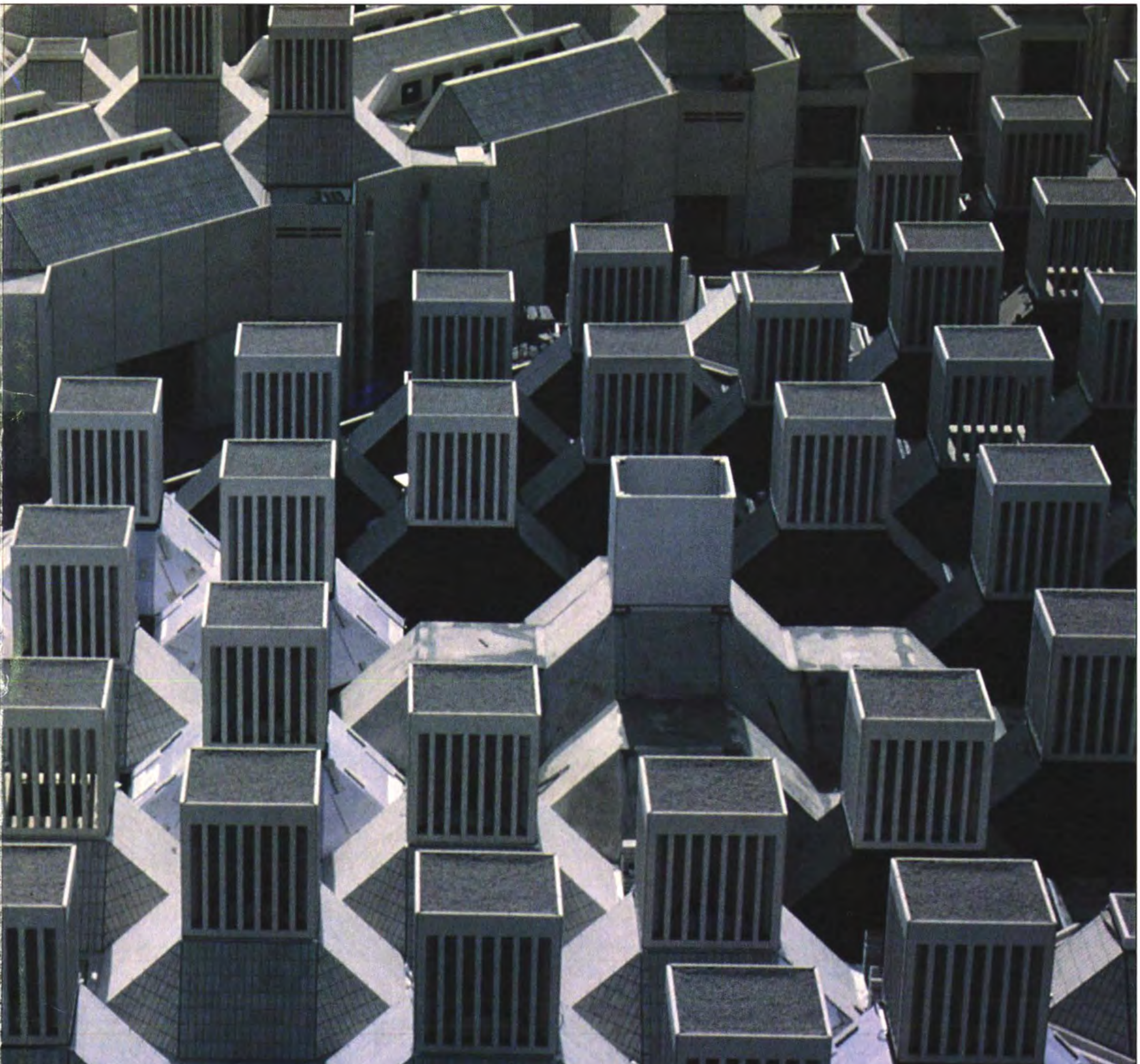
THE ARUP JOURNAL

WINTER 1986



THE ARUP JOURNAL

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Contents

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University of Qatar: Phase 1a

Architect: Dr. Kamal El Kafrawi

Mike Brown
Chris Barber

The first phase of the University of Qatar comprising the academic buildings was inaugurated in February 1985 and has just completed its first full academic year of occupancy.

The campus is being developed to house the University which has grown rapidly since the first 150 students entered temporary buildings in 1973/74. The student population has now reached 4,700 and is expected to continue to rise during the next few years.

The University is considered to be one of the most important current projects in the Middle East and is being planned to the overall design of the Egyptian architect, Dr. Kamal El Kafrawi. Features of the buildings include a modular planning concept based on an octagonal grid, a traditional Islamic form; the use of high quality white precast concrete cladding; and the use of the traditional Arab wind tower over classrooms to allow indirect natural light and cooling ventilation through openable windows within the roof structure.

Total floor area of buildings now complete is 73,000m^2. In addition to classrooms, laboratories and lecture theatres, space is provided for library and exhibition facilities, administration, canteens and a central services unit containing main air-conditioning plant. The building surrounds have been fully landscaped to include car parking and there is a dual carriageway ring road for vehicle circulation to different areas of the campus.

A further phase of sports facilities and student activity buildings is under construction to be occupied during the next academic year.

The structural design solution is a specific response to the architect's planning. The concept for high quality concrete buildings in a modular low-rise form has allowed the use of repetitive precast elements for both cladding and structural walls. The adoption of precasting had the advantages of rigorous quality control in production and increased speed of construction with a reduced labour force.

The planning of the academic buildings is based on two grid forms, an octagon 8.4m in width and a square with sides of 3.5m. The octagons are adjacent and connected with squares to form the modular grid pattern.

For energy conservation, sandwich construction has been adopted in external walls with a make up of facing panels, insulation and loadbearing or infill block inner panels.

Primary structure consists of loadbearing precast concrete walls with floors formed of waffle or trough type cast in situ concrete. The roof structure is created from sloping precast units arranged to transpose the octagon plan module into a square. This forms the base of the tower of winds structure. The tower is characterized by its vertical slatted precast panel sides.

Roof structure variations occur in a number of circumstances. Where two octagons are combined to produce laboratories, vierendeel precast concrete roof trusses span the double octagon. Where four octagons are combined as courtyards, a cast in situ folding plate roof geometry has been adopted.

The policy adopted for main services distribution to the buildings has been to construct a central services unit as the energy centre for the campus with an underground walk-through service duct connecting the energy centre to the other buildings.

The central services unit contains the main cooling plant which supplies chilled water to the air-conditioning systems. The plant consists of four unusually large centrifugal chillers with variable speed drives which produce a total of 18,000kw of cooling capacity.

The basic types of air-conditioning systems adopted within each building are ducted all air (for large areas such as laboratories and lecture theatres) and fan coil units (for classrooms, studies and staff rooms).

Small air handling units of the fan coil type have been developed especially for the project. The unit has been purpose designed to integrate with the ceiling space available in square areas between octagon modules.

In addition to the full air-conditioning system, the facility of controlled natural lighting and ventilation is provided by towers in the octagon structures. These towers operate in the same manner as the traditional Arab wind towers used to cool buildings for many hundreds of years. It is anticipated this natural system will be used to complement the full air-conditioning system.

Power distribution from the central services unit to individual building sub-stations is by 11kv ring main cabling in the underground services duct. Maximum demand for the academic building area is 15 MVA.

Medium voltage power within the buildings is distributed to switch panels local to classrooms and laboratories from which general purpose power and lighting circuits are taken.

In January 1975 Ove Arup and Partners were engaged by the State of Qatar to assist the architect in the development of the masterplan and the first stage of the campus initially known as the Gulf University.

Arups' appointment was as the architect's prime consultant to undertake structural and engineering services design and site supervision.

In 1978 the scope of Phase 1a was redefined and the project was renamed the University of Qatar. Construction commenced in 1979, and following a re-plan, was completed in 1984 at a total cost of approximately £125m.

