architects'

working details 3

edited by Susan Dawson

emap CONSTRUCT

INTRODUCTION

Since 1988, The Architects' Journal has produced weekly Working Details which have been selected and published in a series of volumes. The first volume – from 1988 and 1989 – included details of Michael Hopkins & Partners' Solid State Logic headquarters, Alsop & Lyall's Sheringham Pool and the Truro Courts of Justice by Evans and Shalev.

The second, from 1990, included details of Heron's fabric roof for the Imagination building, the glazed cladding of Ian Ritchie's office at Stockley Park, and stone-clad doors by Fletcher Priest. Summaries of Volumes 1 and 2 (these volumes are still available) are given at the back of this book.

This, the third volume, is a selection of details published in the AJ in 1991 and 1992. It includes Christopher Day's turf-roofed school in Wales, and Rick Mather's Hampstead conservatory, which incorporates glass columns and glass beams.

In building construction, there are many ways of solving problems, but some are more elegant than others and it is these which are illustrated here.

Although the working details are grouped under subject headings, the volumes are not intended to be a comprehensive examination of all aspects of construction. They show architects' solutions to specific problems which arose on particular buildings.

Each detail is placed in context by reference to an AJ building study or feature, and is accompanied by photographs and a detailed commentary. For consistency and legibility, the architects' drawings were re-drawn and scaled to fit the pages of the AJ, with the sizes of individual components annotated rather than drawn to a particular scale.

Acknowledgement

The AJ would like to thank Vic Brand and John Baxter for their drawings, and Alan Brookes, John Campbell, Lionel Friedland, Roland Gibbard, Dean Hawkes, Ron Jewson, Tim Macfarlane and John Pringle for their expert guidance. Editorial contributions were by Mary Langshaw – who wrote 30 of the details published here – Sarah Jackson, Barrie Evans, and John Rawson.

These articles first appeared in The Architects' Journal.

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This volume was first published in 1996 by Emap Construct, 151 Rosebery Avenue, London EC1R 4QX, England

CONTENTS

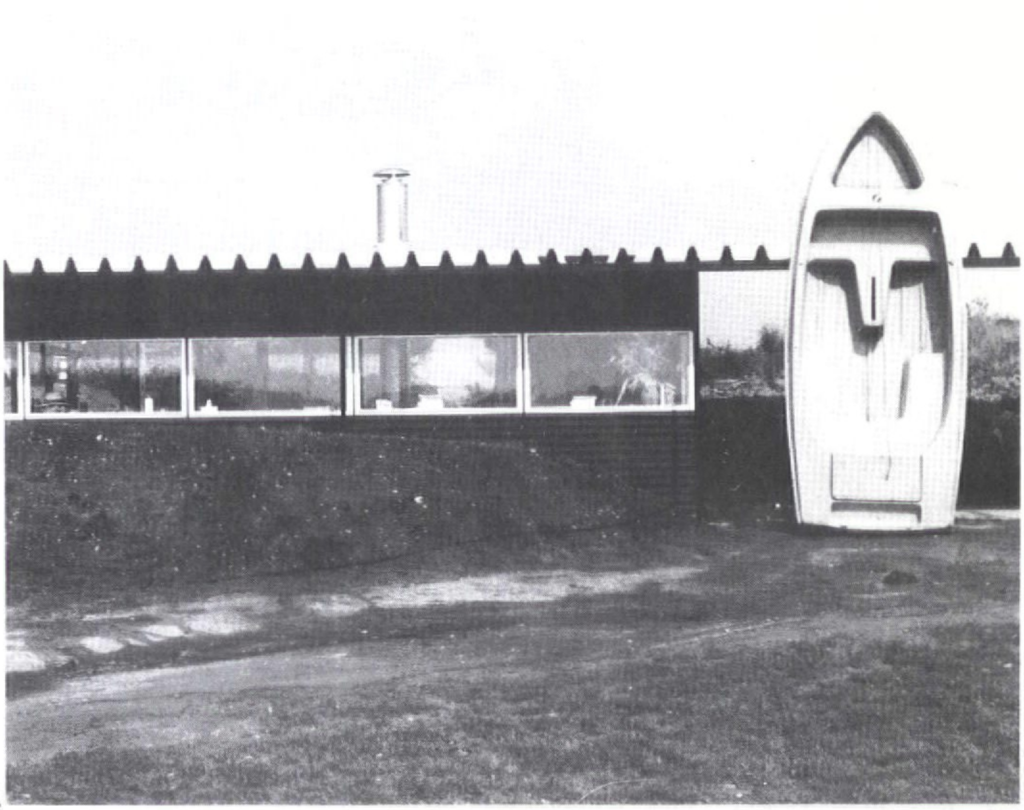
Structure

Internal fittings

Lifts and circulation spaces

EXTERNAL WALLS AND ROOF
BEACH HOUSE
John Winter & Associates

This beach house replaces one that the sea washed away. It has been designed to withstand wind and waves, with a minimum of maintenance.



1

1 Part view of the house from the west. The second space in the carport is designed to accommodate a boat. Almost all the materials visible externally are metal, finished off-site for low maintenance.

This is the third home that John Winter has created for himself (see AJs 18.5.85 and 30.11.88) — but this one is for holidays only.

On an east-facing site on the Norfolk coast, among colourful 1930s beach huts, sits the economically designed black and white shed. The original living space, a converted 1930s timber prefab, was washed away in 1983 by the sea — which eats up a metre of land each year. The completion of an EC funded sea wall in 1987 made it worth constructing a replacement building. The site should now last for another 120 years.

John Winter's brief for the living space (the bedrooms are in a separate building) was that it should have a minimum of stylistic gestures, require as little maintenance as possible, cost less than £500/m^2, and accommodate intermittent use. It has also to withstand strong winds, waves and sea-salt.

The building is constructed principally from steel and timber. The structural frame is two simple steel goalposts, one used also to form the gutter, which, as it conducts rainwater down to the ground, also braces the building. Slender 42.6 mm diameter hollow steel columns support the steel frame at 3 m centres. Solid steel columns with a 36 mm diameter were an option, but the engineer warned that they would be unlikely to remain straight after galvanising.

The steel decking outer skin to the roof, oversailing the building by 750 mm, is supported on the steel frame. The roof's inner skin — formed from pre-finished steel liner trays — bears on timber studs which also support the corrugated aluminium exterior and veneered plywood interior claddings. The warmer finish of timber is preferred internally.

All the timber is finished to Class O (as required where more than 40 per cent of the internal finishes are timber).

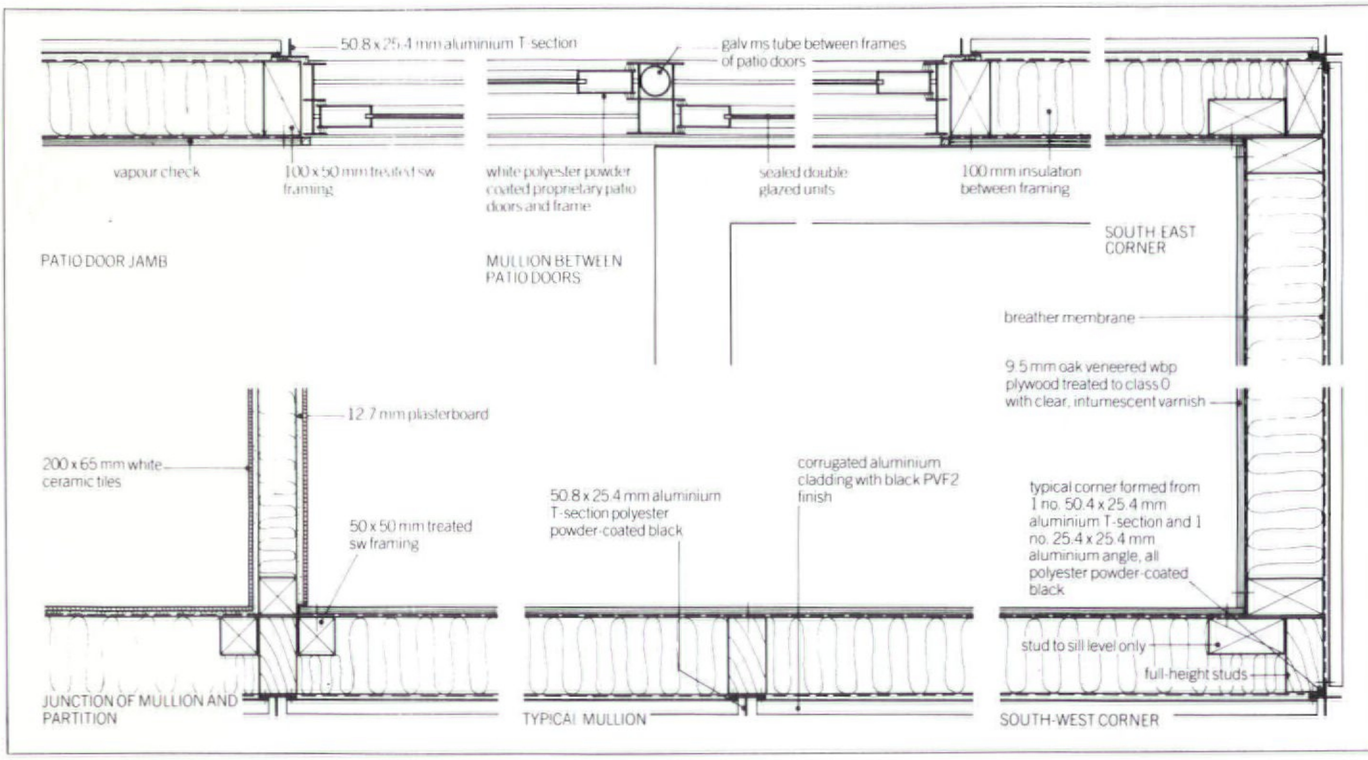
The building sits on a 125 mm concrete raft, with strip footings under the timber stud walls and additional concrete projections under each column. The column foundations have to be tied back to the main building to counteract wind load.

Internally, skirtings and facings are omitted, although externally a combination of steel angles and T-sections helps achieve neat joints in the metal cladding.

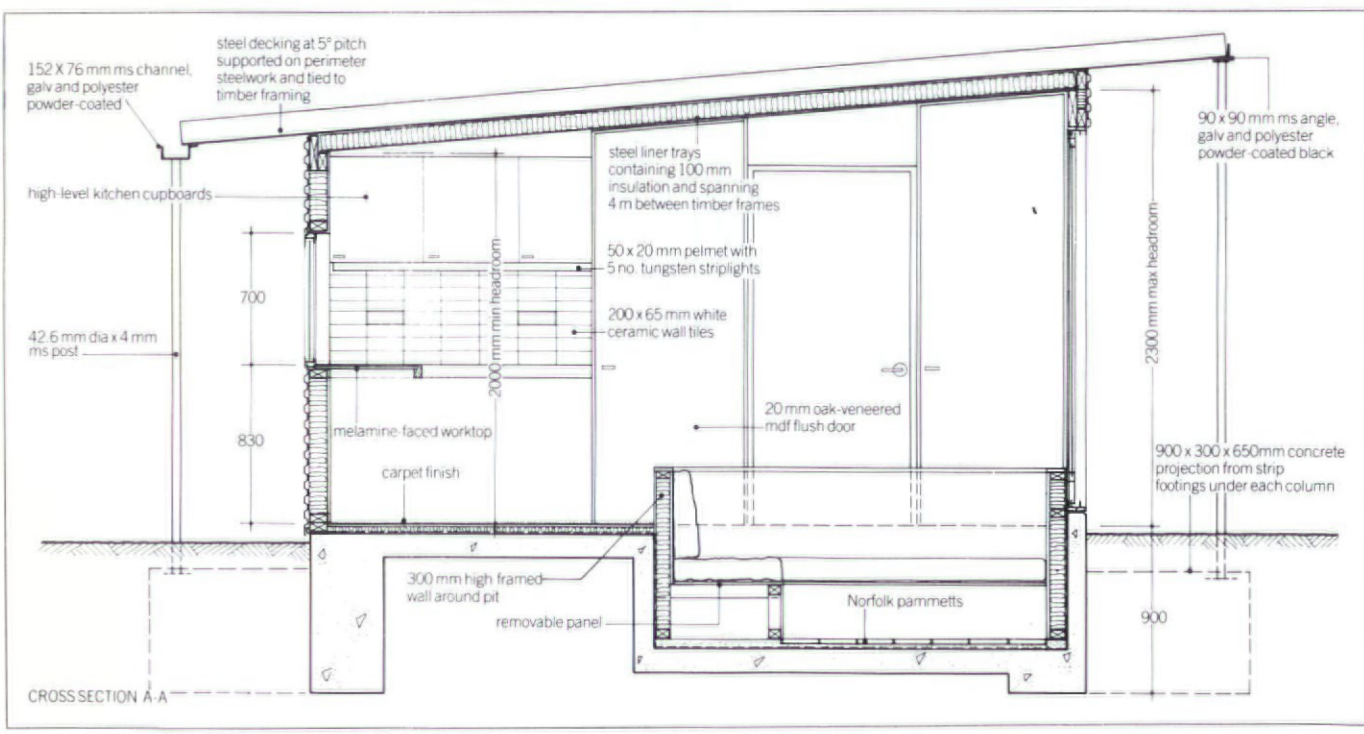
The only painted finishes internally are two door frames and the timber studs where they are exposed to form window mullions. The double-glazed windows and patio doors are all polyester powder coated. The better quality that can be achieved with off-site finishes is particularly valuable in such a corrosive atmosphere.

The building is heated solely from the stove, which can be fuelled with driftwood. The well-insulated light construction will heat up rapidly — as is appropriate for such an intermittently used space. ■

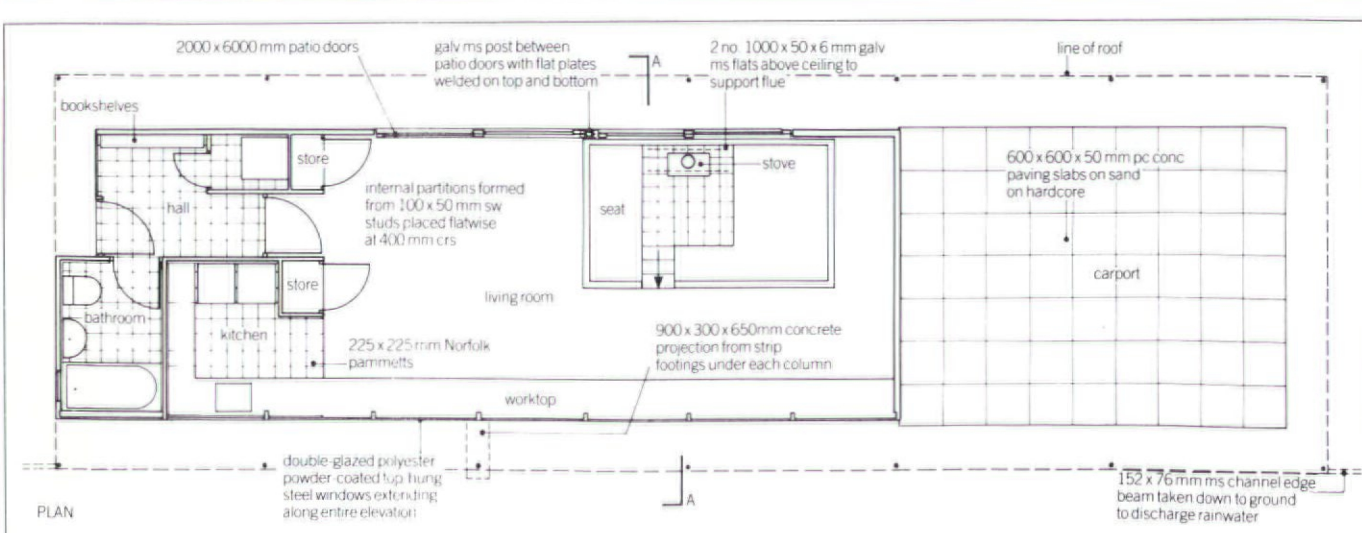
Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company in the preparation of this article.


50.8 x 25.4 mm aluminium T-section
galv ms tube between frames of patio doors
vapour check
100 x 50 mm treated sw framing
white polyester powder coated proprietary patio doors and frame
sealed double glazed units
100 mm insulation between framing
PATIO DOOR JAMB
MULLION BETWEEN PATIO DOORS
SOUTH EAST CORNER
breather membrane
9.5 mm oak veneered wbp plywood treated to class 0 with clear, intumescent varnish
12.7 mm plasterboard
200 x 65 mm white ceramic tiles
50 x 50 mm treated sw framing
50.8 x 25.4 mm aluminium T-section polyester powder-coated black
corrugated aluminium cladding with black PVF2 finish
typical corner formed from 1 no. 50.4 x 25.4 mm aluminium T-section and 1 no. 25.4 x 25.4 mm aluminium angle, all polyester powder-coated black
stud to sill level only
full-height studs
JUNCTION OF MULLION AND PARTITION
TYPICAL MULLION
SOUTH-WEST CORNER

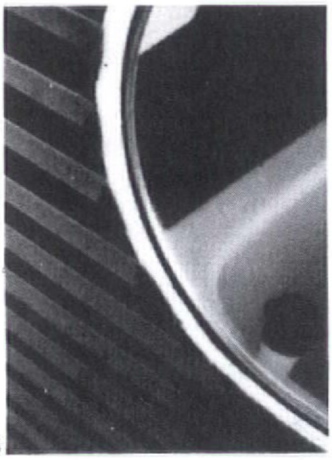
2


152 X 76 mm ms channel, galv and polyester powder-coated
steel decking at 5° pitch supported on perimeter steelwork and tied to timber framing
90 x 90 mm ms angle, galv and polyester powder-coated black
high-level kitchen cupboards
steel liner trays containing 100 mm insulation and spanning 4 m between timber frames
50 x 20 mm pelmet with 5 no. tungsten striplights
200 x 65 mm white ceramic wall tiles
700
830
2000 mm min headroom
2300 mm max headroom
42.6 mm dia x 4 mm ms post
melamine-faced worktop
20 mm oak-veneered mdf flush door
carpet finish
900 x 300 x 650mm concrete projection from strip footings under each column
300 mm high framed wall around pit
Norfolk pammetts
removable panel
900
CROSS SECTION A-A

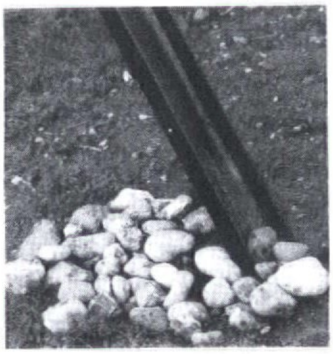
3


2000 x 6000 mm patio doors
galv ms post between patio doors with flat plates welded on top and bottom
A
2 no. 1000 x 50 x 6 mm galv ms flats above ceiling to support flue
line of roof
bookshelves
store
stove
internal partitions formed from 100 x 50 mm sw studs placed flatwise at 400 mm crs
600 x 600 x 50 mm pc conc paving slabs on sand on hardcore
hall
seat
store
living room
carport
bathroom
kitchen
225 x 225 mm Norfolk pammetts
900 x 300 x 650mm concrete projection from strip footings under each column
worktop
double-glazed polyester powder-coated top hung steel windows extending along entire elevation
A
152 x 76 mm ms channel edge beam taken down to ground to discharge rainwater
PLAN

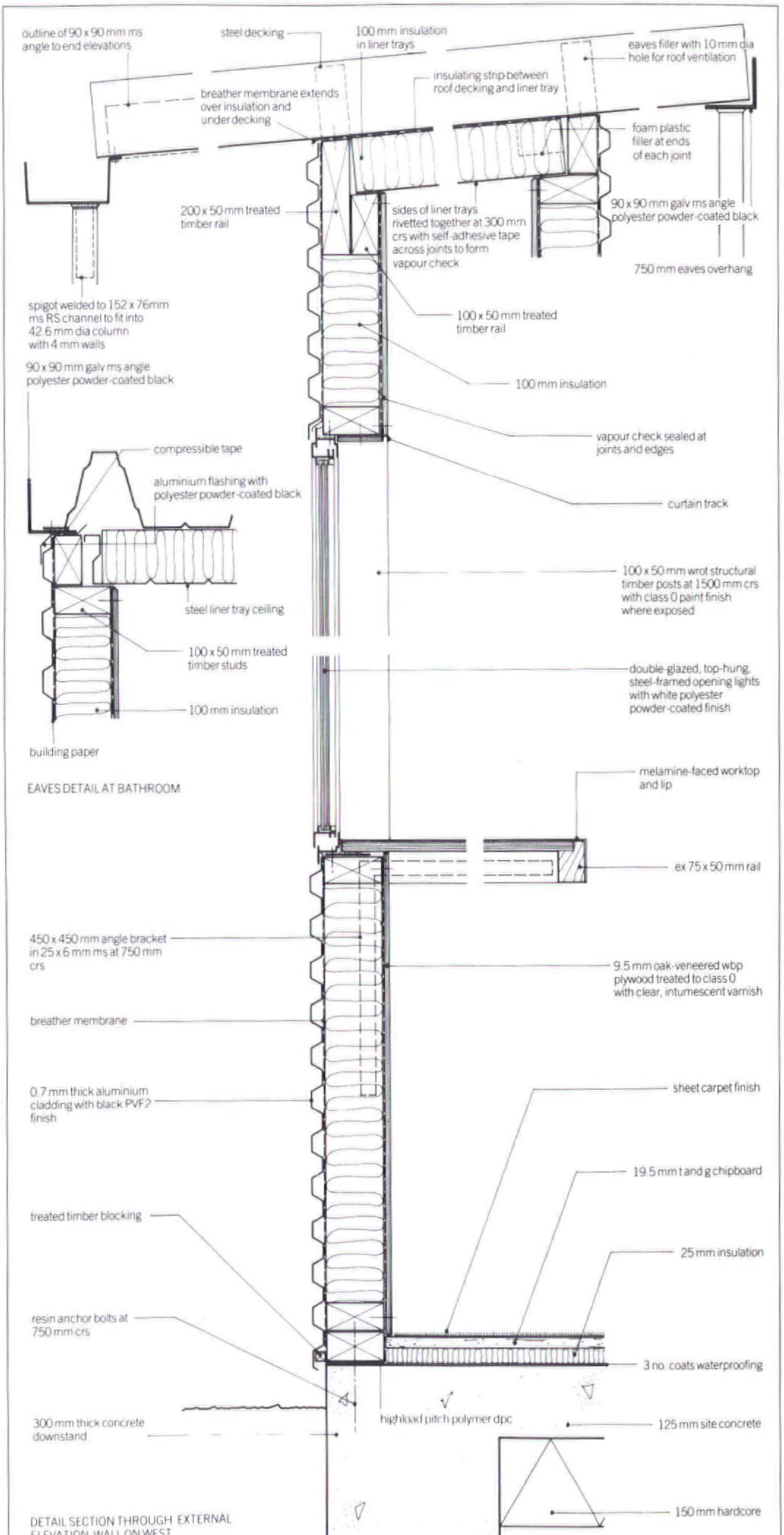
4



5



6



7

2 Plan details.
3 Typical cross-section. Pammetts are local quarry tiles — in this case 225 x 225 mm. They are readily available locally, although only second-hand.
4 Plan.
5 The circular window above the bath. It was difficult to do this elegantly. In this wall only there is a flat backing sheet of aluminium behind the corrugated cladding, to ensure that a watertight seal is achieved around the circular opening. In other situations the soft filler plugs used here would be very susceptible to vandalism.
6 One of the two gutter/ground junctions.
7 Typical section through the external wall and roof.

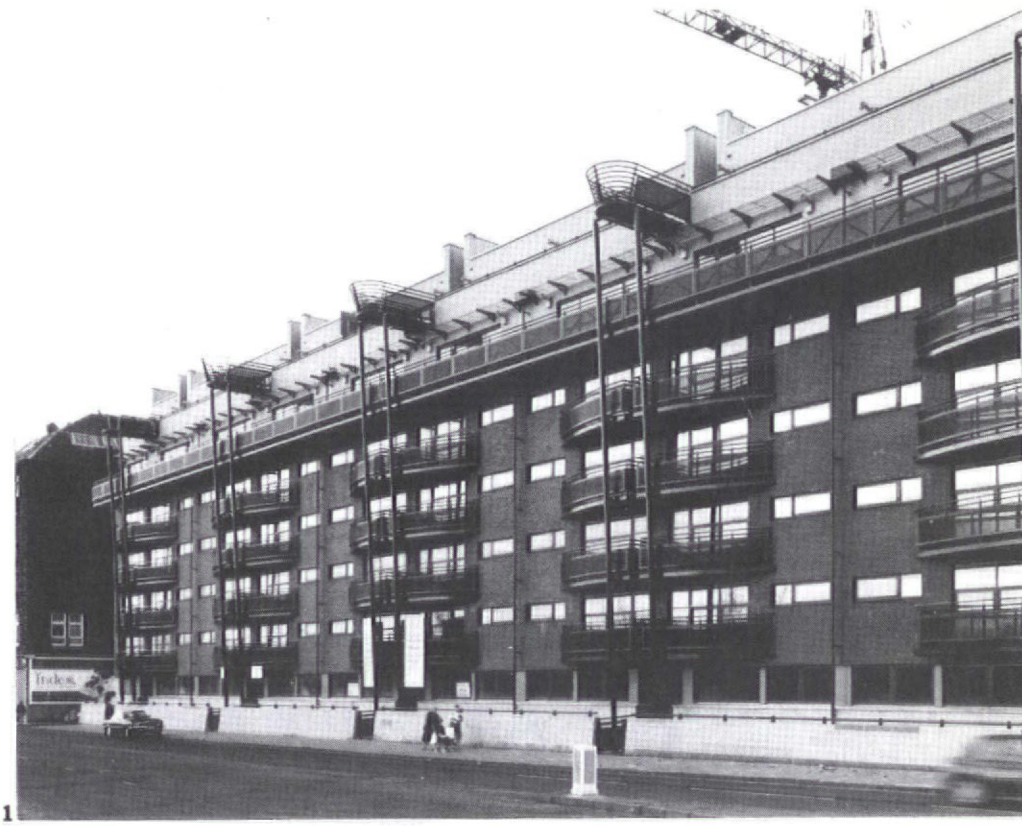
Credits
location 13 Doggetts Lane, Happisburgh, Norfolk
client Valerie and John Winter
architect John Winter & Associates
engineer Whitby & Bird
contractor John Hook
steelwork North Walsham Tractors

AJ Database CI/SfB (A3) or (23.7) Xh2

BALCONIES
PRIVATE HOUSING
The Davis Duncan Partnership

These balconies are not cantilevered, but are supported by two slender columns per bay. Half of the loading is borne by the ground below the pavement.

Related article
Building feature
AJ 27.2.91



1

1 The south-west elevation of Carrick Quay, to Clyde Street. As you go up the building the view to the River Clyde improves, and the size of the balconies increases. The supporting 'masts' are set at 3.5°.

These six-storey flats were designed to fit onto existing foundations. Although built in loadbearing brickwork, to accommodate the large window openings the front elevation is supported on a steel framework.

The steel balcony structure was designed to be supplied and fixed as a self-contained package. Instead of being cantilevered the balconies are supported from pairs of columns, which in turn are supported on footbridges leading into the building. The footbridges act as girders, distributing half their load back into the building, and half onto the pavement — via a concrete pad in each case. This helps to minimise the loading on the existing foundations.

The lower balconies were intended to be attached to the building, for restraint only, via plates fixed to short box sections projecting out from the steel frame through the external wall. But this allowed insufficient tolerance, and a channel section was fixed to the front of the plates. To assist assembly, slotted holes were also used in the balcony structure wherever possible.

All the connections to the columns are pinned, mainly for appearance but also to avoid eccentric loading on the columns, allowing a very slender section to be used.

The building has a horizontal movement joint at third floor and vertical movement joints at bay junctions. In the balcony structure no allowance has been made for thermal movement vertically, but the fifth-floor balcony, although apparently continuous, is made and fixed in discrete bay lengths. It is designed as a series of lattice girders, and is attached to the building via cross members and a steel angle which is fixed to a reinforced concrete beam.

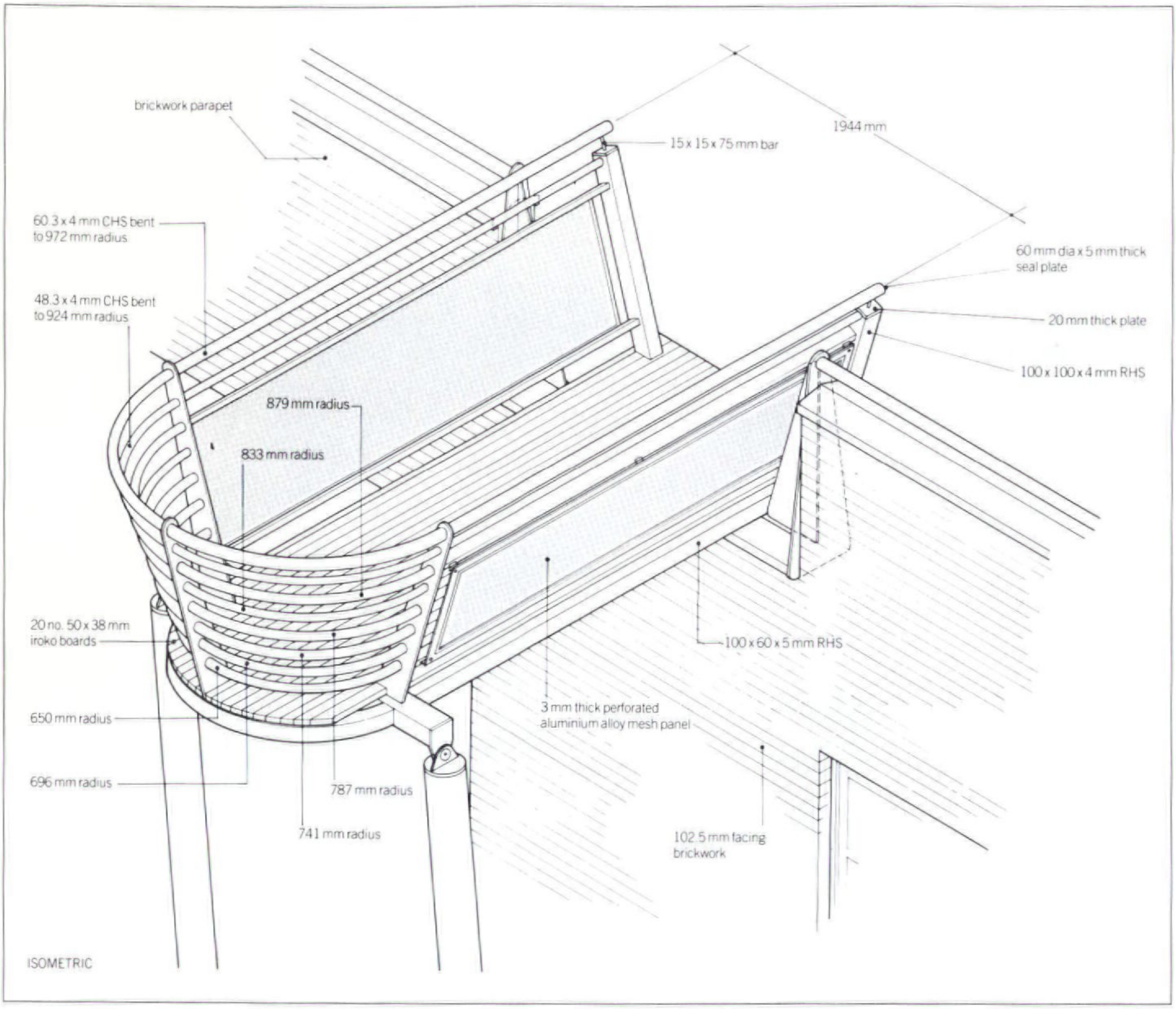
The balcony panels are aluminium mesh in an aluminium frame, with neoprene washers at junctions with steel. Particularly at the 'crow's nests' on the sixth floor it is essential that the mesh is strong enough to withstand the weight of people falling on it. The configuration of the ends of the crow's nests is also, from the inside, rather too like a ladder. A secondary inward-leaning handrail would have been safer.

The untreated iroko handrails and duckboarding should be maintenance free, although the exposed endgrain is vulnerable. (Iroko is a tropical hardwood whose source should be carefully checked.)

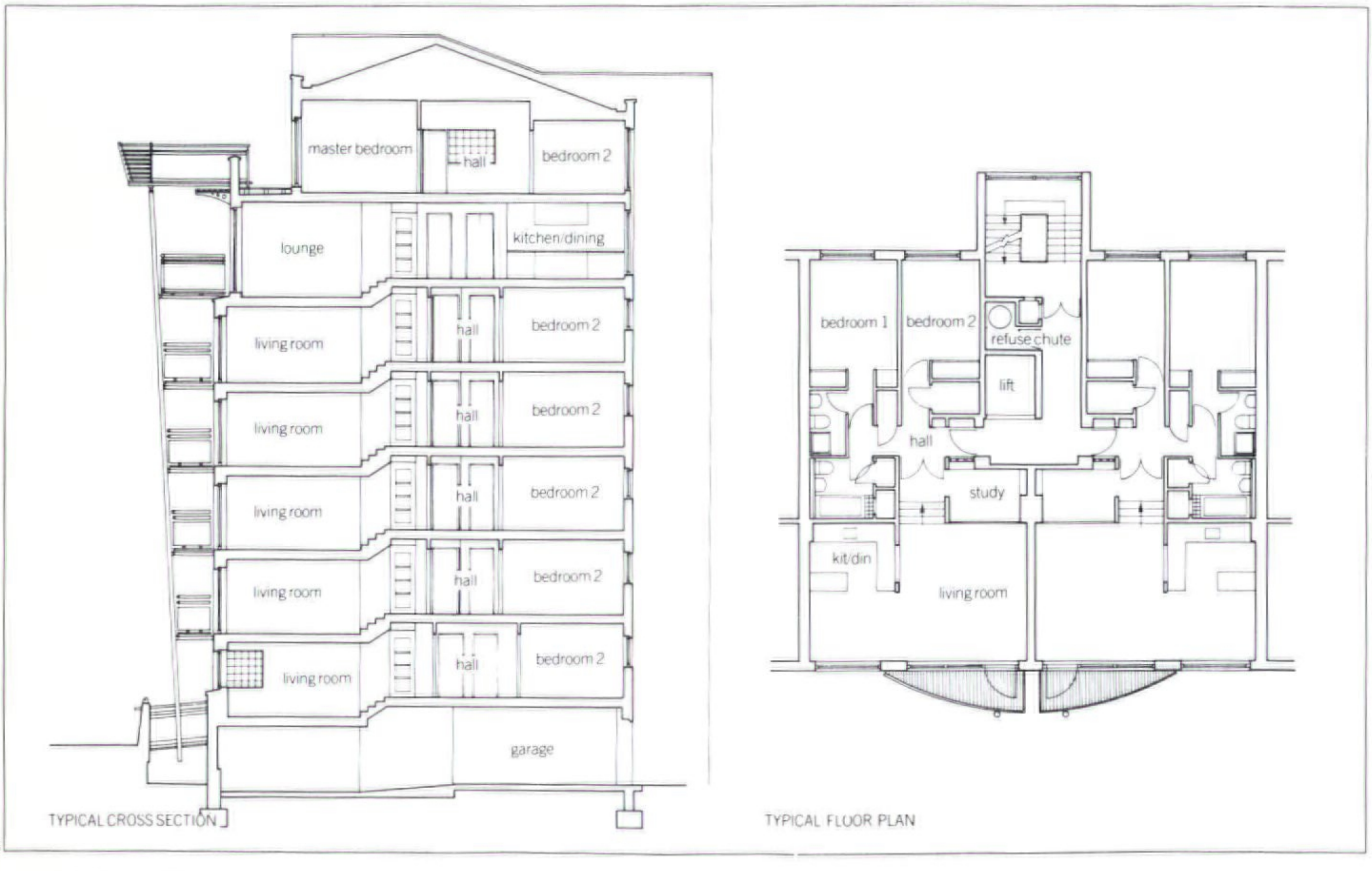
It took about a week to erect the balcony structure for each bay. The bridges went in first, and then the columns, which were restrained at the fifth floor. Extra diagonal ties at the fifth floor were put in during erection and then removed. The balconies were then assembled from the first floor upwards.

The finish to the steel, although not the very top of the range, should last at least 15-20 years. ■

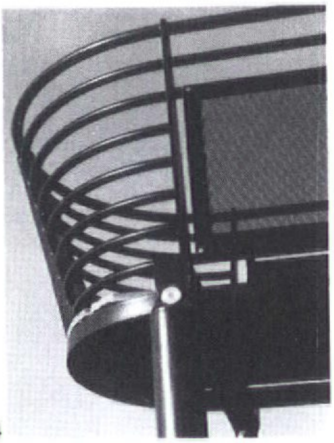
Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.


brickwork parapet
1944 mm
15 x 15 x 75 mm bar
60.3 x 4 mm CHS bent to 972 mm radius
60 mm dia x 5 mm thick seal plate
48.3 x 4 mm CHS bent to 924 mm radius
20 mm thick plate
100 x 100 x 4 mm RHS
879 mm radius
833 mm radius
20 no. 50 x 38 mm iroko boards
100 x 60 x 5 mm RHS
3 mm thick perforated aluminium alloy mesh panel
650 mm radius
696 mm radius
787 mm radius
741 mm radius
102.5 mm facing brickwork
ISOMETRIC

2

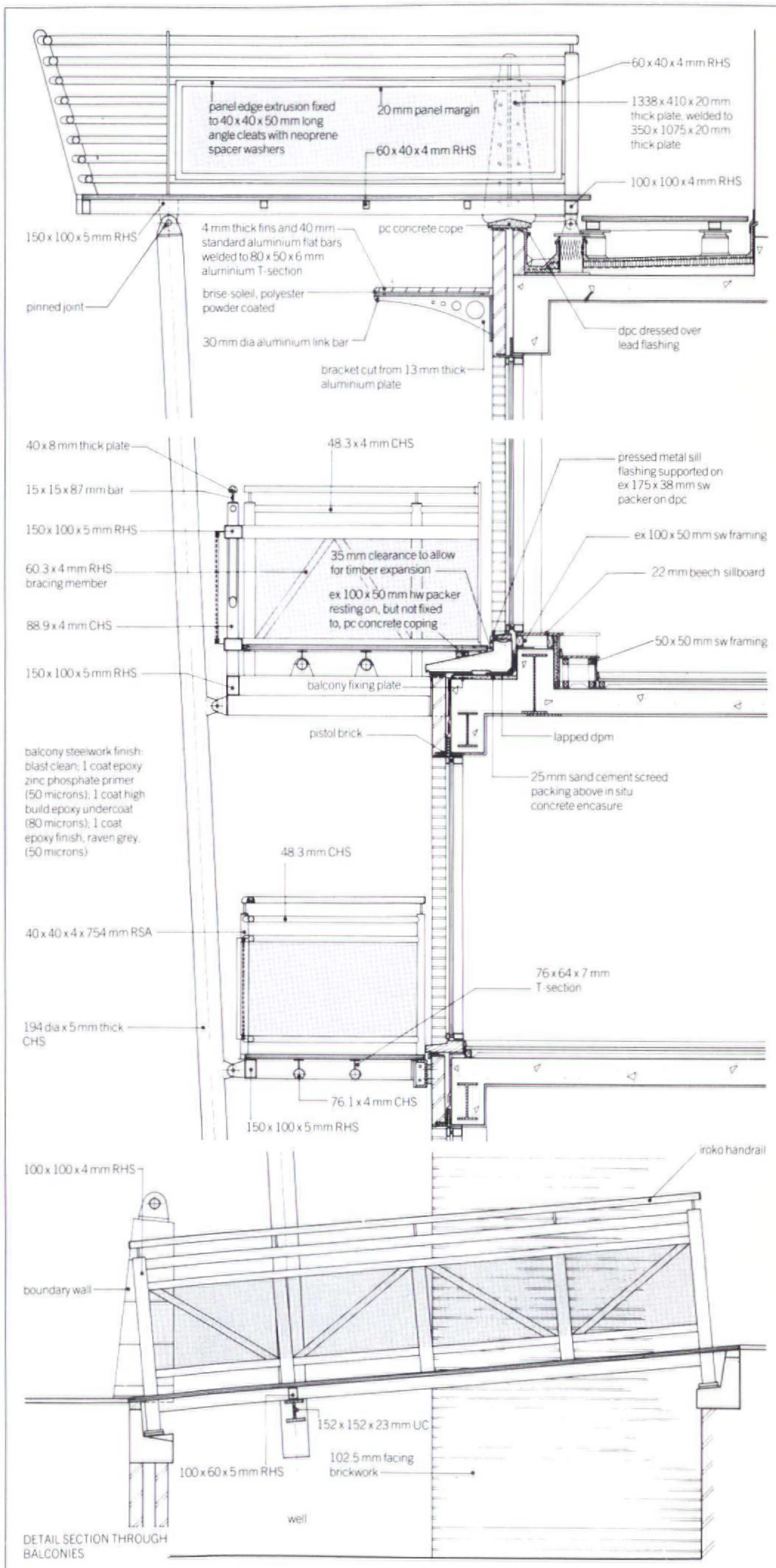

master bedroom
hall
bedroom 2
lounge
kitchen/dining
living room
hall
bedroom 2
living room
hall
bedroom 2
living room
hall
bedroom 2
living room
hall
bedroom 2
living room
hall
bedroom 2
garage
TYPICAL CROSS SECTION
bedroom 1
bedroom 2
refuse chute
lift
hall
study
kit/din
living room
TYPICAL FLOOR PLAN

3



4

2 Isometric showing the projecting balcony at sixth floor. Brise-soleil omitted for clarity.
3 Typical cross-section and fourth-floor plan. The first- to fourth-floor balconies are similar, but vary in depth.
4 Close-up of the sixth-floor balcony.
5 Detailed section through the sixth-, fifth- and fourth-floor balconies, and the bridge supporting the columns. The steelwork to which the balconies are attached is in the plane of the blockwork inner leaf (insulation-backed plasterboard on battens is placed inside of that).



5

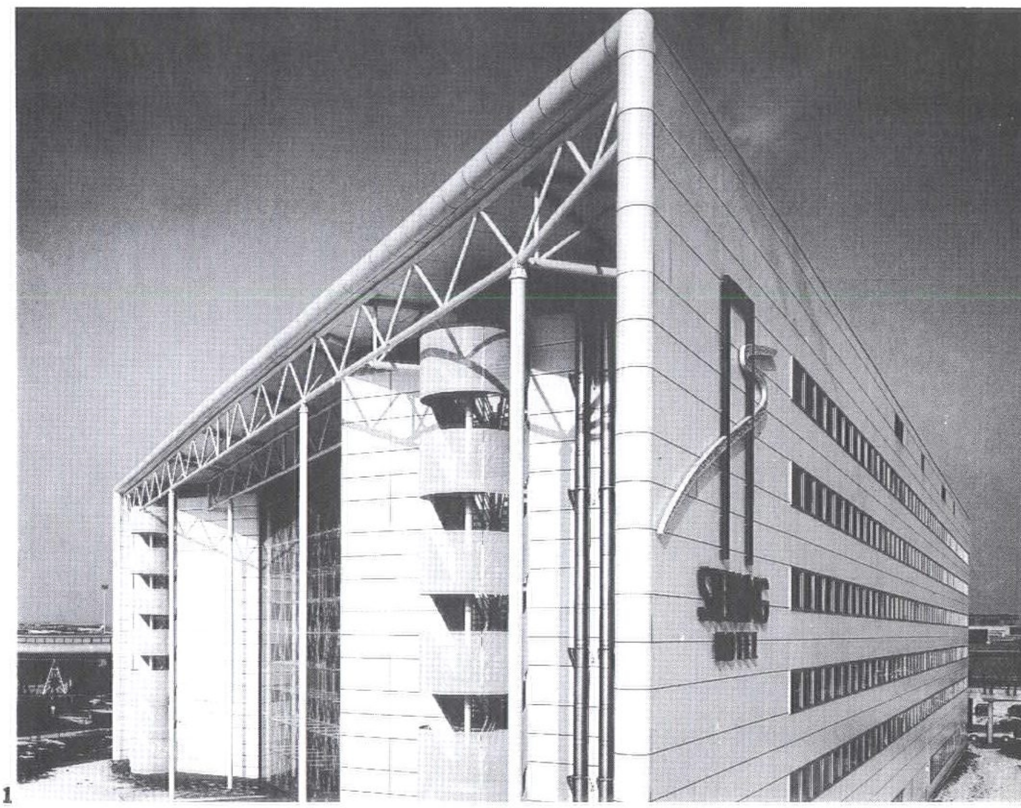
Credits
location Clyde Street, Glasgow
client Carrick Estates, a joint venture formed between the Burrell Company and Balfour Beatty Homes
architect The Davis Duncan Partnership
director in charge Ray Davis
project architect Keith Miller
quantity surveyor Tozer Gallagher
mechanical and electrical engineer ACTS
structural engineer Barclay Dowds JMP
project engineer Ian Wishart
specialist metalwork fabricator Tubeworkers
project engineer Bill Buchanan
main contractor Balfour Beatty Homes
site agent John Moffat
subcontractors: asphalt work Durastic, *timber decking* Balfour Beatty, *scaffolding* SGB Scaffolding, *composite windows and curtain walling* Henshaw & Sons, *structural steelwork* Bone, Connell & Baxter

Photo Credit
Photographs 1 by Guthrie Photography, 4 by Douglas MacGregor.

EXTERNAL WALLS AND ROOF
HOTEL
Manser Associates

This hotel at Heathrow Airport required a high level of sound insulation both externally in its walls and roof, and internally in the walls separating the central atrium and the bedrooms.

Related article
Building study
AJ 13.11.91



1 Both the glazed gable walls and the long walls to the bedrooms are designed to maximise sound insulation.

Located a short walk from Heathrow's Terminal 4, the Sterling Hotel's external envelope had to reduce noise sufficiently to enable guests to sleep. Because half the bedrooms face into an atrium, the atrium walls also needed to provide a high level of acoustic insulation. Dense materials provide the best acoustic barrier, but the architect also wanted to let as much daylight into the building as possible. The gable walls are therefore fully glazed — but with two separate roof-hung sheets of glass. To achieve maximum sound reduction the sheets had to be at least 1 m apart, but increasing the gap to 2.8 m allowed an air-conditioned thermal buffer to be created, and makes cleaning easier.

The external walls to the bedrooms are made from a system of staggered 75 mm steel studs interwoven with insulation in a 150 mm stud wall. Internally the walls are finished with two lapped sheets of cement particle board. As a result of the tests carried out on the proposed construction, acoustic resilient bars were introduced between the boards and the framing, to minimise structure borne sound transmission.

There are no skirtings or cornices, but, as a gap had to be left at the top of the cement particle boards to accommodate any creep in the concrete floors, an acoustic seal has been provided at the top of the walls.

Above the bedrooms is a concrete floor slab to carry plant, which, with two layers of woodwool and a layer of rockwool above, provides sufficient acoustic insulation to the bedrooms. The roof over the atrium is similar, but the ceiling finish is painted woodwool channel-shaped slabs. The air-gap within the 150 mm thick channel section helps cut down noise penetration from outside, and the woodwool finish provides some sound-deadening internally — valuable in a space whose walls are very reflective. The area of rooflighting is the maximum that could be achieved concomitant with the required sound reduction.

The average maximum noise level from aircraft (excluding Concord) is 95 dB(A). The requirement for bedrooms was L_{10} - 35 dB(A), and L_{MAX} (aircraft) - 45 dB(A). The atrium requirements were L_{10} - 45 dB(A) and L_{MAX} (aircraft) - 55 dB(A). Comprehensive site tests have not yet been carried out, but results so far seem at least as good as laboratory tests indicated (see *2*).

The design solution worked out for this particular site will not automatically suit another. But the principle of minimising both construction-borne and air-borne sound is widely applicable. A good working relationship with the contractor, as there was here, is also essential to ensure that detailing is built correctly. Acoustic failure can be more difficult to source than a roof leak. ■

Acknowledgment
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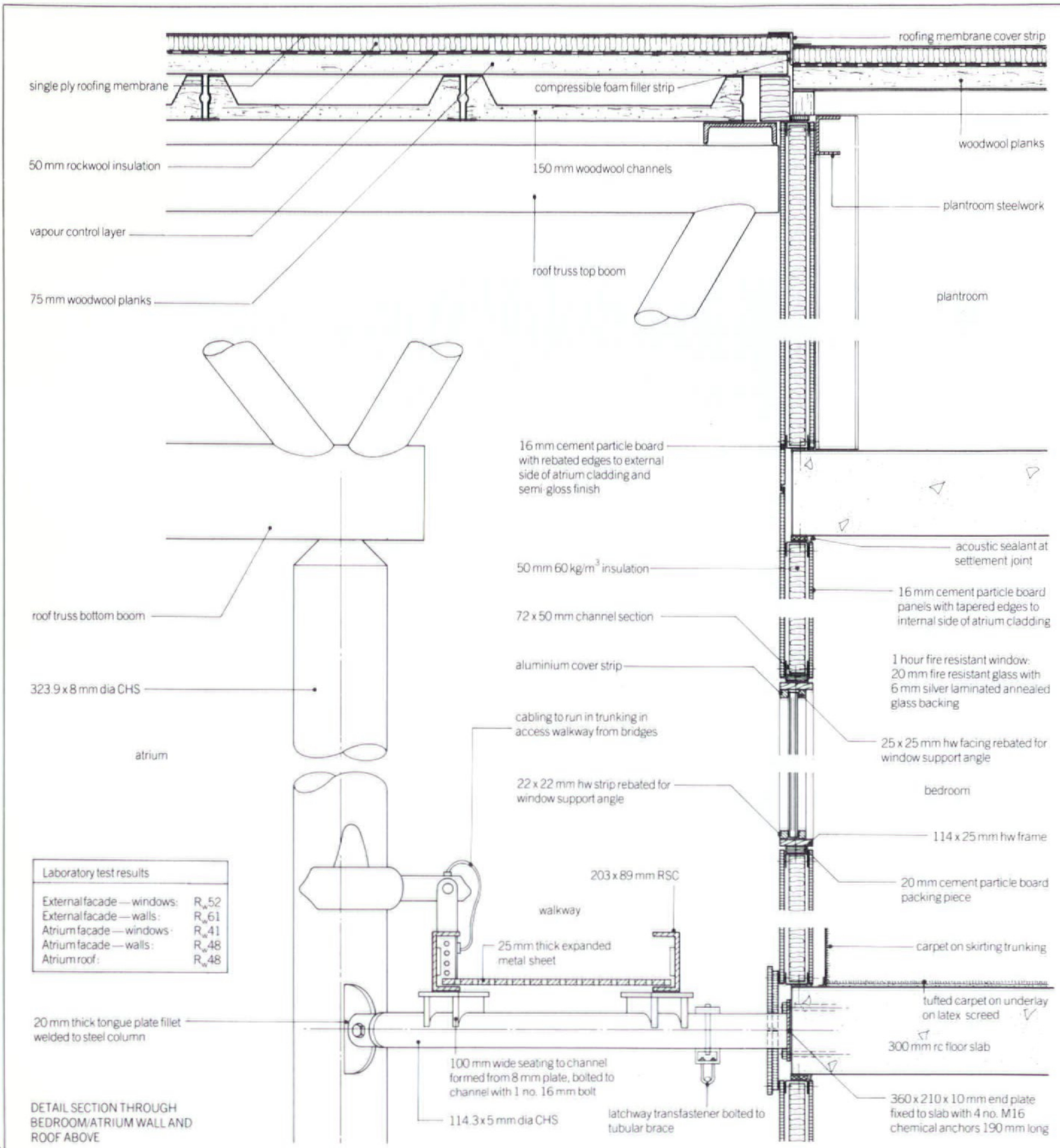
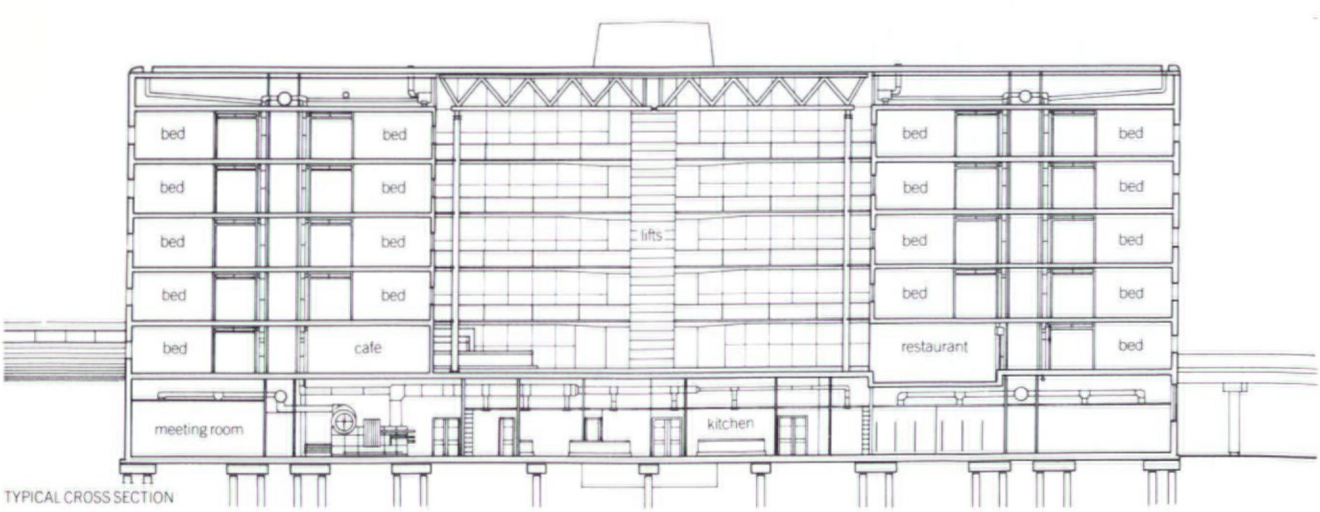
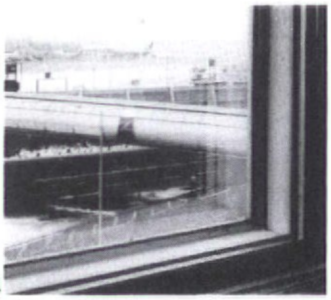


Laboratory test results	
External facade — windows:	R_w52
External facade — walls:	R_w61
Atrium facade — windows:	R_w41
Atrium facade — walls:	R_w48
Atrium roof:	R_w48

2 DETAIL SECTION THROUGH BEDROOM/ATRIUM WALL AND ROOF ABOVE



3 TYPICAL CROSS SECTION



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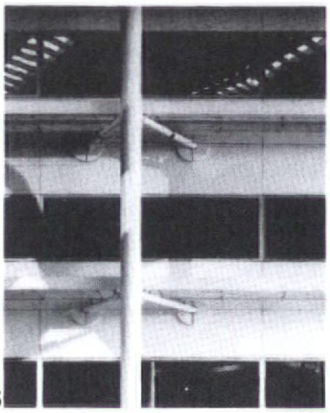
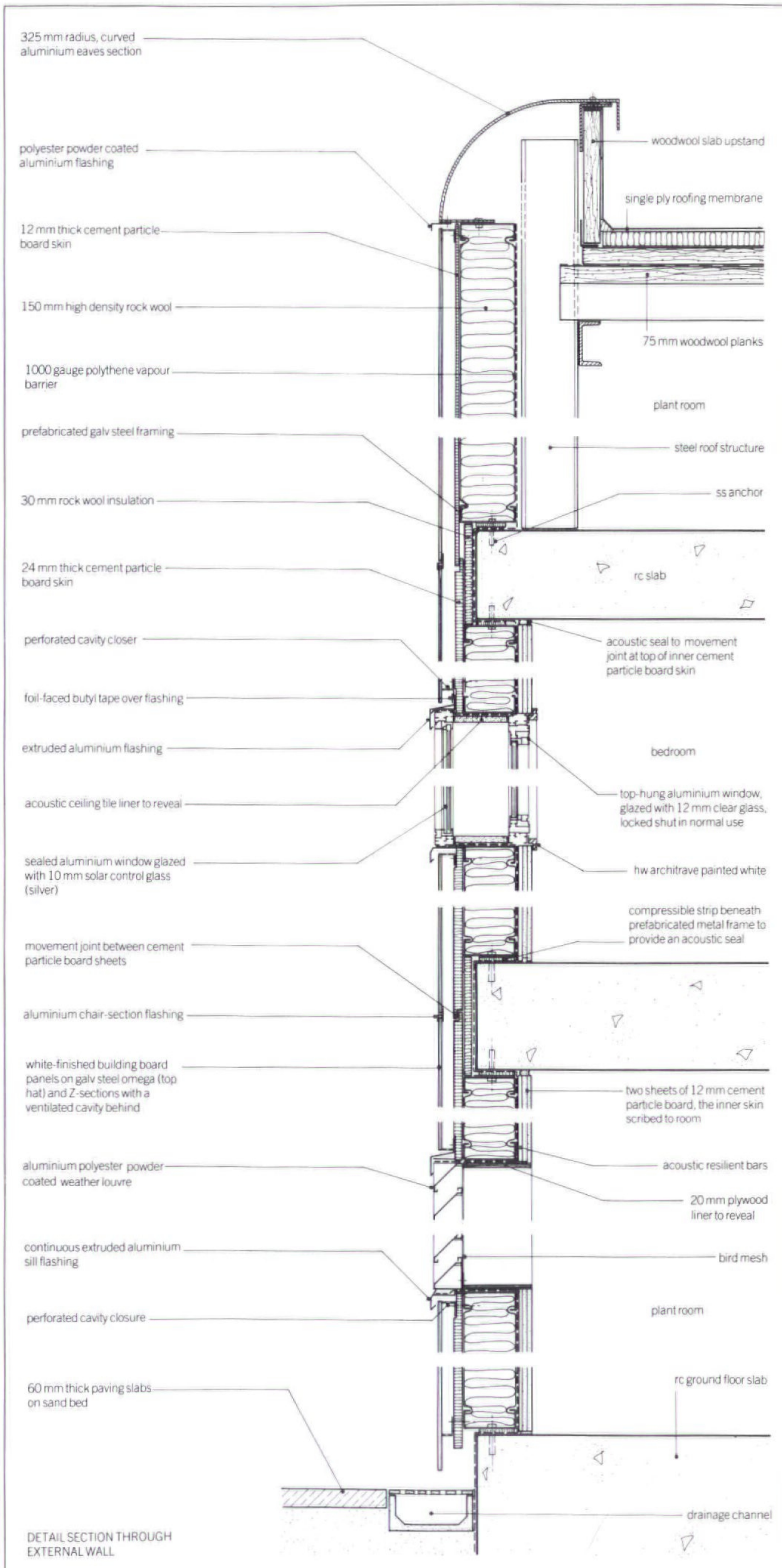


5

2 Detailed section through wall between atrium and bedrooms, and roof above.
3 Cross-section.
4 The view from one of the bedrooms. There are two windows, one on each face of the wall.
5 The bedroom wall seen from the atrium.
6 Section through the external wall. The internal cement particle boards in the bedrooms have verticle joints only. The boards are finished with two coats of emulsion.

Credits
location Terminal 4, Heathrow, Hillingdon
client BAA plc Hotel Development
architect Manser Associates
principal Michael Manser
project architect Jonathan Manser
assistant architects Michael Watkins, Anna Spruit, Daniel O'Sullivan, Annie McDiarmid, Tobias Davidson, Will Hudson, Dominique Gurret, Greg Ward, Steve Taylor
quantity surveyor Walfords
services/mechanical and electrical engineer F.C. Foreman and Partners
structural engineer YRM Anthony Hunt Associates
project manager Gablecross Projects
civil engineer BAA Consultancy
acoustic consultant Hann Tucker Associates
management contractor Higgs & Hill Management Contracting
subcontractors: rc structure Swift Structures, *atrium steelwork* Worldwork International and Surrey Steel Buildings, *external cladding and windows* Exterior Profiles, *internal cladding and windows* Straeker Construction, *composite roof* Robseal Roofing, *dry line partitions* Straeker Construction, *suspended ceilings* Silenzio Acoustics, *carpentry and joinery* Swift (St Albans), *painting and decorating* Wakes Decorating

Photo credit
Photographs by Peter Cook.



6

EXTERNAL WALLS AND ROOF
KINDERGARTEN
Christopher Day Associates

This kindergarten was built, using volunteer labour, in rendered masonry with a turfed timber roof. Environmentally friendly materials were used wherever possible.

1

1 The single-storey nursery is designed to appear to grow out of the ground. The masonry walls are corbelled out at ground level, and the render is coated with earth-coloured lime-based washes.

Inside the womb-like Nant-y-cwm Steiner kindergarten it is impossible to forget that this building is for small children — up to 30 4-6 year olds. Set amid woodland beside a river, it is inseparable from its rural South Wales setting. In designing the building Christopher Day has accommodated all these influences, plus a requirement that it be cheap and buildable by volunteers — as well as still following his own instinct for what he would describe as calm, non-toxic, breathing construction.

Having ruled out timber for the main frame or cladding due to the very humid conditions of the Welsh woodland micro-climate, Day did use a timber roof structure — and masonry walls. The walls are rendered and sculpted inside and out, and the curving shallow-pitched roof is turfed. The insulation-filled cavity blockwork walls on strip foundations (directly on to the rock below), are widened out at the foot of the external leaf by blocks and split-bricks, to give the impression of a solid base. The external render is a 1:1:6 mix, coated with veils (washes) of a lime-milk formulation. The wash is based on the clear alkaline fluid ladled out of a mix of lime, water and a small amount of protein, such as meat, which is all stirred daily for at least a week, and then combined with earth colours.

Internally the ceilings are lined with a 1:4 sand:plaster finish, brush finished, and the walls with ⅔:2½:10 cement:lime:sand render, hand finished, all coated with two coats of non-toxic paint and finished with four or so veil coats of water colour — half a tube to a 500 g margarine tub of water, just enough colour so that it can be seen. If the veils are too thin it doesn't matter, Day points out — the building will just take longer to dry.

The wall finishes are all intended to allow the building to breathe. There are no obvious junctions between walls and ceilings — curves and gentle angles are considered more appropriate for 4-6 year olds.

The undulating roofs are formed from timber joists spanning from timber ring beams to 1200 mm dia plywood discs. Above these sit boxes which allow roof ventilation. The caps are octagonal (to avoid the sharpness of right angles) and monopitched to encourage run-off.

Because the turfed roofs are at pitches as steep as 39°, a twine net is incorporated to discourage soil slumping. A concrete kerb helps to keep the turf in place, and the gutter is formed against the fascia upstand.

Despite its magical qualities, Day is aware that this building is not as green as he at least would have liked. But the compromises — such as treated roof timbers, necessary because of their long periods of exposure, but always separated from the users by ceiling finishes — are not made unthinkingly. ■

Acknowledgment
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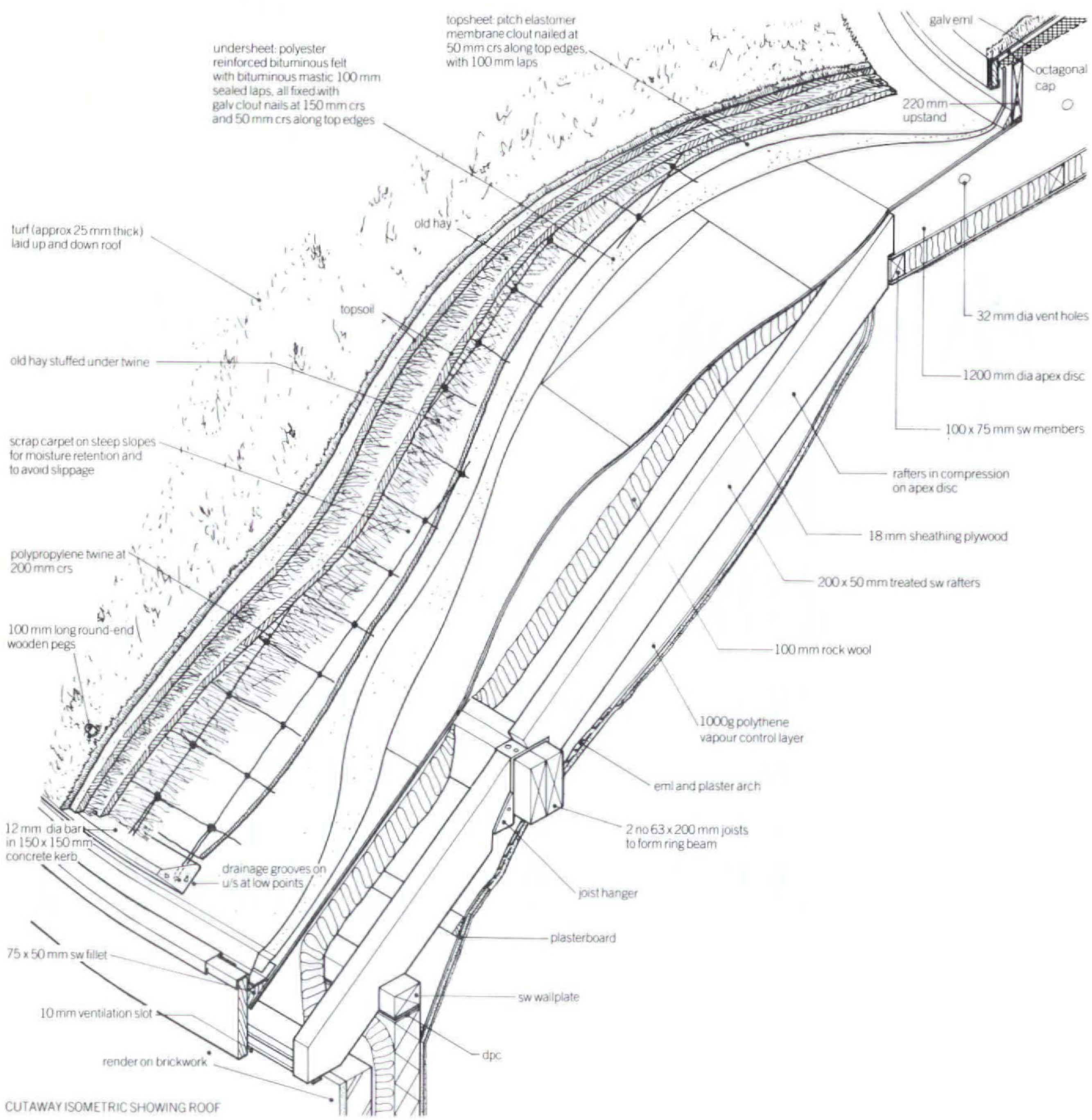
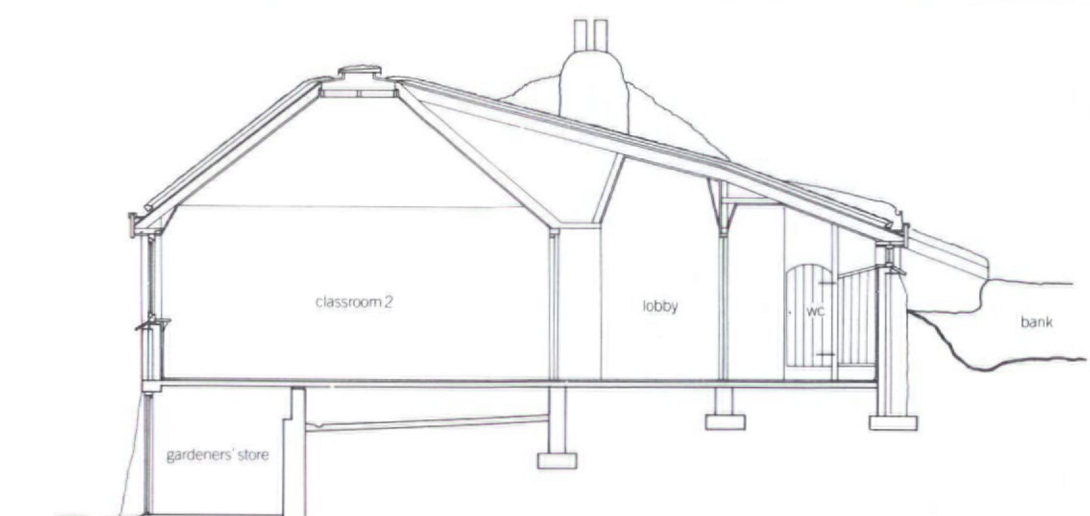


CUTAWAY ISOMETRIC SHOWING ROOF

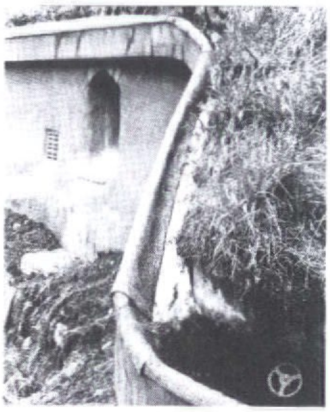
2



CROSS SECTION

3

4



5

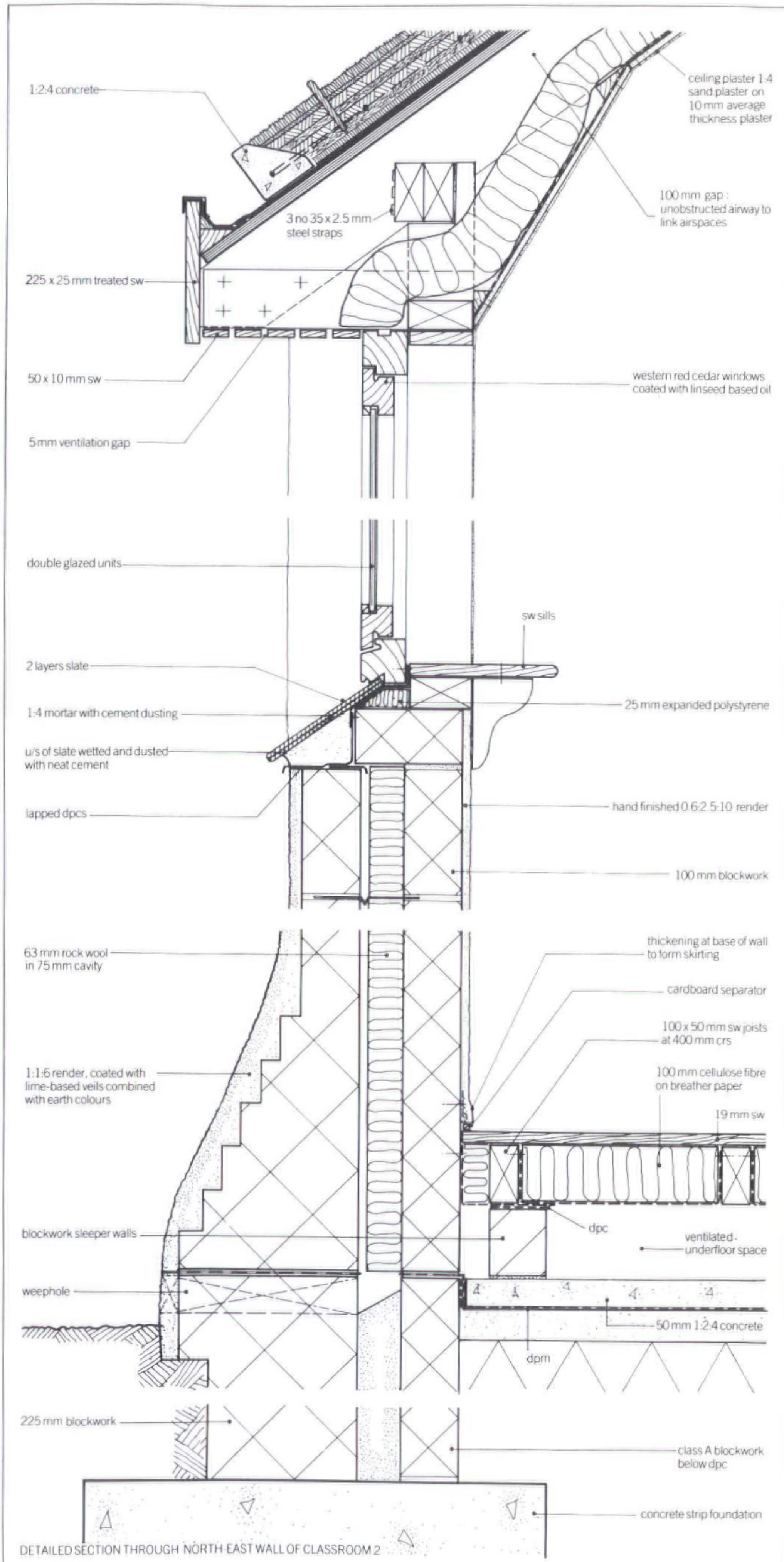
2 Cutaway isometric showing the roof build-up. This roof is similar to the one used by Christopher Day at Ty Crwdd Bach (AJ 3.9.80 p434).
4 The turf roof does need trimming at the gutter from time to time.
5 Close-up at eaves level. The standard of finish on this building is not the same as one would expect on a more traditional project.
6 Detailed section through the external wall. The cardboard separator at skirting level has not lasted.

Credits

location Llanycefn, Clynderwen, Dyfed, Wales
client Nant-y-cwm Steiner School
architect Christopher Day Associates
partner in charge Christopher Day
assistants William Browne, Paul McIntyre, Øyvind Trygstad, Elizabeth Bowker, Marianne Lynum
structural engineer David Yeomans
main contractor mainly volunteer labour
subcontractors: windows and external doors Morgan & Doyle, *windows* James Grian, Stephen Latham, *glazing* Rawleys Glazing, *carpentry* Bill Dobson, *suppliers: principal builders merchant* D. G. Thomas & Son, *builders merchant* Jewsons, *timber and plywood* Malden Timber, *roofing membrane* Ruberoid Building Products, *cavity ties, joist hangers and eml* Catnic Components, *Livos organic paints (Dubron and Valetia)* Jane Foster, *drainage products* Yorkshire Imperial Plastics, *turf* Parry, *insulation* Sheffield Insulations.

Photo credit

Photographs 1,5 by Charlotte Wood.



6

EAVES
AIRPORT
Foster Associates

The eaves detail at Stansted can accommodate movement of ±90 mm. It uses steel, toughened glass and an epdm membrane.

Related articles
Building feature
AJ 29.5.91
Working details
AJ 5.6.91

1

1 Foster Associates wanted the eaves detail to show that the walls do not support the roof. There is therefore a continuous band of toughened glass visible at the junction. Movement (including shear) is taken up in a sheet of flexible epdm, which is hidden from view.

The tubular steel-framed roof to the Stansted terminal is supported by 36 structural trees (each 3 m x 3 m), founded at ground level. From the tops of these, four branches extend diagonally to carry the roof. The construction is braced by pairs of carbon-chrome steel bars, pre-stressed to 330 kN.

The 39 200 m^2 roof is formed from a grillage of 323 mm dia steel beams which support 121 lattice shells (each 18 m x 18 m). The shells are formed from sections of cylindrical barrel vaults with a rise of 2 m.

Each shell has four triangular rooflight openings, each made up of four sealed, double-glazed units. Below each rooflight is a triangular macroperforated metal daylight reflector. This diffuses — but does not eliminate — sunlight, reflects daylight, and avoids 'black holes' at night.

The roof is drained by a siphonic system which has a specially designed roof outlet ensuring that no entrained air enters the pipework with the water. Rainwater passes through the horizontal pipework suspended below the roof to the downpipes on the east and west walls. As the water accelerates down the pipes, the remaining water in the system is 'pulled', under negative pressure, through the pipes back to the roof sumps, where the rate of flow into the sumps is correspondingly increased. Tapered downpipes further increase the acceleration and flow rate. Falls are eliminated and the number and diameter of downpipes minimised.

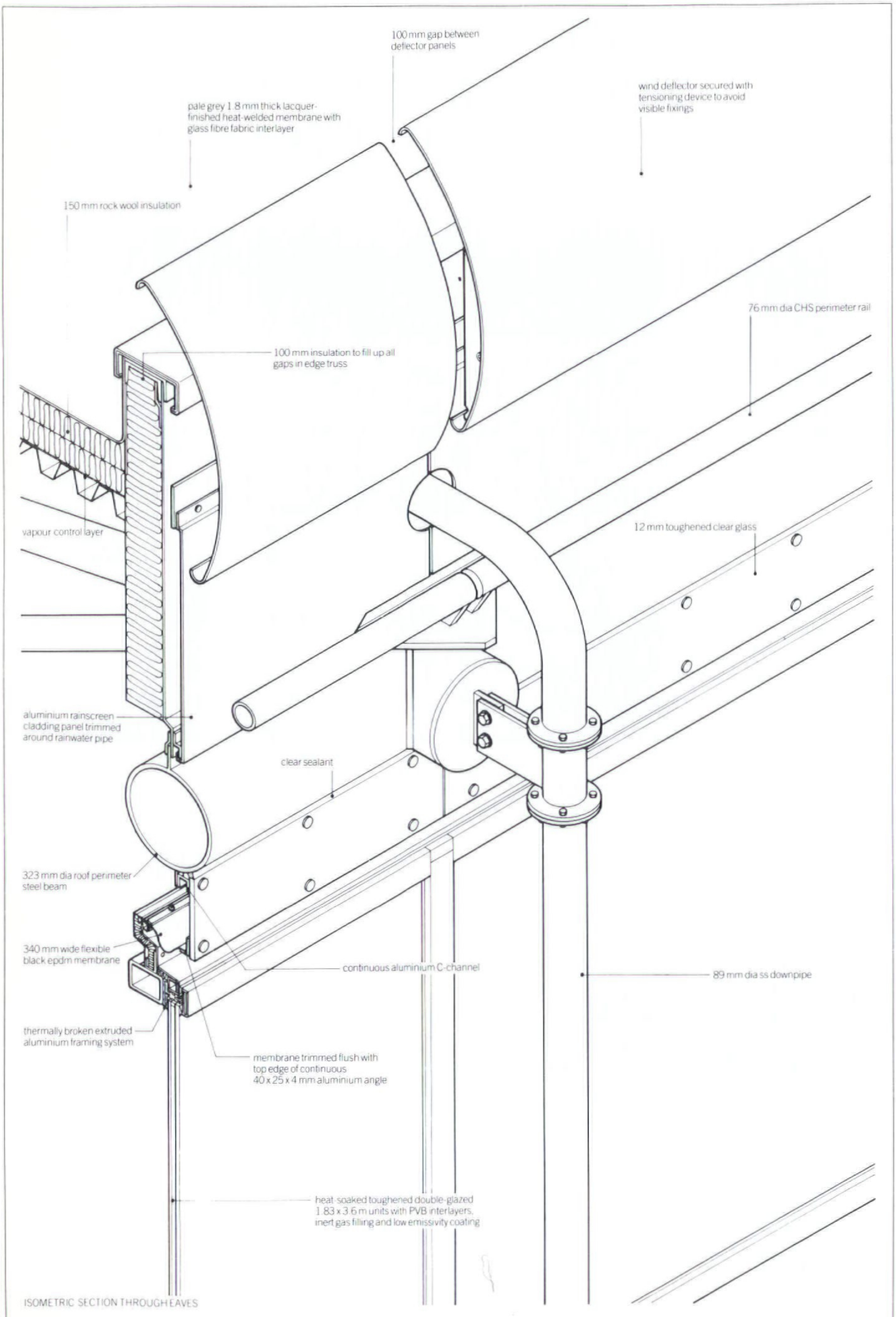
The walling is a system of double-glazed units clamped into an aluminium restraint system, fixed to a steel framework. The overall U-value is 1.6 $W/m^2 °C$.

The concourse glazing framework is fixed to the concourse floor slab, and has expansion joints to match those in the concrete. But this wall must still connect with the roof, which has no expansion joints. An earlier plan to allow roof expansion joints by cross bracing the trunks and separating them from the concourse slab posed severe problems for the roof design. But, as a result of omitting the expansion joints, horizontal movement of ±90 mm may occur at the perimeter (120 mm at the corners).

The eaves detail must still provide a watertight connection, and Foster Associates also wanted it to show that the wall does not support the roof.

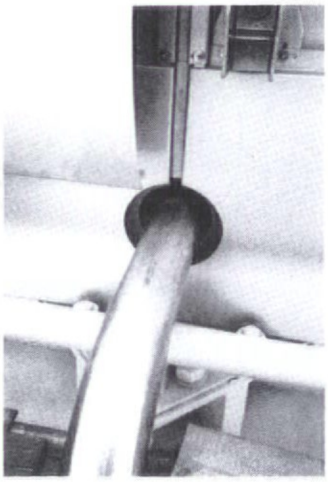
All movement of the structure is therefore accommodated by a hinge connection from the roof perimeter beam to a sliding horizontal steel rod on top of the cladding. Sheets of toughened glass, sealed at and bolted to the underside of the perimeter beam, and then linked horizontally to an insulated extruded aluminium baffle on top of the cladding by a flexible epdm sheet, make the structure watertight. ■

Acknowledgment
The editors acknowledge the assistance of Lionel Friedland of Pentarch in the preparation of this article.



ISOMETRIC SECTION THROUGH EAVES

2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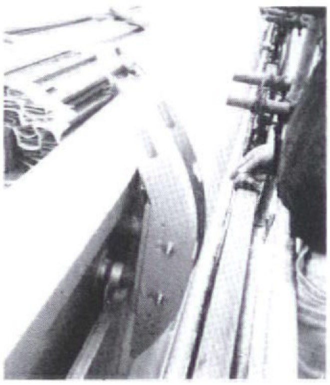
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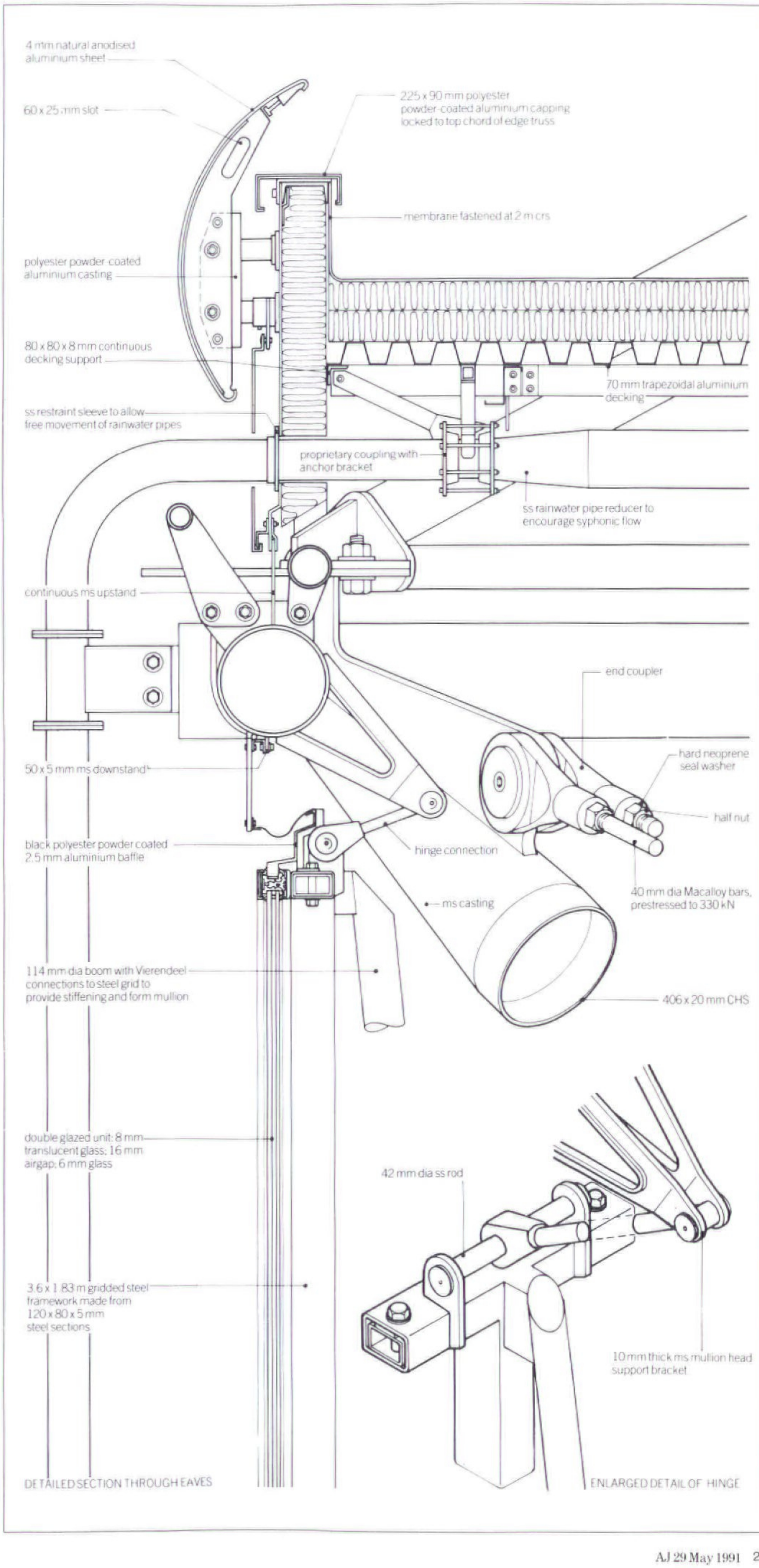
2 Isometric at the eaves (construction photo).
3 The rainwater pipe passing through the rainscreen cladding.
4 Close-up of the deflector during construction. It minimises uplift pressure on the roof membrane.
5 Detailed section through the eaves, with the hinge detail enlarged. The baffle in front of the hinge is designed to maximise sound reduction across the wall.

Credits
location Stansted, Essex
client Stansted Airport
architect Foster Associates
project manager Stansted Development Team
structural engineer Ove Arup & Partners
quantity surveyor BAA with Beard Dove and Currie & Brown
construction manager Laing Management and BAA Consultancy
lighting (public areas) Claude and Danielle Engle
acoustics ISVR Consultancy
environmental wind engineering University of Bristol
fire engineering Ove Arup & Partners
drainage Ove Arup & Partners
subcontractors: architectural metalwork Custom Metal Fabrications, *UV drainage* Drake & Scull Engineering, *rooflight reflectors* Environmental Technology, *lighting* Erco Lighting, *metalwork* Euramco Engineering, *structural steelwork* Fairport Engineering, *lattice painting* Independent Painting Contractors, *roofing* F. J. Prater, *roofing membrane* Sarna (UK), *glazing* Hans Schmidlin (UK), *concourse ceilings* Special Acoustic Services, *steelwork* Tubeworkers.

Photo credit
Photograph 1 by Peter Cook.



5

EXTERNAL WALL
OFFICES
Arup Associates

A glazed curtain wall keeps the front of this building wind and watertight. Additional columns, canopy and plinth provide solar shading and a more crafted elevation.

Related article
Building feature
AJ 16.10.91 p32

1 The complex colonnaded elevation to the Lloyds Bank headquarters in Bristol. The columns are pre-cast stone, but two different French limestones are used for the piers below.

The first stage of the new Lloyds Bank headquarters in Bristol provides 10 000 sq m of office space in a 31.5 m deep, crescent-shaped building.

The concrete frame and coffered slab structure exploit the curve, particularly in the radially ribbed, exposed concrete ceilings, formed using GRP moulds. Light fittings run along the length of the troughs, but are hidden, when viewed from a distance, by the ribs. There are no suspended ceilings in the open-plan offices — the services are run under raised floors.

A curved concrete edge beam on circular columns ties the ends of the structural ribs together, and the building was quickly made weathertight on site with a glazed curtain wall. This allowed time for the construction of the colonnaded elevations — which provide solar shading to the upper floors.

At the base of the wall is a series of French limestone-faced concrete piers at 4.5 m centres. All the stone at this level is natural — because this is where people will be closest to it — the Euville stone used for the plinth is a more durable stone than the St Maximin used above. Between the piers are iroko-framed, double-glazed windows.

It is difficult to get reliable information on tropical hardwood sources, but Arup Associates was assured by its trade contractor that the iroko came from a sustainably managed forest.

The tops of the piers are finished with pre-cast concrete units (crushed Balladon aggregate was used), in a paler colour than the stone, which provides a visual base for the pairs of pre-cast concrete columns.

Behind the columns at first- and second-floor levels is the double-glazed curtain wall. Suspended from it at second-floor level is an aluminium walkway which provides maintenance access.

Between the concrete slabs and the curtain walling are Venetian blinds. These are electronically operated and individually controlled, but only come down to desk-top level to preserve a uniform appearance on the outside of the building.

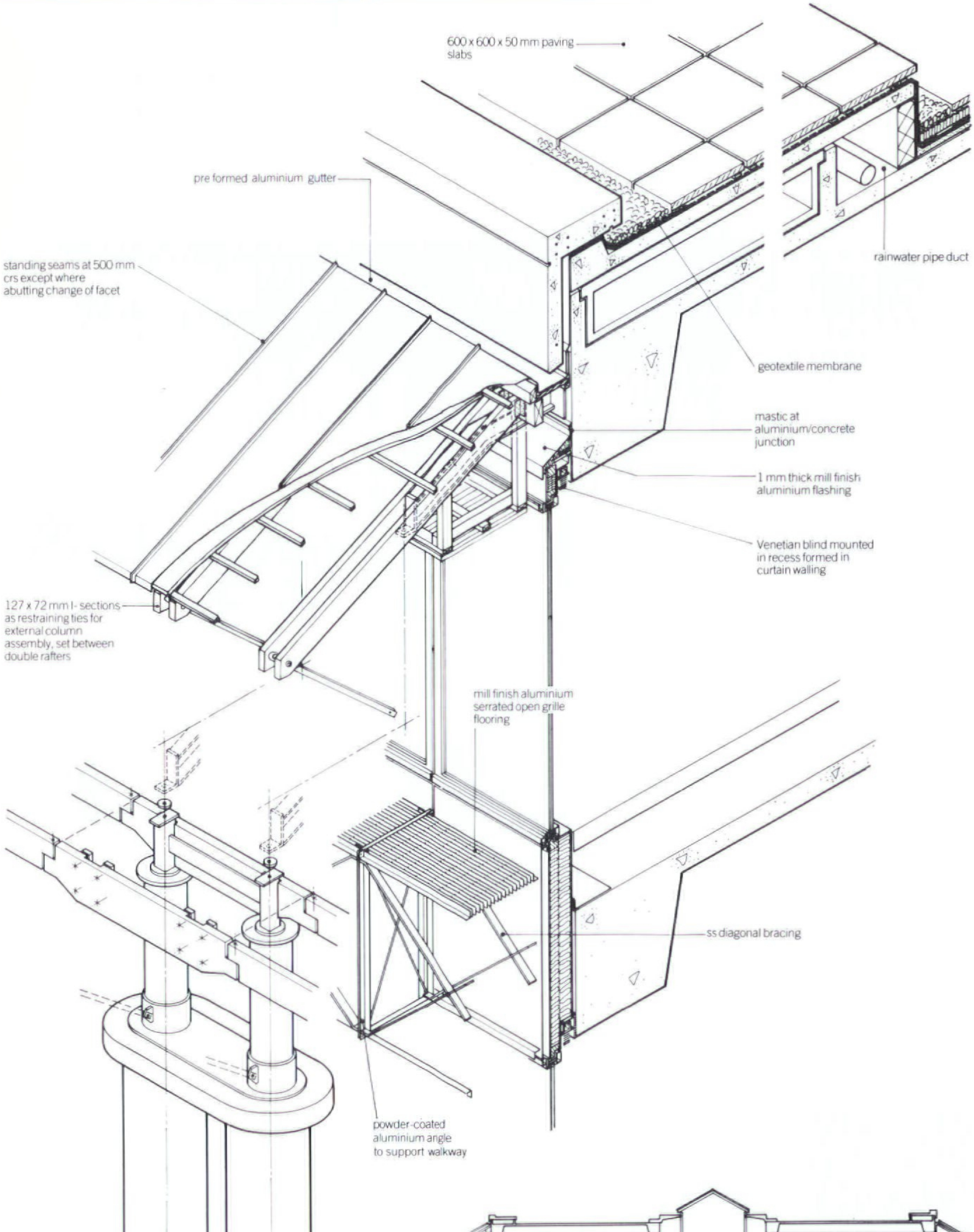
A flashing at the top of the curtain walling is weatherproofed where it meets the concrete structure, the top of which is protected by a pre-cast concrete parapet unit.

There is a gutter at the junction of the canopy and the structure, although not at the bottom of the canopy itself.

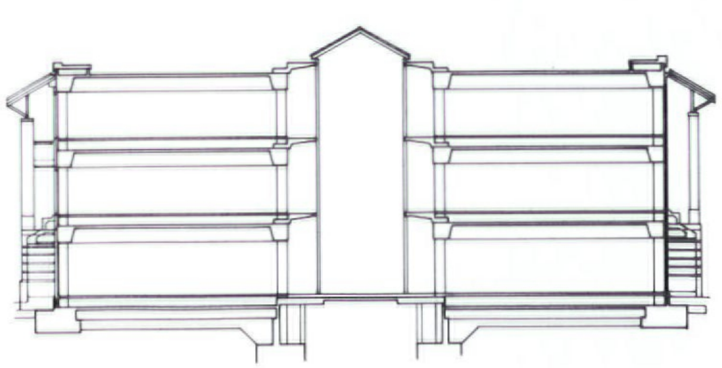
The canopy is lead-coated stainless steel on plywood, on battens on timber rafters. The rafters are paired either side of steel I-sections, which restrain the column assembly.

Two steel flats, set 20 mm apart, form struts between the bottom of the rafters and the base of the steel CHS's which extend up from each pre-cast concrete column. ■

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company in the preparation of this article.

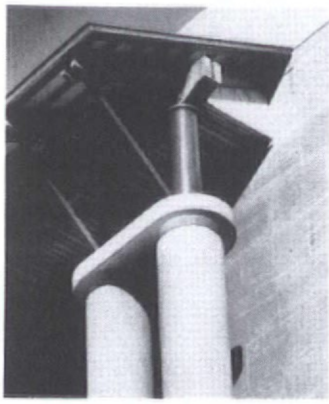


CUTAWAY ISOMETRIC AT TOP OF EXTERNAL WALL



TYPICAL CROSS SECTION THROUGH BUILDING

2



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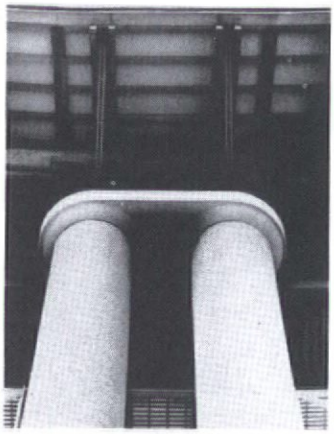

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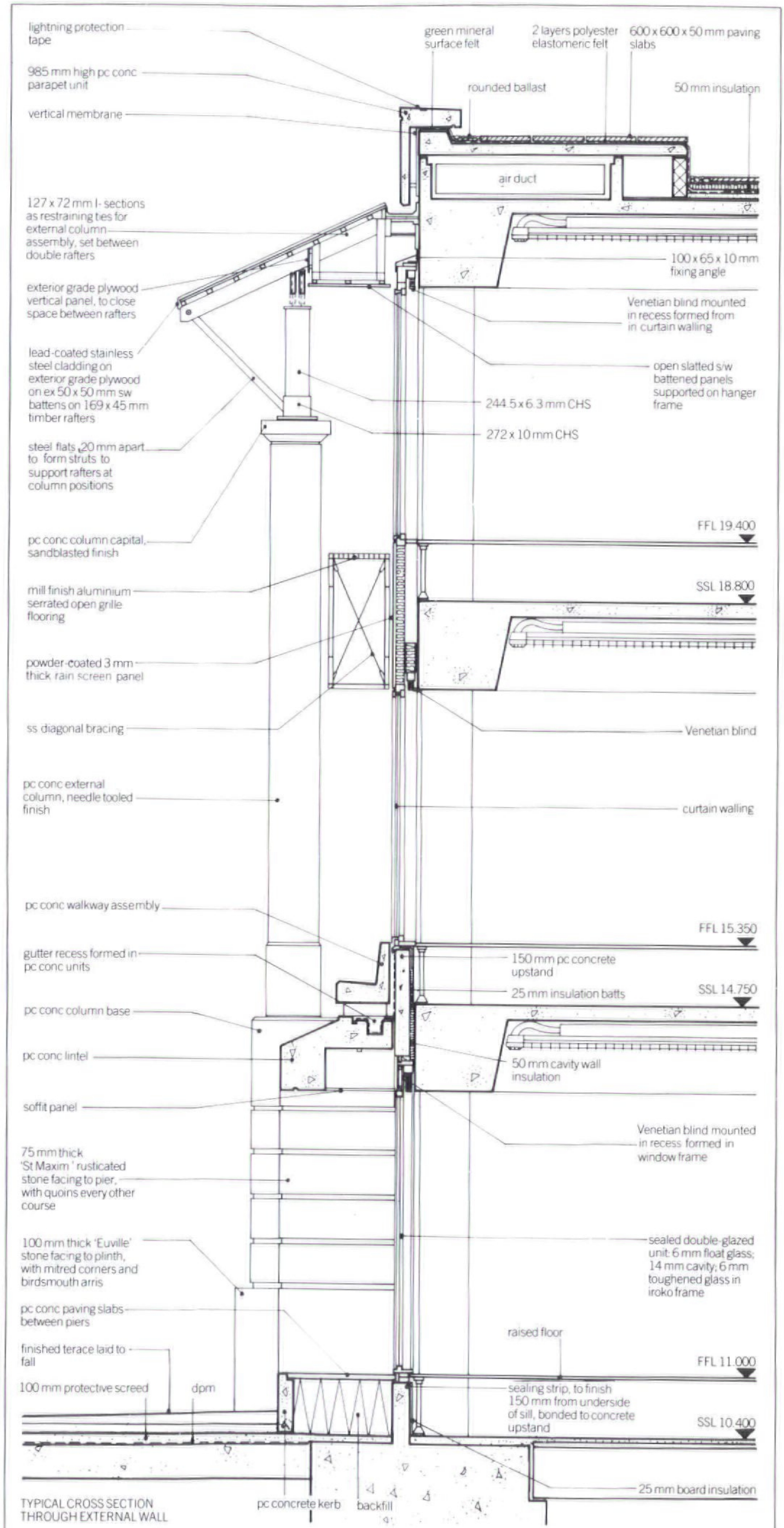
2 Exploded isometric showing the top of the colonnaded wall, and bottom right, cross-section through the building. Pre-cast units have a tooled, acid-washed or bush-hammered finish.
3 Close-up of the end of one of the colonnaded elevations.
4 Looking up at the underside of the canopy. This is all very elegantly detailed, being visible from the office areas on the top floor of the building.
5 Detailed section through the colonnaded wall. This is the detailing used on both long elevations: the end elevations are stone faced, with the only projections being the semi-circular glazed walls to the stair tower.



