponds for stormwater run-off from buildings and car parks. These valleys terminate at the Grand Union Canal.

The landfill that is placed in the green belt is constructed as a semi-permeable membrane for ease of methane gas release. It has graduated layers of old landfill and site clay, and a final layer of 'manufactured topsoil' formed with sludge cake and clay.

The plant species vary depending upon their location, elevation and soil conditions. They include scrub/heath on high ground, light woodland on the sloping flanks, damp woodland and wetland plants in the valley conditions.

The green belt will be generally planted from mass forestry-type material with alder, poplar and willow and longer-term species like oak and ash for the mature landscape. Anticipated plant failures of up to 30% have been allowed for in these areas.

The Business Park is generally formally planted with semi-mature species directly into clay or topsoiled zones. They include limes along the curving necklace, planes at the site entrance and strategic locations, hornbeams as screen planting to car parks, and maples along secondary access routes.

Yew hedges are used to screen service areas and define pedestrian routes together with extensive shrub and evergreen ground covers. The majority of the trees have been imported from Belgium where their nurseries have excellent and consistent material which can be lifted ready for transplanting. The first phase is largely complete and includes 17m high planes and limes up to 35 years old.

Reclamation strategy

Planting concept



The buildings

The business park is made up of a series of seven building zones designated for new office and workshop buildings with an eighth zone reserved for the central amentities building. These areas, together with the space for loads and public open space, can be summarized as follows:

Building Zones 1 – 7		25.17 ha
Central amenities		1.39 ha
Roads		3.94 ha
Sub Total	30.50 ha	
Public open space	6.00 ha	
Total area	36.50 ha	

Each of the seven building zones are subdivided and represent the following site and gross floor areas:

Zone 1	5.45 ha	29,763 m^2
2	3.20 ha	16,237 m^2
3	2.25 ha	12,800 m^2
4	5.90 ha	33,600 m^2
5	2.65 ha	15,000 m^2
6	2.32 ha	13,200 m^2
7	3.40 ha	19,400 m^2
Total	25.17 ha	140.000 m^2

The new buildings within the business park consist of a combination of two and three storey structures and provide a total of 140,000m^2 gross floor area — the maximum permitted on the site. Based on the design considerations for the development and the market research conducted by Duffy, Ely, Giffone and Worthington, Architects & Space Planners, into requirements for technological industries, certain characteristics were adopted for these new buildings. These include:

(1) Medium depth buildings which achieve good levels of outside awareness and natural light, i.e. 18m wide, whilst providing sufficiently adaptable space for a variety of activities.

(2) Buildings planned with central atria both to provide added amenity and efficient layouts.

(3) Buildings planned with pitched roofs to create a distinctive profile and to rationalize positions for mechanical plants.

(4) Buildings related to open space amenities, especially water.

(5) Car parking screened by buildings and landscaping wherever possible.

Space for cars has been planned as an integral part of the scheme with hard surfaced parking areas required to accommodate approximately 4,300 cars.

Initially, three two-storeyed buildings, totalling 13,000m^2 gross floor area, were constructed to form the core of the business park. They were started on site in September 1985 and were ready for occupation when the site was officially opened by H.R.H. Prince Charles on 6 June 1986. Since then Arup Associates have designed further buildings, one of which is three storeyed.

These will provide a total of 37,000m^2 gross floor area. In December 1986 the first tenant moved into a 5,000m^2 building and further tenants are fitting out buildings for occupation by spring 1987.

The Centre, a building designed to accommodate sporting facilities, amenities and shopping, has been sited on the lake between the business park and the golf course, so as to form a focus for the development.

Credits

Client
Stockley PLC
Architects + engineers + quantity surveyors:
Arup Associates
Civil engineering & transportation consultants:
Ove Arup & Partners
Reclamation consultants:
Grontmij N.V.
Landscape architects:
Bernard Ede Associates
Landscape consultants:
Charles Funke Landscapes
Golf course consultants:
Robert Trent Jones
Construction consultants:
Schal International Ltd.
Project managers:
Stanhope Securities Ltd.
Photos:
Arup Associates and Crispin Boyle

PTT telecommunication stand, Amsterdam

Robert Pugh

Introduction

In April 1986 Ove Arup & Partners were approached by the Dutch architects Frank and Paul Wintermans to provide specialist structural advice for a demountable exhibition stand with a distinctive design. The stand would be used by the client, the Telecommunications branch of the Dutch PTT, to exhibit their business equipment products at various trade fairs around Europe. The first such exhibition was to be in Amsterdam in early October 1986 which therefore demanded a design and construct period of less than six months. In view of the limited time available, a Dutch steelwork contractor, Evers, had already been appointed, and Ove Arup & Partners' brief was to provide scheme design information direct to this contractor for the production of detail design and fabrication drawings.