Credits

Client:
The Government of the State of Qatar

Architect:
Dr. Kamal El Kafrawi

Structural and services engineer:
Ove Arup & Partners

Quantity surveyor:
Widnell and Trollope

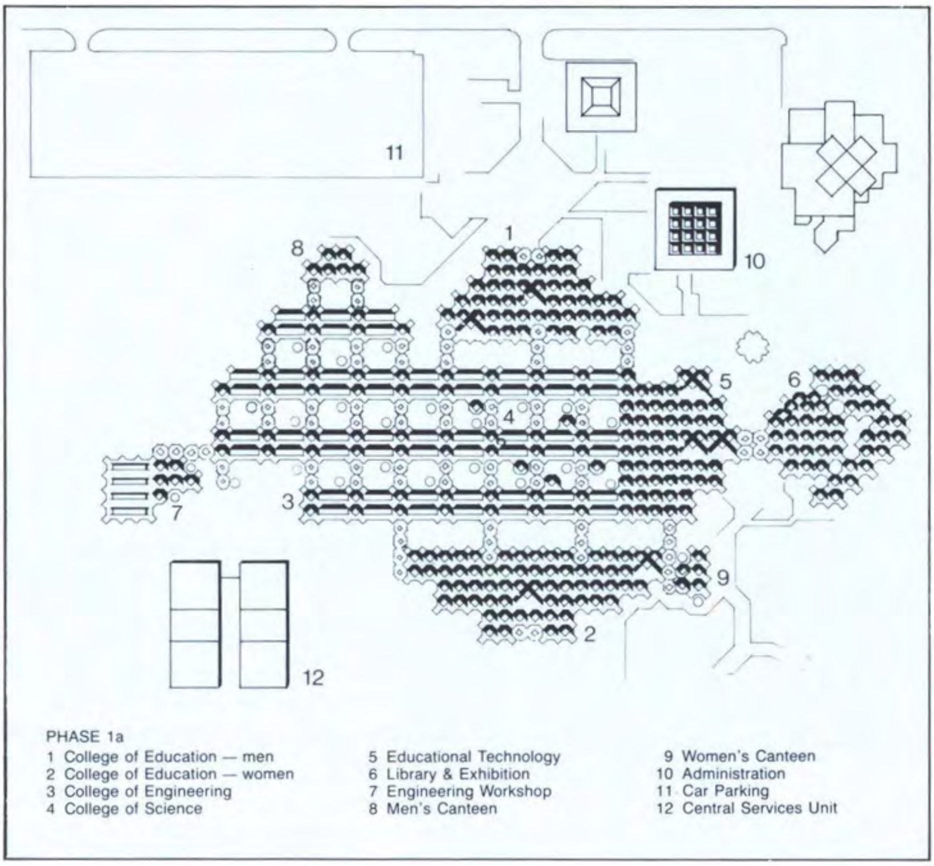
Main contractor:
Fujita, Japan

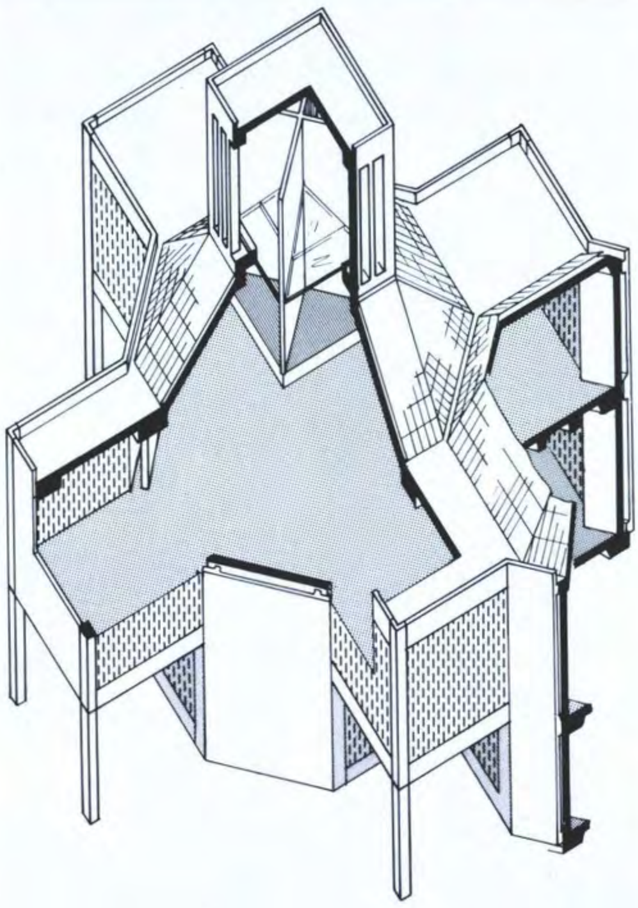
Photos:
Crispen Boyle

Precast concrete:
Interbeton, Holland

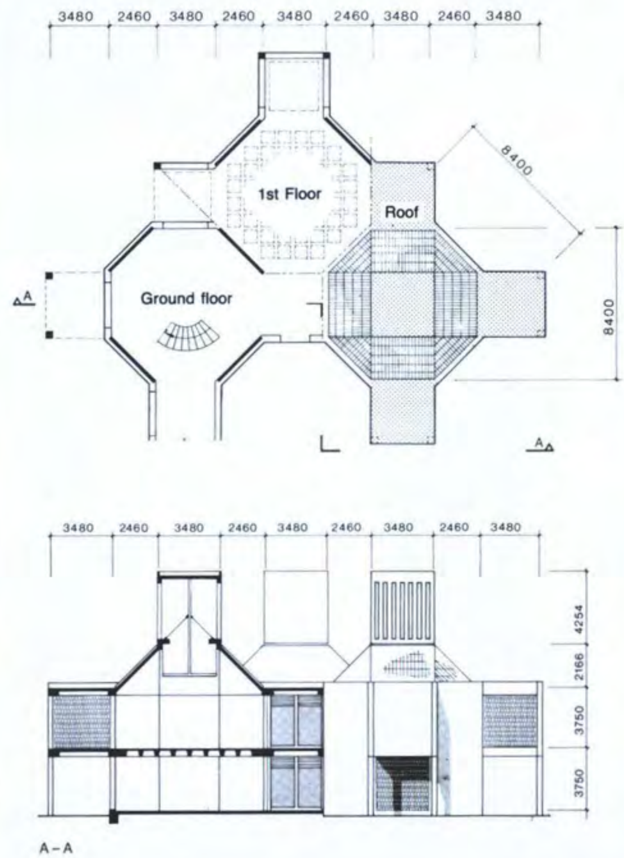
Right: Masterplan of the University of Qatar
Phase 1a buildings

Below: Map showing location of Qatar

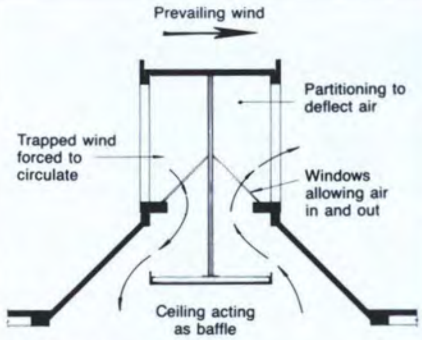




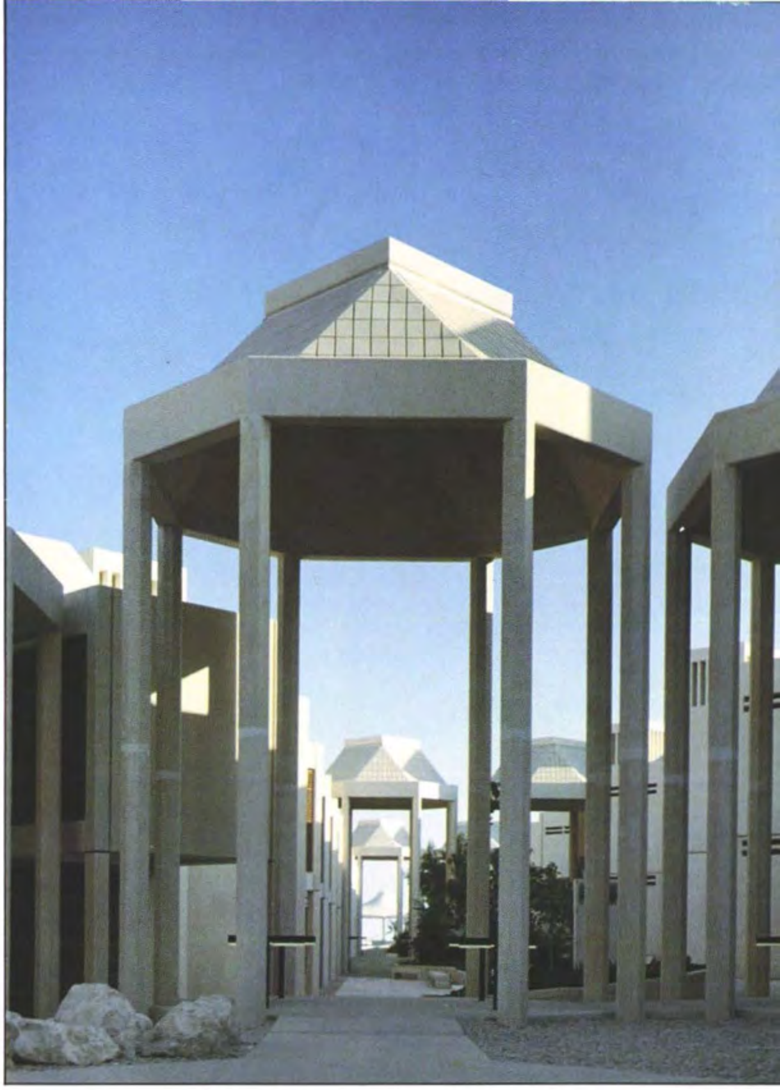
Cut-away view of octagon



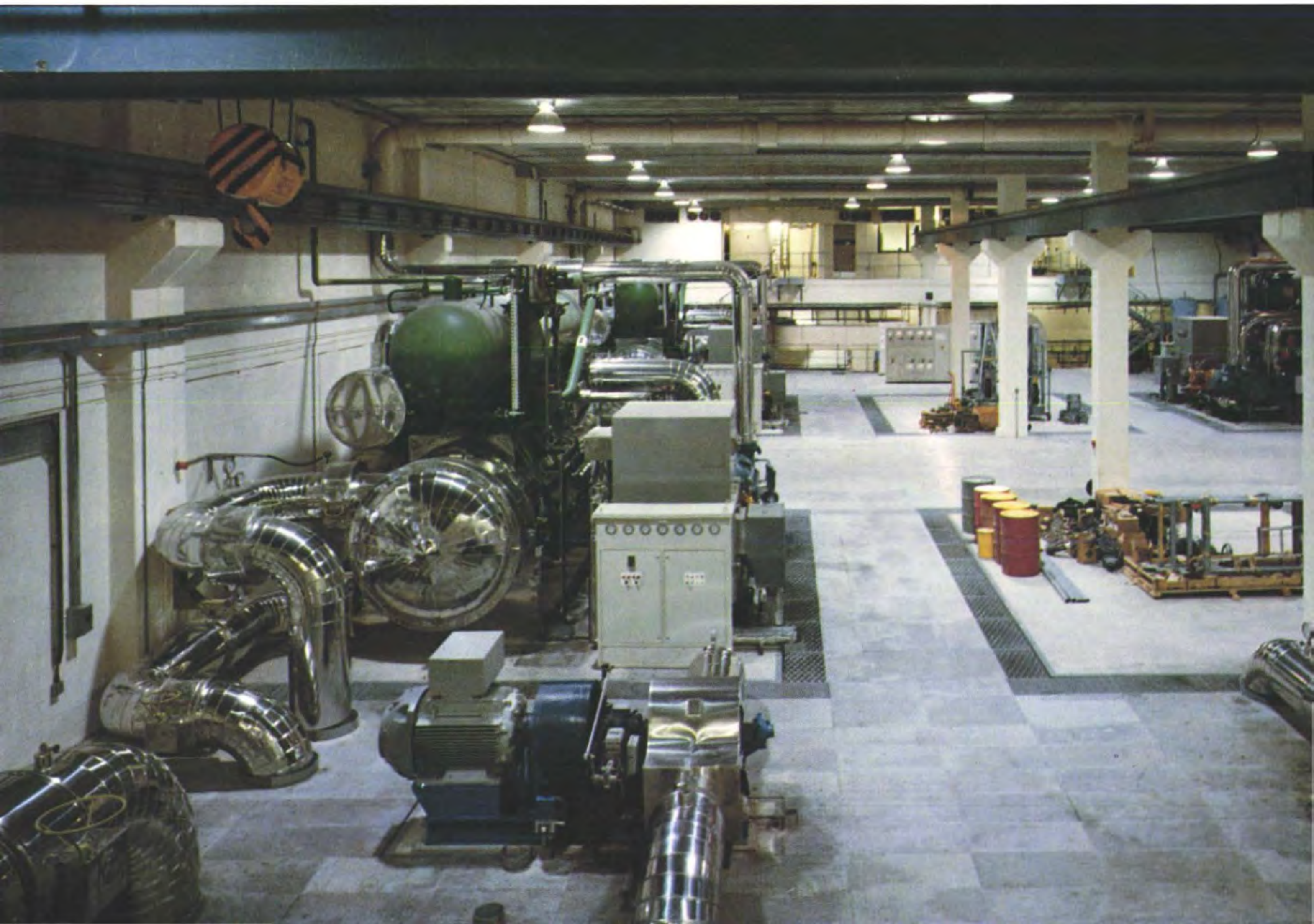
Plan and section
illustrating the octagonal module adopted for the building