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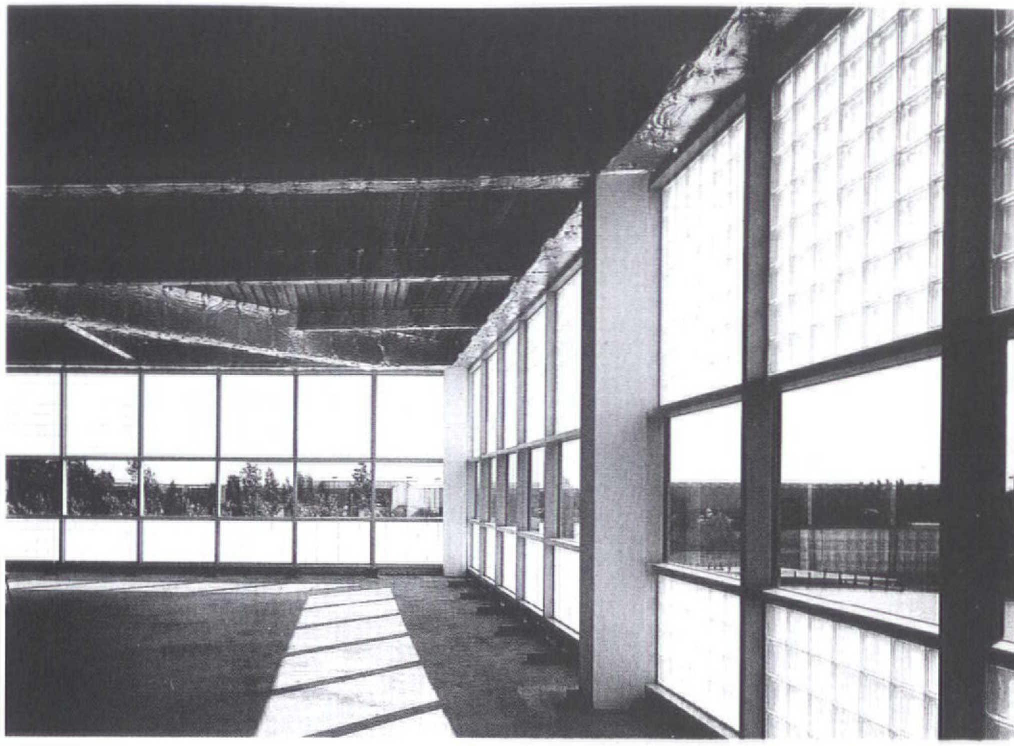
Credits
location Canons Marsh, Bristol
client Lloyds Bank plc
architect Arup Associates
quantity surveyor, services/mechanical and electrical engineer, structural engineer Arup Associates
management contractor Bovis Construction
trade contractors: concrete work Fairclough Civil Engineering, *architectural precast concrete* PCE (Midlands), *brickwork and blockwork* Ferson Contractors, *roofing and insulation* W S M Felt Roofing, *facade stonework* Cathedral Works, *external glazing* Schneider (GB), *ground-floor external windows and doors* C. Cheesman Joinery, *external sunscreen* Ferson Contractors, *architectural metalwork* R Glazzard (Dudley), *Venetian blinds* Regal Blinds.

Photo credit
Photographs by Rupert Truman.



1 The first floor of EP Associates' building at Stockley Park. The glass blocks are contained in extruded aluminium frames which are supported on a proprietary stick-frame system.

External wall
Offices

EP Associates At this Stockley Park building glass blocks have been incorporated into a cladding system that could be pre-fabricated off site.

In Eric Parry's sketches for this Stockley Park building, the use of glass blocks at the first floor was always an essential element. Glass blocks are translucent but not transparent, and have an attractive thickness and solidity, unlike many other cladding materials.

But to maximise off-site operations, Stanhope, the client, required external walls to be prefabricated, and to facilitate packaging of different parts of the works, interfaces had to be clearly identified.

EP Associates' design for the building was developed using 1.5m wide glass block panels in horizontal bands around the two-storey steel-framed building. The initial design for the panelised glass block walls used a framework of mild steel sections, and a double-glazed unit silicone-jointed into the panels.

But the tenders for this system were all too high, mainly because the cladding contractors were having to provide warranties for several different trades.

Alan Smith from UCS, Schal International's cladding consultant, then suggested approaching Hinchliffe, who had a standard curtain-walling stick-frame system, and who had worked at Stockley Park before. The design was therefore developed with Hinchliffe, Schal, Alan Smith, and Pittsburg Corning, the glass block manufacturer, who had been involved as soon as glass blocks were suggested.

As it happened, Pittsburg Corning, in conjunction with Dow Hansil Corning, was in the process of developing a new bonding system for its glass blocks.

The concave meeting faces on the blocks, which allow space for reinforcing bars, also required site applied silicone (an expensive option), so would not have been acceptable at Stockley Park. Economical use of the blocks became possible when Pittsburg had designed a clear polypropylene extrusion, which acts both as a spacer and as a backing for a small silicone bead.

The other key component in the design of the glass block panels is the aluminium extrusion which allows the blocks to be joined to Hinchliffe's standard mullion and transom section, which would normally only receive a slimmer component such as a double-glazed unit or a composite metal panel.

Each glass block panel was produced by sitting the frame on its end, but at about 30° from the vertical. Glass blocks were laid in rows with spacers between them and a continuous spacer bead between each row, and then the silicone bead applied. The tolerance across each panel is only ±2mm.

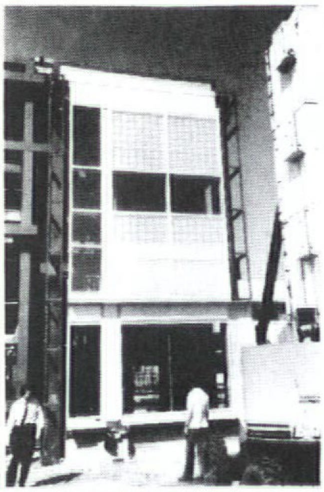
The supporting mullions are pinned to steel angle sections which in turn are bolted to the slab. The mullions have slotted holes to allow for movement under live load. The panel frame polyester powder coating colour is based on the silicone colouring, allowing all the elements to be absorbed into a harmonious whole. □

Related article

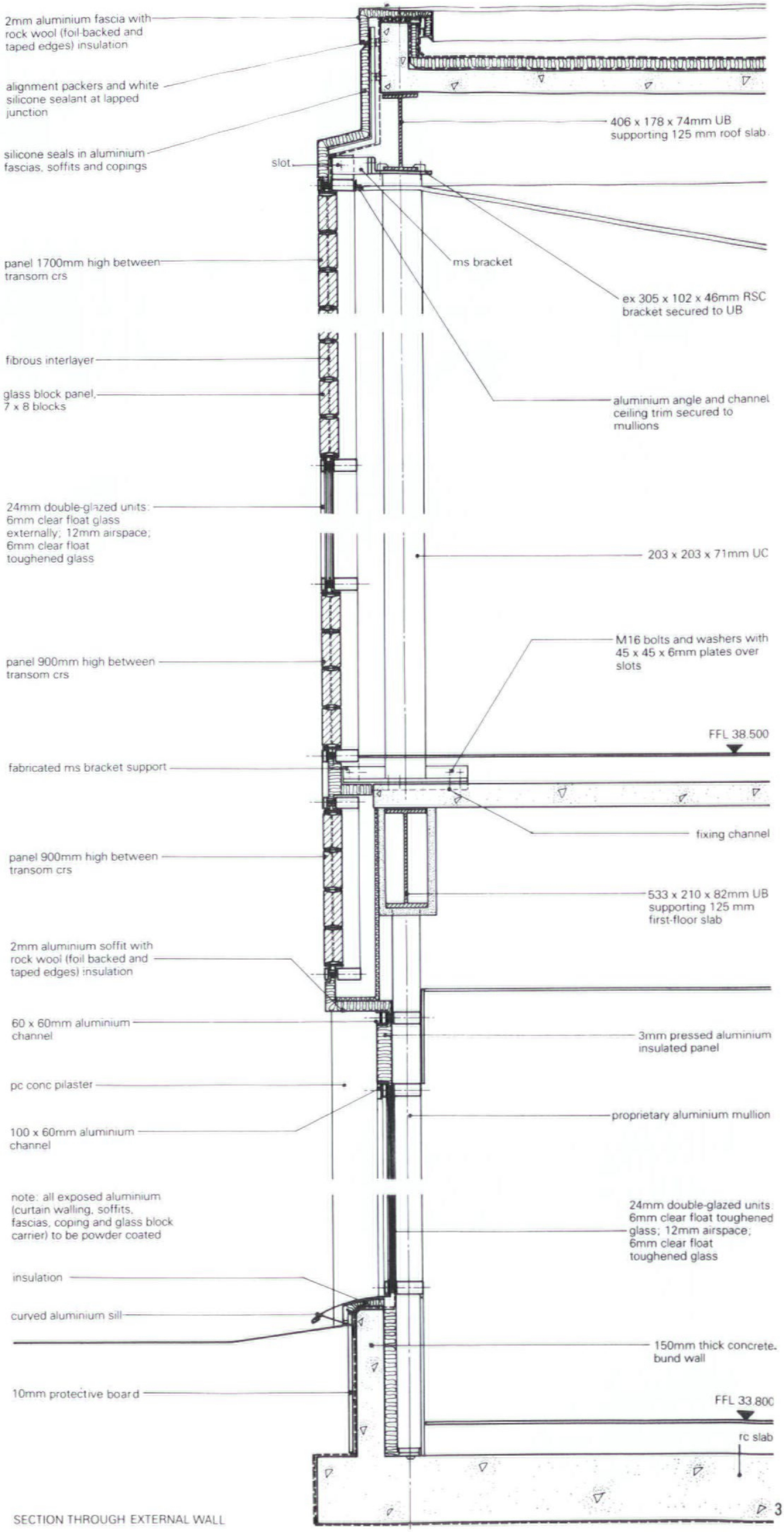
Building study AJ 30.10.91 p45

Acknowledgment

The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.



2 **2 The cladding being tested at Taywood Engineering in Southall, Middlesex.**
3 Detail section through the external wall.
4 Isometric, whose location is shown by a tint on the cross section below.

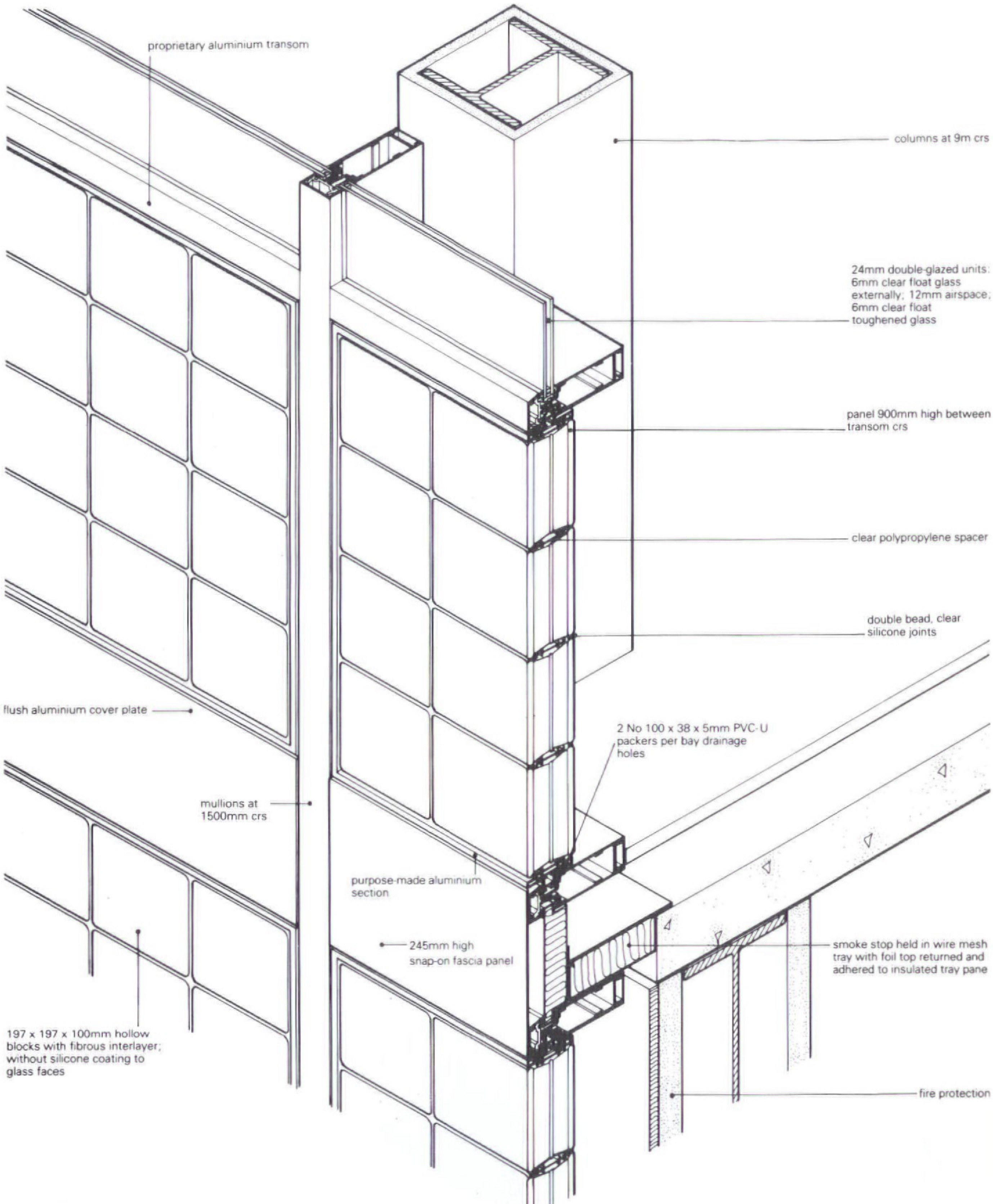


SECTION THROUGH EXTERNAL WALL 3

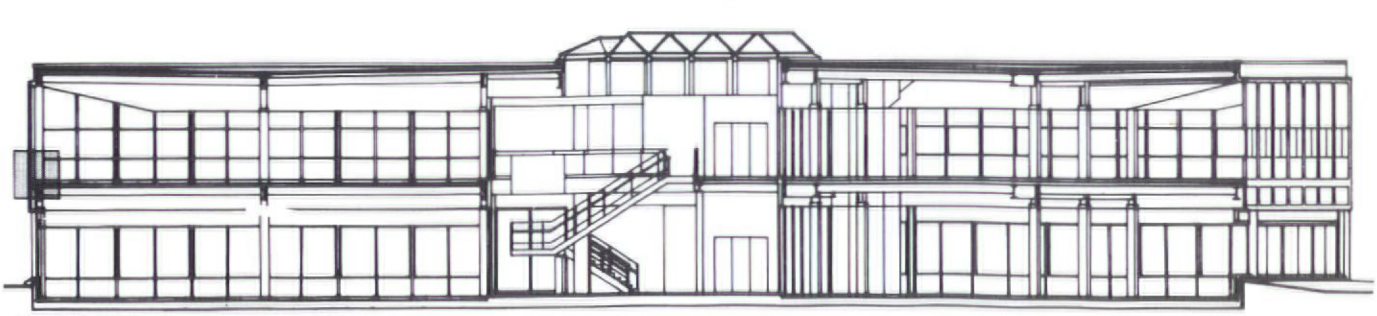
Credits
location 6 Furzeground Way, Stockley Park, Heathrow, Middlesex
client Stockley Park Consortium
architect EP Associates
project team Eric Parry, Phil Meadowcroft (project architect), Ann Griffin, Alberto Miceli, with contributions from Alice Brown, Nello Gregori, Robert Kennett, Chris Wong
cost consultant Davis Langdon & Everest
M&E cost consultant Mott Green and Wall
services/M&E engineer Ove Arup and Partners, Alan Todd, Julian Olley
structural engineer Ove Arup and Partners, Richard Goodson, Daniel Poulsen
director in charge for Ove Arup and Partners Mike Glover
construction manager Schal International
trade contractors: concrete and substructure Expanded Piling, **steelwork** Amco Structures, **fire protection** Baris Fire Protection, **precast concrete** Benton Concrete, **precast cladding fixers** C I C, **external cladding** Hinchliffe & Sons, **entrance cladding** Glass (Cardiff); **suppliers: glass blocks** Pittsburgh Corning, **silicone bonding to glass blocks** Dow Corning.

Project data
contract Stanhope Construction Management Agreement, with individual trade contracts
site start date 1 October 1990
completion date 10 June 1991.

Photo credit
Photograph 1 by Martin Charles.



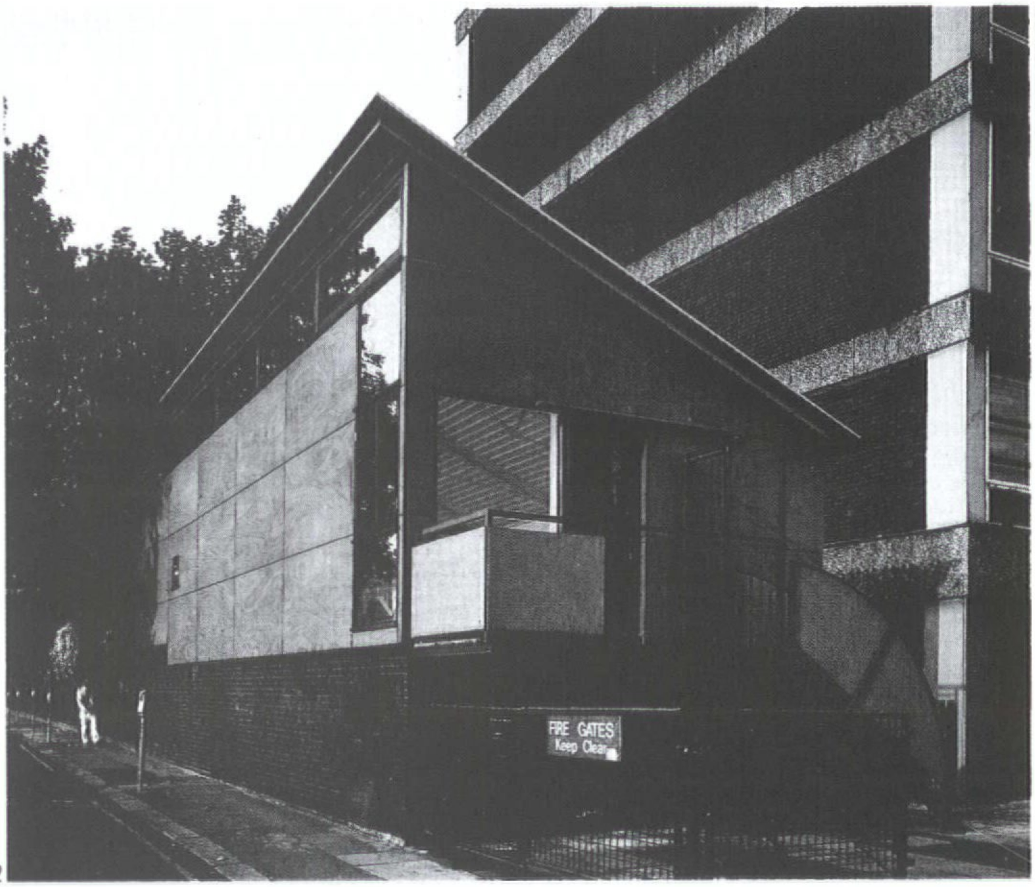
ISOMETRIC



CROSS SECTION

4

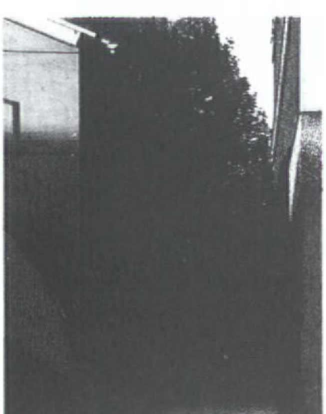
1 The back of the new teaching space for North Westminster Community School. Rainwater run-off is led to an existing gulley.
2 The new building is built on top of a former oil-tank store. It presents a more friendly face to users than either the store (which is one of the first parts of the building that you see) or the multi-storey block behind. The entrance to the school is to the right, beyond the view in the photograph, and is difficult to find. The roof pitch is designed to maximise the view of the new building.



2

External wall and roof
Teaching space

Cullum & Nightingale. This pleasing timber-framed addition to a 1960s school was designed and built by the happy collaboration of a school, an architect and his team, and a builder.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In April of this year Hugh Cullum and Richard Nightingale were commissioned by North Westminster Community School to provide a new music room. The practice was already familiar with the school's 1960s buildings, and its first suggestion was to use the old oil storage tank building (the school heating had been converted to gas some years previously). The grimy brick box is one of the first parts of the school you see from the road, and Cullum & Nightingale thought that by raising the roof to install clerestory windows it could be converted quite cheaply.

But the school caretaker was reluctant to give up his storage space, so the architect suggested building another floor on top instead.

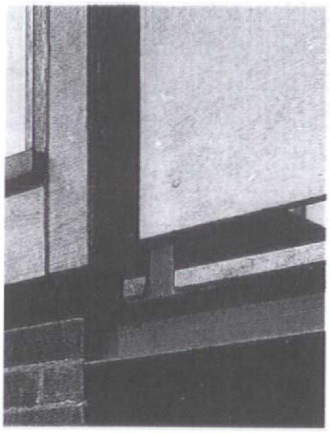
The headmaster, Michael Marland, was keen to extend the school, and was excited by the possibilities that independent architects can now offer under local management of schools. So when the quantity surveyor estimated the cost at £45,000, and the building committee would not meet again for several months, he gave the go-ahead. That was in June, and the building was to be complete for the start of term, 8 September.

Planning permission was received on 20 September (although the architect had verbal agreement before starting on site). The licence only lasts three years, mainly because this modest building will form a focal point between the twin towers proposed for the Paddington basin. The teaching space is in fact screwed together so that it could be taken down and erected elsewhere if required.

The architect also consulted the district surveyor at an early stage, and a builder. Both were sympathetic, even though only 1:100 plans and a schedule of works were available.

The construction is straightforward and efficient. The existing concrete and timber roofs (timber above the store end of the tank housing), at different levels, were retained. A new suspended timber floor is built on top, and a series of 45 x 221mm timber frames rest on the existing 250mm cavity brick walls below. The frames are braced by the wall panels and roof sheeting, and also a light steel truss fixed to the roof timbers. The structural calculations were not done until after the timber had been ordered, and the timber frames, whose centres had increased to save cost and accommodate the Plannja roofing sizes (it was also already ordered because of its six-week lead-in time) proved too light. The elegant stained timber 'strakes' on the roof timbers are the result.

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.



3

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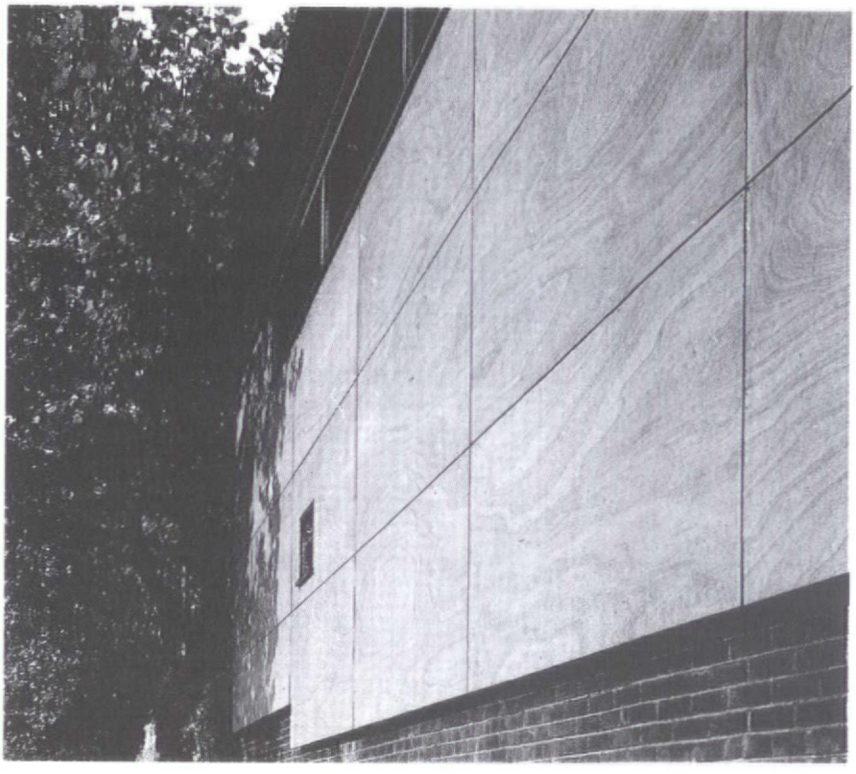
3 Close-up of the detailing where the external stair landing meets the building. The steel stair was designed for off-site prefabrication. The landing is iroko — recycled from obsolete lab benches. Other stained hardwood joinery is nemesu, a strain of meranti grown as an Indonesian plantation crop.
4 The builder took it upon himself to match up the plywood panels. The mastic joints are also very neat — if this had been poorly executed it would have looked very different.
5 A very pleasant teaching space. Although initially it is intended to be used for music, the internal surfaces are generally hard: perforated ceiling sheeting, which would have been more absorbent acoustically, would have taken an additional two weeks' delivery time — delaying completion.



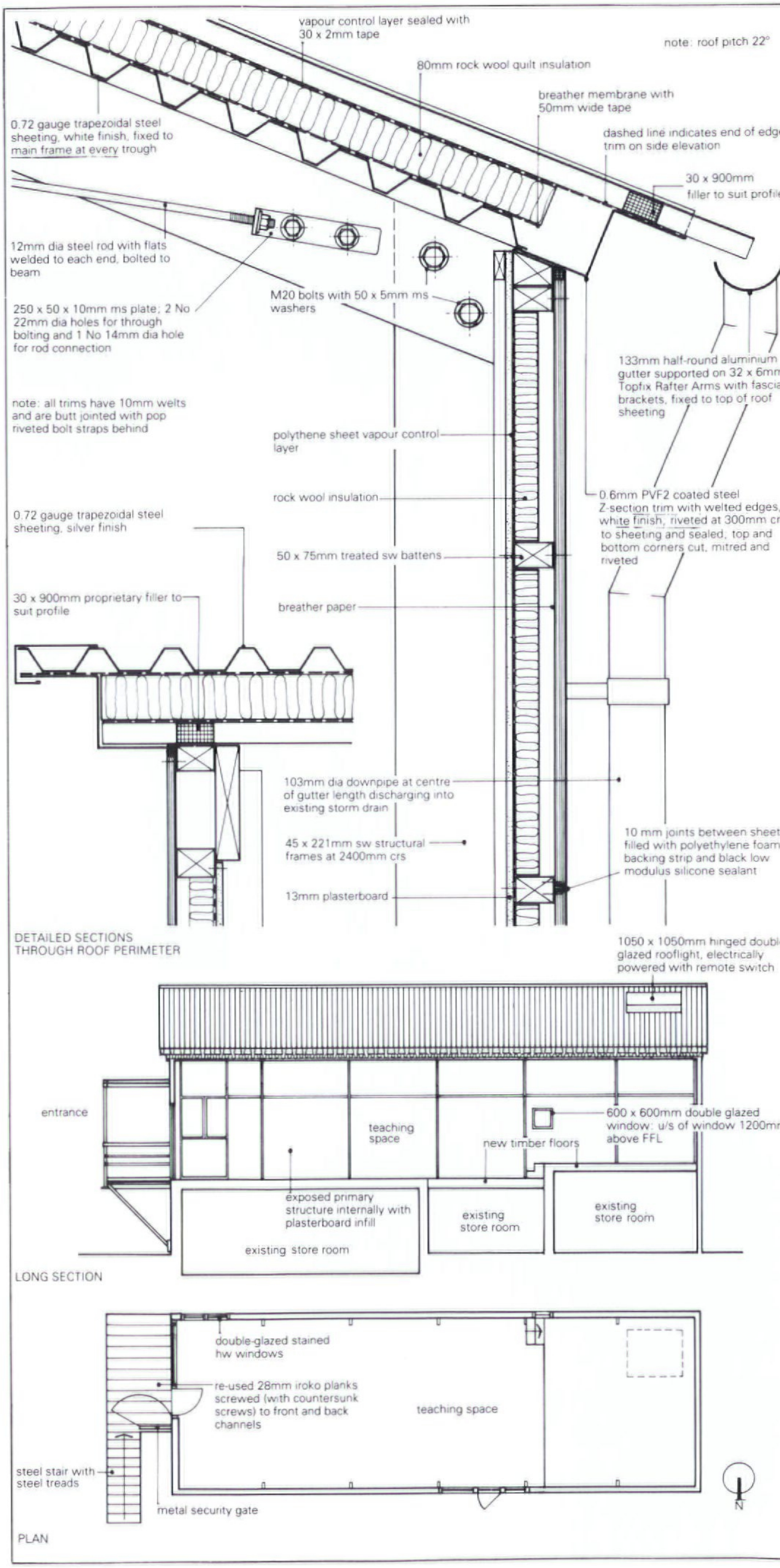
Despite the speed of the project the architect still made a model to assess the lighting of the room, and included a large rooflight over what became the stage (not a requirement, but a natural outcome of the differing existing roof levels), and a small window to light the steps up to the stage. Double glazing is used throughout.

The exterior plywood panels are marine plywood, stained and with the endgrain epoxy sealed. This was specified after discussions with both Trada and architect Alsop and Lyall. The panels are screwed on (most are not immediately accessible, but security screws were used) and the contractor took it upon himself to match the grain in the panels. The standard of workmanship is high — the black mastic joints could have looked very different.

After five weeks on site the building was just completed on time (the stair arrived on the last day) but if money becomes available there is a canopy to follow. At present there is minimal protection over the door provided quite adequately by a sill section installed upside down, set at an angle to allow water to run into the drip and off at each end.

The old brickwork below is to be repointed and then soot-washed — it is in fact red.□

6 Roof edge details with long section and plan below. Fixing two panels on to one 50mm batten is fairly workmanship-sensitive. And in a building with a longer life expectancy the wall cavities should be ventilated.
7 Cutaway isometric with, inset, an enlarged plan of the rod connection. The roof acts as a plate, spanning from one end wall to the other. The timber was ordered before the engineer had checked the building structurally. The sizes proved light (although it was not possible to get planed timber in much bigger sizes) so the 'strakes' were added. The roof timber is restrained by the sheeting, and the rods are added below to prevent the underside from buckling.

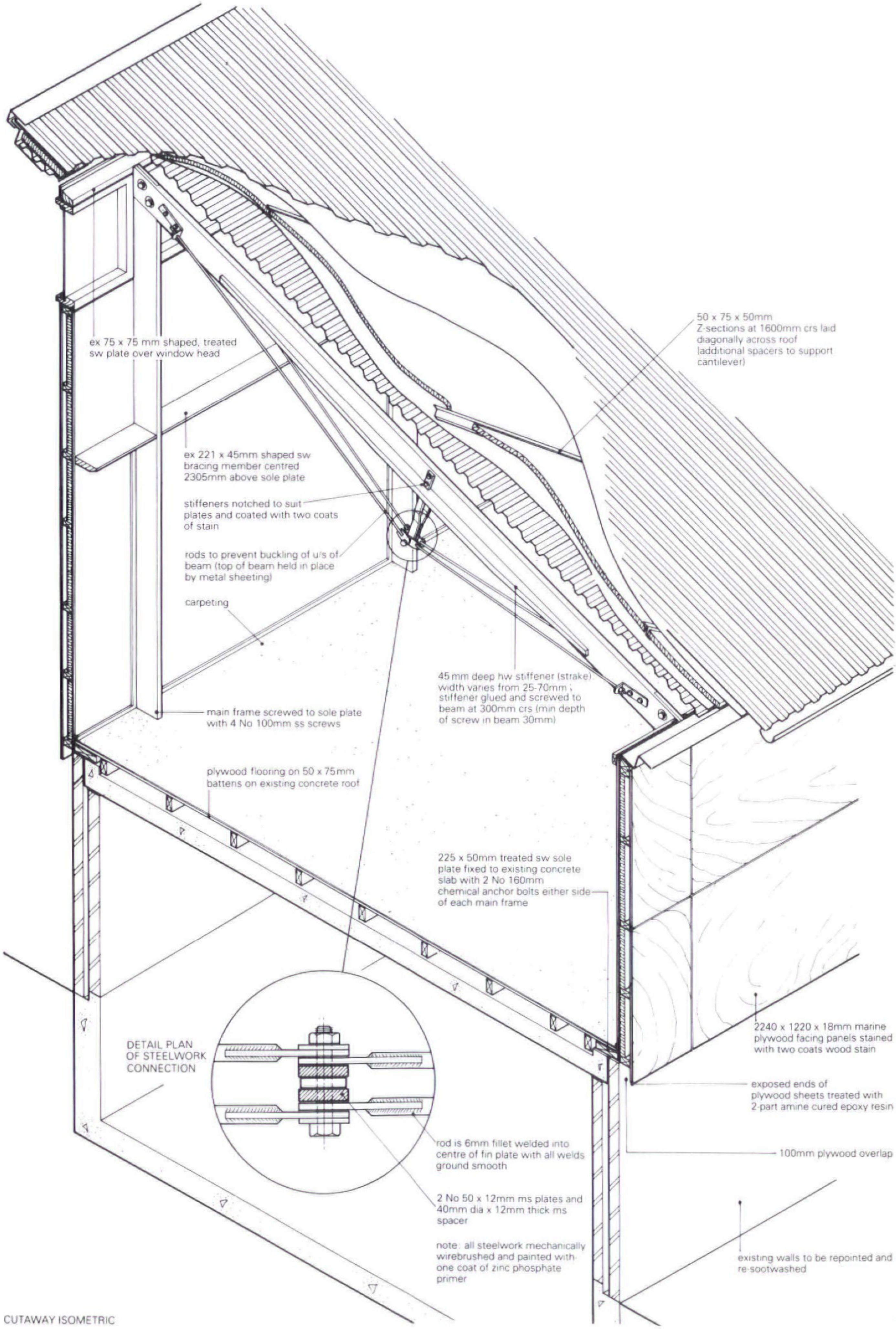


6

Credits
location North Wharf Road, London W2
client North Westminster Community School (headteacher Michael Marland)
architect Cullum & Nightingale Architects
partner in charge Hugh Cullum
job architect Nicholas Warner
quantity surveyor Peter W Gittins & Associates
structural engineer Price and Myers
main contractor Gilby Construction
subcontractors: steelwork Builders Iron & Zincwork, **mastic joints** TA Convoy Mastics, **joinery** Ardern Hodges;
suppliers: plywood cladding and timber Anvil Trading, **glazing** Quickglaze, **roof** Plannja, **roof fixings** SFS Stadler.

Project data
contract IFC 84
start on site 29 July 1991
completion 5 September 1991

Photo credit
Photographs by John Linden

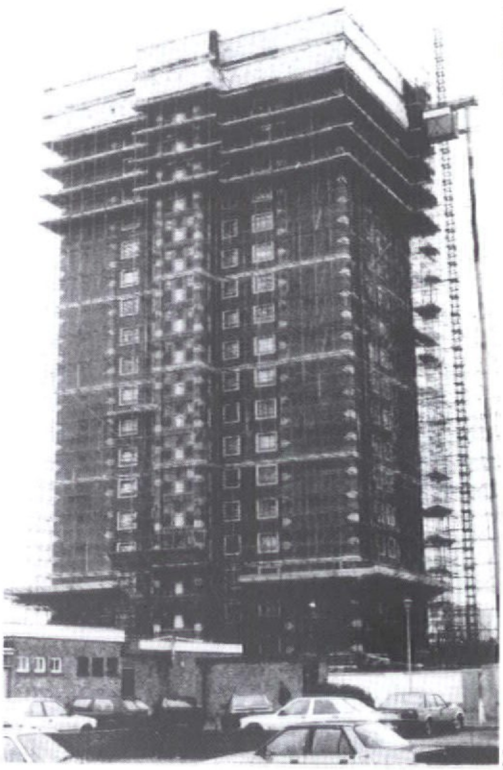


CUTAWAY ISOMETRIC

7

1 South face of Northwood Tower during recladding. The flats were vacated according to the tenants' and architect's rolling decanting programme.
2 North face, nearing completion. Windows replaced the original open concrete blocks in the central refuse chamber and were introduced into the main stairwell.

1



2

Overcladding Northwood Tower

Hunt Thompson Associates This refurbishment of a 1960s tower block was designed and built with tenant participation.

Northwood Tower, one of the 1960s large panel tower blocks, needed strengthening to prevent progressive collapse. The strengthening was required only above 10 storeys (compression in the lower floors should resist blow out). The concrete panel walls shown hatched on the drawing overleaf were given additional steel column supports to ensure that if they were damaged, only one floor would be affected. As the building would be covered in scaffolding, Hunt Thompson Associates and its client, the London Borough of Waltham Forest, took this opportunity to tackle the block's other problems — inadequate insulation, rotting windows and cold bridging.

The existing external concrete walls were clad in brickwork, with timber infill panels. As the tenants were willing to move out, both overcladding (with metal sheet or board) and recladding were possible. Brick recladding was chosen as it was popular with tenants and one of the cheapest options.

The main problem was how to support new brickwork. Because the main strength in the structure is in the cross-walls, a complex hierarchy of supports was developed. Typically, the brick cladding is carried on a stainless steel angle which is bolted to (and isolated from) a mild steel angle spanning between the cross-walls. A long bracket extending back over 400mm from the face of the cross-wall is welded to, and supports, the mild steel angle. Straps fixed to the top of the slab and welded to the mild steel angle, prevent the angles from overturning.

A similar detail applies at the gable, where there is an existing concrete panel from which the floor projects slightly (this projection previously carried the brick cladding), and at the new balconies. The new brick cladding is supported at every floor.

Cavities are typically 125mm, 50mm of which is filled with insulation. Preformed mineral wool insulation batts were specially made to fit above the angles. The pistol bricks above the outer angles were also specials. The brickwork has a minimum bearing of 80mm, greater than the recommended two-thirds minimum. Flexible lead-cored dpcs were used , and stainless steel drain tubes allow any water to escape.

At every third floor there is a string-course, formed with pre-cast concrete components. It was at these areas that the vertical tolerances were most critical, because there are fewer joints through which to spread any tolerance. The design could accommodate up to +/-17.5mm vertically, which proved sufficient. Horizontal discrepancies in size in the existing building were easily accommodated because there were so many brick joints.□

Acknowledgment
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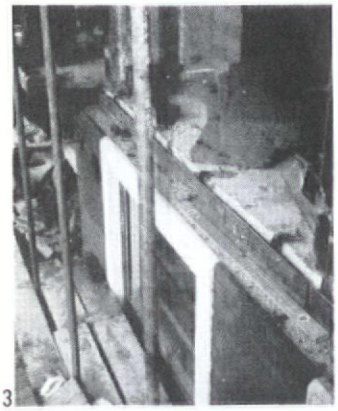

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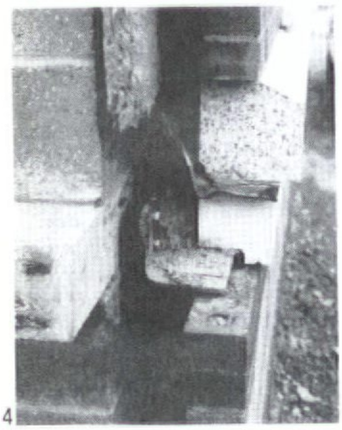


4

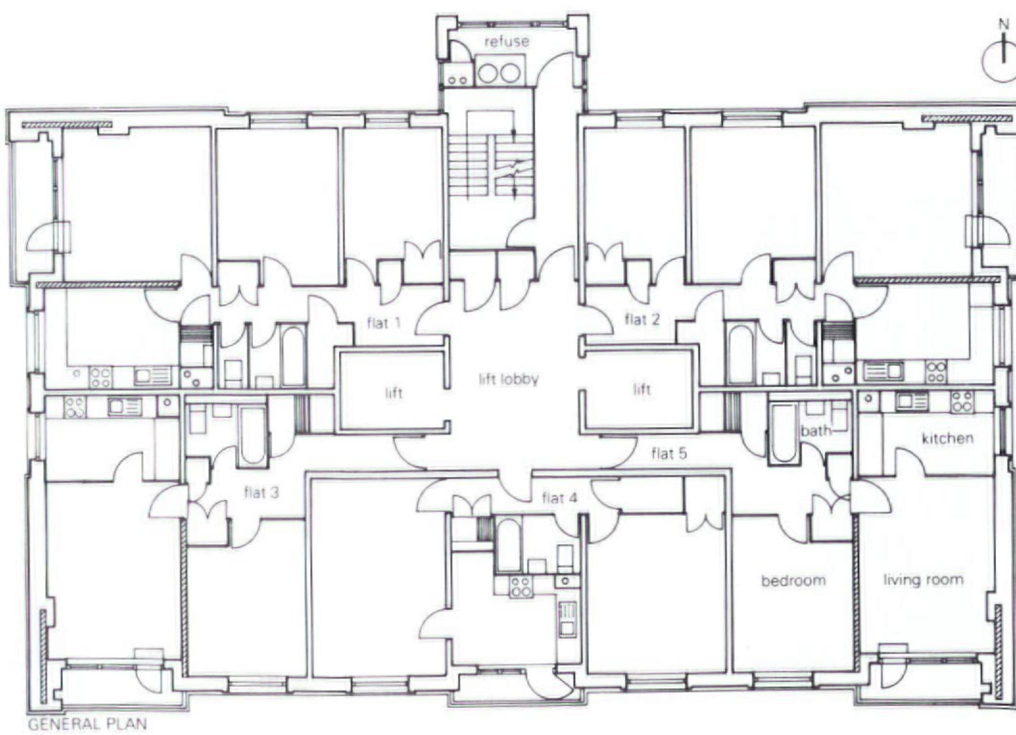
3 Recladding under construction.
4 On-site mock-up of the cladding showing the major (every third floor) string-course.
5 Part original and refurbished south elevations with typical refurbished plan below. Hatched areas in corners indicate additional steel column supports.
6 Details of new cladding strengthening steelwork is shown dotted behind.

Credits
location Wood Street, Walthamstow, London E17
client Housing Maintenance, the London Borough of Waltham Forest: Stephanie Al Wahid, Lewis Walker, Marcel Fargeot
architect Hunt Thompson Associates
partner in charge Benjamin Derbyshire
associate in charge Arne Karlsen
project architect Ian Jolly
assistant architects Fred London, Gordon MacQueen, Caroline Stalker
quantity surveyor William C. Inman & Partners: Allan McEvoy, Ngai Hoh
structural engineer Brian Moorehead & Partners: Peter Butler, Rana Mutsuddi
electrical and mechanical engineer Waltham Forest Energy Services: Soloman Olatoye, John Hughes
landscape architect Community Land Use
main contractor VAT Watkins: Don Keane, Christopher Bradford
subcontractor: security equipment Cable London
suppliers: windows T.F. Sampson, **bricks** Yorkshire Brick, Steetley Brick, Redland Bricks **dpc** Callenders **insulation** Rockwool

Project data
contract JCT 80 local authorities edition with sectional completion
site start date March 1990
completion date April 1992

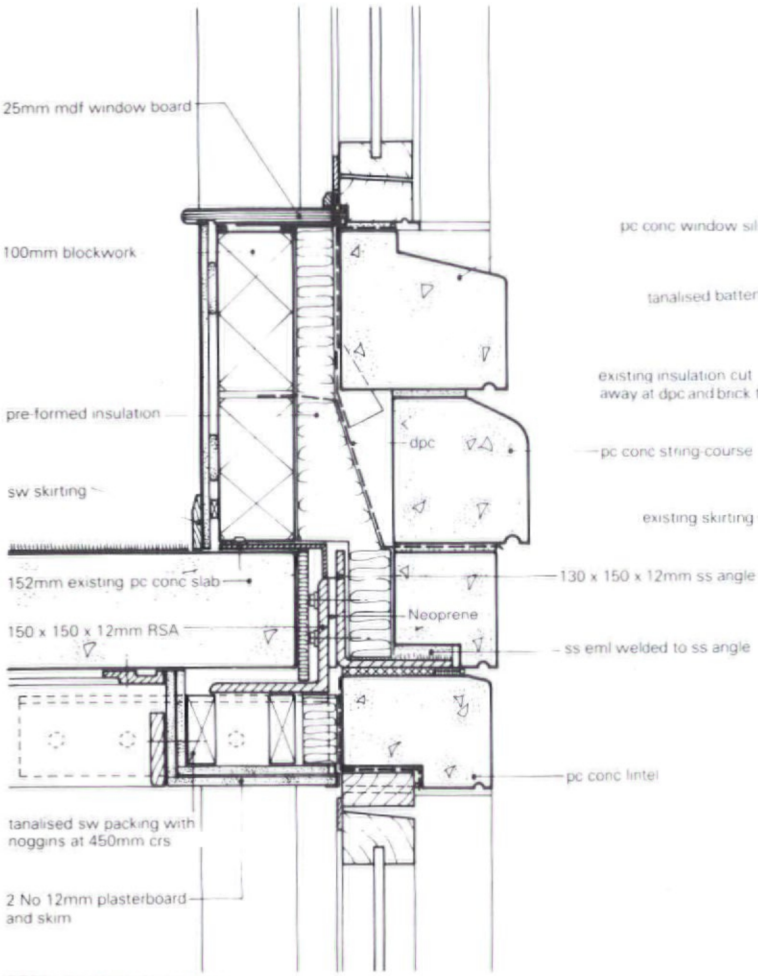
PART ORIGINAL SOUTH ELEVATION

PART SOUTH ELEVATION

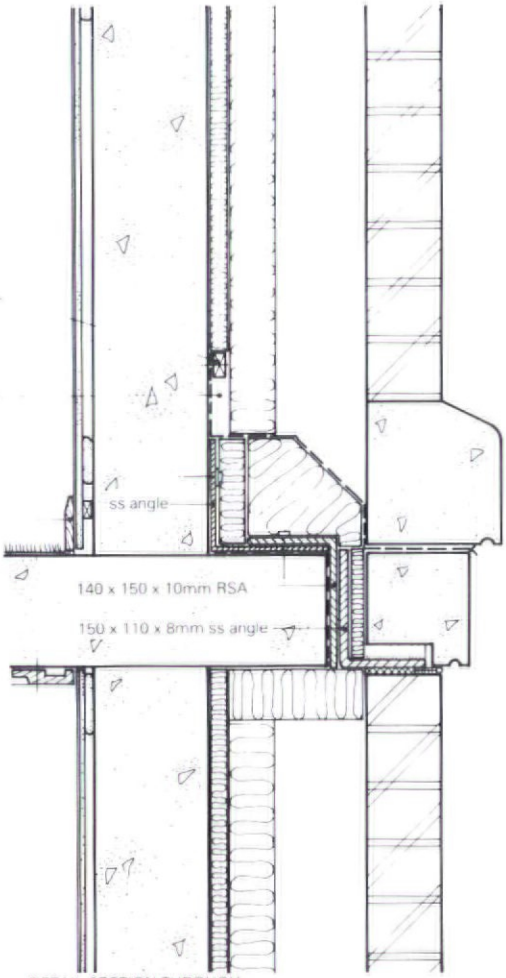


GENERAL PLAN

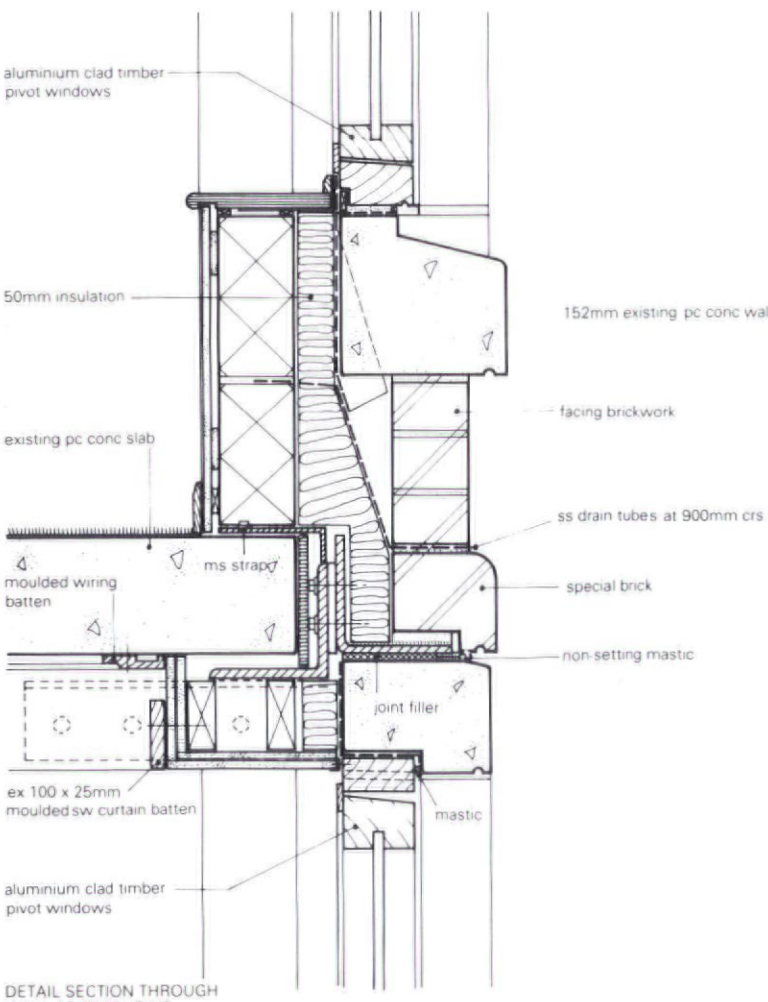
5



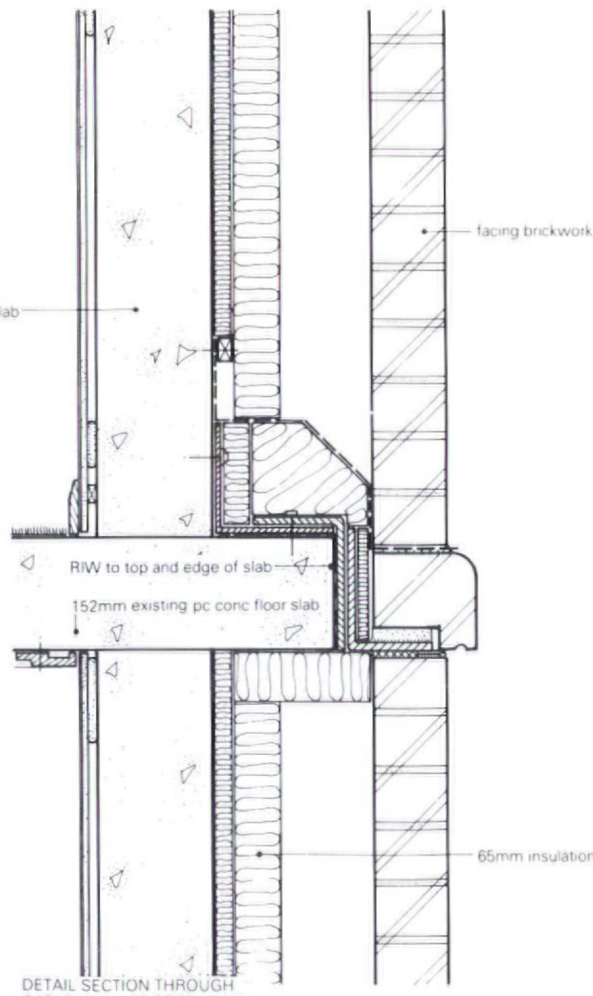
DETAIL SECTION THROUGH WALL AT STRING COURSE



DETAIL SECTION THROUGH GABLE WALL AT STRING COURSE

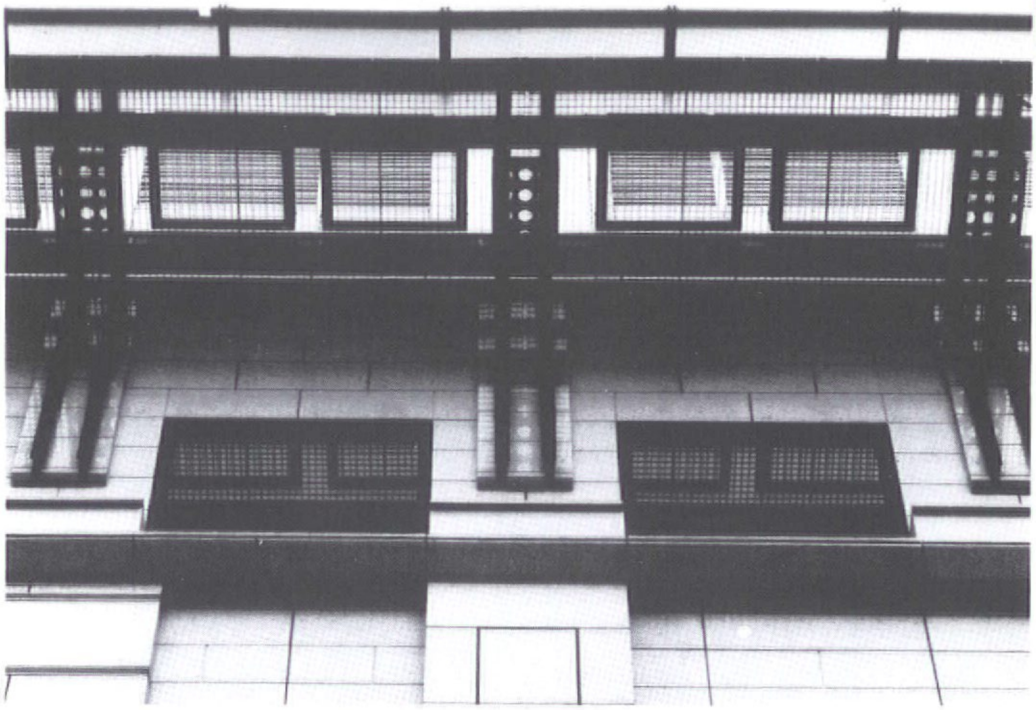


DETAIL SECTION THROUGH WALL AT SOFT JOINT



DETAIL SECTION THROUGH GABLE WALL AT SOFT JOINT

6



1 Looking up to the gantry, from which a cradle allows maintenance and window cleaning to be carried out from the top of the cladding down to the cyma cornice between first and second floors.

Cladding Offices

Building Design Partnership These major new banking offices are clad in a granite rainscreen system incorporating stainless steel faced panels.

The superstructure to J.P. Morgan's new London office (except where existing facades have been retained) is clad with a rainscreen. The Building Design Partnership (BDP) specified a rainscreen to enable the building envelope to be made watertight quickly while allowing plenty of time to fix the visible external finish.

The management contractor chose to separate the external cladding into two different packages. There were several reasons for this: otherwise it was one particularly large package; the backing walls of the two parts were quite different, and top down construction was used making it helpful to have parts of the ground floor open for as long as possible. But it meant that great care had to be taken in the co-ordination of the two sets of detailing.

The building is steel-framed with composite floors. Adjustable fixing channels for the cladding were cast into the slab edges to allow horizontal tolerance, and a 20mm tolerance is allowed vertically and laterally.

The steel inner panels, with encapsulated insulation, have a stainless finish externally — forming the vapour control layer (there are gaskets between panels) — and a galvanised finish internally (with a separating layer between the two to prevent electrolytic action). The 40mm thick granite cladding panels are fixed through to stiffening studs inside the metal panels.

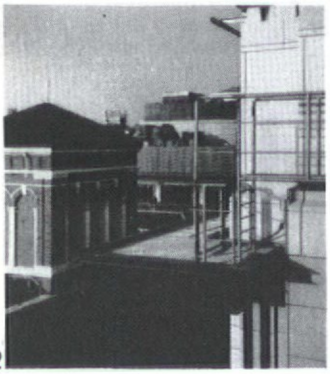
The cladding to the two floors below the cornice was the work of the second trade contractor. Here there is a concrete wall behind the granite panels, with insulation on its outside face, and then a 20mm cavity behind the 40mm granite panel.

The cornice, supported on a truss framework, was one of the last cladding items to be fixed, to avoid it being damaged.

BDP prepared a performance specification for both sets of cladding. Aspects covered included:

- weathertightness of the whole system
- the system had to be an open rainscreen as defined in BS 8200 (1985) — water was allowed to penetrate into the airspace but not into the building interior
- drainage was to be allowed for
- the detailing was to obviate streaking or, staining
- soundless thermal movement was to be accommodated
- the solid parts of the cladding were to have a U-value of 0.6W/m^{2}K, and the glazing, including framing, 2.9W/m^{2}K
- metal frames were to include thermal breaks, and no cold bridging was to be allowed
- minimum sound reduction was specified.□

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.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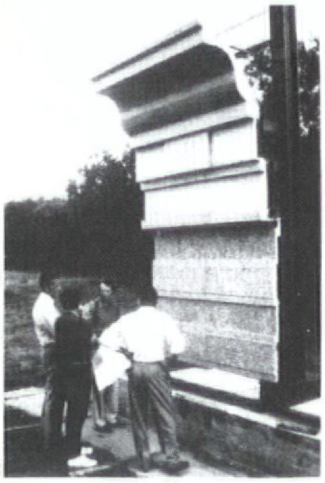
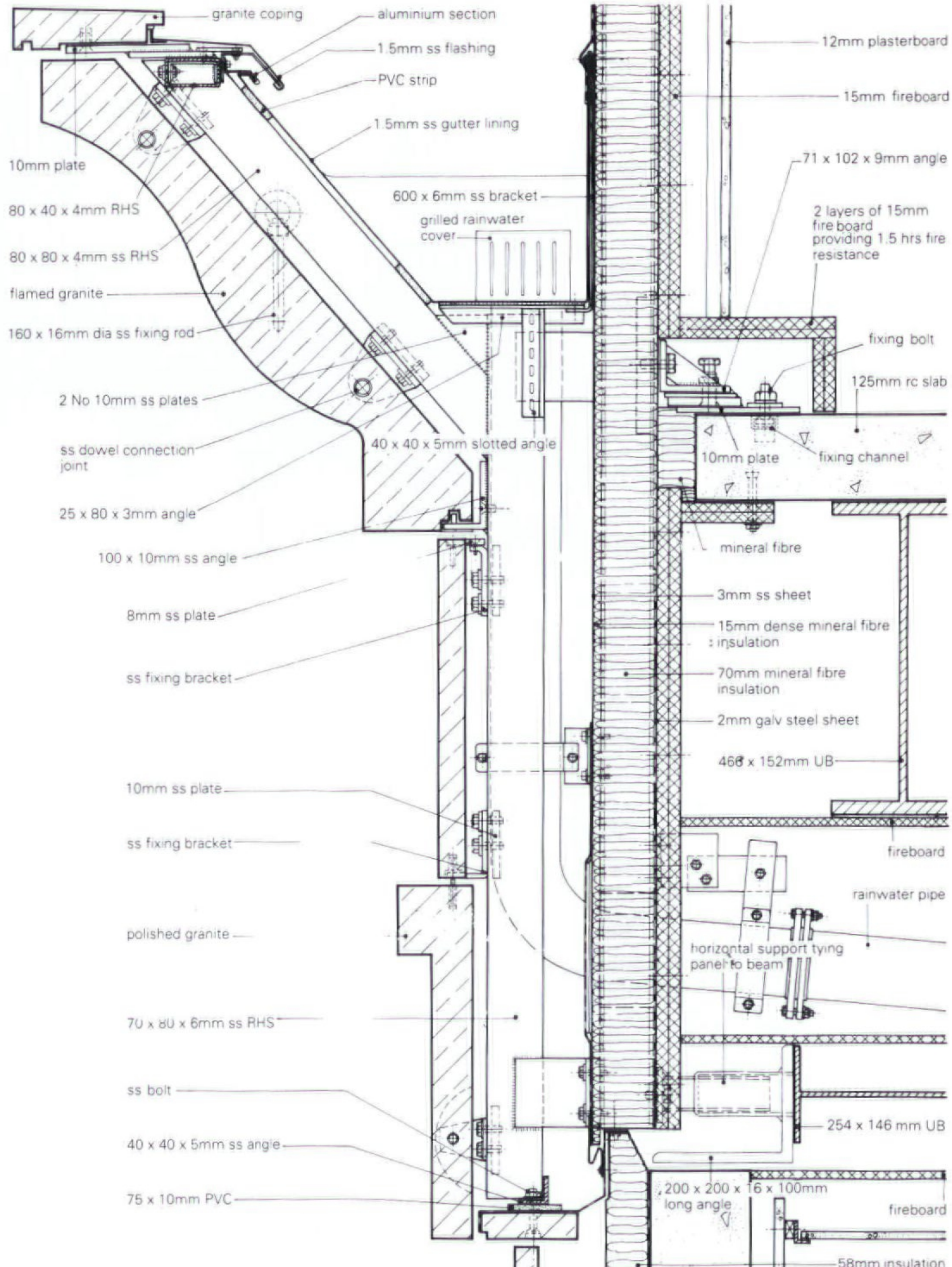
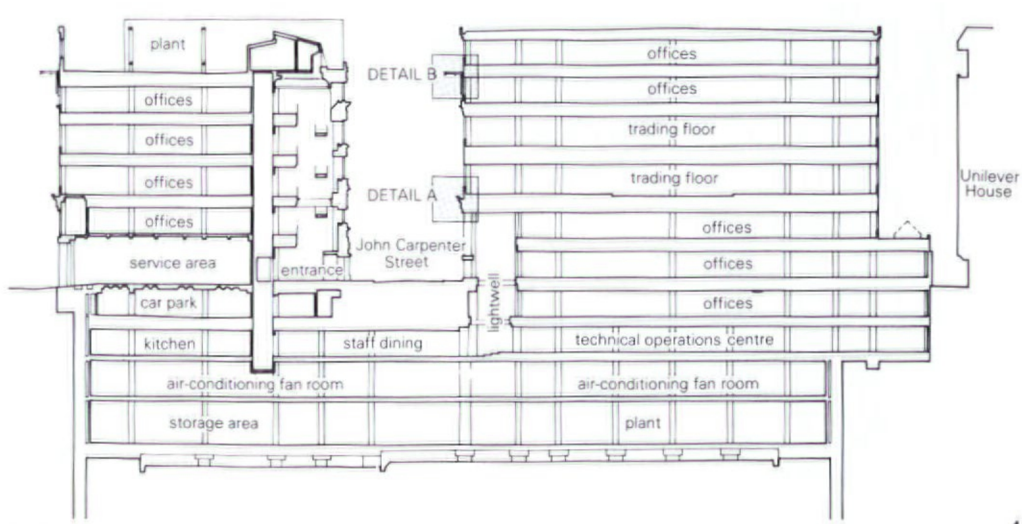

3

2 Access to the gantry is from roof level.
3 A mock-up of the cornice. This is quite different from the profile that was finally used.
4 Detailed section through the cyma cornice — which is also a gutter. Below is a cross-section through the building.
5 Detailed sections through the cladding at the top of the building, showing the gantry and loggia above. The vertical dashed lines show the location of lightning conductor.



DETAIL SECTION THROUGH CORNICE/GUTTER - DETAIL A



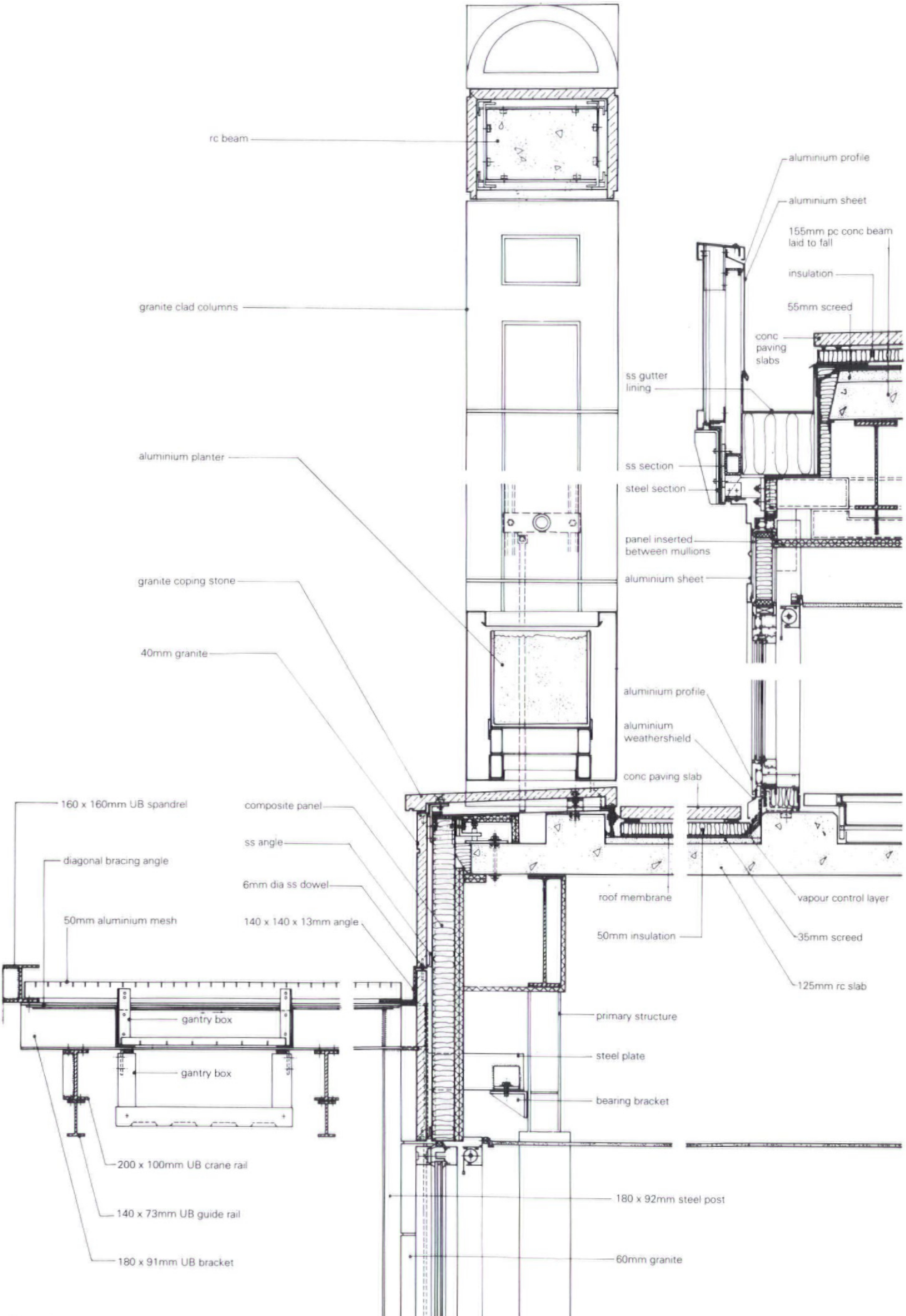
CROSS SECTION

4

Credits
location 60 Victoria Embankment, London EC4
client J.P. Morgan
architect Building Design Partnership (BDP): Christopher Haddon, Stephen King, Stephen Stinton, Dick Sydenham
quantity surveyor Northcroft Neighbour and Nicholson
building services engineer BDP
civil and structural engineer BDP
management contractor Higgs and Hill Management Contracting
trade contractors: rc superstructure frame, structural screeds Raphael Construction, **structural steel frame** Harry Stanger, Rideridge, **external cladding** Fassadentechnik Rudolph GHMB

Project data
contract management contract
site start date spring 1987
occupation commenced spring 1991

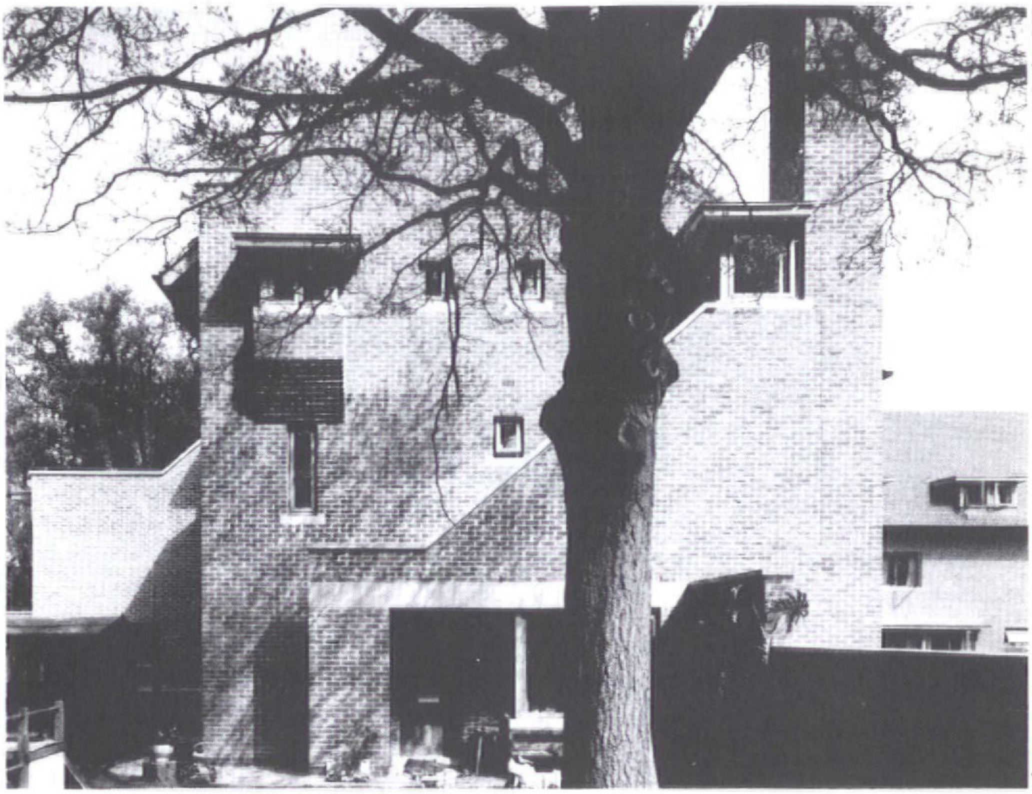
Photo credit
Photographs 1, 2 by Rupert Truman.



DETAIL SECTION AT SIXTH FLOOR/ROOF

5

CI/SfB (21)+(27)



1 The gable end of Reckitt House, the deep eaves emphasizing the assymmetric pitch. The bay window is in a second-floor staff flat. To the right is one of the dormer windows which face the courtyard.

External walls and roof
Residential school house

Nicholas Hare Architects This school house in Reading, Berkshire incorporates several window types including dormers and a corbelled bay window.

Reckitt House, a boarding house for Leighton Park School in Reading, is set in the midst of trees. It is a modest, three-storey, loadbearing brick building planned in a U-shape enclosing a grass court. The pitched roof drops down into the courtyard to soften the scale; second-floor study rooms are pushed into the roof and dormer windows introduced. The full three-storey height is apparent only on the outer elevations. Self-contained staff flats occupy each end, their individuality expressed in the composition of the windows at the gable ends.

The dormers, which are repeated round the court, are simply framed out from the timber roof structure. They are roofed in aluminium and, at the planners' insistence, have side cheeks clad in terne-coated stainless steel (for its duller appearance). While the dormer roof is ventilated, the side cheeks are not, and though the architect does not anticipate any problems, the detail has since been developed for use in another school building with ventilation incorporated.

The main roof, with its asymmetric length pitch, falls in between 'standard pitch' and 'ceiling following pitch' (Building Regulation F2) so it is debatable as to whether ridge ventilation would now be required. The roof was, in fact, designed before this regulation came into effect but the architect still concludes that the air gaps at the eaves are sufficient. The cavity is not closed, allowing moist air to rise into the roof space.

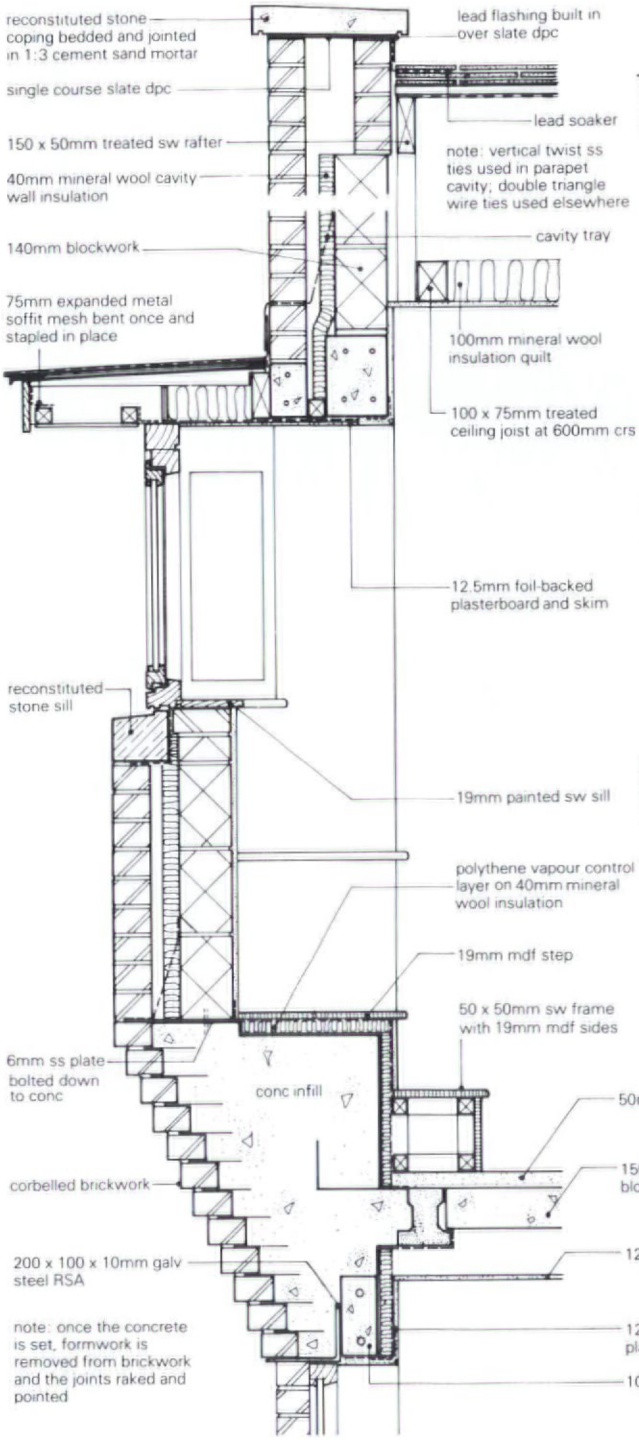
The corbelled bay window in one of the staff flats is a 'one-off' but it gives a good indication of the character of other spaces in the building. A small raised seat built into the bay is the perfect place to read and makes an otherwise ordinary room a bit special — but the massive concrete structure needed to stop the wall overturning illustrates why corbelling is rarely used today. A lighter timber structure is an obvious alternative but the architect felt it would be out of keeping with the building's overall solidity. The bricks were corbelled out on a temporary framework and then used as permanent shuttering for the concrete; columns and an overhanging lintel were cast into the inner leaf forming an integral structure.

All the windows were purpose made in iroko; they have been left unstained allowing the wood to turn, in time, to a natural silky grey. The detailing may allow some water ingress at the straight-through joints. Gaps which may occur due to movement of timber members could have been avoided by lapping the joints; in this case, mastic is the only line of defence.☐

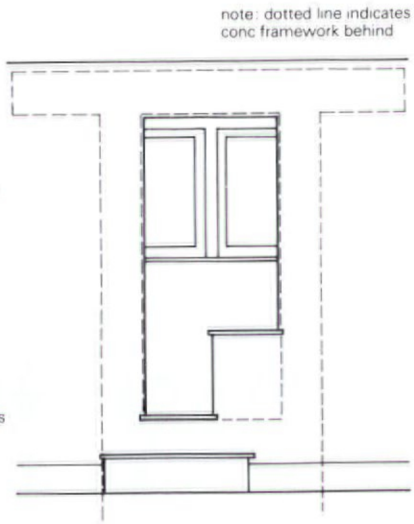
Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.

Working Details

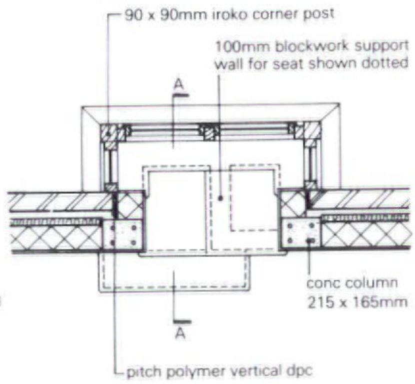
2 Bay window details. The in-situ concrete frame is necessary to prevent the corbelled wall overturning. It is tied back to the pre-cast floor beams with a galvanised steel strap.
3 Part of second-floor plan.
4 Dormer window details. This window is repeated in the student study bedrooms which overlook the courtyard.



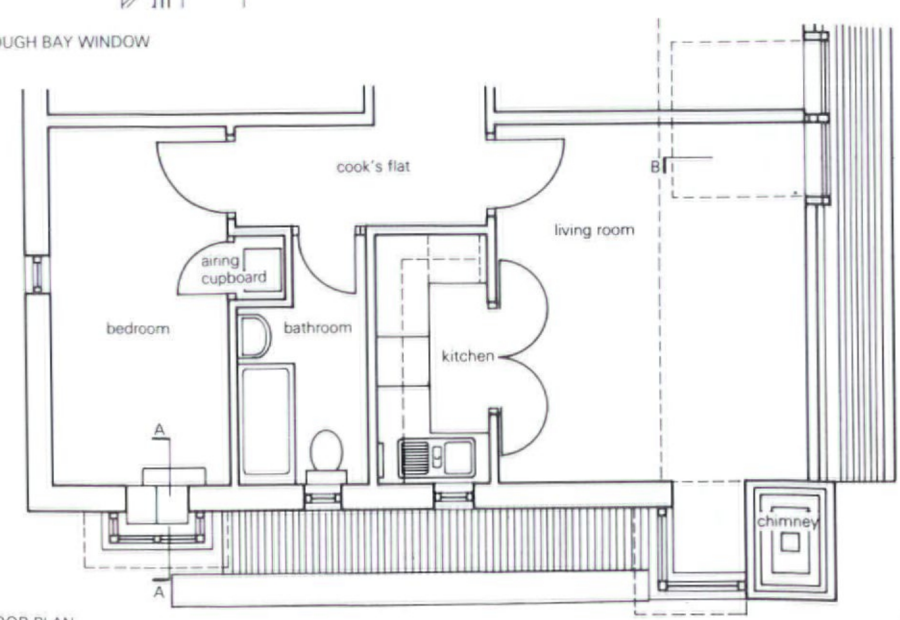
SECTION AA THROUGH BAY WINDOW



INTERNAL ELEVATION



PLAN



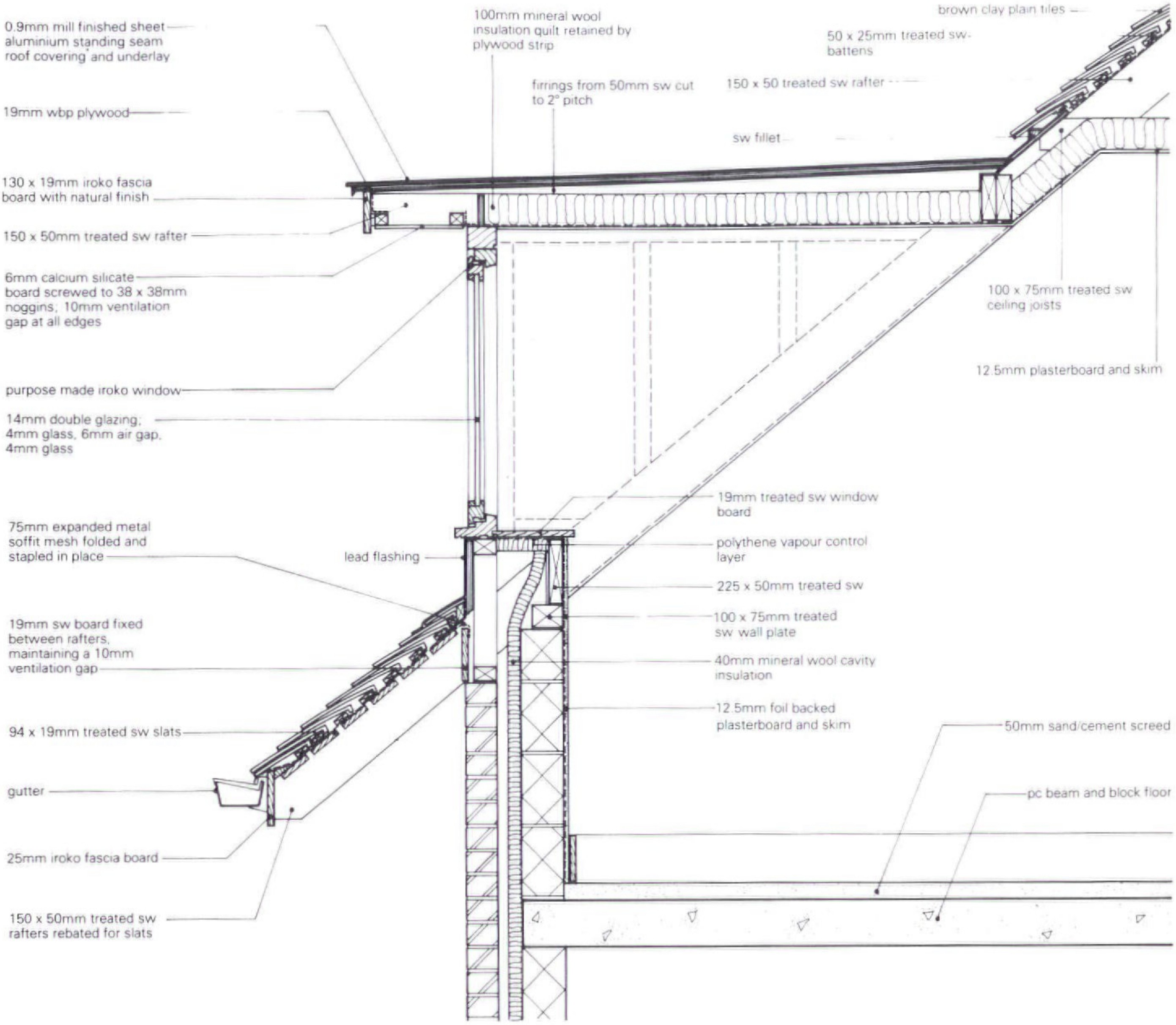
PART SECOND FLOOR PLAN

2

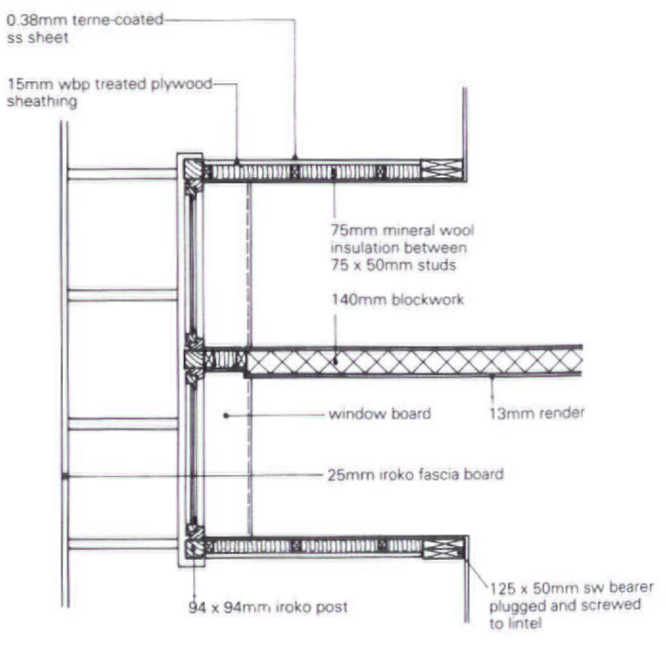
Credits
location Reckitt House, Leighton Park School, Reading
client Leighton Park School
architect Nicholas Hare Architects
design team Jeremy Bailey, Nicholas Hare, Mike Jelliffe, Kieren Morgan, James Wade
project adminstrator Quintin Payne-Cook
models Robert Sawtell
quantity surveyor Ridge and Partners
electrical and mechanical engineer RHB Partnership
structural engineer Price and Myers
main contractor Moss Construction Southern
subcontractors: reconstituted stone Solent Precast, **timber windows and doors** Devizes Joinery, **aluminium roofs** Acten
suppliers: bricks Butterley Clockhouse Rochester, **tiles** La Francaise des Tuiles et Briques, **ironmongery** Miller Morris Brooker Group.

Project data
contract JCT IFC 84
site start date April 1989
completion date April 1990

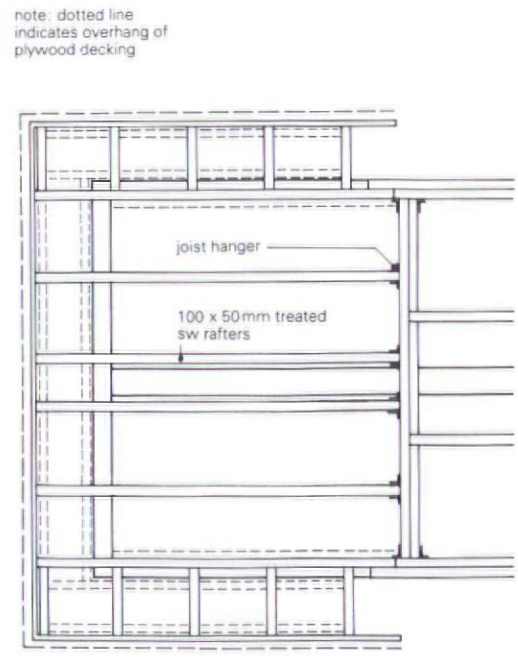
Photo credit
Photograph by Martin Charles



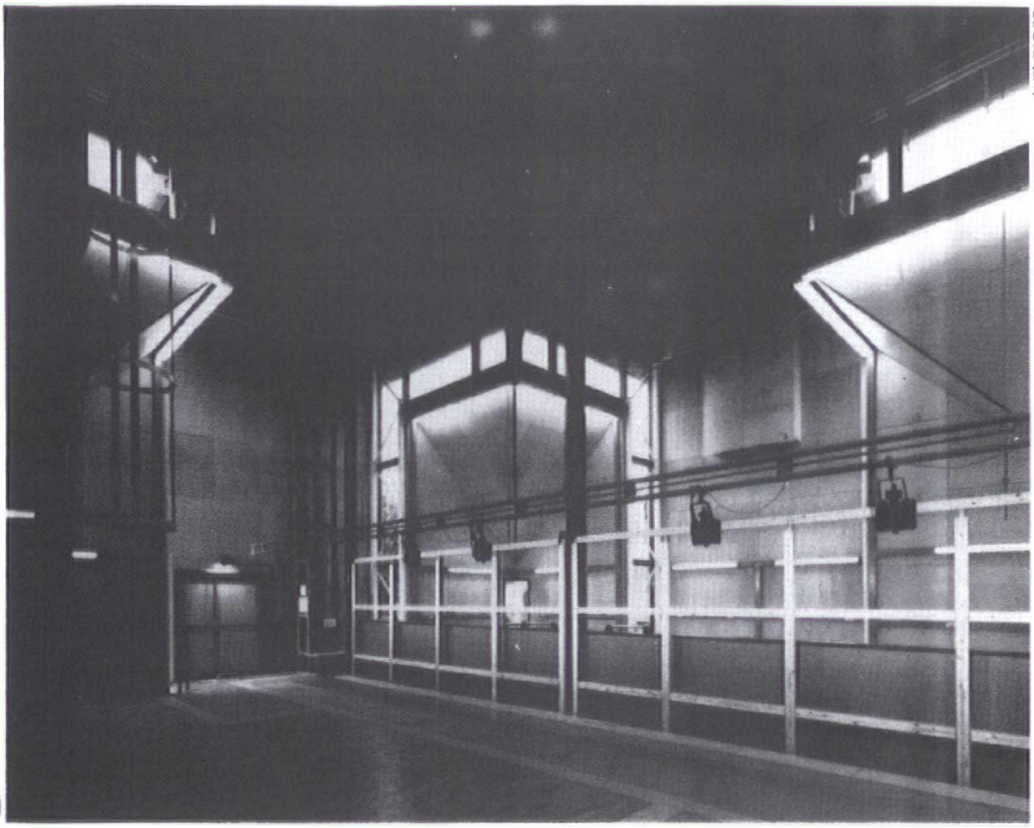
SECTION BB THROUGH DORMER WINDOW



PLAN



ROOF FRAMING PLAN



1 Interior view of the workshop. The hierarchy of structure — lattice trussed column, gable truss, cruciform beams — is emphasised by their different colours. The scenery painting frame, shown here in a relatively low position, is supported by its own independent structure. The lifting mechanism can be seen between the painting frame and the loading door.

External wall
Scenery workshop

Edward Cullinan Architects Interior rubber-cored composite plywood sheets are detailed to provide an acoustic seal.

The new studio theatre and scenery workshop in Carshalton, a 'village' suburb of London, opens up a much needed route between the High Street and the local park. The workshop is on the same axis as the main 'nave' of the theatre, but is separated from it by a small square; it acts as both a full-stop to the complex and a marker from the park. Its strong form, generated from the cruciform plan, is emphasised by soaring cedar-clad gable walls. Lower internal corner bays, slotted in below the clerestory windows, at first distract, but the shop windows and glut of materials provide a lively face to the square. The main workshop is on the first floor, and had to be acoustically sealed to protect residents from the machine noise.

Loadbearing blockwork walls support the first-floor in-situ slab. Above, a clear system of primary steel members defines a high, column-free space. The secondary RSC wall frame was erected after the primary structure had been roofed. Exterior grade plywood and insulation between the steel and composite plywood sheets were built up on site to form sealed undrained wall panels. The composite sheets have staggered joints and are rebated on the internal face to expose the rubber core; tolerance is taken out at the end panels. This simple solution not only provides an acoustic seal but gives a crisp, well-considered order to the space. The external cedar rain screen has alternating square groove and butt joints which emphasise the board's rough texture.

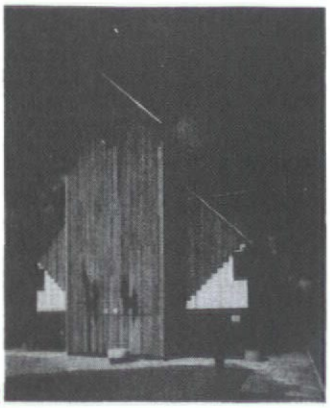
The detailing illustrates the architect's philosophy of lapping junctions to express the materials and to protect joints. The gable corner provides an exception: the external plywood panel junctions are kept watertight with only a rubber seal, and the angle needed to support the cedar edge board looks much like an afterthought.

The deep verges, purposely sized for visual reasons, are vulnerable to wind pressure but a smaller statement could have looked weak on such a tall wall.

The overlapping of the loading doors is visually pleasing but lead- lined doors are heavy and could strain the hinges; there is no sill on which they can temporarily rest. The door is the weakest point acoustically but with the lead lining and the careful attention given to seals round the opening, a sound reduction of 35dB was obtained. The plywood wall panels were designed to give a reduction of about 45dB.

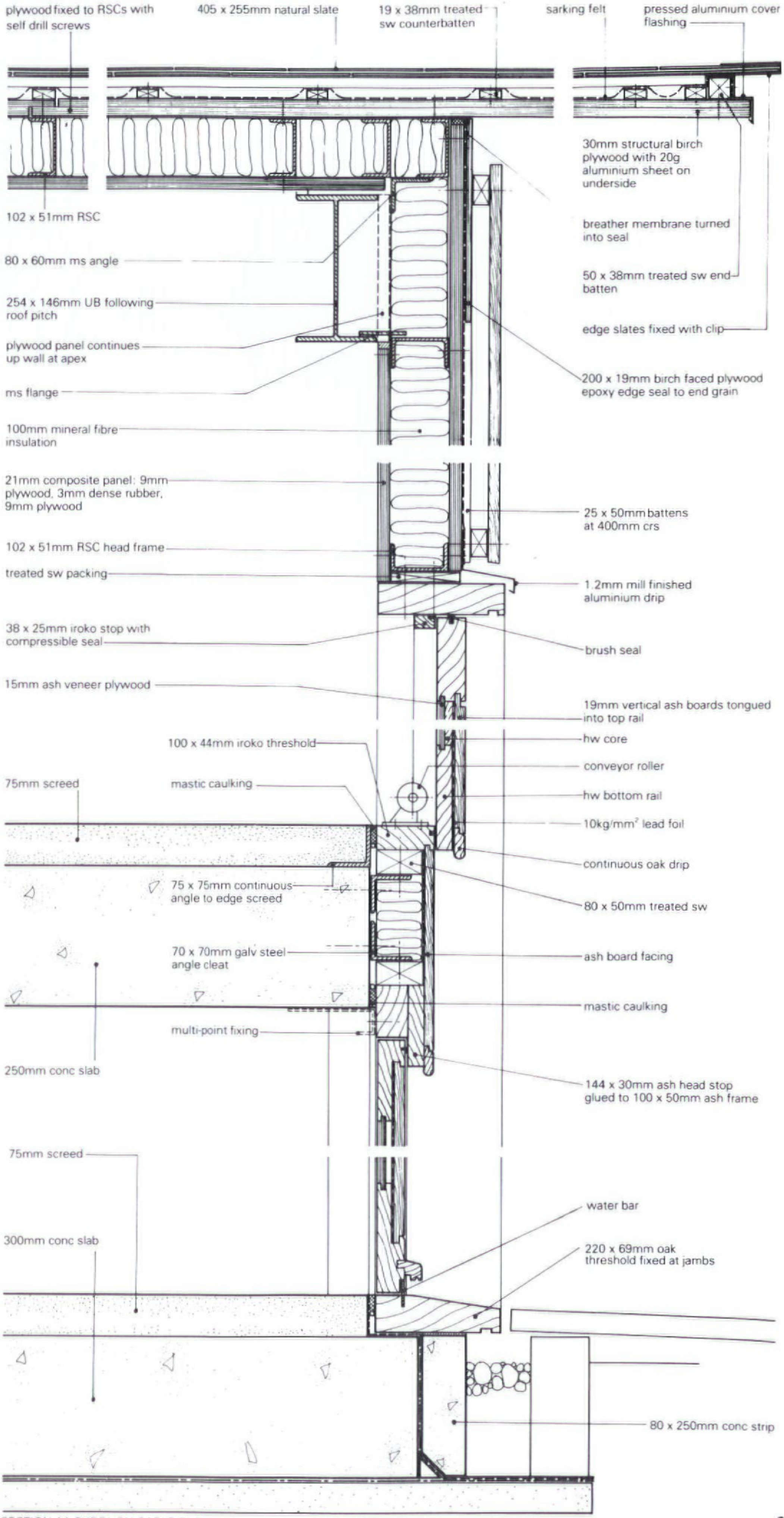
The corner bays provide useful niches for specific tasks and yet remain integrated into the main lofty space by the continuous plywood finish. □

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.



2

2 Exterior view from the square. The loading doors are on the gable to the right of the photograph.
3 Section through the gable.
4 Details of the wall construction. Detail A shows how the end internal plywood panel is detailed for tolerance; it slots in behind the lattice column as far as is necessary, enabling all the rebates to be of constant dimension.
5 First-floor plan and section.