Structure

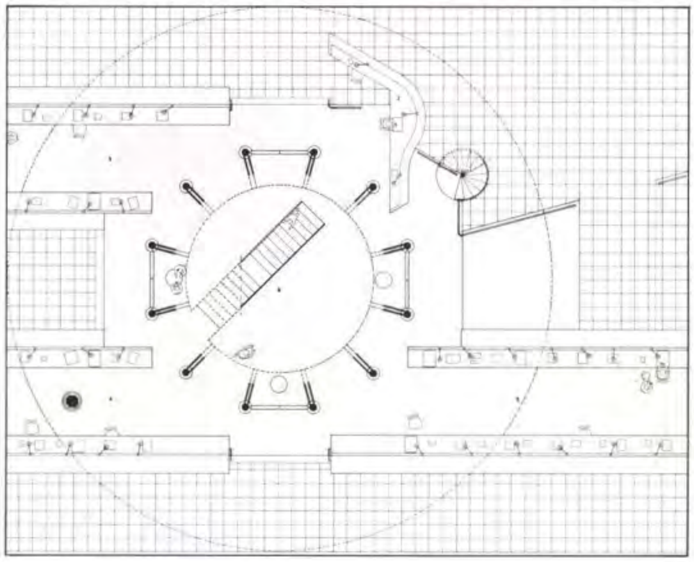
The architects had a clear intention regarding the form of structure to be adopted. The general arrangement consisted of first floor and roof level rings of approximately 20m overall diameter, suspended on a series of 12 radial frames, providing column support near the inner edge of the rings, and hanger and tie support from the column masts to the outer edge.

The actual configuration of the frame support system evolved through a brief but intensive study during May 1986 with the architects working in our London office. As with many structures that are to be visible, aesthetic requirements often take precedence over the simple structural logic. The main structural factor affecting the form was consideration of the potential out-of-balance load condition. Connecting the tops of opposite masts across the centre of the open ring would have resolved this condition but the architects were very keen that the ring centre should remain open. Another alternative would have been to secure tops of individual masts with a tie secured to the ground inside the column ring, but this intruded too much on the ground level circulation. Thus the adopted scheme returned the tie back to the column base, and the horizontal out-of-balance load component was taken via the floor plate to vertically braced bays.

Given this structural form it is evident that the geometry (angles of raking ties and relative position of column mast) affects the resultant horizontal and vertical components of load and therefore strains. These strains can have significant effects on the overall deflection characteristics of the system, particularly with the architectural constraints on the geometry. Accordingly tie members were sized for strain control rather than load. Horizontal beams supporting the floor and roof were split, to sit either side of the column, and twin ties (to provide sufficient sectional area) were aligned in the zone between. Turnbuckles were provided to all ties to take up any imbalance between parallel ties or slack in the system.

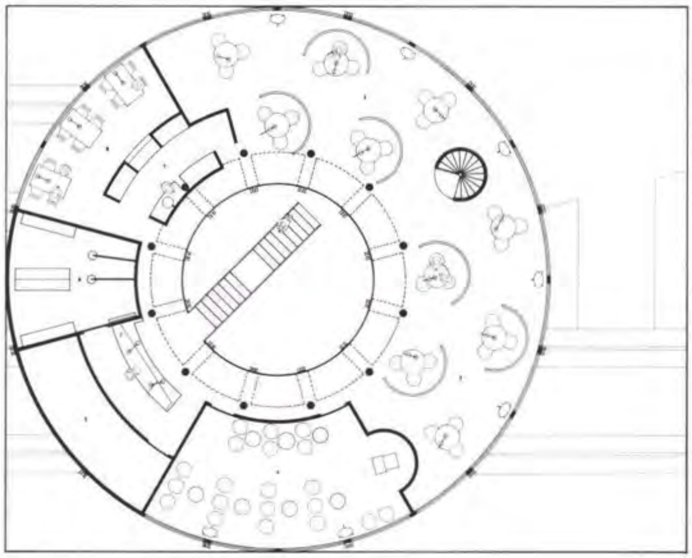
Since the stand was intended for indoor use, column loads were supported by a spread footing system bearing on the exhibition hall floor. A steel beam grillage was initially envisaged but would have proved expensive, and thus precast concrete pads were chosen. The column to pad detail was designed as a moment connection as this