Tower of winds operation



Britoil headquarters

Architect: Hugh Martin and Partners

Derek Blackwood

The rapid growth of Britoil plc since its formation as the British National Oil Corporation in 1976 resulted in the leasing of office space in several locations in Glasgow. Following the decision by the company in 1980 to consolidate its headquarters in the city, a brief was drawn up for purpose-built offices on a central 2 ha site in St Vincent Street. The intention was to provide a building which would house the company's current and projected activities in Glasgow in one location while providing conditions which would improve communications and efficiency within a pleasant working environment. While the company wished to have a building of quality it also required the project to represent good value for money, not only in capital expenditure but also in maintenance and running costs.

The design which evolved resulted in a first phase building comprising some 46,000m^2 gross internal floor area on five floors above main entrance level and three below in semi-basement on the steeply sloping site. Planning permission has been obtained for a second phase and design is progressing on a small addition to the west end to finish off the complex.

When the management contract was awarded in May 1983 Phase 1 of the project was one of the largest private developments undertaken in Scotland.

Concept

On the upper levels, a mix of open plan and cellular office space is provided while the lower levels contain all the technical and staff back-up facilities required in the headquarters of a company involved in high technology. Housed in the semi-basement levels are two main frame computer halls, telecommunications equipment, plantrooms, kitchen, reprographics and stores together with extensive stratigraphic laboratory facilities, for the specialist research and testing work carried out by the company. Car parking for 110 cars is also provided at the lowest levels (with space for a further 65 cars in a landscaped external car park at the west end of the site) as is access for service vehicles.

The main pedestrian entrance is from St Vincent Street. In addition to the main foyer and mall, with lift and escalator access to the upper levels, this level accommodates conference facilities, a medical suite, a large staff restaurant and office space.

Externally the building is clad in high quality, low maintenance materials consisting of polished granite cladding to the walls and column surfaces and glazed curtain walling comprising double glazed solar control reflective glass panels in aluminium frames. Internally the finishes are also of high quality with carpeted raised flooring used extensively in conjunction with proprietary relocatable partitions and suspended ceilings.

The office space is fully air-conditioned by means of an all air, variable air volume system combined with an under window background heating system and the computer halls, laboratories and ground floor accommodation are also air-conditioned. Services comprising lifts, stairs, ventilation ducting and toilets are conveniently and efficiently concentrated in three transverse service zones leaving the office areas free.

The glazing, partition and flooring systems are all designed to minimize noise and the pleasant environment is further enhanced by the provision of 3,000m^2 of roof terraces, landscaped with small trees and shrubs, generally located at the inner elevations of the office spaces. Internal planting is provided in the main ground floor mall, which is brightened by daylighting from a glazed roof.

The form of the building which evolved as economically and functionally the best, presented some interesting challenges in its design and construction, particularly in the lower levels. These arose from the variability of soil conditions over the site, the presence of a 2.5m British Telecom tunnel under the site which had to be retained without significant disturbance and the need to carry out deep excavations without disruption to nearby streets and buildings.

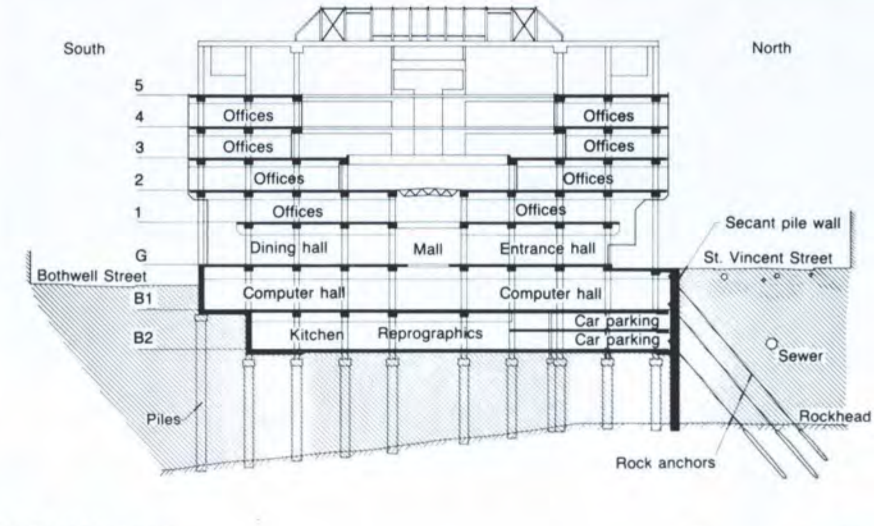
Site

The site was originally crossed by two streets incorporating bridges and terraces and by buildings which were demolished prior to the main contract. However it was not possible to excavate all of the foundations, particularly at the perimeter of the site where basement walls were left to retain the pavements and some demolition material was left in place.

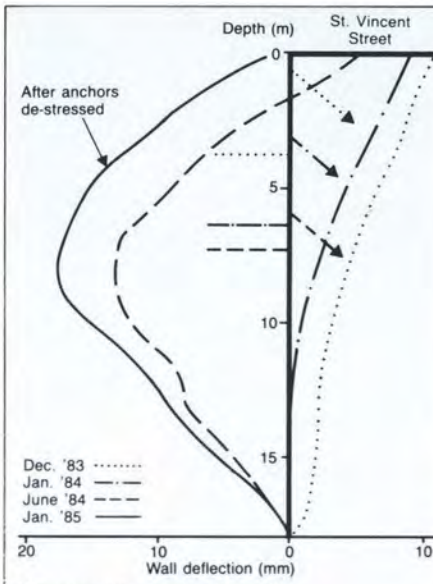
Extensive site investigations were undertaken involving 35 boreholes supplemented by probeholes and trial pits. Standpipes were also installed and monitored to record groundwater levels. While the investigation was concentrated in the Phase 1 area, general information on the whole site was obtained and a number of boreholes were sunk outside the perimeter of the site where it was intended to install ground anchors.

Prior to work commencing on site, inspections of adjacent buildings, roadways and structures were carried out and schedules of dilapidations were prepared by the management contractor and agreed with the adjacent proprietors. The BT tunnel was the subject of particularly close inspection and an accurate survey was carried out to establish its location precisely. Movements in the tunnel and other sensitive structures such as the steeple of a

Landscaped roof terraces (north east)
(Photos: Guthrie Photography)



Britoil headquarters:
Typical cross-section of structure



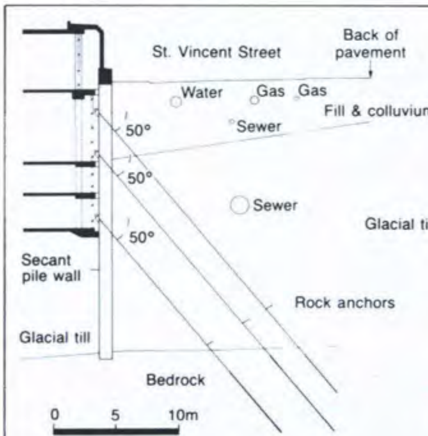
Movement in secant pile wall
at various stages in the excavation

church to the north were monitored throughout the building operations.

The ground conditions were found to be typical of much of Glasgow but were quite variable in the 160m length of the building. Bedrock, generally comprising a strong or very strong sandstone, was found at reasonably consistent levels over the whole site and this was generally overlain by glacial till, a very stiff boulder clay. In some areas the till was absent but towards the north east corner of the site its thickness increased rapidly to a depth of more than 20m. Elsewhere the till was generally overlain by typical Clyde alluvium — a loose to medium dense fine sand — with old basement walls, upfilling and demolition rubble immediately below ground level. The groundwater table was generally found within the sands with some evidence of a perched water table above the till at the north east.

Semi-basement

The relationship of the semi-basement to St Vincent Street is such that a deep excavation was required over the length of Phase 1 from about 7m deep at the west end to 15m near the east end and then back to street level at the extreme east end. Alternative forms of temporary support were considered which would allow the 45,000m^3 excavation to be carried out simply and economically while maintaining the security of the street and its important services including a major sewer and a 120-year-old cast iron water main of 36 in diameter. Internal propping was ruled out because of the restrictions this would have placed on subsequent construction, and the substantial earth pressures involved ruled out options such as cantilevered bored piles or a 'berlinoise' system. Also the latter forms of construction could not have provided any watertightness in the final condition.