3

Credits

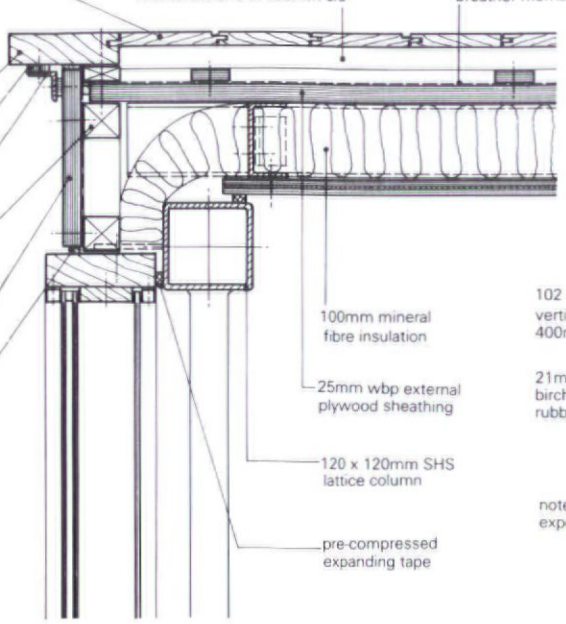
location Charles Cryer Studio Theatre, Carshalton
client London Borough of Sutton Leisure Services
architect Edward Cullinan Architects
project team Mary Lou Arscott, Roddy Langmuir (project architects), Edward Cullinan, John Cadell, Peter Kirkham, Mark Beedle
structural engineer Jampel Davidson & Bell
services/mechanical engineer Max Fordham & Partners
quantity surveyor Dearle & Henderson
theatre consultant Carr & Angier
acoustic consultant Arup Acoustics
main contractor Eve Construction
subcontractors: joinery Wenban Smith Joinery, **painting frame** Stagecraft Engineering, **mechanical services** JW Stubberfields & Sons, **electrical services** RTT Electrical, **structural steelwork** Tubecon Engineering, **rainwater goods** Alumasc
suppliers: internal plywood Schaumann UK

Project data

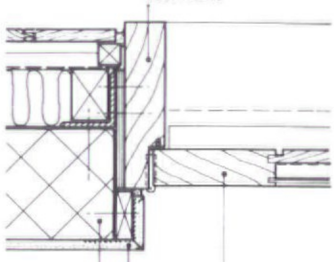
contract JCT 80 (local authorities)
site start date November 1989
completion date July 1991

Photo credit

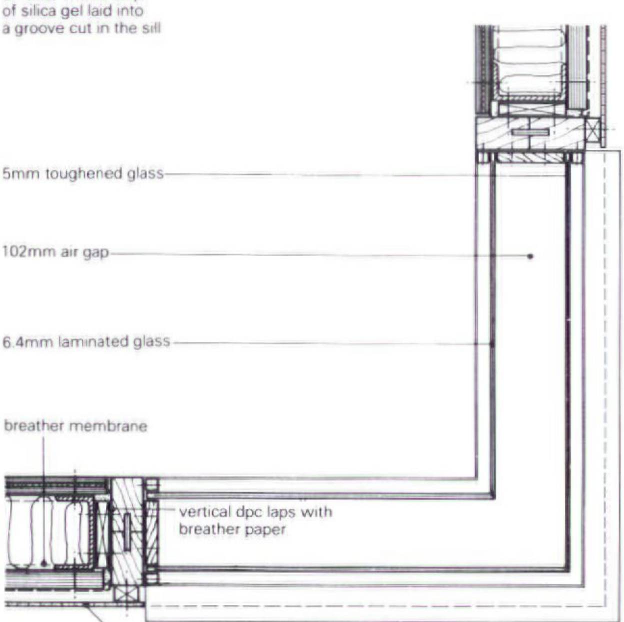
Photographs by Dennis Gilbert



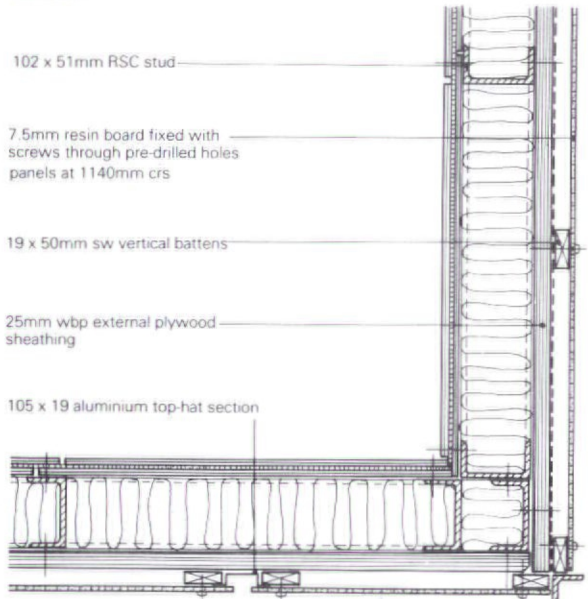
DETAIL A: PLAN AT FIRST-FLOOR GABLE CORNER



DETAIL A: PLAN AT GROUND-FLOOR LOADING DOOR

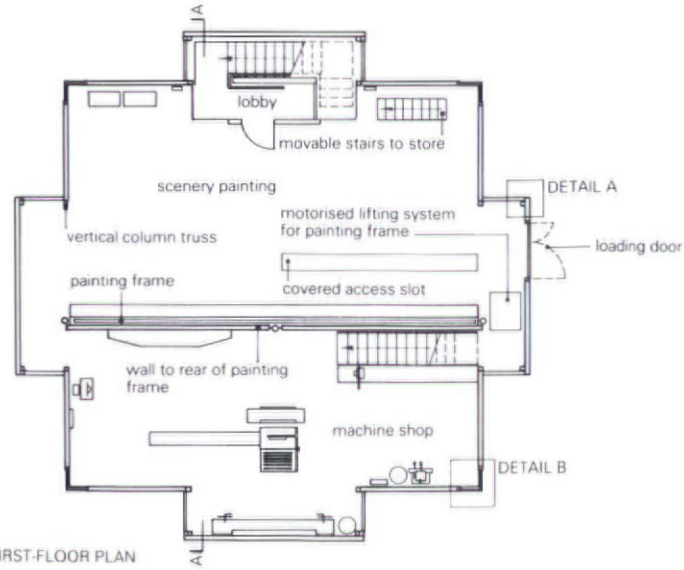


DETAIL B: PLAN AT WINDOW LEVEL

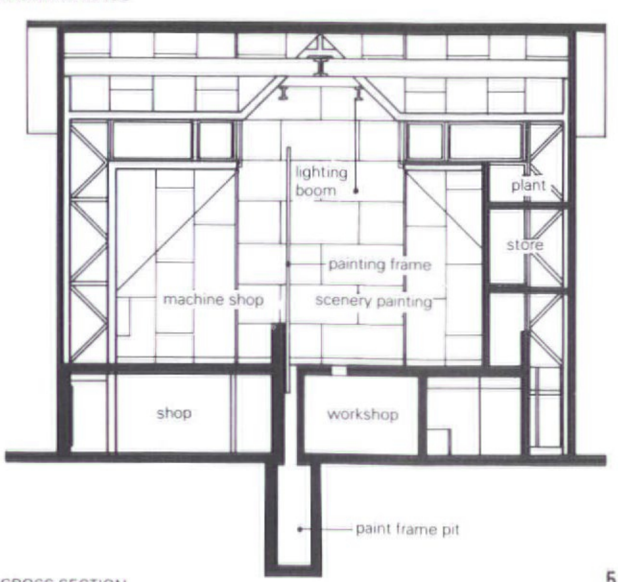


DETAIL B: PLAN AT CLADDING LEVEL

4



FIRST-FLOOR PLAN



CROSS SECTION

5

CI/SfB (21)

1 Interior view of the west wall at the new crossing. The entrance from Liverpool Street is on the left, access to the trains, at the lower level, is to the right.
2 Special brick schedule. Red rubbers are shown tinted, yellow (London stock) bricks are shown plain, bricks marked with an asterisk come in both red and yellow. Nos 6-10 are gauged arch bricks.
3 Part external elevation, section and part internal elevation of west wall.

1

External walls
Station

Architecture and Design Group These walls have steel portal frames within the solid brickwork and incorporate self-supporting arches.

As part of the Broadgate development, Liverpool Street Station — one of London's main commuter stations — was extensively restored and enlarged. The phased building programme was complicated by the need to keep the station open throughout. The existing building, a Victorian brick shed enclosing the wrought iron roof and its cast iron support, was surveyed to inform the appearance of the new work.

The west wall, with its repetitive gabled rhythm, was continued south to the new entrance tower on Liverpool Street. The existing wrought iron spandrels are carried on solid brick piers, the purlins built directly into the brickwork. Despite more than 100 years of standing evidence, the engineer felt it necessary to incorporate a steel portal frame within the brickwork; this enabled the roof to be erected in advance of the walls. The new brickwork therefore supports itself only, not the roof.

Matching existing brickwork is always potentially problematic; the multi-coloured London stocks were chosen after comparing sample panels with the existing, restored wall. They came from two Redland quarries which were on the same clay deposits as the originals. The bricks, with their range of hues, were well mixed on site to prevent dominant bands of colour. Finding the soft red rubbers proved more difficult; only one manufacturer, W.T. Lamb, could procure such vast numbers in time. They were all specials — hand carved to the required shape once out of the kiln.

The brick skin was built up and tied back to the steel columns with stainless steel ties. The void was then backfilled with concrete at every lift. The daily lifts were 1.5m. The concrete protects the steelwork, it does not support the loadbearing bricks, so shrinkage will not affect the bricks' stability. The brick courses visually match the existing wall down to the last quarter brick, but as they are only one brick thick, the bonding is obviously different.

The arches are self-supporting; they were constructed with polystyrene arch formers which remained in place until the walls were built up to full height. The mortar joints, as in the original wall, are, at 10mm, relatively pronounced. Being soft, the rubbers could, with time-consuming craftsmanship, be rubbed up together to almost eliminate the joint, but the original was crafted to standards appropriate to sheds, not palaces.

There are no horizontal or vertical movement joints along the wall except towards the end, where the wall meets a different structure, the entrance tower. Both the restored original and the new work were pointed and washed down in the same way; the mortar mix is 1:2:6, uncoloured and pointed with a hosepipe finish. The join between the restored and the new is hardly noticeable.□

Acknowledgment
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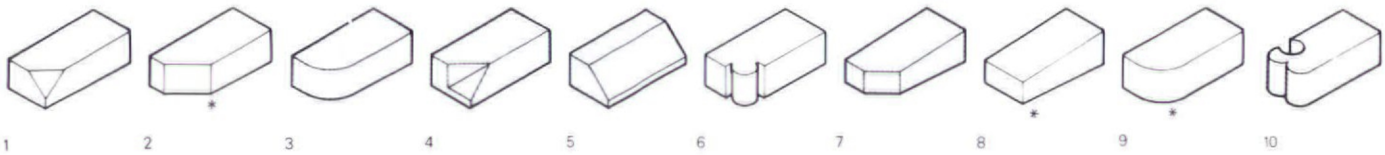
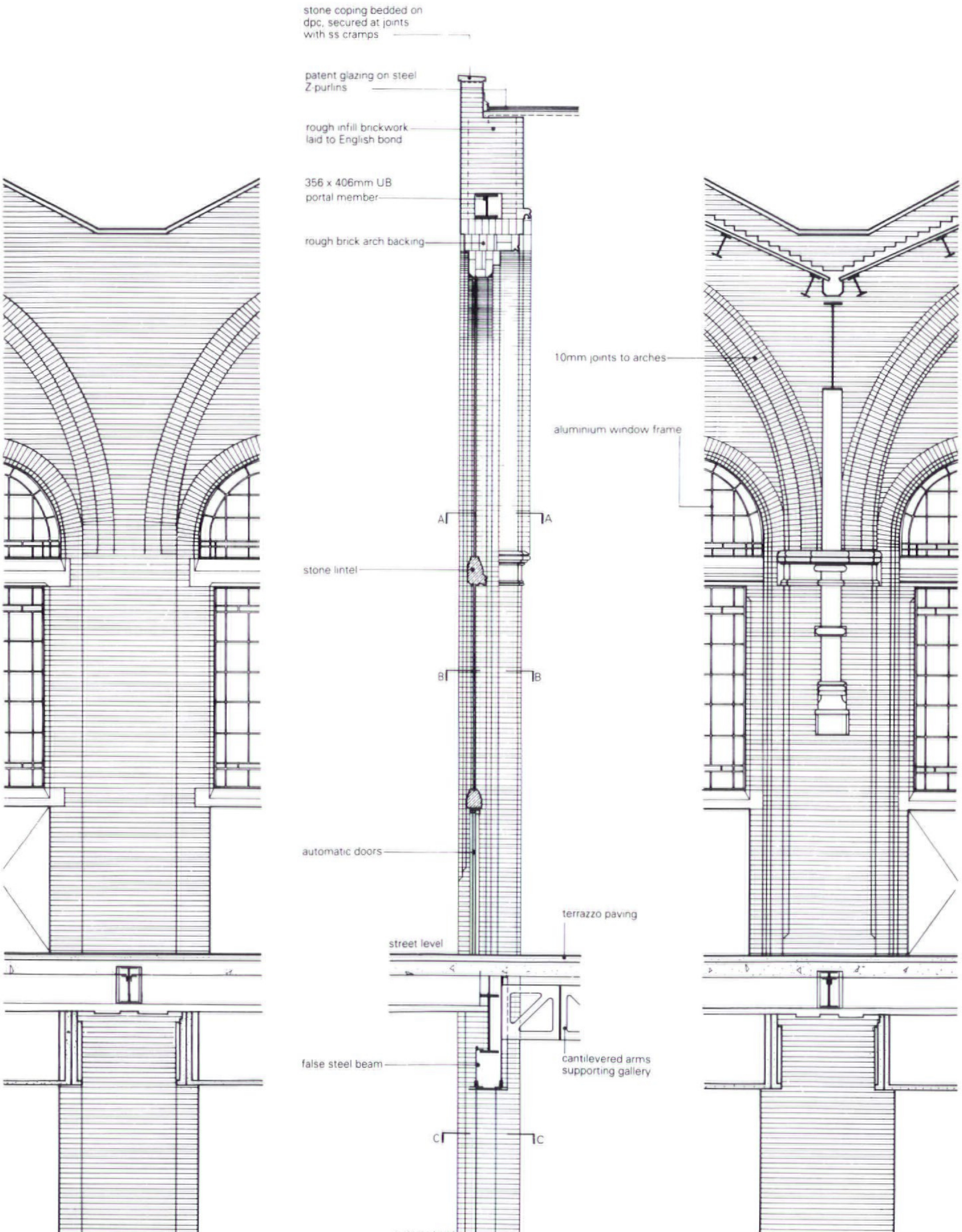


2 SPECIAL BRICK SCHEDULE



3 PART EXTERNAL ELEVATION

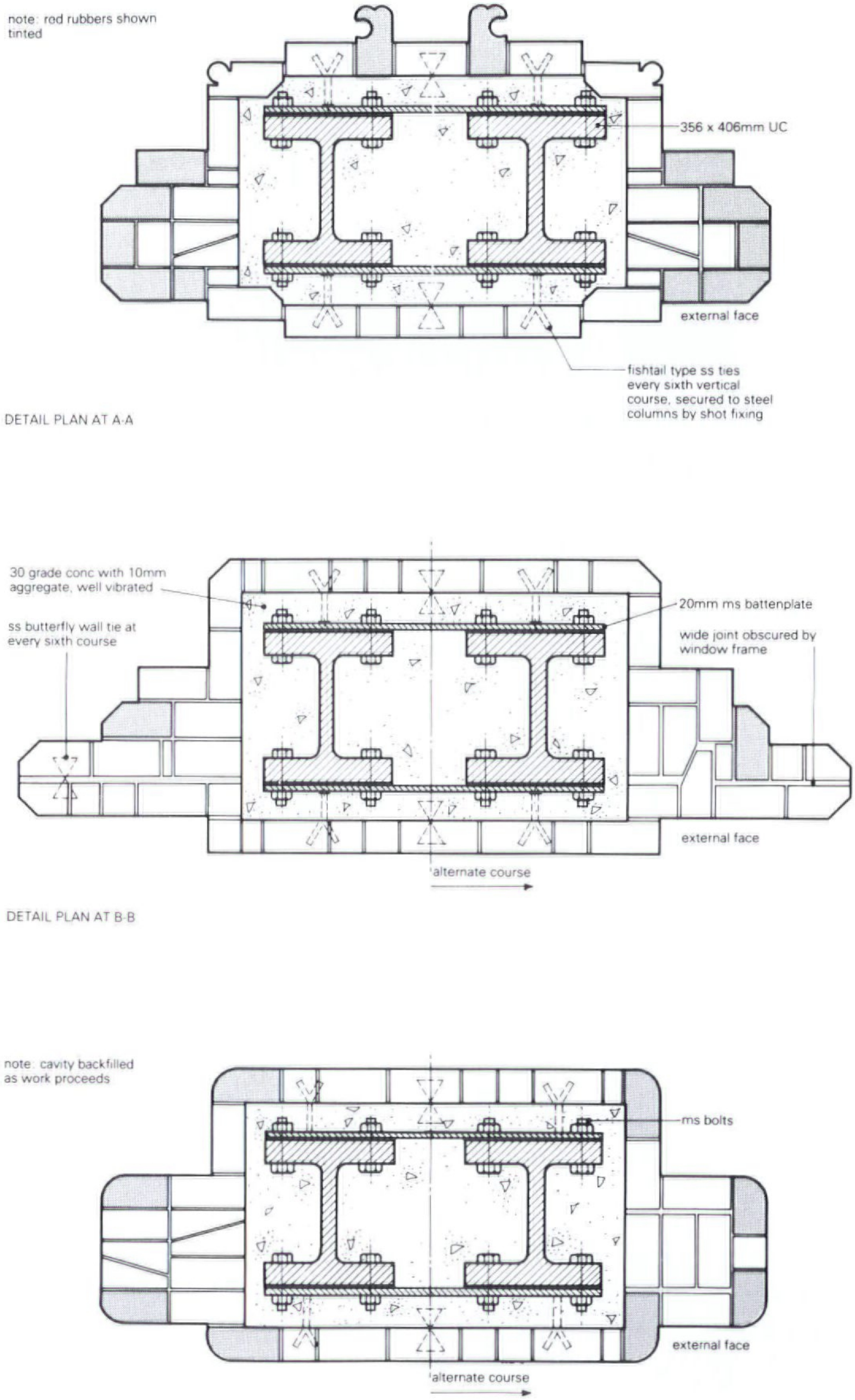
SECTION

PART INTERNAL ELEVATION

Working Details


4

4 Detail of a stone gun barrel bracket which supports the wrought iron spandrel.
5 Detail plans through the piers, details B and C show alternate courses.
6 Part internal elevation of west wall.



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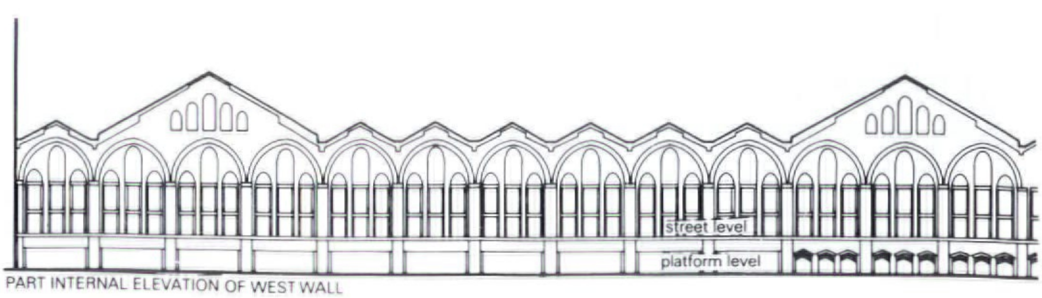
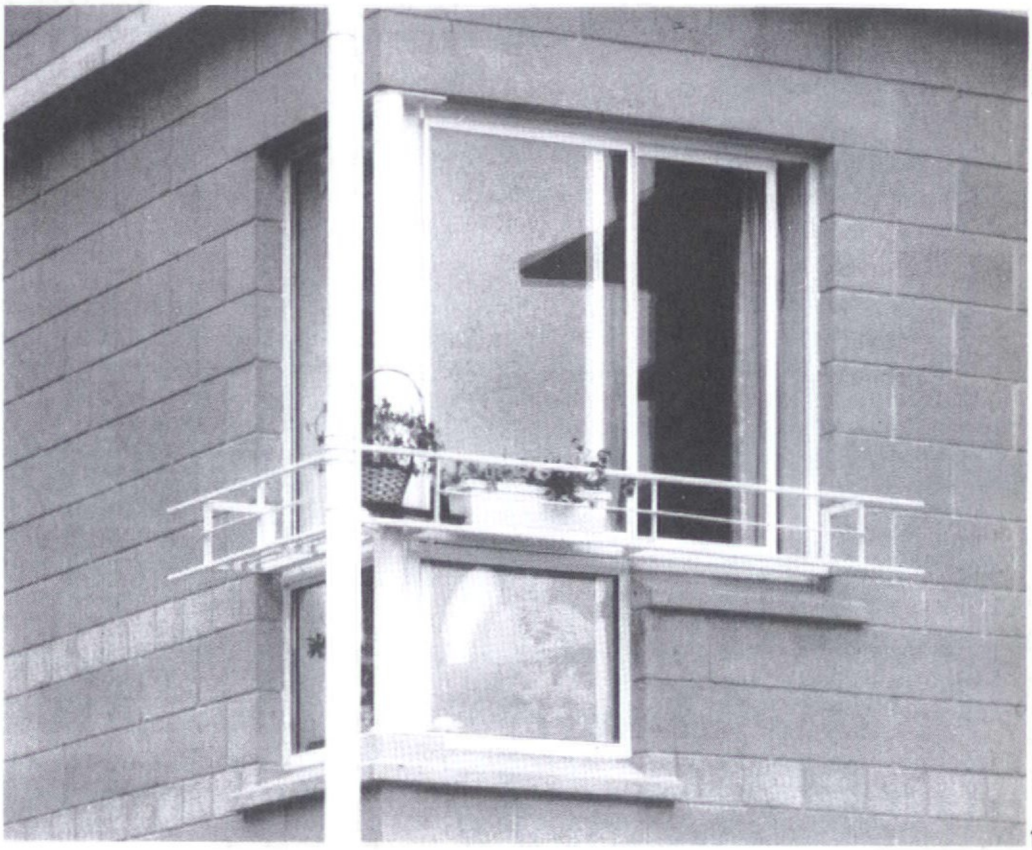


6

Credits
location Liverpool Street Station, London
client Network SouthEast, British Railways Board
architect Architecture and Design Group
director Nick Derbyshire
project architect Alastair Lansley
design team Trevor Banks, Peter Leadill
quantity surveyor Rider Hunt & Partners
structural engineer New Works Engineers Network SouthEast
project management Director Projects British Railways Board
construction consultants Bovis Construction
main contractor Bovis Construction, Harrow (architectural works); Balfour Beaty (main roof construction and civil engineering)
brick and stonework contractor Ben Barrett & Son

Project data
contract project management
site start date 1985
completion date 1991

Photo credit
Photographs by Rupert Truman.



1 One of the corner windows; the window boxes are beginning to be filled. The boxes follow Bath's late Georgian precedence of applied metalwork and also act as guard rails to the low opening windows.

External walls
Residential home

Feilden Clegg Design A shotblasted finish on the block walls exposes the local aggregate, a contrast to the string-courses.

The reduced physical abilities of the residents of Bridge Care in Bath, a home for the frail elderly, drew a sensitive response from the architects throughout the design process. The home is situated in a quiet but accessible area of the city, on a wooded site which slopes down to the River Avon.

Two terraces of individual accommodation generate the form of the building; they skew to enclose a large, more public, hall. The in-situ ground-floor slab is lifted up by fat, terracotta-sheathed columns as a precaution against the 1 in 150 chance that the river will break its bank. Loadbearing blockwork walls, external and cross-walls, support pre-cast floor beams — except where a cantilevered element or irregularities in plan demand an in-situ floor.

The buildings in Bath are, with only a few recent exceptions, built from Bath stone, a soft, creamy yellow oolitic limestone. Using the material in its traditional loadbearing way is expensive, but cheaper, more contemporary materials — reconstituted Bath stone or faced-concrete blocks — can seem insincere and tend to weather less well.

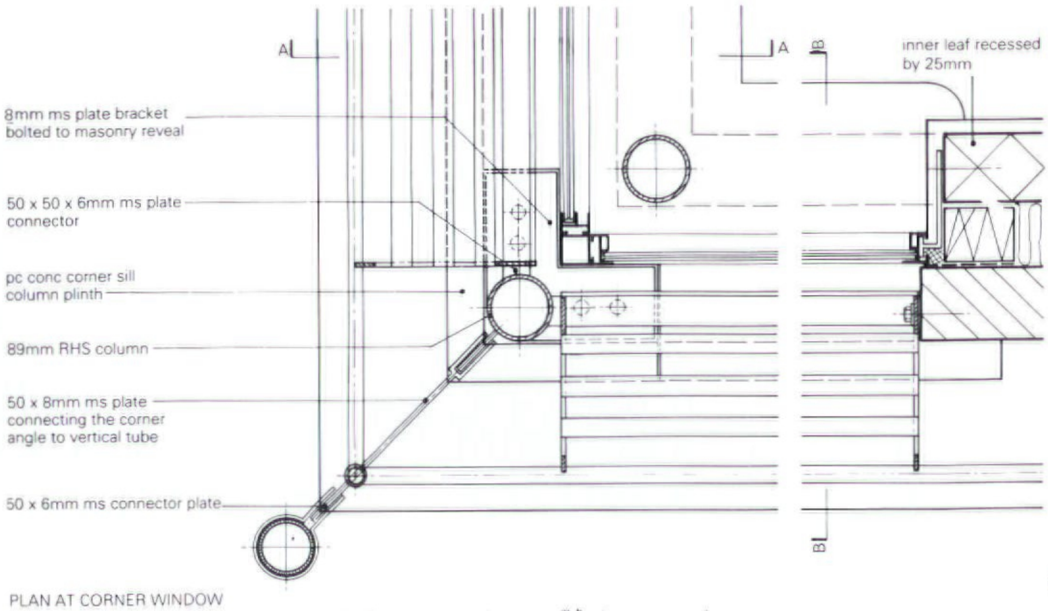
At Bridge Care the architects chose to use a concrete block whose local aggregate is emphasised by its shotblasted finish. By recessing the joints by 5mm (a detail only acceptable in areas of moderate exposure) the architects do not attempt to imitate Bath's existing ashlar walls but produce a textured surface still appropriate to its context. In an attempt both to protect the blockwork and to help order the facade, smooth pre-cast string-courses are used; the grey concrete contrasts well with the cream block.

To reduce cold bridging and the accompanying drafts, the reveals are not returned. This enables the cavities (75mm) to be thoroughly cleaned before filling them with expanded polystyrene insulation beads (not the greenest of solutions). The cavities are closed around the windows with a dense foam board and timber sill. The thermal independence of the two skins is clearly articulated at the corner windows where two steel columns prop the inner and outer lintels.

The horizontal-sliding, aluminium windows are not, however, thermally broken as the architects could not find a suitable thermally broken product; they are recessed behind the external leaf (traditional Georgian practice) to produce a finer elevational line. Each bedroom window has its own steel window box. They are detailed to a high quality and help the rooms to feel more like home. □

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.

2



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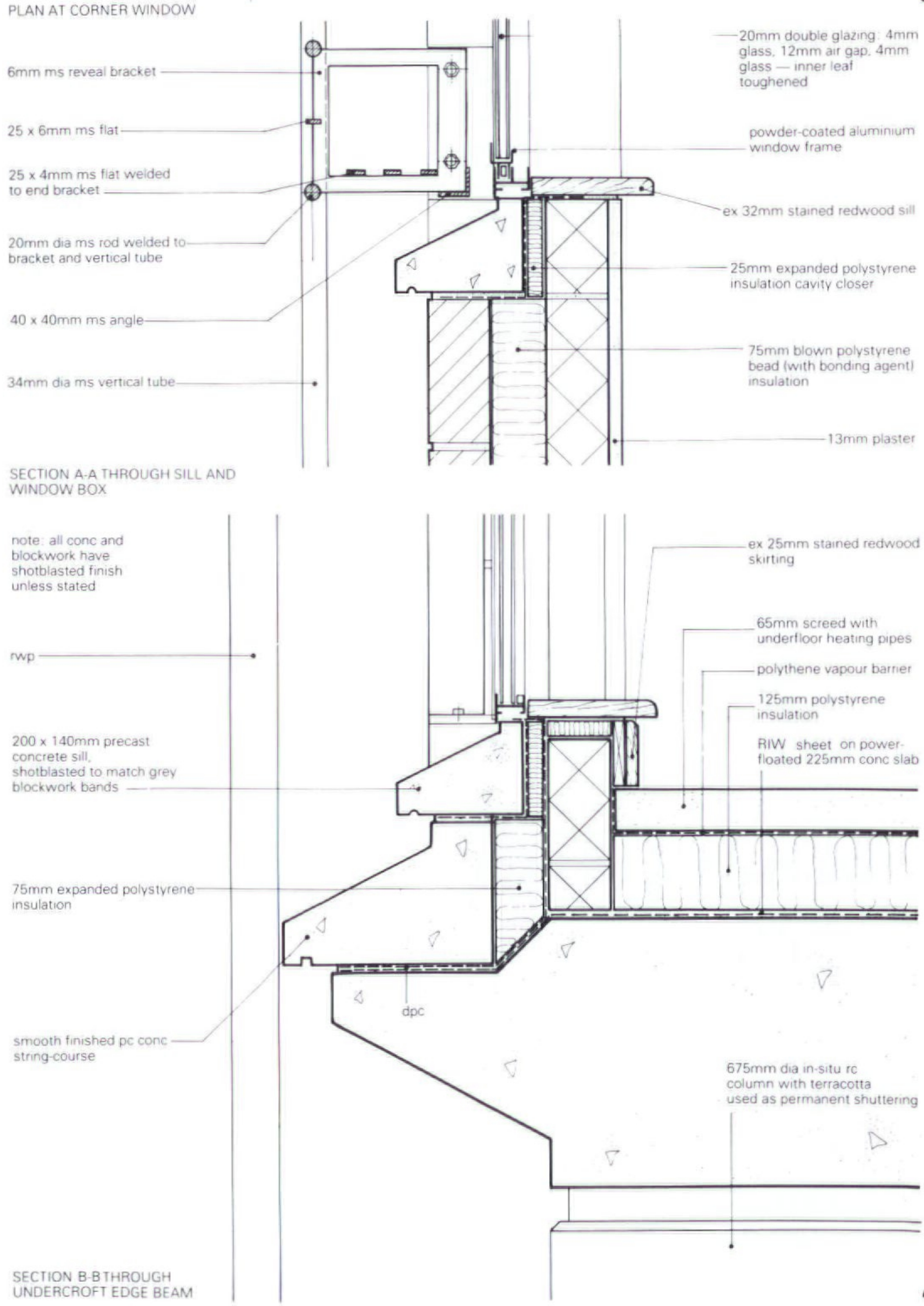


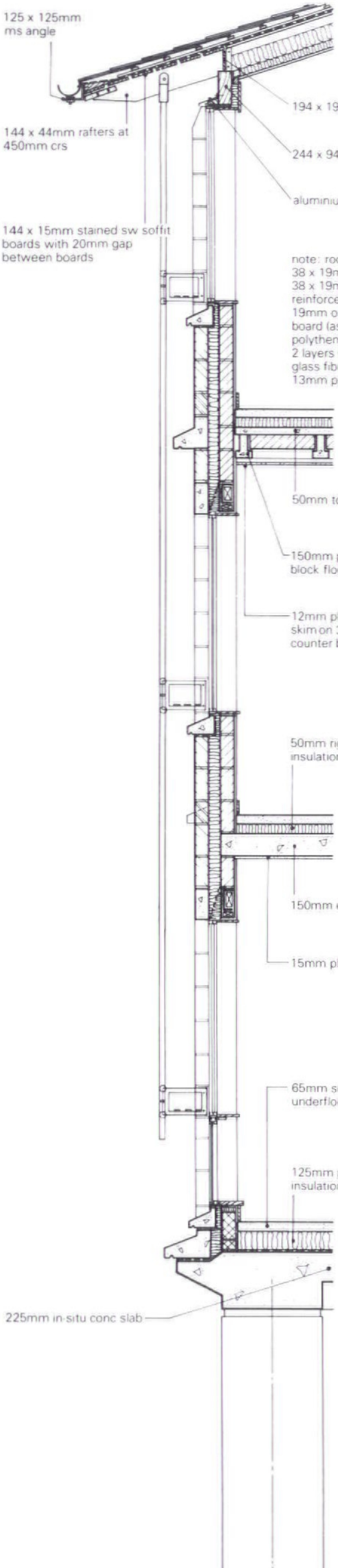
4

2 Detail at the eave.
3 Plan of a corner window.
4 Detail sections through sill and undercroft.
5 Section and part elevation through wall.

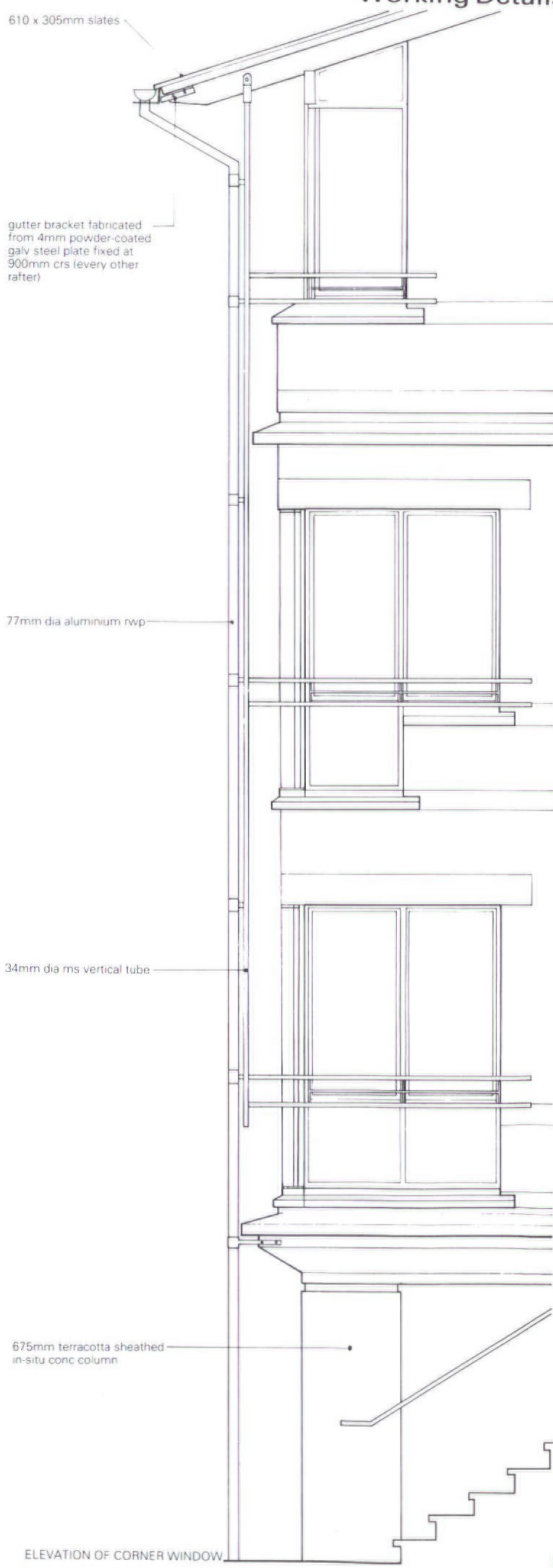
Credits
location St John's Road, Bath
client Bridge Care
architect Feilden Clegg Design
design team Richard Feilden, Keith Bradley, Julia Kashdan-Wade, Pete Shayler-Webb
structural consultants Ove Arup & Partners: Dan Adorisio
mechanical consultants Ove Arup & Partners, Bristol: Chris Ambrose, Dave Fulbrook, Andy May
quantity surveyor Richard Sampson, Bath: Cyril Smith
landscape consultant Stan Hitt & Jane Stoneham
main contractor Willcock Construction, Bristol
subcontractors: cavity wall insulation Miller Pattison, **facework/blockwork** M. Ross Bricklaying, **glazing** M. Caine (GRC Glazing) **groundworks** P. Quirke (Bristol), **joinery** Hawkers Joinery, **slate roofing** Colman Roofing Contractors, **shuttering/formwork** Bath Shuttering and Construction
suppliers: facing blockwork and pre-cast concrete Forticrete, **slates** European Slate Company, **aluminium gutters and downpipes** Alumasc, **steelwork/metalwork** Watkins Wild Engineering, Avonmouth Fabrications, **windows** Archital Luxfer.

Project data
contract JCT 1980 private with quantities
site start date January 1990
completion date January 1992

Photo credit
Photographs by Chris Gascoigne.

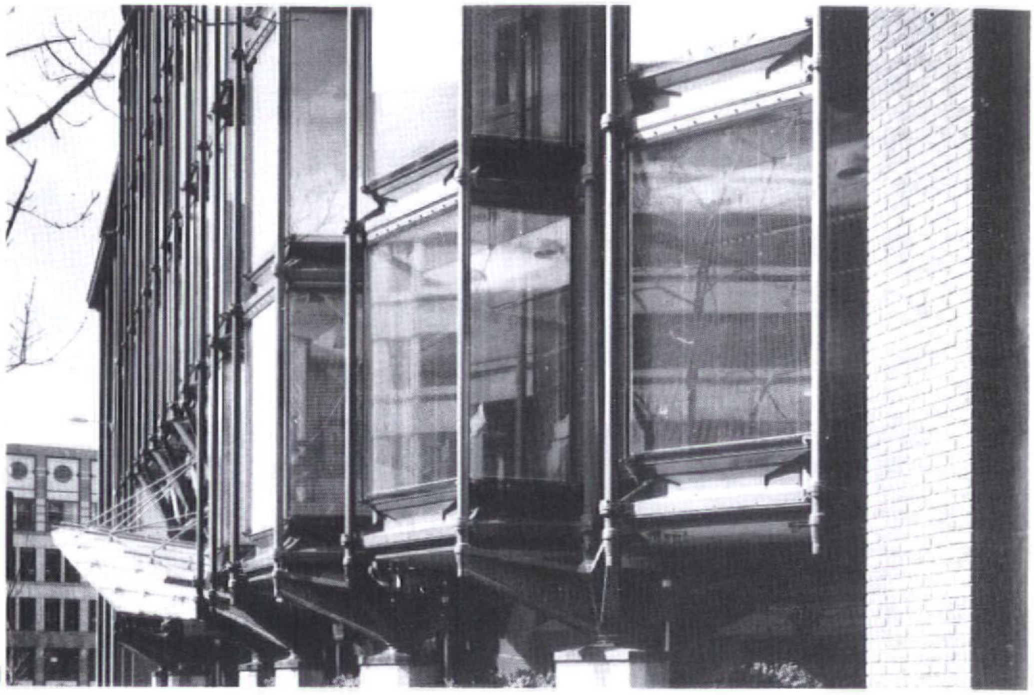


SECTION



ELEVATION OF CORNER WINDOW

5



1 The entrance facade of Bracken House showing the rhythm of the bay windows. The cast gun-metal columns prop up the concrete floor slabs. The pressed bronze spandrel panel takes the profile of the bay fan-coil unit which sits in the floor void behind.

External walls
Office

Michael Hopkins & Partners In addition to its more usual use in extrusions and sheets, here 'bronze' is used as a structural material.

The new oval insertion at Bracken House, the former home of the *Financial Times*, provides six floors of open-plan offices which successfully tie into the two existing wings. Its proximity to St Paul's Cathedral demanded a sensitive response to the form and to the materials used.

The outer 4m zone of the floor plan is cantilevered out from the main concrete frame but is normally propped up by the bronze facade structure; it acts as a pure cantilever only when the bronze structure fails, for example, in cases of fire. The floors and columns are in-situ, the beams and bay window floor panels pre-cast. The cantilevered zone had to be temporarily propped up until the facade was erected. The unpropped cantilever deflections are acceptable in emergency (fire) situations; this allows the facade structure to have no added fire protection.

The use of bronze as a structural building material is unusual; it is more commonly used in an extruded or pressed-sheet form. It is an alloy of copper and tin. The material used at Bracken House is gun-metal, a bronze/zinc alloy with added lead; it has a high resistance to corrosion but is not structurally efficient. Stronger alloys are more expensive, more difficult to cast, and do not colour match the existing Bracken House bronze. Steel, painted to imitate, would have been a cheaper structural option, but as a proportional percentage of the whole project, the difference in cost was negligible. By using bronze, maintenance is minimised and the true richness of the material is evident.

At the base of the building, large, tri-armed cast brackets, borne on solid Hollington stone piers, support the drop-cast hollow columns which run up the facade, acting as a prop to the concrete structure at every floor. The brackets transfer the vertical load down through the stone and rotational loads are taken by a stainless steel tensile rod.

The concrete structure is built to +25mm -15mm, the bronze structure ± 6mm; tolerance is taken up in the connections between the two. Galvanised steel brackets at finished-slab level are bolted through the beam or slab and expressed on the exposed soffit below. They are bolted to the outer gun-metal bracket using an engineering glass fibre as the isolator and thermal break.

The cladding — glass or bronze panels — is hung from a steel clamp plate which runs between the brackets. The floor-to-ceiling double-glazed sheets are fixed through the outer, thicker pane only; the bronze bolts are clearly expressed. The base of the glass is attached to a sliding shoe on the beam bracket, it allows vertical movement but gives lateral (blow out) restraint. Each bay window works as a rigid system which overlaps and moves independently from the rest. The pressed bronze inter-bay panels can be opened to give smoke ventilation.□

Acknowledgment
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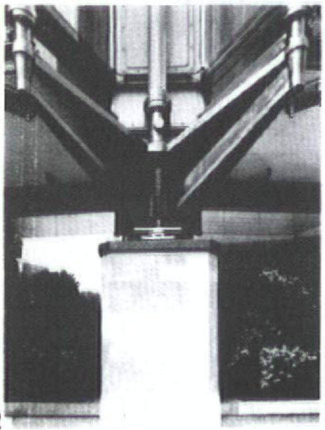
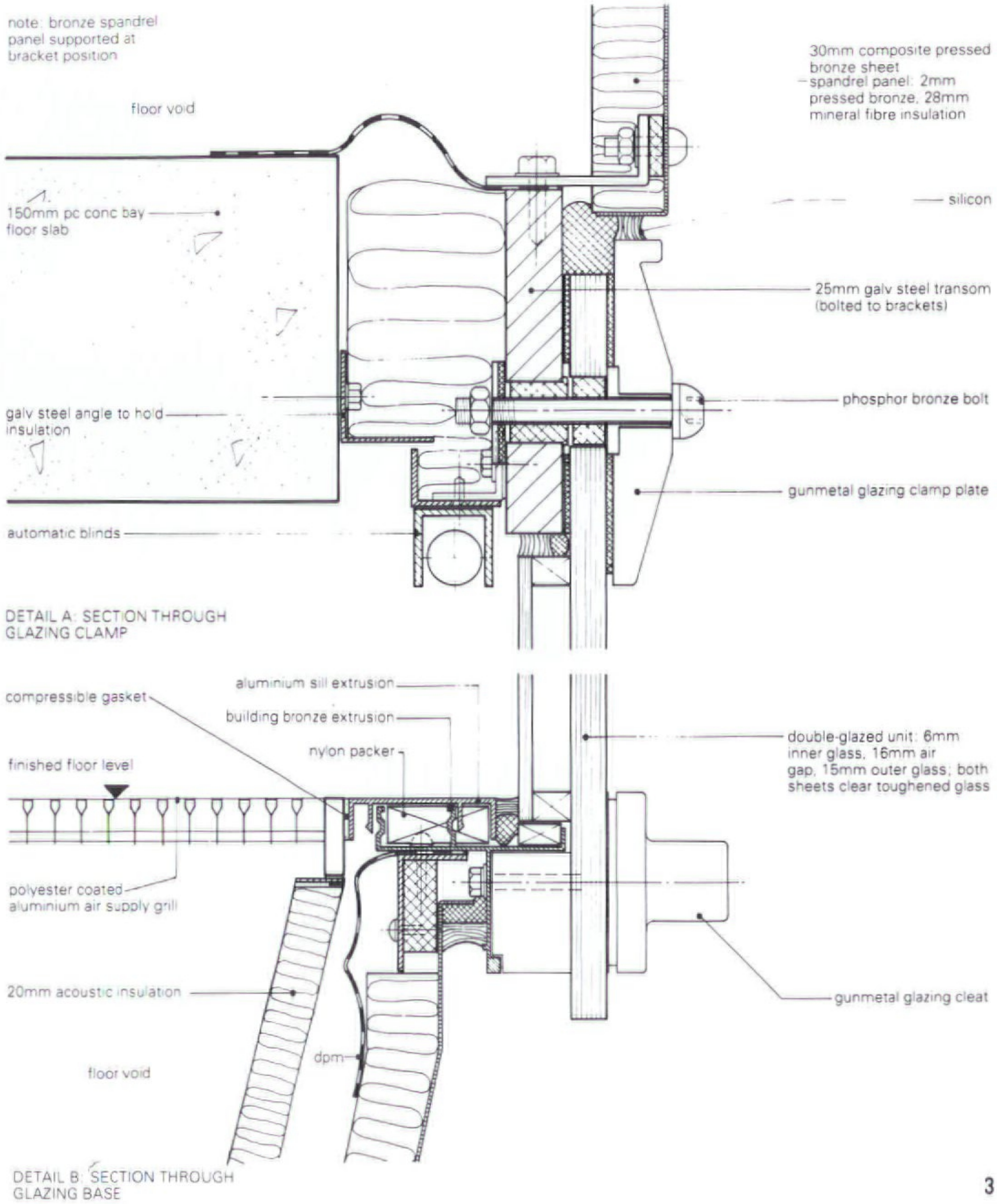


2

2 Detail view of a cast gun-metal bracket; it transfers the vertical compression load down through to the solid Hollington stone pier.
3 Section through glazing head and base detail.
4 Detail plan of a pressed bronze inter-bay panel; these can be opened, in case of fire, to give smoke ventilation.
5 Typical section through bay. The propped cantilever (with downstand beam only) in the outer 4m zone, allows a free service run in the floor void.
6 Typical floor plan of bay.



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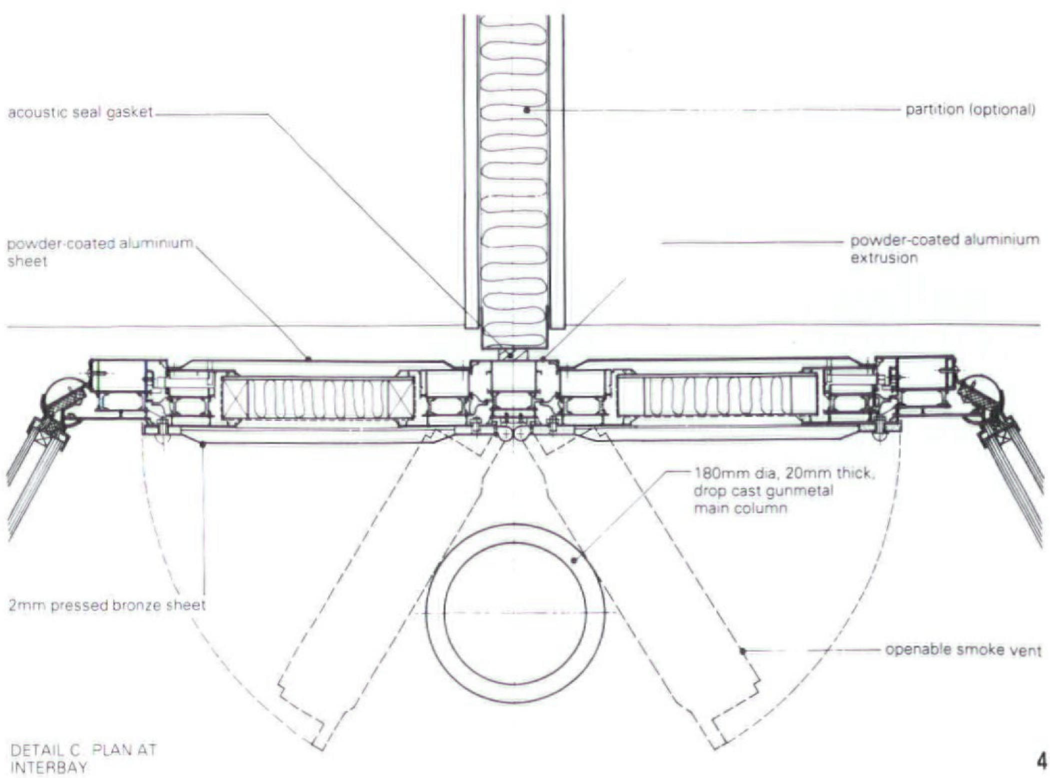
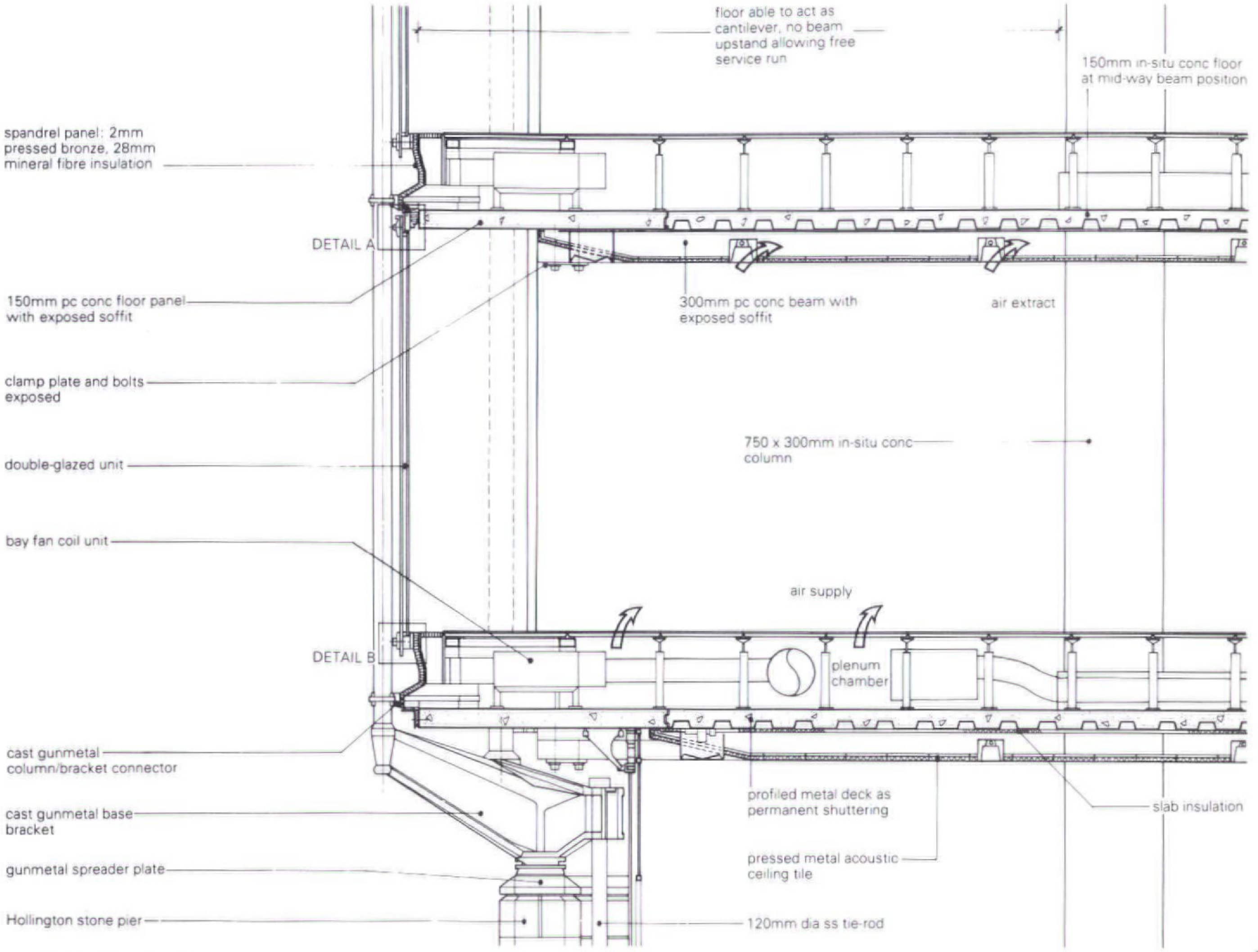


4

Credits
location Bracken House, No 1 Friday Street, London EC4
client Obayashi Europe BV
tenant The Industrial Bank of Japan
architect Michael Hopkins & Partners
partners in charge Michael Hopkins, John Pringle (project partner)
project associate David Selby
architects Bill Dunster, Boon Yang Sim, Patrick Nee
assistants Charles Webster, Sanja Polescuk
structural engineer Ove Arup & Partners
building service engineer Ove Arup & Partners: Rob Kinch, Hanif Humayan
quantity surveyor Northcroft Neighbour & Nicholson
acoustic consultant Arup Acoustics
fire and materials consultant Arup Research & Development
construction & programme consultant Schal International
main contractor Trollope & Colls Construction
subcontractors: curtain walling MBM Fabri-Clad, **M & E services** M.F. Kent, **raised floors** System Floors (UK), **louvre blinds** Technical Blinds, **pre-cast concrete beams** Trent Concrete, **suspended ceilings** Clark & Fenn, **metalwork** Redman, J. Robertson (Engineers), **masonry** Rocamat, **steelwork** MIW Fabrication, **smoke vents** Gradwood, **mastic pointing** Fire Control (NI), **metal decking** Whelan & Grant (Contractors).

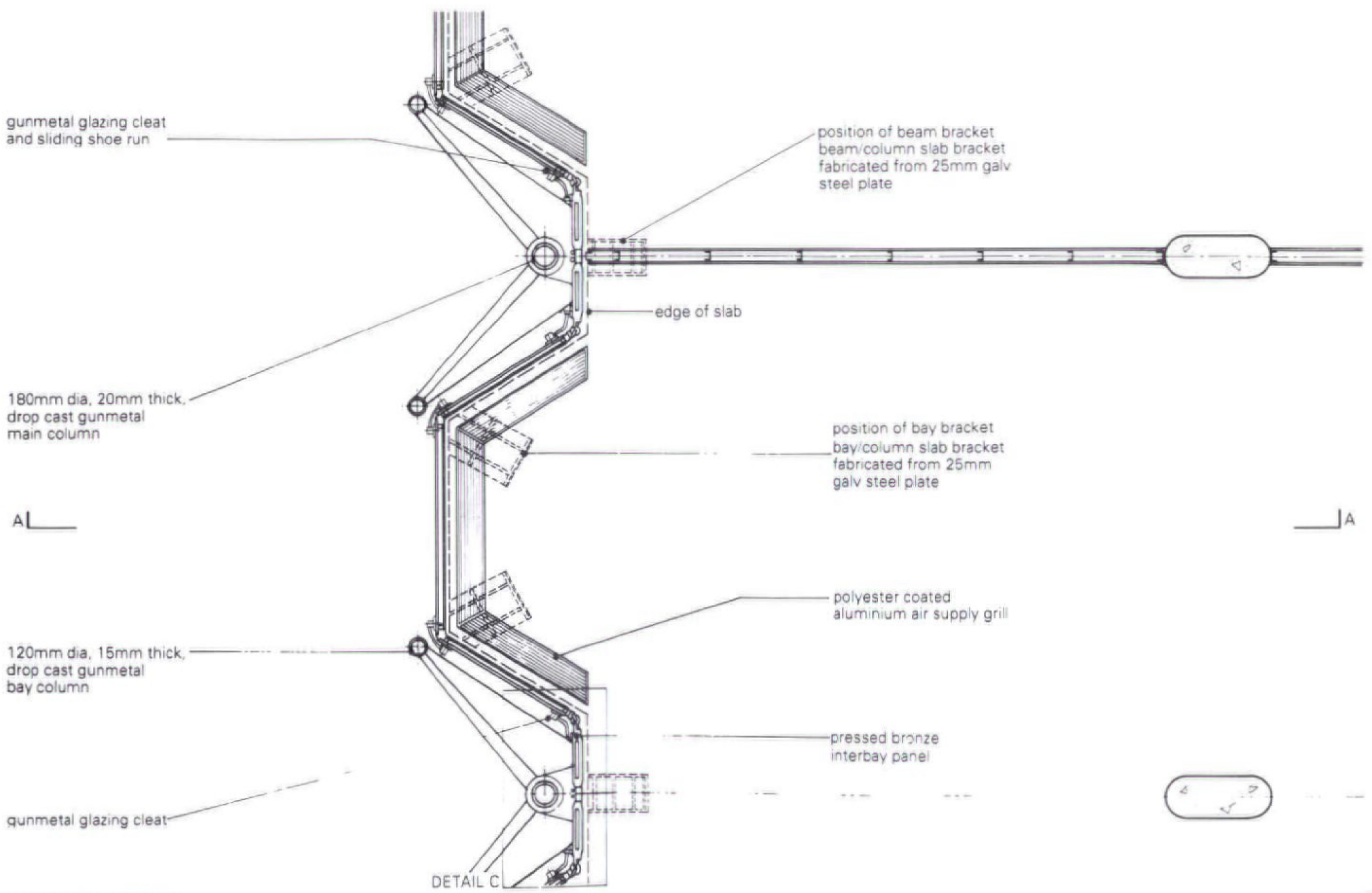
Project data
contract JCT 80 (with quantities)
site start date May 1989
completion date November 1991

Photo credit
Photographs by Martin Charles.



SECTION A A THROUGH BAY

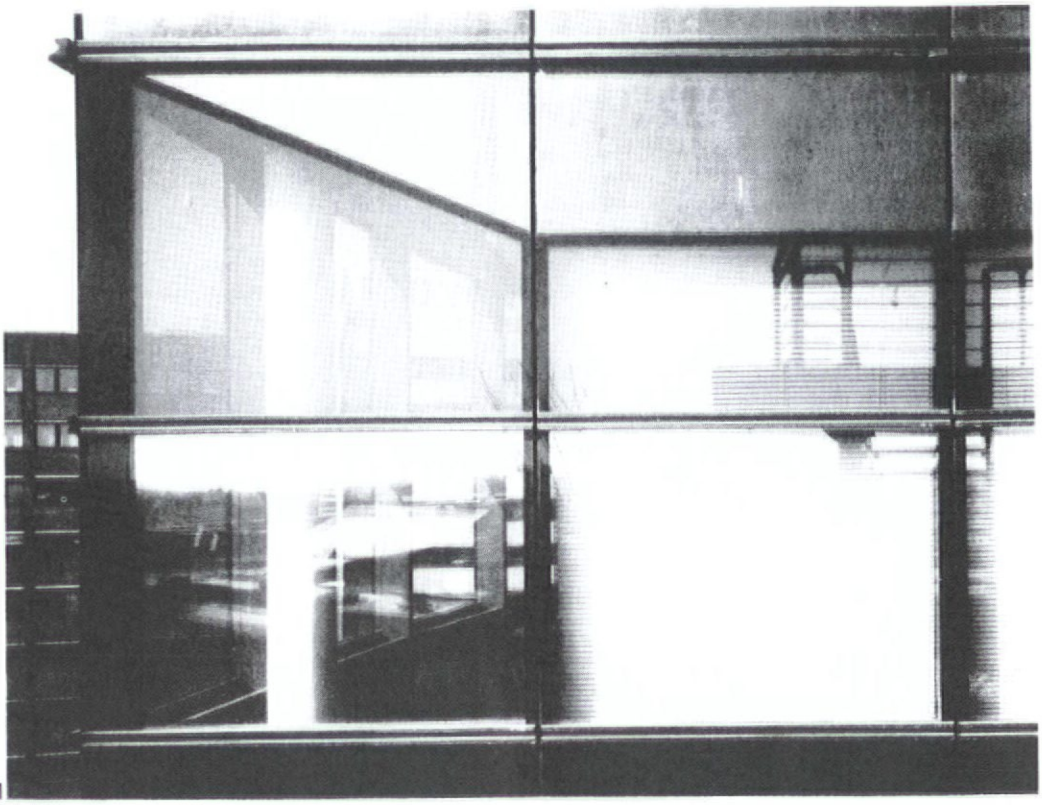
5



TYPICAL PLAN OF BAY

6

CI/SfB (21)



1

Cladding
Office

Ralph Erskine, Lennart Bergström Arkitektkontor and **Rock Townsend** A copper/banded glass, angled cladding system.

1 Detail of the cladding at the entrance cleft where the vertical panels express the ceiling profile. The copper spandrel panels can be seen above the three bands of glazing. The corner is supported by an internal mullion post.
2 Section through cladding.

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.

The Ark is situated in one of London's most hostile environments, on a triangular piece of land bounded by a motorway and train tracks on two sides. Despite its bulbous, organic form, the structure (steel frame and pre-cast concrete floors) is simple and clear.

The floor is a slim-floor construction, with pre-cast beams spanning between the radial RSJs creating an integral beam/slab zone of 300mm; irregularities at the outer zone, due to the curve on the facade, are cast using RSCs as permanent edge shuttering. Each floor overhangs the one below, making progressively deeper cantilevers necessary. From the sixth floor up, the slabs are hung at the edge by columns which act in tension.

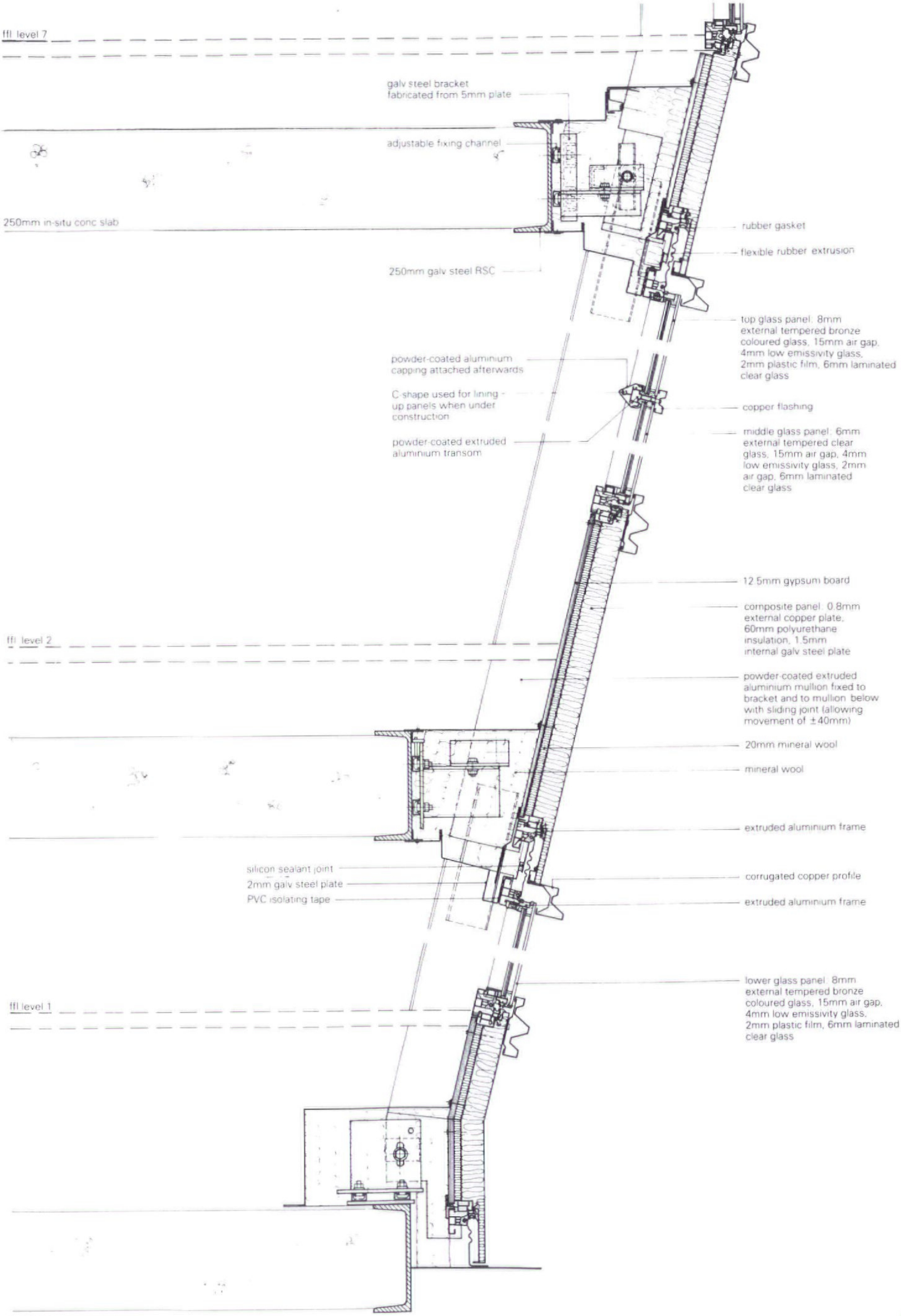
Mullions span from floor to floor at about 1.35m centres. They are fixed back to the RSC slab edge by means of galvanised steel brackets, and attached to the mullion on the floor above with a sliding joint that allows vertical movement of ±40mm.

The cladding consists of three-banded glass (brown, clear, brown) with a copper-faced composite spandrel panel covering the floor void. The stepped double-glazed glass panels arrived on site as complete units (the aluminium frame and transoms were attached under factory conditions) and were lifted into position at the correct angle and bolted on to the mullions. The outer panes at the corners cantilever out by up to 150mm, but surprisingly few were broken in transit.

Copper was chosen for the spandrel panels because of its characteristic green patina which will develop in time — an illustration of Erskine's organic concept of growth and change. Washes from copper tend to stain and create electrolytic reactions with other metals, so the panel was designed to isolate the copper from the aluminium frame extrusions in an attempt to eliminate the problem at source. Cleaning solutions will have to be chosen with care.

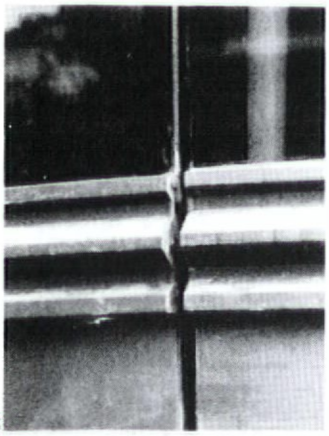
Copper flashings, which were clipped on afterwards, cover the horizontal movement joints, but differential movement between the panels prevents crisp junctions. Despite the Ark's innovative form, the cladding system certainly breaks no new ground.

The walls were designed for a sound reduction of 42dB, but the mock-up test revealed an acoustic weakness in the mullions — the cavity acted as a drum, amplifying the sound. The mullions were given an internal coating of an 'anti-drumming' material — as used in motor vehicles — and a metal bar was added for acoustic mass. After completion the required reduction was achieved.□



SECTION THROUGH CLADDING

2



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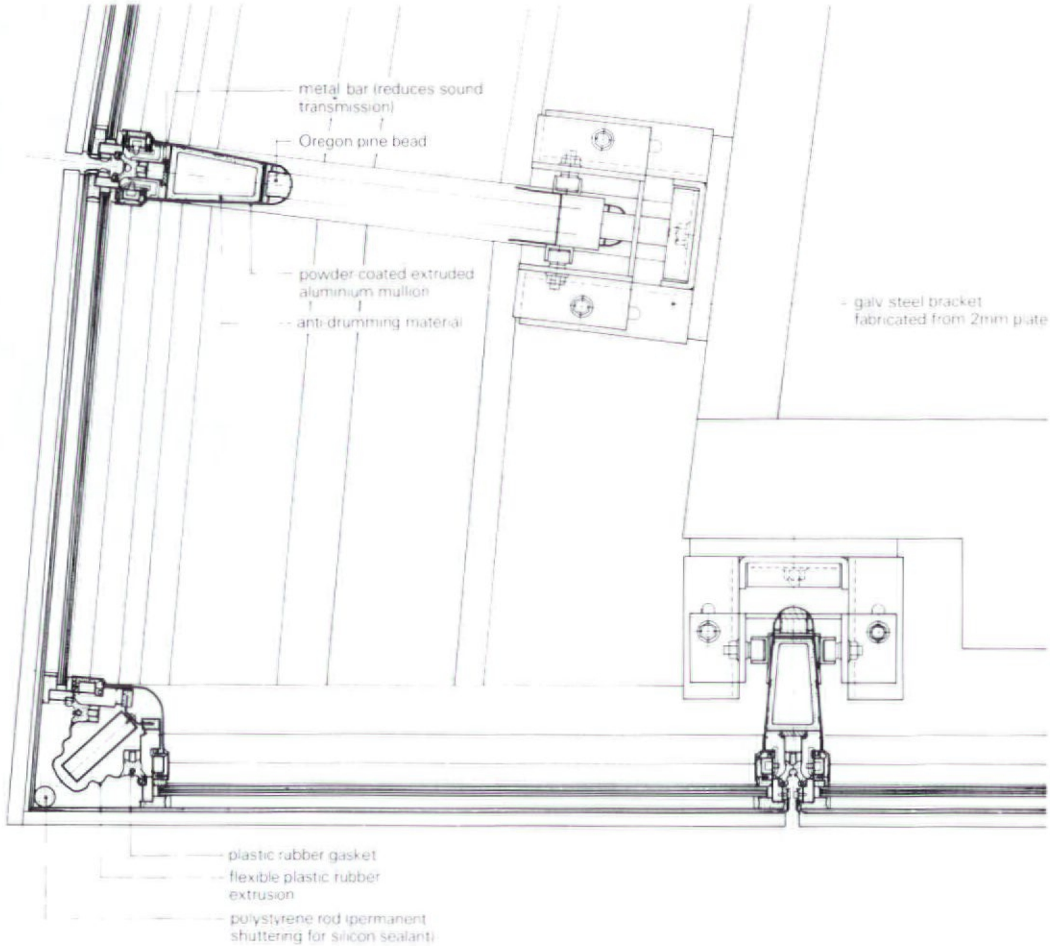
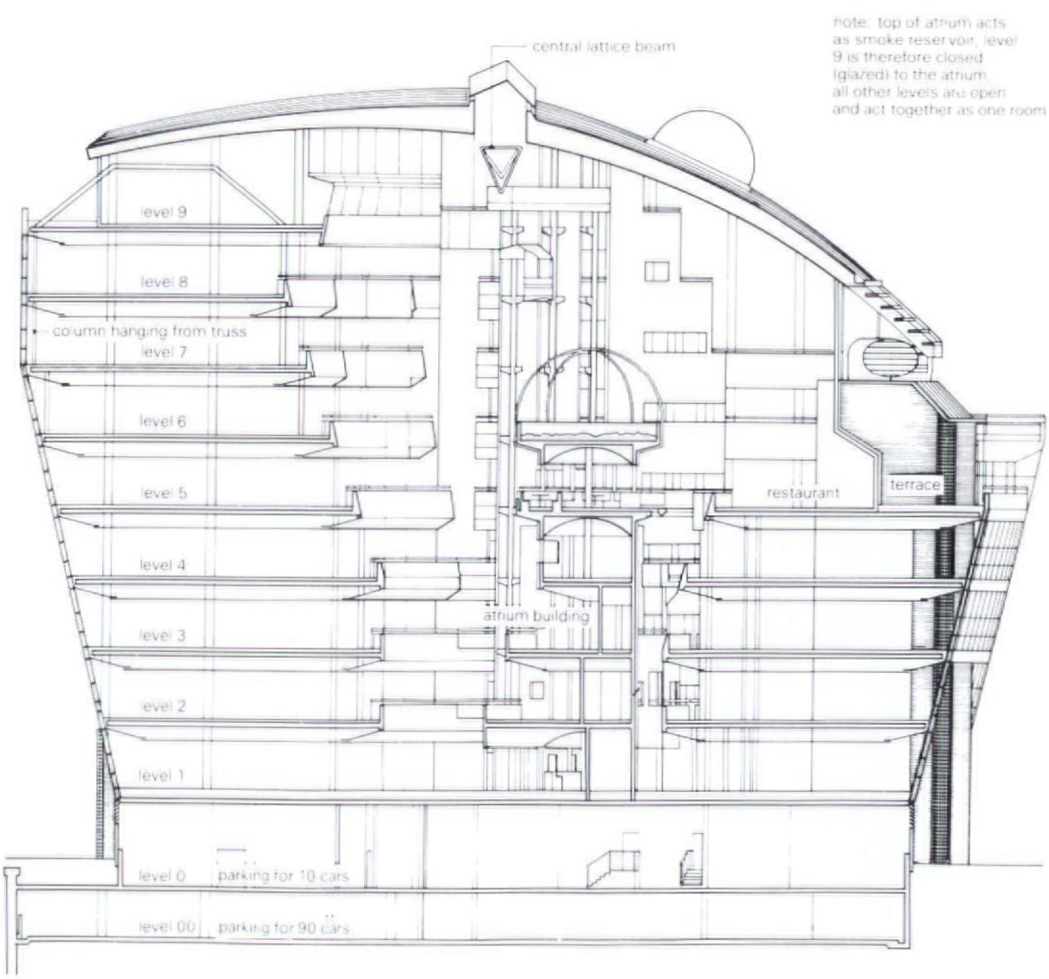
3 **Detail of the copper flashings which were clipped on after the panels had been erected. Differential movement between the panels prevents crisp junctions.**
4 **Plan through glazing at entrance cleft. The polystyrene rod, used as permanent shuttering for the silicon joint, was initially held in place with wires.**
5 **Cross-section: the observation tower is not shown.**



DETAIL PLAN THROUGH GLAZING AT ENTRANCE CLEFT

4



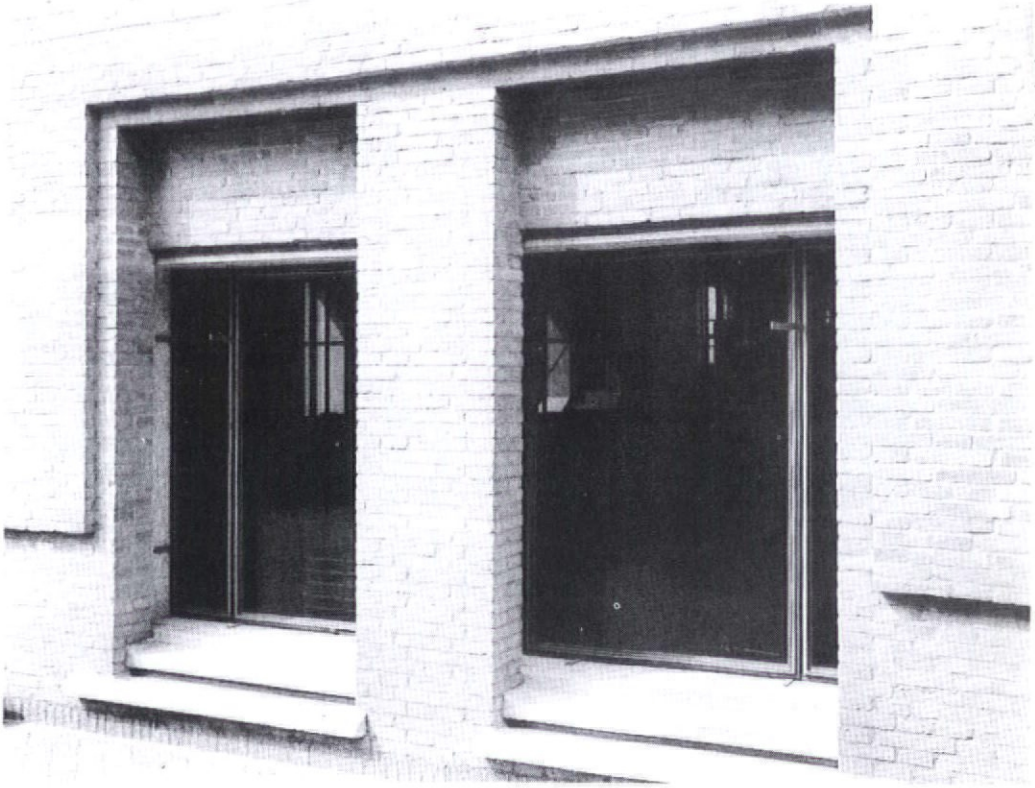
CROSS SECTION

5

Credits
location The London Ark, Hammersmith, London W6
client Talgarth Estates BV
architects Ralph Erskine: Ralph Erskine, Vernon Grade
Lennart Bergström: Bo Svensson, Lars Wilson
Rock Townsend: Alistair Hay, Gordon Swapp
structural engineer Scandiaconsult AB (superstructure), Andrew Kent & Stone (substructure)
acoustic consultant Scandiaconsult AB, Arup Acoustics
project and consultant manager Åke Larson
subcontractors: floor slabs Bison, **cladding** Hallmo, **steelwork** Norrtalje Svets

Project data
contract Åke Larson
standard conditions of contract
site start date September 1989
completion date April 1992

1 Ground-floor window. While many of the windows differ in size and in their relationship with the outer brick wall, the brass and steel frame details remain constant.



1

External wall and window
Research institute

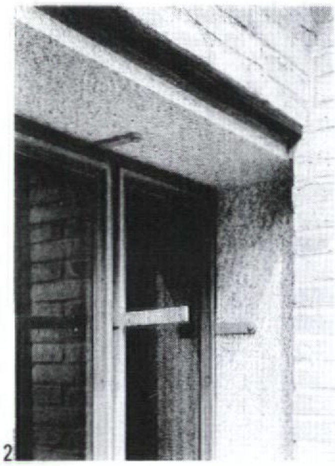
Zibrandsten Architects This solid brick wall construction allows surface modulation and deep window reveals.

The Cambridge Crystallographic Data Centre is an independently funded research institute. The hub of academic activity — work and meeting spaces for 16 research assistants — centres around a lofty, top-lit, double-height space on the first floor. Laboratory and administration facilities provide the back up on floors below.

The stark brick facade gives the first clues to the richness of construction — surface modulations and the depth revealed by the punched windows indicate a solid wall. The outer skin is non-loadbearing, up to 400mm thick, and built from red Danish bricks using an apparently random hybrid Flemish bond which repeats itself at approximately 16 course intervals. The long, thin bricks (40 x 103 x 230mm) tended to warp in the kiln making the mortar depth (10mm min) uneven. Because of the wall thickness, the weak mortar (1:1:12) and its non-loadbearing role, no expansion joints were needed. Insulation is fixed to the inner face of the outer wall, it is aluminium backed in an attempt to prevent condensation forming in the brickwork. The steel frame is therefore at the same temperature as the interior; it is tied to the outer wall by stainless steel sliding channels which allow for a differential movement of ±12mm — a movement that would be too great for standard wall ties. The internal leaf is exposed acoustic brick.

The window reveals are clad in honed grey Tolga granite, a mid-tone colour which helps the eye adjust to the difference in light levels between inside and out. The chamfered joint between slabs reflects the junction between the two wall leaves and allows differential movement. The window frame itself is articulated to a weight which is light but not flimsy; all the components were designed by the architect and made in Denmark. The brass frame is screwed to eight stainless steel cramps which also hold the granite in place; the opening light frame is stainless steel, brass angles keep the glazing in place. Similar details are used for the doors and internal partition screens. All the brass is patinised (an oxidising process which makes it look like bronze) and steel-bead-blasted. Waterproofing at joints is provided solely by plastic rubber, but as the junctions are visible and accessible, they will be easy to maintain. The window pivots vertically around its centre and is secured by four turnbuckle handles which slot into slits in the cramps. The detailing generally is of an unusually high quality — a quality which is reflected in the understated elegance of the building as a whole.□

Acknowledgment
The editors acknowledge the assistance of Lionel Friedland of Pentarch in the preparation of this article.



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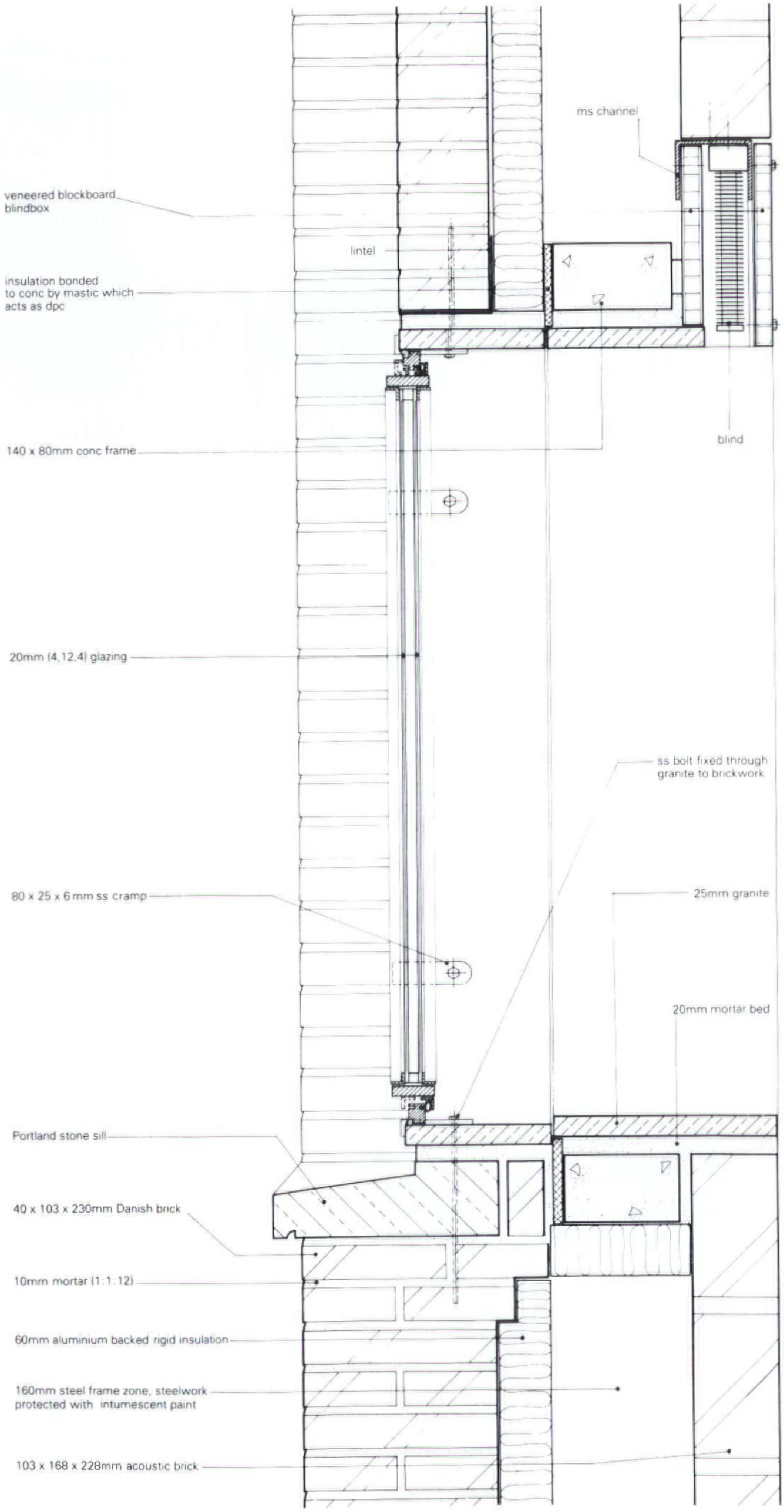
2 External detail of window. The slits in the steel quadrant provide a secure fixing for the turnbuckle handle.
3 Section through window.
4 Detail at jamb.
5 Part external and internal elevation.



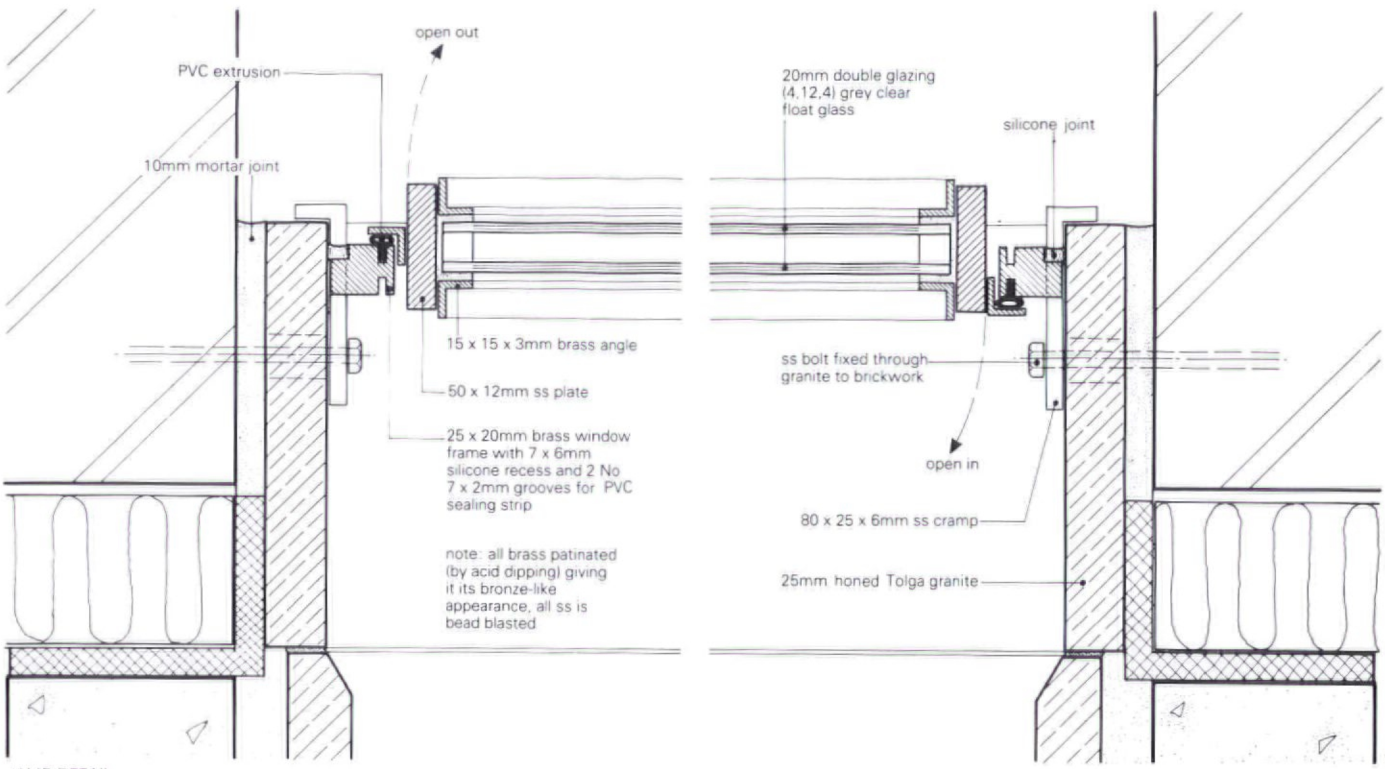
SECTION THROUGH WINDOW

3

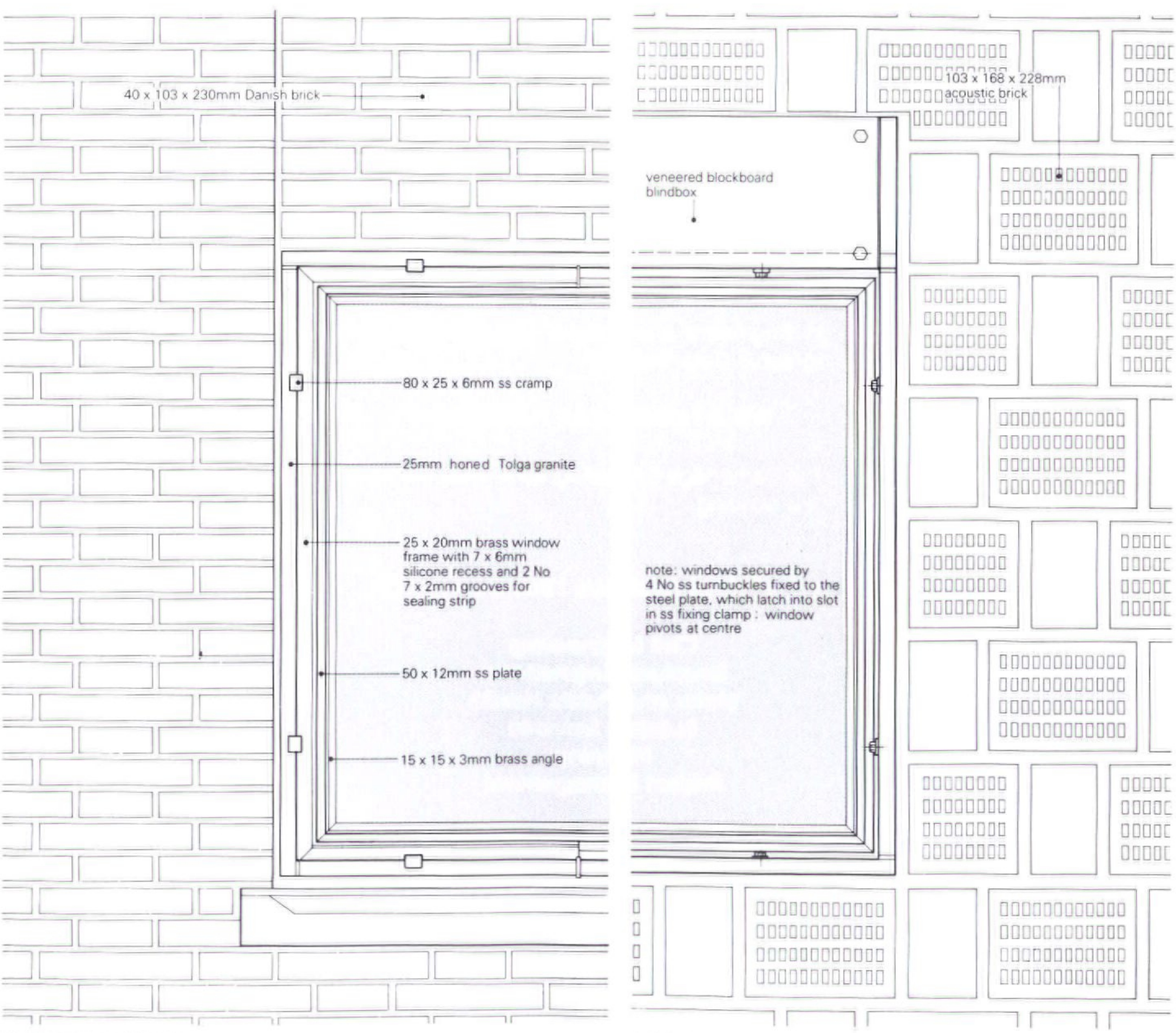
Credits
location Cambridge Crystallographic Data Centre (CCDC), Union Road, Cambridge
client CCDC
architect Zibrandsten Architects: Erik Christian Sørensen, Henriette Schubert
structural engineer and quantity surveyor W.S. Atkins
main contractor Rattee & Kett (a division of John Mowlem Construction)
subcontractors: brickwork Dullingham Developments, **granite work** Bannocks, **mastics** Brock Mastics, **glazing** Solaglass, **steelwork** Rowley Engineering
suppliers: Danish bricks DFT Brick, **general building materials** Ridgeons

Project data
contract JCT 80 private without quantities
site start date September 1990
completion date January 1992

Photo credit
Photographs by Dennis Gilbert



JAMB DETAIL



PART EXTERIOR ELEVATION

PART INTERIOR ELEVATION

5

ROOF
DEPARTMENT STORE
Ahrends Burton and Koralek

This roof accommodates two types of glazing as well as access walkways which double as gutters, artificial lighting, smoke control, a sprinkler system and a suspended louvred ceiling.

Related articles
Front feature
AJ 26.9.90 pp26-29
Building feature
AJ 10.4.91 pp32-45
Working details
AJ 10.4.91 pp47-49
Technical feature
AJ 10.4.91 pp51-54

1

1 The John Lewis department store at Kingston upon Thames has a concrete frame, but the roof is a steel structure supported on 273 mm diameter steel columns at 11 m centres. The strips of 45° glazing, one of which runs across the centre of the photograph, let sunlight into the building, but the larger expanses of 11.25° glazing use a sandwich panel which only allows a diffused light. Around the perimeter of the glazing is a concrete box section smoke duct, which also runs down the centre of the building.

This new store at Kingston occupies a total area of 40 000 m^2 over five floors (with two further basement levels of parking). Above the brick-clad concrete structure a translucent roof (the glazed area is 4200 m^2) provides daylight to all the main sales floors.

The roof is divided into two squares, and each has glazing rising at an angle of 11.25° from the south-east or south-west corner to the centre of the north elevation, *6*.

The roof support structure is formed from steel columns which carry a system of horizontal primary trusses, and secondary trusses spanning the 17 m between them. As well as the shallow-pitched glazing there are, above the primary trusses, rooflights glazed at 45° with a vertical panel behind.

At right-angles to the 11.25° curtain wall glazing (traditional roof glazing could not accommodate the shallow pitch) is a camber to help drain the roof. Even if the glazing sealing gaskets fail, water should be directed to the diagonal drainage channels which discharge into outlet sumps. The channels are also designed to act as reservoirs during heavy rainfall. If there is a blockage or unusually heavy precipitation, the water can escape over the outlet sumps via weirs to alternative outlets — if this fails conventional overflow pipes will operate.

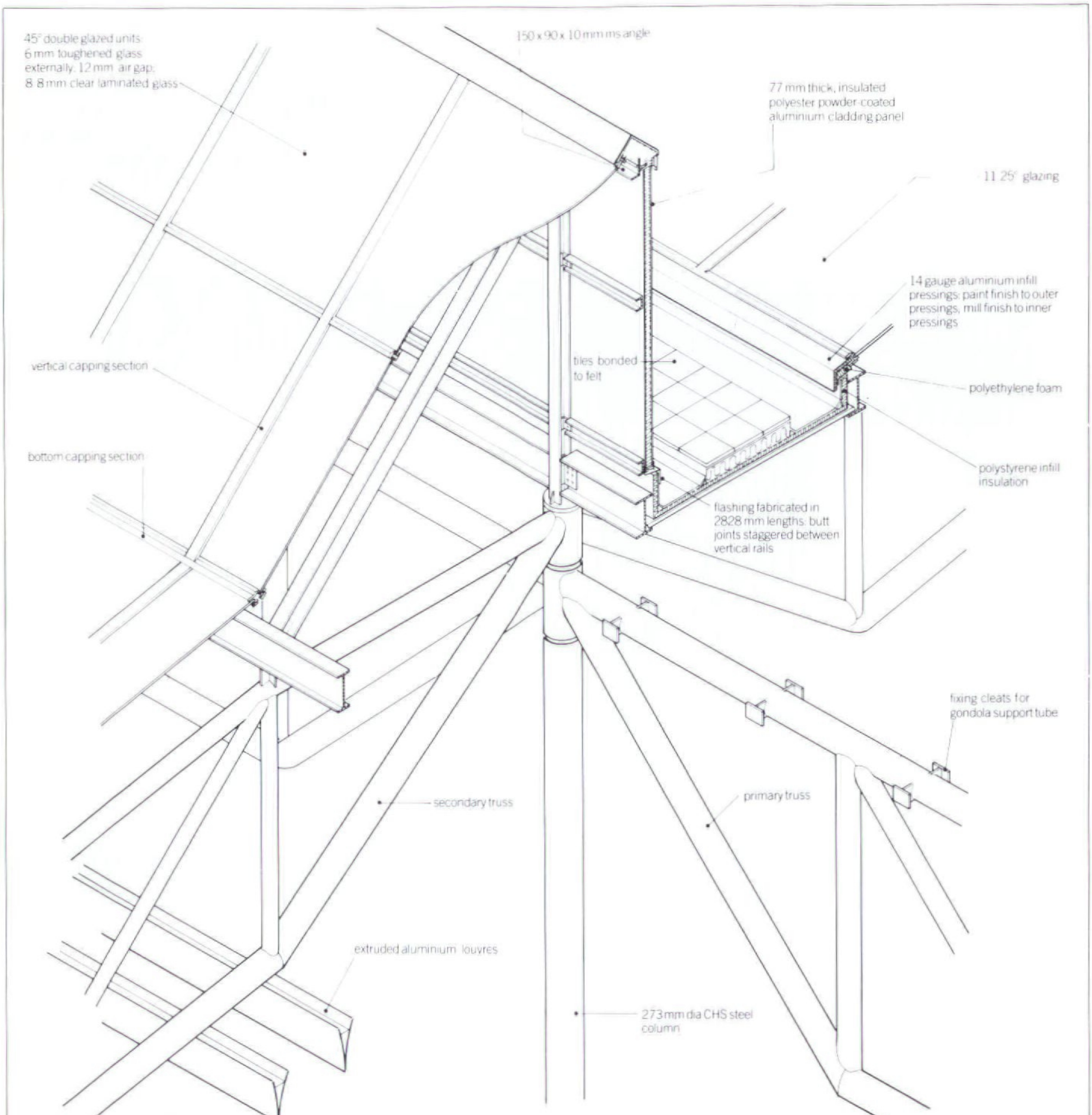
Internally the roof is integral to the design of the services. Sunlight enters through the 45° rooflights, which are controlled by translucent roller blinds. The shallow glazing, which incorporates a translucent capillary diffusing layer (which also provides thermal insulation and reduces ultra violet transmission), allows daylight (but not sunlight) into the building, and that daylight is further diffused by fixed aluminium louvres and the heat-resisting glassfibre 'sailcloths' fixed to the secondary trusses.

Although the primary trusses appear to have similar sailcloths, their baffles also fulfil another function: if a fire occurs steel roller shutters will divide the store in half, and any smoke in the covered sales areas will be mechanically drawn into 2.1×0.75 m ducts surrounding the atrium. That means the atrium need only accommodate smoke generated within its own floor area. That area is again subdivided — by the primary trusses. Smoke is extracted through the port-holes at each end of the areas defined by the primary trusses. (The port-holes and ducts are normally part of the building's heating and cooling system.)