Key
1. Surrounding hall
2. Reception
3-5 Display areas 1-3
6. Atrium

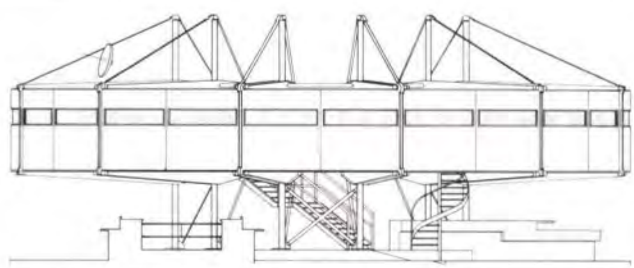


Ground floor

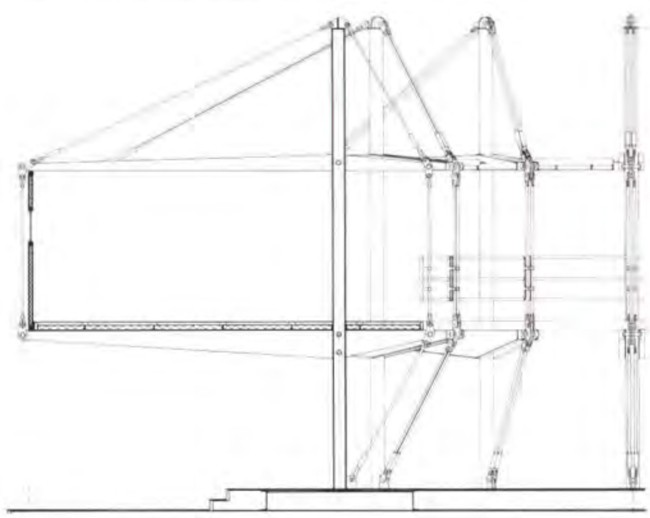
Key
1. Atrium
2. Reception
3. Customer conference area
4. Projection room
5. Equipment room
6. Cloakrooms
7. Kitchen
8. Dining areas



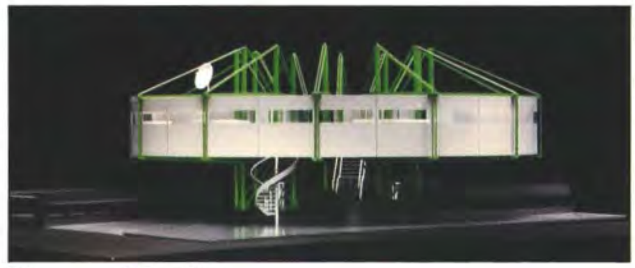
First floor



Elevation

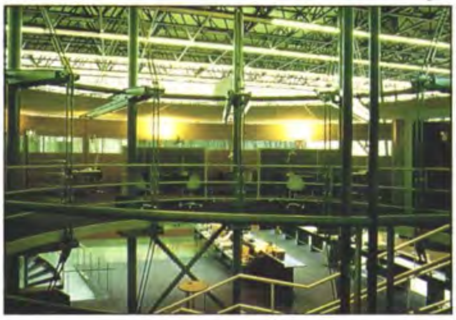


Section through structure showing steelwork



1. Computer drawing
2. Model
3. First floor, exhibition area below
4. First floor reception
5. Customer conference area

1△ 3▽ 2△ 4▽ 5▽



was beneficial for the temporary stability during erection. The self-weight of the pads also act as counterbalance to the overturning moment at the braced bay locations.

The floor plate is constructed from pvc foam-filled pressed steel sandwich panels bolted to the frame members. These panels are formed with recessed trunking routes at their edges to give a trunking network in the completed floor. The roof, as the stand is to be indoors, is only a ceiling covering and consists of translucent fabric sheets stretched on springs between the frame members.

Programme and construction

The scheme design information was given to the fabricator to place the steel order at the end of May 1986. Fabrication commenced at the beginning of July and was ready for a pre-paint trial erection in early September 1986.

Individual frames are part-assembled and, pivoting at the connected pins, are folded longitudinally for transportation. The individual frames are opened out and connected in their final shape while flat on the ground, and then lifted by mobile crane and attached to their respective prepositioned concrete pads. The bracing and circumferential ring members are then introduced to interconnect the frames, followed by the floor and ceiling systems. The erection of the steelwork frame can be performed in little more than a day while the whole construction including fitting out takes a week.

The overall budget for the project was £300,000 of which the 22 tonnes of steelwork contributed £47,000.

Efficiency Beurs '86 (Business Efficiency Exhibition) Amsterdam

The stand was used for the first time at the Efficiency Beurs '86 trade fair at the RAI exhibition centre in Amsterdam from 6-13 October 1986.

The fair was concerned with all manner of business equipment, with computers and communication systems being exhibited by over 300 major companies (Apple, Canon, IBM, etc.) in six large halls. This annual fair, recognized as one of the biggest in Europe for this market, attracts over a quarter of a million visitors during the week's opening.

The PTT exhibition area enjoyed a prominent location by the entrance to one of the two main halls. The ground floor area was used for general exhibition of the PTT's telecommunications products while the stand's first floor area was used to entertain potential customers in more VIP surroundings.

In a competitive market where image is all important there was little doubt that the client enjoyed the prestige that the high profile stand gave him. The stand is to be re-used over the next five years in Amsterdam and at locations in Germany and Switzerland.