Detail of secant pile wall construction

Deep excavation at east end

Secant pile wall

Detail of Mall roof steelwork

Completed structure from south east

We therefore developed a design for a wall which would provide stability in the temporary condition without internal shores and would ultimately provide permanent soil retention and watertightness. It seemed at the design stage that either a diaphragm wall or a secant pile wall, both restrained by temporary rock anchors, could provide the answer. Since it was not clear which would be the most economical, both schemes were developed to tender stage and in the event the secant pile scheme proved to be the cheaper.

Due to the variations introduced by differing ground conditions, wall height, anchor layout and the levels of the floor slabs which provide the permanent propping, a total of 14 typical sections were analyzed by us for stability and deflection. The need to control deflection was of primary importance and the behaviour of the wall was analyzed principally using a computer program developed by us to aid the design of the deep basement for the British Library in London. In order to confirm the design assumptions, inclinometer tubes were cast into selected piles and the deflections of the wall were monitored throughout each stage of the excavation and on destressing the anchors. The recorded movements were within acceptable limits.

The primary piles were installed by casings oscillated and pushed in by a system of hydraulic rams, then the secondary piles were cut into the primaries whilst the concrete was green, to form a continuous wall with 100mm interlocks. No walings were used and only the secondary piles, through which the anchors were installed, were taken to rock level to resist the large vertical component of the anchor forces.

The primary piles were stopped off just below the lowest excavation level. A blast furnace slag replacement concrete mix was developed to ensure low early strength to facilitate cutting into the primary piles while ensuring that the full specified 28 day strength of 25 kN/m^2 was achieved. At the BT tunnel it was not possible to take the secondary piles to rock. Here, the subcontractor used large temporary steel walings and specially heavy anchor forces had to be developed to bridge the gap.

To provide adequate shear transfer and to avoid having to drill through the piles for the anchors a detail comprising a welded assembly of plates, hoops and inclined tubes was developed. These were fixed into the reinforcement cages and cast into the secondary piles. The tubes were filled with polystyrene which was cleaned out prior to anchor drilling.

In order to avoid the legal complexities of extending the rock anchors under the properties on the north side of St Vincent Street and to avoid the services, in particular the sewer, we decided to install the anchors at steep angles of between 40° and 57° below the horizontal. Preliminary anchors were tested at an early stage to confirm the design of the fixed lengths into the rock which vary between 3m and 7m and five trial anchors were also installed and monitored for several weeks to ensure that long-term creep losses were acceptable. A total of 144 anchors on up to three levels were then installed to take design loads of between 500 and 2400 kN.

After completion of the excavation the wall presented a reasonably uniform surface. It was then cleaned by jetting and, with a little remedial work, an acceptable degree of watertightness was achieved. When the superstructure and basement floors were finally constructed the rock anchors were destressed and the soil pressures from the 145m long wall were then resisted by the structure. Finally, brick walling was constructed in front of the wall and the cavity thus created was drained and ventilated.

The ground slabs and other retaining walls are of conventional watertight construction with an external damp proof membrane. These, combined with the drained cavity construction, ensure dry conditions in the extensive semi-basement.

Foundations

Because of concern about noise and the effects of vibrations on the tunnel and adjacent structures and services, driven piling was ruled out and large diameter, bored, cast in situ piles were chosen. The provision of a single pile per column avoided the need for large pile caps and, given the high strength of the bedrock with no appreciable weathering at rockhead, the piles were designed as end bearing. This type of foundation also ensured minimal differential settlement between columns whose loads varied from 2,800 kN to 12,000 kN (1,200 tonnes) as a result of variations in column grid and building height. The lengths of the piles were generally in the range 10 to 15m but were up to 24m bored length at the east end where the basement level is highest. Some 277 piles were constructed in a range of diameters between 750 and 1500mm.

The piles straddle the cable tunnel and the superstructure is designed to span using deep 12m transfer beams to carry the intermediate columns and ground slabs without loading the existing segmental concrete structure. Limitations on working methods adjacent to the tunnel and on the structural measures to be adopted were fully discussed and agreed in advance with British Telecom's consulting engineers.

Left: Landscaped roof terraces (service zone)
Left bottom: Central Mall roof
Below: Reception area

Three piling construction techniques were adopted to suit the varying ground conditions and local requirements. Firstly, 42% of the piles were constructed in the dry by vibrating temporary steel casings into the glacial till to sufficient depth to obtain a seal against the ingress of groundwater. The spoil was then removed by auger, the base formed with a flat bottomed bucket and finally inspected and cleaned by hand. Secondly, where the glacial till was either thin or absent and the temporary casing could not provide a seal against groundwater, a further 37% of the piles were formed by introducing water into the bore to prevent the washing in of debris and the boring was continued under water with the aid of a sand pump, the concrete being tremied. Thirdly, adjacent to the British Telecom tunnel and in other particularly sensitive areas the remaining 21% of piles were constructed using bentonite to stabilize the sides of the bores. Careful control of the condition of the bentonite was essential to ensure cleanliness of the pile bases.

To check the adequacy of the contractor's proposed construction methods two preliminary piles were installed; a 900mm diameter pile bored dry and a 750mm diameter pile constructed under water. These were loaded in stages to 2½ times their design load. The load/settlement response was practically linear with no impending sign of failure and the measured movements at design load for each pile were approximately 4mm. Lateral load tests were also carried out to confirm design assumptions.

Careful supervision of the construction of the contract piles was necessary to maintain the required quality. As already described almost half of the pile bases were visually inspected.

This was supplemented by four contract pile load tests using kentledge and in addition all piles were integrity tested by the transient dynamic response method and by ultrasonic logging for which capped steel tubes were cast in each pile.

Superstructure

The superstructure is constructed almost entirely of in situ reinforced concrete except for the tubular steel trusses spanning 9m to support the flat glass roofs over the malls and the steel frames enclosing the roof top plantrooms. Limited use has also been made of precast concrete in stairs and ramps and, in the case of the stairs, lightweight concrete was used to minimize handling proolems.

The final choice of in situ reinforced concrete beam and slab construction was only made after a comprehensive comparison with alternative schemes in steel and precast concrete to ascertain the cheapest and most appropriate structural form. While reinforced concrete was considered essential for the foundations, the watertight basement walls and floors, the basement suspended slabs (which were required to transmit large lateral earth pressures into the foundations) and the vertical and horizontal structure in the transverse service zones (or TSZs), in the remaining areas, it was possible to examine the use of other structural materials. We prepared several steel frame schemes but the advantages of speedier construction and the cost savings in construction time were found to be offset by the extra cost of the material and fire protection and, since all the schemes had concrete flooring in common, the lower weight of the steel frame gave only a small saving in foundation costs. It was consequently found that all of the concrete schemes were cheaper than those involving steelwork and, of the concrete schemes, a totally in situ beam and slab construction was the most economical.

Other major considerations in the choice of the structural form were the need to provide an unobstructed space for the lateral distribution of services in the ceiling spaces and to provide a structure which would result in a minimum overall floor depth. The latter was particularly important in a building subject to height restrictions.

In general a 12m × 6m column grid was considered desirable to provide reasonably column-free interiors. This, combined with the need to distribute the main services in the ceiling space in the east-west direction from the TSZs lead to the adoption of east-west beams generally at 6m centres with flat slabs between. This provided an 800mm deep clear services space within a floor zone of minimum depth.

An additional advantage of the in situ structure was its ability to cope readily with cantilevers, upstands, variations in floor level and variations in loading. The areas of flat slab

Above: Reception area. Below: Office area

also provided the services sub-contractors with maximum freedom for the location of fixings and small services holes.

The three transverse service zones contain lift shafts and stair walls which are constructed in reinforced concrete and form natural points for lateral and longitudinal stability. However, it was considered advisable to make some provision in the 125m long superstructure for thermal and shrinkage movement so two sliding joints were introduced and from considerations of architectural detailing it was decided to locate these adjacent to two of the TSZs. The detail which was developed involved the provision of proprietary structural bearings between the ends of the in situ reinforced concrete floor beams and corbels on the supporting columns.

The bearings were specified to provide free rotation and longitudinal sliding in addition to rigid vertical support for a load of 1,100 kN and since the wind forces on the facade of the building were transmitted through these bearings to the stabilizing TSZs they were also required to take a transverse load of 40 kN without movement.

Construction

Work began on site in September 1983 under the Management Contractor who had the demanding task of co-ordinating the activities of five major subcontractors and many other specialist subcontractors. The 48,000m^2 of floor and roof slabs were topped out in June 1985 and the Phase 1 building was handed over on programme in September of this year.

It had been predicted that the most likely movement of the British Telecom tunnel due to construction work would be a rise caused by the removal of up to 9m of over-burden by the excavation above. In the event the tunnel did rise but less than had been predicted and the disturbance was minimal.

The form of the superstructure resulted in simple and repetitive formwork with steel moulds being utilized for the standard circular columns in the upper levels. Progress on construction during the winter was maintained by the use of large tented structures to provide substantial areas of weather protection.

Provision is made in the structure to facilitate the addition of the second phase. For example the secant pile wall has been extended into the Phase 2 site and is restrained by rock anchors installed to a fully protected, more durable standard than those in Phase 1 which are now destressed. Also the temporary metal cladding erected on the west gable is designed to be easily removable when this imposing addition to the Glasgow scene is extended.

Credits

Client:
Britoil (Development) Ltd.
Architect:
Hugh Martin and Partners
Structural and civil engineer:
Ove Arup & Partners Scotland
Mechanical and electrical engineer:
Blyth & Blyth (M & E)
Quantity surveyor:
Gardiner & Theobald
Acoustic consultant:
Sandy Brown Associates
Landscape consultant:
W J Cairns and Partners
Catering consultant:
GWP Associates
Management contractor:
Wimpey Construction UK Ltd.

Above: Computer suite. Below: East elevation (Pitt Street)

Above: View from Pitt Street / St. Vincent Street (north east corner)

Sheriff Court Glasgow and Strathkelvin

Architects:
Keppie Henderson Architects

Arun Save

Introduction
The need for new buildings for the Sheriff Court in Glasgow was first identified before many of us were born! To say that the gestation period has been generous would be an understatement considering it has been more than half a century. To be precise the Court House Commissioners' decision to go for an entirely new building was taken as long ago as 1932, and the adoption of Lanarkshire House and former Stamp Office as Sheriff Court House annexes in 1964 and 1981 was a matter of temporary expediency. The inadequacies of the former Court House facilities were clearly apparent when one looked at the overcrowding, lack of space, and ill-designed accommodation with inherent defects which could not be rectified. In 1965, PA Management Consultants were commissioned by The Court House Commissioners to examine the sizes of the problems, identify the refinements of the Courts for the next 20 years and prepare a design brief.