The roof also incorporates a sprinkler system powerful enough to reach the ground floor. At basement level, sprinklers around the atrium are angled into it.

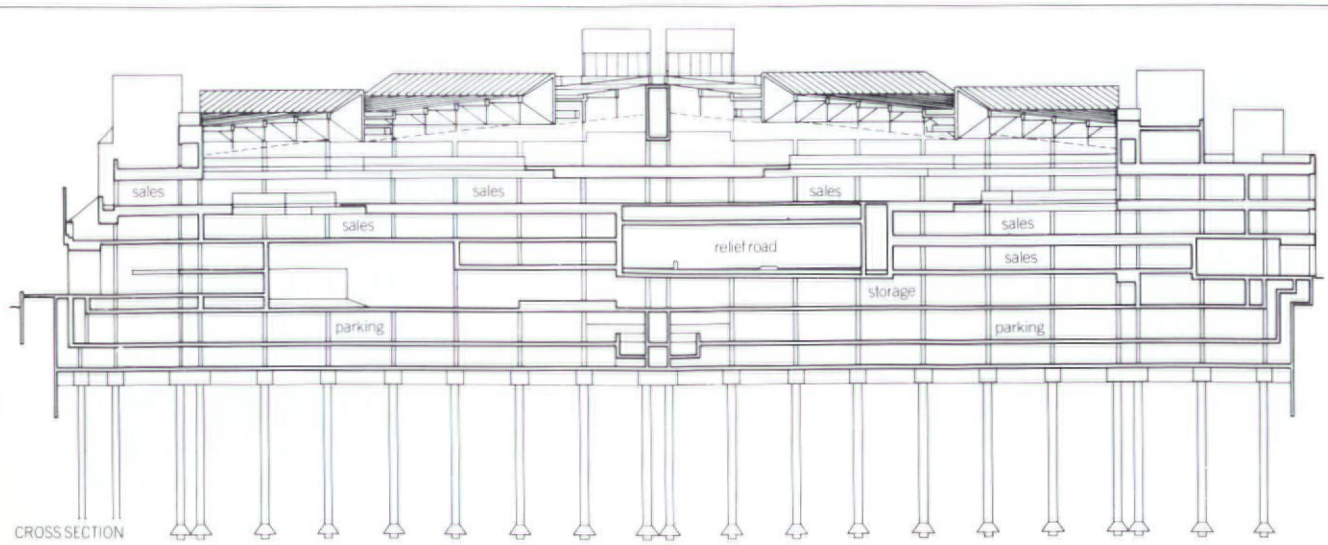
Externally, maintenance access is possible from boards fastened to cleats projecting up from the glazing system and, internally, gondolas provide access to all the roof services. ■

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch.



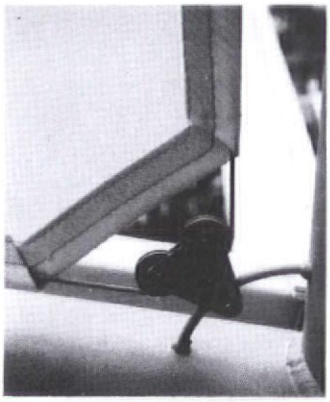
ISOMETRIC AT HEAD OF COLUMN

2



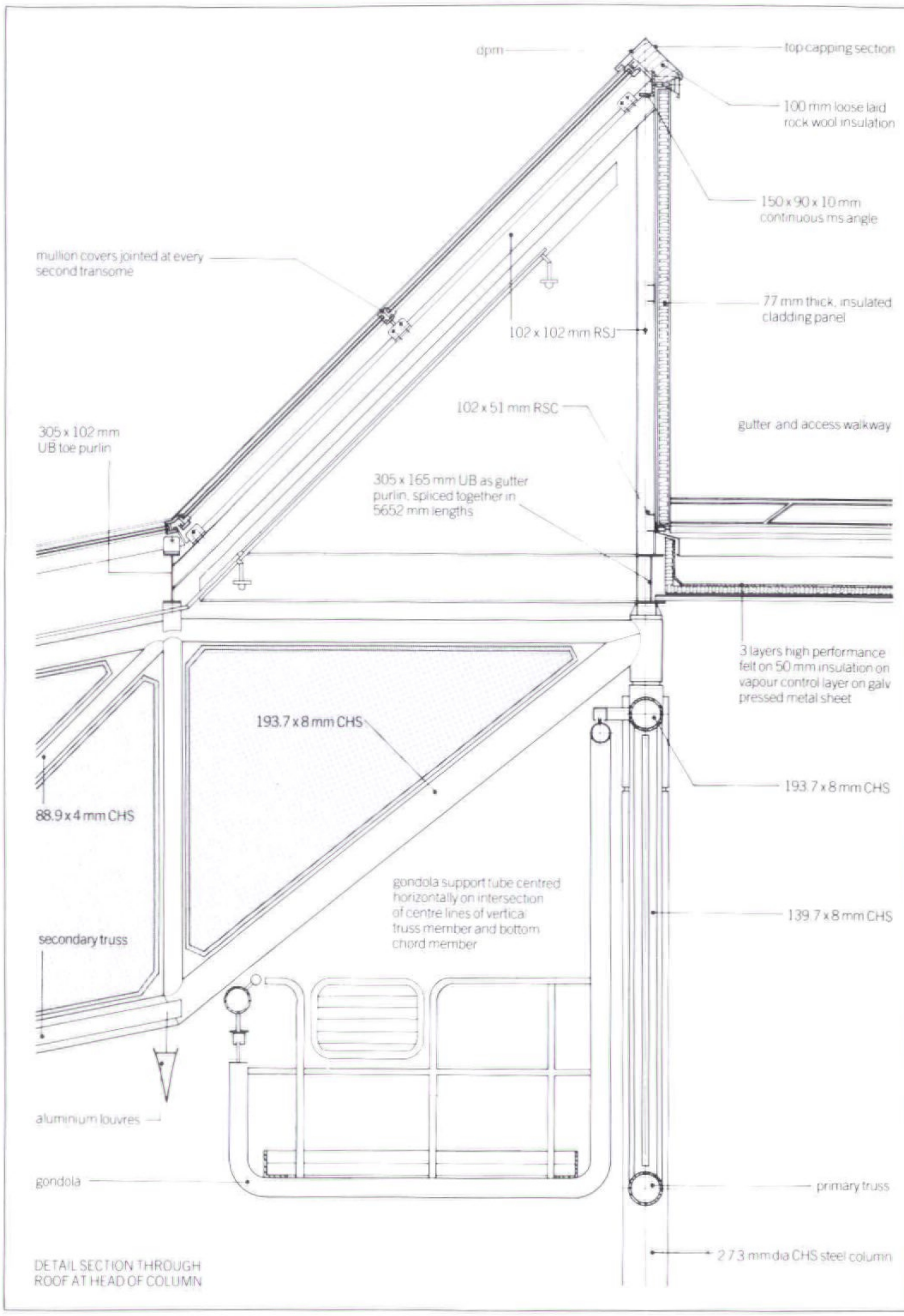
CROSS SECTION

3



4

2 Isometric of the roof at the head of one of the columns. 'Sailcloths' not shown.
3 Long section through the building, showing the roof sloping up from the south-east and south-west corners to the centre of the north elevation.
4 Close-up showing how the glassfibre 'sailcloths', which both diffuse light and help to contain smoke, are fastened to the trusses.
5 Detailed section through the edge of the main roof glazing. The roof is designed to accommodate thermal stresses rather than having movement joints around the perimeter.
6 Roof plan. The 11.25° glazing is shown with a light tint, the 45° glazing with a dark tint. To minimise the number of roof penetrations the 2.5 m wide diagonal walkways are used as low-flow channel gutters, leading to the outflow sumps. These are separated from the perimeter walkways by overflow weirs. A camber of 1:200 on the diagonal gutters was specified to counter any differential settlement — estimated to be up to 40 mm (including 6-10 mm of intermittent, recoverable store loading) at certain columns. In the report on the roof drainage the engineer states both that a 'monitoring system is recommended' and that the 'standard of workmanship required will be high, but not higher than . . . customary' for such a project. If there is flooding a moisture detector should be activated as part of the building management system.



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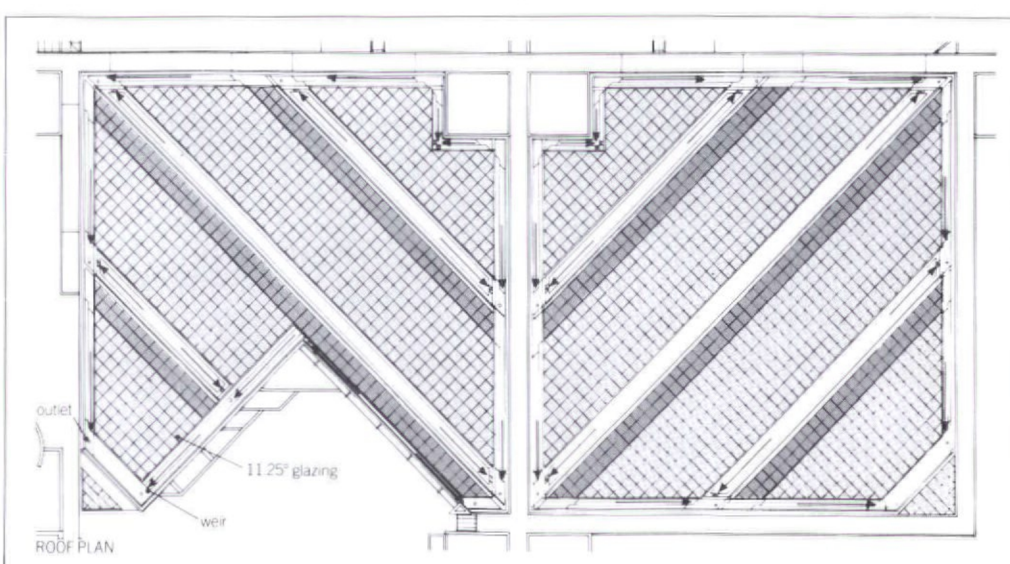


6

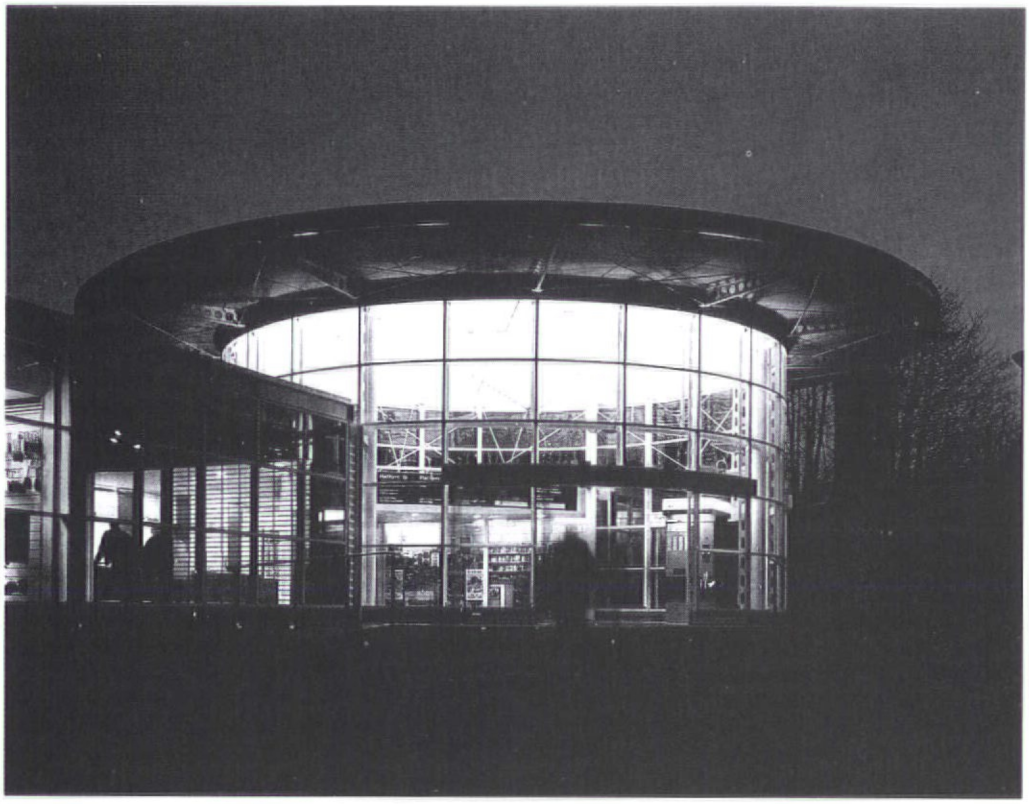
Credits
location Wood Street, Kingston upon Thames, Surrey
client John Lewis Partnership
architect Ahrends Burton and Koralek
quantity surveyor Davis Langdon & Everest
structural and drainage engineer Ove Arup & Partners
project management Clarson Goff Associates
main contractor Mowlem Building
subcontractors: steelwork Tubeworkers, *roof glazing* Heywood Glazing Systems, *fire protection services* Wormald Fire Systems *glazing and windows* Solaglas Coventry (Projects) *supplier: glazed sandwich panels* Daylight Insulations (Glasgow).

Photo credit
Photographs by Martin Charles.

EXTERNAL WALLS AND ROOF
REDHILL TICKET HALL
Troughton McAslan

The ticket hall at Redhill's new station is a steel-framed, fully-glazed drum, tied into a single storey building.

Related article
On the right track
AJ 13.3.91 p26



1

1 Light from uplighters fixed on mid-height steelwork is used to articulate the structure at night.

In form, Redhill station's ticket hall is in the tradition of Holden's lofty, circular, daylit volumes. In construction it has more in common with the prefabricated iron and glass structure of a Victorian train shed. The focus here is the two-storey high, glazed steel-framed drum which fits into a surrounding single-storey, steel-framed building along its diameter. Structurally, much of the drum's stability comes from being tied into this frame which is tied back to a concrete retaining wall.

Steelwork erection began with four tubular columns equally spaced on a circle. The roof framing was welded on the ground as a stiff plate and craned onto the columns. The tubular ring beam at half height, the small tubular columns that sit on it, and the tie rods were then fitted. This storey-height truss serves a secondary structural function, providing lateral restraint against wind loading on vertical glazing mullions.

The roof build-up began with profiled galvanised steel sheet spanning between the radial beams, the troughs normal to the radius. Over these is a vapour control layer, then tapered cork insulation which provides a 1:100 fall. The roof is finished with a two-layer, high performance felt with capped upstands 75 mm above the roof surface. The gutter where the drum meets the single-storey roof has the same build-up and fall. The roof is guaranteed for 10 years.

Insulated rendered panels (Dryvit) are fixed to the decking soffit which has been painted black to define the joints.

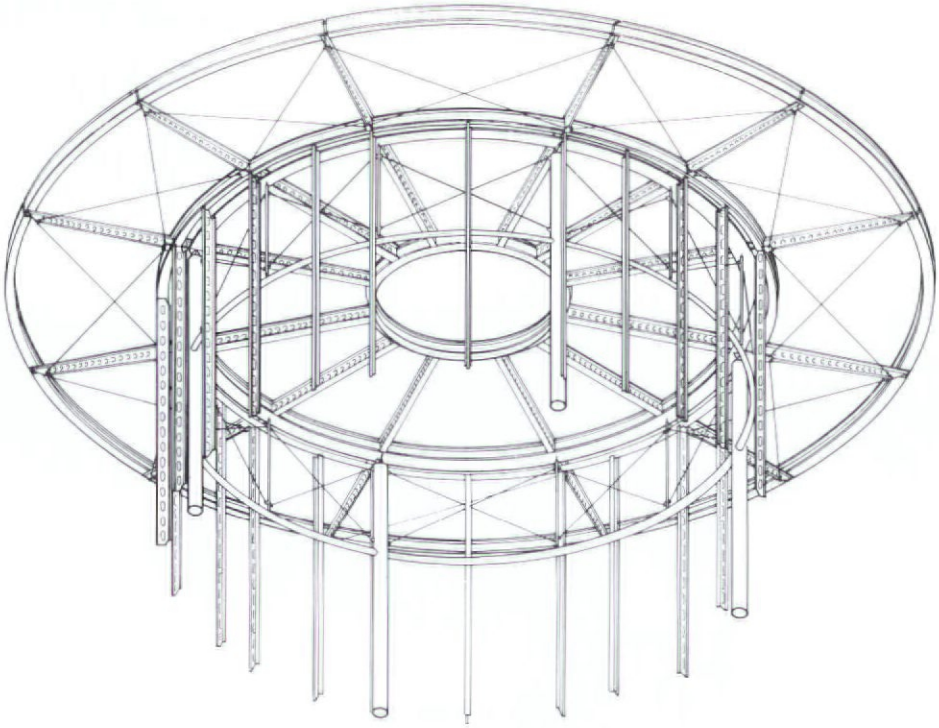
Steelwork was blast cleaned, then coats of zinc-rich primer, micaceous ferrous oxide and a decorative oil-based paint were applied in the factory. Site welding and scratching led to limited site repainting.

The proprietary curved glazed cladding is fixed at its base and restrained at its head. The effects of thermal movement on the glazing, where the mid-height of the full-height elements meet the fixed base of the half-height glazing elements at the back, are designed to be taken up within the flexible sealant used in the glazing sections.

At the base of the glazing the 100 mm wide upstand is narrow for good concrete placing, so required careful construction. The upstand is faced with terrazzo which spans the gap between upstand and cladding base, supported on mesh reinforcement fixed through the dpm.

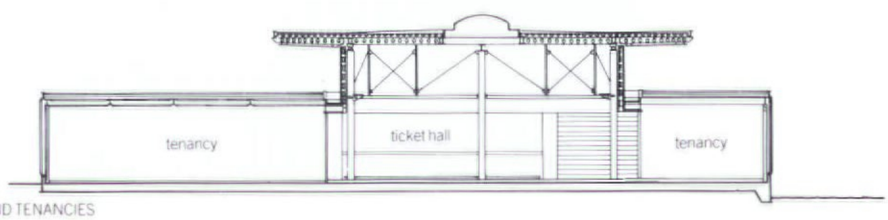
The drum is unheated. Thermostatically controlled extract fans in the roof prevent heat building up in summer. Shading from the insulated overhanging roof will reduce solar heat gain. The roof relies on normal air humidity levels and on small temperature differences from inside to out to eliminate condensation risk within its structure: the vapour control layer is present as part of the proprietary roof system. ■

Acknowledgment
The editors acknowledge the assistance of Lionel Friedland of Pentarch and John Campbell of Terry Farrell & Company in the preparation of this article.



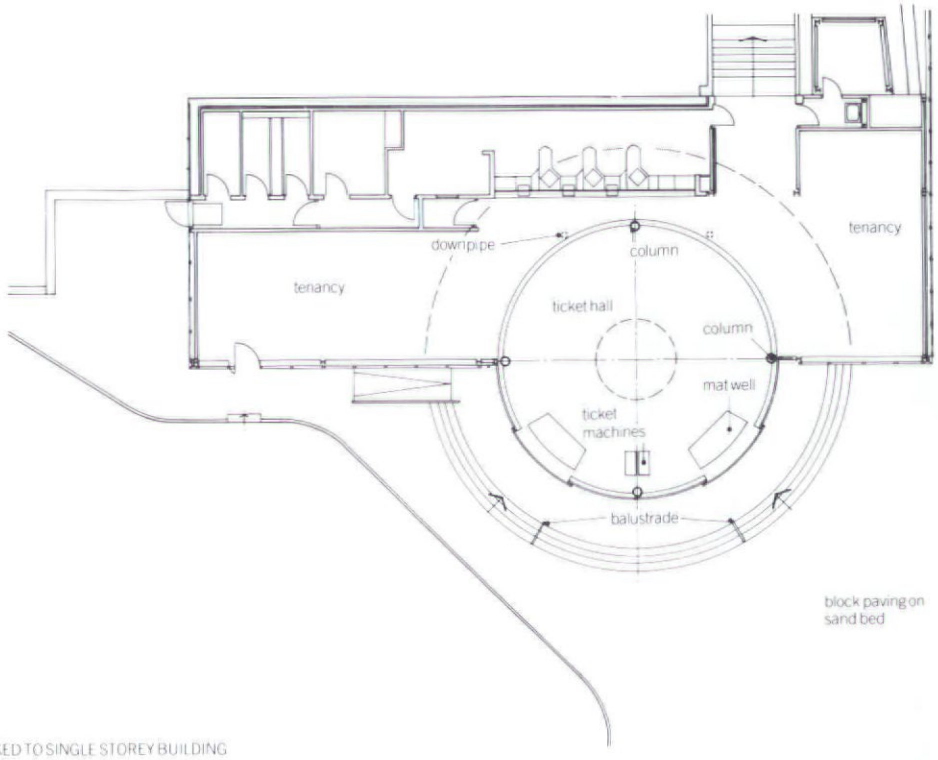
THE STEELWORK OF THE DRUM

2



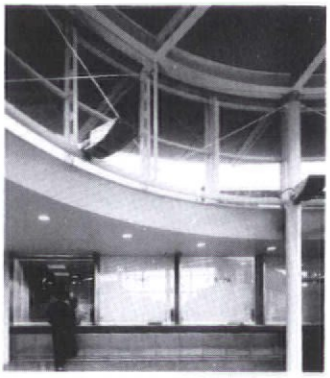
SECTION THROUGH DRUM TICKET HALL AND TENANCIES

3



PLAN OF DRUM LINKED TO SINGLE STOREY BUILDING

4



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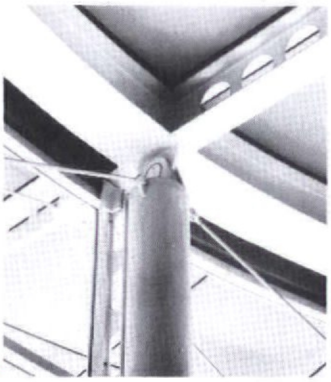
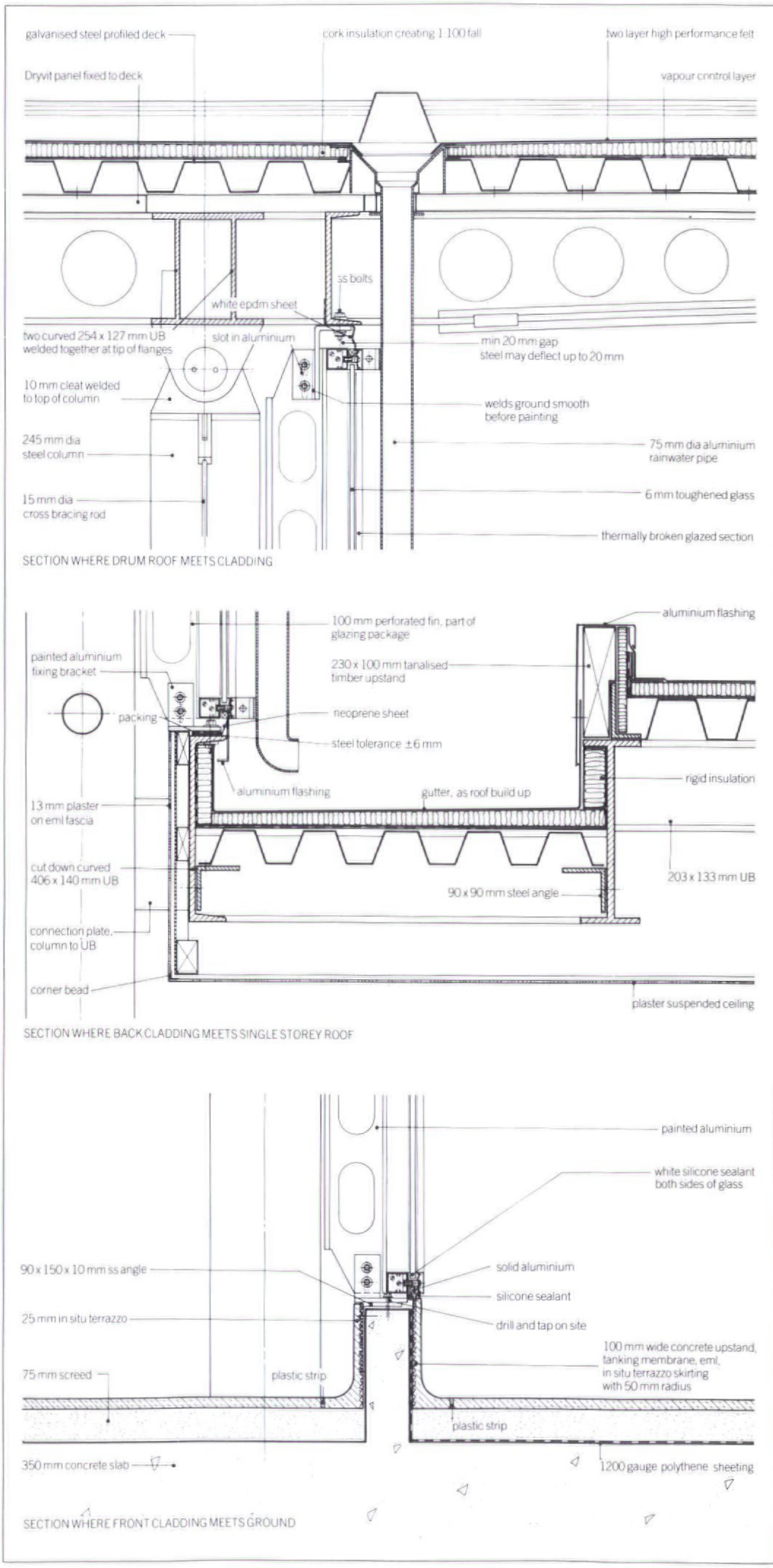


6

2 Steelwork of the drum.
3 Building section.
4 Plan of drum tied into single-storey structure.
5 Where the drum meets the single storey.
6 The steel detailing and composition reads well whether in close-up, as shown here, standing back as in 5, or in long focus silhouette as in 1.
7 Sections through drum skin at roof, at mid-height at back, and at ground level at front.



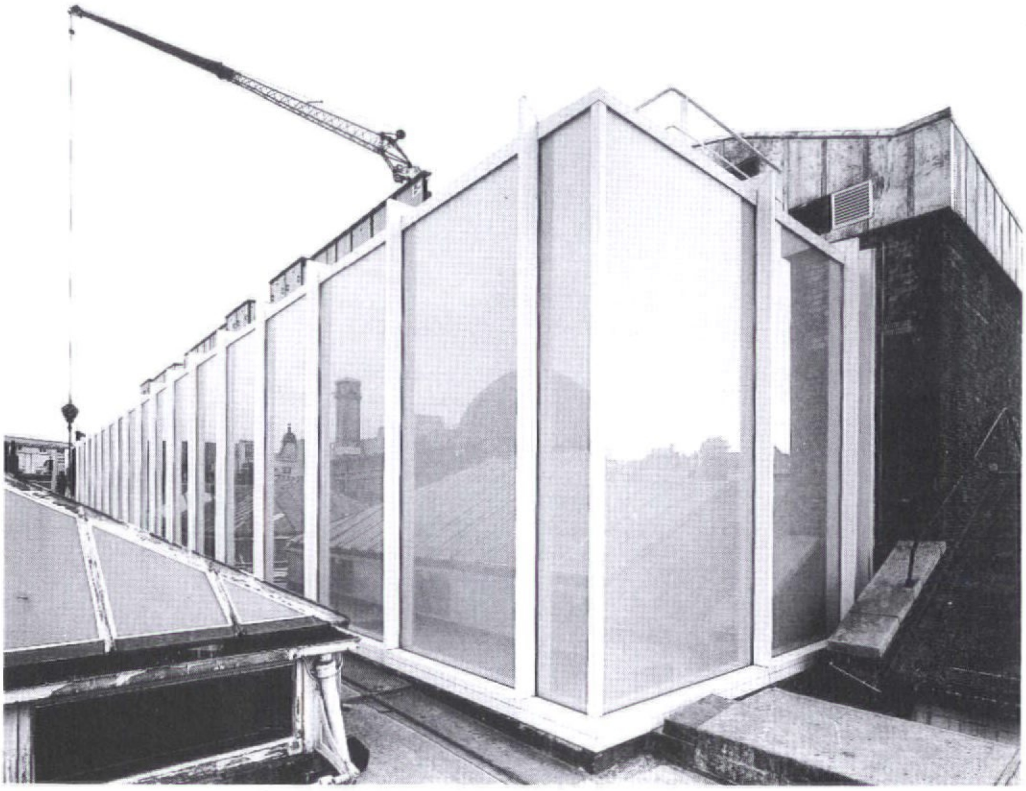
7

Credits
architect Troughton McAslan
job architects Kevin Lloyd, Stephen Pimbley, Aidan Potter, Bob Atwal
associate architects British Rail (Southern) Department of Architecture, Design and Environment
structural engineer Alan Baxter & Associates
mechanical engineer Steensen Varming & Mulcahy Partnership
quantity surveyor Boyden & Company *main contractor* Lovell Construction

EXTERNAL WALLS AND ROOF
ART GALLERY
Foster Associates

An existing lightwell has been given new translucent walls and roof to transform it into an exhibition and circulation space.

Related article
Front feature
AJ 12.6.91 p24



1

1 A view of the new enclosure (at the top of the lightwell) which the public will never see. The cladding was installed from outside, by crane, because of the access restrictions inside. The main depth of the mullions is therefore visible externally rather than internally.

In the course of its work to the Diploma Galleries on the top floor of the Royal Academy, Foster Associates has brought into use the lightwell that was formed between Burlington House and the mid-nineteenth century academy extension by Sidney Smirke.

Reminiscent of the space that Herron Associates converted for Imagination, this space has been used primarily to create an imaginative solution to circulation problems. It has a curved glass hydraulic wall-climber lift, big enough to take the largest exhibits, and a cantilevered glazed stair. But the space at the top of the lightwell is used for exhibiting sculpture — a series of pieces stand on what was once the external parapet of the Victorian extension.

To enclose this space Foster Associates has walled it on three sides, and partially roofed it, with translucent glazing.

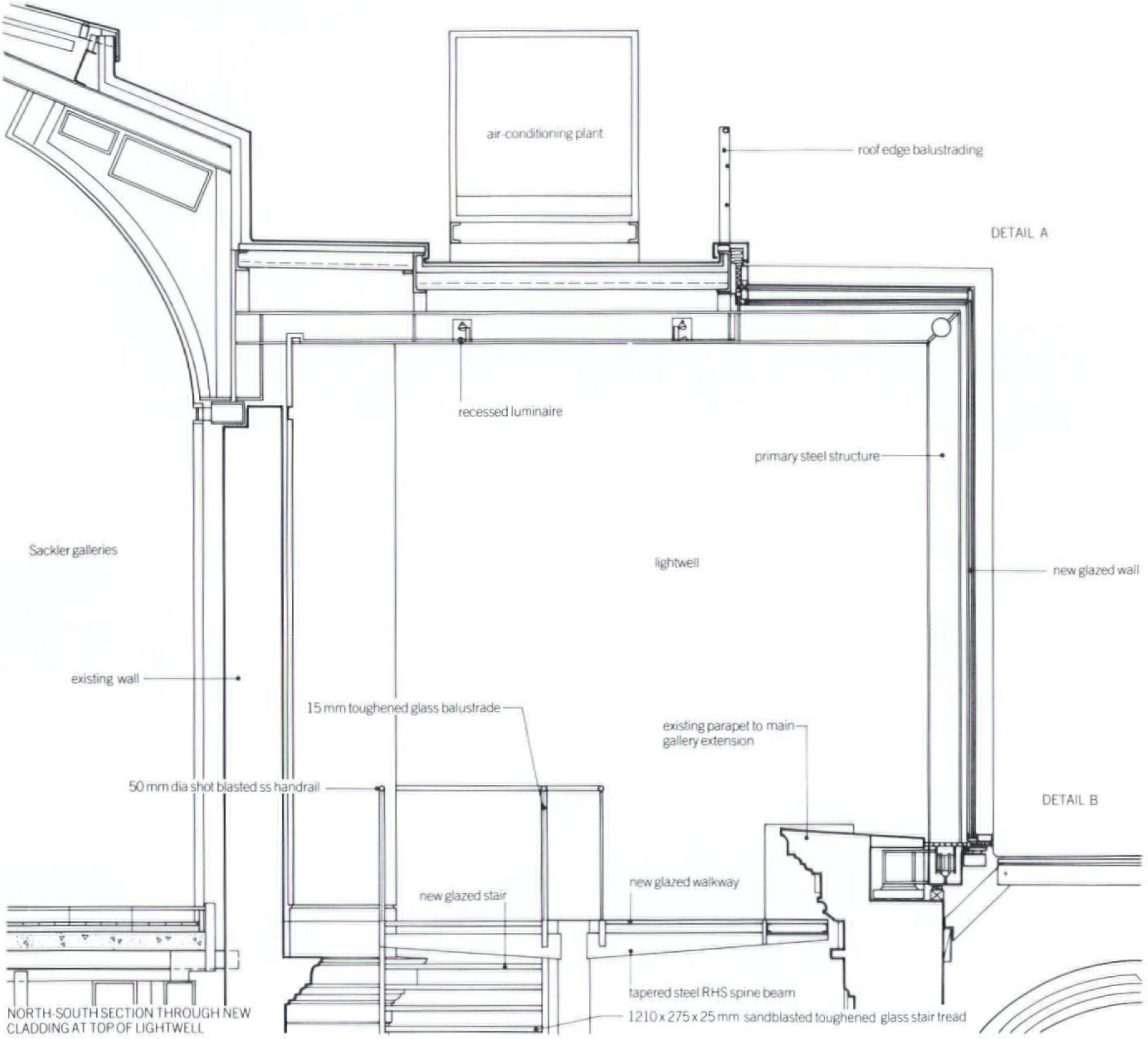
The glazed cladding system is supported on a new steel frame, which is in turn supported on the existing parapet wall of the main galleries and the existing wall of Burlington House. To allow maximum use of the top of the parapet for display, the steelwork is connected to the outside of the wall by a knee joint. The pin joints at the column-to-beam connection allows the steel sections to be slimmer than if a fixed joint had been used. A continuous gap between portal frame and cladding shows their structural independence from each other.

The height of the space was determined by the biggest sheet of glass which could be laminated — 4.2 m high. Czechoslovakian glass has been used for its lack of green tint. At the roof there is an additional horizontal layer of glass, so that the external layer above it can be laid to fall.

Because of the size of the glass panels and the need to keep the academy open, the panels were craned in and installed externally. The thickness of the mullions is therefore only visible externally. Foster Associates was concerned about the shadows that this might cause. In fact, in bright sunlight they are satisfyingly crisp and in cloudy conditions they disappear completely.

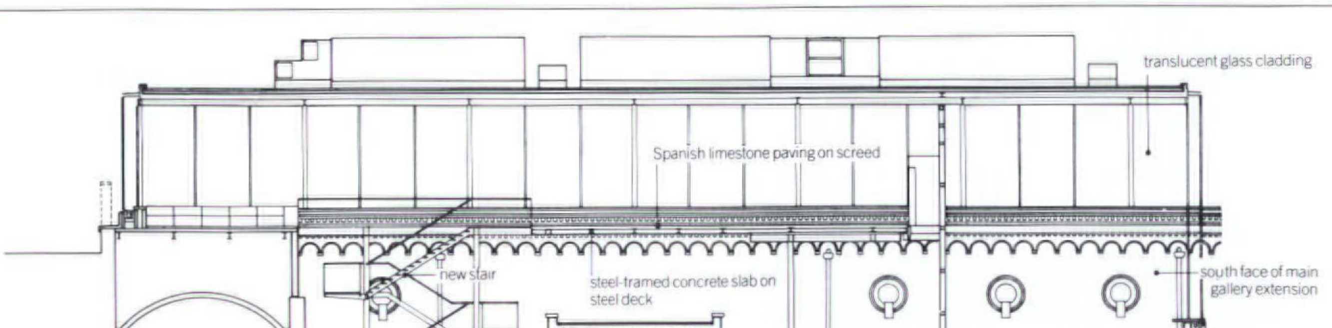
With the galleries remaining open ingress of water had always to be guarded against, particularly when the existing roof was opened up. (A slit was also cut through the existing parapet to allow the insertion of the east cladding wall which extends down through the floor below. This makes a visually neat junction, although it does irreparably destroy a small section of the parapet.) To induce an airflow up the surface of the glass to avoid condensation there is a continuous heater at the base of the new cladding to eliminate any condensation. There is also an overflow system that drains into a sump and on to the old roof, in case the heated water pipes should leak. ■

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Co and Lionel Friedland of Pentarch in the preparation of this article.



NORTH-SOUTH SECTION THROUGH NEW CLADDING AT TOP OF LIGHTWELL

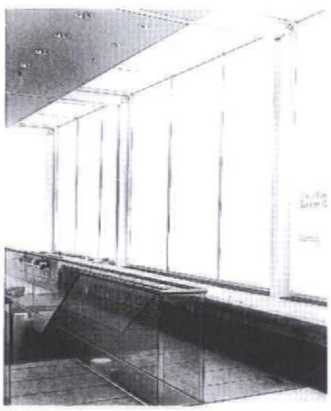
2



EAST-WEST SECTION THROUGH LIGHTWELL

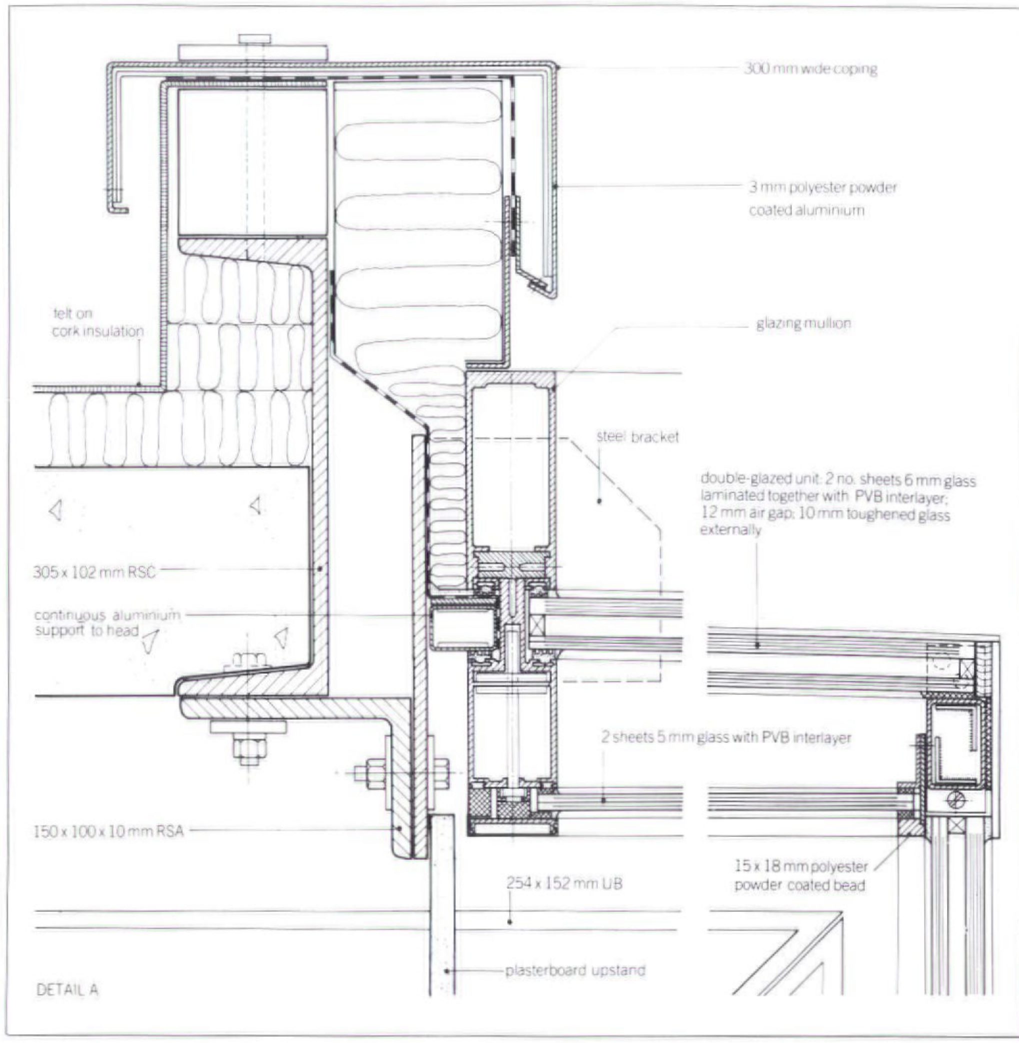
3

4



5

2 Cross-section through the new cladding to the top of the lightwell.
3 Long-section through the lightwell.
4 The neat slice through the parapet for the glazing next to the lift. A similar slot was made for the new cladding.
5 The new cladding. There is a continuous gap of 50 mm between the cladding and the steel frame, showing their structural independence from one another. Sculptures will sit on top of the original parapet wall, which forms the shelf at the bottom of the new glass cladding.
6,7 Details of the new translucent cladding at its junction with the adjacent roof and with the original parapet wall below. A 50 mm angle fillet was provided for the roofing felt at the base of the upstand. The roofspace between single and double glazing is ventilated. The support for the new roof membrane in 7 is omitted for clarity.



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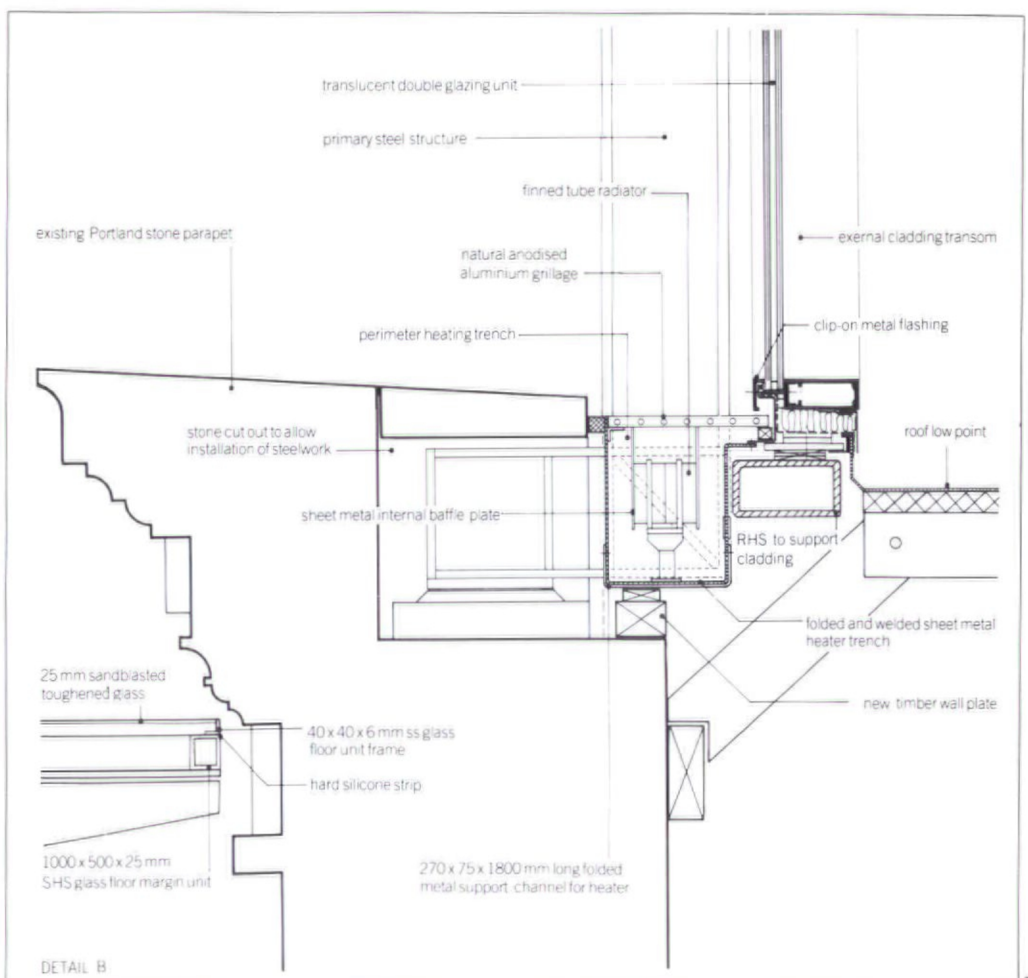


7

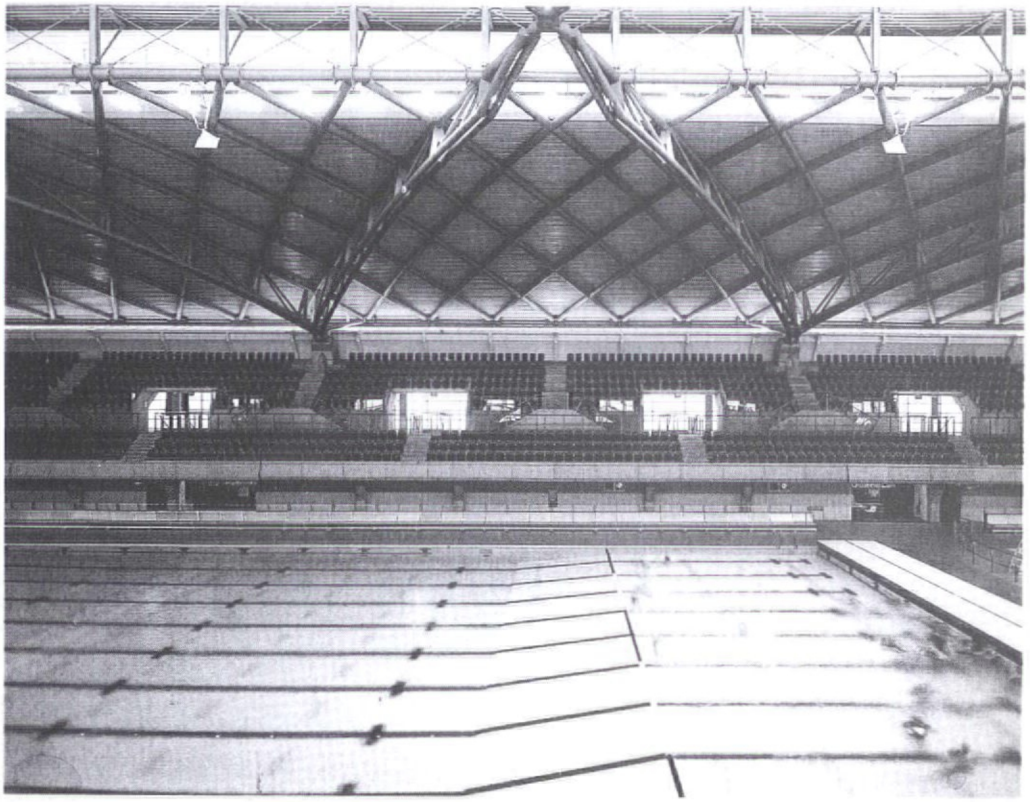
Credits
location Royal Academy of Arts, Piccadilly, London W1
client Royal Academy of Arts, London
architect Foster Associates
structural engineer YRM Anthony Hunt Associates
services engineer James Briggs Associates
lighting consultant George Sexton Associates
historic buildings consultant Julian Harrap Architects
quantity surveyor Davis Langdon & Everest
construction management Bovis Construction
subcontractors: glazed wall cladding GIG

Photo credit
Photographs by Dennis Gilbert.

ROOF
SWIMMING POOL
FaulknerBrowns

Ponds Forge swimming pool has a tubular steel roof built as a three-hinged arch. It is free of services and has an acoustically absorbent deck.

Related article
Building feature
AJ 17.7.91 p18



1 Three pairs of main tubular steel lattice arches span the hall. The tubular secondary steel can also be seen, and a roof walkway with its lighting fittings.

This swimming pool, built for the World Student Games, has a roof structure of welded steel tube, free of ducting. To achieve this the air supply system is integrated with the floor structure.

Concrete air input ducts are located below the seating at the sides of the hall. The air rises from these up the curve of the roof and descends over the pool to be extracted at its sides. Located below the pool surround are 9 m^2 concrete extract ducts and the air leaves through gratings along the whole length. These gratings also take water that splashes out of the deck-level pool into concrete gutters in the air ducts. As the ventilation air flows across the hall and then downwards, it keeps the moist air from the pool away from the roof steel and the spectators.

The roof has a main structure of three pairs of diagonal tubular lattice arches, plus two more arches for the gable ends, hinged to four bearings on each side of the hall, each on a concrete A-frame support. There are hinges in the centre of the span, and the roof is shallow for a hinged arch, having a rise of 5 m on a span of 58 m. Secondary diagonal steel tubes span between the arches. Deeply corrugated perforated decking, with acoustic infill, spans 4 m between the secondary steel. It is jointed above the diagonal tubes, not visible from below.

Above the decking is insulation and the aluminium roof sheeting which has standing seams and is in single lengths from eaves to roof lights. Because the services are at low level there are no pipes protruding through the roof surface. The main roof bearings had to be set out very accurately. Temporary towers on the centre line of the pool supported the central hinges during erection. On completion of the roof these towers were removed and the resulting deflection was about 150 mm.

The roof steel is finished in a micaceous iron oxide paint. Owing to site welding of the tubular steelwork, the last coat had to be applied after erection by specialist painters who climbed the steel.

The pool hall is kept at a constant temperature day and night, the air-handling plant running continuously, so movement of the steel structure is mainly caused by wind and snow loads. There is an allowance for 100 mm of movement at the gable ends.

There are two long internal roof walkways, accessible from a sliding ladder from the top diving board. The main light fittings are fixed to the underside of the walkway floor panels. These panels hinge upwards giving very easy access to the lights. Permanent TV lights are also accessible from these walkways.

To minimise glare all glass is obscured with glass-fibre in the cavity of the double-glazed units. At night ultraviolet uplighters make the edge of the roof glow. ■

Acknowledgment
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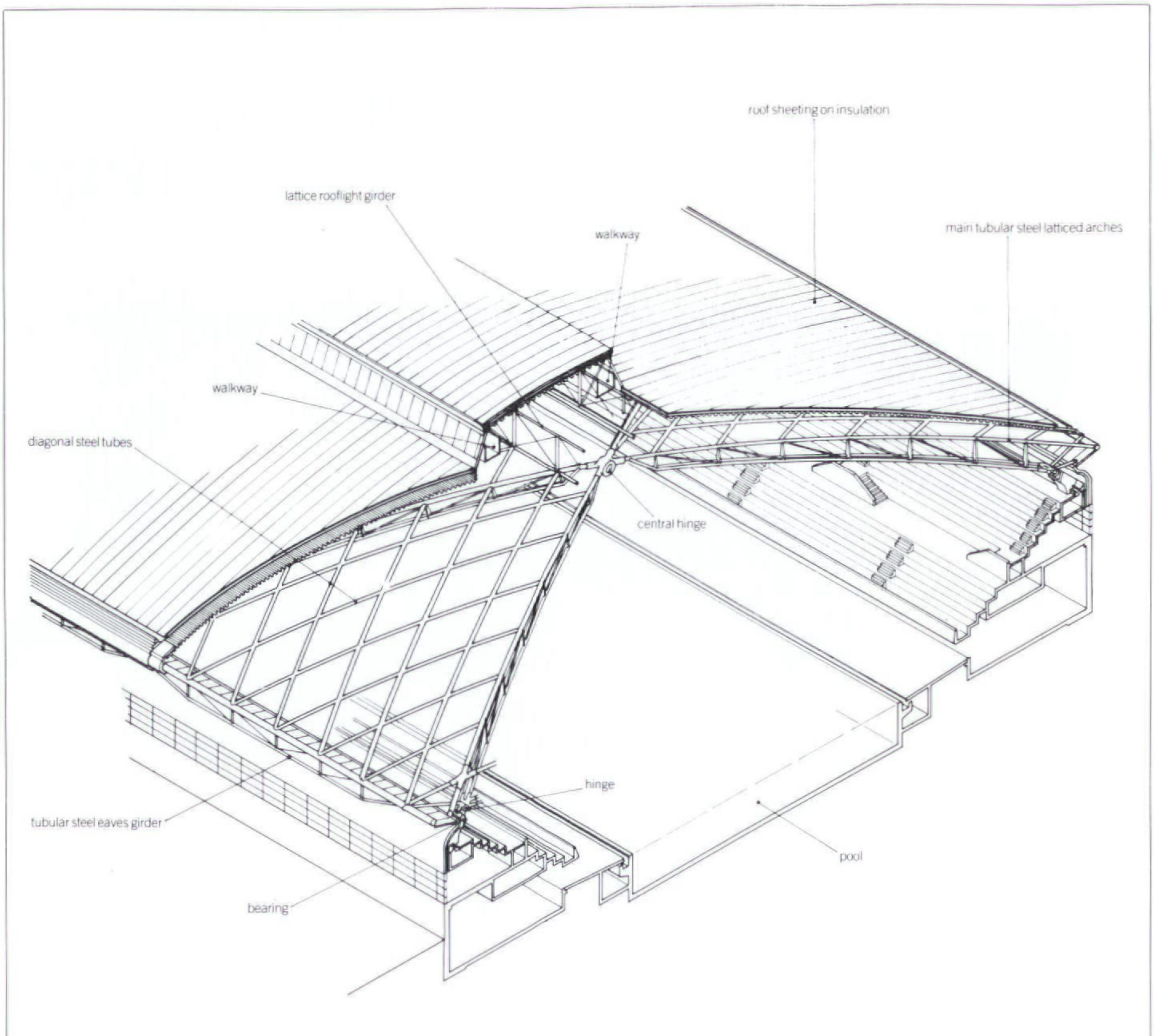
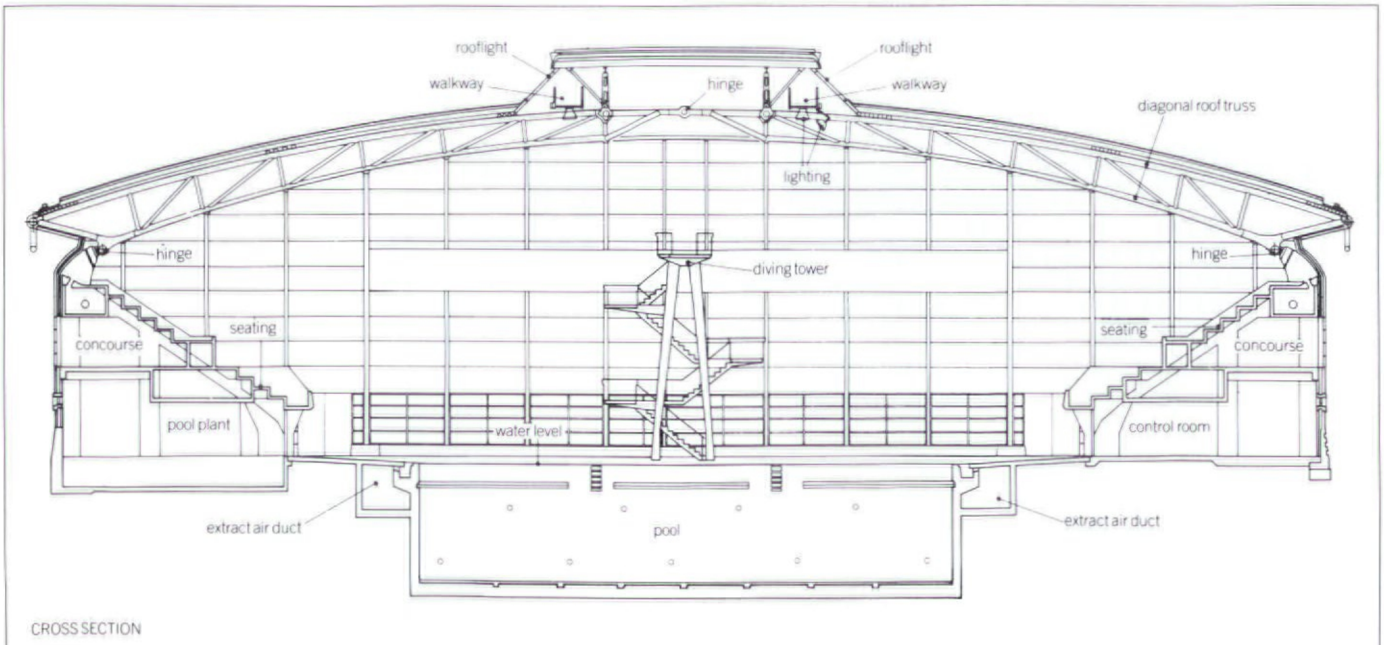
2



ISOMETRIC OF POOL ROOF

3



CROSS SECTION

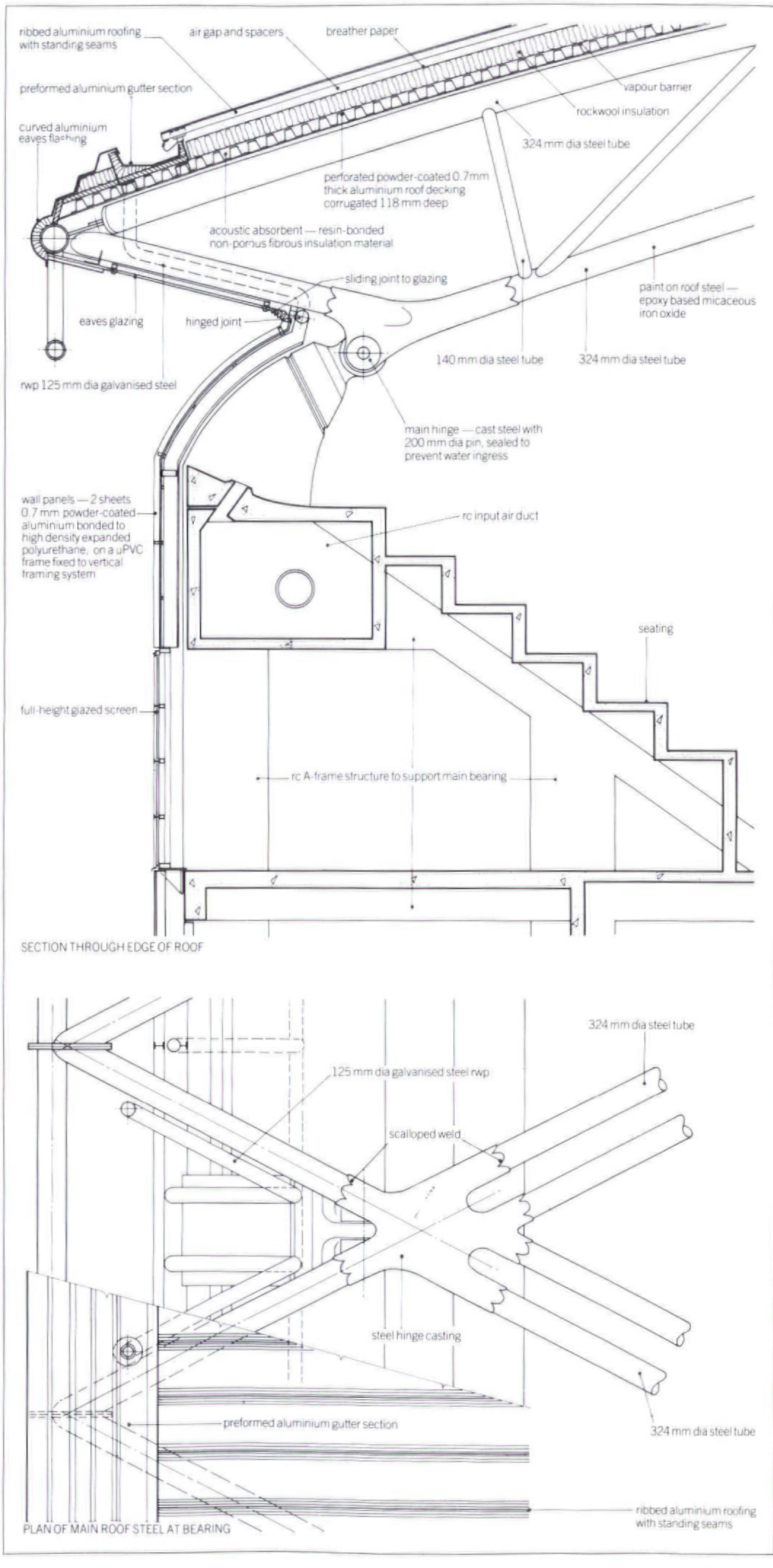
4

5

2 Cutaway isometric of roof.
3 Section through pool hall.
4 One of the main roof bearings.
5 One of the walkways showing access to the light fittings.
6 Section through the edge of the roof and plan of a main roof bearing. If condensation forms below the roof sheeting, the breather paper sheds it into the gutter. The inside of the concrete air duct is treated with a proprietary sealer.

Credits
location Sheaf Street, Sheffield. *client* Sheffield City Council *architect* FaulknerBrowns *partners in charge* Bill Stonor, Stuart Hendy *project architect* Jon Ignatowicz *contract administrator* Gareth Gunn *assistant architect (pool hall)* John Holt *technical manager* Keith Robson *water treatment design* Tom Devin *services co-ordination* Derek Laws *quantity surveyors* Gleeds, Newcastle, Gleeds Nottingham *services: electrical and mechanical engineering* Ove Arup & Partners — Manchester *structural engineer* Ove, Arup & Partners — Newcastle *swimming consultant* Hamilton Bland *sports consultant* George Torkildsen *acoustics* Sandy Brown Associates *management contractor* Mowlem Management Ltd *subcontractors: steelwork* Robert Watson, *high-level walkways* RJD *fabrications*, *roof glazing* Briggs Amasco, *wall cladding* Graingers, *roof decking* Percy Rowles, *scoreboard/timing* Omega Electronics, *water treatment* Thermelek, *tiling* Andrews, *electrical* Hall Electrical, *balustrading* Mears & Priestley, *pool roof painting* High Rise Services, *seating* Tubular Engineering, *floating pool floors* Polymarin BV, *moving bulkheads* Recreonics Corporation, *pool accessories* Racco Products.

Photo credit
Photograph 1 by Peter Cook.



6

GLAZED CONCOURSE
COURTHOUSE
Kit Allsopp Architects

Running through the centre of this building is a glazed public concourse. It is supported by central concrete columns, and concrete beams on columns built into the blockwork side walls.

Related article
Building feature
AJ 4.9.91

1

1 The steel framework supporting the glazing sits on continuous in situ concrete beams along the side walls. Fixed to the front of the beams are heating pipes to minimise any condensation on the glass.

The Northampton courthouse is a concrete-framed building with a steel-framed roof. The buff aggregate-faced blockwork (to match the nearby fire station and swimming pool) is non-loadbearing. The accommodation is layered across the site, and the middle layer in the sandwich is a double-storey glazed public concourse.

The architect wanted this area to feel like outside space, but it also houses the reception area, seated waiting areas outside the courts on the upper floor, and circulation (by ramp, stair and lift) between the two.

Its main support structure (see also Nurses' Centre, Barking, AJ 24.2.88 p33) is therefore very visible — circular concrete columns at 6 m centres (the best spacing structurally for the building) support a light steel framework. The roof configuration is formed from a series of inclined steel beams, which are also supported by *in situ* concrete beams running the length of the side walls. These beams form the valley gutters along either side of the concourse, tie together the column heads and have extended toes to form lintels over openings. Rainwater pipes run down beside the columns, hidden behind blockwork, but with accessible rodding eyes at ground-floor level.

Glazing along each side of the roof allows the space below it to be daylit. Any more glazing could have led to overheating, particularly as one of the cost savings made was to omit extract ventilation from the roof apex. Grey Antisun glass is used in the outer skin to the double glazing over the first-floor seating area. The double-glazed units are typically 7.5 mm externally and 6 mm internally with a 10 mm gap.

The central area of the concourse roof is framed in steel and timber with painted plasterboard below and Terne-coated steel (stainless steel with a 20 micron coating of 80 per cent lead and 20 per cent tin). The coating has a similar appearance to lead and is as durable, but cheaper. The architect would have liked copper, but the potential for electrolytic action with the aluminium glazing bars made its use inadvisable.

Four ducts supply heating to the seating area, and additional finned central heating pipes run in front of the glazed gables at ground- and first-floor level (hidden below grilles). Just below the roof glazing simple heating tubes have been installed to minimise the risk of condensation on the glass. The only ventilation is through the manually operated louvres in the gable walls and via the supply and extract ventilation to the gallery.

The lighting comes from fittings which provide up- and downlighting. There are also lights to the ramp, and downlighters under the bridge.

The roof and gables are detailed so that the position of the gables almost looks arbitrary — emphasising the feeling of the concourse being in an external space. The finishes are all appropriate to an exterior space, including the paving flags.■

Acknowledgment
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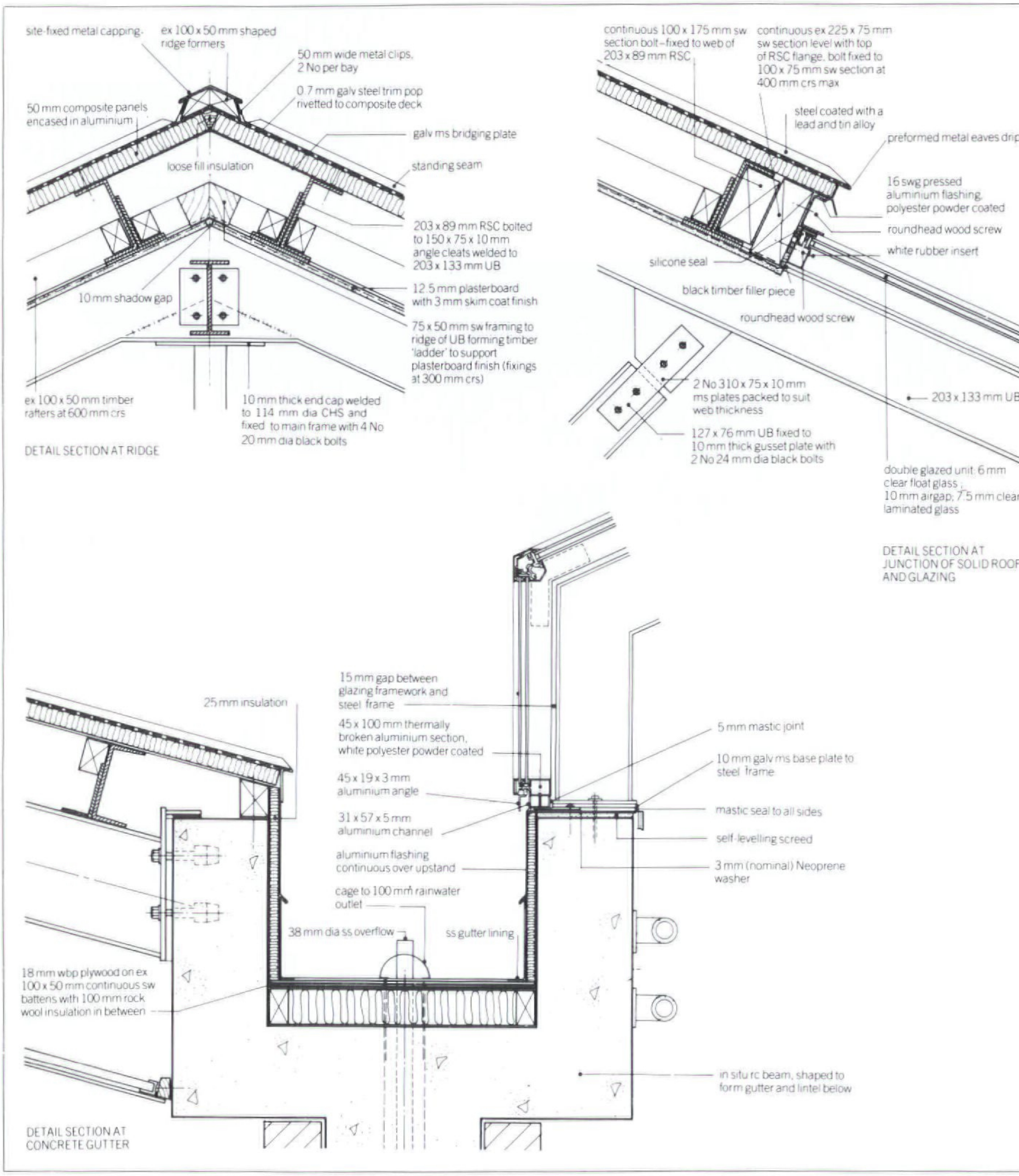
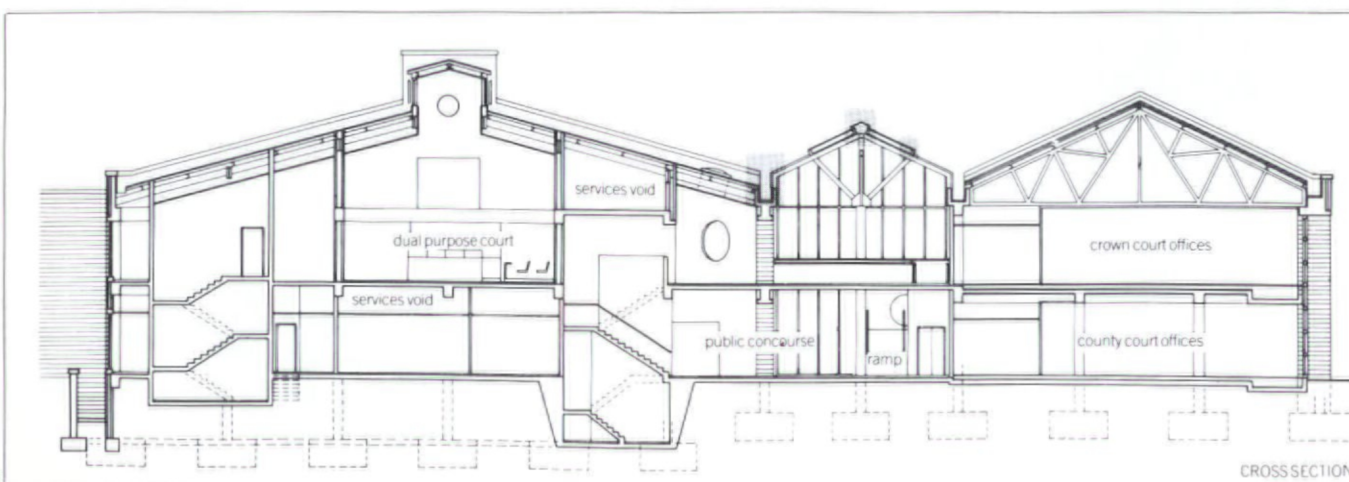

site-fixed metal capping
ex 100 x 50 mm shaped ridge formers
50 mm wide metal clips, 2 No per bay
0.7 mm galv steel trim pop rivetted to composite deck
50 mm composite panels encased in aluminium
galv ms bridging plate
loose fill insulation
standing seam
203 x 89 mm RSC bolted to 150 x 75 x 10 mm angle cleats welded to 203 x 133 mm UB
10 mm shadow gap
12.5 mm plasterboard with 3 mm skim coat finish
75 x 50 mm sw framing to ridge of UB forming timber 'ladder' to support plasterboard finish (fixings at 300 mm crs)
ex 100 x 50 mm timber rafters at 600 mm crs
10 mm thick end cap welded to 114 mm dia CHS and fixed to main frame with 4 No 20 mm dia black bolts
DETAIL SECTION AT RIDGE
continuous 100 x 175 mm sw section bolt-fixed to web of 203 x 89 mm RSC
continuous ex 225 x 75 mm sw section level with top of RSC flange, bolt fixed to 100 x 75 mm sw section at 400 mm crs max
steel coated with a lead and tin alloy
preformed metal eaves drip
16 swg pressed aluminium flashing, polyester powder coated
roundhead wood screw
white rubber insert
silicone seal
black timber filler piece
roundhead wood screw
2 No 310 x 75 x 10 mm ms plates packed to suit web thickness
203 x 133 mm UB
127 x 76 mm UB fixed to 10 mm thick gusset plate with 2 No 24 mm dia black bolts
double glazed unit: 6 mm clear float glass, 10 mm airgap; 7.5 mm clear laminated glass
DETAIL SECTION AT JUNCTION OF SOLID ROOF AND GLAZING
15 mm gap between glazing framework and steel frame
25 mm insulation
45 x 100 mm thermally broken aluminium section, white polyester powder coated
5 mm mastic joint
10 mm galv ms base plate to steel frame
45 x 19 x 3 mm aluminium angle
31 x 57 x 5 mm aluminium channel
mastic seal to all sides
self-levelling screed
aluminium flashing continuous over upstand
3 mm (nominal) Neoprene washer
cage to 100 mm rainwater outlet
38 mm dia ss overflow
ss gutter lining
18 mm wbp plywood on ex 100 x 50 mm continuous sw battens with 100 mm rock wool insulation in between
in situ rc beam, shaped to form gutter and lintel below
DETAIL SECTION AT CONCRETE GUTTER

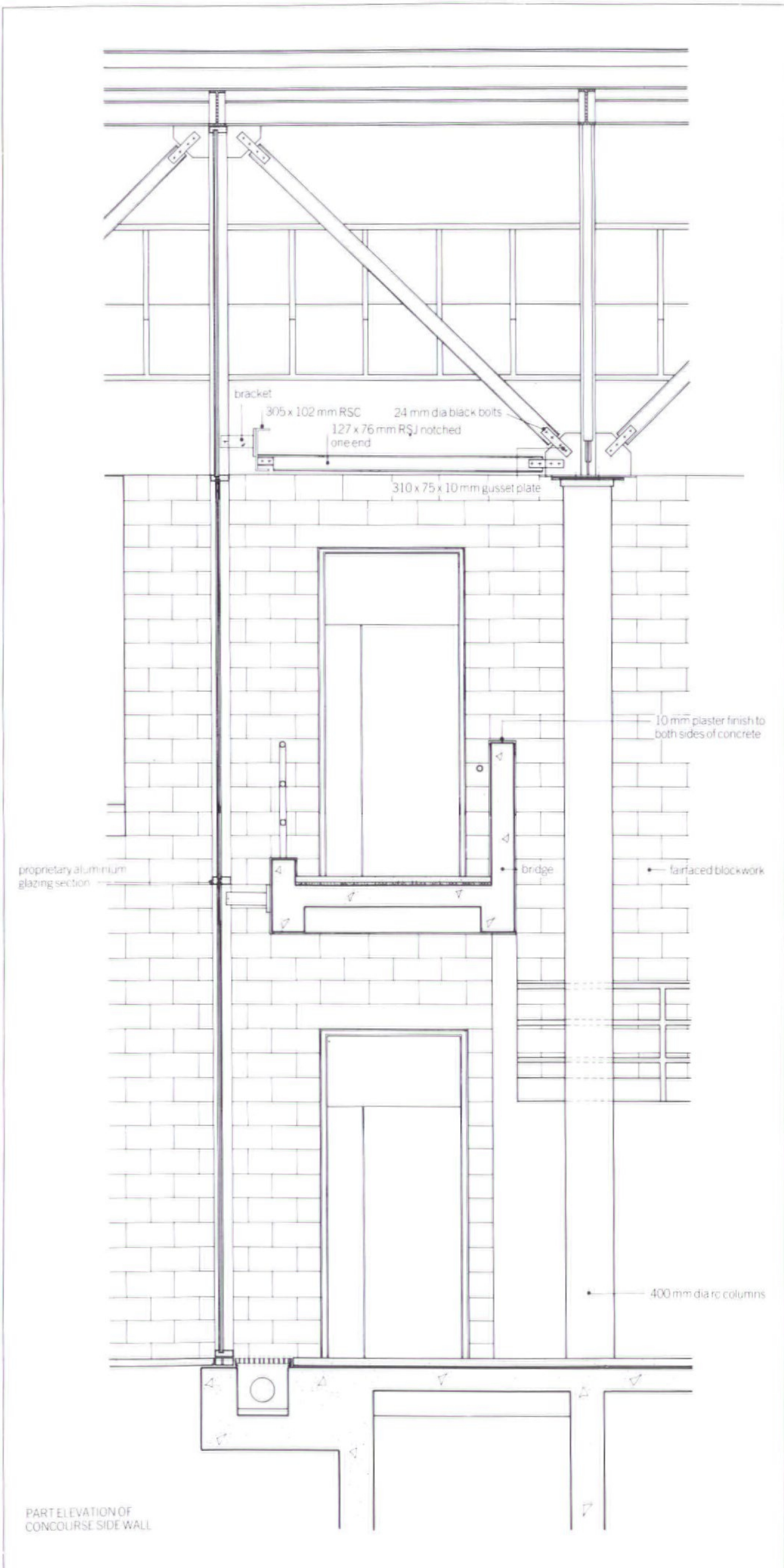
2


services void
dual purpose court
services void
public concourse
ramp
crown court offices
county court offices
CROSS SECTION

3

4

2 Details of key junctions in the concourse roof. The solid area of roof is shown unventilated — in which case any condensation occurring will be unable to escape.
3 Cross section through the building, the tinted areas showing the location of the details in 2.
4 Close-up of column heads.
5 Part side elevation of the concourse showing the junction with one of the end gables.



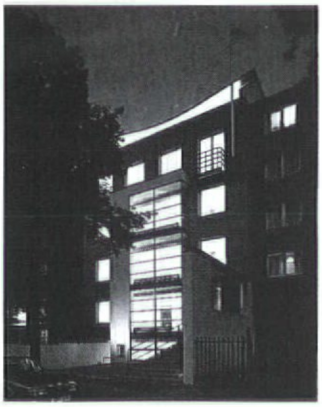
5

Credits
location Lady's Lane, Northampton
client Lord Chancellor's Department/Property Services Agency
architect Kit Allsopp Architects: Kit Allsopp, Andrew Bowyer, Vicky Browne, Peter Hughes, Brendan Phelan, Richard Russell
quantity surveyor Francis C Graves and Partners
services/electrical and mechanical engineer HL Dawson and Partners
structural engineer PSA Projects, Birmingham
project manager PSA Projects Birmingham, Lois Hall, David Greenwood
clerks of works PSA Projects Birmingham, Keith Woods, Derek Bull, Neil Adie
main contractor Taylor Woodrow Construction (Midlands)
subcontractors: mechanical services Lorne Stewart, HAT Engineering Services, *electrical services* Sunderland Forge, *paving* Slater Construction, *concrete works* CEDO Construction *handrailing/balustrading* JR Pearson, W and G Metalwork, *glazing systems, windows* Turner Fain Shopfronts, *steelwork* Smallman Construction, *roof coverings* IMI Broderick Structures, *suppliers: pavings* Marshalls Mono, Minster Stone (Wharf Lane), *rooflights* William Cox, *blocks* Boral Edenhall, Plean Precast, *tiling* Birmingham Tile and Mosaic, *heating grilles* Myson RCM, *doors* Shapland & Petter, *ventilation grilles* Waterloo Ozonair.

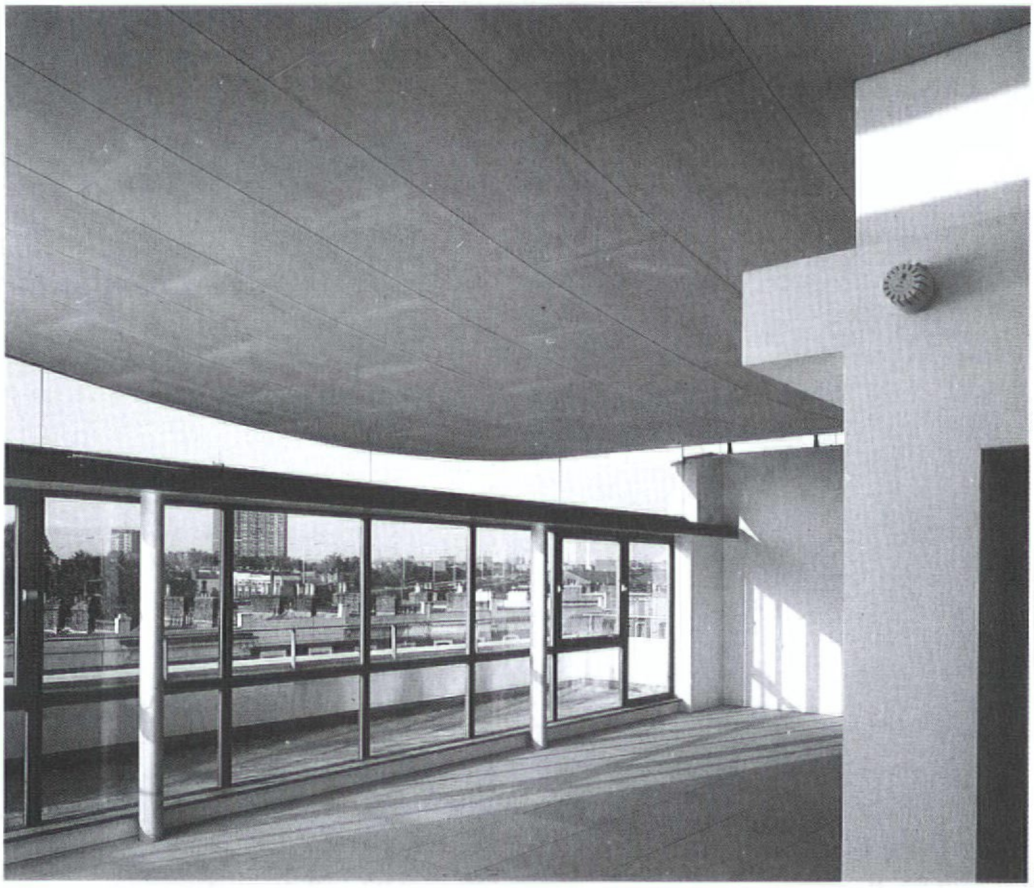
Photo credit
Photographs by Charlotte Wood.

ROOF
OFFICES
Munkenbeck + Marshall

This 225 mm thick stressed skin plywood roof spans 12 m. It appears to float on top of a glazed wall and clerestory windows.



1



2

1 No 87 Lancaster Road at dusk.
2 View out from the top floor.
3 View of the junction of different levels at the rear.
4 Front corner of the roof, showing the series of hinges behind the butt-jointed glass.
5 The side of the roof with its continuous glazed slot.
6 The upper storeys of the building.
7 Close-up of the eaves overhang at the front of the roof. The top of the glass can slide up and down in a slot in the roof.

Munkenbeck + Marshall's client, who already had planning permission for an office building at 87 Lancaster Road, had bought the site from another developer for whom maximum floorspace had been the aim. Munkenbeck + Marshall's redesign of the building gave it not only an extra floor, but also a gracefully slender concave roof that might just have flown in from Heathrow. The client liked it and the planners liked it — the architects had to make it work.

The offices are concrete-framed. To achieve a curved roof with a 12 m unsupported span engineers advised using steel, but this gave a minimum overall depth of 375 mm, far greater than the architects wanted. Alf Munkenbeck had already experimented with stressed plywood in his own house and finally found an engineer who thought it was possible to use stressed plywood here. The concrete frame was extended up to the top floor and a stressed plywood skin box is supported on simple steel hinges secured to a concrete ring beam.

Structural calculations were done for the roof not as a catenary curve, whose horizontal reactions would have been difficult to accommodate, but by treating it as a simple beam imposing only vertical reactions. The curved profile merely increases, slightly, the self weight of the roof. The roof is not in fact a continuous curve but one with a straight section at each side.

Roof/wall junctions

The main problem in use with such a shape, whose height is 750 mm, is deflection, which was calculated to reach a maximum of 75 mm. Assuming that those working in the top floor would not mind seeing their roof bending (they would already be sitting under a sloping ceiling), the problem was how to accommodate the movement at the roof/wall junctions. At this type of junction in the Stansted terminal hinges were also used (although the potential movement was much greater), but the weatherproofing was provided by an overlapping membrane. Munkenbeck + Marshall wanted glass elevations too — so that the roof would appear to float — and specified 10 mm toughened glass so that sheets could be butt jointed without mullions. But here movement is accommodated by a continuous check in the plywood skin roof, and a double weather seal allows the glass to slide up and down inside it while keeping out wind and rain. A single-ply membrane secured to the timber fascia is loose laid on the roof, whose underside tapers up to the fascia to help

Acknowledgment
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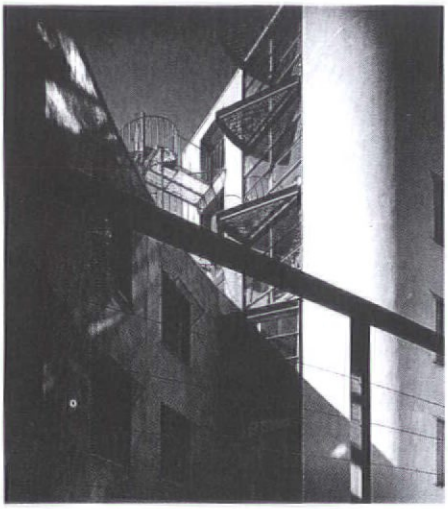
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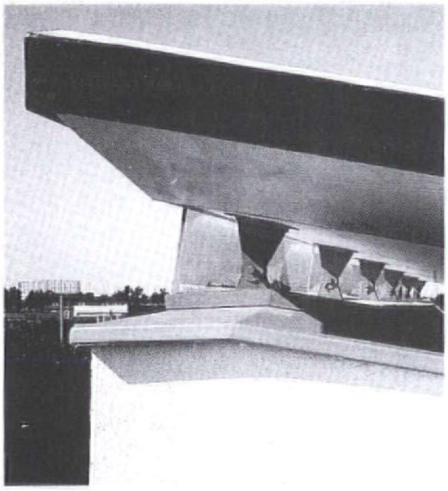
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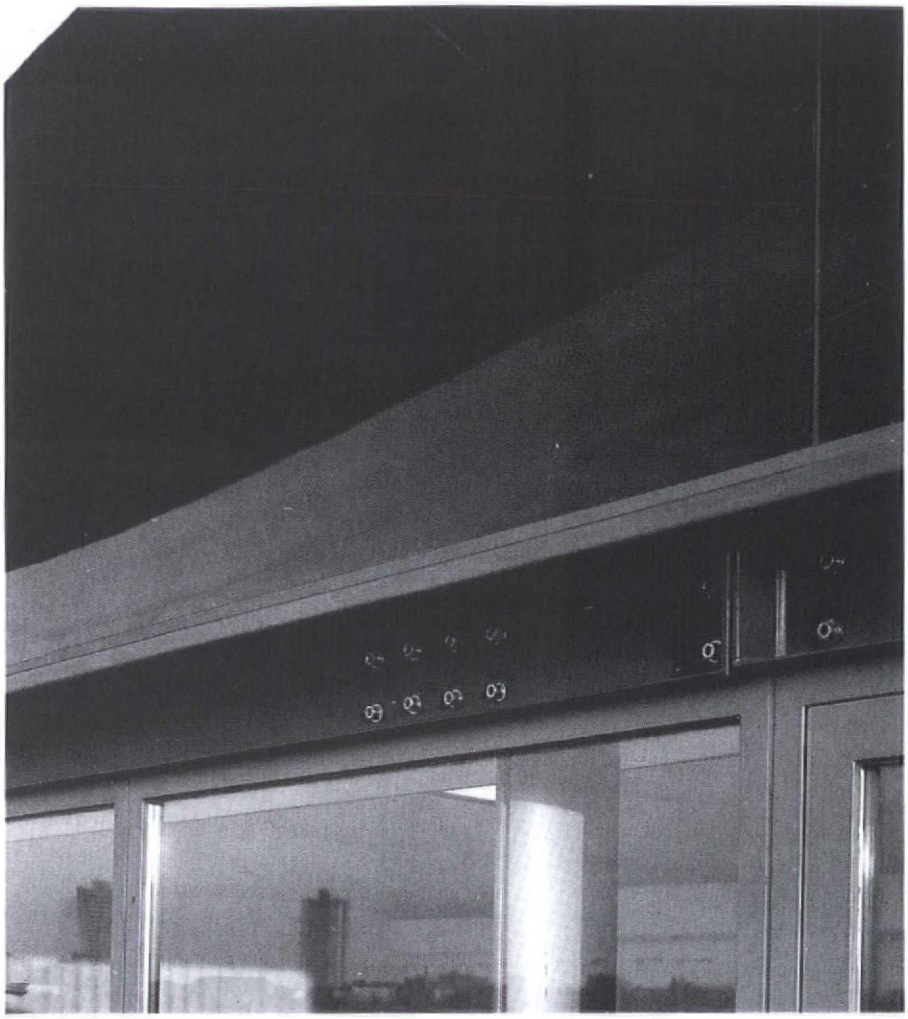
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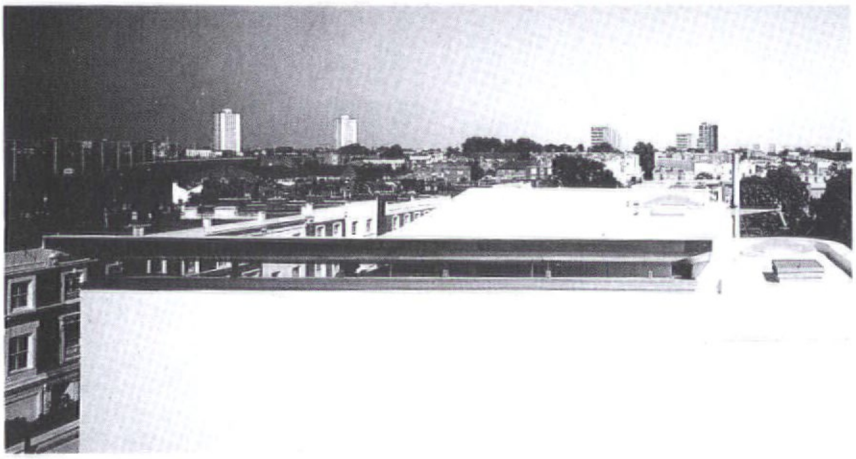
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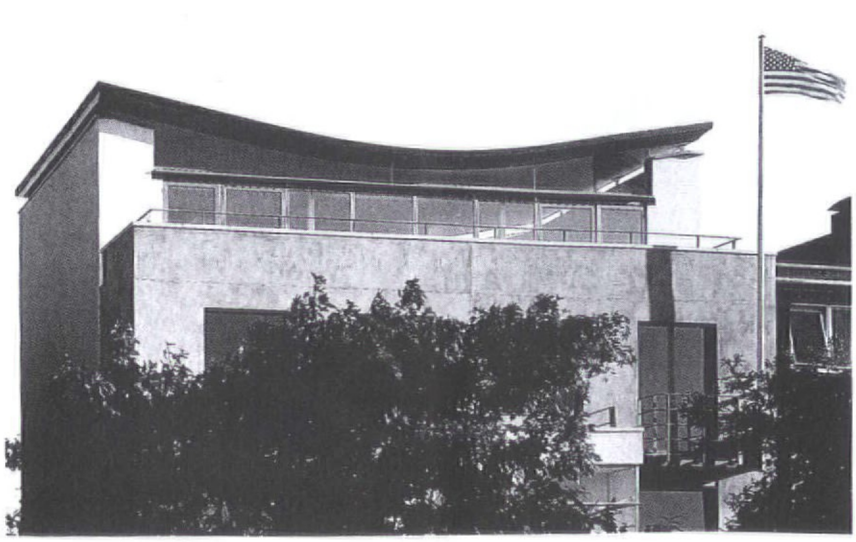
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emphasise the slenderness of the roof.

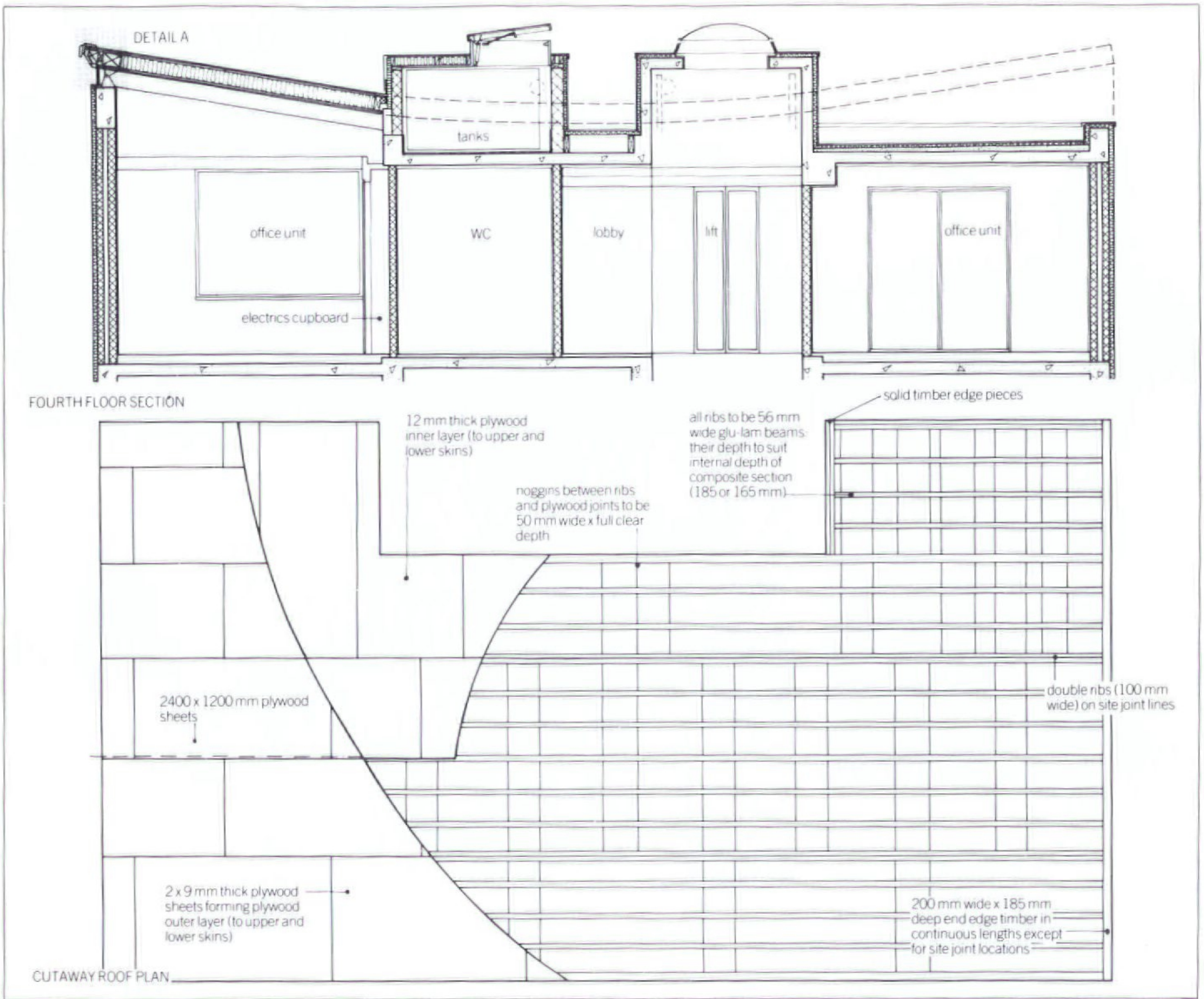
The roof also slopes to the back of the building, allowing rainwater to drain off. It has to fit around upstands surrounding tanks and lift housing, and further movement joints were designed for these. The strain on the roofing membrane is likely to be considerable but the manufacturer has guaranteed it for 10 years.

Filling the voids

Glu-lam beams imported from Sweden give the roof its shape, with 18 mm birch plywood (which has good strength properties) top and bottom. Plywood was very suitable, having a high specific strength but low stiffness (about one-thirtieth that of steel). Even so, the 18 mm thickness is built up from two 9 mm sheets because they are easier to bend. There is an additional inner layer of 12 mm plywood around the projections at the back of the roof. The voids between beams were filled on site with foamed vermiculite. Timber is already a better insulant than more commonly used long span components, such as steel. Internally a veneer is applied, jointed at close centres, and varnished with two coats of matt lacquer.