Credits

Client:
PTT Telecommunicatie, Gravenhage, Holland
Architect:
Architektenkombinate van Klooster/Wintermans, Eindhoven, Holland
Consulting structural engineers:
Ove Arup & Partners, London
Steelwork fabrication/erection:
Evers, Hillegom, Holland

Photos: 1. Ove Arup & Partners 2. Jac Beckers 3-6. The architects

6. The finished stand

Early Arups' prestressed concrete work

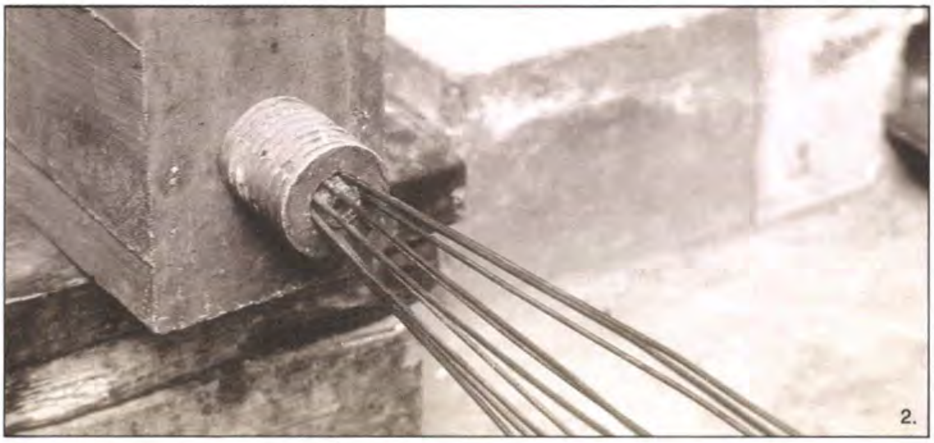
Francis Walley

As the projects which appear in this article were designed before the introduction of metrication, all dimensions are in imperial units.

Three years ago a paper[1] entitled 'The childhood of prestressing' was presented at the Institution of Structural Engineers. This took the history of prestressed concrete up to the early '50s. It was thought that an account of the exploits of the firm in the field in the '50s and '60s could be of interest particularly to those who have joined since those days. One could speculate on the reasons why this method of construction enters less and less into the vocabulary of engineering solutions (except for bridges) these days. An arbitrary date has been set at the end of the '60s, largely because of the limitations of space, but also to be able to stand back and reflect on what was achieved using what at the time was a non-proven but exciting solution.

Rather than set down in simple chronological order the works as they were designed, an attempt has been made to group jobs, or rather the parts of them which were prestressed, to illustrate the way solutions to the problems posed were obtained. Clearly not all jobs can be dealt with in this way since some are unique solutions to unique problems.

The Festival of Britain footbridge (Job 606, 1951, Bob Hobbs) (Fig. 1) is the first job chosen. It was prestressed using the old Freyssinet wire wound anchorage with a concrete wedge (Fig. 2).



2.

1▽ 3△

1. The Festival of Britain footbridge 1951 (Photo: Sydney W. Newbery)

2. Freyssinet cone and anchor

3. The Barbican redevelopment diversion of the railway using precast bridge units (Photo: Sydney W. Newbery)

4. Wexham Springs, workshop building (Photo: Sydney W. Newbery)

5. Bank of England Printing Works, Debden (Photo: John Holden)

6. RAF Abingdon, hangar (Photo: Ove Arup & Partners)

The Iddo overbridge, Nigeria (Job N36, Tom Ridley) and the diversion of the railway under the Barbican (Job 1023, Tony Stevens) (Fig. 3) using precast bridge limits were the only examples of bridge works during this period. The Civil Engineering Bridges section had not been set up.

The Festival footbridge had the distinction of being tested to destruction during the subsequent clearing of the site.

The second job chosen is one familiar to the thousands who have visited Wexham Springs. The workshop building (Job 737, 1953, Bob Hobbs) (Fig. 4). This was one of the first group of buildings built in the grounds of the old house at Wexham Springs which the C&CA took after World War II to set up their research laboratories. Arups were suitably modest about this building when holding the celebrations there in 1985. It was the beginning, as far as we were concerned, of the association of prestressed concrete with shell structures. In this case no edge beams were employed — Lee McCall rods were used in the shells, the tie forces thrust being carried by Freyssinet cables in the high level window sill beams. When first constructed, no roof covering over the concrete was used since it was considered the prestressed concrete shells would be watertight. Many years later they were, however, covered.

From early on the problem of creating large uninterrupted areas exercised the ingenuity of the practice. Brynmawr Rubber Factory (not prestressed concrete) was possibly the earliest example. The first attempt using prestressed concrete was the Bank of England Printing Works at Debden (Job 634, 1956, Bob Hobbs) (Fig. 5), the main column-free hall was 800ft. long with a width of 125ft.

The solution was to use prestressed precast concrete arches with a series of in situ reinforced concrete shells between them. In the case of the smaller printing hall this method was reversed.