The proposal was to rehouse all Court business under one roof with 21 courts comprising four Criminal Jury Courts, 11 General Purpose Courts, a Diet Court, an Appeal Court, two Juvenile Courts, a Civil Court and a Criminal Custody Court. This posed a complex situation of identifying the needs and relationships between various disciplines of the Court House users for which there was no precedent in this country. The resulting Court House building, which now replaces the three buildings at different locations in the city, is the third largest Court House in Europe, the largest being in Hamburg, followed by one in Liverpool.

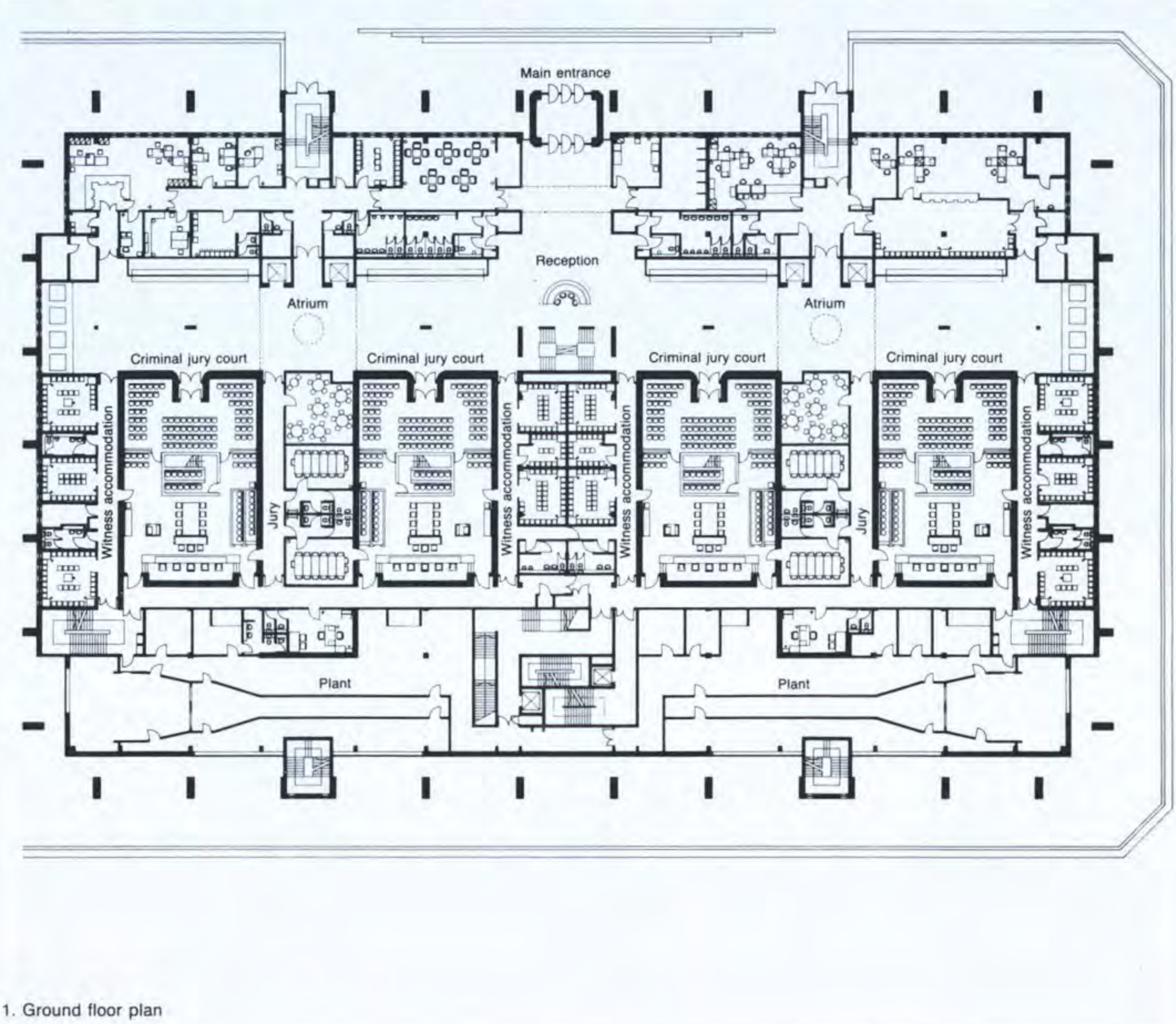
Over the period of time it was no surprise that the original brief changed a few times and, of course, tighter purse strings also resulted in delays to the original programme.

In 1971, the Court House Commissioners' responsibilities were vested in the newly-formed Scottish Courts Administration, thus finally severing the ties with local government. The Property Services Agency of the Department of the Environment was formed in 1972 to provide courts, among many other things. In early 1978, the Secretary of State gave final approval to proceed with the scheme to tender stage.

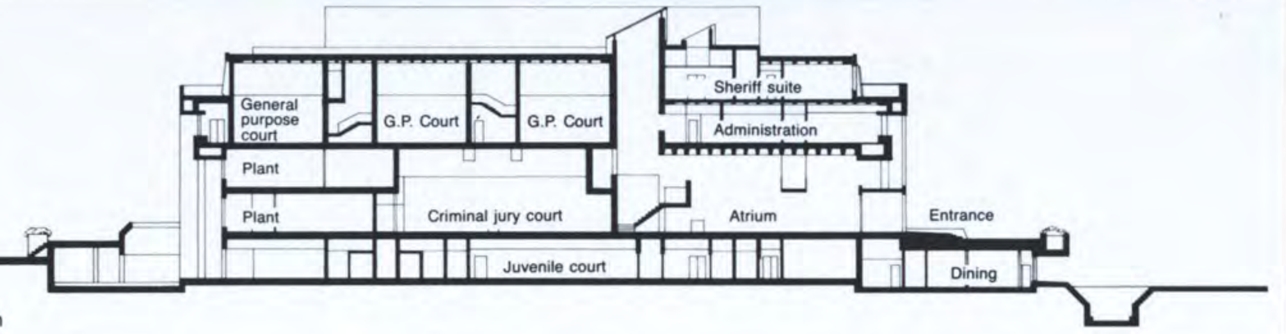
The location
The New Sheriff Courts occupy some six acres of land on the south bank of the River Clyde extending west from Victoria Bridge up to the most attractive 19th century terraces of Carlton Place. The impact of the New Sheriff Court building on the riverside environment and its relationship with the terraces in Carlton Place was emphasized by the Royal Fine Arts Commission for Scotland and was carefully considered in the final design. This has resulted in siting the building further back from the river than the adjacent terraces to reduce the impact on the general environment and to create a larger landscaped area at the riverside.

During the desk study of the site, in the process of examining Ordnance Survey maps, etc., it came to light that over the past 150 years the site had been developed twice with different layout for buildings and roads, perhaps reflecting on the rapid growth of this industrial and commercial heart of Glasgow at that time. In the early 20th century dramatic changes took place influenced by the war depression and the Gorbals began to deteriorate. By 1970 most of the buildings on the site were demolished in preparation for the construction of the New Sheriff Courts.

General description and design of new building
Externally the architecture of the building expresses a strong structural form with external slab columns and distinctive order in the relationship between levels. The slab columns support the edge beam at level four and go past to pick up the overhanging structure at level five. These full-height columns and deep beams at levels four and five are clad with polished granite imported from Denmark and provide a striking contrast to the matt finished Catcastle sandstone forming the recessed walls round the building.



1. Ground floor plan



2. Section

Once inside the building at level two, you are immediately in a majestic atrium extending the full length and height of the building. At the apex of this cathedral-like atrium are large aluminium framed rooflights providing adequate light during the daytime. The floor, walls and columns of the atrium are clad with off-white Hoptonwood limestone imported from Middleton Quarry, Wirskworth.

The building accommodates 21 courtrooms, their associated witness and jury rooms, prisoners' cells, along with the police department and administrative accommodation for the Sheriff Clerk's Department. The Sheriffs have their own accommodation with robing rooms, and the use of their private balcony, common room and library.

The architectural concept in planning separate, clearly defined circulation routes was of paramount importance. Access to all the courts by the Sheriffs, police bringing prisoners from their cells, jurors, witnesses, clerical staff and the public, is well defined. The simplicity of the solution is a triumph of planning (see Fig. 1).

A large car park to hold 140 cars is located on the south side of the Court House with an easy access to the building.

Landscaping surrounding the south car park and that on the north side of the Court House extending to the river bank, softens the impact of the strong lines of the structure.