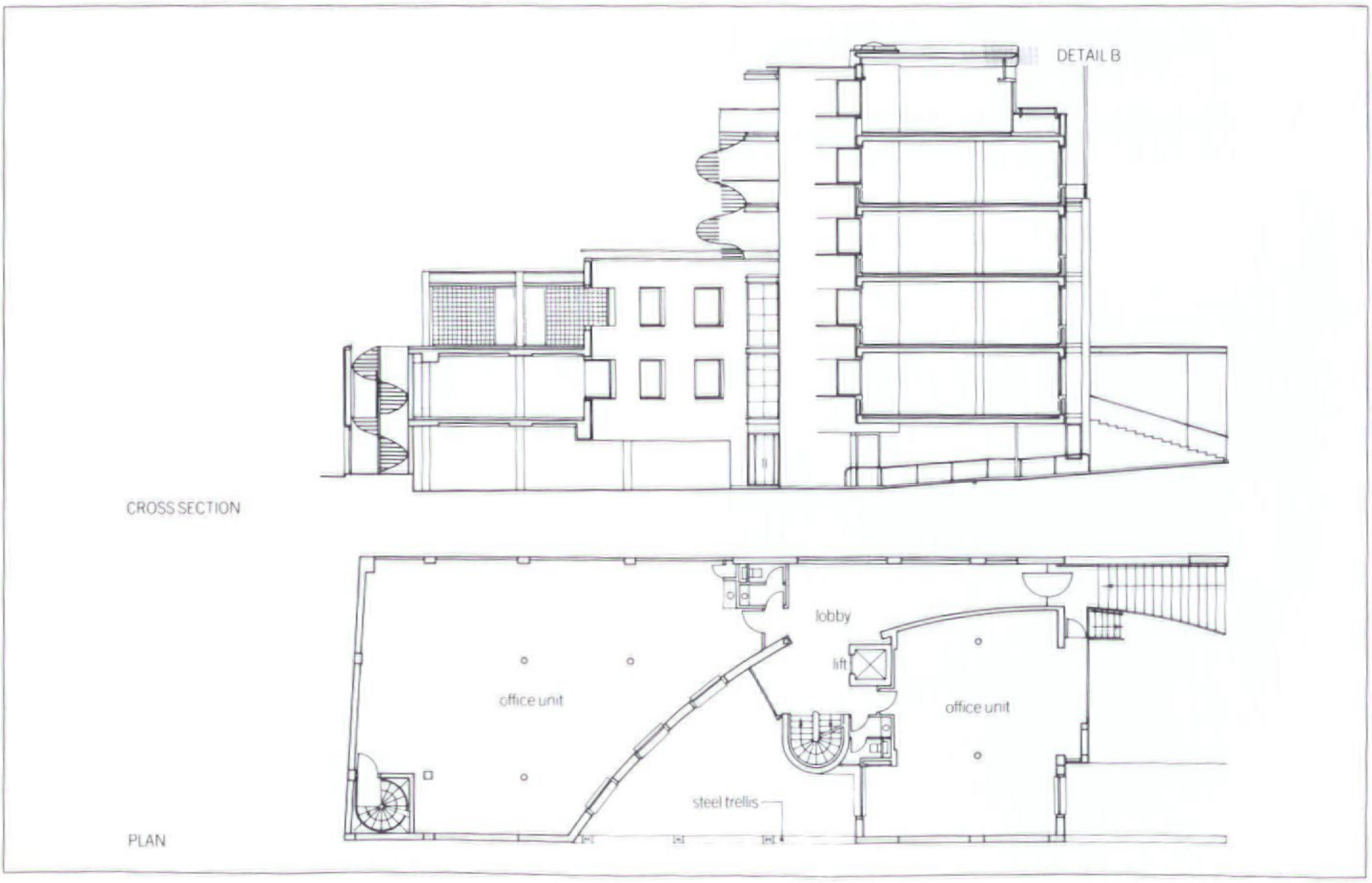
The roof was prefabricated off-site in five 12 m long sections and craned in. The roof weighs nearly 3 tonnes, but its designed load is 5.5 tonnes, and its designed wind load is 6 tonnes.

Strains on the fixings and waterproofing will be considerable — time will tell how successful the detailing is. But creative use of such an energy-efficient material on a commercial building should be encouraged. ■



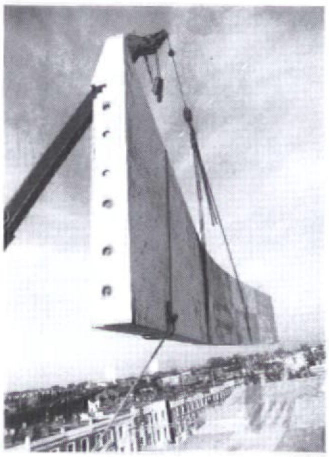
DETAIL A
tanks
office unit
WC
lobby
lift
office unit
electrics cupboard
FOURTH FLOOR SECTION
12 mm thick plywood inner layer (to upper and lower skins)
all ribs to be 56 mm wide glu-lam beams: their depth to suit internal depth of composite section (185 or 165 mm)
solid timber edge pieces
noggins between ribs and plywood joints to be 50 mm wide x full clear depth
2400 x 1200 mm plywood sheets
double ribs (100 mm wide) on site joint lines
2 x 9 mm thick plywood sheets forming plywood outer layer (to upper and lower skins)
200 mm wide x 185 mm deep end edge timber in continuous lengths except for site joint locations
CUTAWAY ROOF PLAN

8



DETAIL B
CROSS SECTION
lobby
lift
office unit
office unit
steel trellis
PLAN

9



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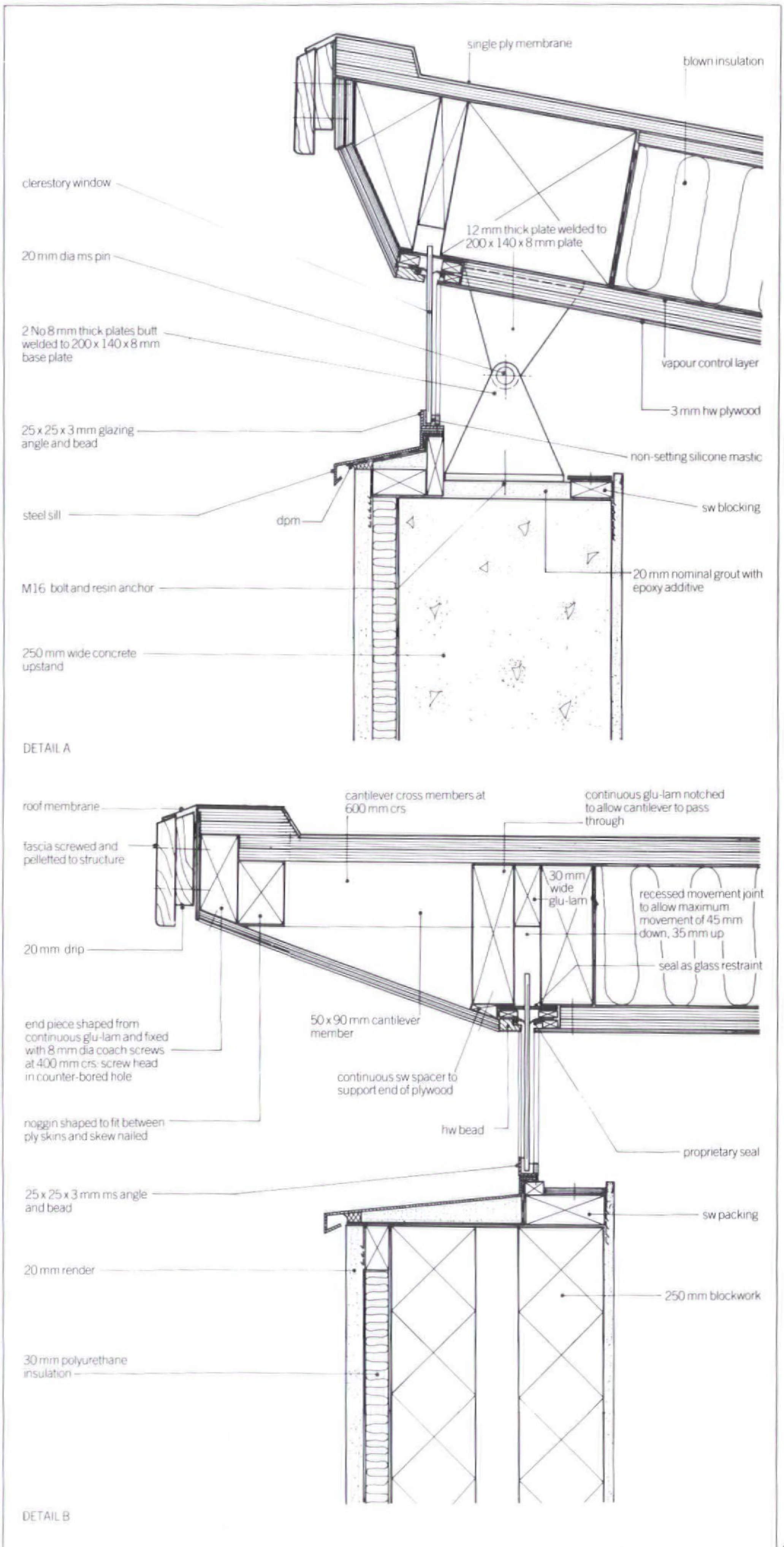
8 Cross section through and plan of the fourth floor. The centre 3.12 m of the roof is on a 19.5 m radius, but to avoid it appearing to curl up at the edges the outer 3.453 m on each side is straight.
9 Cross section and plan of the building.
10 One of the roof panels being craned in. The check to allow the formation of a movement joint can be seen at the top of the picture.
11 Detailed section through the edge of the roof at A, the front and B, the side of the building. The outer part of the fascia is teak and the inner part maple.

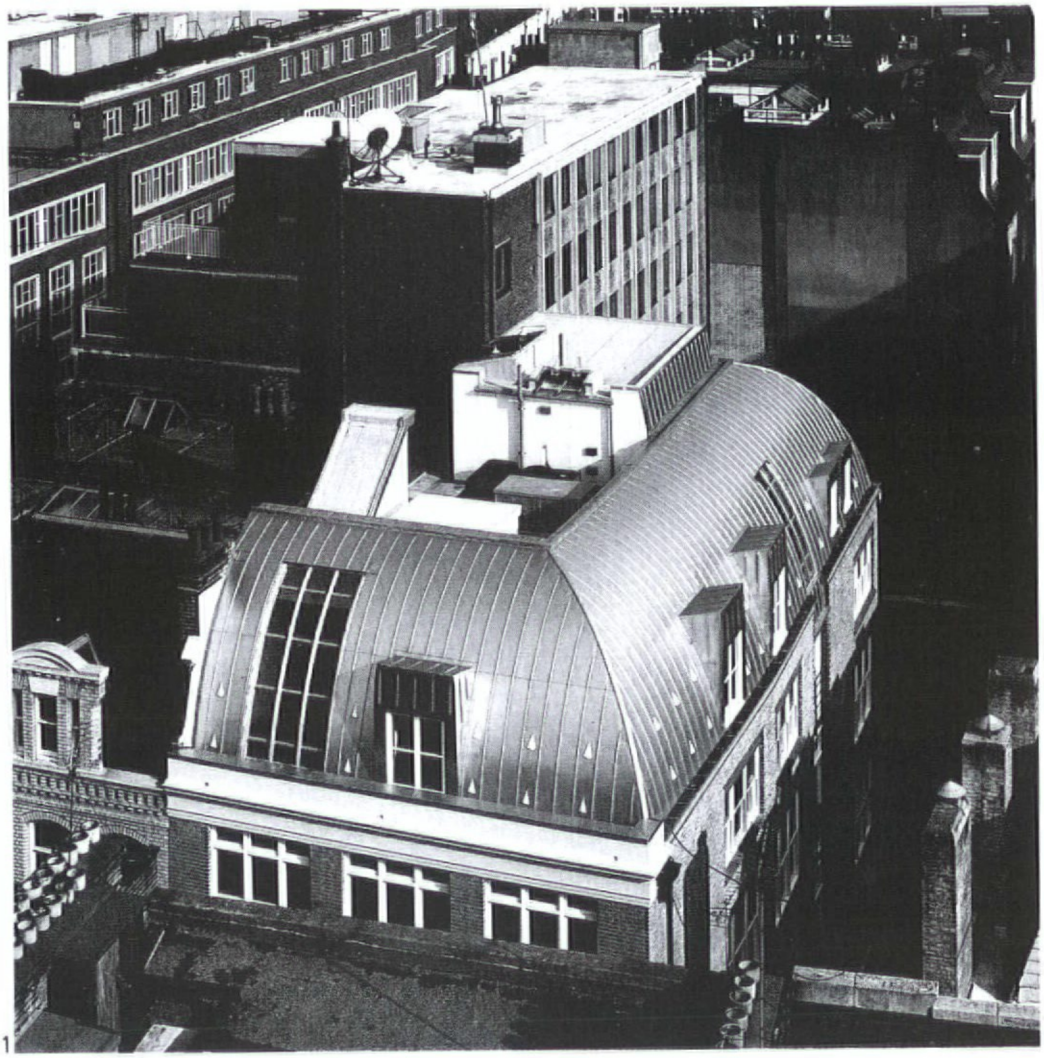


11

Credits
location 87 Lancaster Road, London W11
client Gladding Estates and Development
architect Munkenbeck + Marshall
partner in charge Alfred Munkenbeck
project architect Jonathon McDowell
assistant architect Jeff Allsbrook
quantity surveyor Cowley & Partners
services/mechanical and electrical engineer Fulcrum Engineering Partnership
structural engineer Barton Wells (curved timber roof), Edward Roscoe Associates (rc frame)
landscape design Michèle Osborne
main contractor T G Baker
subcontractors: heating and plumbing Fred Jarvis & Son, *electrical installation* W H Reynolds Electrical Contractors, *lifts* Axis Elevators, *concrete frame* Bucks Construction Services, *timber roof* Dixon Joinery, *specialist metalwork* Milstead Engineering, *specialist glazing* A S Lee, *windows* Senlec Metal Casements, 'Marmarino' *render* Perucchetti Associates, *steelwork* E H Savill Engineering; *suppliers: ironmongery* Elementer Industrial Design, *terrazzo* Marriott & Price, *roofing membrane* Sarna UK, *spiral stairs* Weland, *render/insulation system* Coolag, *special light fittings* Isometrix (London), *rooflight glazing* Mellowes Patent Glazing.

Photo credit
Photographs 1-7 by John Linden.

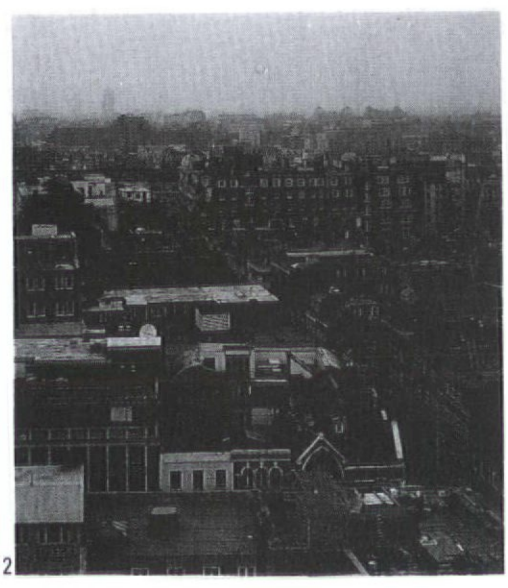
1 Looking down on Nos 42-44 Beak Street. The new curved mansard is only just visible at street level.
2 View of the new roof in its context. The curve extends around three sides: the fourth side is clad vertically with stainless steel and a curtain wall.



1

Roof Offices

Hawkins Brown. This partly new, partly refurbished building is roofed with a stainless steel covered curved mansard. Built on a steel frame, it incorporates both curved glazing and dormer windows.



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Beak Street is a narrow Soho street lined with mainly brick, four- and five-storey buildings. Hawkins Brown's square site already had six existing buildings.

The planning authority, the London Borough of Westminster, requires any increase in office space to be matched by an equivalent increase in residential space, so Hawkins Brown replanned the buildings to provide both the necessary residential requirement, and new offices, for its client. The offices were located in the corner building, Nos 42-44 Beak Street. The existing corner building had four storeys, to which Hawkins Brown added a usable basement and a dramatic fifth storey with a mezzanine. The building was also extended southwards, increasing the floor area by about 50 per cent.

This being a conservation area, the planners asked for a mansard roof, and after negotiation with the planning department Hawkins Brown

Acknowledgment
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3

came up with not a traditional 70° slated mansard, but a sophisticated curved stainless steel covered roof.

The offices are steel-framed with loadbearing masonry walls, and the roof is supported on a steel frame. The complex curve was developed, using cardboard models and computer simulations, to look right and to maximise the floor area beneath it. An added complication was the 1° kink in the plan: the ridge and gutter are always parallel but the ribs are not.

Timber purlins at 400mm crs between the steel ribs carry a curved, foil-backed plasterboard lining and the plywood which forms the backing for the stainless steel. The architect specified three layers of 6mm plywood, but on site the curve was achieved with two 9mm sheets.

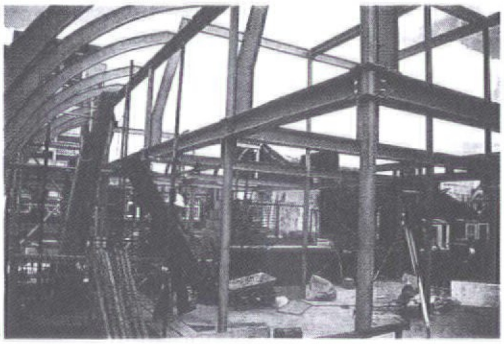
Quilt insulation was laid between purlins, which had holes drilled through to allow air to circulate. Triangular projections in the stainless steel allow ventilation, although if any condensation occurs there is nowhere for it to drain to, and the angle at which the purlins are set could encourage water to sit at the purlin/plasterboard junctions.

To let in as much light as possible, curved polycarbonate windows, almost as high as the mansard, have been installed on three elevations. Steel RHS frames support these internally. Curved windows are a lovely idea, but will be difficult to clean, although access is possible from the flat area of roof and safety fixings have been provided. Thermal movement in such large sheets of polycarbonate could be as much as 10-15mm: this is allowed for in the window head section. There will also be considerable heat loss or gain through these windows, aggravated by the fact that they are difficult to screen with curtains — the architect designed them to allow a roller blind to be fitted.

Dormer windows, larger in the office areas than in the flat, are designed to shed water back to the curved roof.

The detailing of the stainless steel is similar to that used for lead, although steel is less malleable. Some steelwork was formed off-site, although a considerable amount was still worked by hand on site by the subcontractor who did the metal cladding on the Thames Barrier. □

3 The light interior. The curved window is glazed with polycarbonate sheeting. The manufacturer recommended that this would be self-cleaning, this has been the architect's experience to date. All other windows are traditional double-glazed glass.
4 Erection of the steel frame.
5 The rear of the roof under construction. The bridge bottom right is a fire escape leading to an adjacent roof.



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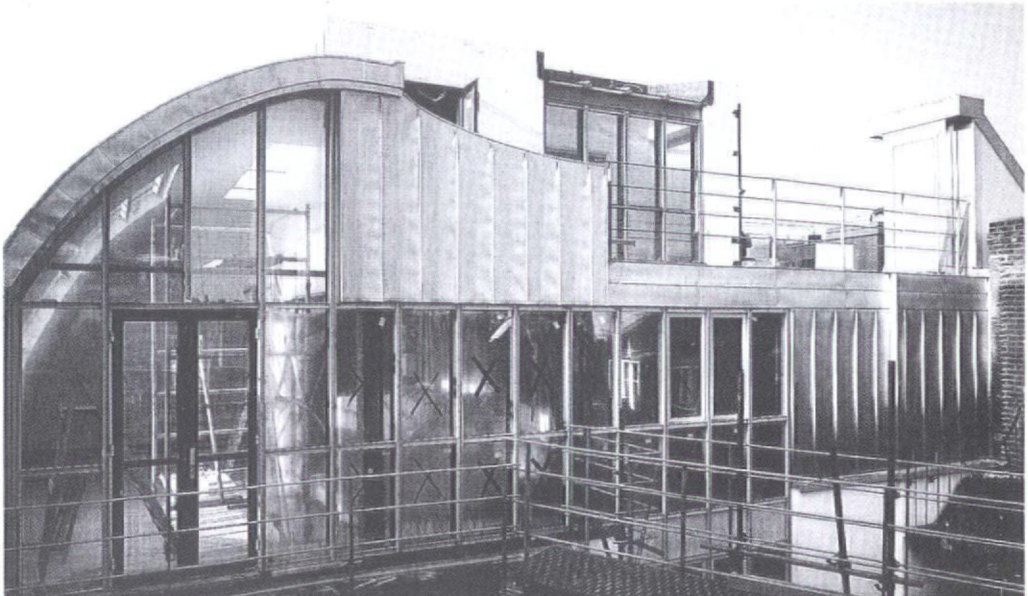

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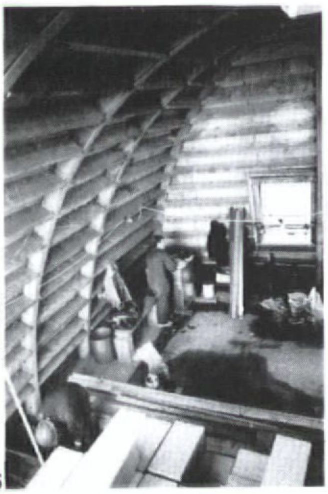
Working Details



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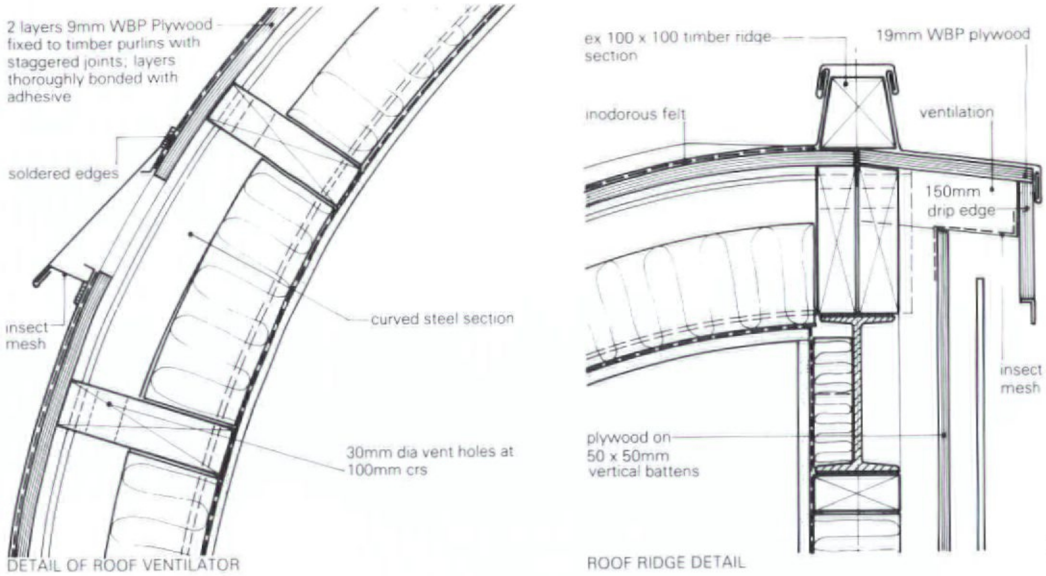

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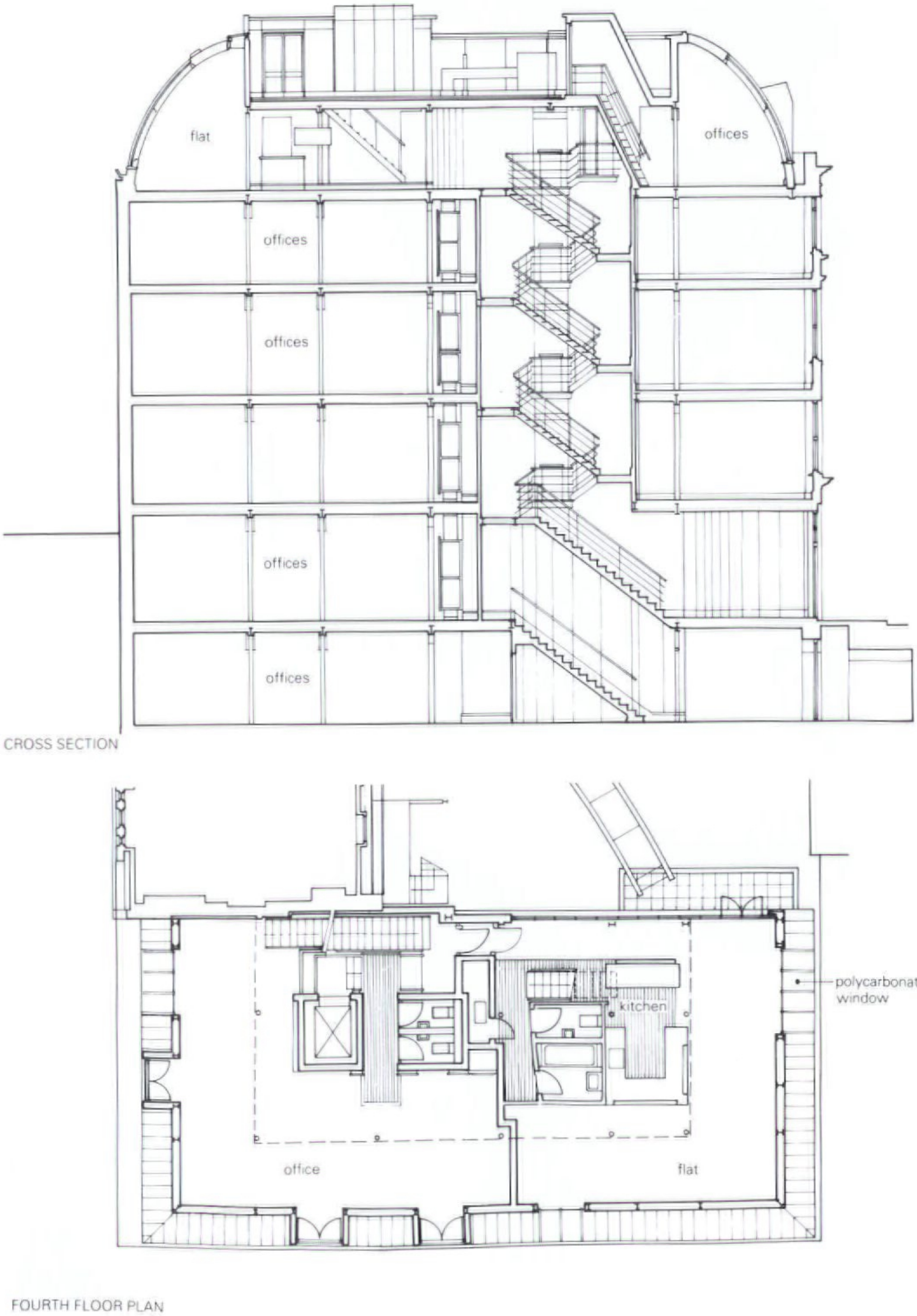

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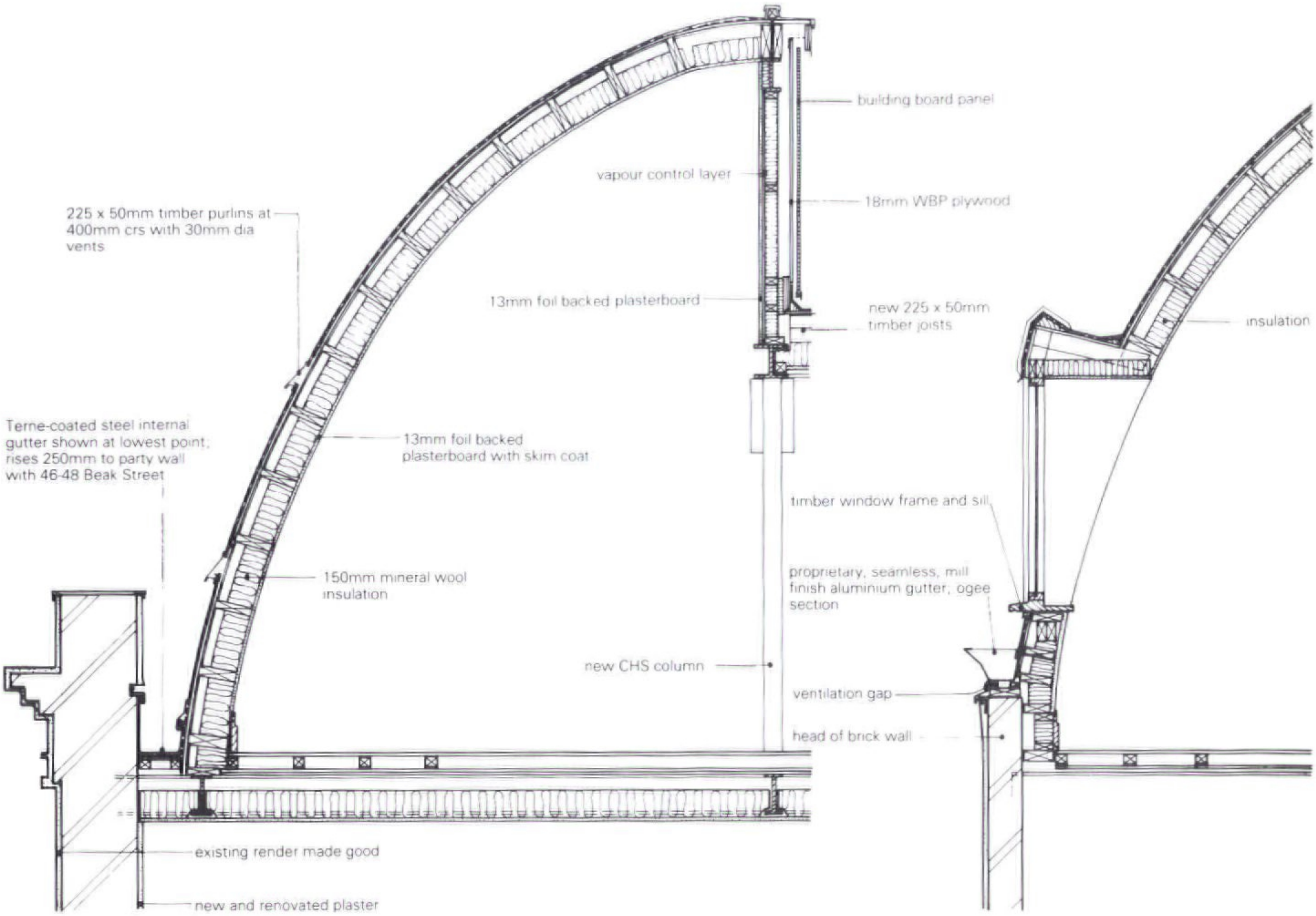
6 The roof under construction. The external plywood cladding is in place, but there are no internal finishes yet.
7 Details through roof ventilation on the curve and at the ridge, long section and the fourth-floor plan. In calculating U-values, the high ratio of wall to window area compensates for heat losses.
8 Cross-section and fourth-floor plan.
9 Sections through the curved roof and through a dormer.
10 Cutaway isometric of roof.

Credits
location Nos 42-44 Beak Street, London W1 **client** London and Gloucester Investments
architect Hawkins Brown
partners in charge Russell Brown, Roger Hawkins **project architects** Andy Gollifer, Lucy Montgomery, Shane Lincoln
quantity surveyor Henry Cooper (Steven Whitton)
services/M&E engineer SA Walsh Partnership
structural engineer Price and Myers (Adrian Cox, Ali-Salehi)
main contractor Willmott Dixon Symes
project manager John Wrieden
site manager Alex Tricker
subcontractors: structural steelwork HM Fabrications, **curved Steelex roof** MPC International, **curtain walling/patent glazing** M Price, **timber windows** Lewis Products, M&E installation BL Plumbing & Mechanical Services, beech flooring **Phoenix Floors; suppliers: door ironmongery** Beaver Ironmongery, **window ironmongery** Comyn Ching, **linoleum** Forbo Nairn, **office sanitaryware** Armitage Shanks, **flat sanitaryware** Caradon Twyfords, **veneer panels** FR Shadbolt and Sons, **intumescent and specialist paints** W and J Leigh and Co, **stainless steel gutters** Specialist Rainwater Supplies.

Project data
contract JCT 80
site start date April 1990
completion date April 1991

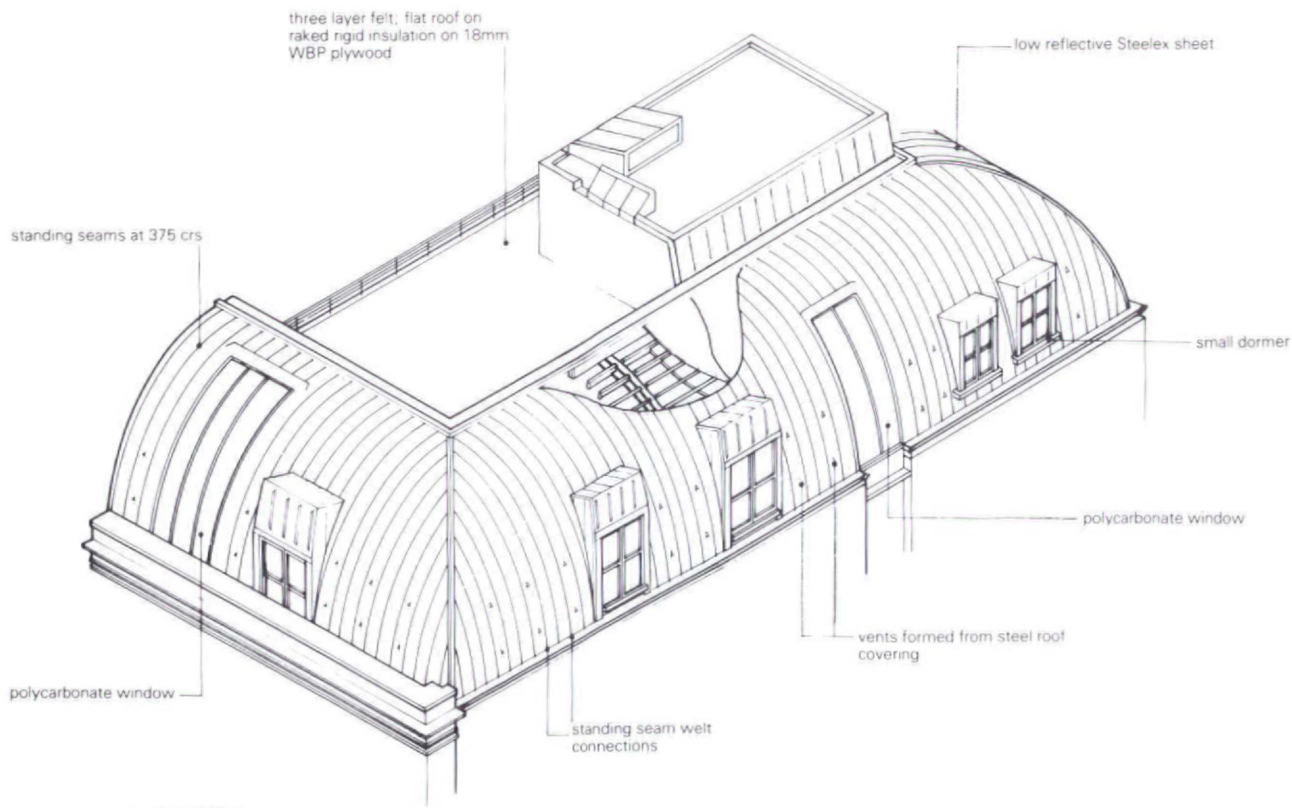
Photo credit
Photographs 1, 2 and 5 by David Nicholson.



SECTION THROUGH ROOF ON BEAK STREET ELEVATION

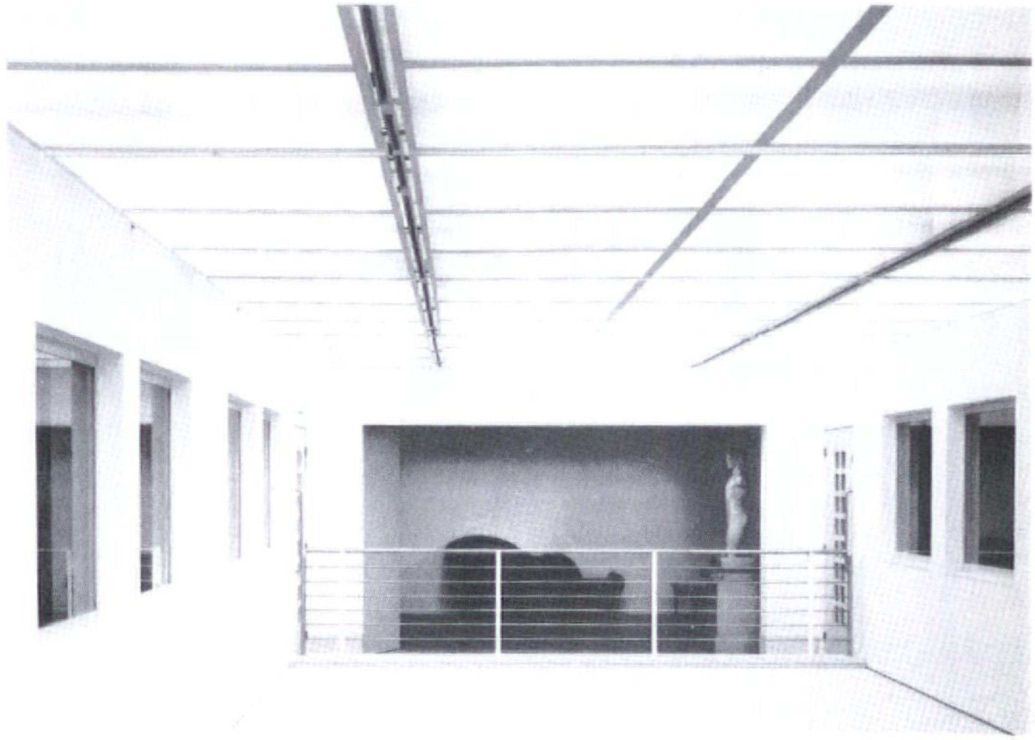
SECTION THROUGH DORMER WINDOW

9



CUTAWAY ISOMETRIC

10



1

1 The lay light above the exhibition area at the heart of the Royal College of Art's new Stevens Building. The wide strips between panes incorporate lighting tracks.

Lay light
Royal College of Art

John Miller + Partners. This elegant lay light allows air, daylight and artificial light to pass through it. It incorporates tracks for a lighting system, and provides a sense of place in the heart of the building.

The Royal College of Art's Stevens Building is a complex knitting together of three existing houses on Queen's Gate with a new building extending back from them to Jay Mews. At the heart of this is the new three-storey exhibition gallery, whose lighting and ceiling are combined into an elegant but efficient lay light. It allows the passage of artificial and natural light, and ventilation. While maintaining a simple planar shape it is articulated into bays which not only create visual interest, but subdivide the glass into suitable pane sizes for maintenance by incorporating a track system for spotlighting.

The conventional patent glazed rooflight above the lay light is supported on a concrete upstand which is monolithically formed with the two-way spanning concrete roof slab. The roof at this point is supported on a series of concrete fin walls on a 3.6m (compatible with brick sizes) module (see also p34). The walls rising up on either side of the rooflight step back so that the internal exhibition space walls can continue straight up to the roof.

On top of the concrete upstand is a simple tubular steel truss, fixed to the concrete via L-shaped steel cleats. Immediately above the concrete is a series of vertical glazed louvres, supplied by the patent glazing subcontractor. These are thermostatically controlled, to counteract solar gain, but there is also a manual override. The controls are in the porter's lodge at the entrance. The space allowing the passage of air through the lay light equals the area of the vertical louvres.

As the exhibition area is not part of a means of escape (being in the centre of the building) there was no need for smoke venting.

The lay light itself is suspended from the steel trusses by a series of plates and rods which allow levelling. Luminaires (with daylight compatible fluorescent tubes) are also suspended from the structure, set low enough to provide a steady spread of light, but high enough to avoid their shadows appearing on the glass below. All the finishes above the lay light are white.

The exhibition area could have become very hot in summer, but it is well protected from the sun by surrounding buildings, and did not overheat last summer. A heating tube around the rooflight prevents condensation.

Access for cleaning, especially important when there are opening louvres, is provided though a hinged panel at each end of the laylight. Although the exhibition space is 7.3m high, the access panels are above the gallery and are therefore only 2.4m above floor level. Duckboards can be laid between channels which run longitudinally down the rooflight. Each panel can be lifted out for cleaning.□

Acknowledgment
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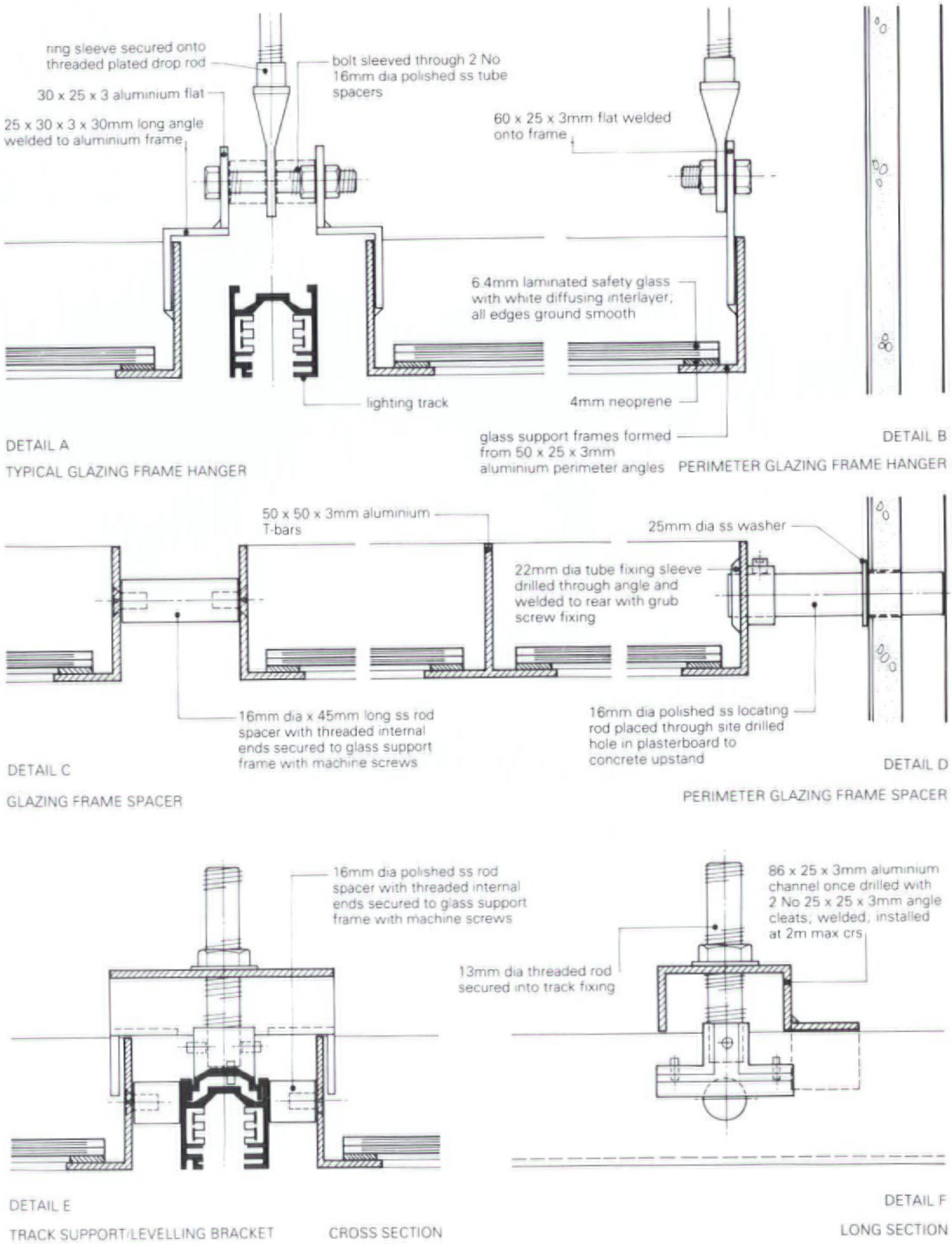
2

3

2 The rear of the new part of the Stevens Building (to Jay Mews) showing the rooflight (above the lay light) in the foreground.
3 A lay light in Colquhoun Miller + Partners' refurbishment of the Whitechapel Art Gallery: a forerunner of the lay lights (there are six altogether) here.
4 Lay light support details.
5 Cross-section through the exhibition area.
6 Cross-section, part long section and part plan of the lay light. The counterbalanced access panel can be seen at the end of the long section.



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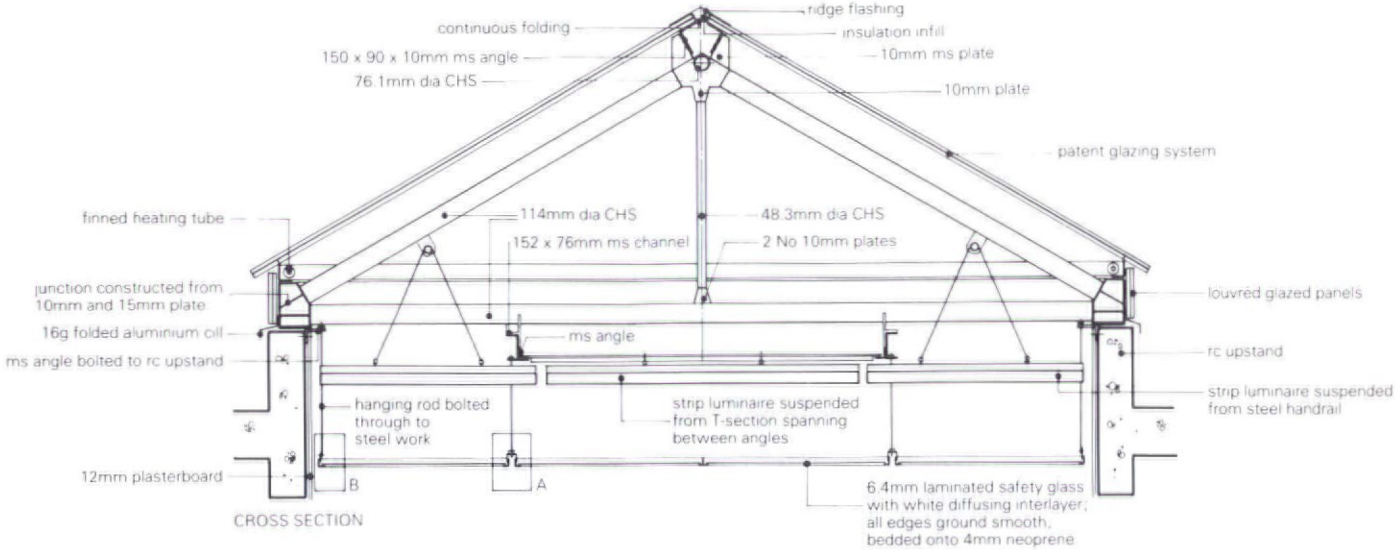
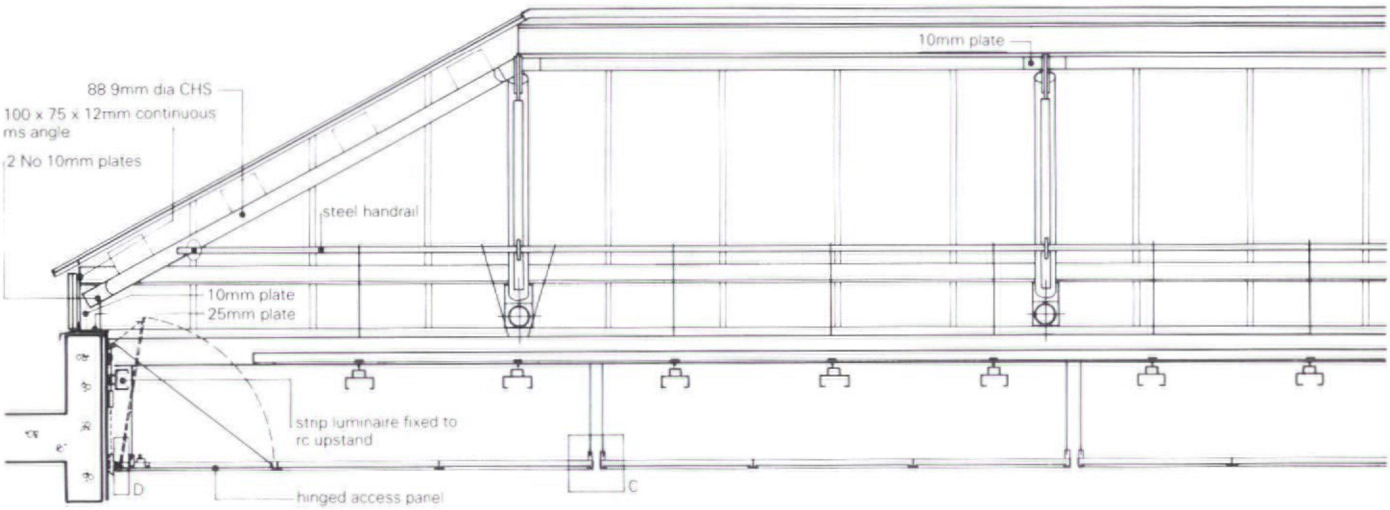
Credits
location Royal College of Art, Jay Mews/Queen's Gate
client The Rector and Vice-Provost
architect John Miller + Partners
architects in charge John Miller, Su Rogers, Richard Brearley
associates Patrick Theis, Graham Smith
quantity surveyor Davis Langdon & Everest
services/mechanical engineer Ove Arup & Partners
structural engineer Ove Arup & Partners
acoustic consultant Arup Acoustics
main contractor Myton
subcontractors: electrical services Phoenix Electrical Company, **mechanical services** Haden Young, **lighting** A S Green & Company, **patent glazing** Mellowes Patent Glazing

Project data
contract JCT 80 private with quantities
site start date August 1988
completion date August 1991

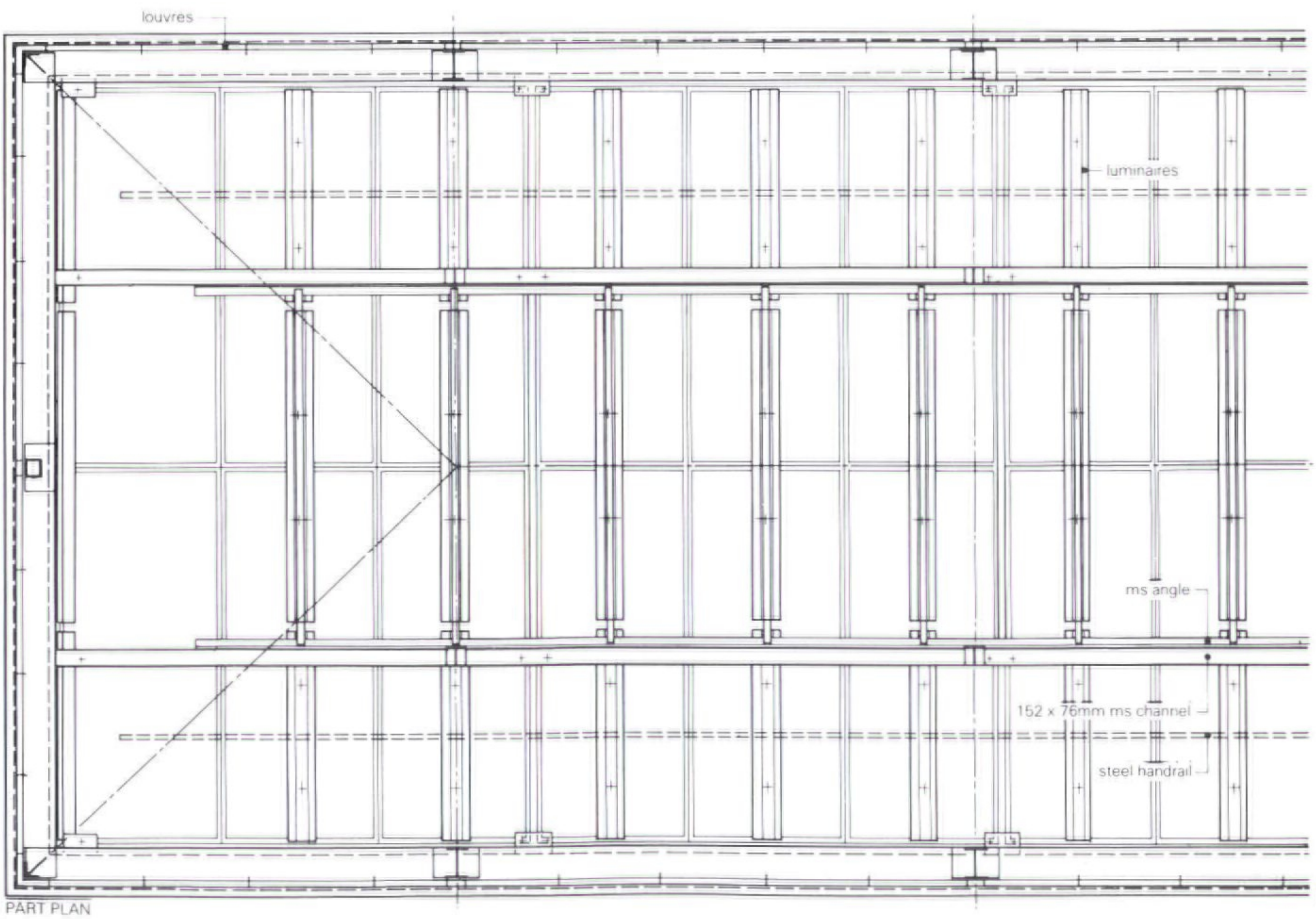
Photo credit
Photographs by Martin Charles.



CROSS SECTION



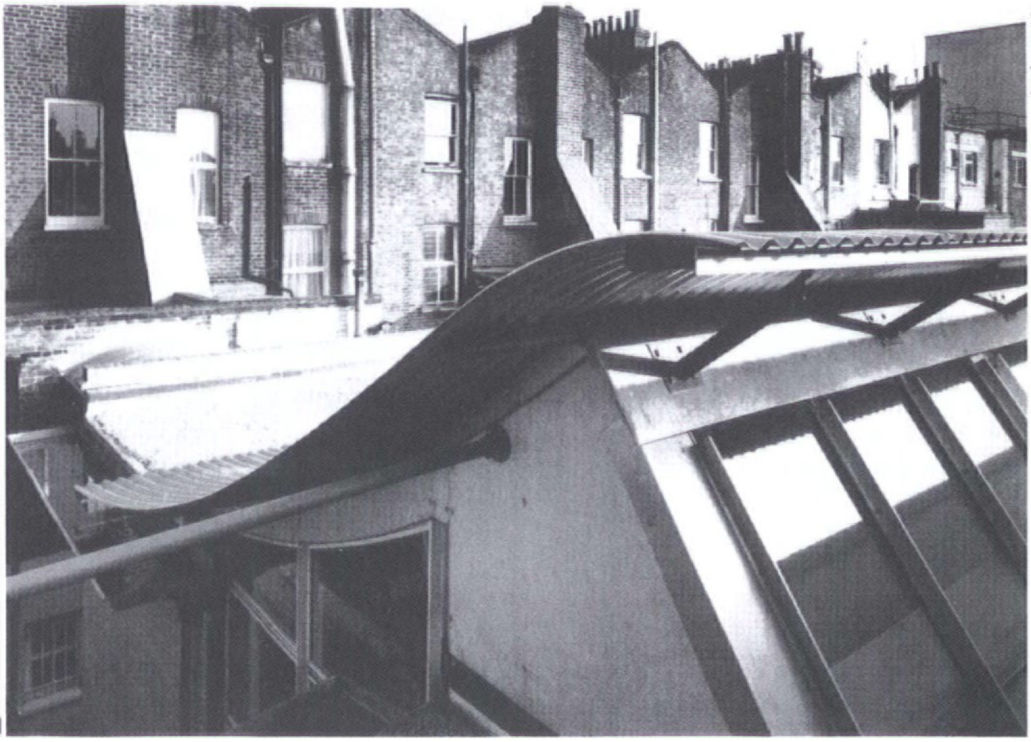
PART LONG SECTION



PART PLAN

5

1 The roof of the new surgery behind Walworth Road. Although clad in aluminium, the timber structure gives it a domestic feel.



1

Roof
Doctors' surgery

Penoyre & Prasad Architects This aluminium covered roof is constructed with an obvious simplicity appropriate to its use.

This new south London surgery sits tightly in the backyards of Walworth Road. Planned around a small courtyard, the main volume is differentiated from the side 'wings' by a curved aluminium roof which lifts up towards an existing party wall allowing extra light into the top rooms. The other roofs are flat.

Gable ends and ground-floor walls are built in brick and support the first-floor in-situ concrete slab. Due to lighter loading, the first-floor walls can be, and are, expressed differently. First-floor walls facing into the courtyard are timber framed and clad in Finnish birch plywood. Although stained bright yellow, the visible grain of the plywood softens the impact, making the effect definitely warm, not brash.

The main roof build-up was initially developed in conjunction with BRE. Because it was the architect's fourth roof of this type, potential problems had been previously explored. The continuous ventilation gap, formed by battens and counter-battens, allows moisture collected on the breather paper to drain. Even under the new 1992 Building Regulation (part B3, table 14) a fire stop cavity barrier is not needed because the roof is under 10m in length. Thermal expansion is taken up by the sheet fixings.

The concave curve of the roof is formed by the I-section at the gable, enabling all the other structural members to be straight.

Timber purlins span across and are strapped down and built into the block cross-walls. Aluminium sheets are simply screwed down to the battens; the sheets are mill-finished, curved off-site in a single length and have joints lapped just once. A sine curve profile was chosen as, once past the internal roof structure, the curve changes to convex and a square section could crumple. The large overhang is fixed to a galvanised tube which is supported off the main structure by brackets. An angle had to be added on site to provide extra rigidity.

The large aluminium gutters not only collect water but also act as eaves, protecting the plywood from the worst excesses of the rain. They are not laid to a fall (for visual reasons) and so always contain a shallow layer of water (inviting weeds to grow) but they are both strong and wide enough to walk along so maintenance is possible.

As with all buildings, general maintenance is important and the architect is currently in the process of instructing its clients in the building's needs. It is possible, after prolonged rain, that the original party wall will become saturated and eventually cause the timbers in the flat roof to rot. But access panels in the void do enable the space to be monitored, and while not perhaps ideal, this traditional wall construction is not unusual. And surely, regular 'check-ups' are part of what this building is about.□

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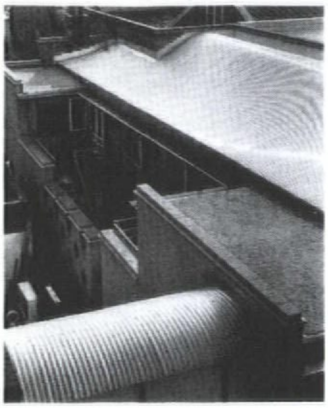

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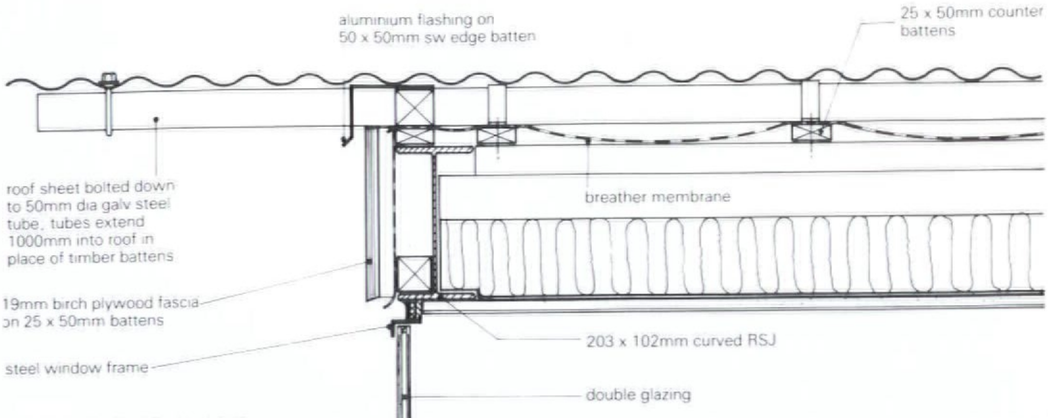
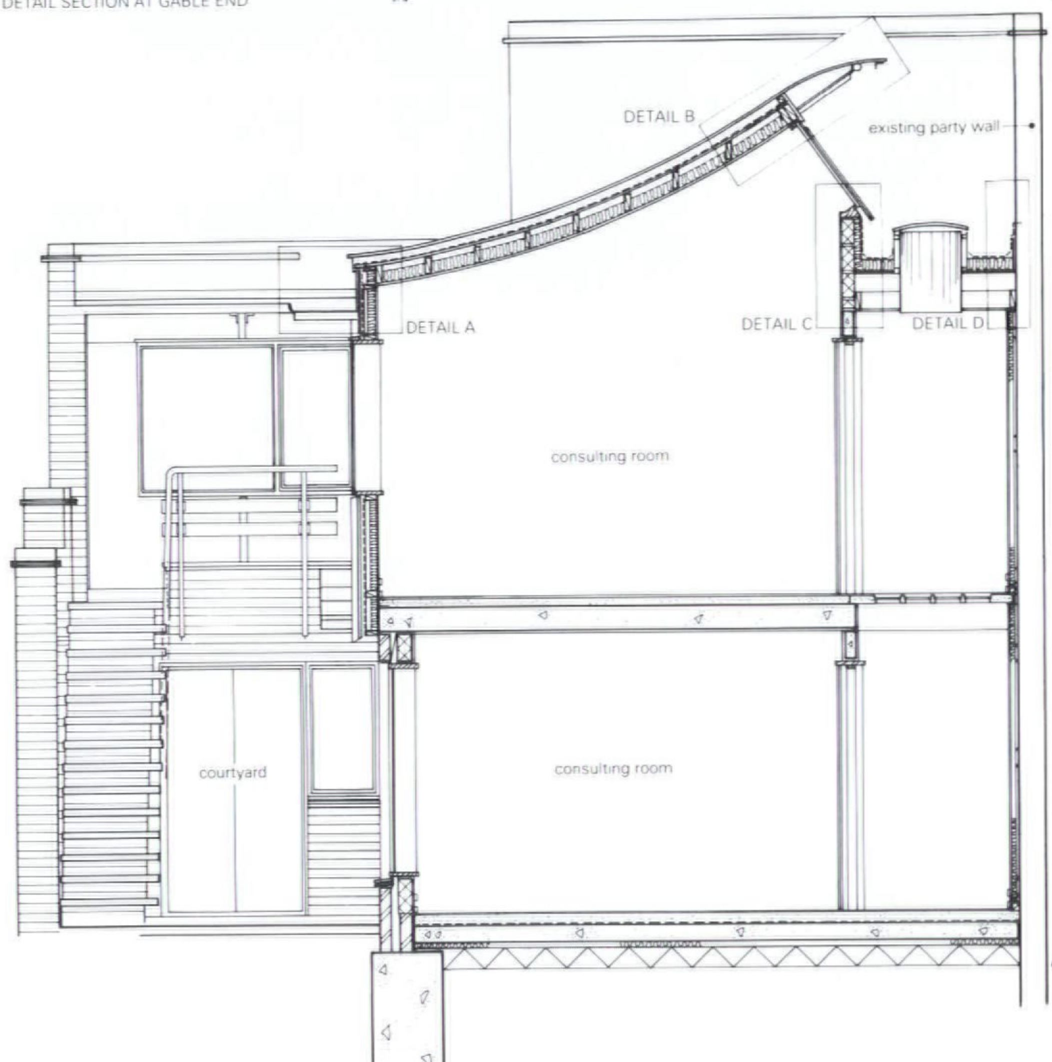


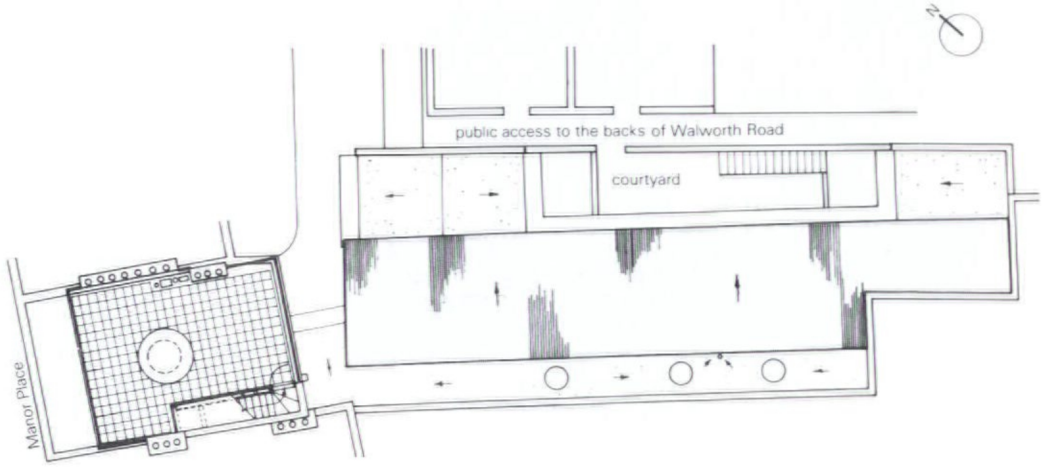
DETAIL SECTION AT GABLE END

3



CROSS SECTION

4



ROOF PLAN

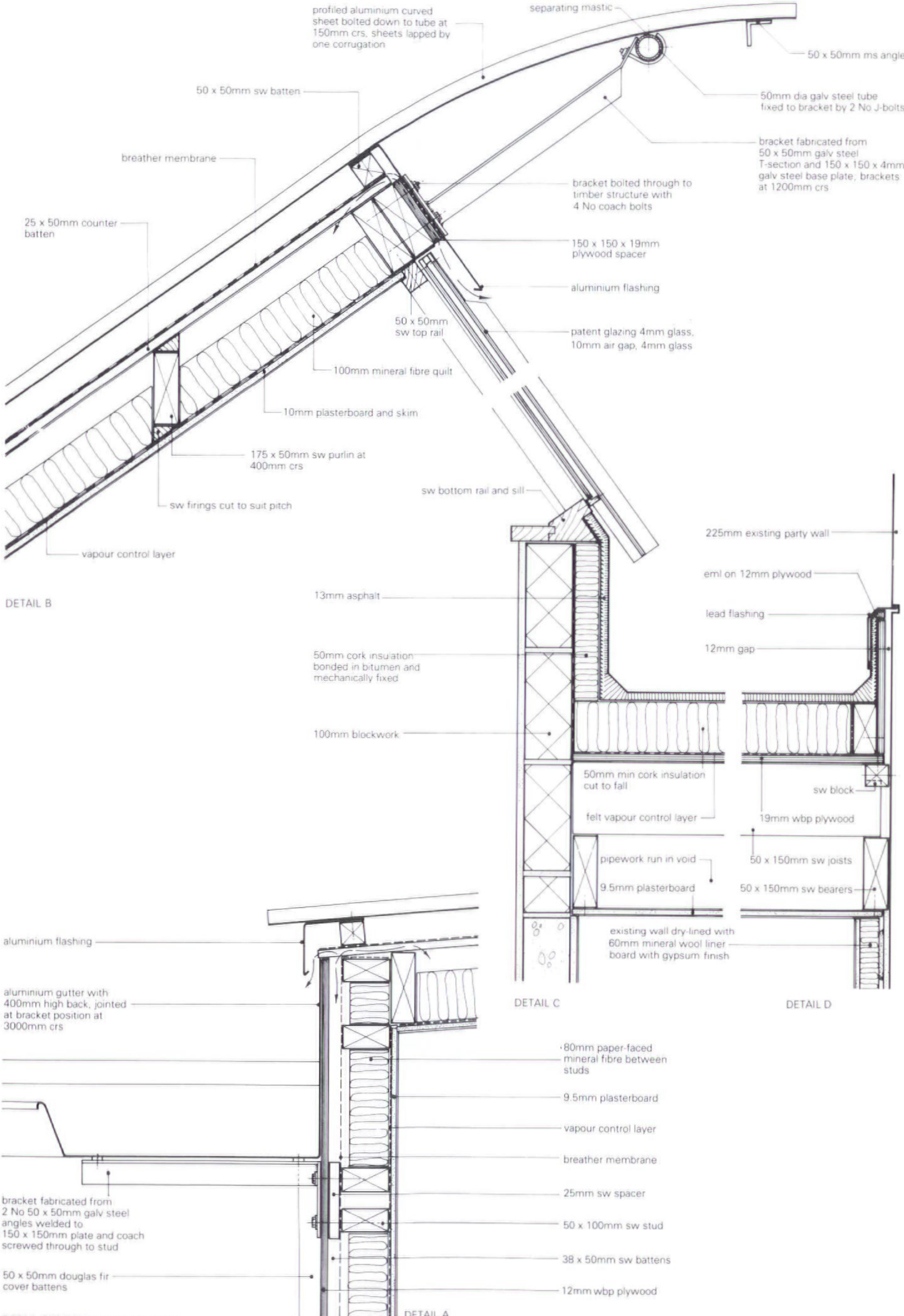
5

2 View into the courtyard. The large gutters also act as eaves and are not laid to a fall.
3 Detail at the gable showing the steel section, the only curved structural member.
4 Cross-section through courtyard and consulting rooms. The first-floor timber stud wall gives a larger floor area and thinner wall; all window reveal depths, however, remain constant. The buildings next door take up two-thirds of the party wall; the coping was replaced along its length.
5 Roof plan. The curved roof is shown tinted.
6 Roof details. Access to the roof void occurs between the rooflights.

Credits
location 1 Manor Place, London SE17
client Doctors Higgs, Haigh, McKay and Reyburn
architect Penoyre & Prasad Architects
project team Gregory Penoyre, Mark Tinker, Sunand Prasad with Evelyn Duff, Pippa Mansell, Simon Knox
quantity surveyor Ken McCarthy
services/M&E engineer Fulcrum: Daren Whitehouse
structural engineer Trigram Partnership: Rene Weisner
main contractor EC Sames
subcontractors: roofing and metalwork HLC Engineering, **patent glazing** Twide Paragon

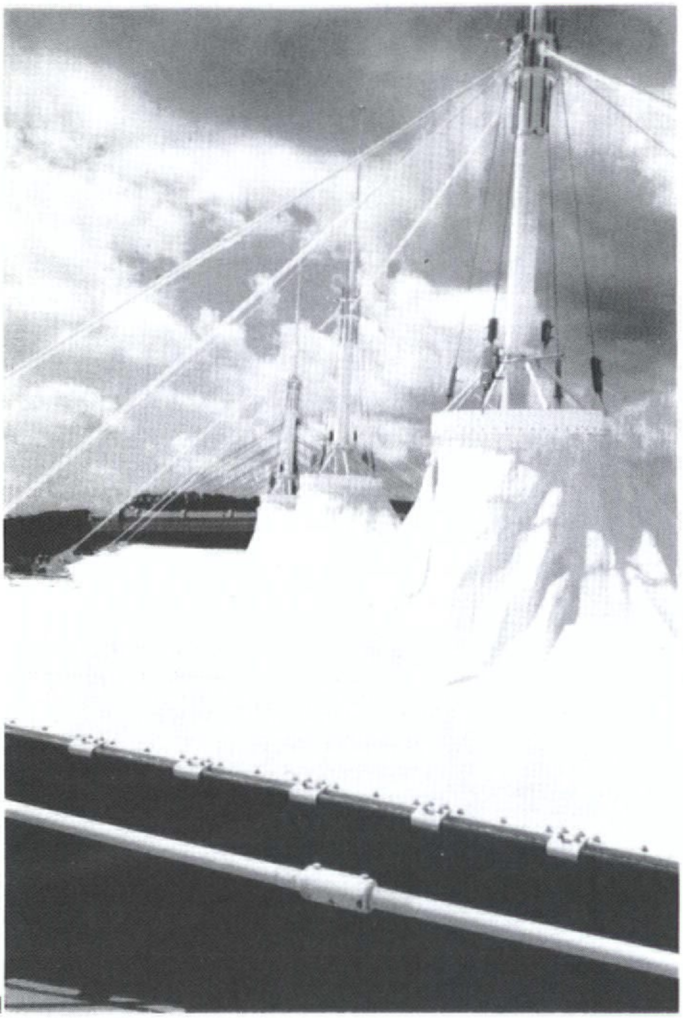
Project data
contract JCT Intermediate
site start date October 1989
completion date June 1991

Photo credit
Photographs by Denis Gilbert



DETAIL SECTIONS THROUGH ROOF

CI/SfB (27)



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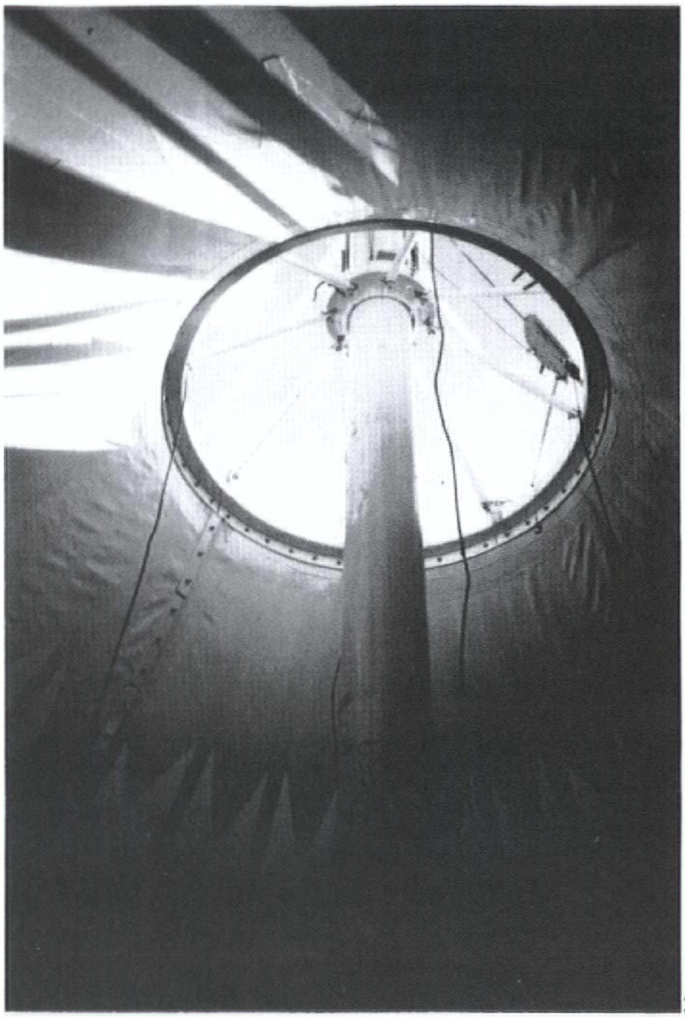
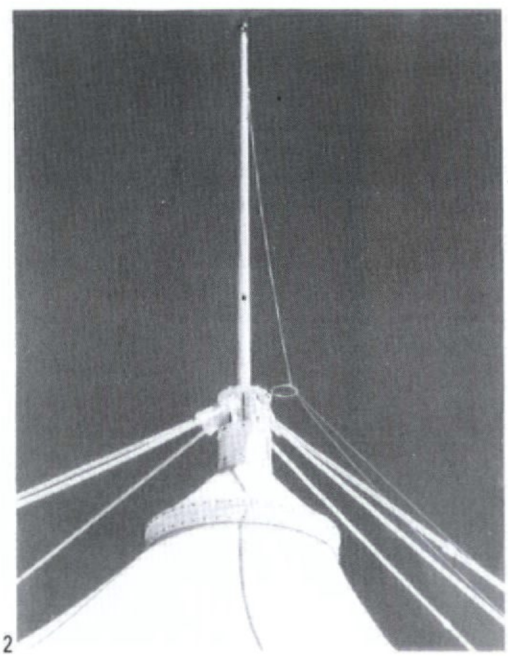


3

Roof
Grandstand

Arup Associates The Sussex grandstand at Goodwood has a polyester reinforced PVC roof supported on braced-out tubular steel.



2

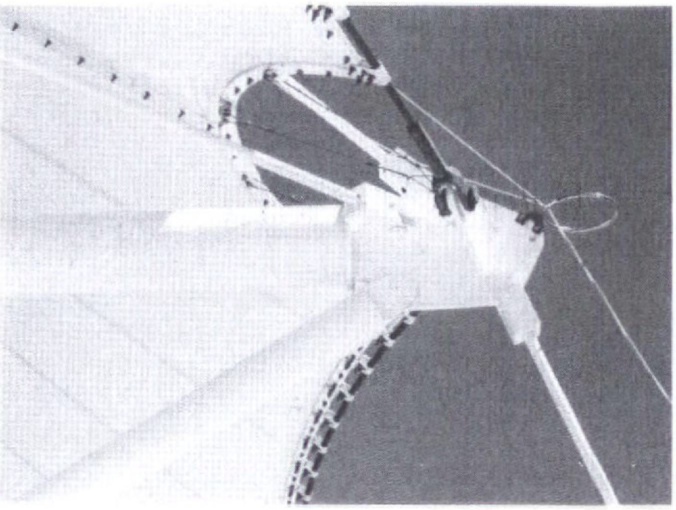
Goodwood might, like most racecourses, have had an immaculate green sward, and a rather motley collection of buildings. However, in 1987 Arup Associates was appointed to prepare a masterplan for the entire grounds and, as part of this, to design the new Sussex grandstand.

At ground-floor level the stand contains a betting hall, restaurant and meeting areas, and at first-floor level are the hospitality suites — narrow boxes with a carefully cordoned off section of balcony. These lower floors have a conventional framed structure, but the roof to the tiered seating above seems simply to float above them.

Next to the Sussex grandstand is a 10-year-old concrete grandstand designed by Howard Lobb and Jan Brabowski. Its north-facing concrete shell roof casts a heavy shadow over both spectators and the ground. In order to make the new stand lighter, Arup Associates chose a fabric roof for the upper tier of seating.

Acknowledgment
The editors acknowledge the assistance of John Pringle of Michael Hopkins & Partners in the preparation of this article.


4


5


6

1,3,4 The new fabric roof being erected. All three bays had to be erected simultaneously. The most stressed area of fabric is around the lifting rings; 3 shows the additional reinforcing layer of fabric provided.
2 One of the three masts. The small ring to the right (see also 5) allows a flag to be hoisted.
5 One of the cusps.
6 The stand on a race day.

The lower levels of the stand are built in concrete, with a brick outer skin to match the existing buildings on the site. The roof is supported on a steel framework, bolted to stub columns cast in the perimeter beam to the coffered slab below.

Having chosen a fabric roof, the engineers embarked on a formfinding exercise, an iterative process to find the best shape for both membrane and structure. The shallower the roof the greater the stresses on the membrane.

Wind pressures were estimated at values nearly double those in central London, but the greatest stresses come from within the roof itself. Here, the stresses are greater because the roof is assymmetrical. The maximum stresses are exerted at the lifting ring — the membrane is reinforced (with a second layer of fabric) just below it. In spite of its appearance the membrane has limited stretchability, so the exact shape had to be determined to allow the contractor to work out a cutting pattern.

The fabric is polyester reinforced PVC. It was about half the cost, with half the life expectancy, of Teflon coated glass fibre. But both need cleaning (increasingly so with age) and in 15 years' time — the likely life of the PVC — superior fabrics may be available.

Coloured fabrics were a possibility, but at the time of specifying there were still questions over their colour fastness. The fabric used here is white, as are all the finishes to the primary steel structure. The steel was shotblasted, flame sprayed with zinc, and finished with micaceous iron oxide and two coats of gloss paint. The gloss finish may need recoating every few years, but the barrier coat should last as long as the fabric. All steelwork directly supporting the fabric has a galvanised finish.

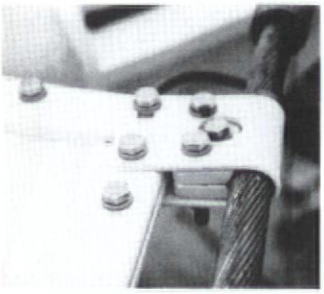
The roofing subcontractor was Koit, who was also responsible for the roof at Michael Hopkins & Partners' Mound stand at Lord's cricket ground. Apart from size and shape, one of the main differences between the two roofs is that the Sussex stand primary structure uses rods in preference to cables.

The Sussex grandstand is used for only 17 days each summer, so it was constructed between one season and the next.

Erection of the roof took several days. The fabric was brought to site rolled up, already welded into shape apart from one seam in each third. These allowed the fabric to be unrolled either side of the three masts, clipped on to the cables, and fitted around the cusps. The last three seams were then bolted together. Hawsers were used to lift the fabric via the rings. The fabric around all three masts had to be lifted simultaneously. Bolts were jacked to provide the required pre-stress.

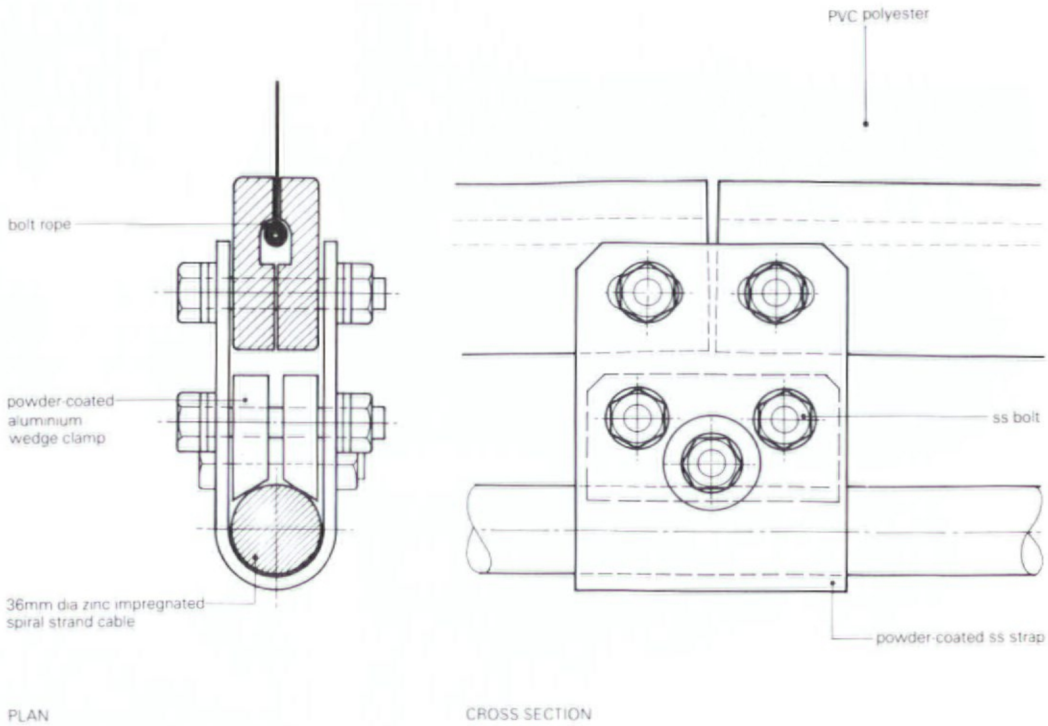
On the first try the fabric did not appear to fit very well, but on checking it was the steelwork that was out of place, not the fabric. Without the fabric in place the steel skeleton geometry was extremely sensitive to small adjustments to the pre-stress in the tie-down rods. Resetting these solved the problem. Restressing was carried out after four to five months. Koit will check it every year or so.□

Working Details

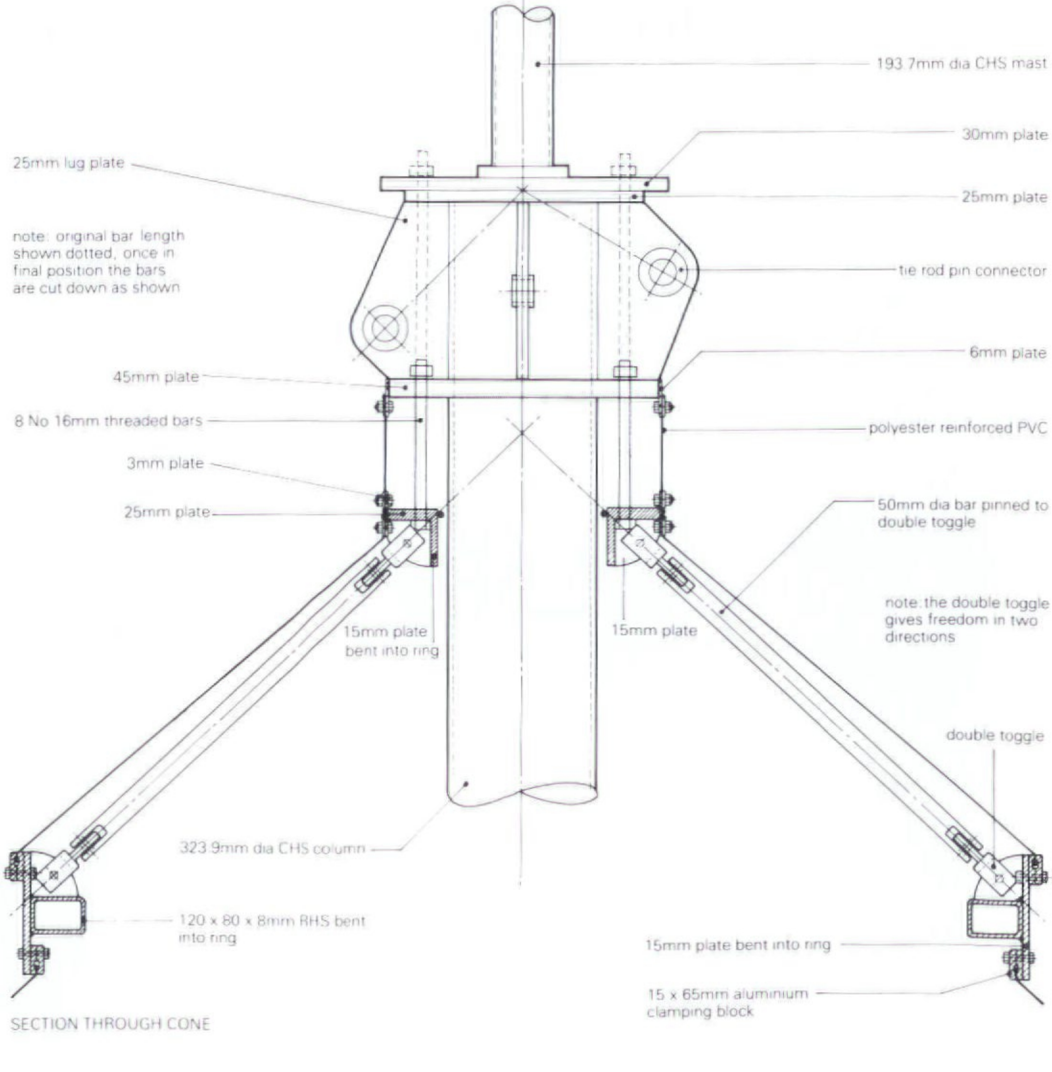


7

7 Close-up of the adjustable edge strip.
8 Section through and plan of the fabric edge detail. The PVDF coating should make the fabric more dirt resistant.
9 Section showing the construction of the lifting ring.
10 West elevation.
11 Roof plan. The bay size is bigger than at the Mound stand, but there are only three bays here instead of five, and no suspended peaks midspan. The patterning of the fabric is at least partly determined by the roll width.
12 South elevation.



8 ADJUSTABLE EDGE STRIP DETAIL



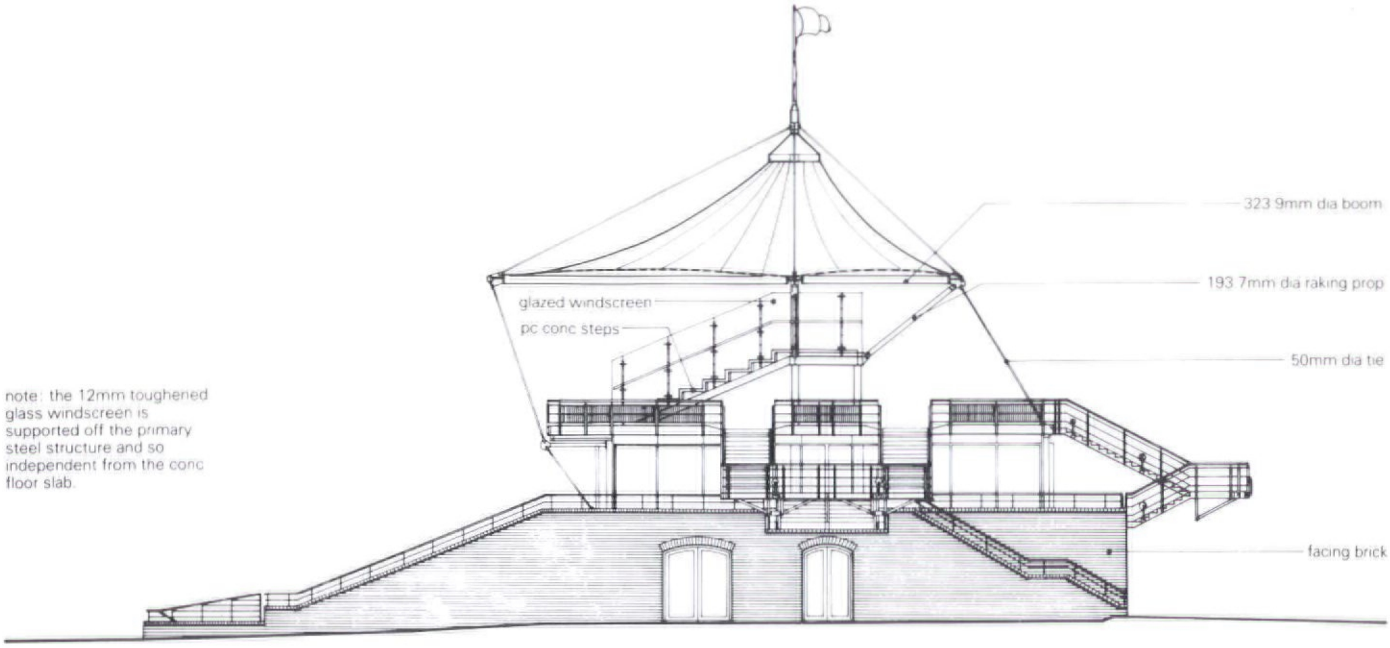
SECTION THROUGH CONE

9

Credits
location Goodwood Racecourse, Sussex
client Goodwood Racecourse
architect Arup Associates
quantity surveyor Arup Associates
services/mechanical and electrical engineer Arup Associates
structural engineer Arup Associates
lightweight structures consultant Ove Arup & Partners
main contractor James Longley
subcontractors: specialist steelwork Littlehampton Welding, **membrane** Koit, **lighting** Thorn Lighting, Concord Lighting, **glazing** Avdon, **brickwork** Salveson Brick, **canvas awnings, screens** Arun Sails, **blockwork** Forticrete, **washable paint** Leyland Paint & Wallpaper.

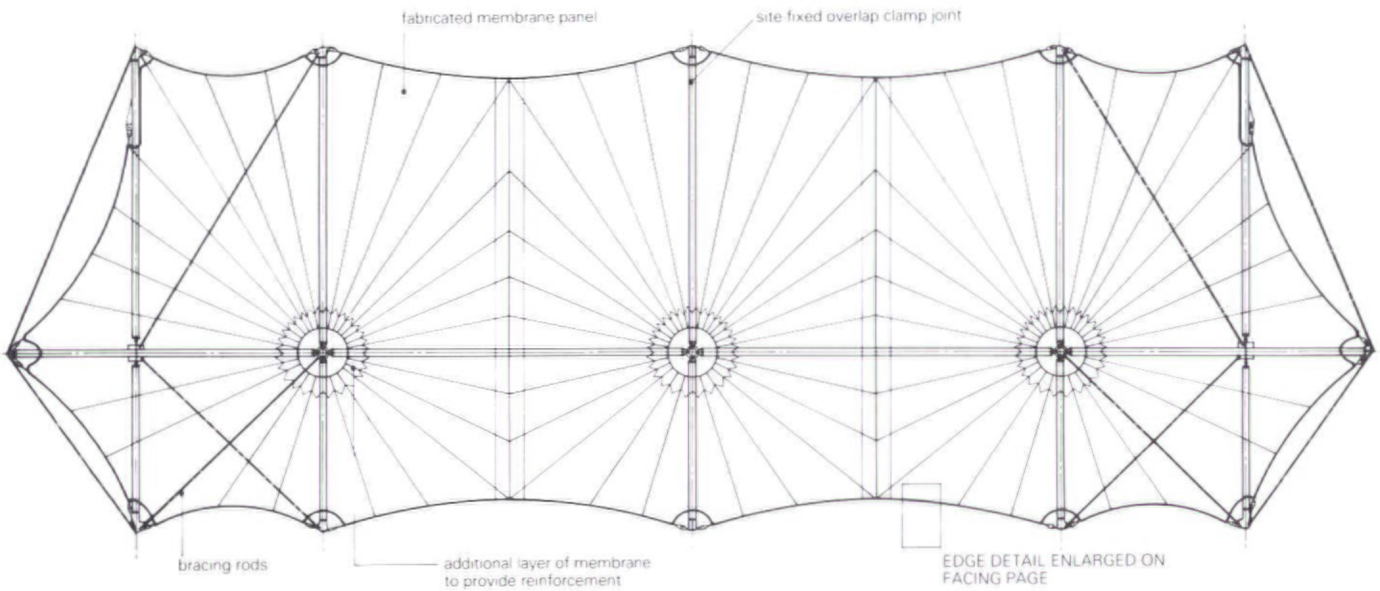
Project data
contract negotiated JCT 80
start date August 1989
completion date July 1990.

Photo credit
Photograph 6 by Peter Cook.



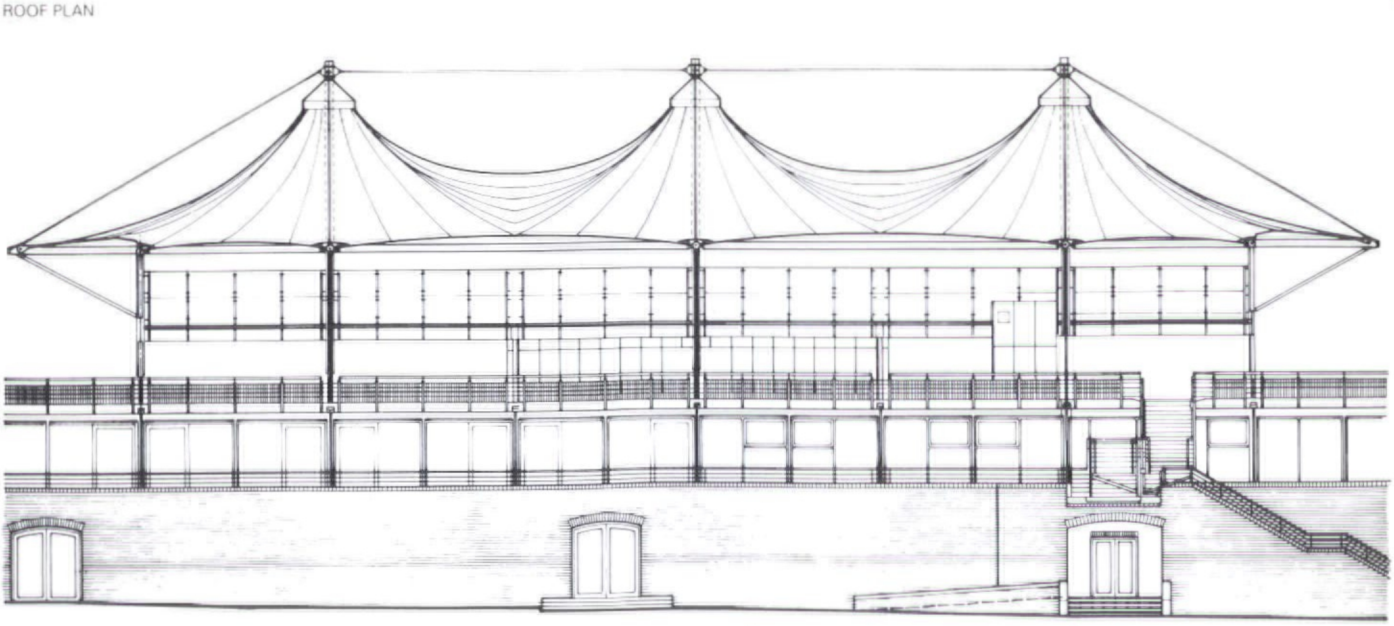
WEST ELEVATION

10



ROOF PLAN

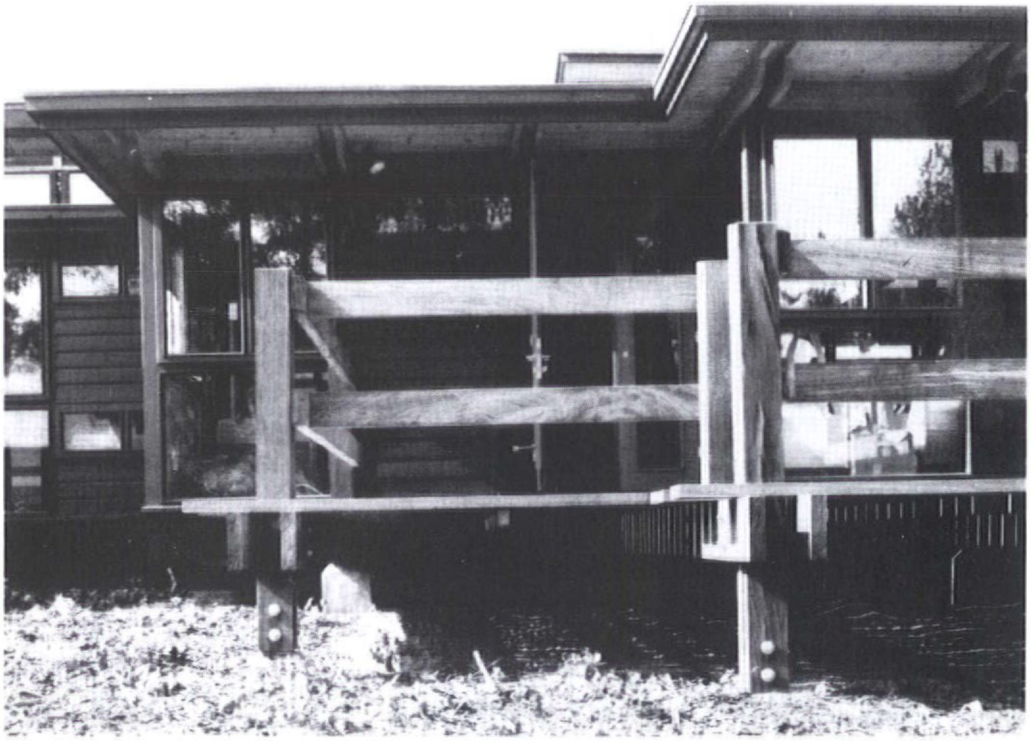
11



SOUTH ELEVATION

12

CI/SfB (21) + (27)



1 View of the infants' wing from the bowl, the external centre to the building. The timber decks have direct access to the classrooms — they are used for both structured learning and free play. The light structure is a contrast to the solid brick bases on the other more public side. The adjustable eaves detail can be clearly seen; here, in an attempt to reduce solar gain, the overhang is large.