A similar column-free area was required for a hangar at RAF Abingdon (Job 1026, 1958, John Blanchard) (Fig. 6). This required clear areas of 180ft. × 105ft. The solution, which later became commonplace for shell structures, was to employ reinforced concrete shells with prestressed concrete edge beams. In this case the areas were created by using a group of three shells each 180ft. long by 35ft. wide. The four edges, two internal, two external, were prestressed using the Freyssinet system. A unique feature of this job was that each group of three shells was cast on the ground and jacked up at the four corners. The columns at these points were made of precast blocks and progressively built as the roof was raised. On completion of the lift the columns were prestressed with Lee McCall rods.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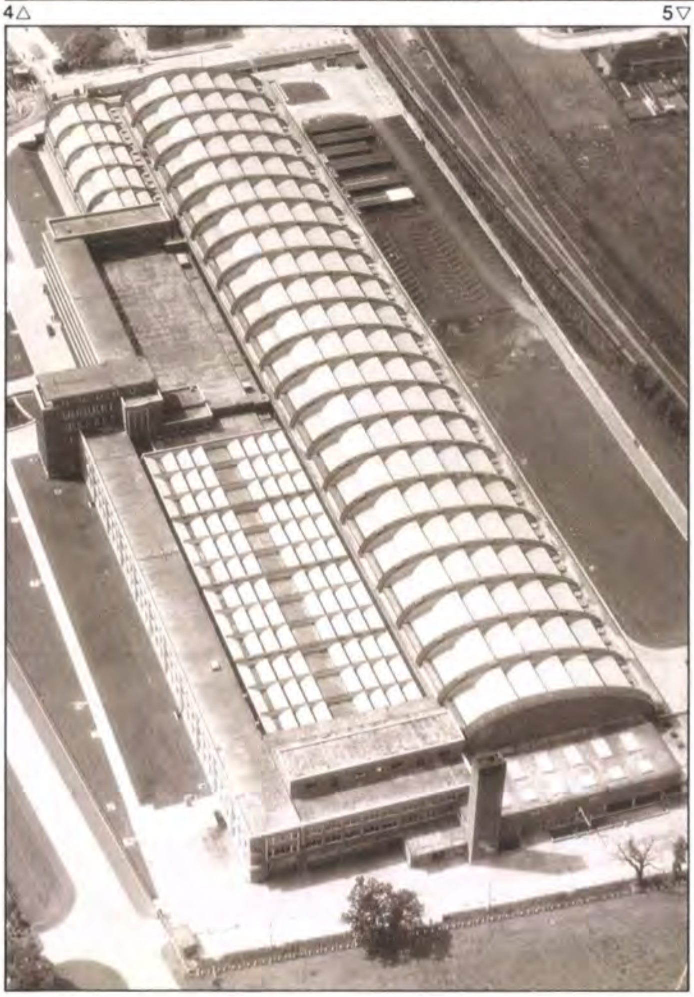

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7 & 8. Smithfield Market
(Photos: Sydney W. Newbery)

9. Peter Lind factory, Purfleet
(Photo: Archie Handford)

10. Holloway Comprehensive School
(Photo: LCC)

11. Test Floor, Civil Engineering laboratories, Imperial College

12. Sydney Opera House concourse
(Photo: Ove Arup & Partners)

13. St Catherine's College, Oxford: dining hall (Photo: William J. Toomey; copyright *Architects' Journal*)

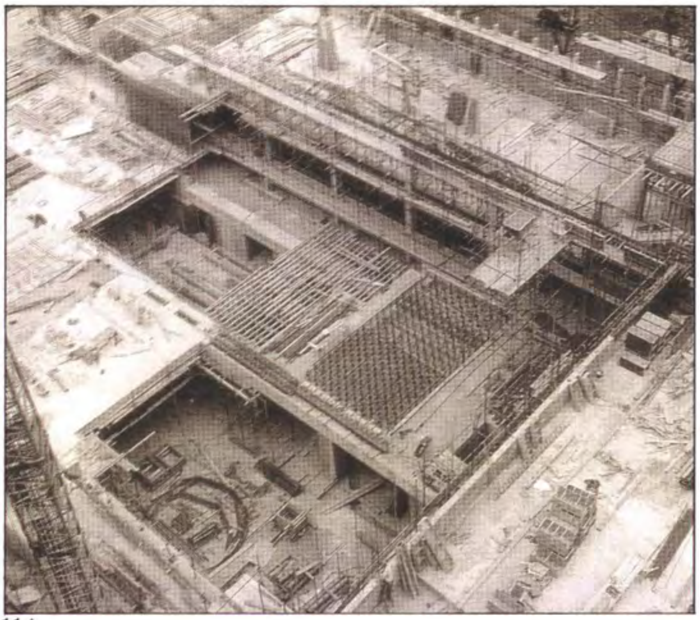
Another solution to the covering of a large space is illustrated by the Smithfield Poultry Market (Job 1265, 1963, Povl Ahm) (Figs. 7-8). Here an area 225ft. × 128ft. was covered by a single elliptical paraboloid shell of reinforced concrete — the largest of its kind in Europe at the time. In this structure the edge beams are of in situ prestressed concrete and follow the curve of the shell. The thickness of the shell was 3in. at the centre increasing to 6.75in. at the edge.