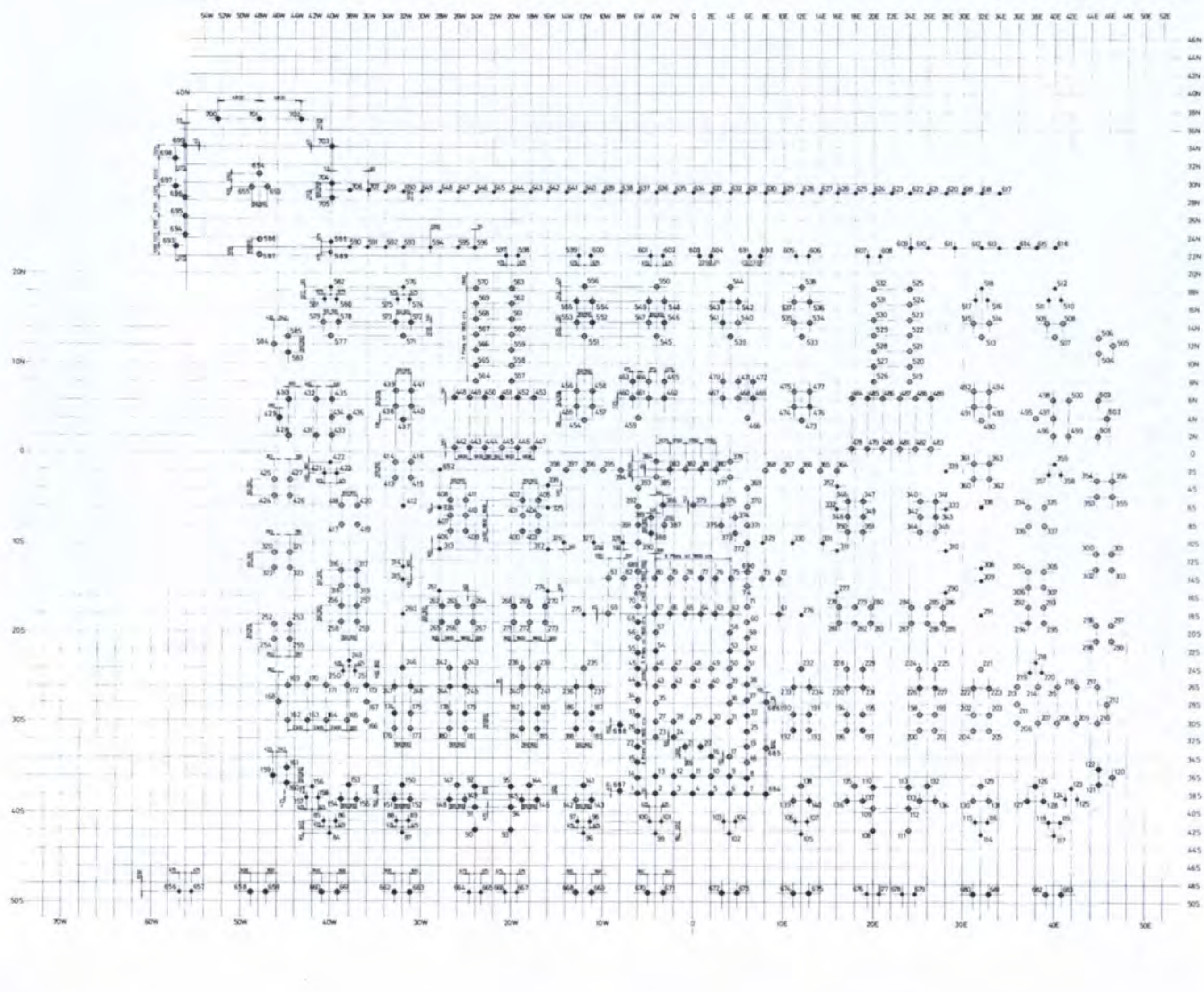
Naturally, security was a major factor in the planning of the Court House. Siting the building line away from the river front and sinking the building some 2m, were some of the fundamental steps implemented to enhance the security. Construction of a ha-ha immediately north of the Court House discourages the public from entering the building at the lower level.

Structural design

The shape of the building was dictated by the need to restrict the overall height so that it would not oppress the view of the adjacent terraces. To achieve this the entire building has been sunk into the ground and a dry moat has been created at level one. This level had to be carefully judged to ensure that under normal circumstances the surface water would be discharged into the River Clyde by gravity. The dry moat acts as a security barrier with controlled access from Nicholson Street.

An elevated roadway surrounds the building and in addition to providing an access to the main entrance to the Court House at level two, it also provides an elevated route for the fire tenders.

Throughout the building the structure has been carefully integrated with the architectural needs, space planning and services location and distribution. Most of the courts



3. Piling layout

are two storeys high. The structure, therefore, spans some 12m across the width of the courts at their ceiling levels. The building structure is of in situ reinforced concrete for columns, beams, floor slabs, stairs, etc., with nominal use of precast concrete at upper levels. Aluminium is used in the design of the large rooflight structure (see Fig. 2).

The courtrooms in the core of the building are air conditioned. The external offices have natural ventilation and the spaces between are artificially ventilated. All the ventilation systems and electrical installations are controlled by a microcomputer. The main plantroom is located at levels two and three, while the boiler plant is on the recessed top floor.

Access to the lighting system is achieved without disruption of the normal business wherever possible. The facility of maintaining the services to the courts is achieved by the provision of suspended service floors above the ceilings.

In all, six lifts are provided in the building, four of which serve the general public and staff. All of these are hydraulic lifts with the hydraulic ram extending some 20m below ground floor level in some cases.

Site preparations

Occupying the prominent corner of the site at the riverside there stood the elegant John Knox Church of the Gorbals. The church had been out of use for many years, neglected and badly needing attention to its decaying structural elements. The spire of the church, one of the prominent landmarks in its original form, was struck by lightning in 1929. The church had to be demolished to provide adequate area for the court building.

The site now extends from the River Clyde on the north to Norfolk Street on the south and from Gorbals Street on the east to Nicholson Street on the west.

The basements and the foundations of the buildings from previous developments still existed under the vacant site.

The most significant single item which required immediate attention was the 2m diameter main sewer constructed in 1910 and flowing at its full capacity. It crossed the site from east to west and had to be diverted under separate contract in advance. The construction of this sewer for most of its length was of bolted cast iron segments lined with concrete. The diverted section is in prestressed concrete segments and is reconnected to the original route at both ends by introduction of large manholes. The new section being well below the ground water table required dewatering, interlocking sheeting for protection and temporary piling during construction under roads.

Certain lengths of temporary piling were left in as a safety measure and the abandoned length of the original sewer filled with fly ash.

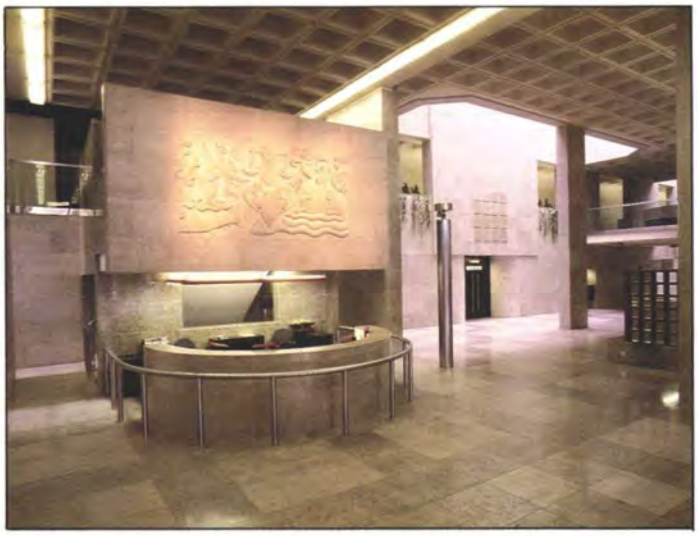
Construction

The preliminary contract of nine months duration to divert the main sewer together with the services of the statutory supply of authorities commenced in March 1979. The construction work for the main contract commenced in June 1981 and completed in January 1986, allowing the court to commence its functions in May 1986.

At various stages prior to the commencement of the main contract several site investigations were put in hand. The comprehensive data compiled through boreholes, trial pits, Dutch cone penetration tests and load tests, revealed that the soil conditions in the site consisted of silty sand and gravel and that the rockhead was some 33m below the ground level. The bearing capacity of the upper layers was very poor.

This led to the piled foundation design. Taking cognisance of the delicate structural condition of the ageing buildings adjacent to the site, it was necessary to adopt a piling technique with least possible vibrations. The most acceptable solution therefore was continuous flight auger type with minimum vibrations and noise during construction. A total of 707 piles were installed with 450mm and 600mm diameters. The trial load tests confirmed the designed lengths to be 21m and 24m respectively (see Fig. 3).

During construction, some interesting problems were encountered, the most common



one being the concrete blockage in the shaft of the auger due mainly to the inability to dislodge the plug! The only solution was to withdraw the auger, clean out and redrive. This gave us cause for concern. However, all piles were subjected to non-destructive testing which confirmed that the homogeneous concrete section of the required length was satisfactorily achieved in each pile.

The space between the pile caps and the ground slab was effectively utilized for accommodating drainage and other essential services.

Certain parts of the structure local to the lift pits are below the ground water table and the construction of this was achieved by using the dewatering technique local to the area. The spacing of the well points was designed to keep the water table effectively below the formation level. All works up to the ground slab level are of watertight construction.

The suspended floor slabs are of coffered construction and in some instances after experimentation the shape and size of these coffers were designed specially to suit this project. In the atrium the soffit of the coffer slabs is exposed to give a pleasing effect, and is featured under the links to give attractive details. Presence of two-storey high courts with access platforms for services, coupled with the philosophy of achieving maximum open space without intrusion of vertical structure led to long spanning, heavily reinforced, horizontal structural elements which no doubt tested the contractor's expertise for temporary works. In some instances where structural elements were repeated precast construction was favoured for speed and economy.

One of the many significant stages representing the achievements of the contractor was the 'topping out' of the building. This ceremony was undertaken by Mr. Michael Ancram, M.P., the then Minister for Home Affairs and Environment at the Scottish Office in September 1983.

The assessed total value of the project including the preliminary works contract is £30m.

Acknowledgements

We would like to thank Property Services Agency for permitting us to produce this article. We would also like to thank Keppie Henderson Architects for allowing us to reproduce their drawings.