External wall and roof
Primary school

Hampshire County Architects Simple, adaptable details are used in this brick and timber-framed school.

The new primary school at Whitehill, Hampshire, is tightly planned around a natural bowl at the top of a densely wooded site. Although its organic form appears complex, the school was simple to build and is simple to understand.

There are two methods of construction — the solid brick outer 'crust' and a lighter timber frame, both using the same 1200mm grid. Principles for dealing with junctions were established and communicated to the builders either by quick sketches or verbal explanations on site. Junctions were designed to allow flexibility — the eaves, for example, have a constant soffit profile but are easily adaptable to suit different conditions.

The section through the infants' wing illustrates the basic education and construction philosophy. Small brick 'bases' used for quiet activities, are clad externally in timber — softening the crust — but have a cold, painted finish inside.

The timber-framed areas are open-plan yet subdivided by the floor and roof treatment. In the tiled wet area, large clerestory windows, although slightly shaded by the deep eaves, have produced excessive solar gain — blinds are going to be fitted. The brick side walls and floor tiles provide some thermal mass but the light structure reacts quickly to changes of temperature; it is easy to open the windows to allow through ventilation, but it will be slow to heat — a drawback as small children are affected by temperature more quickly than adults.

In response to the sloping ground, the structure changes to post and beam with a suspended timber floor. Tapered insulation is used to create the fall on the flat roof, producing a thickness of up to 200mm; lifting the structure or using tilting battens is more common but dependent on good workmanship.

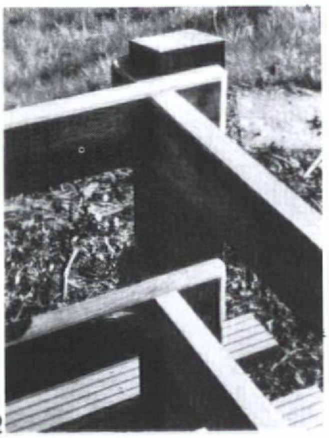
The loadbearing external stud walls were fabricated off-site (panel size up to 3.6 x 9.6m) and could be erected by two men. The vapour barrier is consistently breached by the internal boarding fixings, but the wall is drained through gaps between spacers, so trapped condensation can escape.

The chunky external timber deck is built from tropical hardwoods, iroko and keruing. The planks have semicircular slip-grooves — these have better self-cleaning properties than a rilled (square) cut.

Timber-framed buildings have been thought to be unsuitable for school buildings because of their low fire resistance and maintenance difficulties; the small scale of this building reduces these problems and proves their worth. Structural timber members are obviously sized for charring and are finished with a fire-resistant lacquer; distances to the fire escapes are short. The timber boarding needs re-staining every five years.□

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.

Working Details



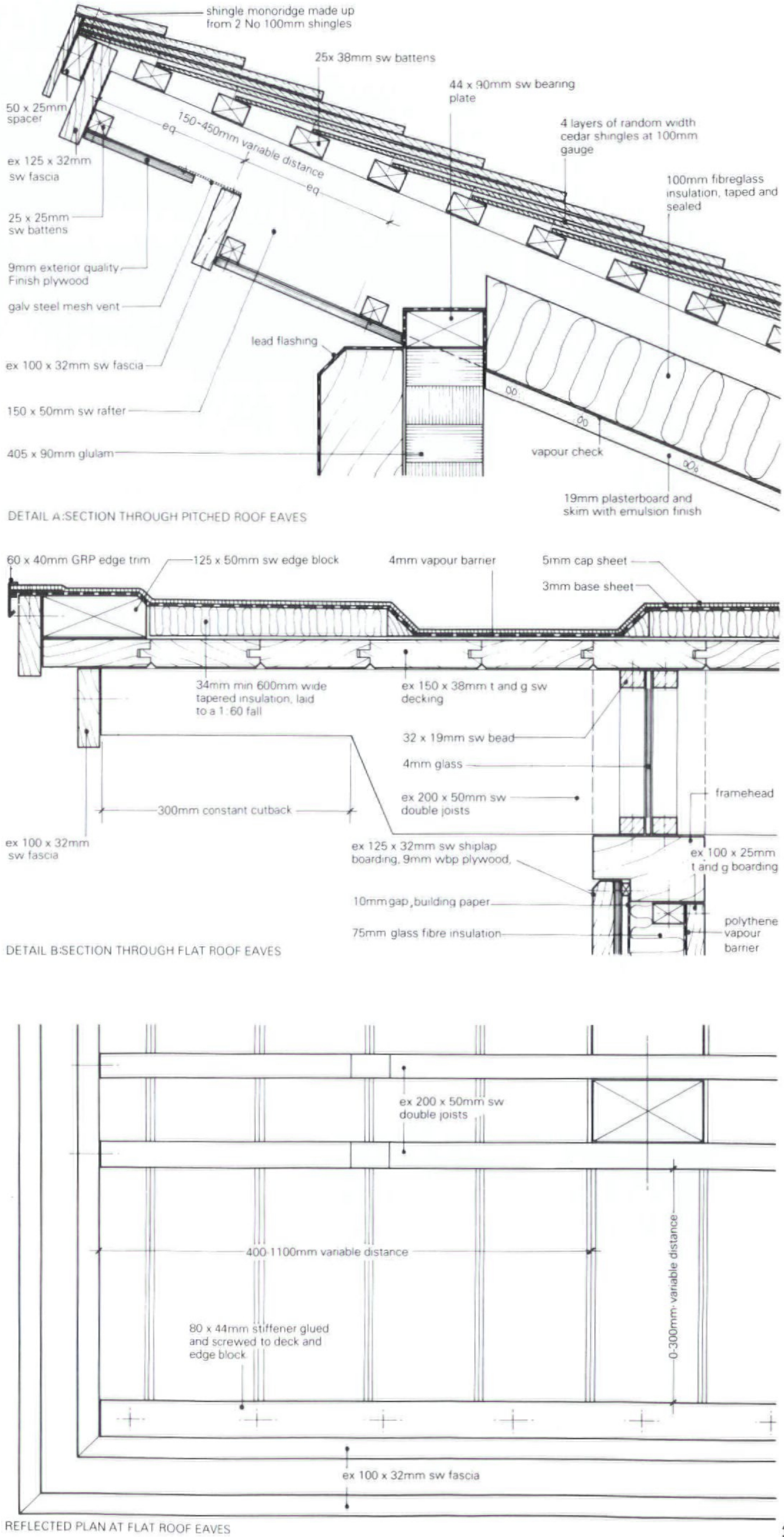
2

2 Detail at the iroko corner deck post. The handrails are not notched round the post; a section of rail is attached afterwards.
3 Two roof details (pitched and flat) are used in different overhang conditions throughout the building. The drawings show the fixed and adjustable dimensions.
4 Isometric of the timber deck.
5 Section through the infants' wing. The architect uses the two methods of construction — brick and timber frame — to form a range of spaces suitable to the various needs of the class.

Credits
location Woodlea Primary School, Whitehill, Bordon, Hampshire
client Hampshire County Education Department
architect Hampshire County Architects
county architect Colin Stansfield Smith
design team Nev Churcher, Sally Daniels
technician Jeremy Cox
clerk of works Danny Fisher
landscape design Pirkko Higson and Stuart Pearson
structural engineer Watkinson and Partners: Michael Wharf
M&E engineer RHB Partnership
quantity surveyor Dadson & Butler
main contractor John Lay & Co (Portsmouth)
site agent Russell James
nominated subcontractors: mechanical installation Privett Heating, **electrical installation** Renelec Building Services, **domestic subcontractors: floor tiling** A.G. Rutter, **patent glazing** British Patent Glazing, **flat roofing** Pallard Contracts, **shingle roofing** Binfield Roofing Co, **glazing** Solaglas, **plastering** A.P. Easton, **decorating** W. Foster, **suppliers: specialist joinery** John Lay & Co, **bricks** Redland Bricks, **shingles** Colt Building Products, **laminated timber** Moelven, **flat roofing and insulation** Erisco Bauder, **ironmongery** Elementer, **terracotta floor tiles** Melissa Fergusson Tiles, **decorated floor tiles** Life Enhancing Tile Co, **paints & stains** Valtti (Holman Specialist Paints).

Project data
contract JCT 1980 local authority with quantities
site start date May 1990
completion date August 1991

Photo credit
Photographs by Charlotte Wood.



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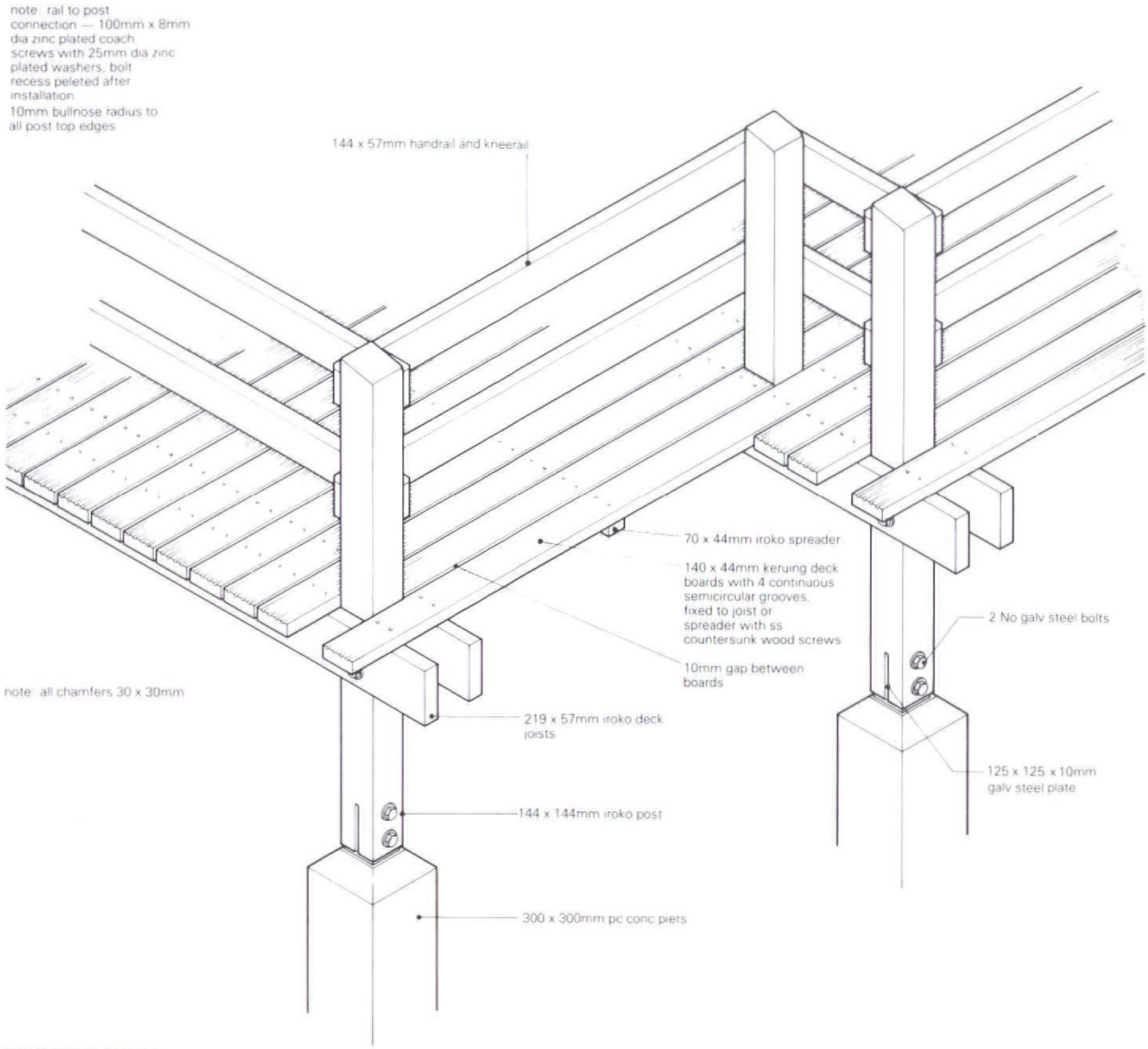
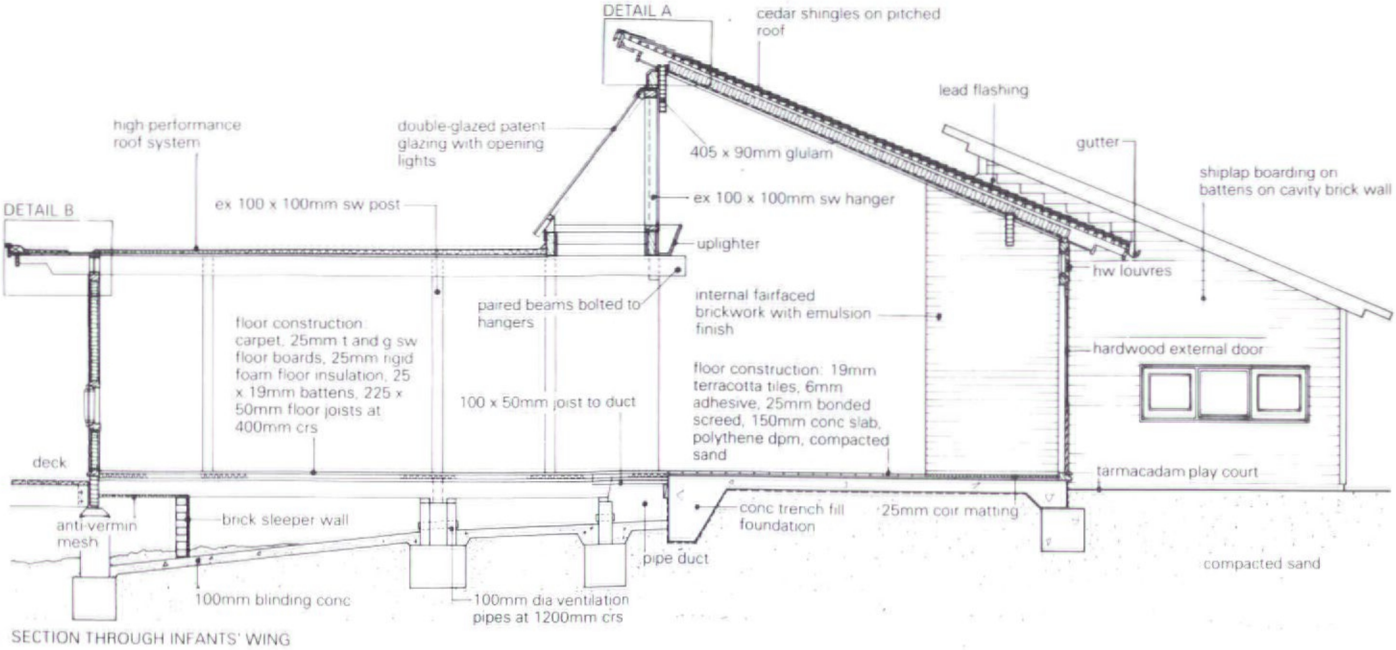
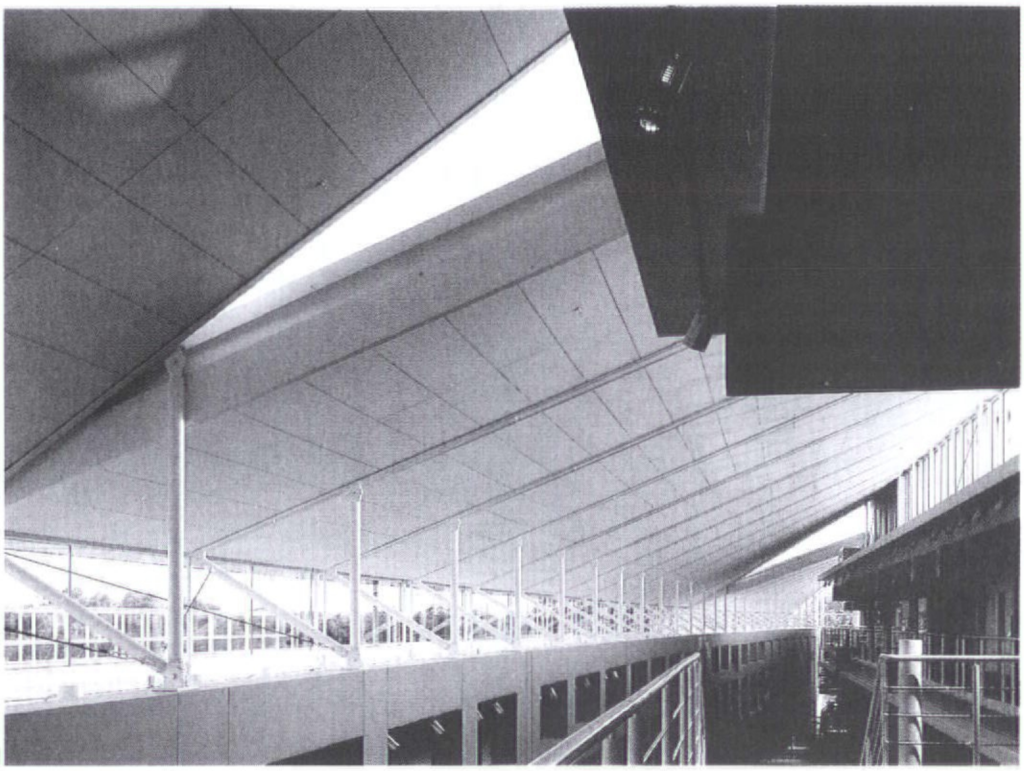


4 ISOMETRIC OF DECKING



5 SECTION THROUGH INFANTS' WING

1 View of the roof structure showing its twisted form. The breaks in the roof — formed by a split in the double channel spanning member — reflect the staggered floor plan of the office (north) block.


1

Roof
Office

Arup Associates This twisting steel roof structure successfully bridges the gap between the different geometries of two blocks.

The new office building for Royal Insurance provides a self-contained work and leisure space for 1000 people; it is situated in the Peterborough Business Park, five miles to the south-west of town.

The dual nature of the building is clearly articulated through the planning and structure. The south (entrance) block has a radiating steel frame which gives the flexibility needed for the variety of support facilities, while the office floors, with their consistent planning and loading, use an exposed in-situ concrete frame. The two wings are connected at ground level by an internal street.

The roof to this street follows the radiating grid of the south block. Its elegant, twisted form appears wilful, but it is based on a rationale which gives an order to the otherwise unruly space. The dimensions and pitch of the steel roof structure at each grid line were calculated by setting two constants — the height of the south clerestory window, and the height from the edge of the concrete roof slab. Variations in pitch (20-50°), span (3-11m), and the desire to keep the details constant mean its structural efficiency is inevitably compromised. A double channel spans the space and is supported by pin-jointed struts; a 50 x 50mm solid square section, in the plane of the south clerestory, was added to counteract the effects of uplift or slippage (depending on the pitch) and acts as either a tie or a prop. The double channel splits at two grid lines (in response to the staggered office floor plan); each channel takes a different pitch, which has the visual effect of breaking the roof into three.

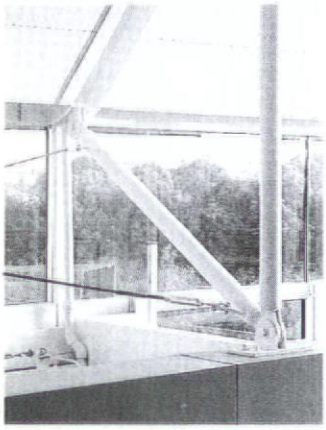
Every element of the roof build-up has to twist. A mock-up of the most extreme case was done on site to prove that the chosen materials would be suitable. Profiled metal decking trays span across the top of the channels to form the structural deck; this acts as the vapour control layer and holds the insulation in place. Timber counter boards maintain a 10mm air gap above the insulation and close boarding provides the continuous backing for the felt and terne-coated stainless steel. The metal roof is seamed every 450mm with a capped joint. These relatively thin strips allow the differentiation in width (due to the radial twist) to be taken at the upstand of the cap — enabling the sheet to be a constant width.

The ceiling is made up of non-demountable microporous acoustic panels. These sit between the channels and are hung from tags which wrap over the deck upstands (so not puncturing the vapour-control layer). Sprinkler pipes run up between the double channels.□

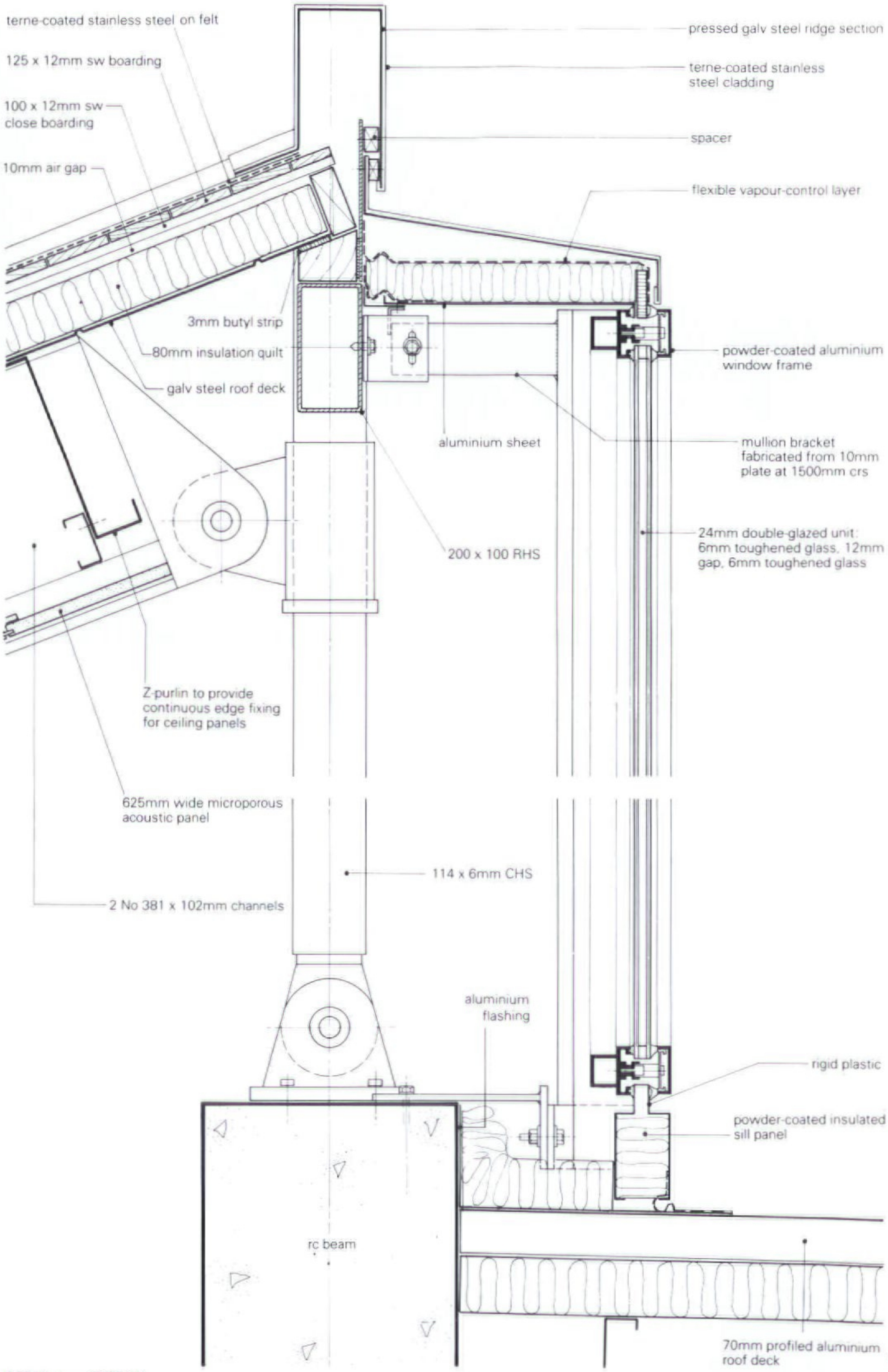
Acknowledgment
The editors acknowledge the assistance of Lionel Friedland of Pentarch in the preparation of this article.

Working Details


2

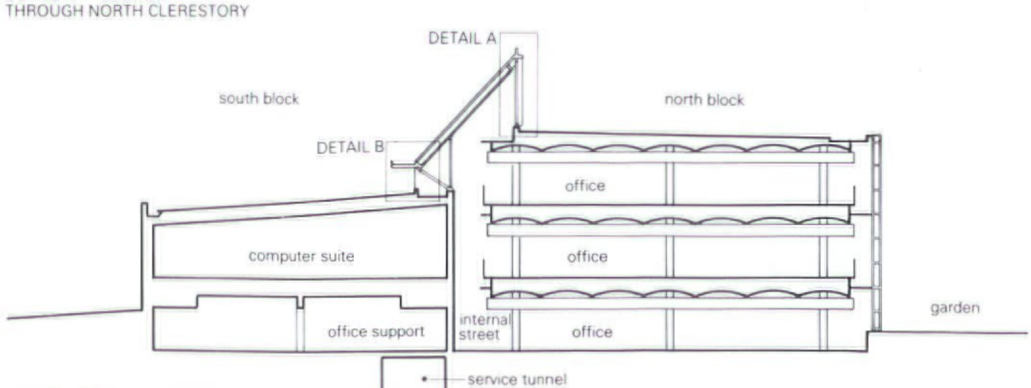

3

2 West elevation, where the roof is at its narrowest and steepest pitch.
3 Detail at the south clerestory. The sprinkler pipe can be seen running up between the double channel — this neat solution avoids the need to constantly puncture the ceiling panels.
4 Section through the north clerestory (at the minimum pitch).
5 Cross-section.
6 Isometric at south clerestory showing roof and gutter build-up.



4

DETAIL A — SECTION THROUGH NORTH CLERESTORY

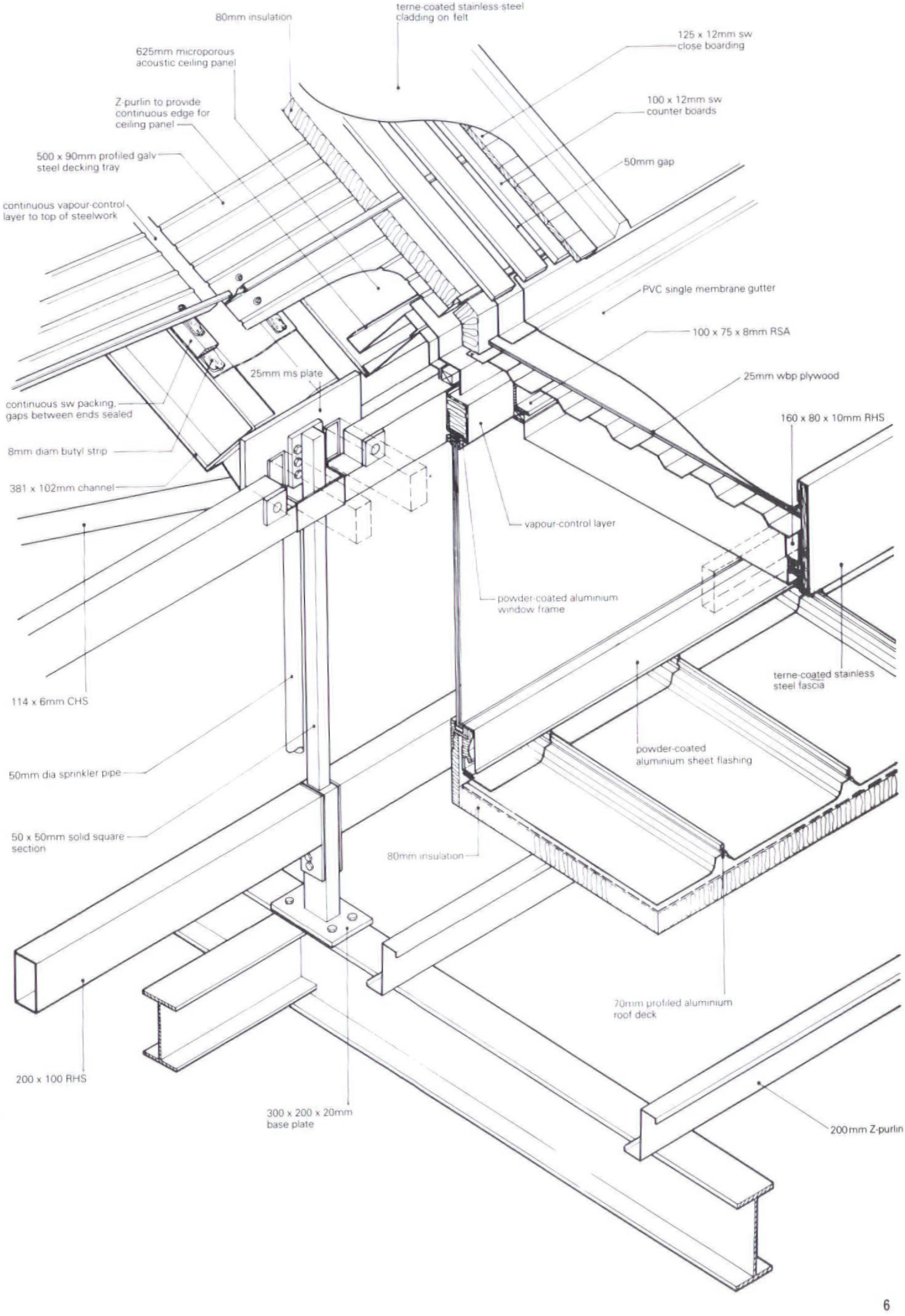


CROSS SECTION SHOWING THE STREET AT ITS MINIMUM WIDTH

5

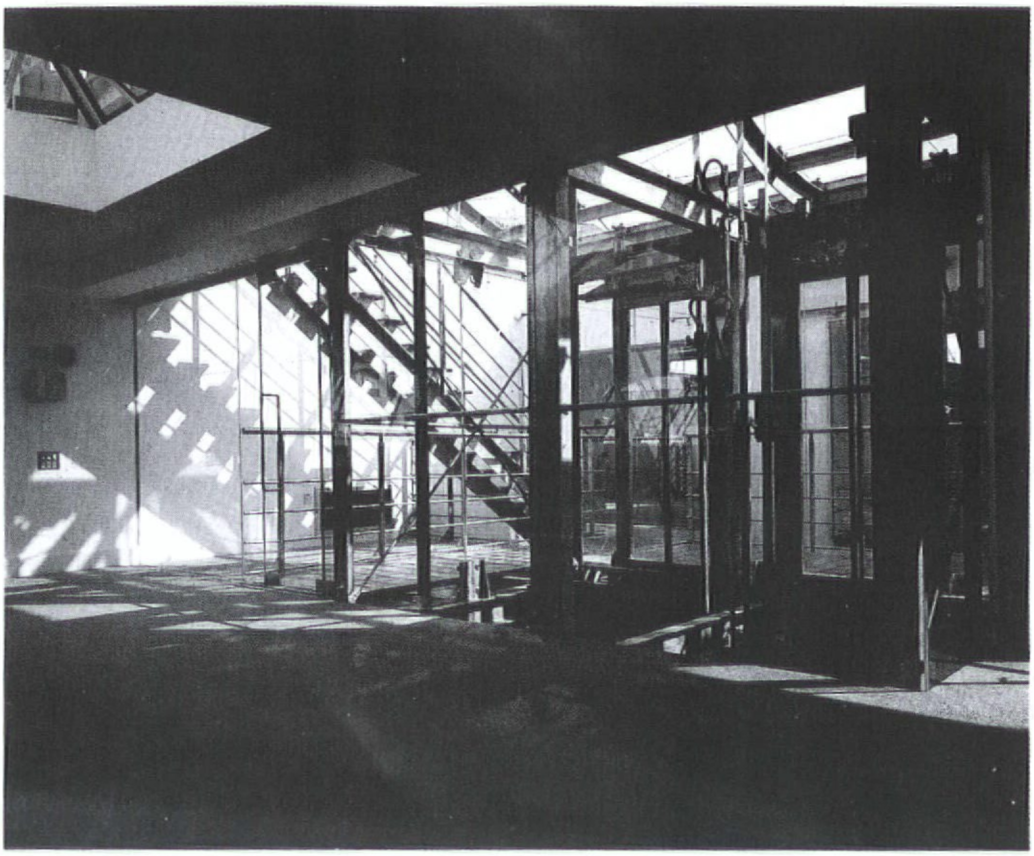
Credits
location Royal Insurance House, Peterborough Business Park
client Royal Insurance
architect, engineer and quantity surveyor Arup Associates
landscape consultant Derek Lovejoy and Partners
management contractor Bovis Construction
subcontractors: street roof structure Robert Watson, **street roof covering** Hook and Slate, **sprinklers** Chubb Firekil

Project data
contract Management Contract
site start date March 1989
completion date March 1991


80mm insulation
terne-coated stainless-steel cladding on felt
625mm microporous acoustic ceiling panel
125 x 12mm sw close boarding
Z-purlin to provide continuous edge for ceiling panel
100 x 12mm sw counter boards
500 x 90mm profiled galv steel decking tray
50mm gap
continuous vapour-control layer to top of steelwork
PVC single membrane gutter
100 x 75 x 8mm RSA
25mm ms plate
25mm wbp plywood
continuous sw packing, gaps between ends sealed
160 x 80 x 10mm RHS
8mm diam butyl strip
381 x 102mm channel
vapour-control layer
powder-coated aluminium window frame
terne-coated stainless steel fascia
114 x 6mm CHS
powder-coated aluminium sheet flashing
50mm dia sprinkler pipe
50 x 50mm solid square section
80mm insulation
70mm profiled aluminium roof deck
200 x 100 RHS
300 x 200 x 20mm base plate
200mm Z-purlin

6

CI/SfB (27)+(31.4)

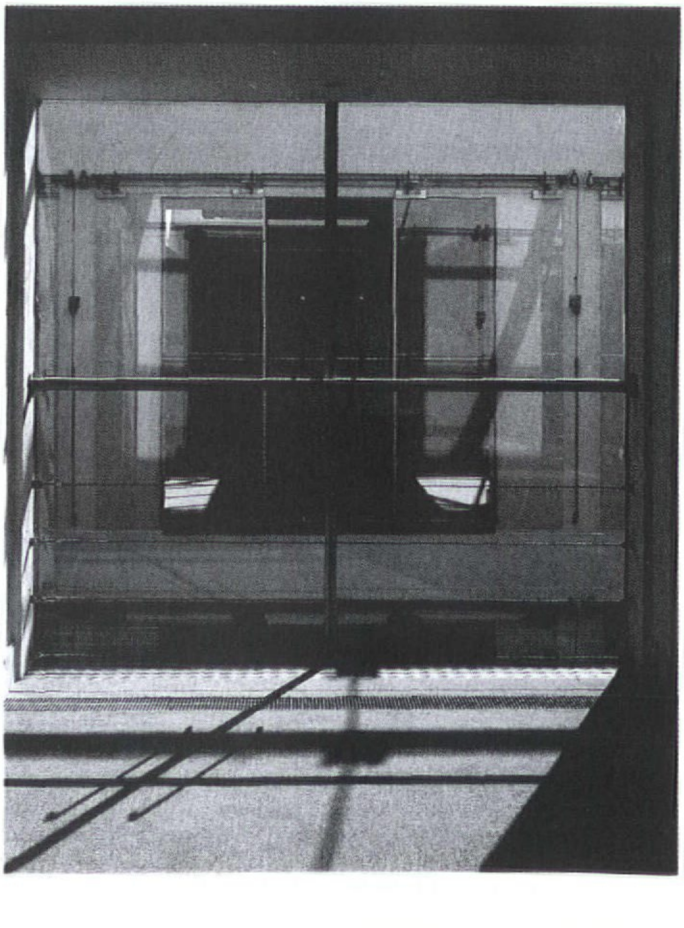


2

Roof and windows
Office

Jestico + Whiles designed the new atrium in this warehouse to maximise the entry of natural light and ventilation.

1



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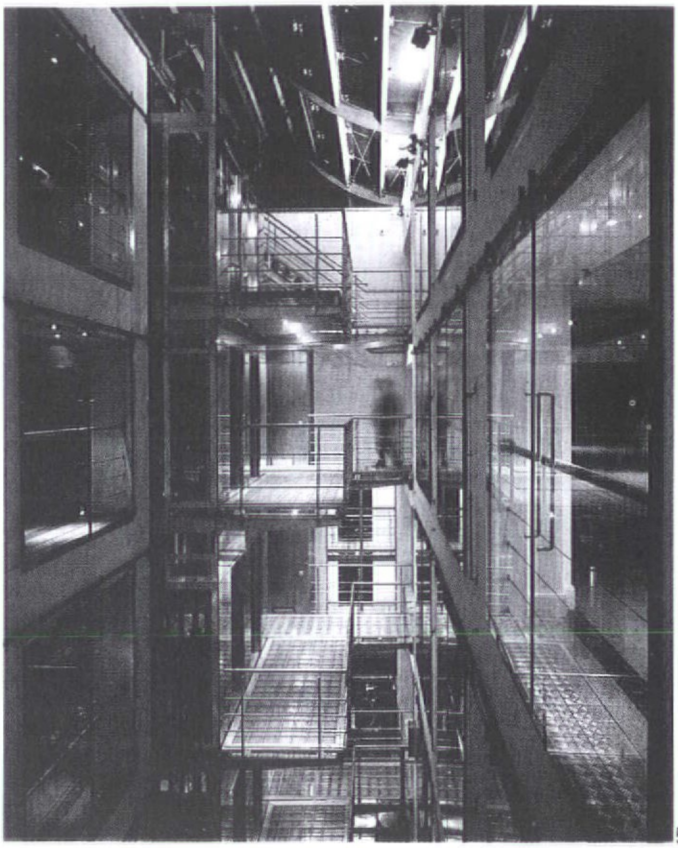


5

No 20-22 Stukeley Street was an Edwardian warehouse built on a corner site in London's Covent Garden. The building was divided by a small, dingy lightwell. The brief was to convert the building into office units within a budget of approximately £1.2 million (about £60 per sq ft).

The key to the architect's approach was to give the building's users a high degree of control over their environment by using natural light, natural ventilation and by the provision of self-contained, gas-fired heating systems on each floor.

An atrium has been created with circulation and sanitary accommodation on either side of a vertical shaft — all covered with an undulating glazed roof and open along both sides. The offices are open plan and can be partitioned by tenants.

Glass casings to the lifts and specially made glass lenses on the balconies allow light to filter down through the atrium, and stainless steel wire mesh screens along the internal parapet are used to bounce sunlight down the walls — mesh was used because air has to pass through the screens. To make maximum use of the daylight, window sills in each office are taken down almost to floor level and thin cable balustrades act as safety barriers.

To create an environment relying on natural air circulation, the atrium is used as a ventilation shaft in which hot air rises thereby drawing air from the offices. For this to work, the windows onto the atrium and street have to be open with few restrictions between. It is intended that when air flows across the top of the roof from the lower side to the higher, negative air pressure will be created at the mouth of the wider opening, drawing air from the atrium. During winter, windows are unlikely to be open and the air in the atrium will remain static. In practice this set-up would be better if it did not rely on the vagaries of human nature to keep windows open, particularly given that there will be draughts. Further complications would arise if the floors were partitioned.

Being an open atrium, only one smoke detector was required to operate electro-magnetic closing devices on the glass windows to the offices. When a window is opened an electro-magnet keeps the vertical spring in tension. If the current is switched off the spring is released so closing the door.

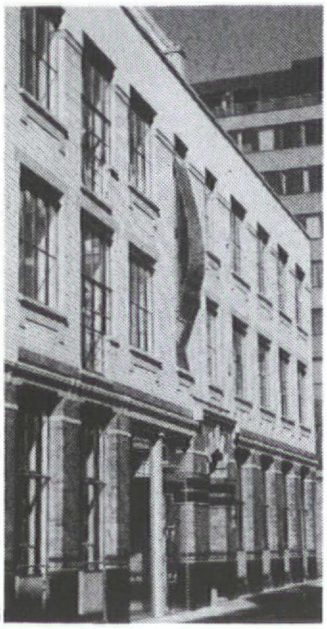
The roof to the atrium is made up from a Greenberg's Thermospan glazing system on a galvanised mild steel structure of undulating T-beams with T-purlins bolted on to them. The web of each purlin is gripped by cleats welded to the web of the beam, so the flanges of the purlins and beams remain flush. Welded to the top of the purlins are flat plates to which are bolted 170 x 170mm T-plates for the glazing. Horizontal slots allow for tolerance when bolting on the plates. The glazing system is made up of 1500 x 1200 x 10mm toughened glass sheets, gripped in each corner by a bolting system and sealed along the joints by silicone sealant. The beams are supported by circular hollow sections anchored down to concrete beams.

The structure is stabilised to prevent movement — the end bay braced diagonally with steel cables, and the two central vertical supports also braced diagonally to stop the beams toppling over like dominoes. The stub columns at the low end of the beams are stiffened to prevent the structure from tilting from front to back.

Uplift is a problem that occurs in all roofs — here the roof has been designed to create the effect. To counteract this, the beams that support the glass are considerably larger than normal. □

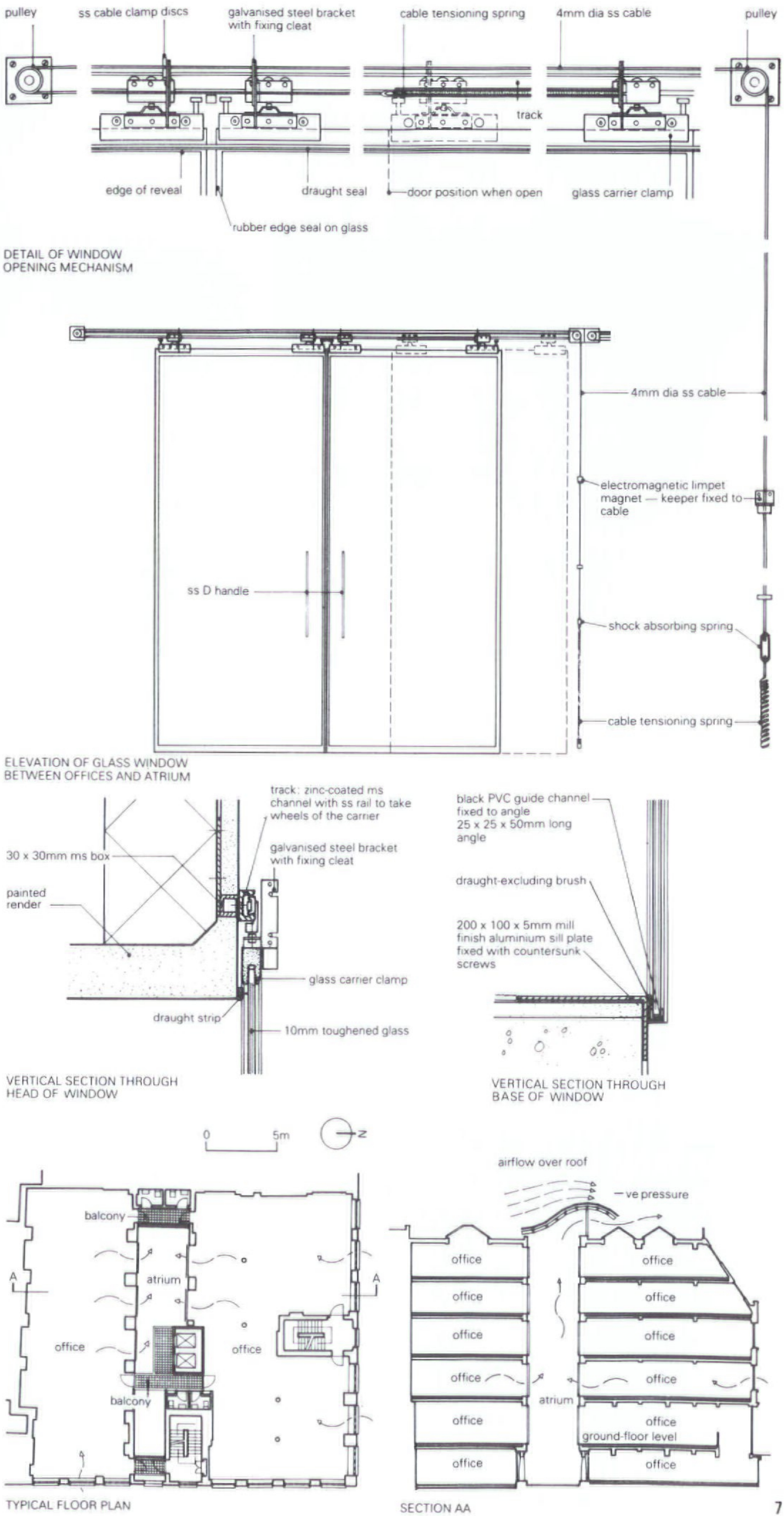
1 The atrium at fourth-floor level, with the roof access stair behind.
2 A rear view of the lifts, from the fourth-floor office.
3 The windows between the offices and the atrium.
4 The entrance area. The reception desk is galvanised mild steel.
5 The atrium at night. The end bay of the roof had to be braced.

Working details



6

6 Exterior of the refurbished building.
7 Window elevation and details, and, below, a typical floor plan and section. The plan and section show anticipated air movement. Air is drawn out of the atrium because of the negative pressure created by the shape of the roof, to be replaced by air entering through the window openings in the outside walls.
8 Section through the top of the atrium showing the stair and roof, and above, roof details.

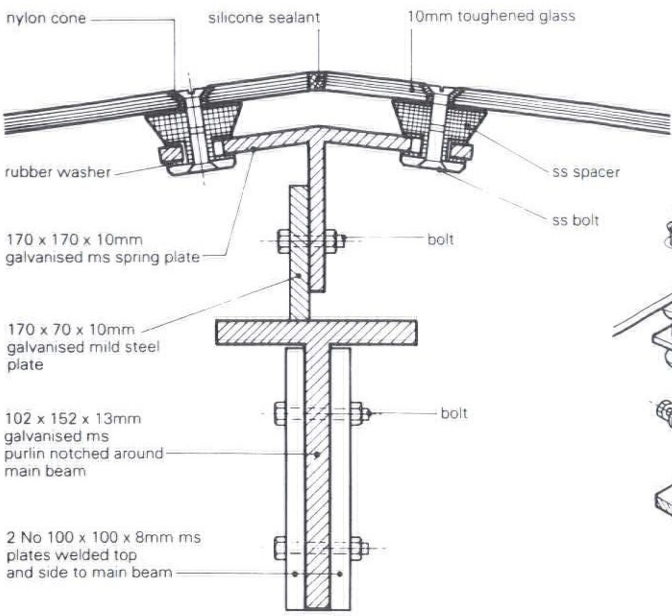


7

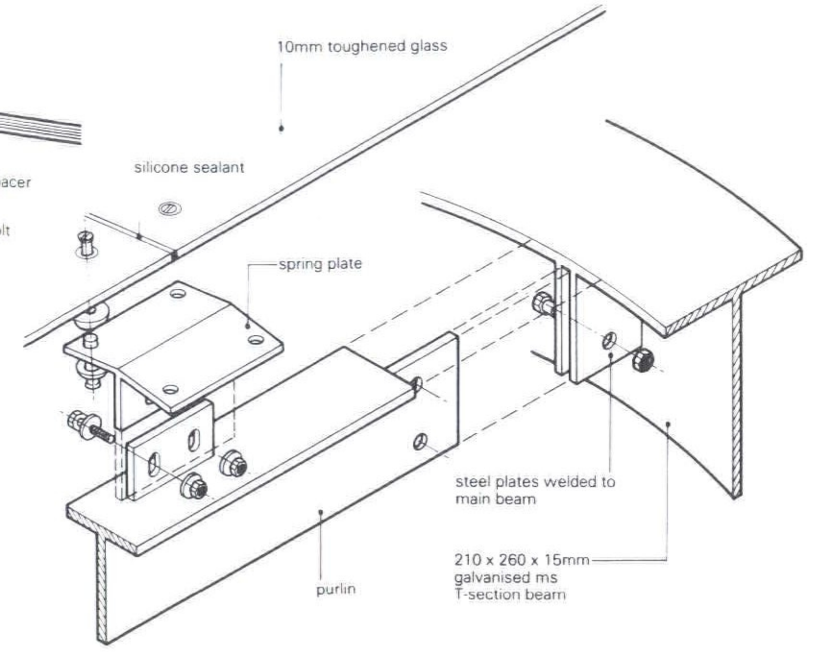
Acknowledgment
The editors acknowledge the assistance of Lionel Friedland of Pentarch in the preparation of this article.

Credits
location No 20-22 Stukeley Street, London
client Burswood BV
architect Jestico + Whiles: Alan Cardwell, Tony Ingram, Eoin Keating, Tony Ling, Jane Ostler, Anne Rowall, Martin Williams
structural engineer Price + Myers: Nick Hanika
services engineer HGS Engineers
quantity surveyor Michael Gregory Associates
project surveyors Watts and Partners
contractor Mansells

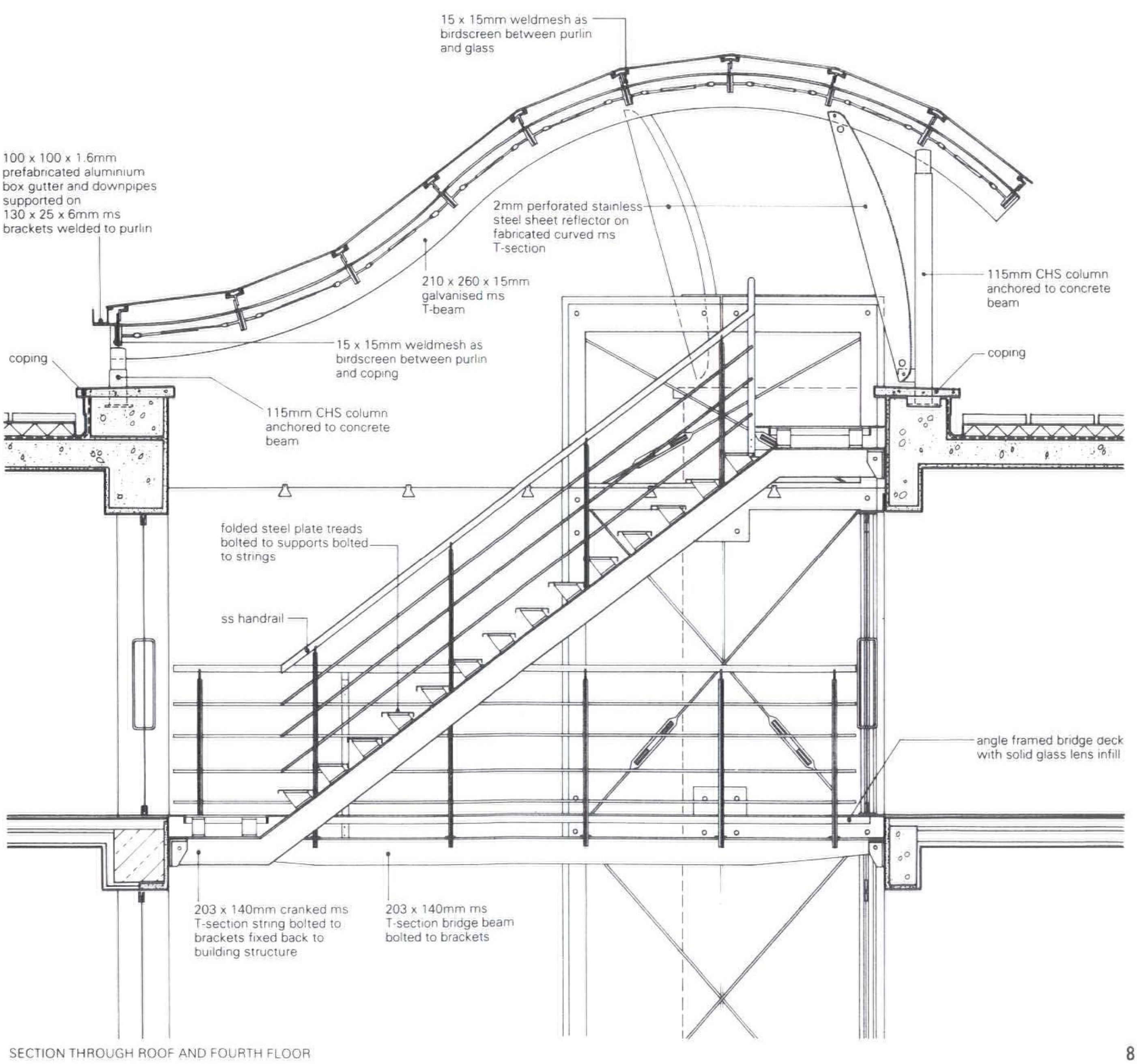
Project data
Contract JCT Management Contract
site start date May 1990
completion date February 1991



DETAIL THROUGH ROOF GLAZING SYSTEM



ISOMETRIC OF GLAZING AND STEELWORK JUNCTIONS



SECTION THROUGH ROOF AND FOURTH FLOOR

8

EXTERNAL WALLS AND ROOF
PLAY CENTRE
Hawkins Brown

AJ Database CI/SfB (A3) or (21) + (27)

This play centre — originally designed as a prototype — was adapted to the needs of the client and site. Glu-lam beams support a metal decking roof and give the building its distinctive shape.

Related article
Building feature
(AJ 6.2.91)

1

1 View of the play barn from the south-west. The glu-lam arches give the building its distinctive shape.

This 404 m^2 play barn is formed from a series of glu-lam arches fixed to the concrete foundations with — and kept off the ground by — steel T-pieces. Proprietary aluminium decking, with a U-value of 0.18 Watts/m^2 °C, wraps round the arches to form the roof and north wall. The gable walls are plywood-clad stud walls, and the vertical south wall is glazed, but then protected by roller shutters fixed to the arches.

The outer skin of the decking — an insulated sandwich — is bent to 5 m, such a tight radius that it shows some crimping at the edges (although this radius was advertised as achievable by the manufacturer).

The steel windows in the south wall were preferred by the architect to aluminium windows because of their lighter sections. To protect this wall from vandalism at night, to provide a space for storing play equipment, and to shield the building from excessive solar gain, each bay is fitted with a roller shutter. Standard shutters had to be adapted to allow them to be fixed centrally, and follow the curved profile, between the glu-lam arches. The steel plates carrying them are fixed to the universal beams above the columns which support the windows.

The shutters are operated from switches behind the glu-lam arches. Each switch operates three shutters — it takes one person about six minutes to close up all the shutters at night.

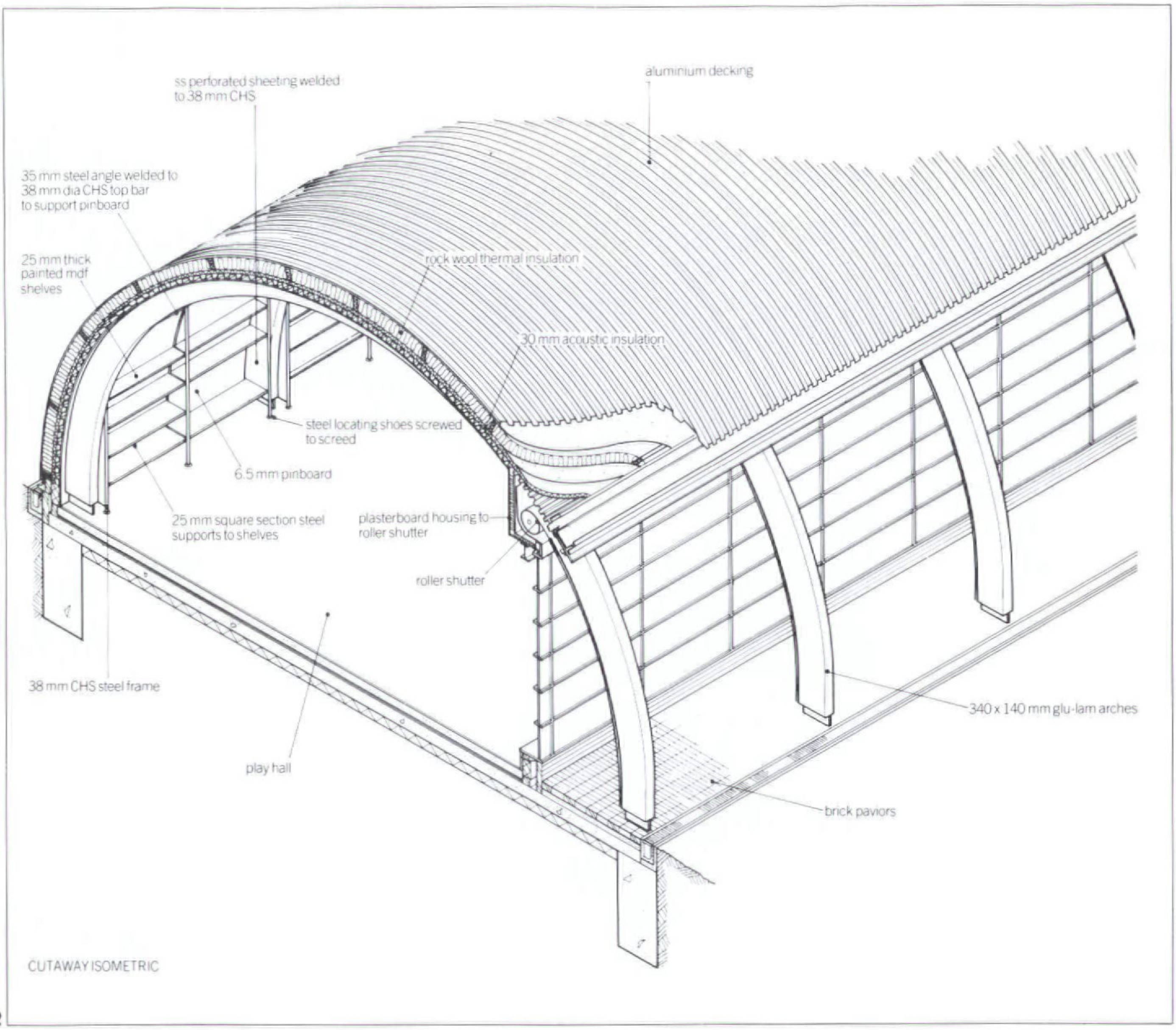
The architect originally considered forming gates in the end walls between the glazed walls and the shutters, but chose mesh infill panels instead, for greater security. The 1.5 mm perforated metal sheet panels are framed with 40 x 40 mm galvanised steel angles fixed to the structural slab.

The external plywood to the gable walls was intended to be finished with an epoxy-resin coating, but the client chose to simply varnish it, and, when the inevitable graffiti appeared, to make cleaning it off and revarnishing the panels a play activity. This requires committed management to avoid the building looking shabby very quickly. In the eight months since the building opened, the varnish finish to the arches has almost completely disappeared — possibly due to the specified finish (two coats exterior quality varnish) not being correctly applied.

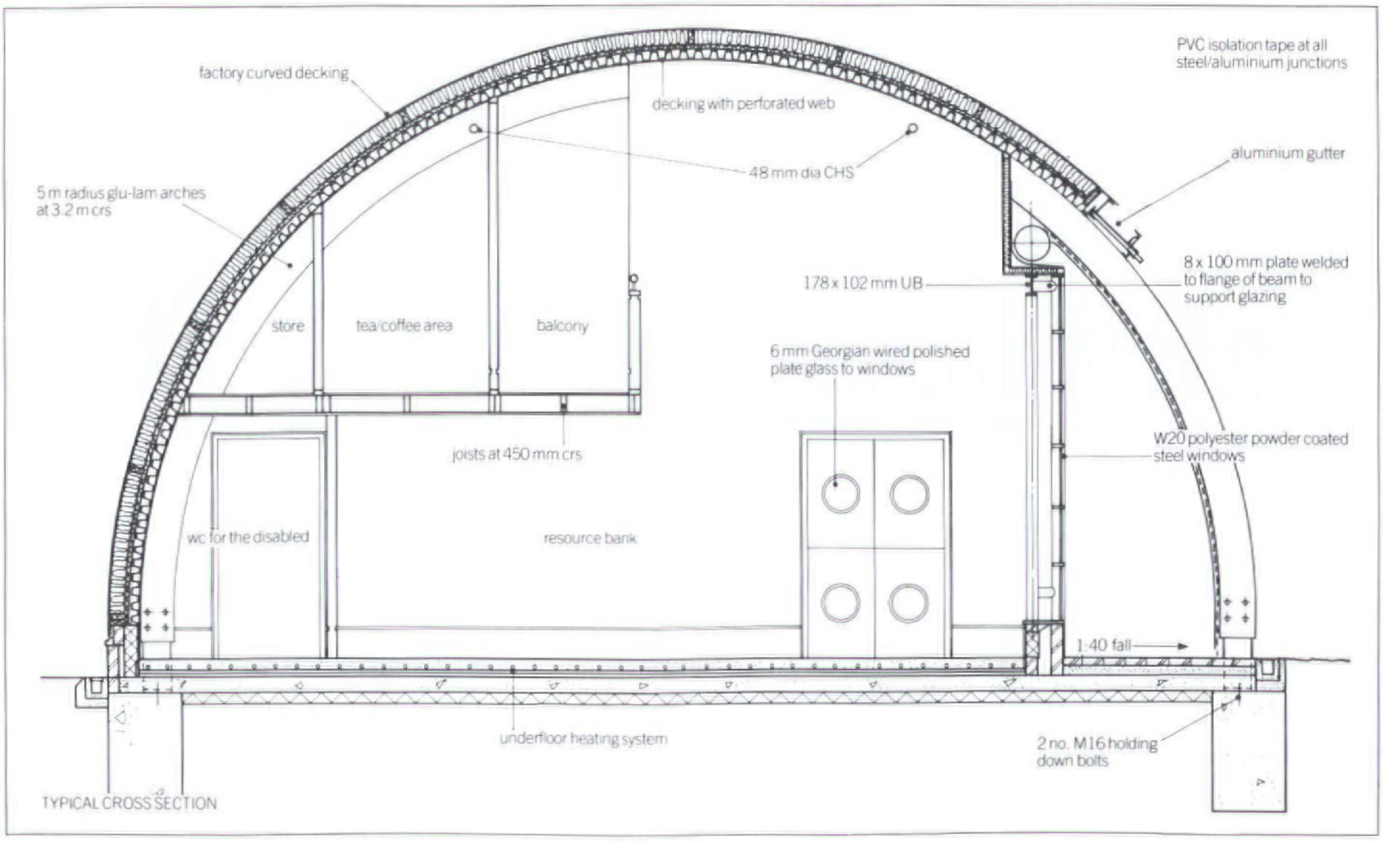
The glu-lam arches were positioned on site by using two runs of 48.3 mm dia steel tubes as spacers, and these were then used to support the lighting. Once erected the roof provided lateral restraint and wind bracing for the arches.

A German underfloor heating system warms the building. Once installed, it is impossible to repair without digging up the screed — but the building itself is only expected to have a life of 20-30 years. ■

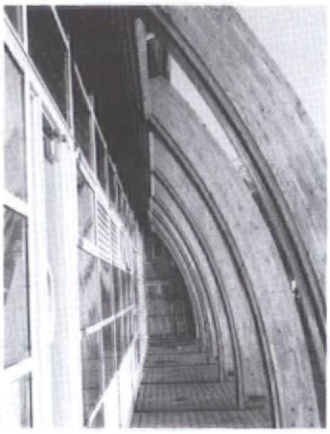
Acknowledgment
The editors acknowledge the help of Lionel Friedland of Pentarch in the preparation of this article.


ss perforated sheeting welded to 38 mm CHS
aluminium decking
35 mm steel angle welded to 38 mm dia CHS top bar to support pinboard
25 mm thick painted mdf shelves
rock wool thermal insulation
30 mm acoustic insulation
steel locating shoes screwed to screed
6.5 mm pinboard
25 mm square section steel supports to shelves
plasterboard housing to roller shutter
roller shutter
38 mm CHS steel frame
340 x 140 mm glu-lam arches
play hall
brick paviors
CUTAWAY ISOMETRIC

2


factory curved decking
decking with perforated web
PVC isolation tape at all steel/aluminium junctions
48 mm dia CHS
aluminium gutter
5 m radius glu-lam arches at 3.2 m crs
178 x 102 mm UB
8 x 100 mm plate welded to flange of beam to support glazing
store
tea/coffee area
balcony
6 mm Georgian wired polished plate glass to windows
joists at 450 mm crs
W20 polyester powder coated steel windows
wc for the disabled
resource bank
1:40 fall
underfloor heating system
2 no. M16 holding down bolts
TYPICAL CROSS SECTION

3



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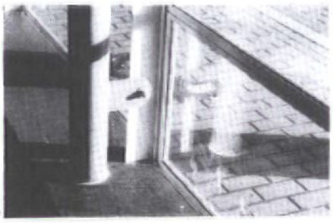
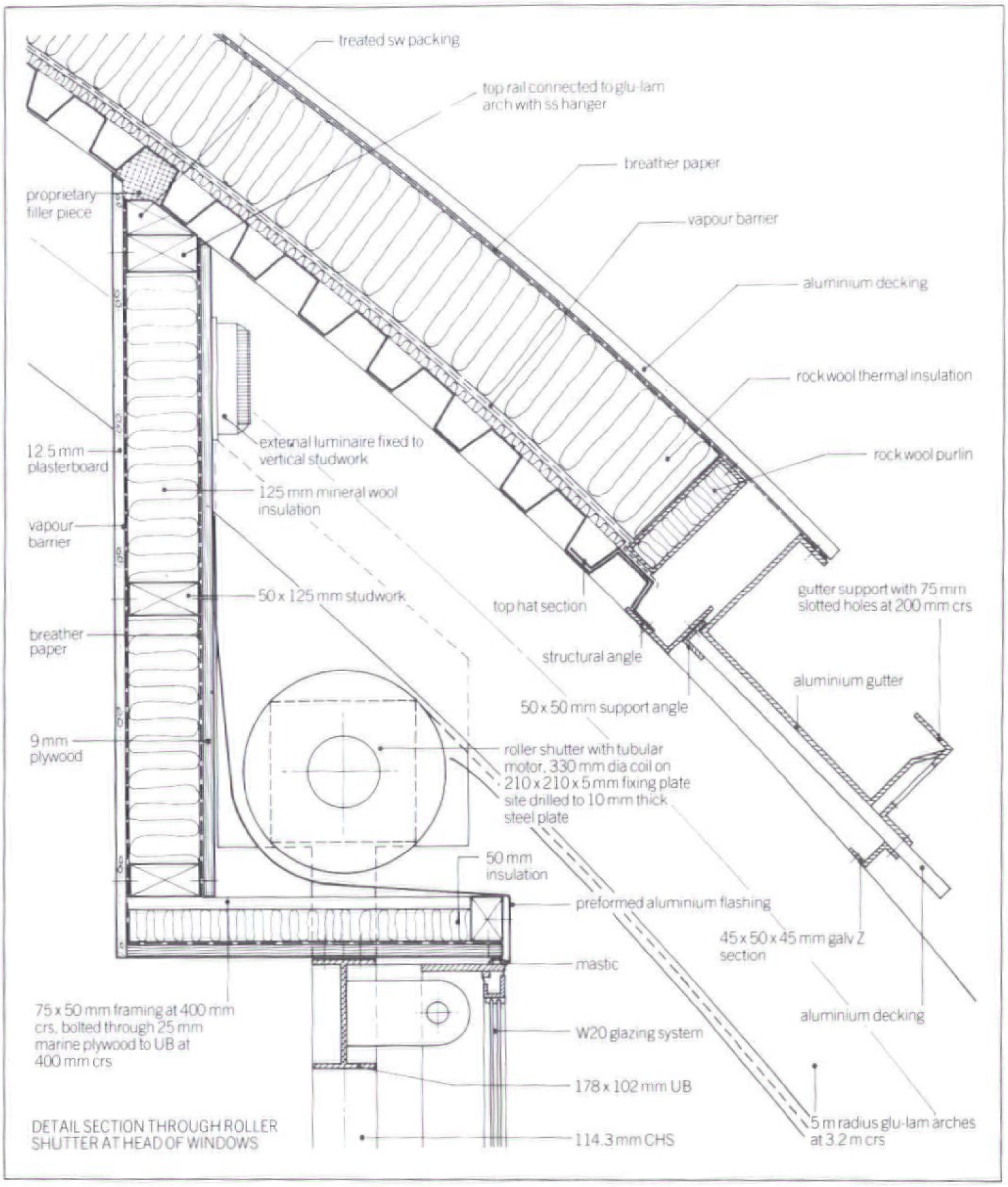


5

6

2 Cutaway isometric showing the structure of the building.
3 Typical cross-section.
4 When the shutters are down, this space is secure — protecting the glazing from vandalism and providing storage space for play equipment.
5 The column supporting the windows in the south wall.
6 The arch/ground junction, with the guide for the roller shutter to the left.
7 Detail section at the head of the roller shutter.
8 Detail section at the base of the north wall. The underfloor heating should prevent the uninsulated masonry wall from creating a cold bridge.



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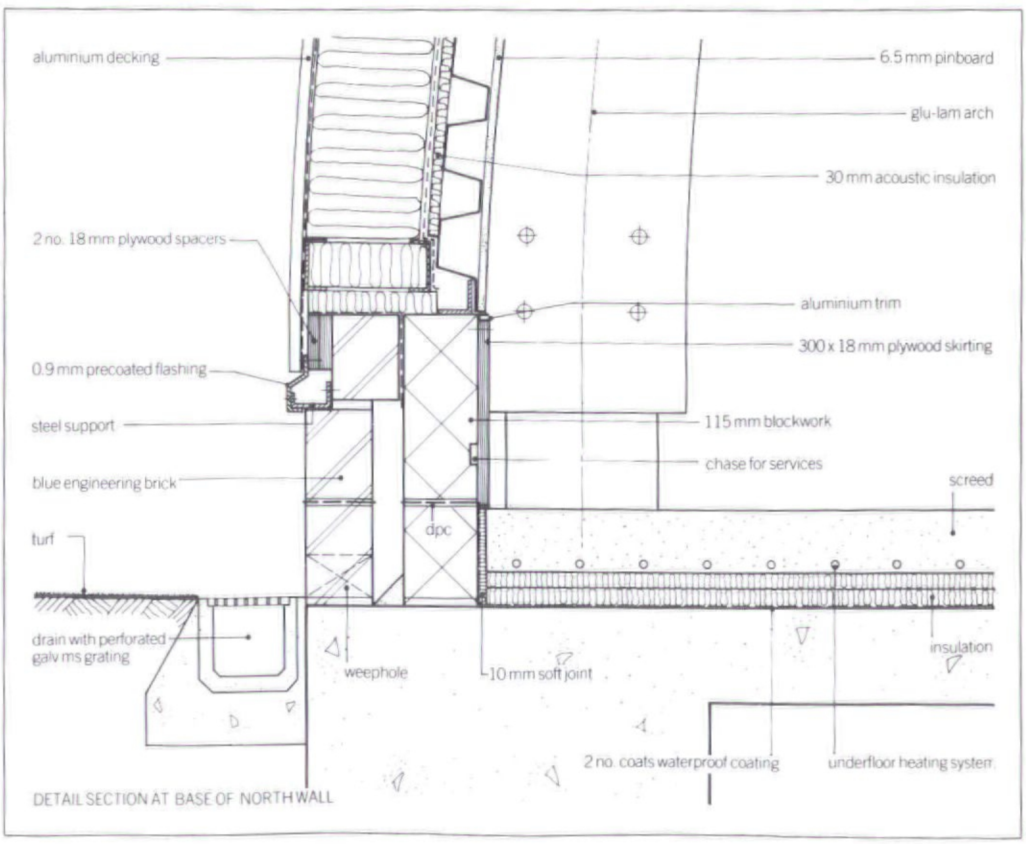


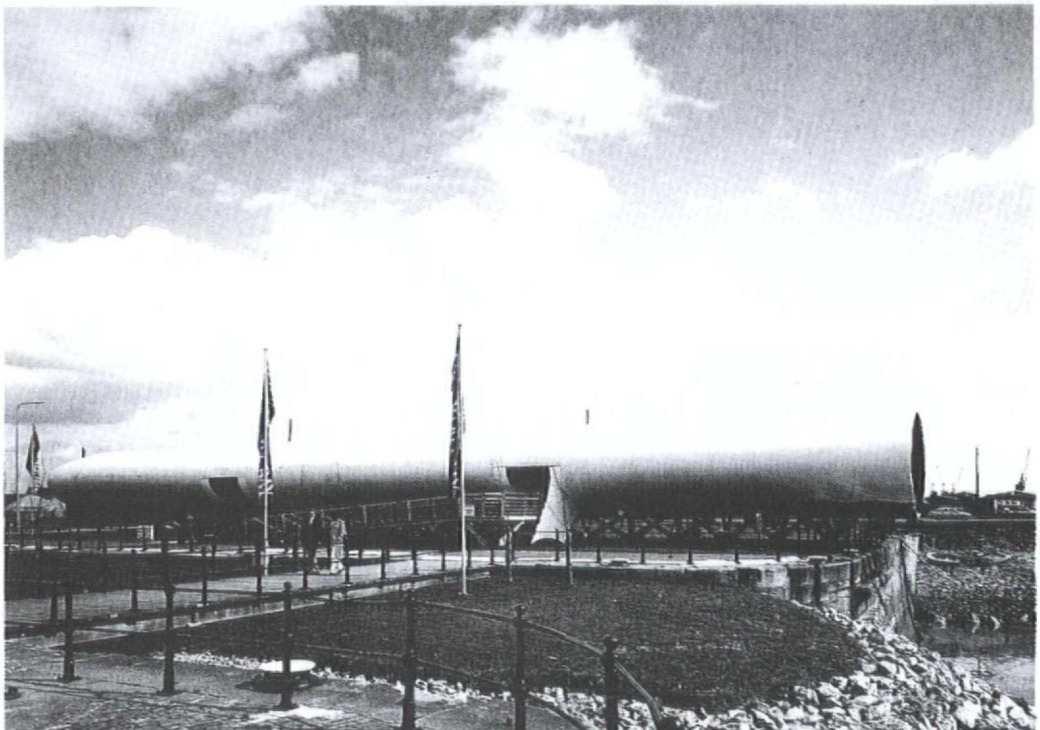
8

Credits
location Greengate Street, London E13
client Interplayce for the London Borough of Newham
architect Hawkins Brown
partners in charge Roger Hawkins, Russell Brown
project architect Andrew Watts
assistant architects Jane Foulkes, Richard Rees, Giles Vallis
quantity surveyor Crandon Pfeffer Partnership (preliminary costings)
structural engineer Millais Mackeith
project engineers Malcolm Millais, Lesley Paine
play consultant Interplay
main contractor J. Jarvis and Sons

TEMPORARY STRUCTURE
VISITORS' CENTRE
Alsop, Lyall & Störmer

AJ Database CI/SfB 983:34

This curving steel structure is clad in plywood, insulation and a PVC-coated fabric. Light allowed through perforations in the plywood and insulation gives the impression of a sunlit interior, even on a grey day.



1

1 Looking east to the visitors' centre, with Cardiff Bay on the right.
2 The structure of the building is clearly, but not aggressively, expressed. The underside of the tube is pleasingly free of clutter and litter.
3 Most of the interior is used as exhibition space. The perforations in the plywood and insulation allow light to percolate through the PVC-coated membrane, giving the effect of sunlight and shade even on a dull day.
4 View across Cardiff Bay through the end of the tube. The patent glazing is protected by being installed one bay in at each end of the building. To prevent ponding on the plywood at the bottom of the ellipse, holes have been drilled along each side of the lowest cross members.

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.

As part of its commitment to architecture, the Cardiff Bay Development Corporation ran a competition for the design of the first of its new buildings — a visitors' centre. The competition result was announced in March 1990, work started on site in June and the building was completed four months later.

Although it has had to comply with planning and building control requirements, the building is temporary, and will probably have to be removed from the site by 1993 — possibly to be re-erected elsewhere.

But as so often with temporary buildings, the architect, freed from the straitjacket of at least 10 years' liability, has allowed himself to be more innovative than he might otherwise have dared.

The resulting structure is eye-catching, attracting people to the visitors' centre even if only out of curiosity about the building.

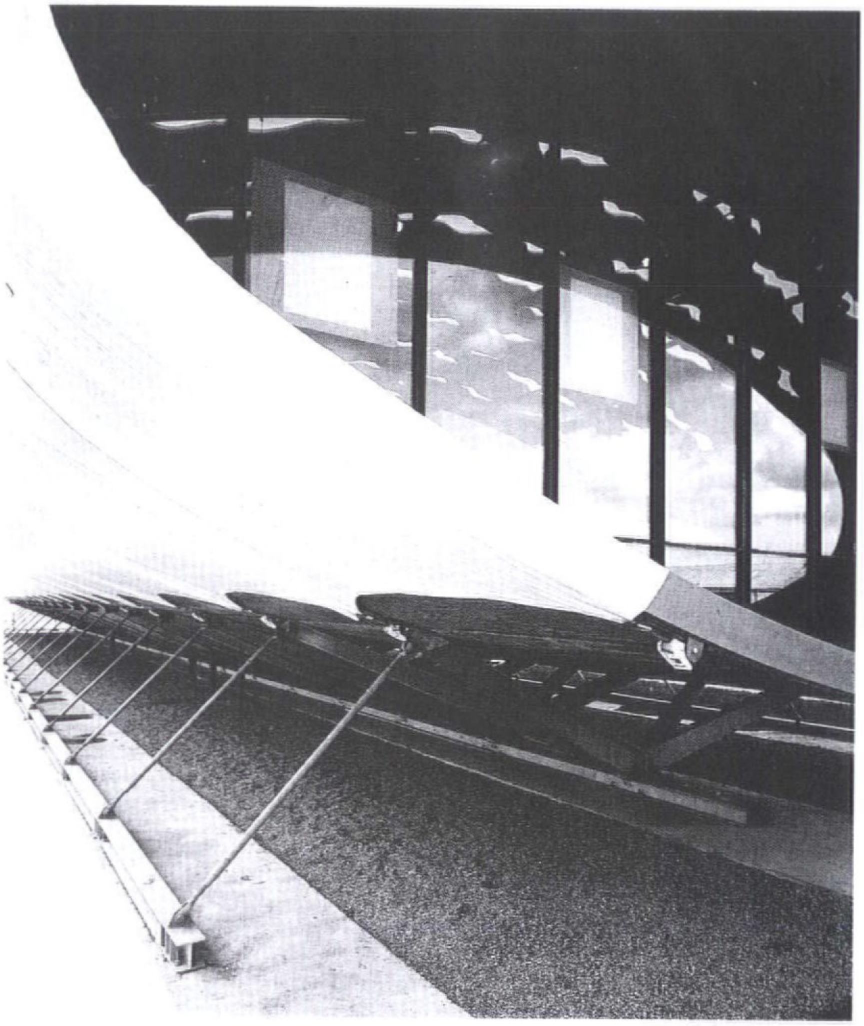
The distinctive tube is formed from a series of steel ellipses at 2.4 m centres (to suit plywood sheet sizes), raised above the ground and supported by a flattened, M-shaped steel structure. Lifting the structure up not only raised its profile, literally, it also allowed it to be neatly cantilevered over the dock wall so that its very south end floats above the water.

The steel ellipses were brought to site in four parts (top, bottom and two sides) and were fabricated on site in pairs linked by the cross-members.

Once these were fixed to the foundations the plywood was screwed on. Three layers of scored 6 mm plywood were used to form the tighter curves, and 19 mm ply elsewhere. But before the roof sheeting was fixed it was laid on the ground at the site, and templates were used to cut perforations out of both the plywood and the insulation which is stuck to it. These slots allow daylight to pass through the outer, flame-retardant, membrane to the centre of the building. They are not transparent but their shape and disposition is such that the internal effect, even on a grey day, is of dappled sunlight.

The outer skin is a PVC-coated polyester membrane, stretched around the building and fastened at the underside. The wrinkling at each end is the result of the friction between the membrane and the closed-cell insulation — several weeks were spent trying, unsuccessfully, to eliminate it. The streaking now apparent at the bottom of the fabric ought to be able to be washed off.

The floor appears to float within the tube, and the space below not only contains the services but is itself a plenum duct for the heating and the air-conditioning that may be necessary in very hot weather. The air-conditioning units are the only items located ouside the building. The air is supplied and extracted through floor grilles. The electrical main runs between steel angles. Underfloor insulation is provided by air



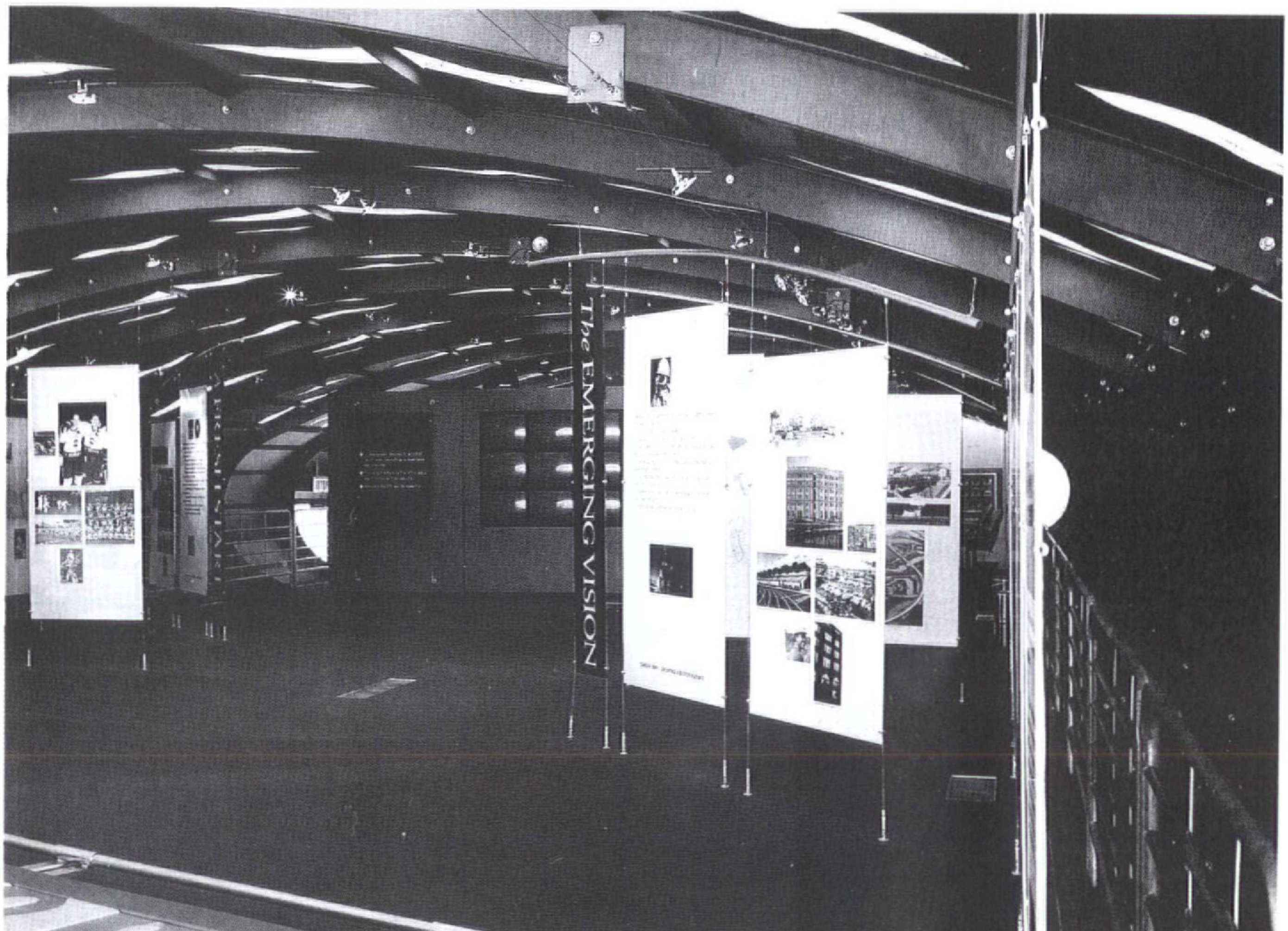
2

4

cushions — encapsulated in aluminium foil.

The only penetrations through the building are on the underside.

One of the most traditional aspects of the building is the vertical patent glazing recessed 2.4 m into each end of the tube. Because of the curves it was relatively expensive, and the double-glazed units have no guarantee because they are not conventionally sealed along their curved edges — curved sections weré too expensive. The glass is 6 mm laminated clear float, film-coated, because toughened glass could not be cut and processed in time. ■



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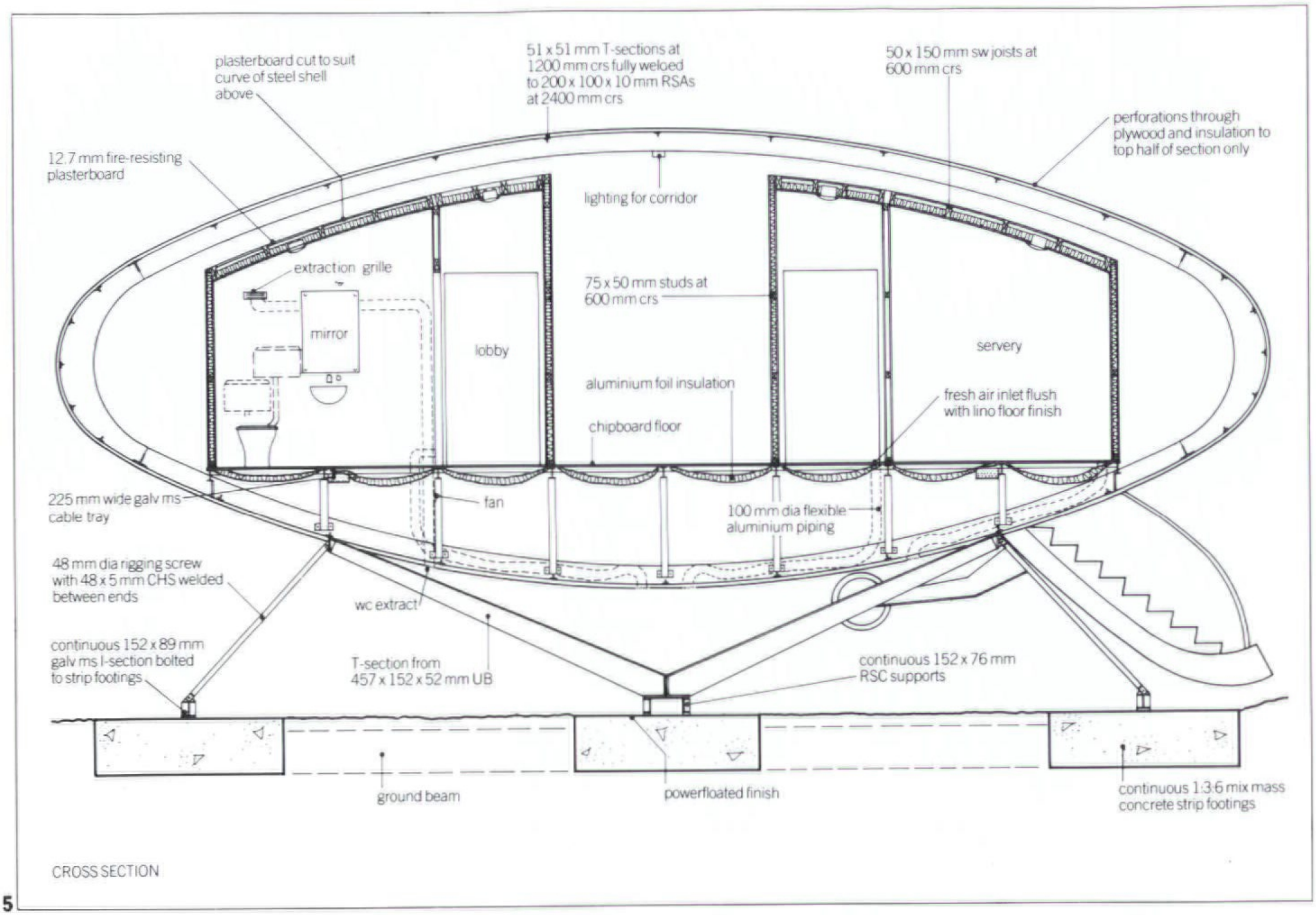
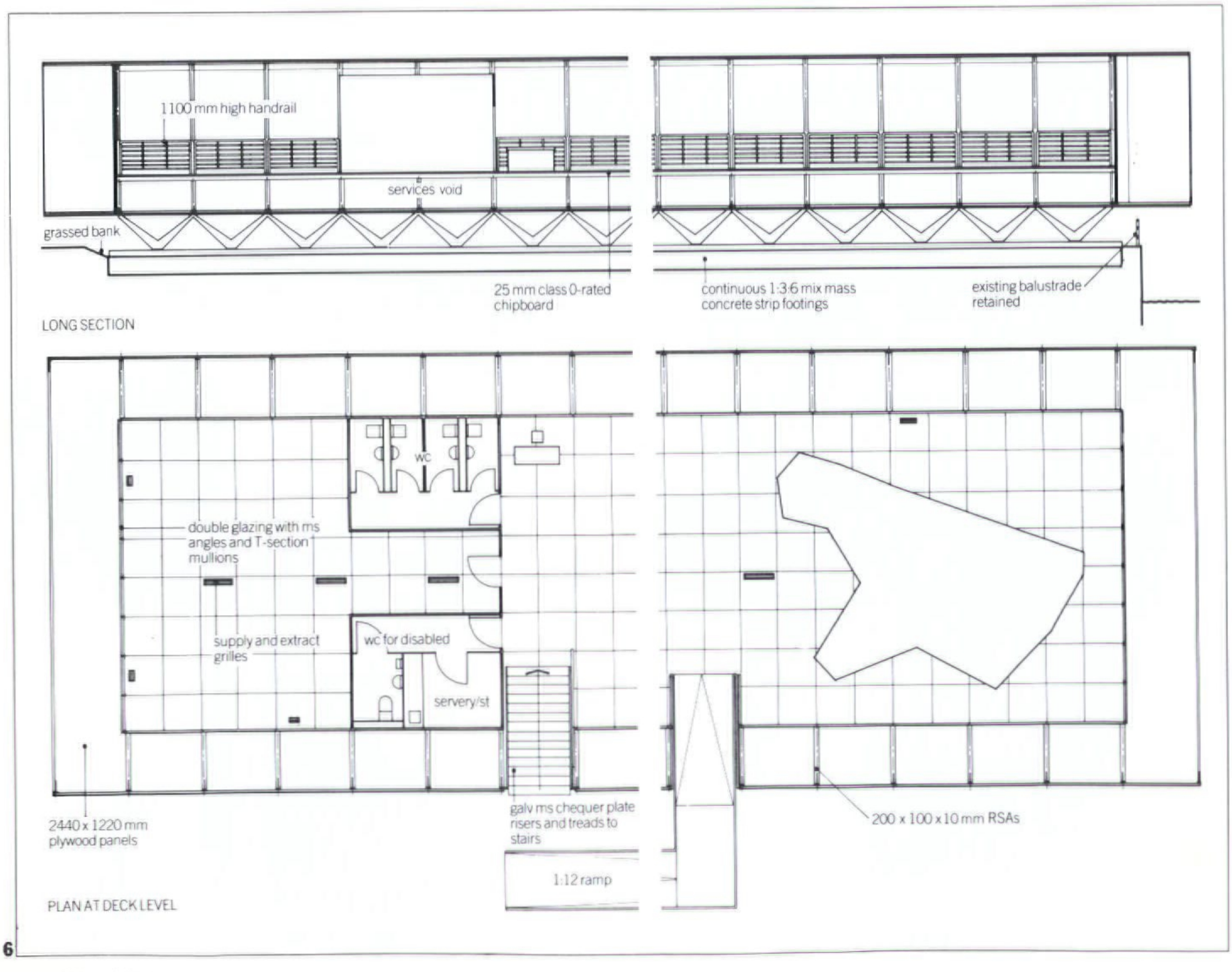
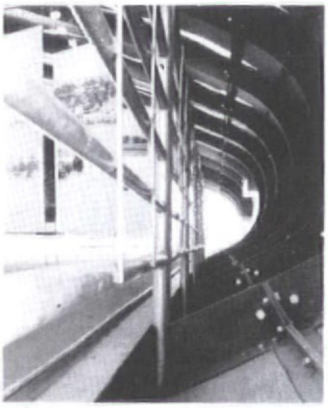

plasterboard cut to suit curve of steel shell above
51 x 51 mm T-sections at 1200 mm crs fully welded to 200 x 100 x 10 mm RSAs at 2400 mm crs
50 x 150 mm sw joists at 600 mm crs
perforations through plywood and insulation to top half of section only
12.7 mm fire-resisting plasterboard
lighting for corridor
extraction grille
mirror
lobby
75 x 50 mm studs at 600 mm crs
servery
aluminium foil insulation
chipboard floor
fresh air inlet flush with lino floor finish
225 mm wide galv ms cable tray
fan
100 mm dia flexible aluminium piping
48 mm dia rigging screw with 48 x 5 mm CHS welded between ends
wc extract
continuous 152 x 89 mm galv ms I-section bolted to strip footings
T-section from 457 x 152 x 52 mm UB
continuous 152 x 76 mm RSC supports
ground beam
powerfloated finish
continuous 1:3:6 mix mass concrete strip footings
CROSS SECTION

5


1100 mm high handrail
services void
grassed bank
25 mm class 0-rated chipboard
continuous 1:3:6 mix mass concrete strip footings
existing balustrade retained
LONG SECTION
wc
double glazing with ms angles and T-section mullions
supply and extract grilles
wc for disabled
servery/st
2440 x 1220 mm plywood panels
galv ms chequer plate risers and treads to stairs
200 x 100 x 10 mm RSAs
1:12 ramp
PLAN AT DECK LEVEL

6



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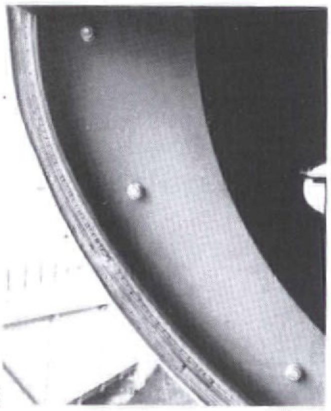

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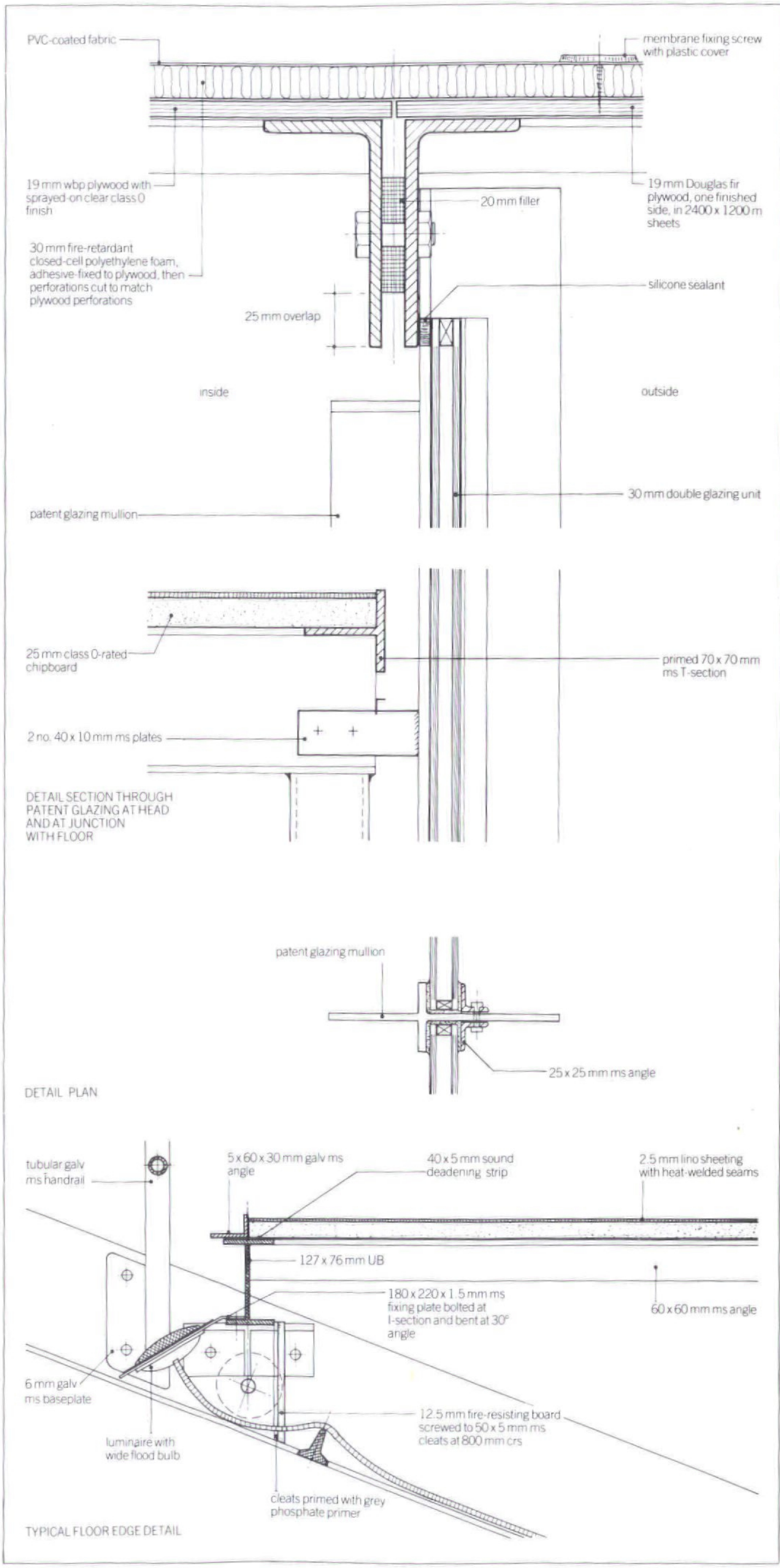
5 Cross-section through the building. The elliptical shape is followed through in the design of the stair, which when folded back into the building continues the shape of the tube.
6 Long section through, and plan of, the building (cross-members omitted for clarity). The outline of a model of Cardiff Bay can be seen on the right side of the plan.
7 Close-up showing the junction of the walls and the floor.
8 Close-up at one of the entrances to the building showing the three curved layers of plywood.
9 Details of the patent glazing and the wall/floor junction. The detailing of the patent glazing, although acceptable in a temporary building, is relatively crude. But special patent glazing sections and glass to accommodate the curves would have been very expensive.