Domed roofs of more modest dimensions with the edges supported by prestressed beams were used on several jobs such as Kidbrooke School (Job 609, 1954, Bob Hobbs). One interesting development for factory roof structures was the construction of Warren girders in prestressed concrete for north lights often in association with shells.

This is exemplified by a factory for Peter Lind at Purfleet (Job 866, 1956, Bob Hobbs) (Fig. 9). In the 90ft. span trusses the diagonals were precast and the bottom beam was prestressed using Gifford-Udall cables, some of these being taken up the diagonals towards the ends of the girders.

Another interesting roof structure was that used on Burton-on-Trent Technical College (Job 617, 1953, Jack Zunz) where the 'roof covering' was suspended from post-tensioned prestressed concrete beams (the first Arup hanging structure?).

Perhaps one other type of roof which had an architectural vogue in the 1950s should be mentioned. This was the diagrid roof made up of precast units placed on a square pattern with an in situ concrete joint at their juncture. The job illustrated is the Holloway Comprehensive High School (Job 726, 1962,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André Bartak) (Fig. 10) but this solution was also used at Harlow Secondary School (Job 706, 1958) and for the Regatta restaurant (Job 606, 1951) at the Festival of Britain. In each case a different prestressing system was used, Lee McCall, Magnel and Freyssinet.

So far no mention has been made of, so to speak, the use of straightforward prestressed concrete beams or slabs. One of the advantages of prestressed concrete which perhaps has been exploited most often in bridges is that, as the parlance went, it carries itself, so that longer spans can be achieved with shallow depths of beams. The next group of jobs incorporate such solutions.

One of the earliest was the test floor of the Civil Engineering laboratories at Imperial College (Job 1202, 1963, Povl Ahm) (Fig. 11) prestressed using the CCL system; a floor over which many engineers have walked but probably not thought much about.

The Sydney Opera House shells (Job 1112, 1959, J. Zunz), which were constructed using precast units stressed together, has been well-documented but little or no mention is made of the concourse (Ronald Jenkins) (Fig. 12) which comprises 300ft. wide steps and platform carried by 104 prestressed beams of spans varying between 136 and 184ft. These were stressed by 1.14in. strand cables using the Gifford-Udall system.

A more visual example is the pretensioned prestressed concrete beams over the dining hall at St. Catherine's College Oxford (Job 1230, 1964) Povl Ahm (Fig. 13). These are 75ft. long, 5ft. deep and 6in. wide, precast and transported from Norwich to Oxford.

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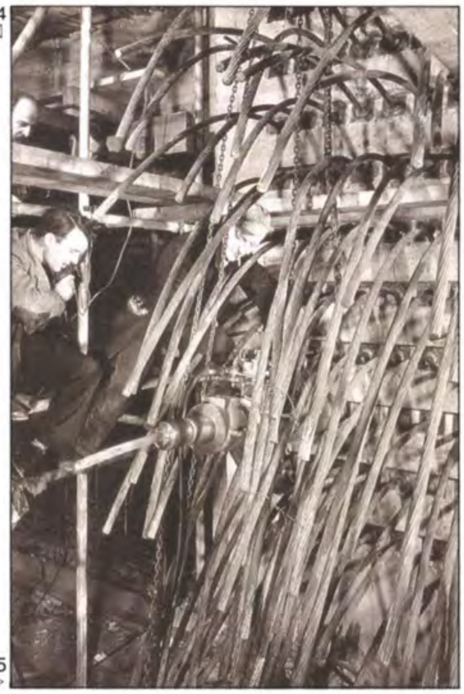

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Another job in this category should be mentioned and that is the roof of the swimming pool of the Hampstead Civic Centre (Job 1210, 1964, David Lowes). The beams are 230ft. long (Fig. 14), supported near their centre and are of I-section 5ft. 6in. deep post-tensioned using the CCL Spiral Strand System.

As a further example, the Wilton Hotel Development (Job 1337, 1960, John Martin) (Fig. 15) should be mentioned. This is a large beam, 78ft. span which supports the building over the main circulatory road system close to Victoria Station. It is again one of those hidden structures which the public are blissfully unaware of but which they travel under every hour of the day and night — a forerunner of Alban Gate — London Wall?

The final job chosen to illustrate our early work is the Royal College of Physicians (Job 1344, 1963, Peter Dunican) (Fig. 16). The two-storey library which projects over the main entrance is supported at one end by prestressed walls acting as deep beams. These walls are cantilevered half the width of the building over a central column. The floor and roof were constructed using precast pre-tensioned beams.

It has not been easy to give a snapshot of Arups' early work in prestressed concrete. Perhaps enough has been illustrated to give a flavour of what, no doubt with a measure of nostalgia, appear to have been heroic days. Certainly there were no Codes of Practice to set rules and honest commonsense engineering could prevail. One cannot also help but speculate on why it does not occur more often these days as a solution to an engineering problem. Is it simply cost or is it that it is not one of the possible solutions which enters the thinking of engineers today?