Credits

Client:
Scottish Courts Administration
Property Services Agency

Architects:
Keppie Henderson Architects

Structural consultants:
Ove Arup & Partners Scotland

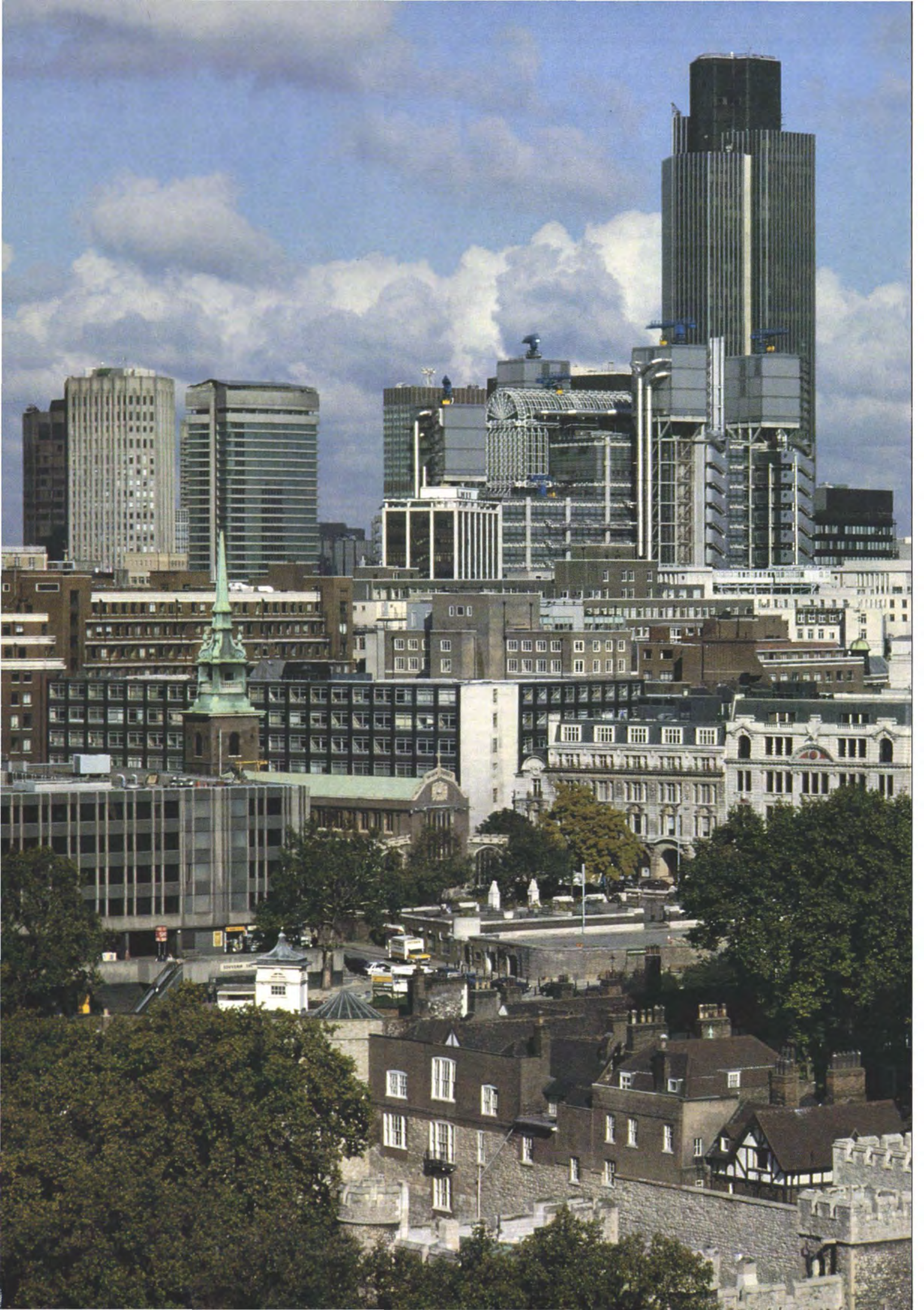
Quantity surveyors:
John Danskin & Purdie

Mechanical and electrical consultants:
Ramsay & Primrose

Main contractor:
Sir Robert McAlpine

Photos:
Guthrie Photography


Court 7
EXIT
Lifts to all Floors
SECOND FLOOR
GROUND FLOOR
BASEMENT



Lloyd's

Architects: Richard Rogers Partnership

There have been two previous articles in *The Arup Journal* dealing with the Lloyd's project. John Thornton discussed the structure in the June 1982 edition and John Roberts wrote about the toilet modules in October 1984.
To commemorate the official opening we are publishing here a selection of photographs of the finished building.

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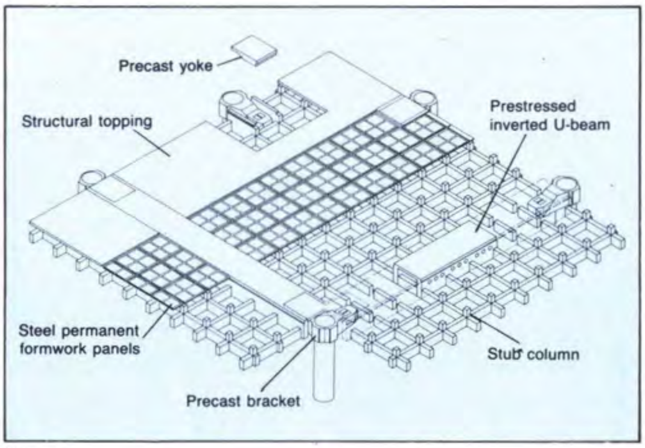

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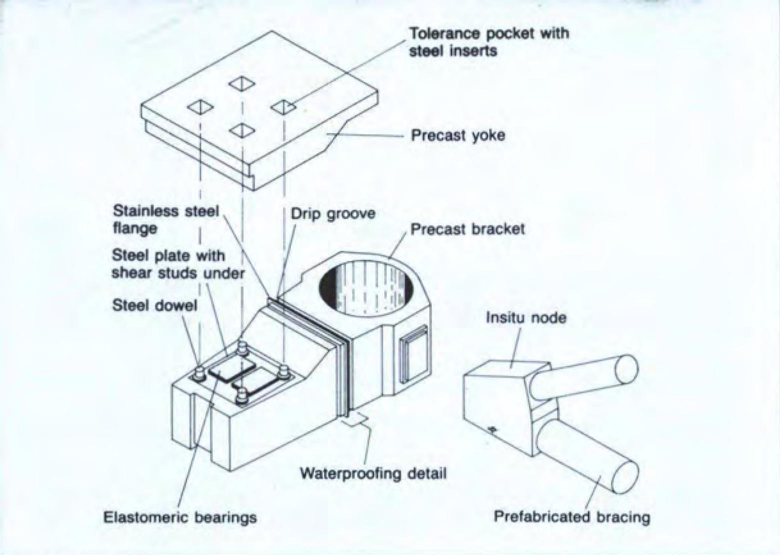
1. View from the north west

2. Corner view showing main components that appear on the exterior: horizontal and vertical ducts, wall-climber lifts, escape stairs, main building columns

3. Axonometric showing the components of the main building structure

4. Corner view of the beam grid

5. The beam grid from inside



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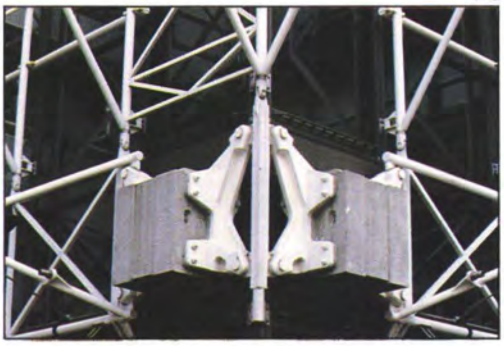

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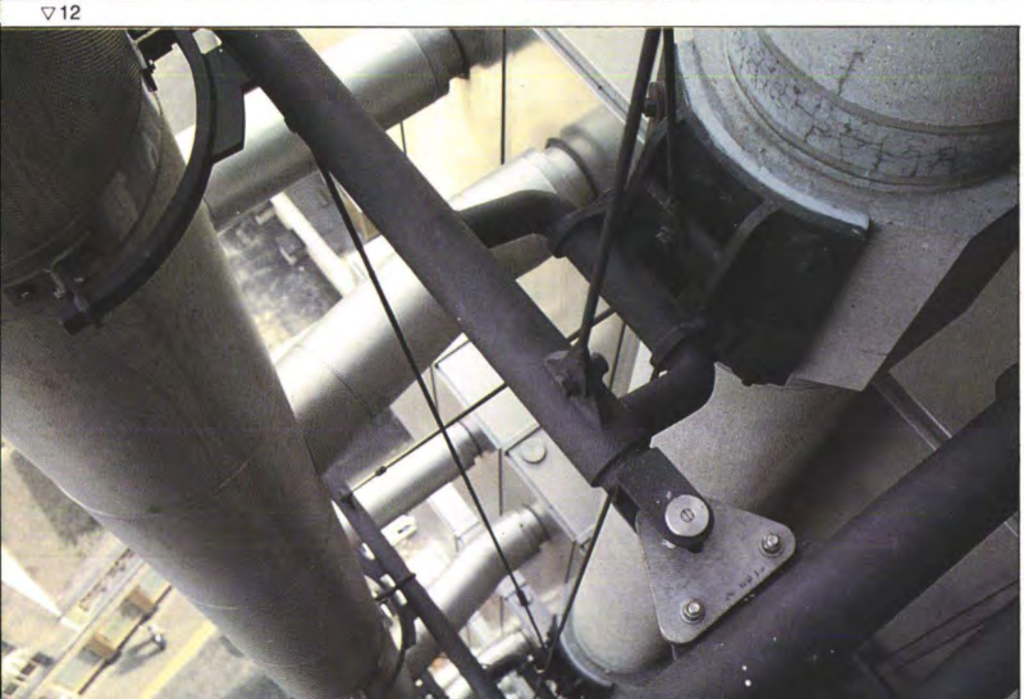