Credits
location east of Pierhead Building, Bute Docks, Cardiff Bay
client Cardiff Bay Development Corporation
architect Alsop, Lyall & Störmer
architectural team William Alsop, John Lyall, Pankaj Pandya (project architect), Ulrike Dorn, Simon North, Tony Reason
quantity surveyor Roger Farrow
structural engineer Atelier 1: Neil Thomas, David Dexter
mechanical consultant Rybka, Smith Ginsler & Battle
main contractor Constructors Tern
subcontractors: steel structure Sheetfabs (Nottingham), *fabric* Landrell Fabric Engineering, *lighting* SKK Lighting, *air-conditioning* McWhirter/SWEB, *handrails* IAE Industrial & Agricultural Engineers, *supplier: plywood and chipboard* S. Silverman & Sons.

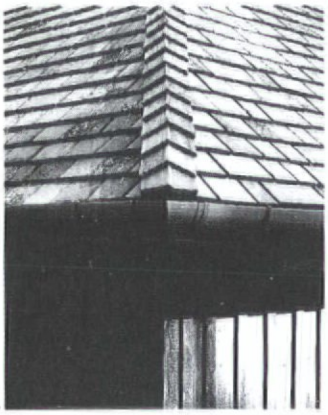
Photo credit
Photographs by Charlotte Wood.



9

STRUCTURE AND ROOF
HERITAGE CENTRE
Andris Berzins and Associates

Set in the midst of pine forest, this building uses timber framing and cedar roof shingles and, in its hall, resin-jointed timber connections, a technique developed for timber restoration.



1

2

1 Cedar roof shingles are used everywhere except on the main hall, which has a tiled roof. Preformed units are used for the hips.
2 The Heritage Centre is set in a mature Scots pine plantation in Windsor Forest.

Bracknell Heritage Centre forms a gateway to the 1050 ha of woodland, part of Windsor Forest, that the Crown Estate (in co-operation with Bracknell Forest Borough Council) have opened to the public for the first time. The building is surrounded by mature Scot pines and has accommodated existing trees in its quadrangles.

The main building provides an exhibition hall, an audio-visual theatre, reception, café, education base, and shop. Housing for forest rangers, workshops, offices, a temporary exhibition area and a lookout tower also form part of the complex.

The main building is planned around two quadrangles with covered walkways. Most of this is single storey, built on a structural timber frame (at 2.4 m centres) which supports cedar shingle roofs. The dominant 8 m high hall has an internal heavy Douglas fir frame on a 2.4 m grid carrying a tiled roof (tiles were used here to emphasise the hall's importance). A base storey of loadbearing masonry supports a mezzanine floor and studframed galleries.

Before you enter the building you see the first unusual timber feature. The portico is supported on eight tree trunks, still covered in bark. Local Douglas firs were selected, felled, and erected green. The bark was only left on to prevent the timber from drying out too quickly, but the client liked it and insisted on its preservation.

More heavy timber is evident on the underside of the cloister walkways. 200 mm half-round timbers support the planted roof formed from plywood decking which glued and close screwed to form composite loadbearing panels.

Shingle roofs are uncommon in this country, although shingles are readily available. The construction is similar to that for a tiled roof, except that the shingles are 600 mm long. Laid on battens at 125 mm centres the roof is always effectively covered by four thicknesses of shingle. The warm roof consists of insulation laid on top of 9.5 mm plywood, which sits on 97 x 50 mm rafters at 600 mm centres. The shingles are expected to last for at least 40 to 60 years.

Some of the timber inside the hall is very large — the biggest section is 400 x 200 x 9000 mm. This was not only hard to source (some was eventually found in Newcastle), but difficult to check for moisture content. This was particularly important because of the innovative joints that the consultants wanted to use.

Some of the most complex timber joints in the building are conventionally cleated, but for beam to beam and upright to cross beam connections, where historically tenon joints might have been used, the structural engineer designed a resin fixing. The technique uses toothplate connectors and stainless steel studs resin bonded into timber

Acknowledgment
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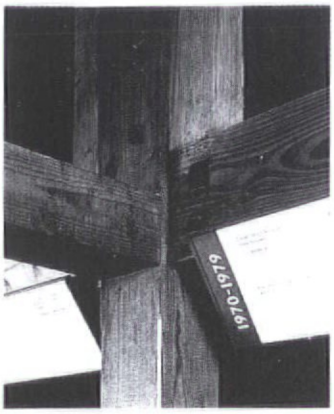

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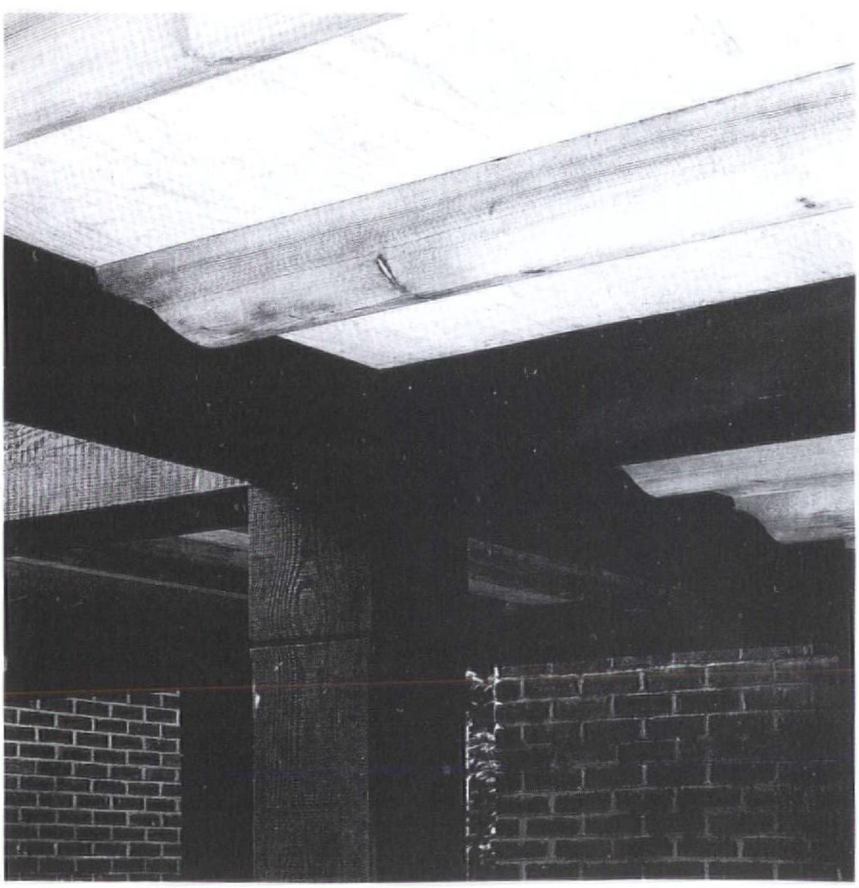
3 One of the timber connections in the hall. Resin fixings could not be used for all the connections in such a complex junction, but were often used, as here, at beam-to-post T-connections, where there would once have been a mortice and tenon joint. The use of chemical fixings has minimised the number of heavy cleats required.
4 The underside of the walkway around one of the courtyards. The planted roof above is supported on plywood decking on half-round timbers.
5 The exhibition hall. No glu-lam has been used — the timber is all solid. The connections have a mixture of bolted and chemical fixings.

5



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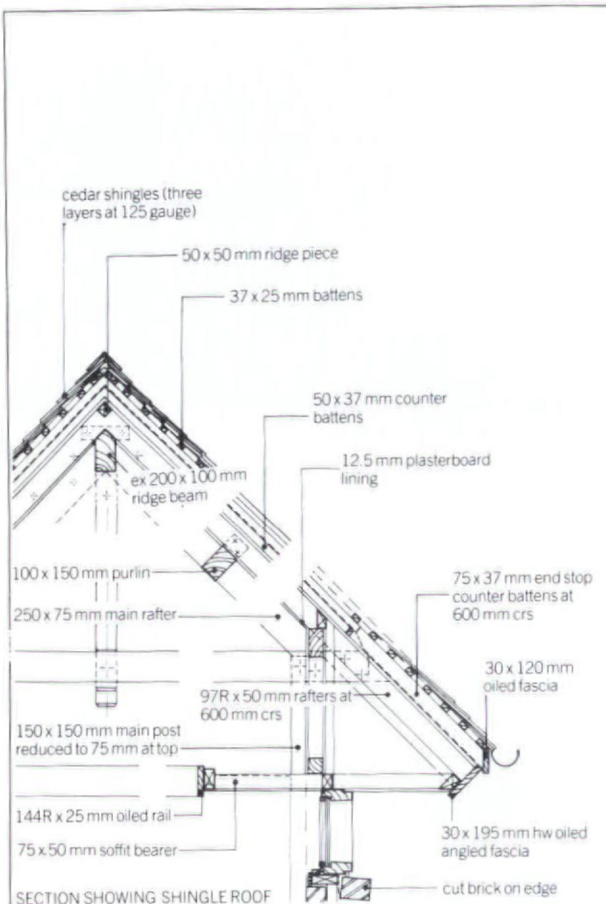
end grain. It has developed from the use of resin fixings to conserve historic timbers — Andris Berzins and James Tyne, the engineer, had previously restored the No 5 Boathouse at Portsmouth Dockyard to form the Mary Rose Museum.

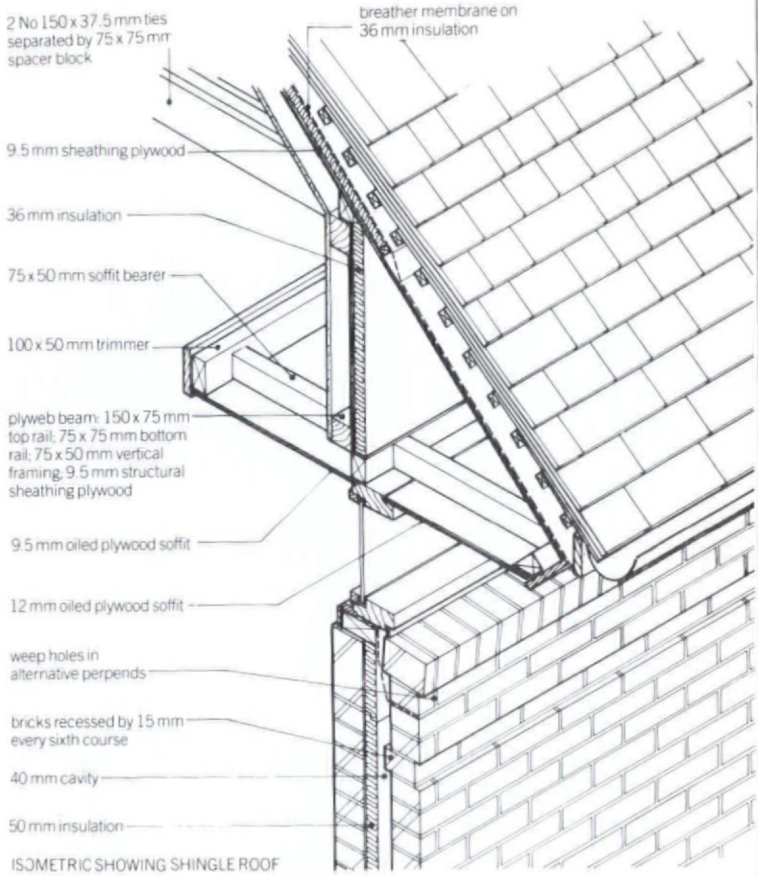
There was little available guidance on the use of resin fixings in solid timber, so the client agreed to commission a testing programme at the Polytechnic of Central London, where initial testing had already taken place. As with traditional morticed joints the tests showed that, even under less than ideal conditions, with, for instance, oversized holes, too little resin or poor quality wood, the timber sheared before the joints failed.

On site the main problem was in determining the moisture content (the target was 20 per cent at erection, 14 per cent in use) in such large sections, because BS 4471 only requires testing by short prongs. The way round this proved to be by oven drying a length of timber and calculating the moisture content by weight, then comparing this with the prong test results. Testing using 37 mm prongs achieved results comparable to those resulting from the oven drying method, but a resin formulation tolerant of dampness was also used.

Douglas fir was used for all the structural timber. It was the strongest structural softwood available in the sizes required. ■

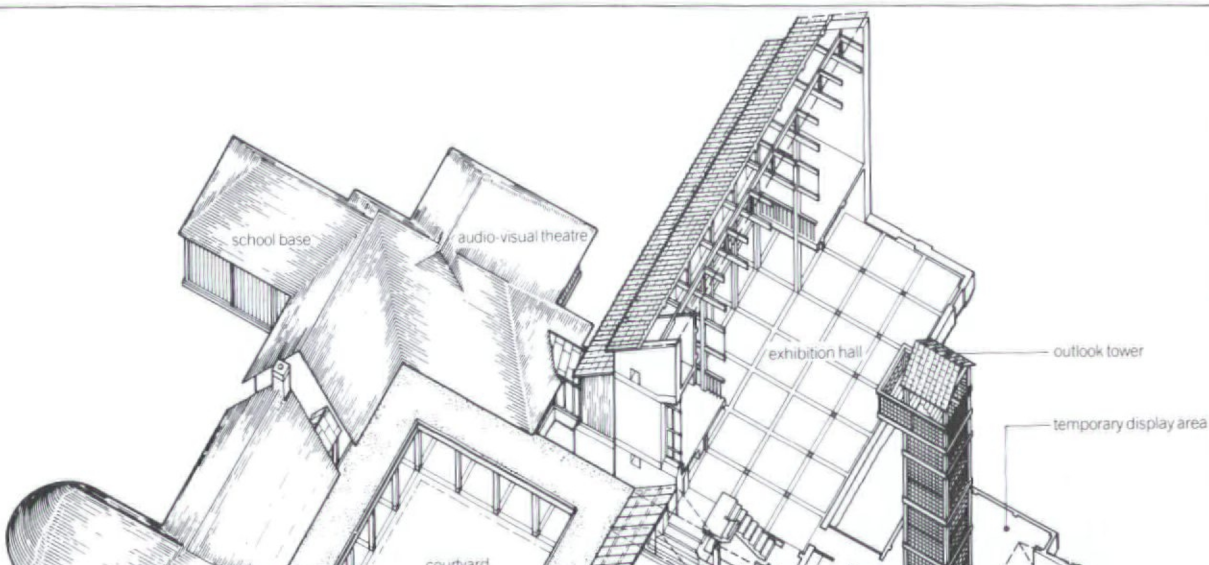


SECTION SHOWING SHINGLE ROOF



ISOMETRIC SHOWING SHINGLE ROOF

6



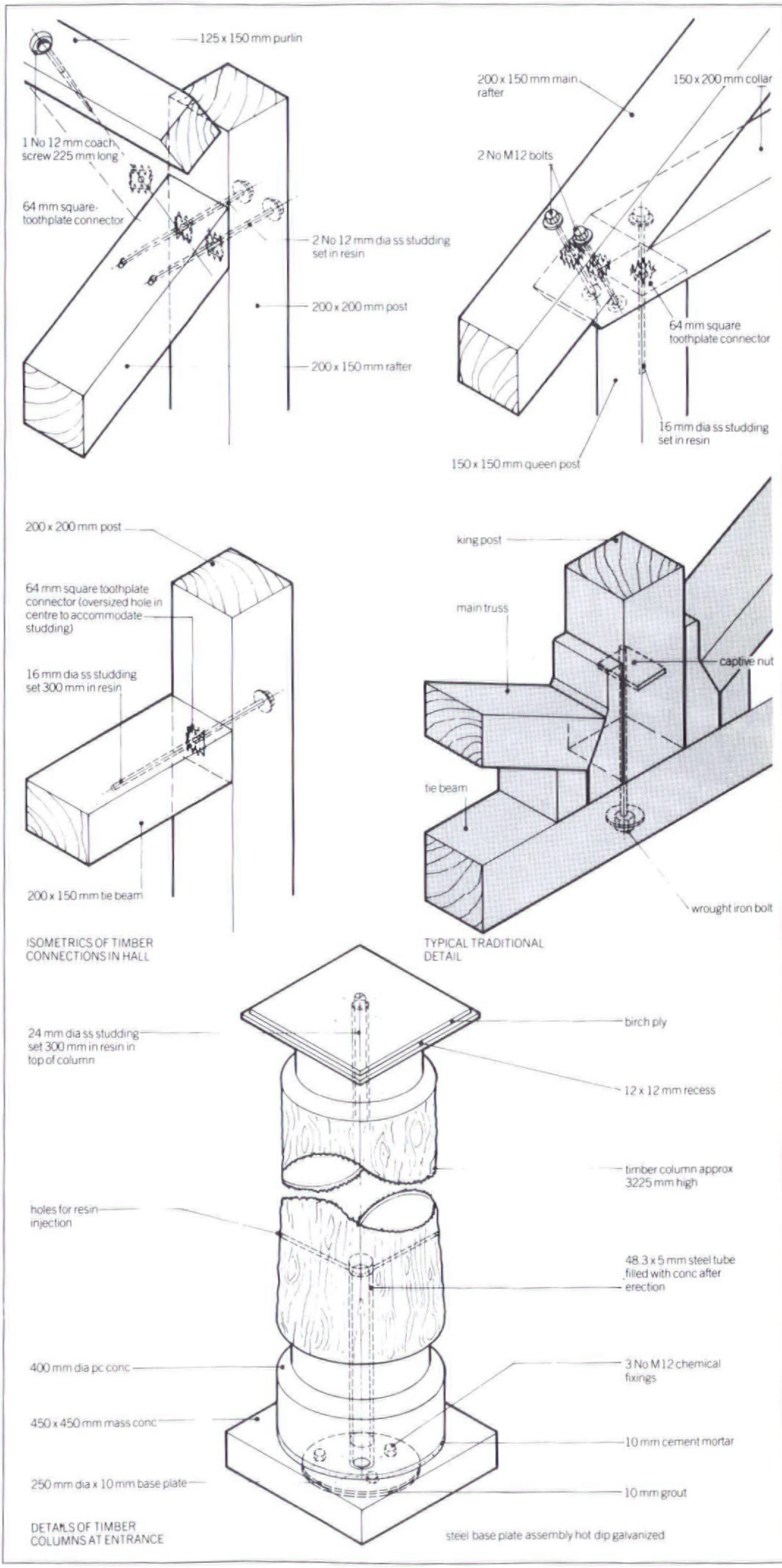
7 AXONOMETRIC

6 Section through and isometric of one of the shingle roofs. The counter battens are secured by helical, hammer-driven twist fixings. Compared with other roof finishes shingles are light and provide good thermal insulation, but may require treatment with a fire retardant. Their thickness is likely to vary from approximately 3 mm at the head to 10 mm at the tail. They come in random widths from 75-360 mm. The minimum pitch they require is 14°.
7 Axonometric.
8 Isometrics of three of the new timber joints in the hall that use resin, beside a traditional mortice and tenon joint (shown with a tint). Testing showed that, without the connectors, the new, stainless steel studding joint was significantly weaker. At the bottom, an isometric of one of the entrance portico columns.

Credits
location Nine Mile Ride, Bracknell, Berkshire
client Bracknell Forest Borough Council
architect Andris Berzins and Associates
partner in charge Andris Berzins
project architects David Lewis, Karin Kubschewski
assistant architects Oliver Tyler, Ainslie O'Connell
assistants Mark Fineberg, Hal Curry
quantity surveyor Henry Cooper
partner in charge Richard Foster
services/electrical and mechanical engineer Edwards and Partners
structural engineer James Tyne
main contractor Wickens and Sons (now Wickens Construction)
subcontractors: terazzo Alpha Mosaic & Terrazzo Co, *tile and shingle roofing* Binfield Roofing Co, *electrical* Callas Electrical, *mechanical* K.R. Coumbe & Co, *timber frame* N.H. Etheridge (Building), *steelwork* Forrest Steel Services, *metalwork* Garmon & Mount, *woodblock flooring* Hewetson Activity Floors, *roofing* Robseal Roofing, *concourse patent glazing* The Standard Patent Glazing Company; *suppliers: cloister posts* Crown Estates Sawmill, Swinley, *tree trunk columns* Crown Estate Forestry, *decorative finishes and oils* Holman Specialist Paints, *bricks and pavers* Ibstock Building Products, *window and door joinery* I.G. Timber Products, *structural, general sw and cladding timbers* John Lenanton and Son, *roof shingles* The Loft Shop, *rainwater products* Marley Extrusions, *aluminium guttering and light ss components* John Offord, *insulation* DOW Construction Products, *purpose-made doors and windows* Nuthalls Joinery (Wickens Group), *resins and ancillary equipment* Rotafix Resins.

Project data
contract
JCT 80 LA with Quantities
start on site May 1989
completion November 1990

Photo credit
Photographs by John Linden.



8

1 The front of the house in Hampstead, north London.
2 The new glass extension, on the north-facing rear of the house. The ground slopes down to the back of the house, so the base of the glazed structure sits on a concrete retaining wall.

Glass structure
Private house

Rick Mather Architects This elegant house extension uses glass for its structure and its heating, as well as for its light and views.

The owners of this listed eighteenth century Hampstead home wanted more living space, but did not want a conservatory or a 'cold' building. The house had other problems, including a kitchen/dining/living layout designed for a household with servants, and a dank area of garden at the back of the house.

After 19 months' discussion, English Heritage and the local planners agreed to Rick Mather's proposals — for a glass extension to the north-facing rear of the house. But part of the agreement was that there should be no aluminium glazing bars — and the client did not want 'repro'. So Mather and his office, which had already stretched the potential of glass in the Now and Zen restaurant in central London — started to explore the possibilities of all-glass construction.

The resulting 3.375m-wide extension runs along the entire length of the back of the house, with a new 150mm floor slab turning up to form a 700mm-high retaining wall. Fixed to the top of the concrete upstand at approximately 1m centres are open-ended steel shoes, into which slot laminated glass columns. Laminated glass beams span from these structural cantilevers to a new recess formed within the back of the house, and lined with a steel channel. Concealed inside the recess are steel angles between which the glass is pinned (allowing it to rotate).

Movement is also allowed at the beam/column junction (a mortice and tenon joint) — and between any two hard surfaces is a layer of silicone.

The roof and wall panels are built up from two layers of toughened glass (laminated) and an outer layer of low-E glass, separated by glass spacers (cut by water jet). To achieve optimal comfort levels and avoid the winter 'chill factor', Mather opted for heat-radiating

Acknowledgment
The editors acknowledge the assistance of Lionel Friedland of Pentarch in the preparation of this article.

3 Through ventilation is allowed by the two glass doors (which also have glass handles) at opposite corners.
4 The new structure at night. The extension has no exposed light fittings. Fluorescent tubes are concealed at its junction with the original house, and below strips of glazing between the glass columns. There are also light sources directly beneath the columns.
5 The main glass door leading from the extension to the terraced garden.
6 One of the joys of this extension is that the glass is warm to the touch — the glazed panels incorporate a heating film.

glass. It is no longer available in the UK — the heating film had to be applied in Finland. The Finnish double-glazed units have aluminium spacers and black adhesive. For assembly with clear spacers and adhesive (a paintable, ultraviolet-activated glue) a German firm had to be used.

The second 6mm layer was added by the heated glass supplier because the German panel assembler would not bond directly to a leaf with an electrical current running through it (the current actually runs through the invisible metallic coating).

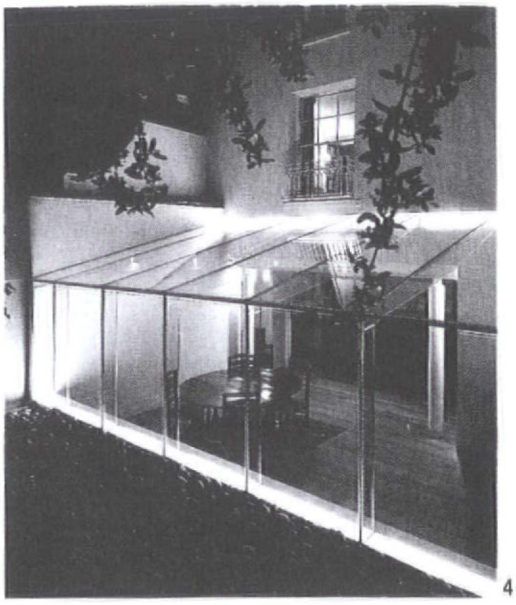
The low-E glass prevents excessive solar gain, although as the extension is on the north side of the building it gets little sun.

The self-load of the glass is 0.5kN/m^2, more than enough to compensate for wind suction, and there are no overhanging edges. (The ability of the glass to take loads was recently tested by a burglar attempting to escape across the roof — leaving his footprints). The engineer also satisfied himself that permissible tensile stresses in the glass panels would not be exceeded.

Lighting is provided by fluorescent tubes running continuously around the perimeter of the building, beneath etched glass panels between the columns.

Mather also took the opportunity to replan the kitchen and dining area — the gloomy dining room is now a light, airy, L-shaped room, twice the original size. The house was extensively refurbished, including re-rendering of the back wall, and a land drain was laid around the extension.

The thickness of the glass gives the extension a green hue and some of the silicone joints are very thick, and the time delay in replacing such special panels is already evident (one of the original panels arrived broken and has taken months to replace). But the client is delighted with his innovative extension.□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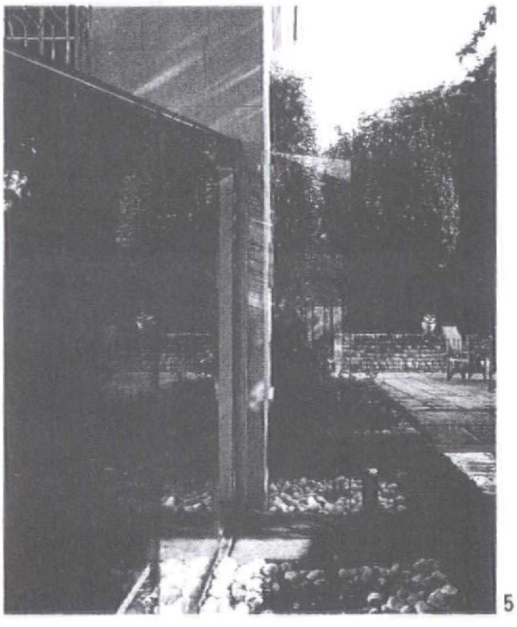
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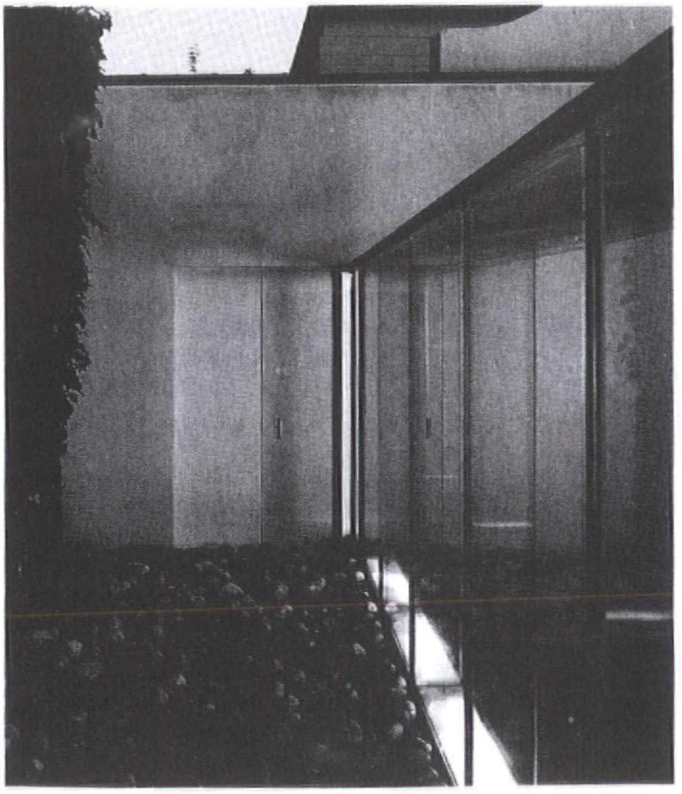
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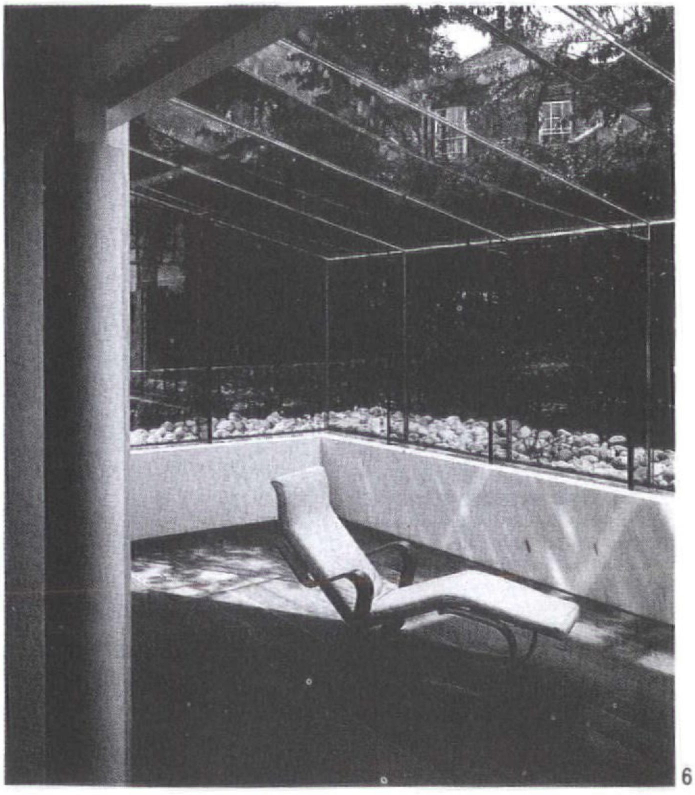
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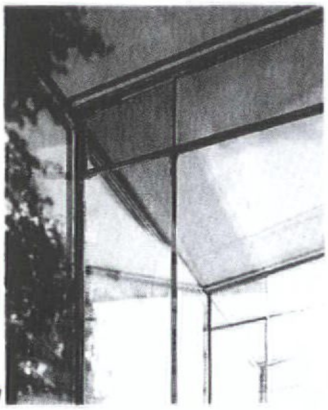

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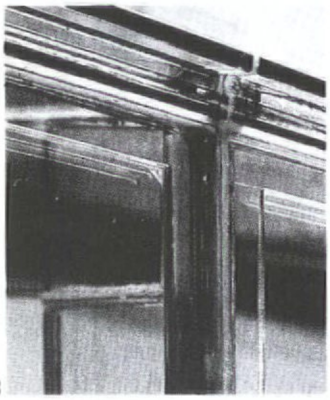
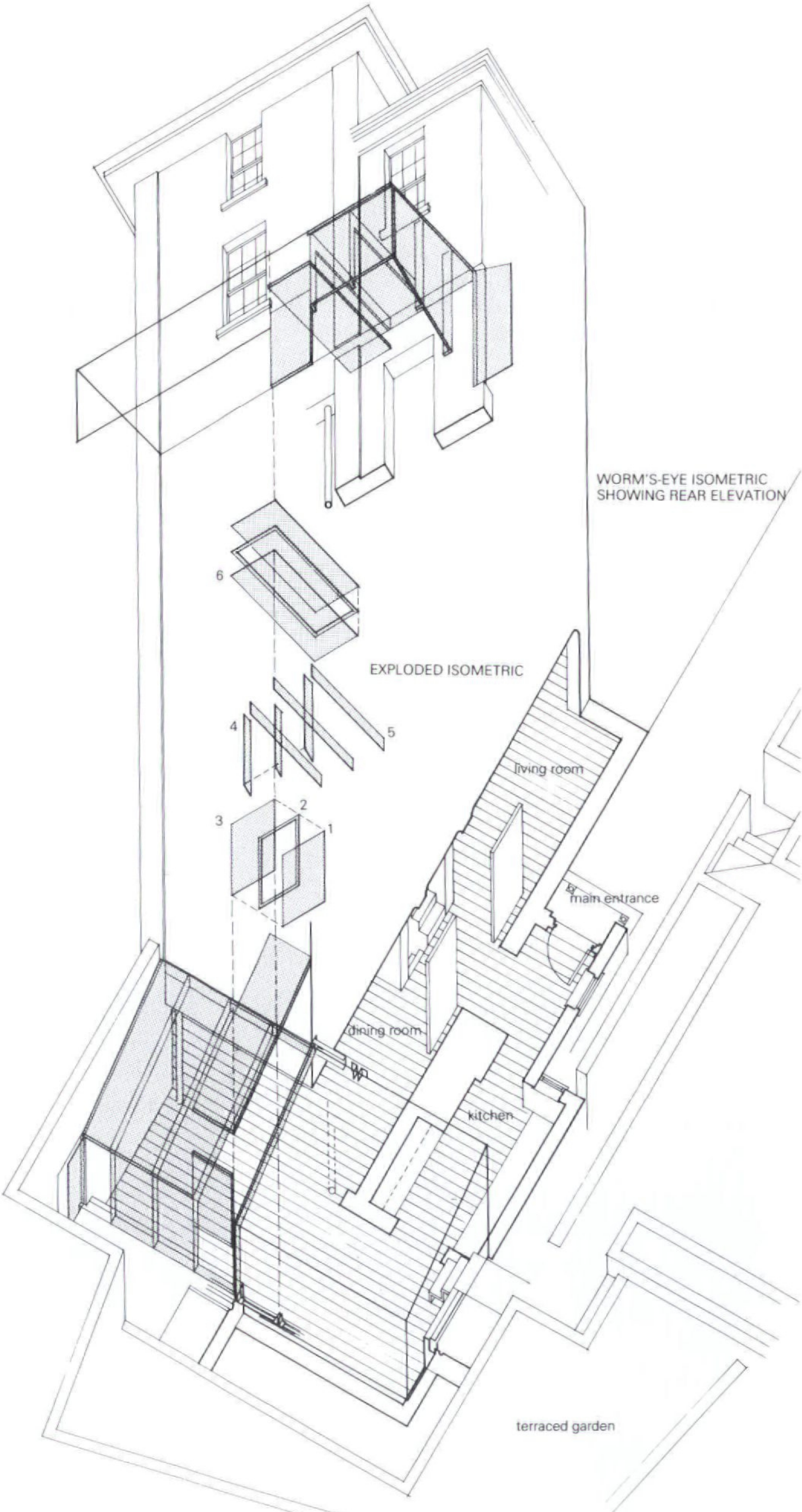


8

7 The junctions of the glass components are quite neat from the inside.
8 The junctions were harder to achieve successfully externally. There are silicone joints at all the main junctions.
9 Plan, exploded isometric showing the construction, and at the top a worm's-eye isometric view of the rear elevation.
10 Details of the key junctions.

Key to 9
1 1500 x 1500 x 12mm composite glass panel
2 Glass spacer
3 1500 x 1500 x 10mm low-E glass
4 Glass column
5 Glass beam
6 Glazed roof panel

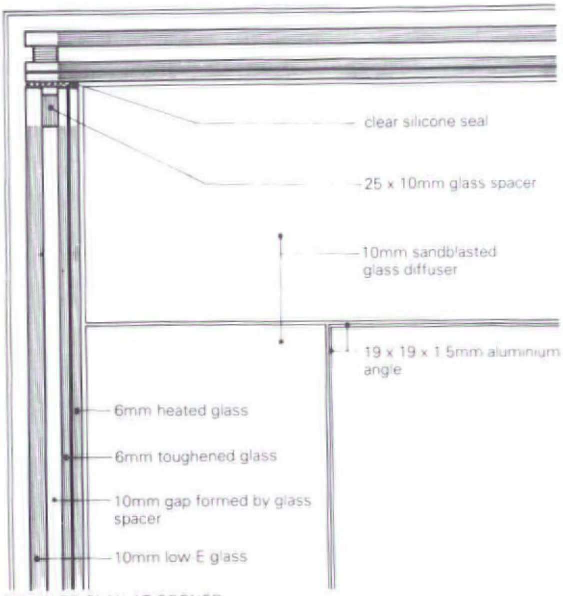


9

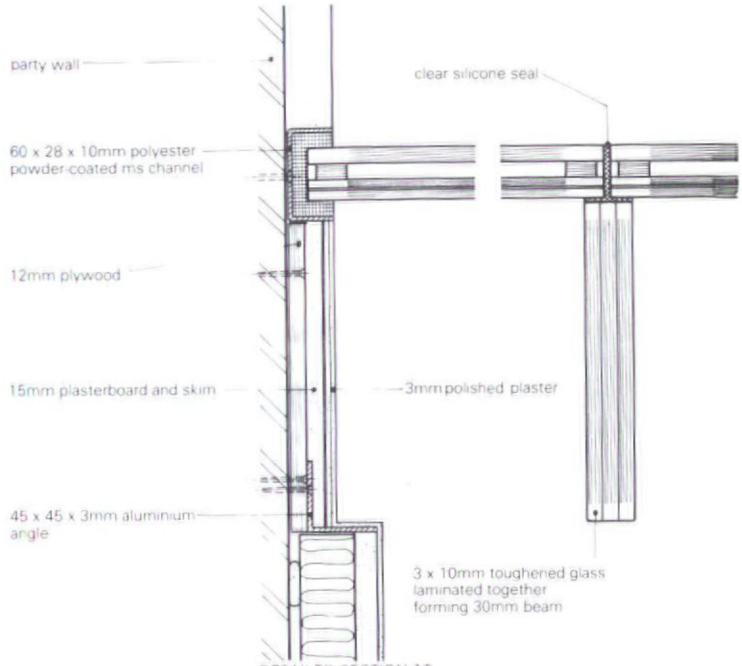
Credits
location Hampstead, London NW3
architect Rick Mather Architects
architects Tim Dodd, Ian Hay
engineer Dewhurst MacFarlane
quantity surveyor Peter Henderson Associates
service consultant Fulcrum Engineering Partnership
general contractor and specialist glass installer Pat Carter Shopfitting
landscaping George Wolton
suppliers: structural glass and doors F. Firman, **inner and outer glass skins** Sähkölasi oy, **glass spacers and glass panel assembly** Glasbau Hahn GMBH, **timber floor** Qi-netics, **specialist plaster finishes** Perucchetti Associates.

Project data
contract IFC 84
site start date 1 July 1991
completion date 13 October 1991

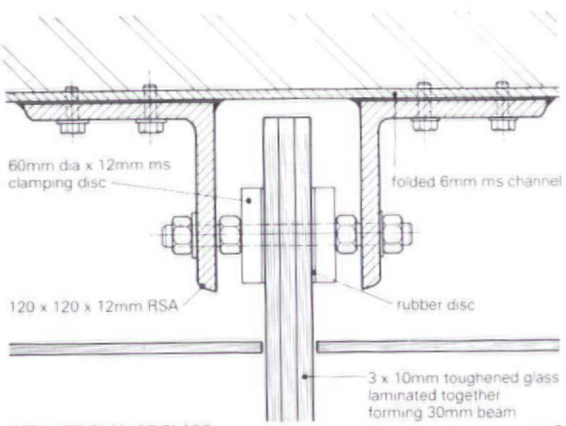
Photo credit
Photographs by Chris Gascoigne.



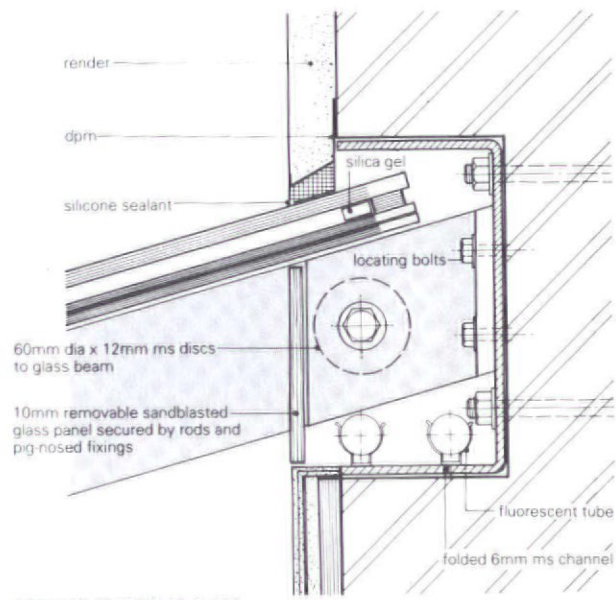
DETAILED PLAN AT CORNER



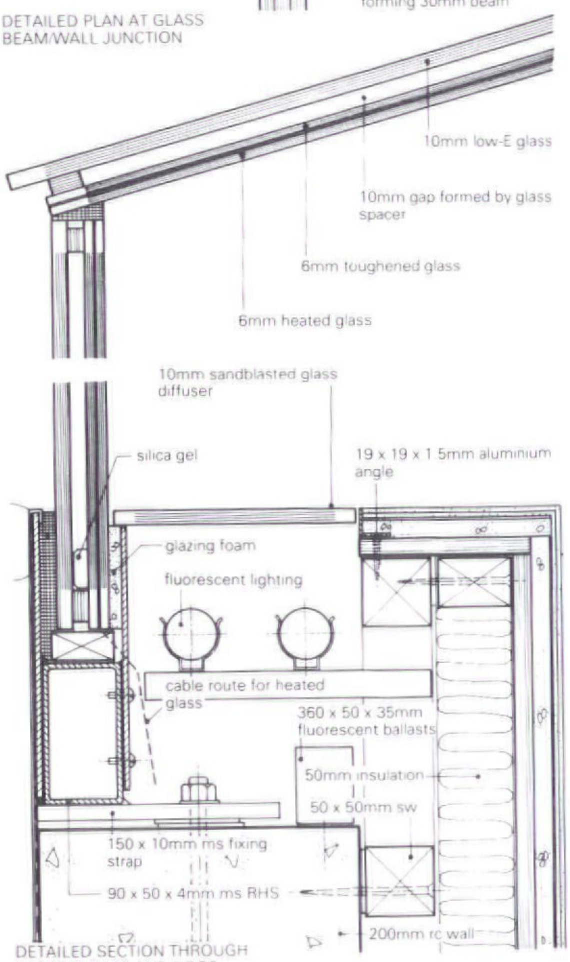
DETAILED SECTION AT ROOF/PARTY WALL JUNCTION



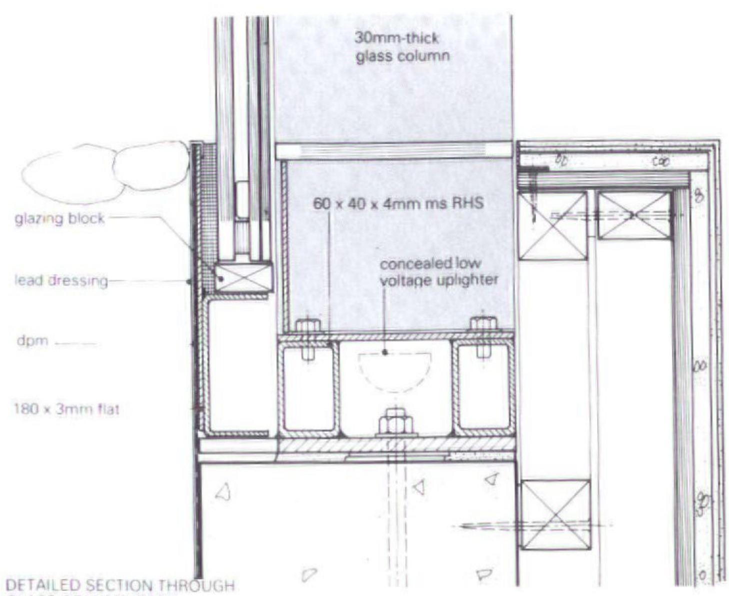
DETAILED PLAN AT GLASS BEAM/WALL JUNCTION



DETAILED SECTION AT GLASS BEAM/WALL JUNCTION



DETAILED SECTION THROUGH GLAZING BASE AND ROOF



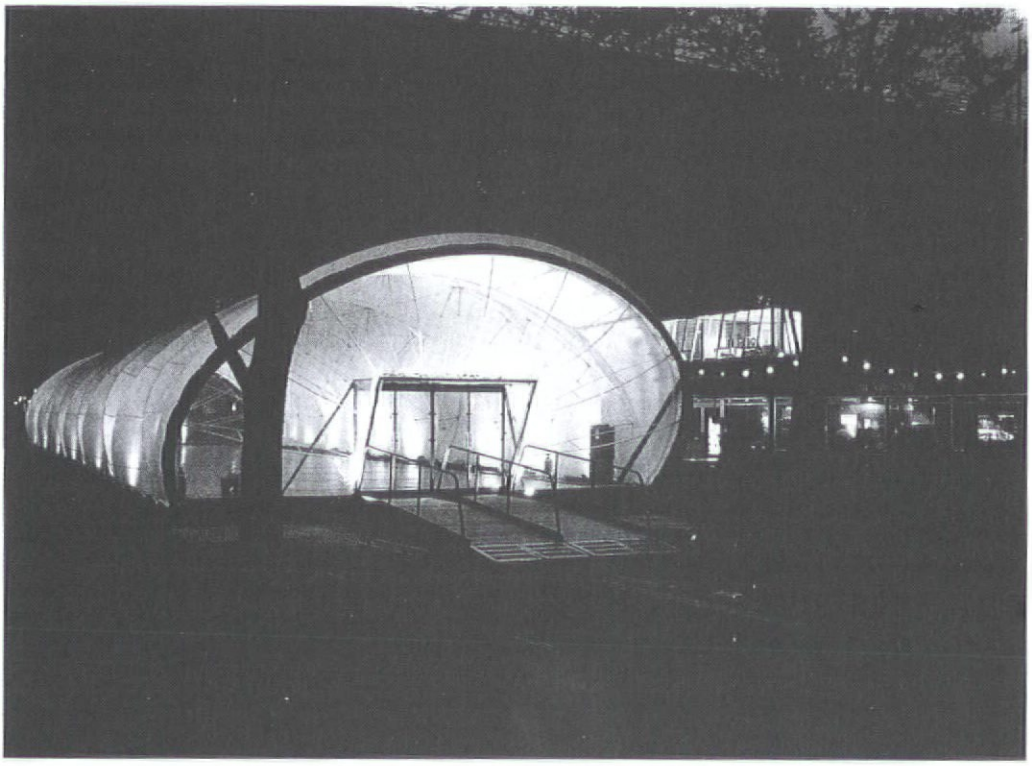
DETAILED SECTION THROUGH GLASS COLUMN BASE

10

CI/SfB (983)

Temporary structure
Hospitality tent

Future Systems This light and airy shelter makes efficient use of elliptical grp ribs and a PTFE woven fibre membrane. The structure is elegant — and demountable.



1

1 The MOMI structure in its temporary setting underneath Waterloo Bridge. Its apparent lightness is achieved by using fine elliptical grp ribs and a highly translucent PTFE woven fibre membrane.

Acknowledgment
The editors acknowledge the assistance of John Pringle of Michael Hopkins and Partners in the preparation of this article.

There is a welcome, albeit temporary, new addition to London's South Bank. Underneath Waterloo Bridge, between the National Film Theatre and stalls of second-hand books, sits a taut, elliptical structure — the first fragile threads of a translucent cocoon. Although delicate, this structure acts tough and competes well with its raucous environment.

The tent is the thoughtful and elegant response of Future Systems and Ove Arup & Partners to the brief set by the Museum Of the Moving Image (MOMI) for a high-quality, demountable, hospitality building.

The magical lightness of the structure is attained by the elegant and minimal use of the grp ribs and a PTFE fibre membrane. The components were sized to ease storage and transportation; once demounted, the structure can fit onto three lorries, and the fabric fits into a $1m^3$ box.

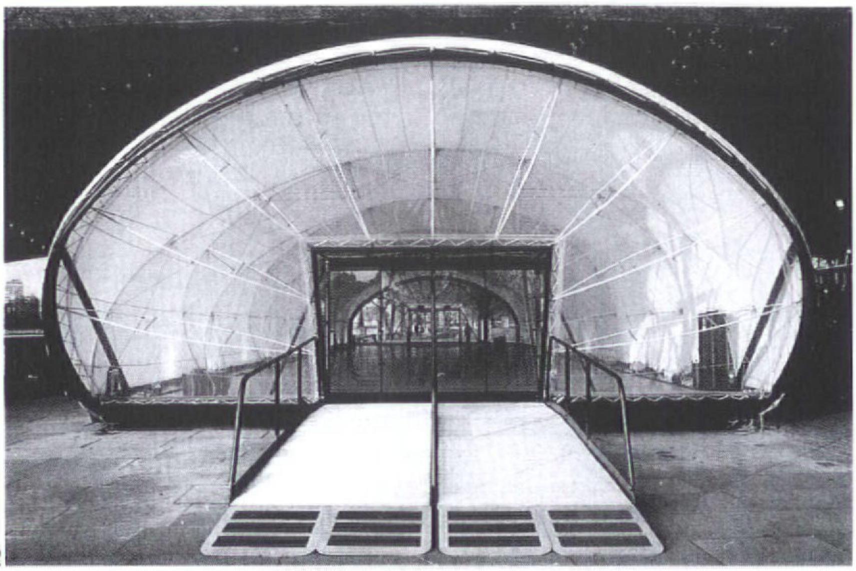
The fabricator, Koit, is contracted to erect and maintain the structure, and erection takes six men just two days. The structure's dimensions are 28.8 x 9.6m allowing up to 450 people to use it at one time.

The bulk of the storage space is taken up by the floor elements. These steel rafts, supported on jack legs, are positioned — in 9.6 x 2.4m sections — by a fork-lift; they are finished with a shiny aluminium sheet mat.

Two end arches, each fabricated from two CHS's and steel plate, are then lifted in and pinned and braced to the floor raft. These arches lean outwards and are painted black to emphasise the lightness of the white ribs and fabric.

The fabric is supported by pairs of inclined arches. Each arch is made up from two 32mm diameter grp rods which are connected through a stainless steel spigot and socket joint. It is tensioned into the partial elliptical shape by a series of stainless steel props and cables — the grp is epoxy glued into the cup of the prop which is then tightened until the correct curvature is reached. Due to the concentration of stresses at the base fixings, the ends of the grp rods are connected to mild steel CHSs. All the junctions are joined in one plane to increase the sense of lightness. The arches are erected in pairs, they lean together and are connected at the crown. Temporary bracing is needed until the fabric is fully tensioned.

The use of grp as a structural building material is rare, but because of its frequent use in industry and yacht technology, its properties are well known. It is ideally suited for this type of structure as it is light and flexible. Calculations were complex, but this was due to the sprung state of the grp, not the material itself.



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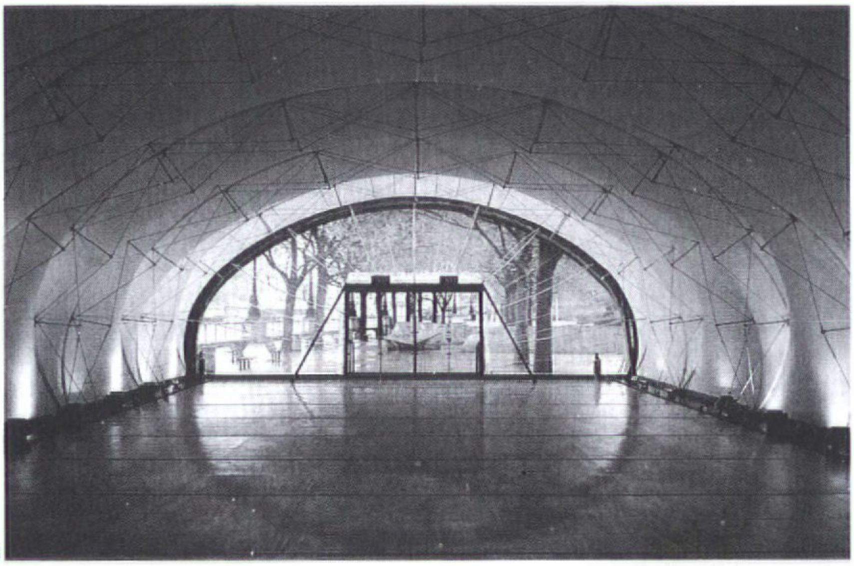

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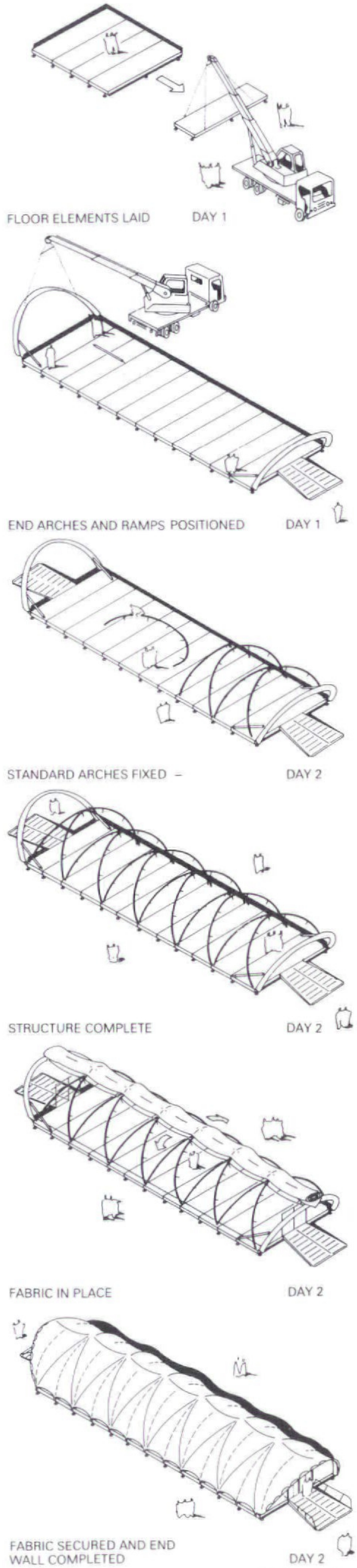
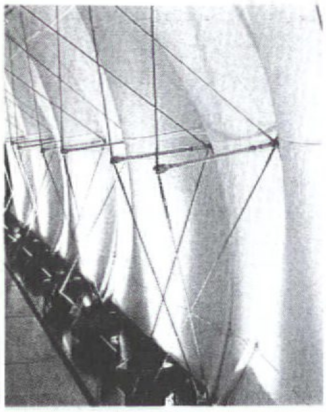


4

2 The structure is entered at either end through acrylic doors set into the transparent, inclined end walls.
3 Interior view. Services are kept to the perimeter leaving the floor area free and uncluttered — up to 450 people can use the tent.
4 Erection sequence.

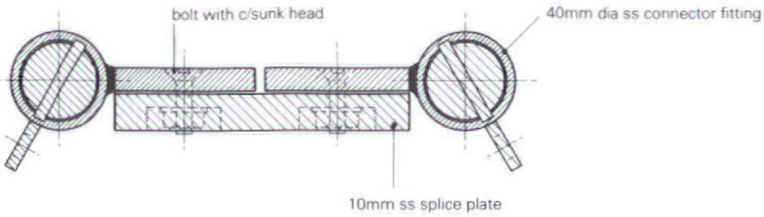
The PTFE fibre membrane was patterned and seamed in Germany; it works compositely with the arches (creating a semi-monocoque structure) so allowing the minimal rod diameter. It is placed over the structure, pulled down mechanically, then laced. Stability is only achieved when the membrane is fully tensioned against the floor edge beams and end arches. In this country, PTFE has only been used as a coating on glass fibre; the PTFE woven fibre has the same 'easy clean' properties but is not as strong (compensated for by using smaller radii of curvature) and is less brittle (important for a demountable membrane). The most obvious property is its high translucency (60 per cent — cf Schlumberger at approx 15 per cent) which enables the structure to exude its characteristic glow. ETFE, transparent fluorocarbon film, is used for the end walls.

The structure is entered at either end through acrylic doors which, because of the incline of the end arches, are like inverted dormers. There are adjustable flaps in the cheeks which allow cross ventilation. The space is fully serviced: uplighters and air supply and extract fans are located on a raised perimeter zone. This simple device keeps the floor free and reduces the chance of people getting close to the skin. All the cables run under the floor. □

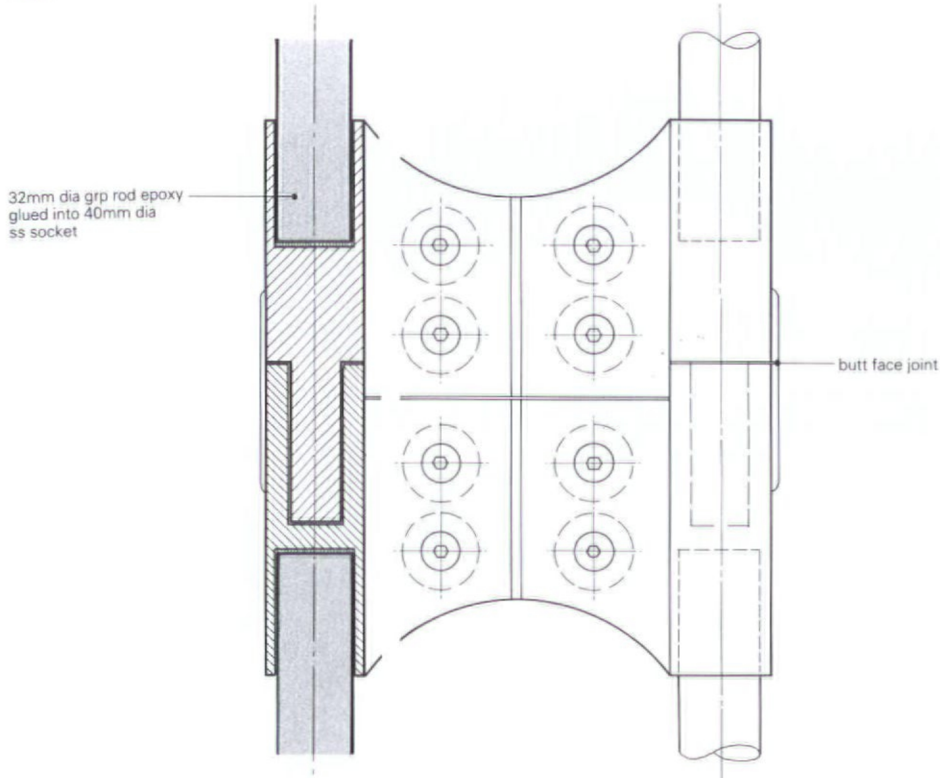


5

5 Detail of the grp ribs, stainless steel props and PTFE woven fibre membrane. Uplighters and air supply/extract fans are located on the raised perimeter zone.
6 Details of the grp rib and prop.
7 Detailed section through end arch.
8 Detailed section through base.
9 Part cross-section, part long-section.

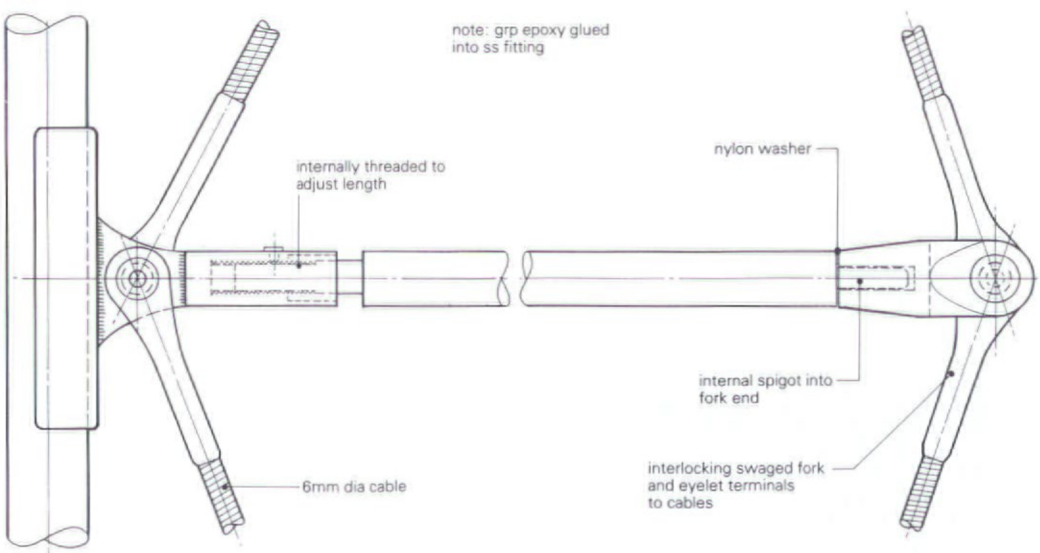


DETAIL A — SECTION THROUGH RIDGE CONNECTOR PLATE

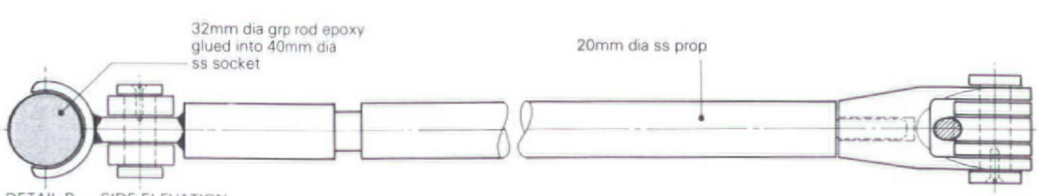


DETAIL A — SECTION THROUGH GRP ROD/ CONNECTOR PLATE

DETAIL A — PART ELEVATION OF RIDGE CONNECTOR PLATE



DETAIL B — ELEVATION OF PROP



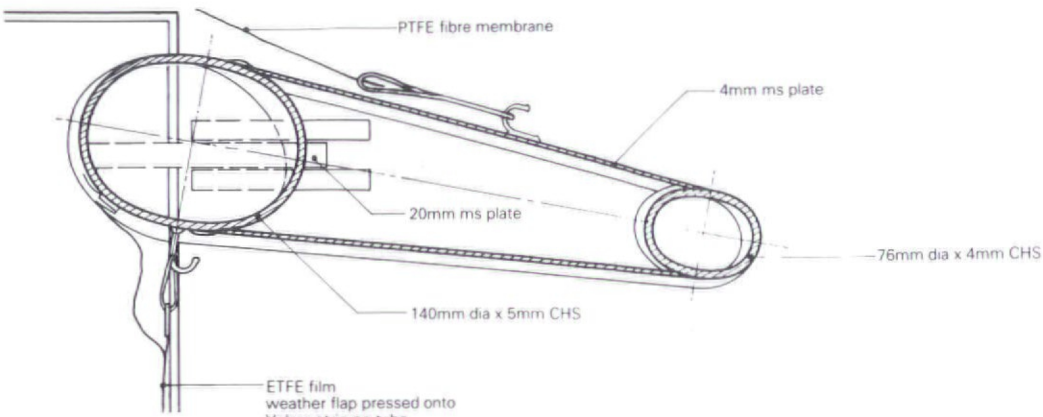
DETAIL B — SIDE ELEVATION OF PROP

6

Credits
client Museum Of the Moving Image
architect Future Systems: Jan Kaplicky, Amanda Levete, Mark Newton
structural engineer Ove Arup & Partners: Brian Forster, Alistair Lenczner, Peter Rice
services engineer Ove Arup & Partners: Mike Beaven, Andy Sedgwick
subcontractors: fabricators Koit High-Tex, **steelwork** Littlehampton Welding

Project data
contract JCT 80.

Photo credit
Photographs by Geoff Beckman



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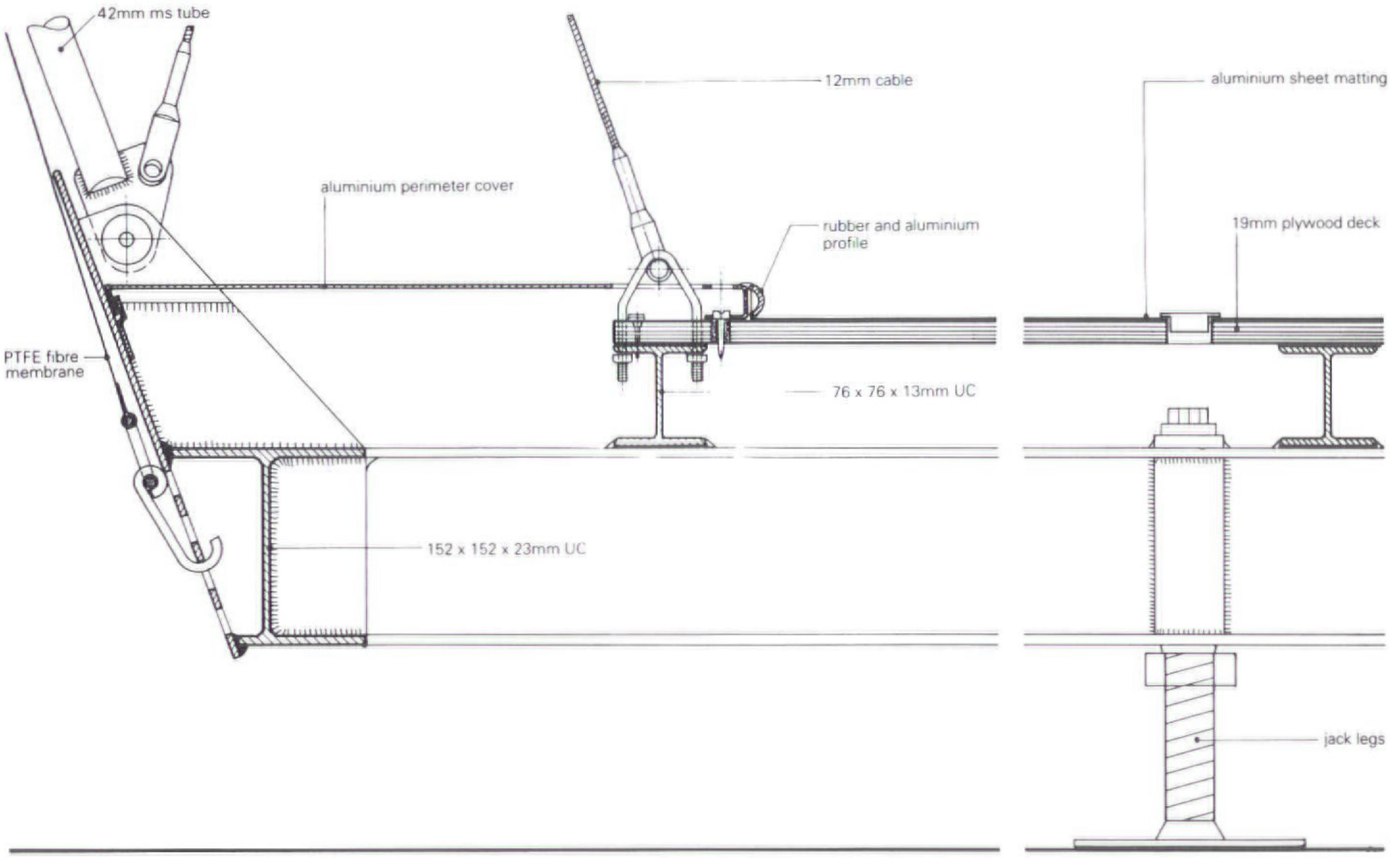
DETAIL C — SECTION THROUGH END ARCH



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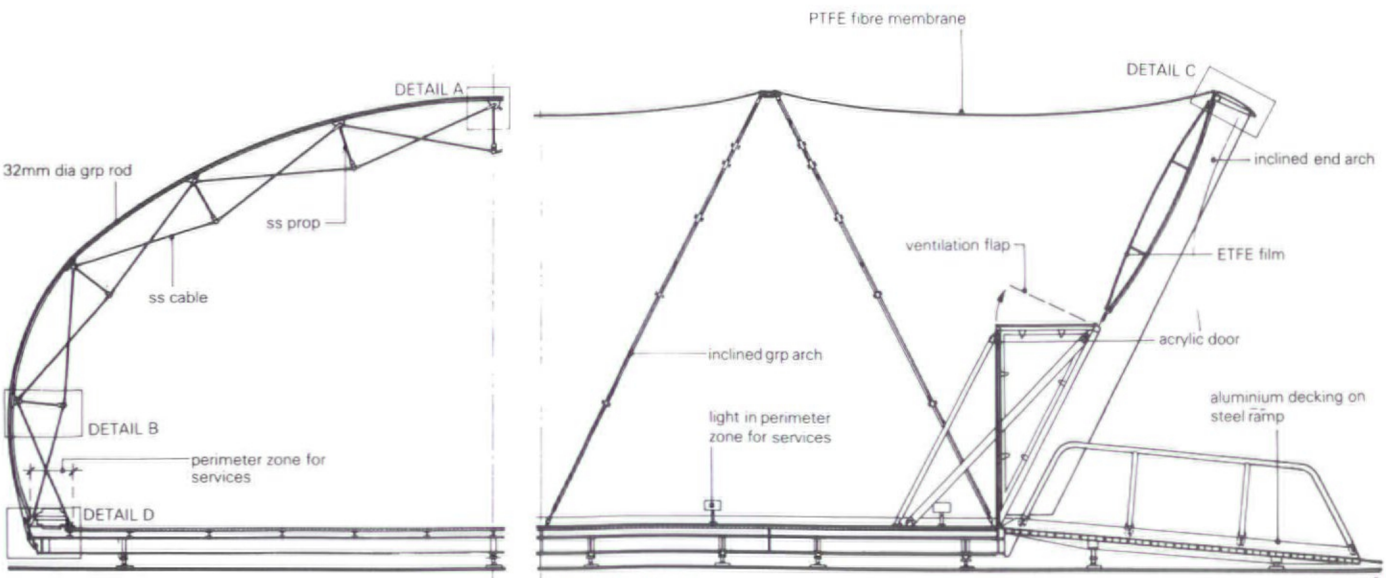
DETAIL D — SECTION THROUGH BASE



PART CROSS SECTION

PART LONG SECTION

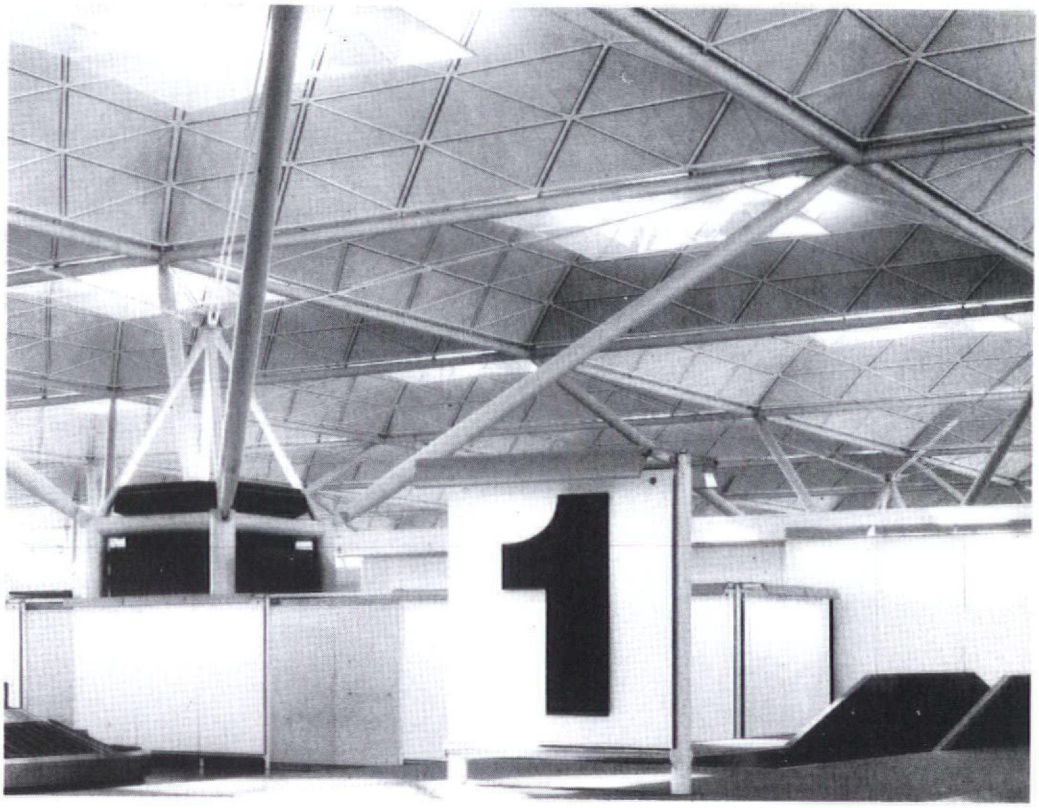
9

SCREENS
AIRPORT
Foster Associates

AJ Database CI/SfB (A3) or (22.3)

One basic screen design has been adapted to be glazed or solid cored, to take signs and advertising displays, and to accommodate sliding or swing doors.

Related articles
Building feature
AJ 29.5.91
Working details
AJ 29.5.91



1

1 The simple 1200 x 2600 mm screen module is adapted to many uses. There are 10 standard alternatives.

Foster Associates' commission for Stansted was not only for the external envelope, but also for the design of the interiors. Adapted standard products were used where appropriate (for the seating for instance), but the practice could not find a screen design that fulfilled all its requirements. The screens had to appear simple but be very flexible. Although they were, in the end, purpose-designed and manufactured, the design is such that they could be bought from more than one manufacturer, and they are no more expensive than comparable proprietary screens.

The system is based on 88.9 mm diameter powder-coated mild steel posts, linked at the top by 63.5 mm diameter transoms and braced by infill panels. The basic module is 1200 mm, but there are also standard units two and three bays wide.

Adaptations of the basic glazed or solid-cored panel include a three-bay advertising panel, a panel to take slat signs or leaflets, and sliding or swing doors. Wiring can be housed in the posts and transoms — as it is for the lights for instance, for which fused switches are provided every 3.6 m.

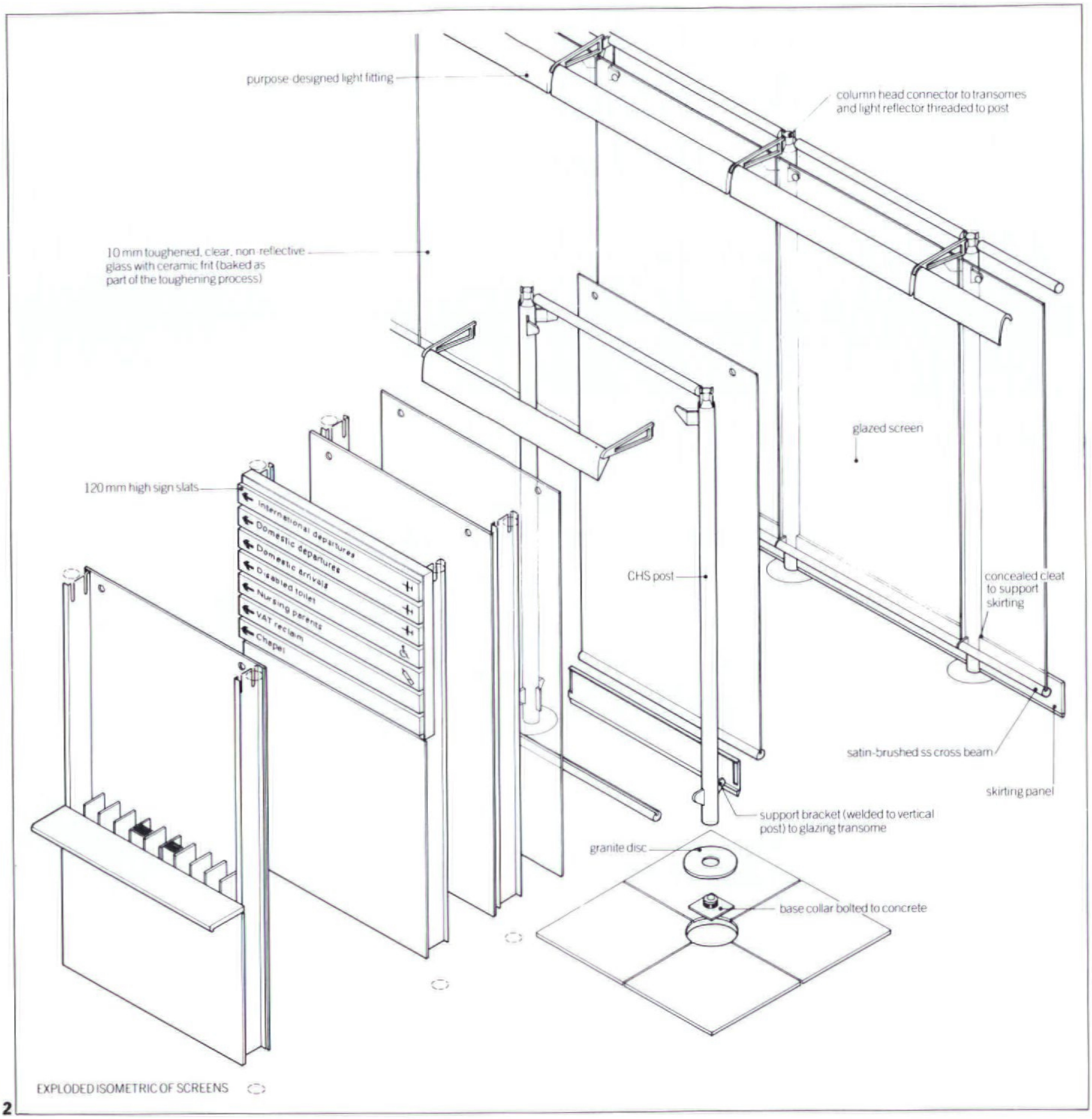
A neat coring and capping system was worked out so that the screens can be demounted and re-erected with the minimum disturbance to the rest of the building fabric. Above the base plate, which is bolted to the concrete waffle slab, is a granite disc of the same diameter. If a screen is moved, this disc can simply be lifted out and then replaced.

The glazed screens have a graded circular white frit, which provides some privacy and is much easier to keep clean than exposed acid-etched glass for instance. Fritted glass also minimises any problems caused by reflection.

The 10 mm toughened glass is hung from brackets fixed to the posts and rails. At the foot of the screens it sits in a slot in a 63.5 mm stainless steel transom (avoiding drilling more holes in the glass), which is bracketed back to the posts and cleated to the steel-faced skirting. Above the concealed 10 mm wide brackets to the posts is the junction between glazed panels (for a multiple bay width screen). This 10 mm maximum gap is sealed with a clear silicone gasket. The skirting, a steel tray with a solid core, extends down to the polished granite floor, with a Neoprene seal at the junction.

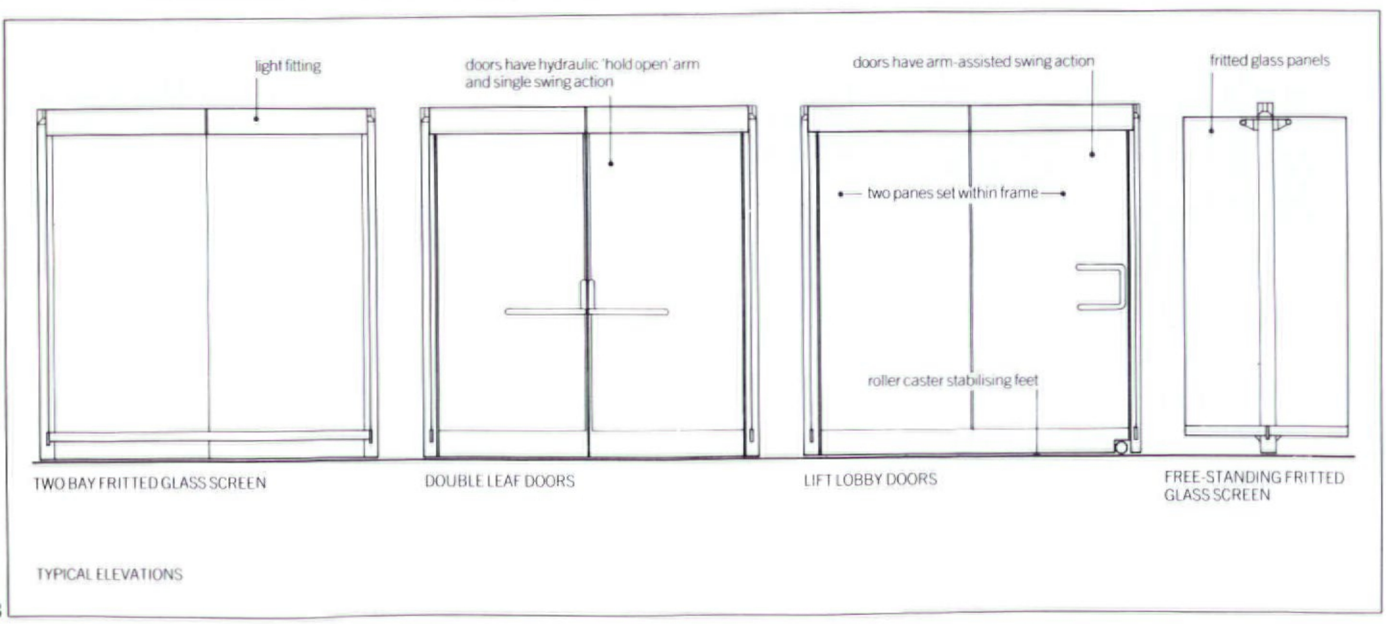
Stainless steel is ideal for a buffer-type element; polyester powder-coated mild steel, as used for the skirtings and solid-cored panels, has much less impact resistance. The detail at the head of the posts is designed to allow a four-way panel junction — and the light fittings, specially designed in conjunction with Erco, can be fitted back to back when required. ■

Acknowledgment
The editors acknowledge the assistance of Roland Gibbard of YRM Interiors in the preparation of this article.



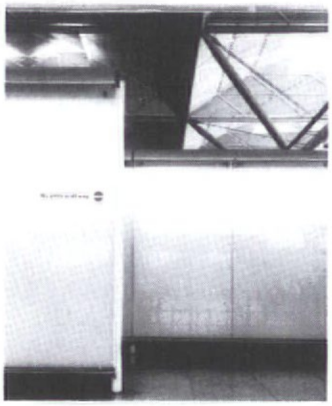
EXPLODED ISOMETRIC OF SCREENS

2



TYPICAL ELEVATIONS

3



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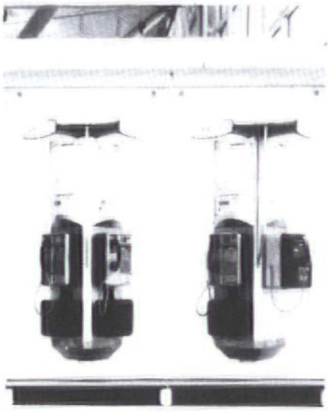
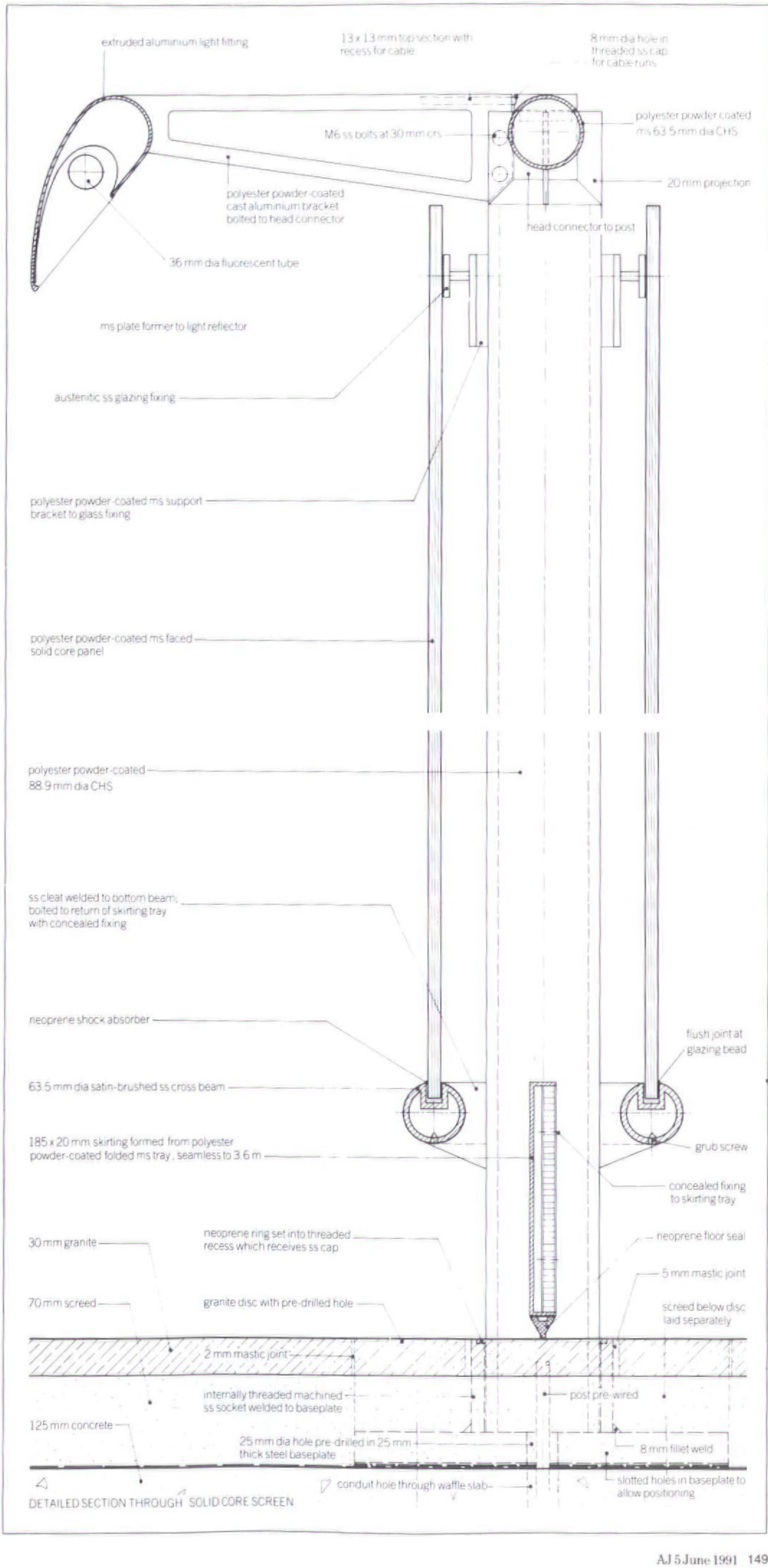


5

2 **Exploded isometric showing a variety of types of screen.**
3 **Typical elevations. There is also an adaptation to form a single swing door.**
4 **Basic screens with light fittings which were specially designed for Stansted, and can be fixed on both sides of a screen if required.**
5 **The screens can also support telephones.**
6 **Detailed section through a solid-cored panel. The core is 18 mm plywood, and the overall thickness of the panel is 25 mm.**

Credits
location Stansted, Essex
client Stansted Airport Ltd
architect and interior designer Foster Associates
project manager Stansted Development Team
structural engineer Ove Arup & Partners
quantity surveyor BAA with Beard Dove and Currie & Brown
construction manager Laing Management and BAA Consultancy
lighting (public areas) Claude and Danielle Engle
acoustics ISVR Consultancy
graphic design Pentagram
subcontractors: architectural metalwork and glazed screens W & G Sissons Ltd, *lighting* Erco Lighting, *steelwork* Tubeworkers, *large-scale graphics and secondary signs* Bull Signs.

Photo credit
Photographs by Peter Cook.



6

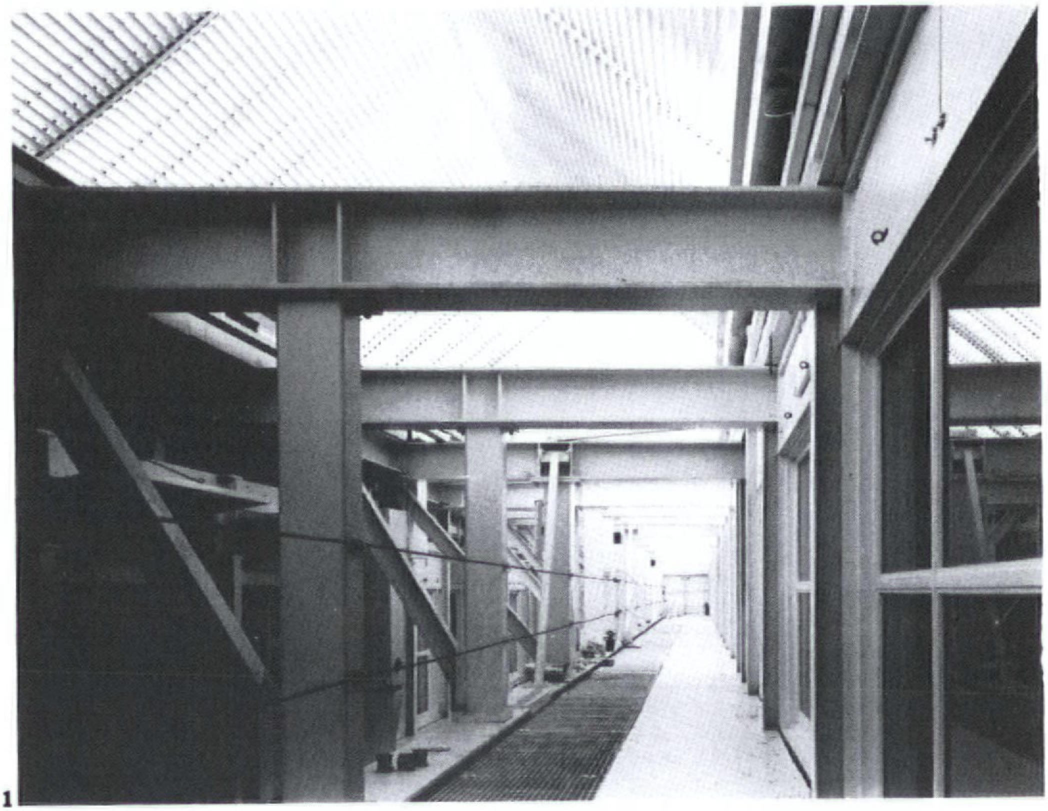
LIGHTING

ART GALLERY

Venturi, Scott Brown and Associates

One of the chief influences on the design of the National Gallery extension was the lighting to the galleries. They appear substantially daylit, but in fact receive less than 1 per cent of the daylight available.

Related article
Building feature
AJ 21&28.8.91 p26-33, 36-43



1

1 A view down one of the lightboxes between galleries. Daylight enters through uv-filter-coated glass in the sloped glazing overhead. It is then modulated by the louvres, and again by the vertical timber-framed windows which can be seen on each side of the photo.
2 Cross section through lightbox.
3 Cross section through the Sainsbury Wing: the rooflights are not above, but between galleries.

The external walls and the structure from ground level down in the Sainsbury Wing are concrete, but the upper parts of the galleries and the walls between them are framed in steel. The configuration of the steel was dictated by the specific lighting requirements.

The constraints included not only the now stringent environmental requirements for paintings, and the architects' own decision that the rooflight ridges should line through, but also included the planners' requirements that the rooflights be kept down to a certain level, as a result of which 250 mm had to be lost from the height of the rooflights at a relatively late stage.

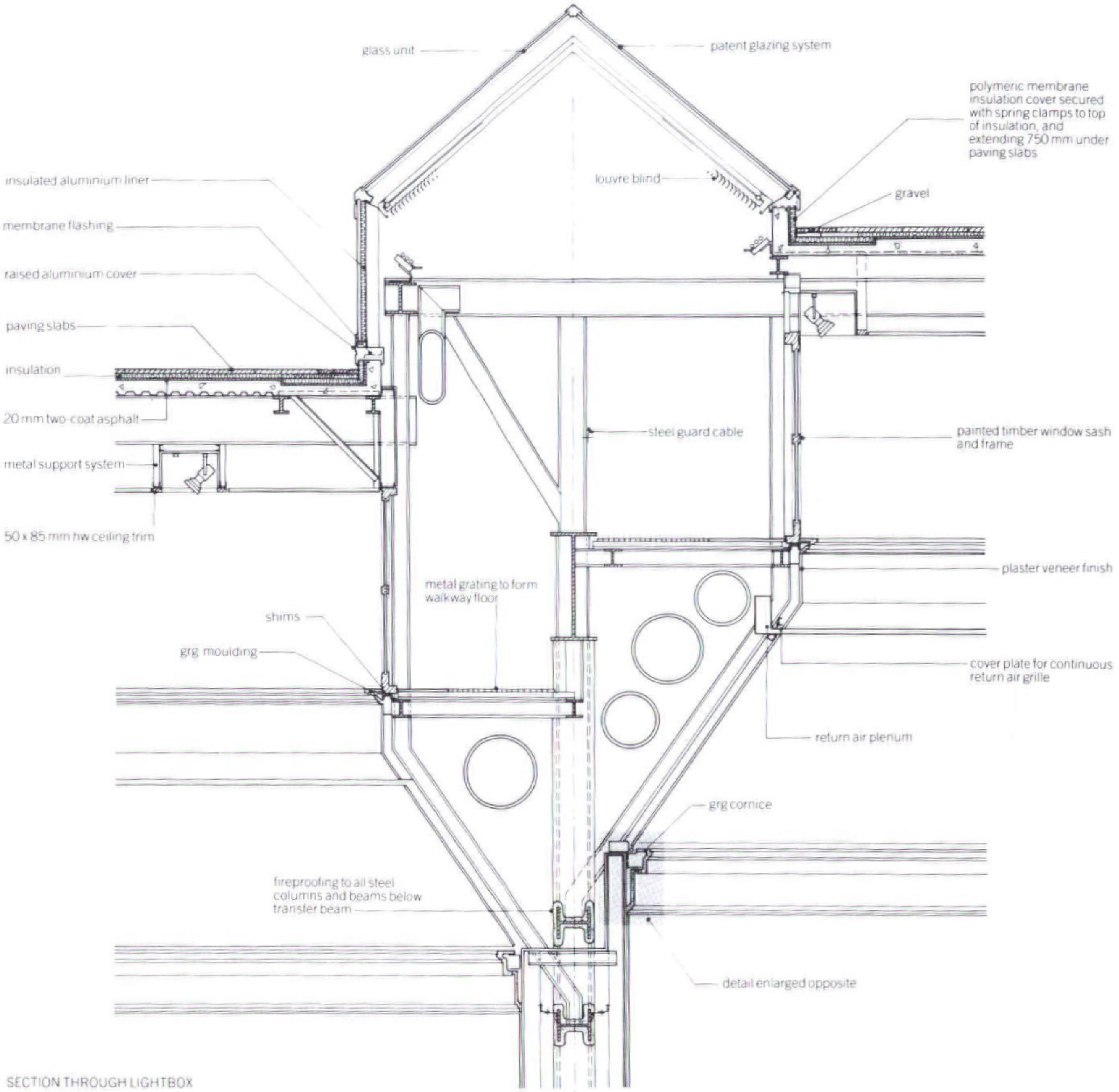
The galleries are always artificially lit. Daylight is secondhand: you are aware of the intensity of sunlight, or of the sun being obscured by clouds, but you should never see a sunbeam. The filter to effect this, and to provide the complementary artificial light as necessary, is a complex construction, referred to as the lightbox.

The angles and sizes are all dictated by what will produce the best lighting effect internally. The roof glazing, which Venturi wanted to be legible, is a proprietary double glazed system, the inner sheet of which cuts out ultraviolet light. The louvres directly underneath this are operated by externally mounted sensors to regulate the level of light penetration. The louvre positions are reviewed every two hours. When the building is unoccupied the louvres are closed. Internal sensors were tried on the mock-up built at Shepperton film studios, but locating them, and ensuring relevant readings were obtained was less satisfactory. Each sensor covers a zone — not just an individual gallery.

Daylight enters the galleries through vertical etched glazing. Much effort has gone into eliminating the appearance of shadows through the glass, but they can still occasionally be seen. The lightbox is by no means an empty space merely allowing the passage of light, but also contains substantial steel structure and services. Air conditioning supply ducts run above the angled parts of the ceilings and air is extracted through a slot at the back of the lower cornices.