14. Hampstead Civic Centre
(Photo: Henk Snoek)

15. Wilton Hotel
(Photo: A'Court Photographs)

16. Royal College of Physicians
(Photo: Ove Arup & Partners)

Reference

(1) WALLEY, F. The childhood of prestressing — an introduction. *Structural Engineer, 62A* (1), pp.5-10, 1984.

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Triton Court

Architects: Sheppard Robson

This refurbishment of Royal London House, 13-18 Finsbury Square, London EC2, was carried out between 1982 and 1984, to provide some 30,000m^2 of high class, air-conditioned offices within a building originally constructed between 1904 and 1930.

Triton Court has received the following awards:

Structural Steel Design Award

Stone Federation Award

Patent Glazing Award

Landscape Award

PA Award for Innovation in Building Design and Construction

Civic Trust Commendation

Credits:

Client:
Royal London Mutual Insurance Society Ltd

Project manager:
Richard Ellis

Architects:
Sheppard Robson

Quantity surveyor:
Gardiner & Theobald

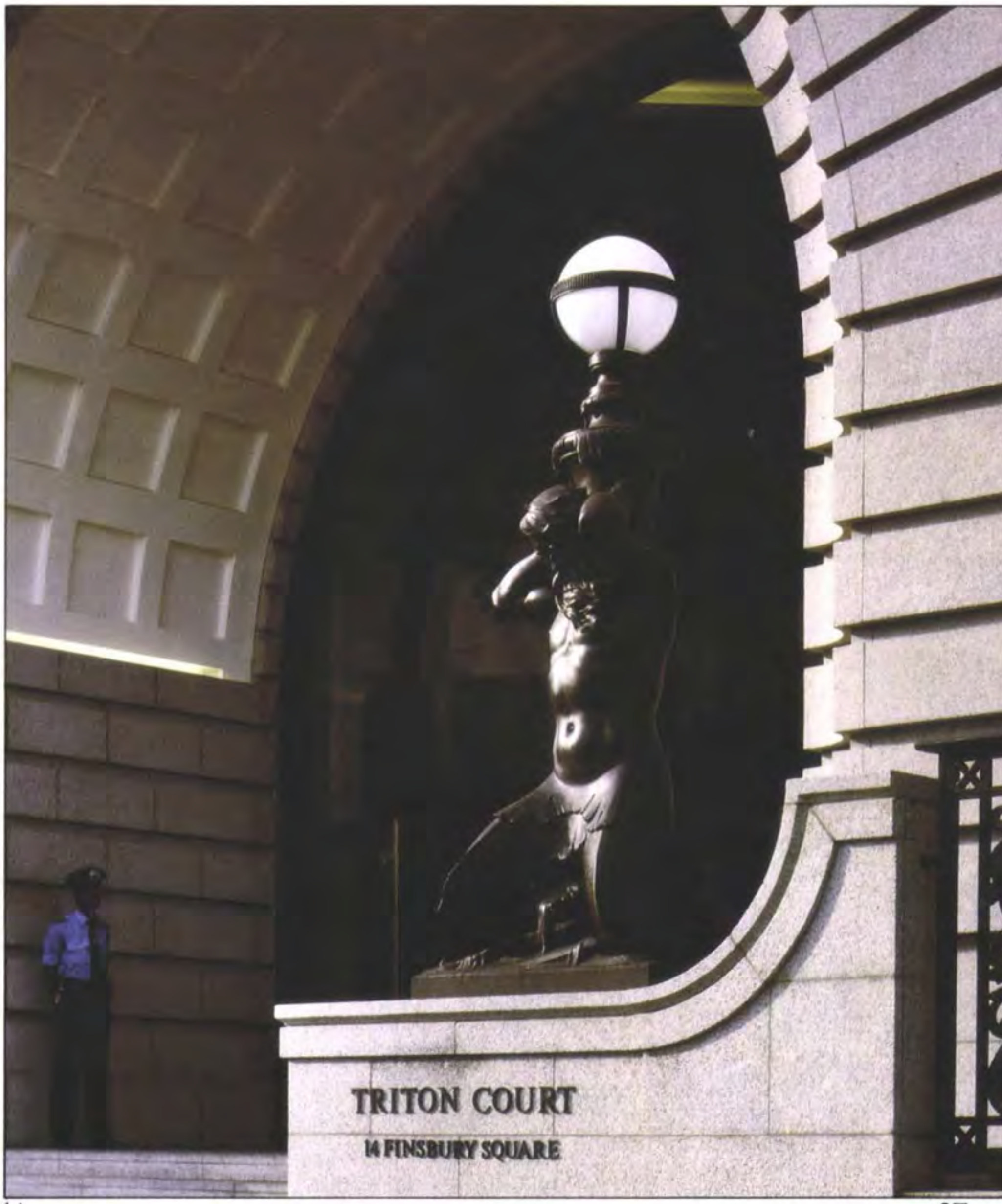
Structural and services engineers:
Ove Arup & Partners