6. Floor bracket assembly

7. Bracket during construction

8. Bracket/column/bracing assembly which is the key structural detail

9. Castings for the atrium steelwork bolted to a derivative of the main building brackets

10. The precision of the concrete was most important

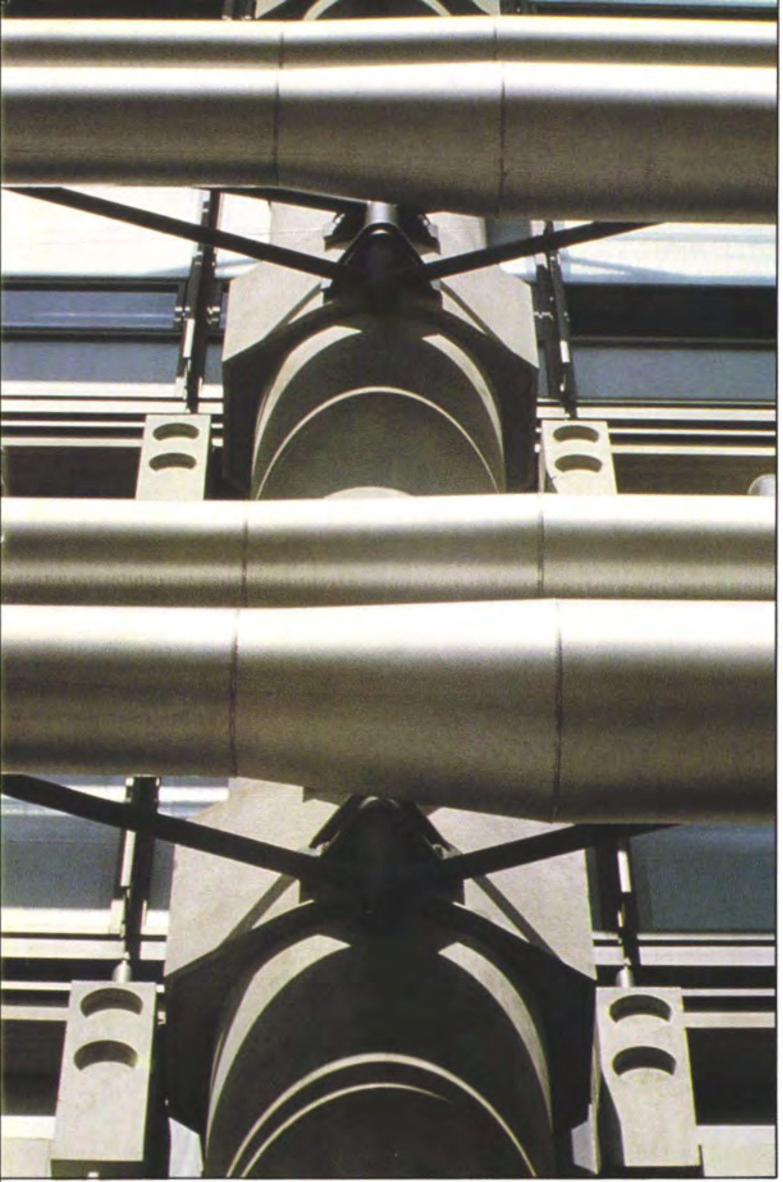
11. Main vertical air ducts and lift guide ladders on the satellite towers

12. All the services support brackets were specially designed. The one shown supports toilet ventilation ducts and stabilizes a services riser platform; it incorporates a sliding joint to allow relative vertical movement.

13. Horizontal air ducts and their supports

14. The satellite link and services passed through the stability bracing with very little clearance

15. The Room



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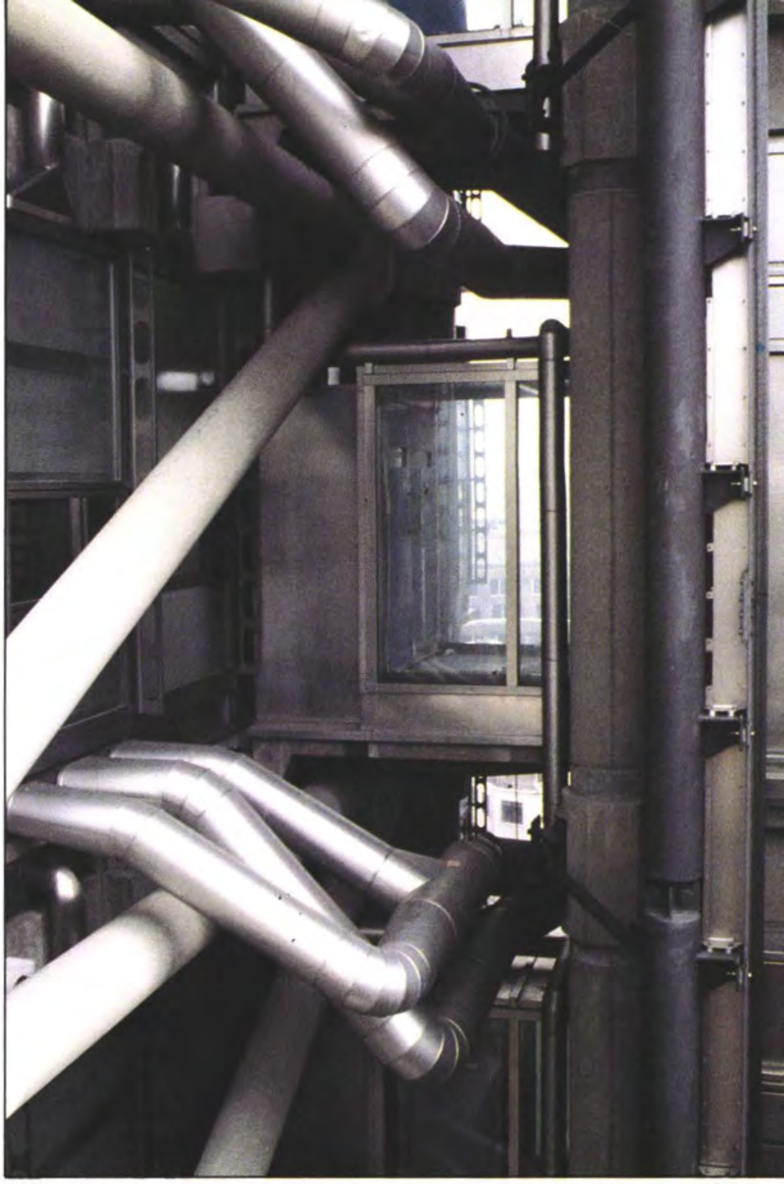

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16. View of the atrium from the Room

17. The main entrance stairs and canopy

18. The escape stairs with the lowest flight in steel

19. The support details for the escape stairs

Facing page:
The underwriting Room
(Photo: M. Taylor)

Credits

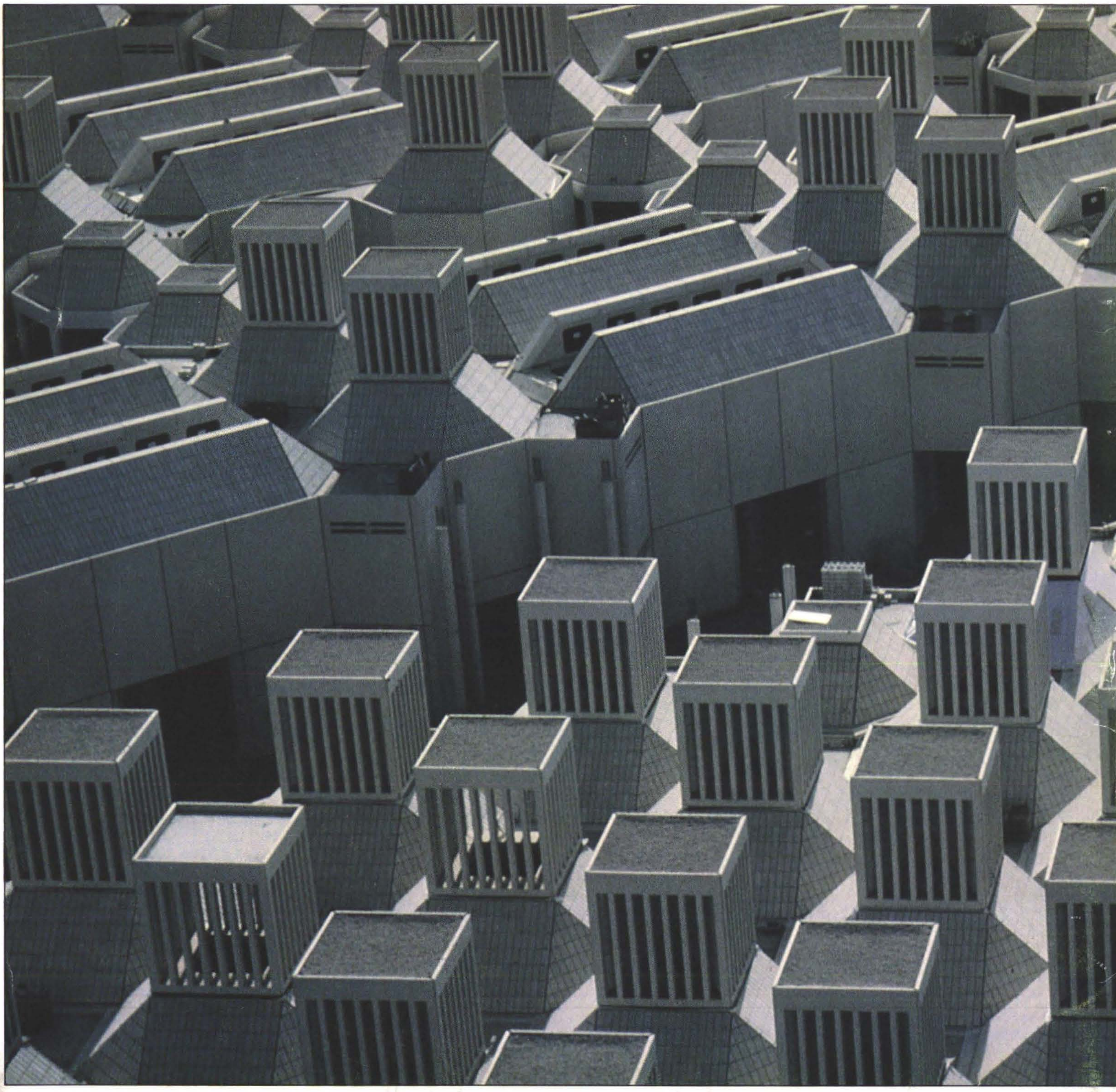
Client:
Lloyd's

Architects:
Richard Rogers Partnership

Structural and services engineers:
Ove Arup & Partners

Photos:
Harry Sowden

Captions:
John Thornton



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