Main contractor:
Trollope & Colls

Photos:
1. Richard Bryant
2. Richard Ellis
3-21. Ove Arup & Partners

1. Close up of archway

2. Triton Court viewed from Finsbury Square



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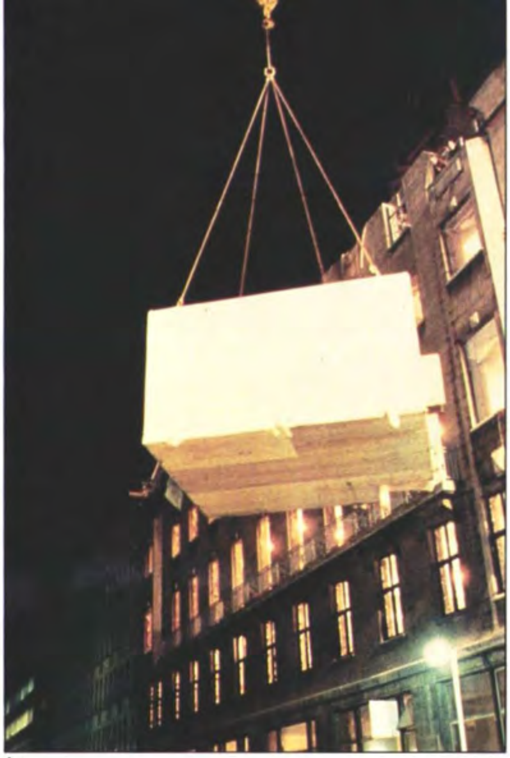

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3. Temporary support to Finsbury Square elevation during construction

4. Toilet module en route to its final position

5. Typical prefabricated *Omnia* floor

6. Prefabricated toilet module

7. Steel beam connection to slipformed concrete core

8. Interior of typical toilet module

9. Security and control centre with building automation monitoring system

10. Chiller room in basement

11. Coal-fired boilers in basement

12 + 14 Glazed atrium roof

13. Exterior of octagon boardroom

15. Seventh floor glazed octagon boardroom

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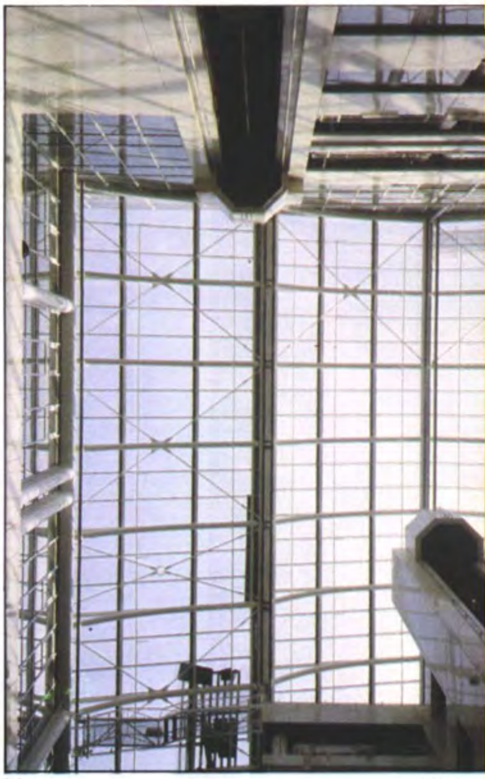

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16. Atrium entrance showing escalators to lower level reception area, with Roux Bros. restaurant in background

17. Corner view of Triton Court showing refurbished clock tower

18. Top of atrium wall climber lift

19. Top of wall climber lift and support to atrium roof truss

20. Glazed rooftop air-handling plant

21. The atrium floor from above

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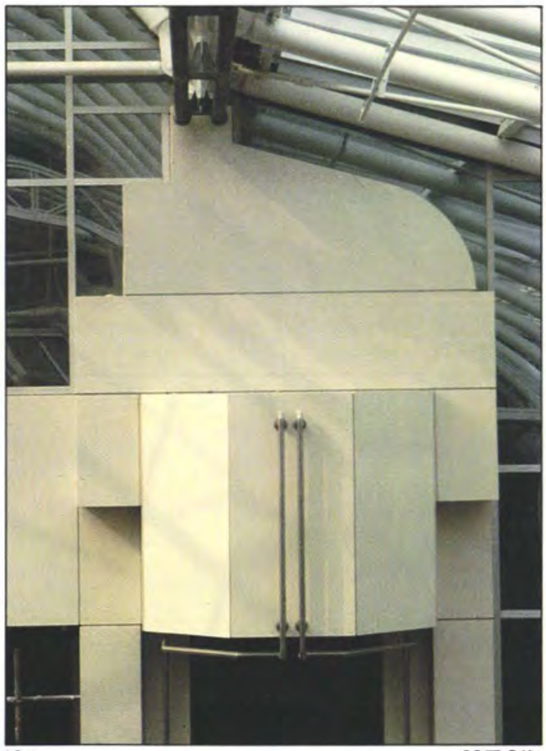

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