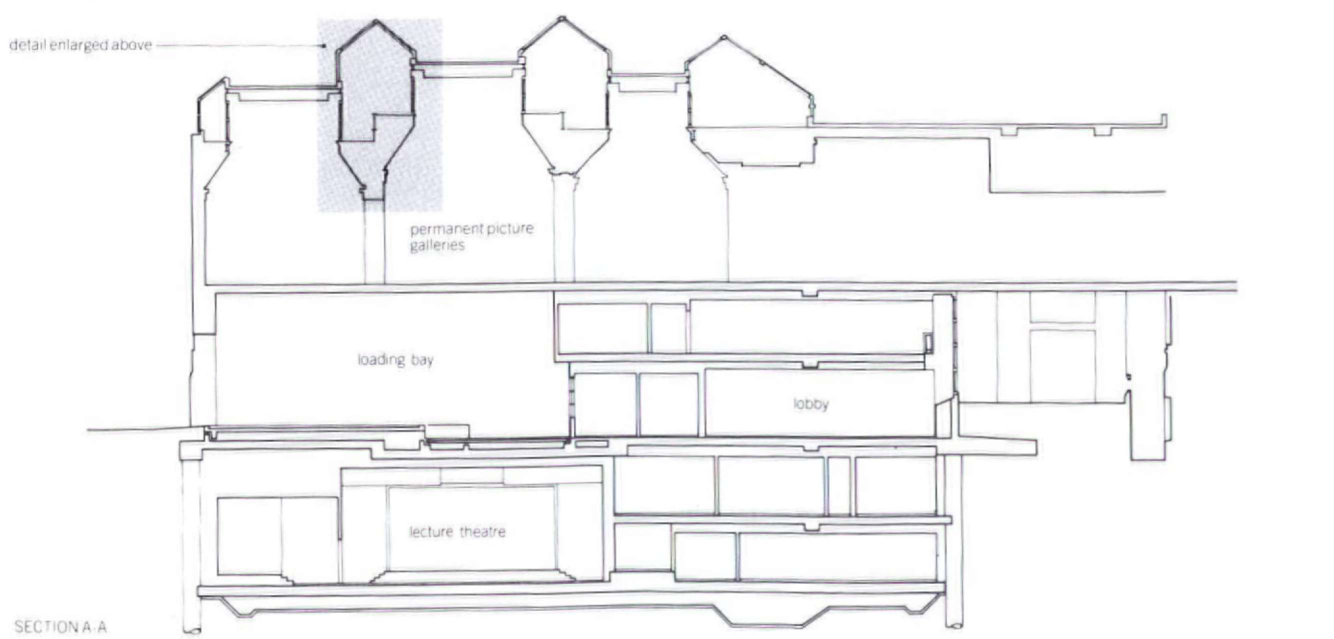
By the time the daylight reaches the galleries it has already been mixed with artificial light from batteries of colour-corrected fluorescent tubes fixed just below the rooflights. Within the galleries themselves are two tracks of low voltage spotlights which can each be directed at individual paintings. Where these back on to the lightbox a flap is provided for maintenance access. Within the lightbox there are two access walkways, and externally a sliding cradle allows maintenance of the rooflights. ■

Acknowledgment
The editors acknowledge the assistance of Dean Hawkes, who teaches at the University of Cambridge Department of Architecture, and is a partner in Greenberg, Hawkes and Bentley.



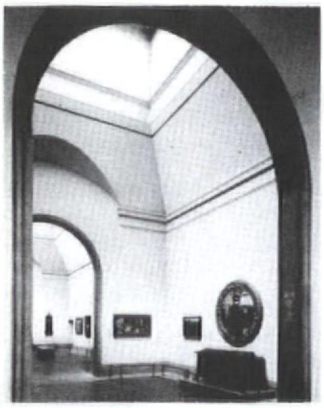
SECTION THROUGH LIGHTBOX

2



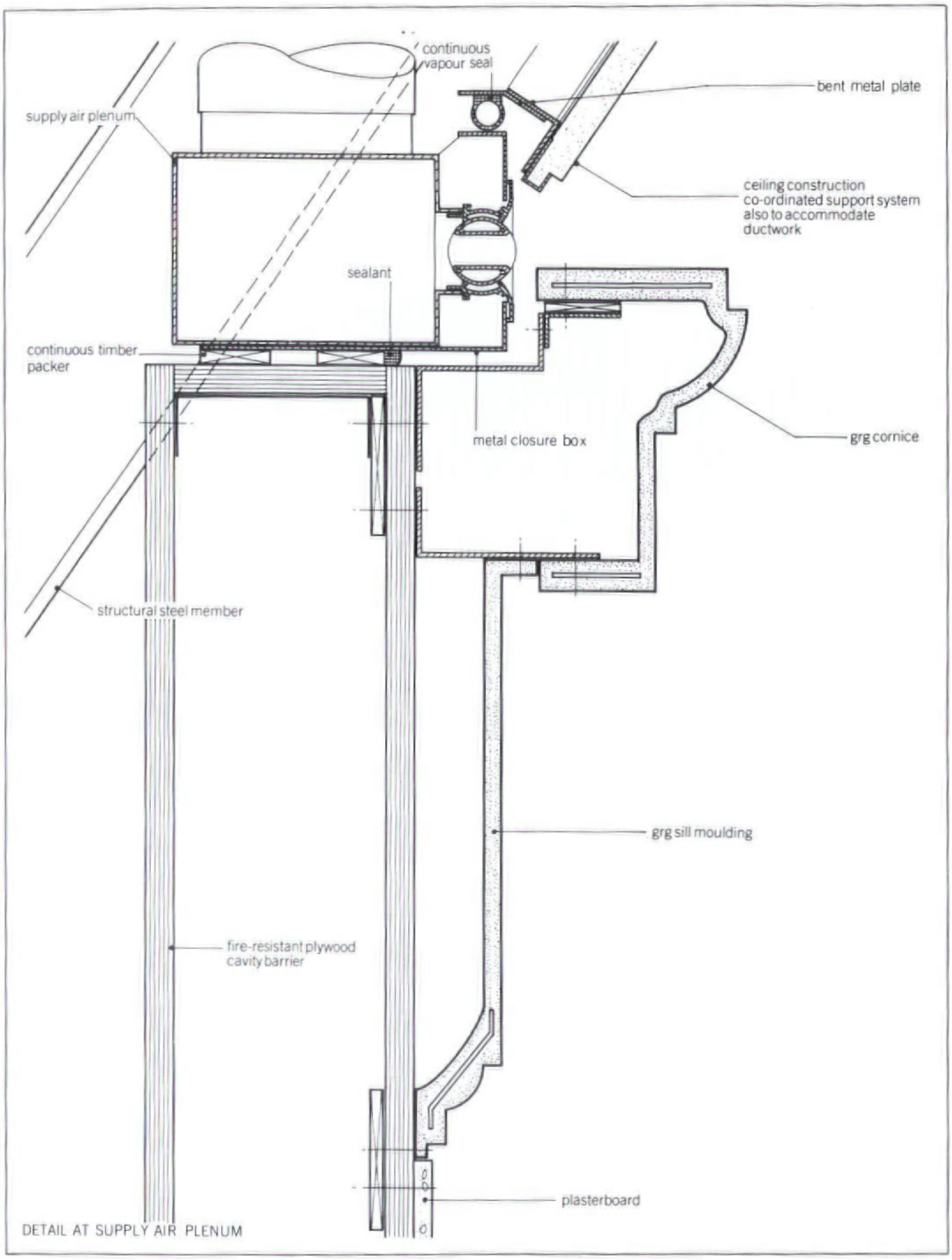
SECTION A-A

3



4

4 View into the galleries with filtered daylight entering at high level: average illuminance levels are between 150 and 275 lux.
5 Detailed section through one of the supply air plenums: the ductwork for the gallery vav air-conditioning system is housed below the walkways in the lightboxes. Air is extracted at the level of the upper cornice, just below the window, and supplied at the lower level as shown.
6 Roof plan: in spite of this extensive array of glazing less that 1 per cent of the available daylight will illuminate the galleries, yielding an average wall luminance of less than 32 candelas per m².



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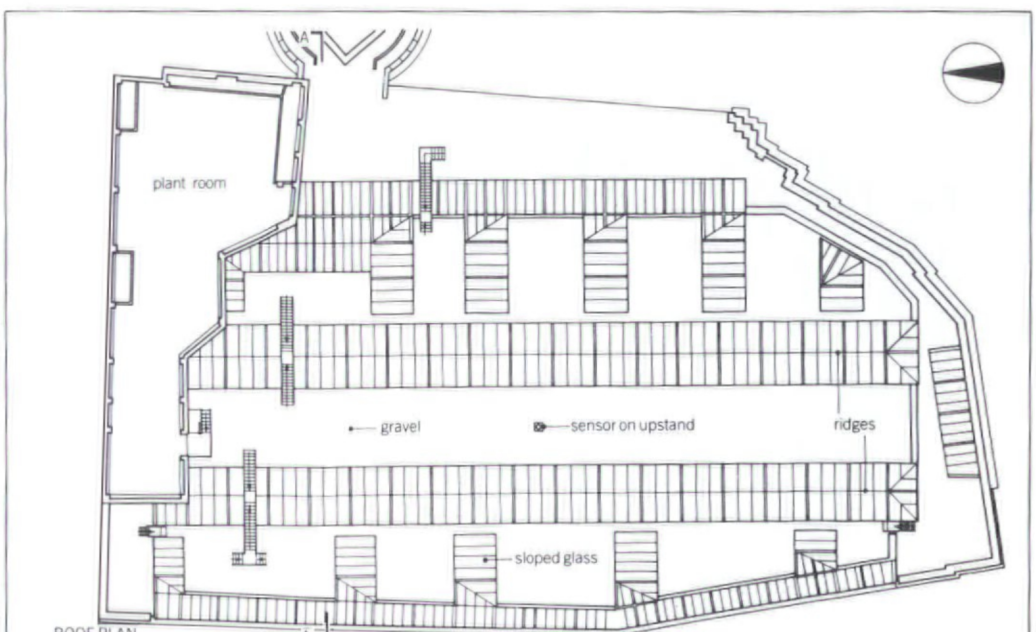


6

Credits
location The National Gallery, Trafalgar Square, London
client The National Gallery
architect Venturi, Scott Brown and Associates
principal in charge Robert Venturi
project director David Vaughan
project architects John Chase, John Hunter
associated UK architect Sheppard Robson Architects
principal in charge William Mullins
project manager for construction administration John Hunter
structural engineer Ove Arup and Partners
services engineer Ove Arup and Partners with Jaros Baum and Bolles
quantity surveyor Gardiner and Theobald
services quantity surveyor Mott, Green and Wall
lighting consultant Jules Fisher and Paul Marantz
trade contractors: roof membranes and finishes Asphaltic Contracts, *rooflights* Irving Whitlock, *services* Crown House Engineering, *environmental control system* Satchwell Control Systems, *internal partitions and plasterwork* Jonathon James.

Photo credit
Photographs by Martin Charles.

CI/SfB (5-)

1

Service structure
Testing facility

ORMS Designers & Architects As part of its redesign of this workshop and office suite for de Beers, ORMS and Ove Arup & Partners have designed a suspended walkway to allow services to be rationalised.

The life of Charters as a Berkshire country house was all too short. Designed by Adie, Button & Partners and completed in 1938 for an engineer named Parkinson, it was bought in 1959 for commercial use by Vickers, who extended it, and then sold it in the early 1970s to de Beers, the present owner.

The ground floor of the large extension is now used for technical suppport to those producing industrial diamonds. Worldwide there are few companies in this field: competition is based not on price, but on the technical back-up available. One of the most important functions of this area is as a showroom. The floor finish around the perimeter of the workshop — the visitors' route — has a non-slip finish, differentiating it from the highly polished, easily cleaned surface elsewhere.

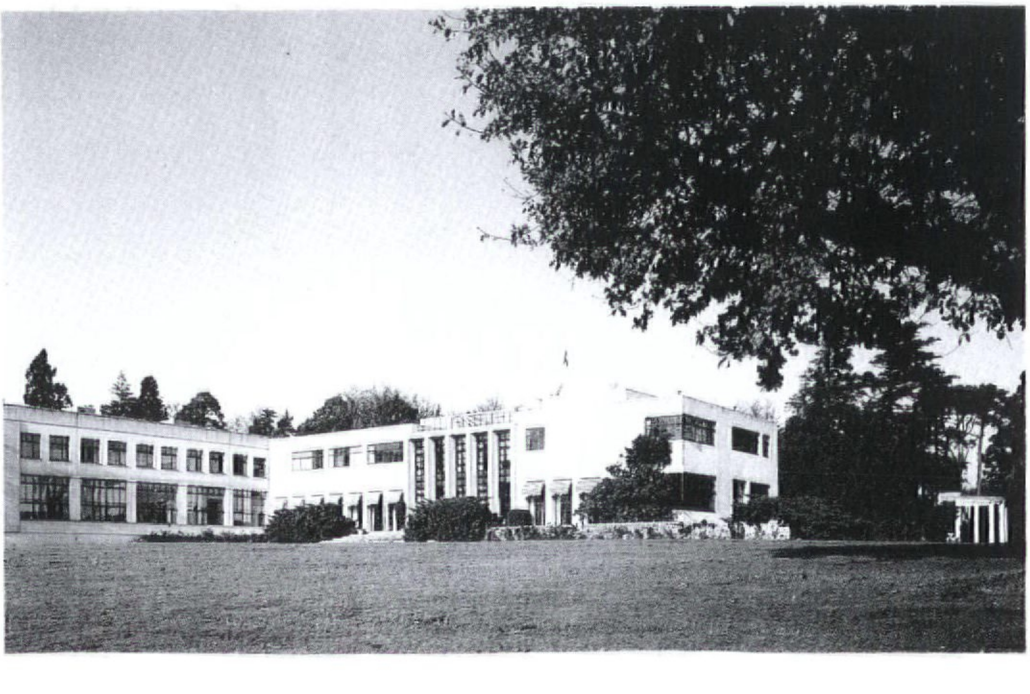
Originally the high-windowed, high-ceilinged ground floor of the extension, **2**, had a large workshop on the west side, separated by a corridor from cellular offices — which had suspended ceilings butted up against the windows.

But environmental conditions, particularly in the workshop (where dust and fumes were produced), were becoming less and less satisfactory, so de Beers' first idea was to install a dust and fume extraction system in the workshop — estimated at about £600,000 — and to refurbish the offices, budgeted at about £400,000. Before any of this work was carried out ORMS became involved (at Ove Arup & Partners' invitation). Starting again from the beginning, ORMS came up with quite a different solution, described below — which in the end cost slightly less.

Another of de Beers' concerns was that the existing layout did nothing to encourage teamwork. As part of the solution, all internal walls on the ground floor were removed, despite the engineer's concern that one of them was required for bracing (steel bracing has therefore been added in one bay).

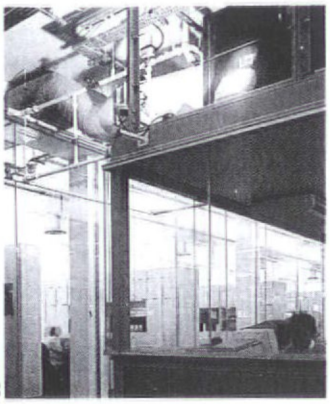
The cellular offices have become open plan work areas, separated from the workshop only by a toughened glass wall. The new services to the workshop have been grouped around a steel gantry which runs down the centre of the workshop at high level, and is suspended from the existing columns via a series of yokes.

The steel yokes, **4**, are fixed to each column by a single stainless steel bolt, whose hole was diamond drilled (by de Beers) through the column. At each end of the yoke is a steel casting; the same design of casting is also used, although the other way up, at gantry



2

Acknowledgement
The editors acknowledge the assistance of Alan Brookes of Alan Brookes Associates in the preparation of this article.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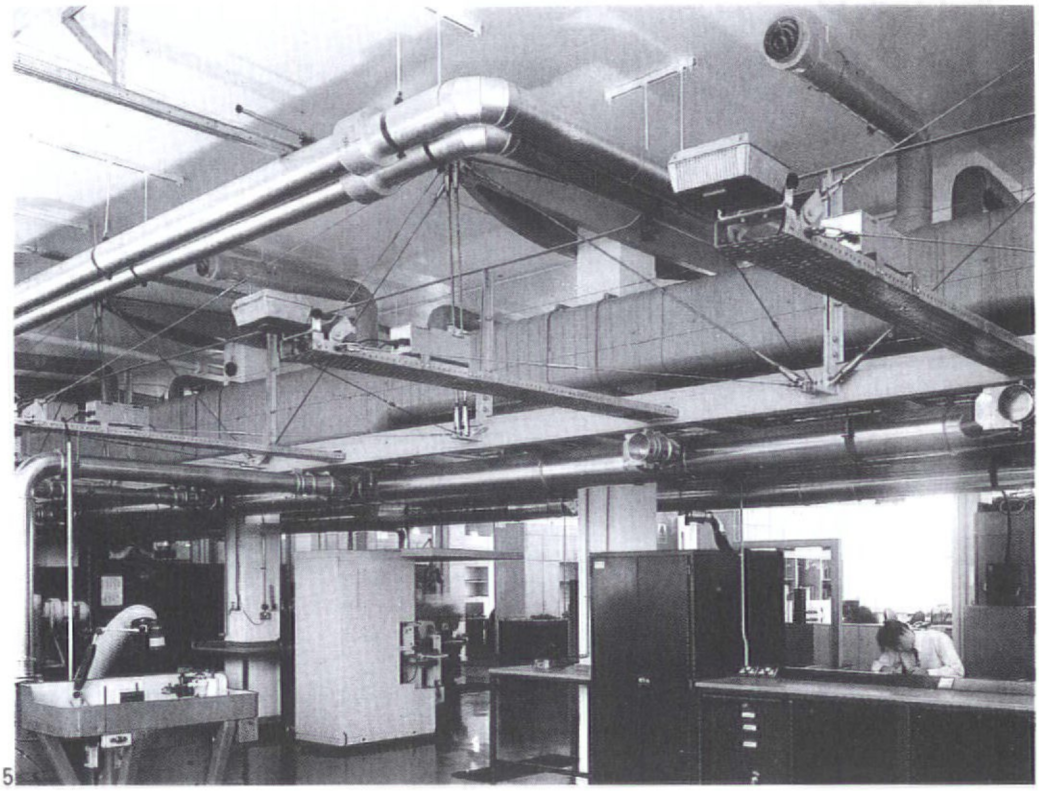
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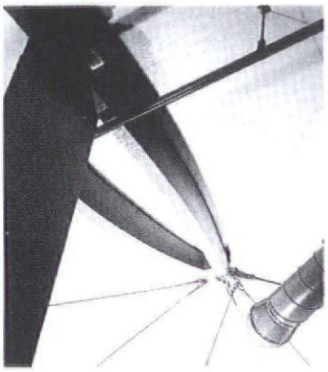

4

level. The castings take the fixings for the various means of support for different services. By using the same design in both locations — 28 castings were required — it became financially viable to have a specially designed casting. The floor above prevents rotation and gives added stability to the yoke.

Air extracted from the workshop is filtered immediately after the outlets (which are as near the plant as possible) to avoid lubricant oils travelling any further down the air extract system. Extract air is filtered of particles centrally before it reaches the extract fan. The extract ductwork is suspended below the gantry, and the supply ductwork is bracketed either side of the columns in the centre of the walkway. In office areas there is no air extraction, only supply. Grilles in a bulkhead above the glass screen equalise air pressures between the workshop and offices.

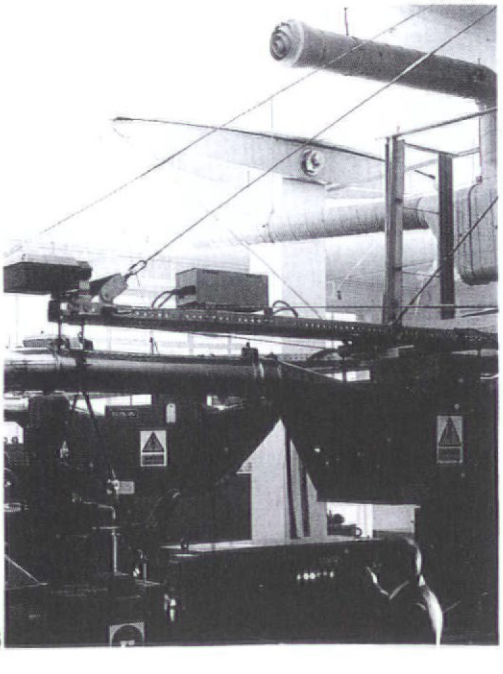
The services are coloured to complement the machinery, which could not be repainted because it was in constant use. In fact, apart from the last three months, both workshop and offices remained in use while the alterations were being carried out — although if they were to do it again de Beers would look for temporary accommodation.

ORMS also helped to design the machine layout. The plant does not represent one continuous process, rather there are groupings of machines that carry out related tasks.

There are just two enclosed pods at the north end of the workshop. One is used for measurement, and one has been fitted with two furnaces which are required for wheelmaking.

Ladders provide access to the service gantry above.□

1 Looking into the new office area (subdivided by the units which can be seen on the right and left of the picture) and the workshop beyond. Offices and workshop are now separated only by a glazed screen.
2 Charters, built in 1938 as a country house, and now owned by de Beers. The wing on the left, whose ground floor houses the workshop and office suite, was built for Vickers in 1959.
3 View of the north end of the workshop with one of the two enclosed pods in the foreground.
4 Looking up at one of the yokes, which are bolted to the existing columns and from which services are suspended.
5 The workshop showing the gantry at high level.
6 A series of branches come off the main service spine. Filters are as near to individual machines as possible.
7 Offices to the left, workshop to the right, and only the glazed screen in between.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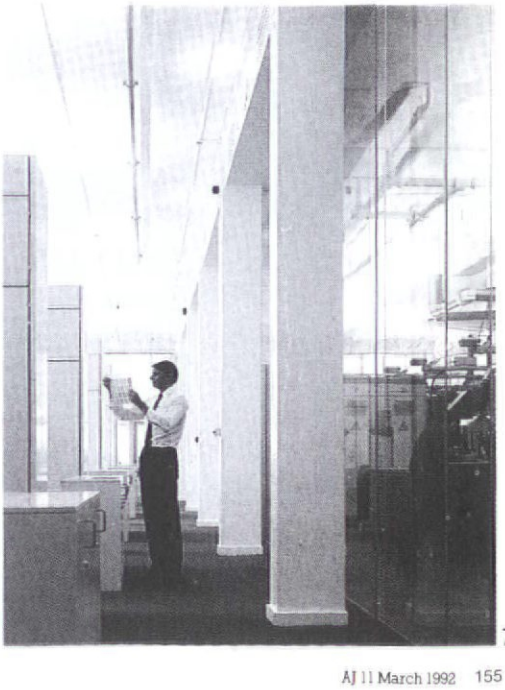
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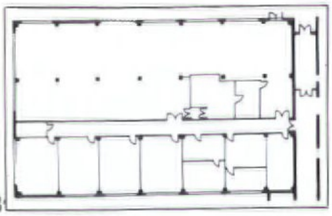

8

8 Ground floor plan of the 1959 wing before the redesign by ORMS. Removal of the righthand wall to the main space meant that a heavy bracing frame had to be added around soffit, columns and across the floor of one end bay there.

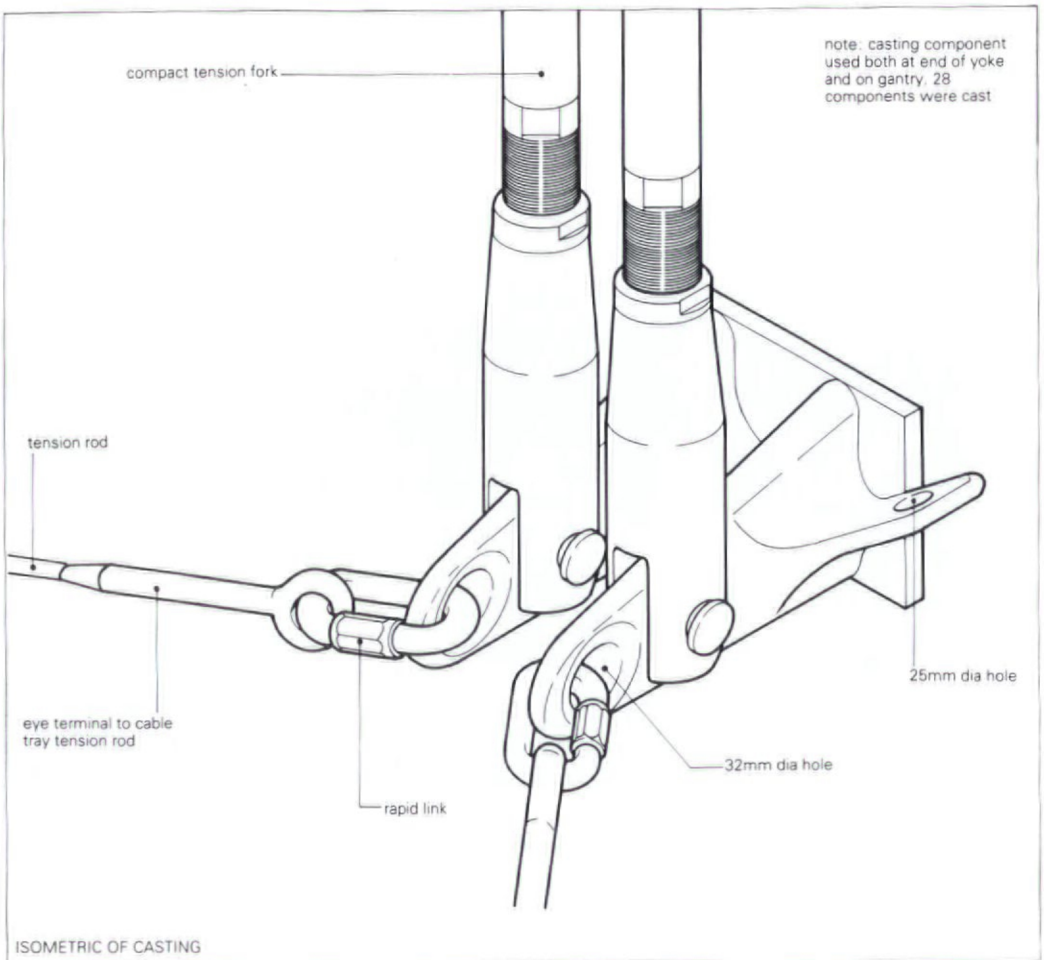
9 Isometric of one of the castings. The same casting is used, but the other way up, at each end of the yoke to carry services.

10 Cross-section showing the rationalisation of the services and the glazed wall separating offices and workshop.

11 Plan. In this new layout there is a display/entrance area which allows a good view of the workshop as soon as you enter this part of the building.

12 Elevation, plan and section of one of the yokes.

13 Isometric of the gantry and services located around it. Ladders (not shown) provide access to the gantry.



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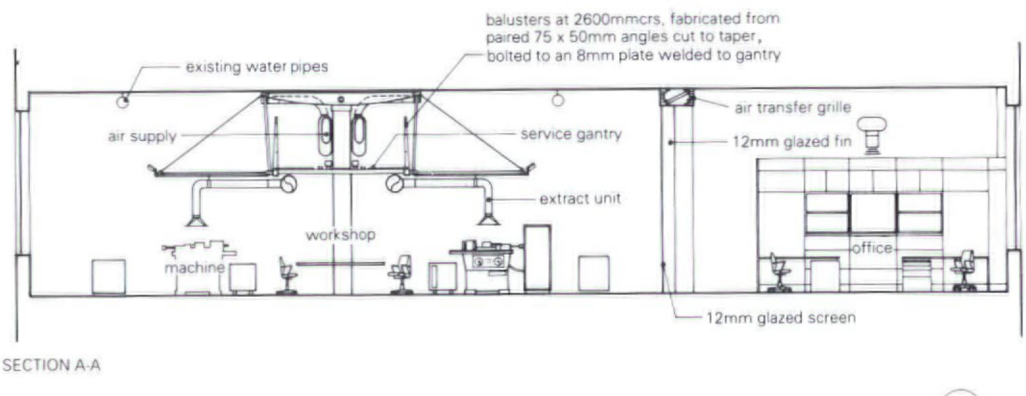

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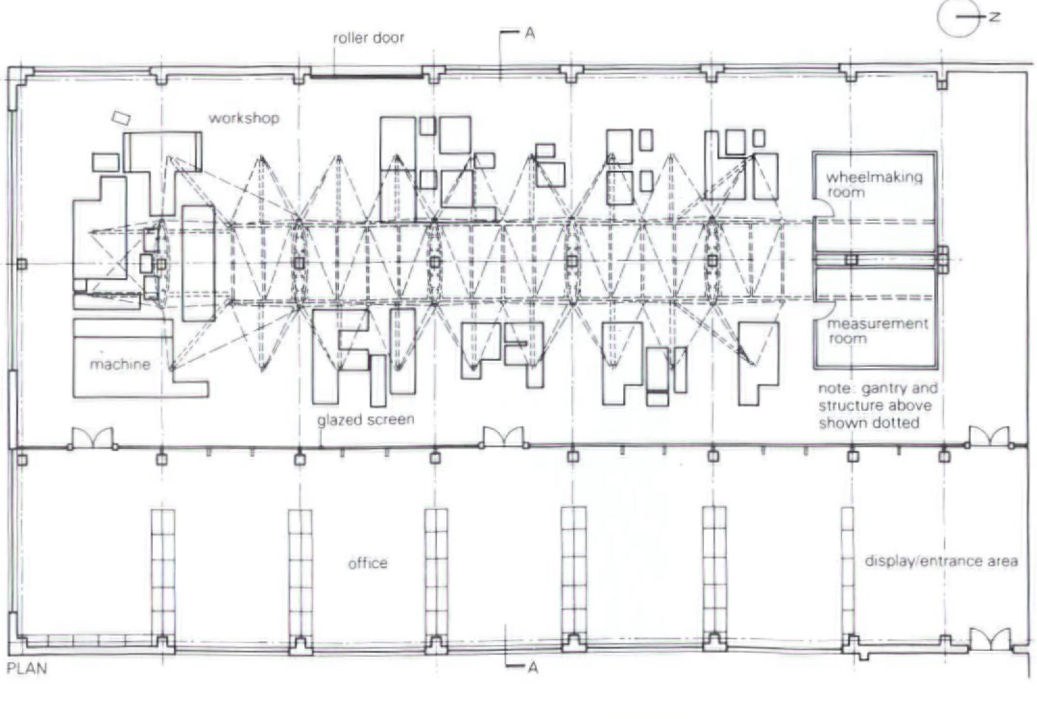
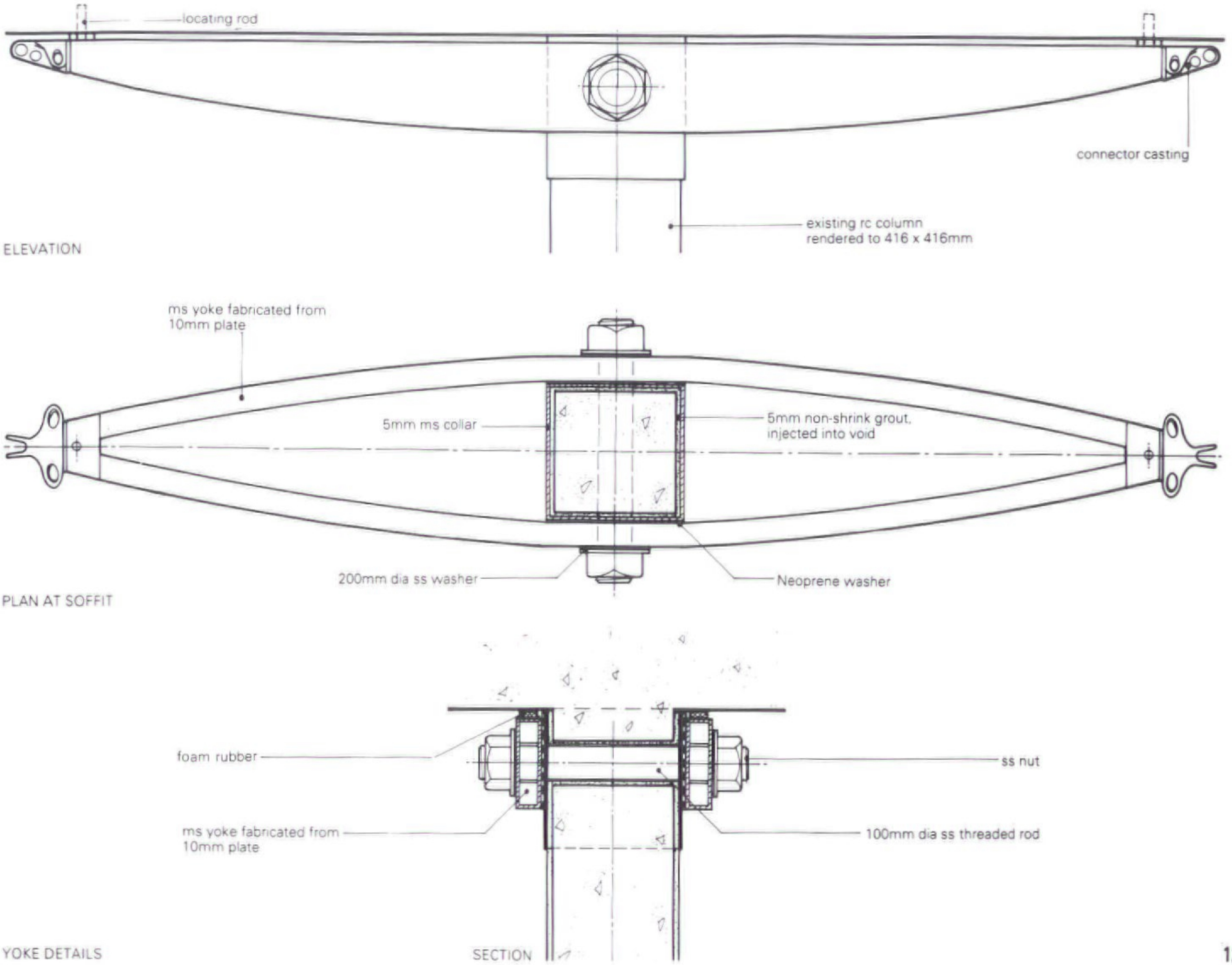


11

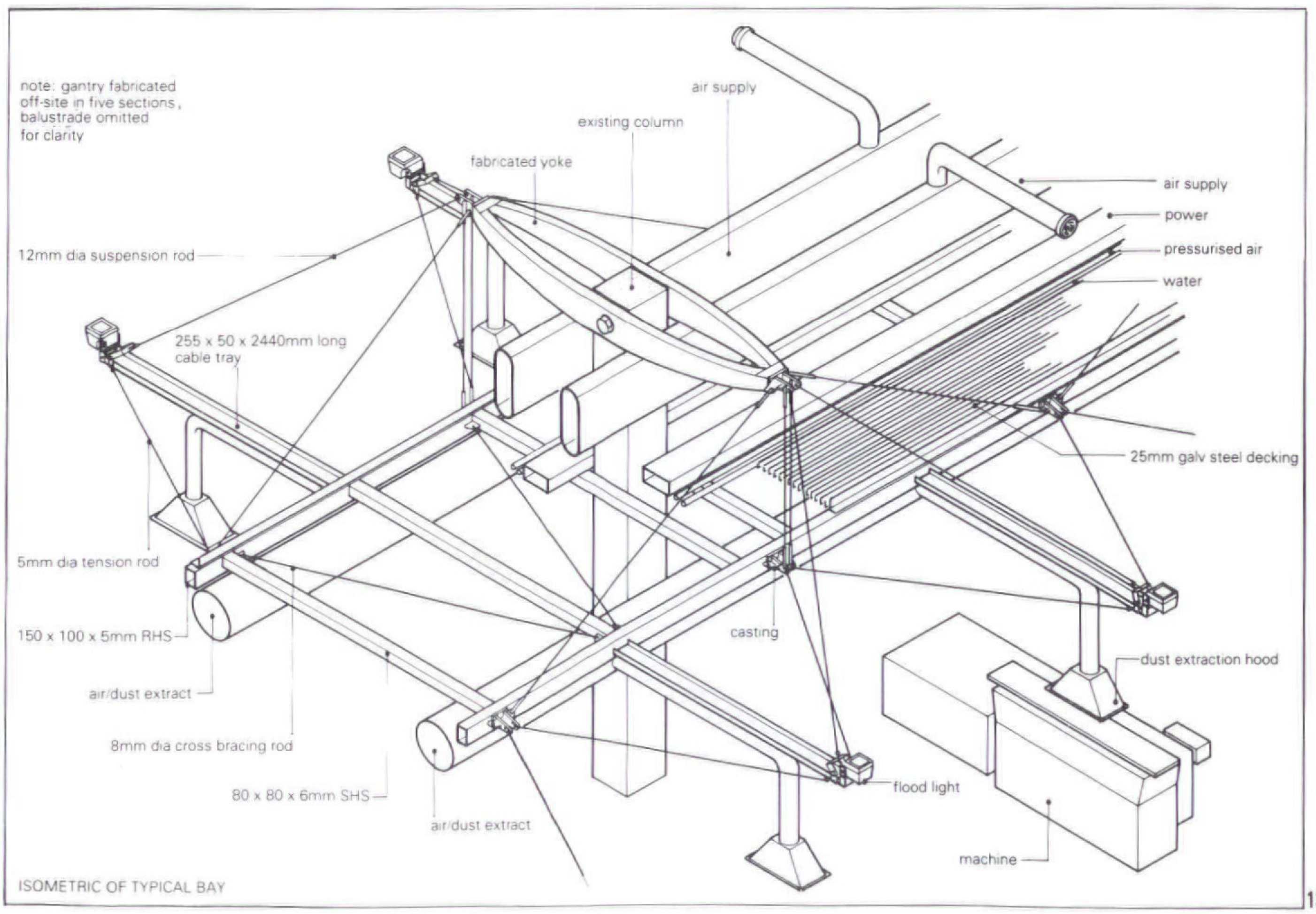
Credits
location Charters, Sunninghill, Berkshire
client de Beers Industrial Diamond Division (Pty): Dr Malcolm Bailey, Horst Wapler
design team ORMS Designers & Architects: **partner** Martin Shirley, **associate** Gavin Edwards, **project architect** Nick Cowie
design team Ove Arup & Partners: **project manager** Jeff Willis, **structures** Peter Chapman, **HVAC services** Guy Channer, **electrical services** Paul Pompili
quantity surveyor Edmond Shipway and Partners **partner** John Farrar, **project QS** Norman Birchall
main contractor Wiltshier Reading
subcontractors: mechanical services How Engineering Services, **dust extraction, a/c services** Duscovent Engineering, **glazing** Solaglas, **structural steelwork** Steelcon, **workshop floor** Thames Industrial Flooring
suppliers: tensile systems Guy Linking, **storage wall** K+N International, **desking** Marcatre, **display benching** Windmill Furniture, **chairs** Vitra, **workshop furniture** Pinders, **castings** Holbrook Precision Castings.

Project data
contract JCT IFC 1984
site start date January 1991
completion date September 1991

Photo credit
Photographs by Peter Cook.

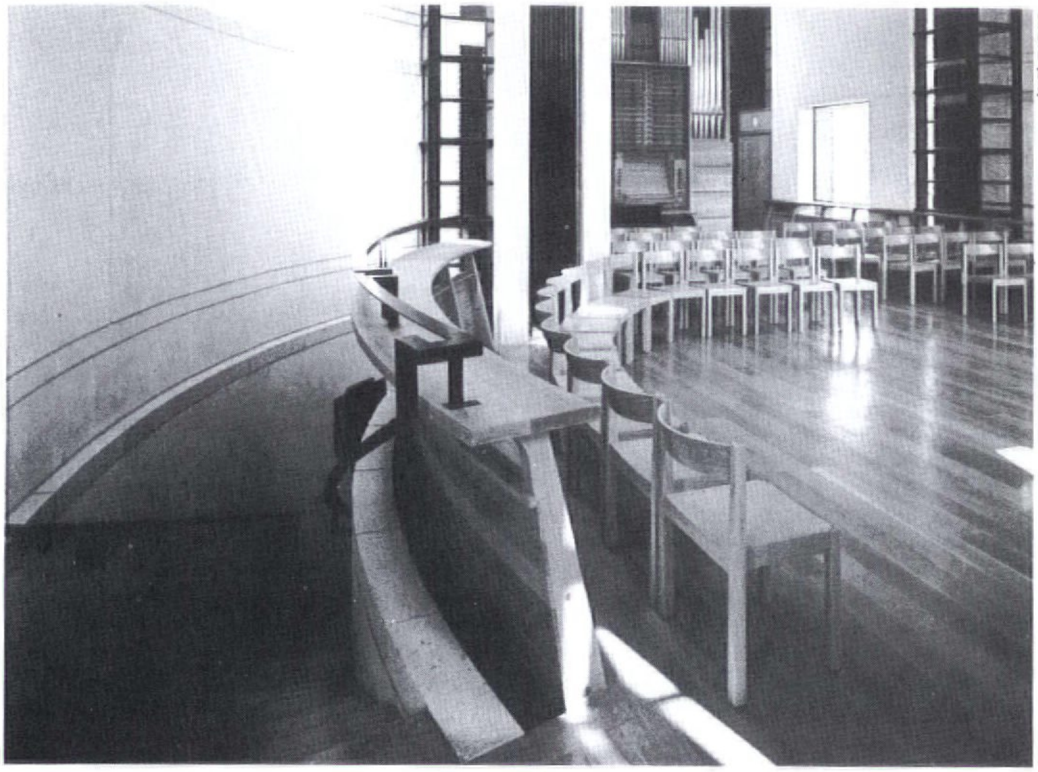

locating rod
connector casting
existing rc column
rendered to 416 x 416mm
ELEVATION
ms yoke fabricated from
10mm plate
5mm ms collar
5mm non-shrink grout,
injected into void
200mm dia ss washer
Neoprene washer
PLAN AT SOFFIT
foam rubber
ss nut
ms yoke fabricated from
10mm plate
100mm dia ss threaded rod
YOKE DETAILS
SECTION

12


note: gantry fabricated
off-site in five sections,
balustrade omitted
for clarity
air supply
existing column
fabricated yoke
air supply
power
pressurised air
water
12mm dia suspension rod
255 x 50 x 2440mm long
cable tray
25mm galv steel decking
5mm dia tension rod
casting
150 x 100 x 5mm RHS
dust extraction hood
air/dust extract
8mm dia cross bracing rod
80 x 80 x 6mm SHS
flood light
air/dust extract
machine
ISOMETRIC OF TYPICAL BAY

13

1 The two balustrade details — curved and straight — can be clearly seen: the straight type forms the nave of the chapel and becomes external over the entrance below.


1

Internal joinery
Chapel

MacCormac Jamieson Prichard This oak balustrade has been detailed for both internal and external use.

The chapel for Fitzwilliam College, Cambridge, was designed within the context of the MacCormac Jamieson Pritchard now-aborted masterplan for the college; it extends from the end of an existing residential wing into the garden.

It was built for a fixed sum of £670,000, agreed with the contractor at sketch design stage; all detailed design decisions were subsequently made in close liaison with the contractor. The contractor was chosen because of its in-house joinery and concrete skills and because its previous relationship with the architects was good. There were no claims, despite a six month overrun on site.

The concept for the chapel is based on strong archetypal images of square, circle and boat. The boat 'floats' between two volumes, the chapel above and the crypt below.

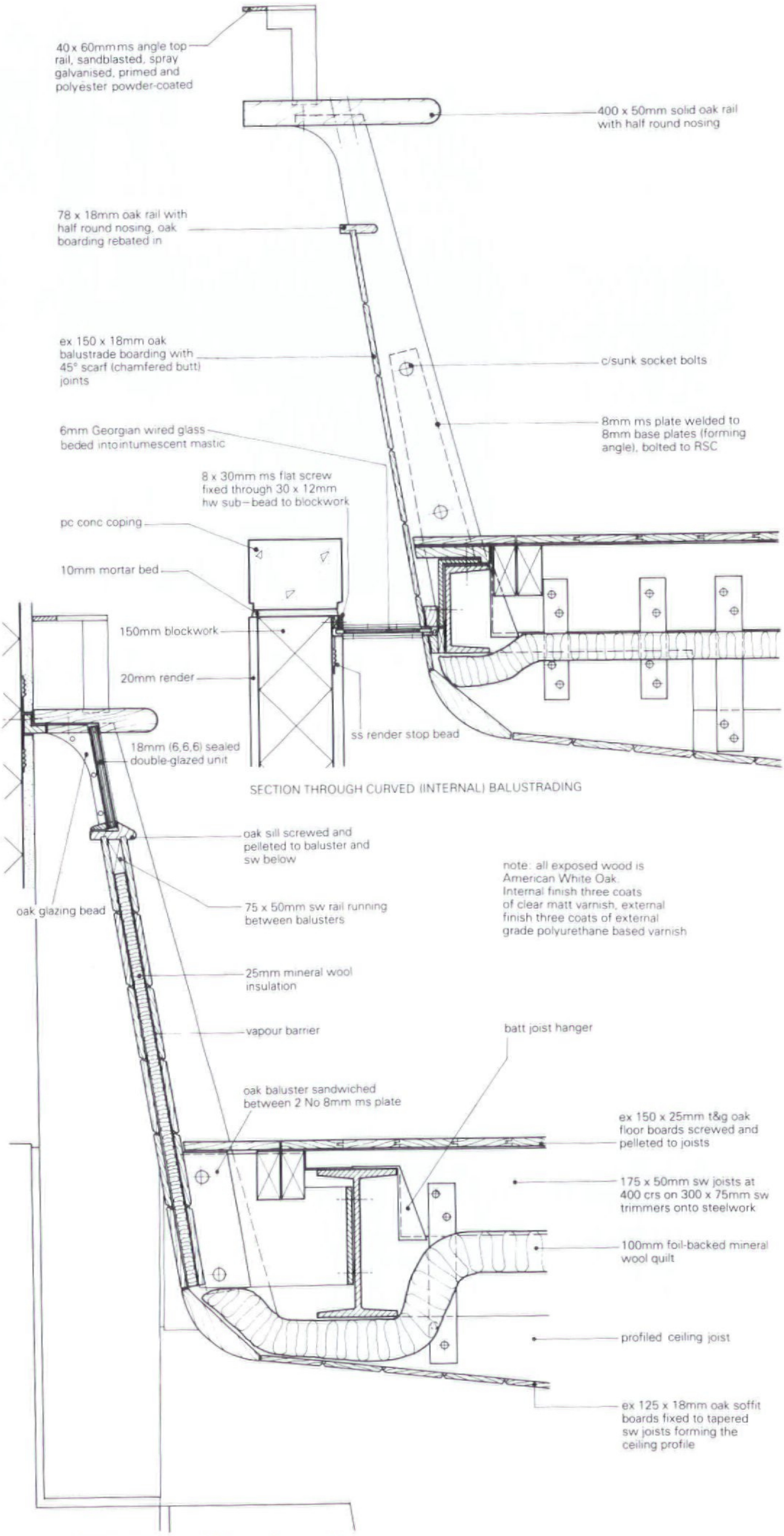
The boat is anchored by four concrete columns which mark a square on plan. Steel beams span between the columns and support the timber floor joists from which lower ceiling joists hang. The boarding of the boat, the cladding, is American oak; it is scarf (diagonal butt) jointed — the diagonal joints allow for movement and reduce the gaps through which light can pass. Because of the two-directional curved form, each board is of varying curvature. The exact dimensions were worked out by building a 1:1 softwood mock-up, planing the boards to the correct dimension and using them as templates for the hardwood version.

There are two main balustrade details: curved (which echo the circle started by the outer brick walls); and straight (forming the nave — these become external when bridging the entrance). The exposed balustrading has insulation sandwiched between two layers of boarding — it has not been purposely drained or ventilated, but the gaps between boards will allow moisture to escape.

The fire rating between the two volumes is half an hour. The separating materials are predominantly glass and the rating is achieved with wired glass and intumescent strips. Insulation quilting was needed within the floor. A class 0 varnish was required on the exposed underbelly boarding to prevent possible surface spread of flame, but due to the small scale, number of exits, the timber being hardwood and the use of smoke detectors, the requirement was waved — the originally specified varnish (clear matt) was then used. Three coats of external grade varnish were applied outside; the visual difference between the two is minimal. □

Acknowledgment
The editors acknowledge the assistance of Lionel Friedland of Pentarch in the preparation of this article.

2 Section through curved and straight balustrades.
3 Detailed plans through curved and straight balusters and detailed section through crypt partition.
4 Long section.

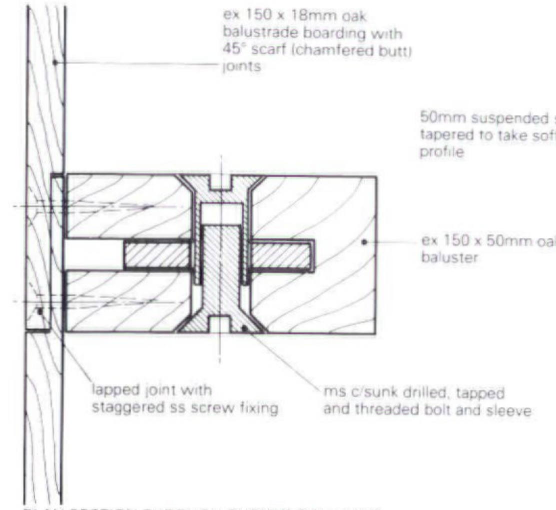


2

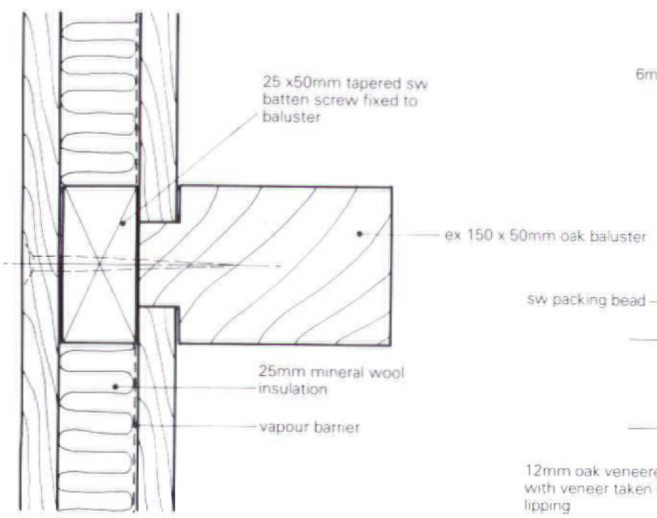
Credits
location Fitzwilliam College, Cambridge
client Fitzwilliam College
architect MacCormac Jamieson Prichard: Richard MacCormac, Peter Jamieson, Dorian Wiszniewski, Andrew Taylor, Peter Greenwood, Pankaj Patel, Oliver Smith
structural engineer Ove Arup & Partners: Cecil Balmond
quantity surveyor Dearle and Henderson: Peter Hancock, Peter Kelsall
services engineer Ove Arup & Partners: Tudor Salusbury
contractor Johnson & Bailey

Project data
contract JCT 80
site start date June 1989
completion date February 1991

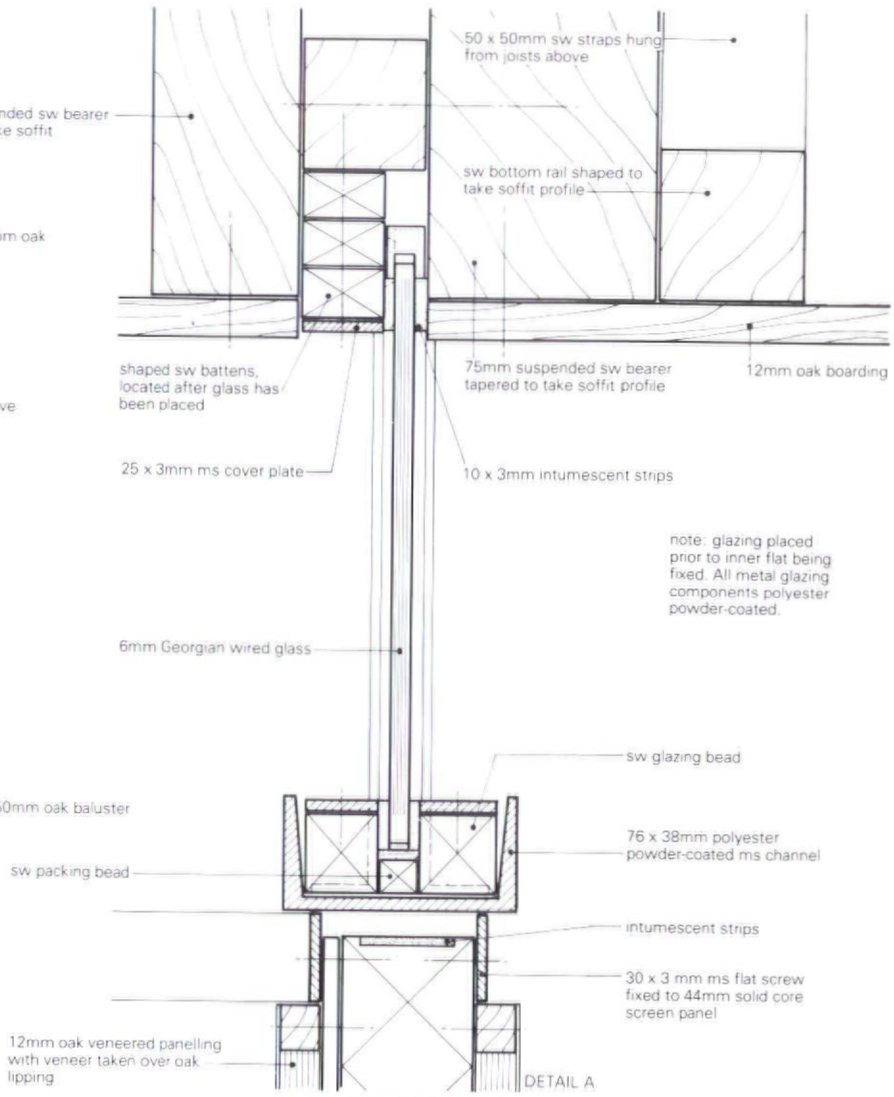
Photo credit
Photographs by Peter Blundell Jones.



PLAN SECTION THROUGH CURVED BALUSTER

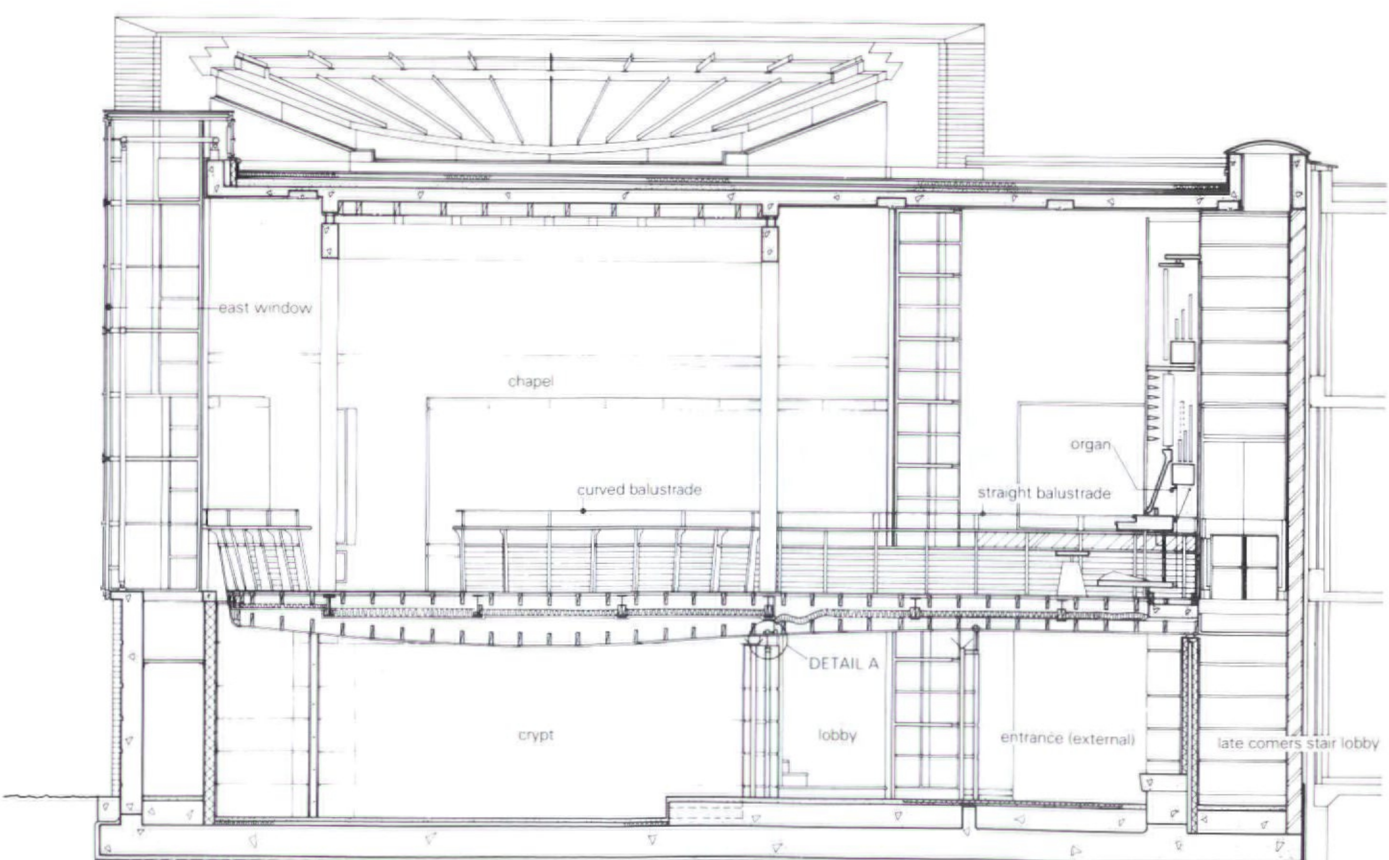


PLAN SECTION THROUGH STRAIGHT BALUSTER



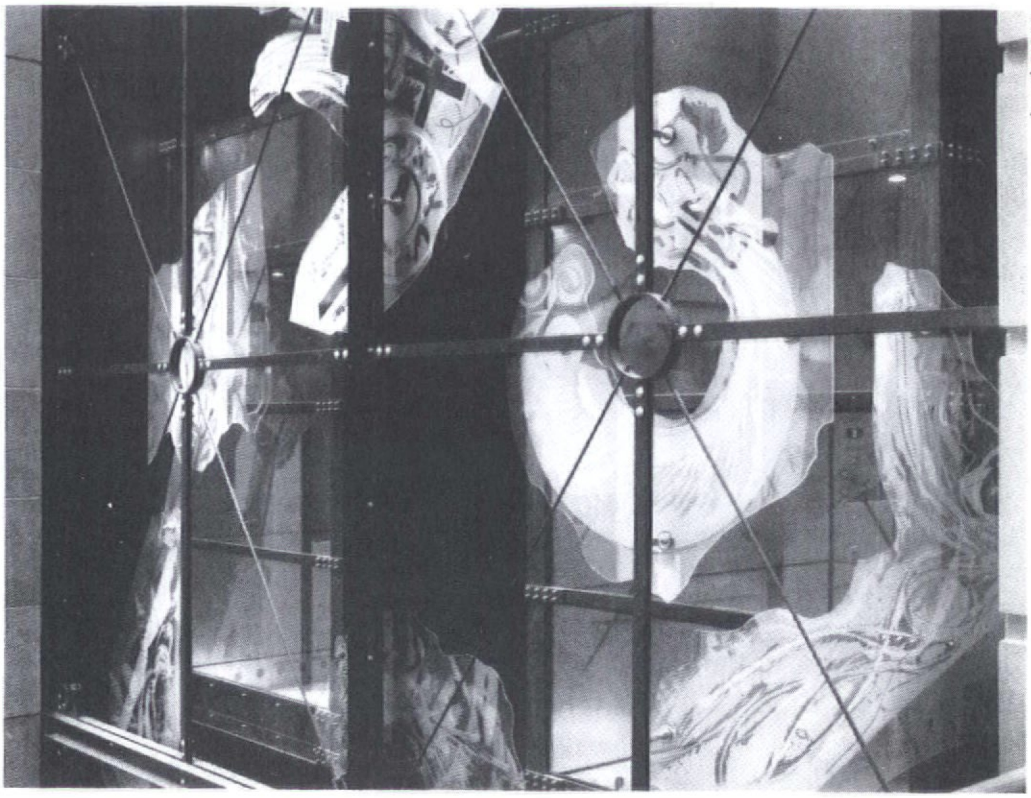
SECTION THROUGH PARTITION

3



LONG SECTION

4



1 View of the lift car and steel screen from the large atrium. The glass sculpture, specially commissioned from the artist Danny Lane, is simply bolted onto the screen.

Lift
Offices

Campbell & Arnott Specifically designed as a social focus, these lifts bridge the gap between offices and public spaces.

Saltire Court, a large multi-purpose development, is situated in Edinburgh's West End, below the castle. Its rectangular plan is effectively divided into four by the central hall (the office entrance) and two atria (one for the restaurants and theatre, and a smaller private one for office use), both bring light into the building and provide social foci.

The main vertical circulation for the offices, a bank of four lifts, is placed at the crossing of the hall and atria; their degree of transparency enables the users to be aware of the life in the atria beyond. The lift lobbies are open to the central hall, the cars themselves to the atria; the lift lobby wall therefore had to be detailed to give half-hour fire stability and integrity. The principle carcass of the lobby wall was fabricated off-site from steel angles; once in place it was glazed and given the required fire protection by covering the structure with insulation tape and mild steel plate.

It was the architect's initial intention to complement the glazed lobby wall with fully glazed landing doors but cost considerations prevented this. Stainless steel doors were used and are probably a better solution as they help focus the view from the car's glazed end wall into the atrium. The ceiling of the car is made of perforated steel plate which allows some oblique views from and into the cars.

The car itself runs on a roller guide system which is more expensive than the more normal sliding option but gives a smoother ride. It is a dry system so oil residue is minimised — an important deciding factor as the structure is exposed to view and attracts dust.

The lift cars and cables are separated from the atria by a chunky steel screen; it forms the back 'wall' to the large atrium, and is the backdrop for the specially commisioned glass sculpture. It is a physical, not visual, barrier between the theatre/restaurants and the offices. It is constructed from simple elements — steel angles, tie-rods and turn buckles — but is structured for effect not function. There is a glass safety screen behind it at ground level.

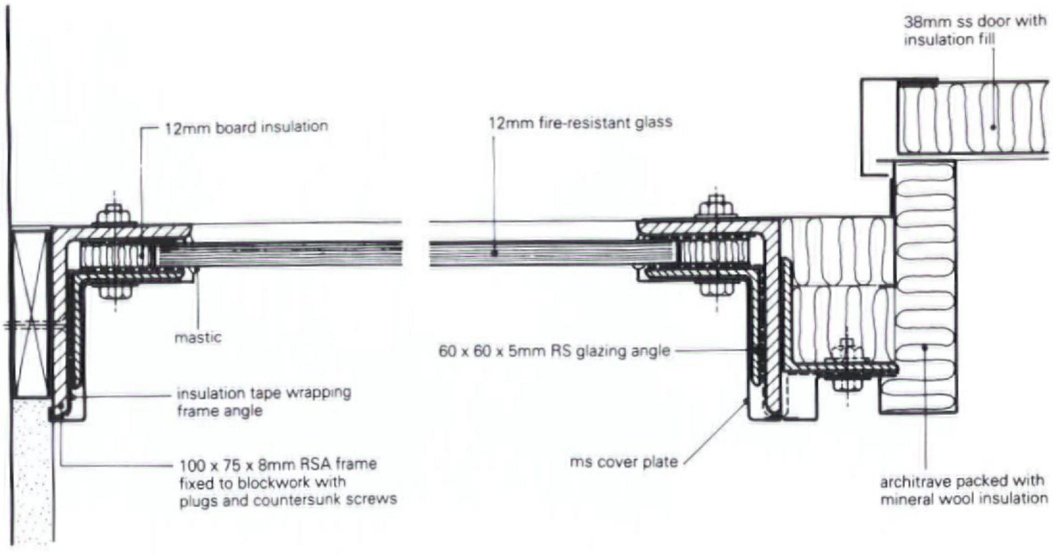
The shaft structure and the lift mechanism can be seen from the lobbies and the atria — it quickly and obviously gets dirty. The manufacturers are contracted to check the lifts every month; this includes a schedule of cleaning which is carried out by riding on top of the car.

The lift motor room forms part of the 'roof-top village', the architect's attempt to reduce the visual impact of this massive building when seen from the castle. It is barrel vaulted and glazed so exposes the machinery when it is lit at night.☐

Acknowledgment
The editors acknowledge the assistance of Ron Jewson of YRM Engineers in the preparation of this article.

Working Details

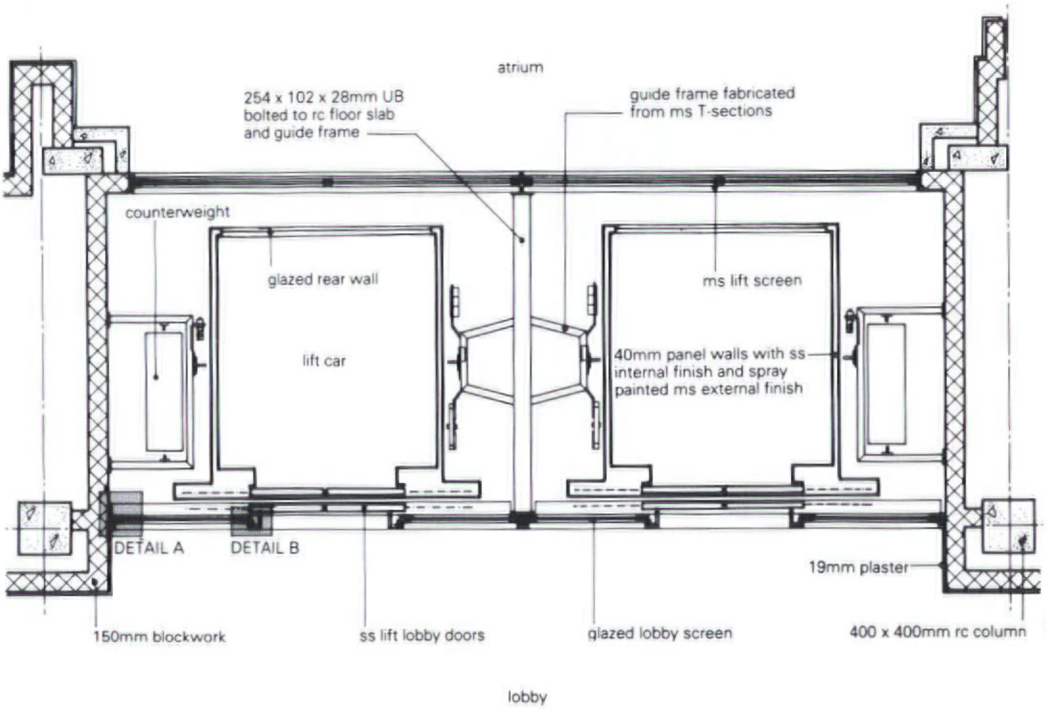
2 Details of the glazed lobby screen.
3 Typical lift plan.
4 Long section showing the relationship between the atria and the lifts.
5 Detail of the glazed lobby screen and isometric of the lift car.
6 Part elevation and details of the lift screen.



PLAN DETAIL A: GLAZED LOBBY SCREEN/ WALL JUNCTION

PLAN DETAIL B: GLAZED LOBBY SCREEN/ DOOR JUNCTION

2



3

TYPICAL LIFT PLAN

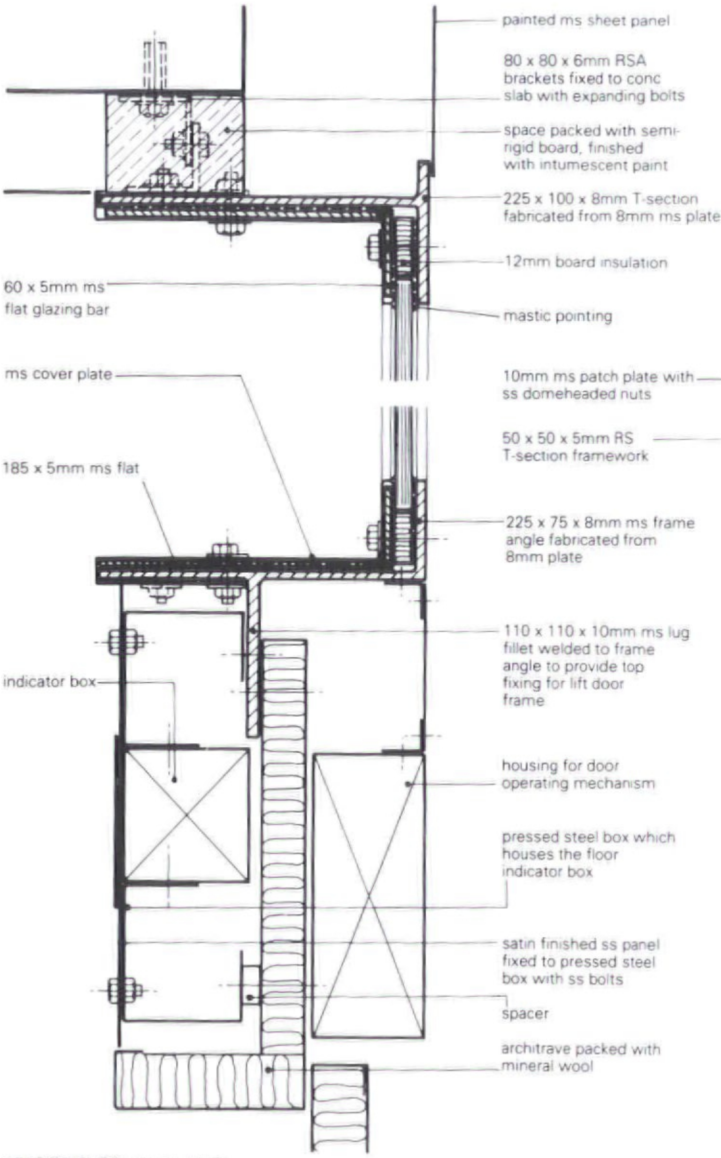
LONG SECTION

4

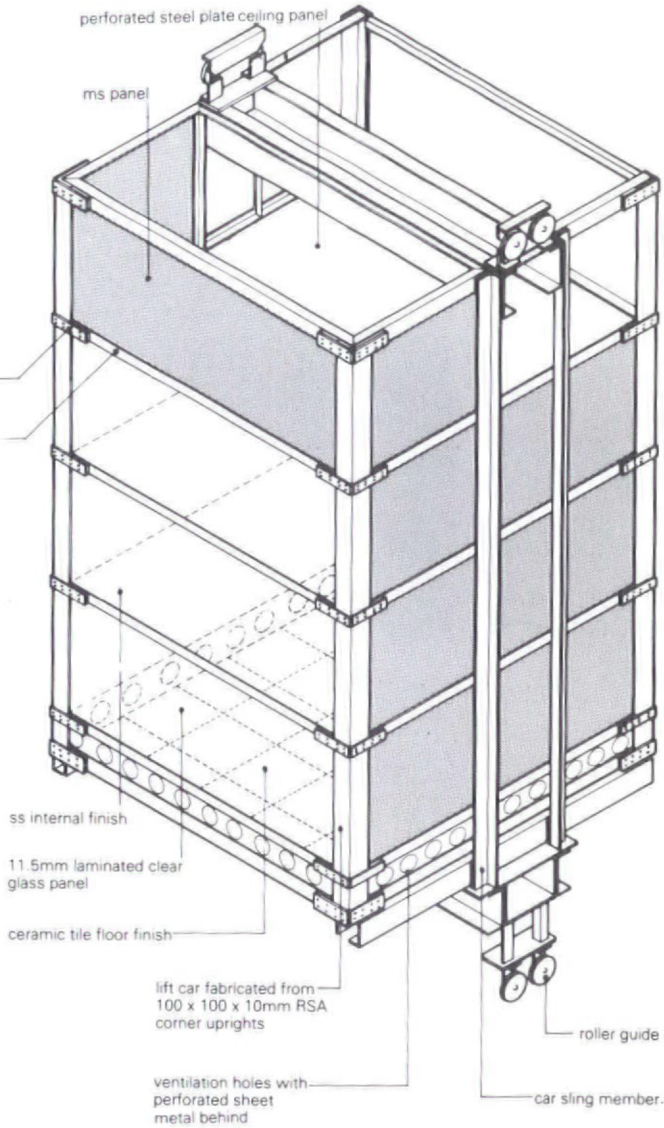
Credits
location Saltire Court, Castle Terrace, Edinburgh
client Scottish Metropolitan Property
architect Campbell & Arnott
design team Alan Robinson, Allen Whitehead, Mark Cousins
quantity surveyor Peter Graham & Partners
electrical/mechanical engineer Hulley & Kirkwood
structural engineers Derick Sampson & Partners
management contractor Sir Robert McAlpine Management Contractors
artist Danny Lane
subcontractors: lifts Express Lift Company, **lobby wall glazing** Charles Henshaw and Sons, **steel screen** Cameron Structures, William Reid & Sons

Project data
contract management contract
site start date April 1988
completion date October 1989

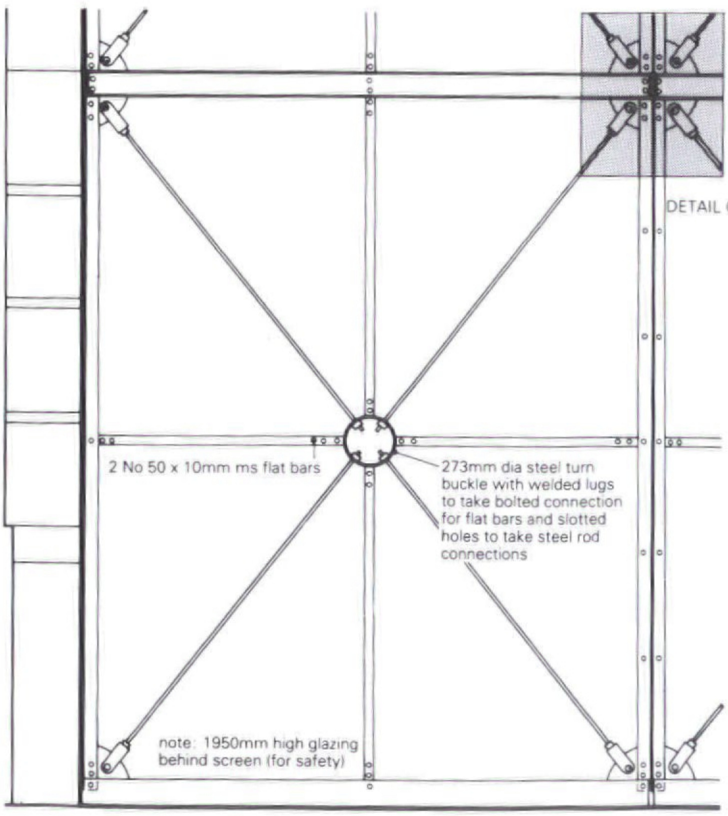
Photo credit
Photograph by Dennis Gilbert.



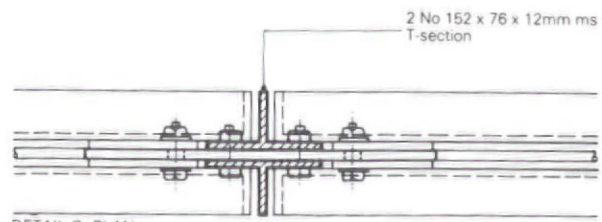
SECTION THROUGH GLAZED LOBBY SCREEN ABOVE DOOR



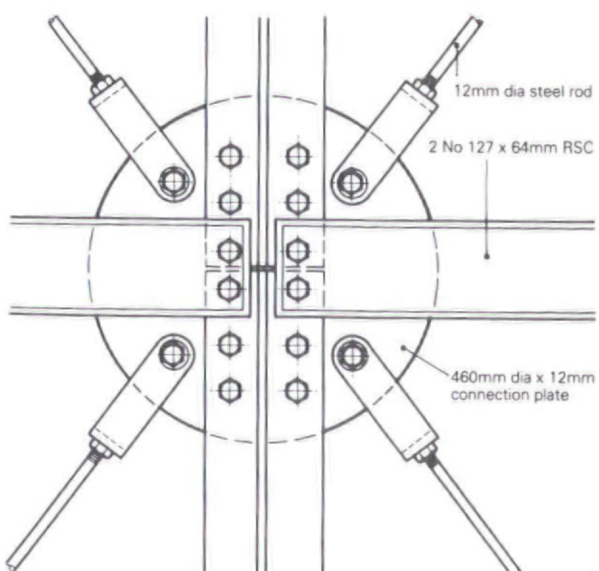
ISOMETRIC OF LIFT CAR



PART ELEVATION OF LIFT SCREEN

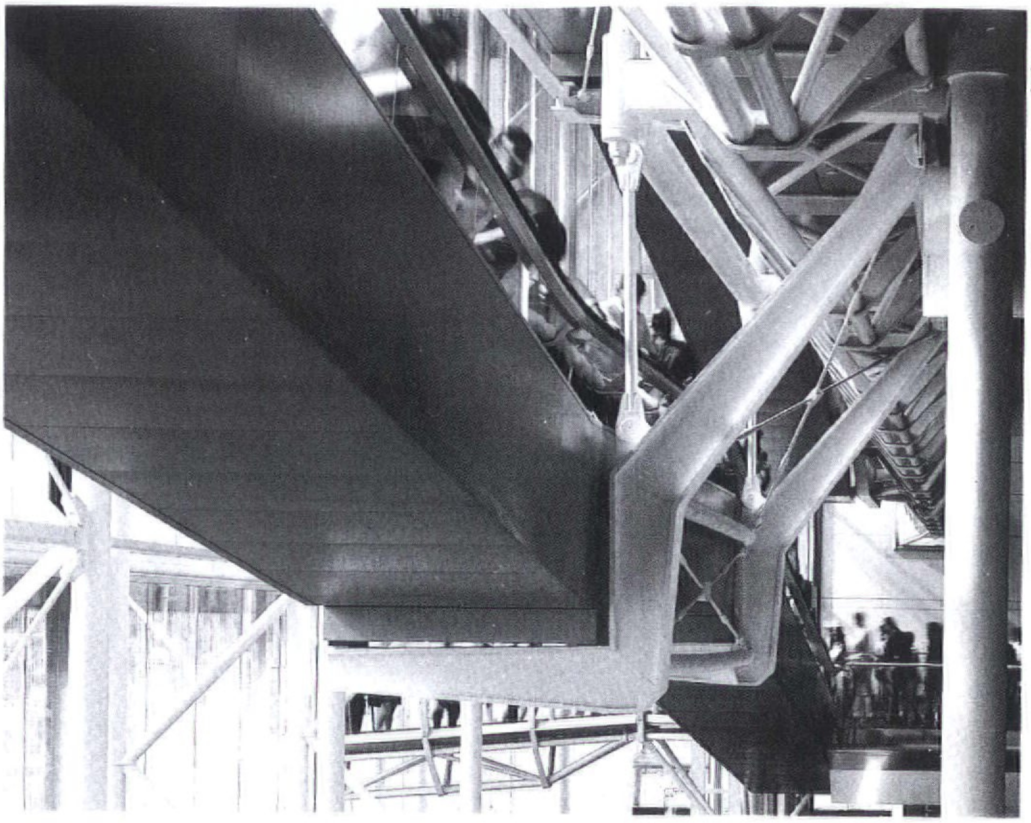


DETAIL C: PLAN



DETAIL C: ELEVATION

6



1 The underside of the lower travelator showing its central support, a pair of cranked cradle arms. The major circulation routes, the travelators and bridges, are suspended from the internal 'pod' structure. The main entrance and the start of the controlled route through the building is situated on the water wall or east elevation; it can be seen at the bottom left of the photograph.

Internal structure
Exhibition building

Nicholas Grimshaw & Partners Circulation routes are suspended from the internal pod structure to maximise exhibition floor space.

With the exception of a few key buildings, the pavilions at Expo 92 in Seville, Spain, are temporary. Although the fate of the British Pavilion is as yet unknown, the structure and fabric were designed to be taken down and re-erected elsewhere. All the steelwork was fabricated and painted in England then shipped and driven to Spain; joints were designed to minimise site work — most are simple pins.

The external envelope, with its flamboyant water wall and solar roof structure, both waves the British flag and provides the initial environmental control. The internal structure, divided into three 'pods', houses two multi-purpose lecture halls, an exhibition space, and service facilities. The pods are connected to each other and to the outside by the main circulation routes.

Each pod structure is supported by four double columns; the columns were fabricated from 10m lengths of tube which were full-strength butt welded and collared up to their full height before being brought to site. The pod trusses are pinned between the double columns; top trusses cantilever out from the line of the column, lower trusses are flush. All the structural steelwork is coated with intumescent paint.

To maximise exhibition space and to minimise foundation footings, the circulation routes — the travelators and bridges — are suspended from the pod structure by means of bridge support arms. The top bridge support arm, fabricated from 20mm plate, is held between the double pod columns and pinned to the extended pod truss. It has three major functions: a tie rod drops down from it to the bridge support arm on the floor below (instead of the arm/pod truss connection), it supports the bridge truss and, in the central pod only, the structure which holds the travelator.

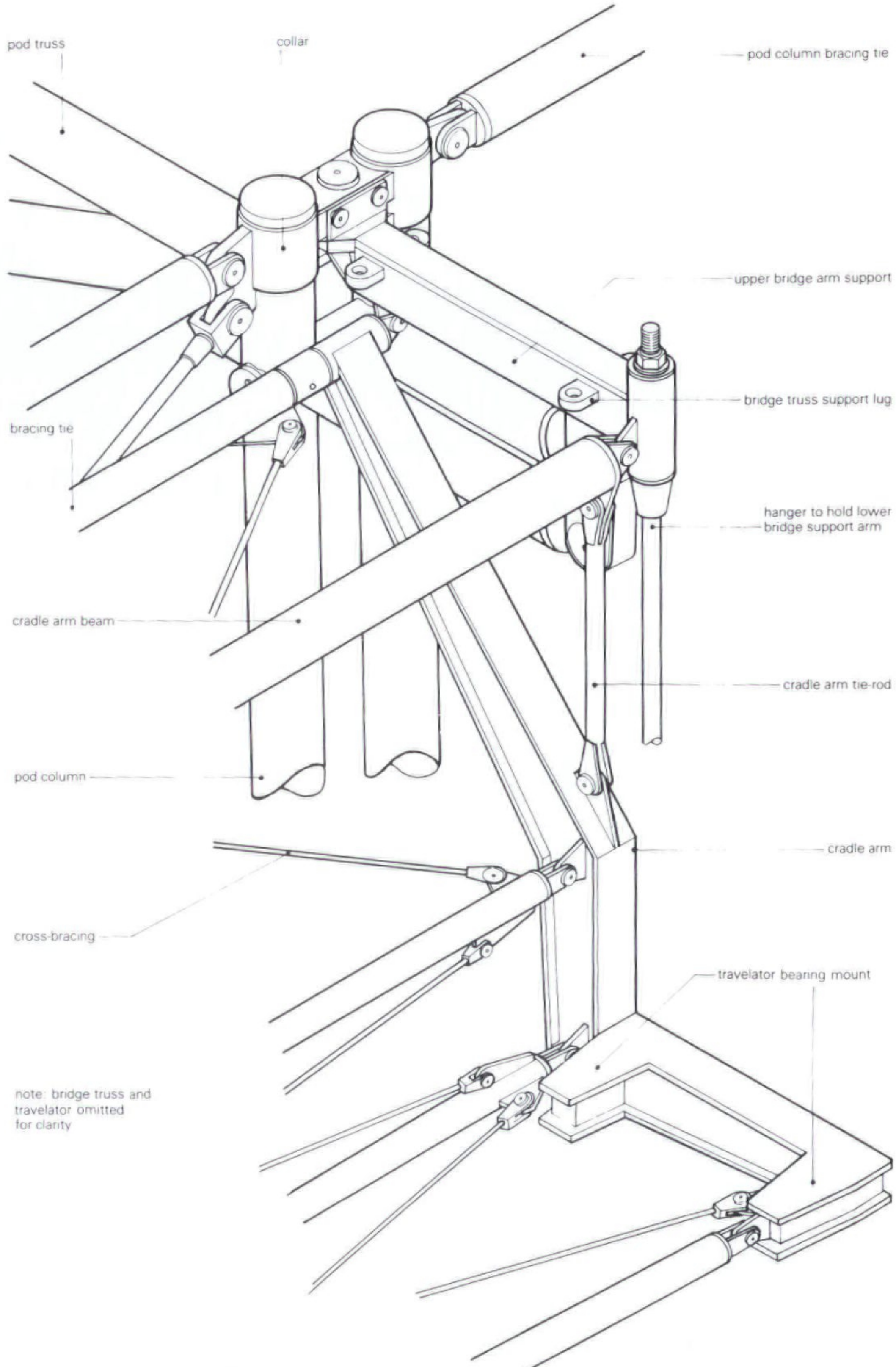
This central travelator support structure — a pair of braced cradle arms — along with the two end supports, has to deal with the high dynamic loading applied by the travelator and, to prevent the moving mechanism from locking, be accurate to ± 2mm. The cradle arms are cranked to allow headroom on the bridge below.

The large bridge trusses sit between the bridge arms above the cradle arms. Floor trays are lowered into place in 1.7 x 1.7m sections and bolted to the truss. The walkways, which are the main escape route, are continuously washed with light from behind the lens at skirting level.□

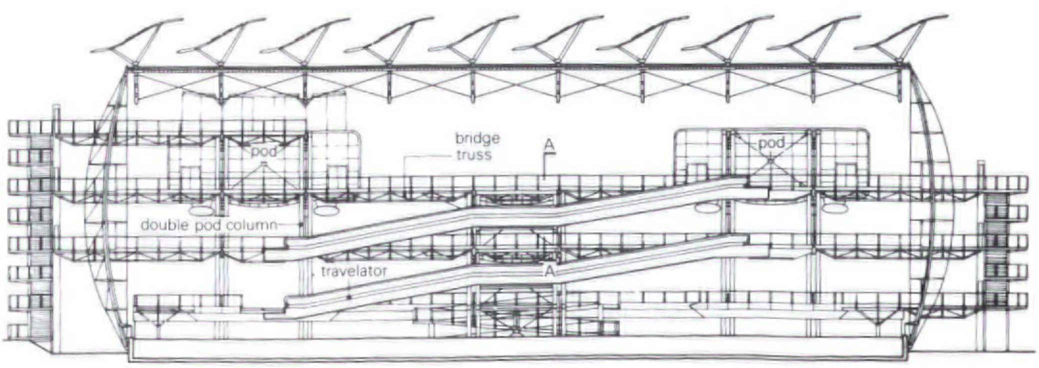
Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.

2 

2 Underside of bridge truss showing the braced cradle arms.
3 Isometric of travelator support structure. The bridge truss and travelator have been omitted for clarity.
4 Long section.
5 Section through upper bridge and travelator.



ISOMETRIC OF TRAVELATOR SUPPORT STRUCTURE 3



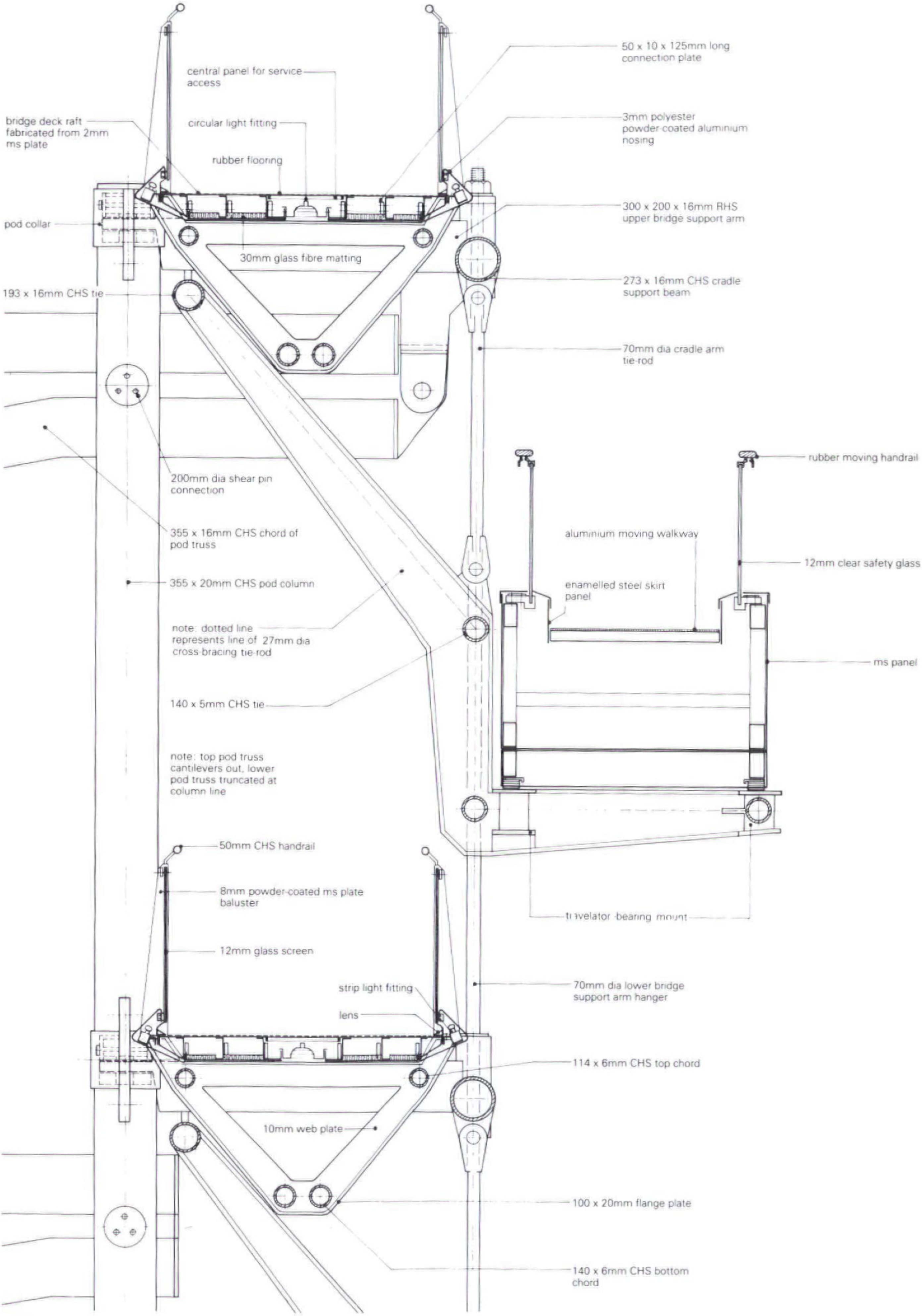
LONG SECTION 4

Acknowledgment
The editors acknowledge the assistance of John Campbell of Terry Farrell & Company and Lionel Friedland of Pentarch in the preparation of this article.

Credits
location Expo 92, Seville, Spain
client Department of Trade and Industry, HMG
architect Nicholas Grimshaw and Partners
project team Mark Fisher, Nicholas Grimshaw, Christopher Nash, Rob Watson
structural and environmental engineer Ove Arup & Partners: Ian Gardner, David Hadden, Matthew King
quantity surveyor Davis Langdon and Everest
contractor Trafalgar House Construction Management
subcontractors: steelwork Tubworkers, **M & E contractor** Rotary International, **travelators** Otis
floor modules and pressed metalwork, Environmental Technology **balustrading** Architectural Metalwork, **floor finishes** Floorcraft.

Project data
contract Management contract JCT 87
site start date June 1990
completion date April 1992

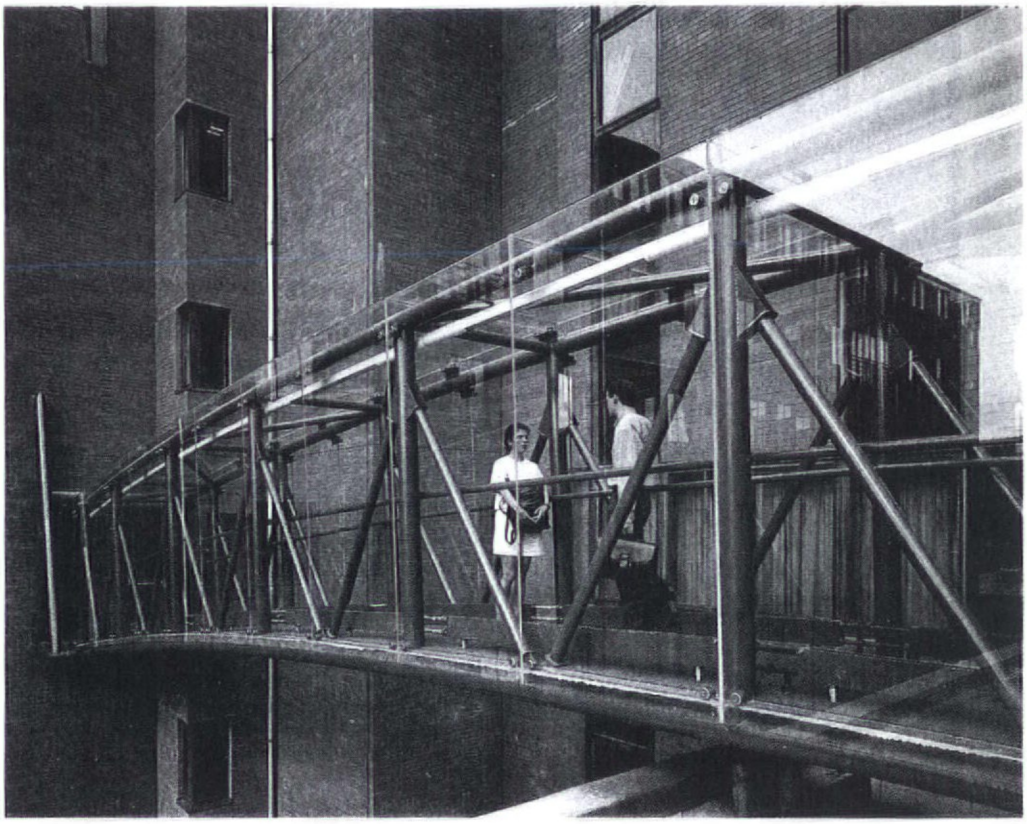
Photo credit
Photographs by John Edward Linden



SECTION A-A THROUGH BRIDGE AND TRAVELATOR

5

CI/SfB (1823)



1 The bridge spans across from the new Strathclyde Graduate Business School to the existing Sir William Duncan Building; it curves to clear the parapet of the building below.

Bridge University building

Reiach and Hall This gently curving steel and glass footbridge provides the link between two associated buildings.

In order to compete succesfully with other established business schools, Strathclyde University decided to expand its existing school, based in the Sir William Duncan Building, to house new graduate facilities.

Independently funded, the new Graduate Business School is connected to the Duncan building by a steel and glass bridge.

As a result of a lack of clarity in the planning, the entrance to the bridge is off a lobby between two escape stairs and at 90° to its direction. Its arrival in the reception of the Duncan building is, however, more dignified. The bridge spans 25m and is gently curved to clear the parapet of the existing building below. It is glazed to reduce its physical impact on the buildings nearby.

The structure has an overall square section fabricated from CHSs; the members appear chunky. It was made in one piece then cut into three for transportation.

The first section is small — just one bay. It includes the bracket piece which is tied back to the new concrete structure, via additional steelwork, in three places. This first bay, acting as an extension of the floor slab, provides a solid bearing base for the bridge proper. The other two sections were lifted into place and propped until the splice joint had been welded. No extra loads could be taken by the existing roof below.

At the Duncan side, the bottom booms of the truss are supported on sliding shoe cups. These polished connections allow thermal movement of ±25mm. Steel beams had to be added to take the extra load, but, as they were inserted in the ceiling void of the floor below, the new structure caused little disruption. Once the bridge structure was erected, concrete was poured on to the steel trays to form the floor deck. The steelwork was finished with gloss enamel paint.

The curved elevation means that the glazing panels are not square; only one template was cut, and this was handed each time. The glass is simply bolted through to the angles which are welded to the tubular frame. The joints between the glass are sealed with silicone.

The bridge is heated and permanently ventilated through slots in the perimeter floor angles. Some slots were blocked to reduce draughts in the reception area; but now, in the summer, it is unbearably hot.

Junctions with the buildings are flashed with powder-coated aluminium pressings; at the Duncan building end, these were designed to allow bridge movement.□

Sarah Jackson

Acknowledgment
The editors acknowledge the assistance of Tim Macfarlane of Dewhurst Macfarlane in the preparation of this article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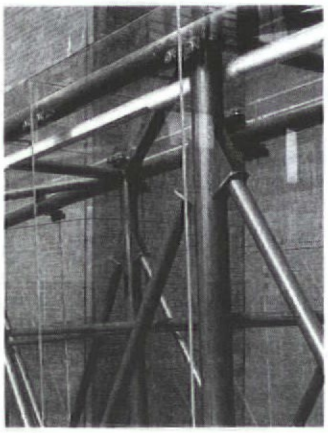
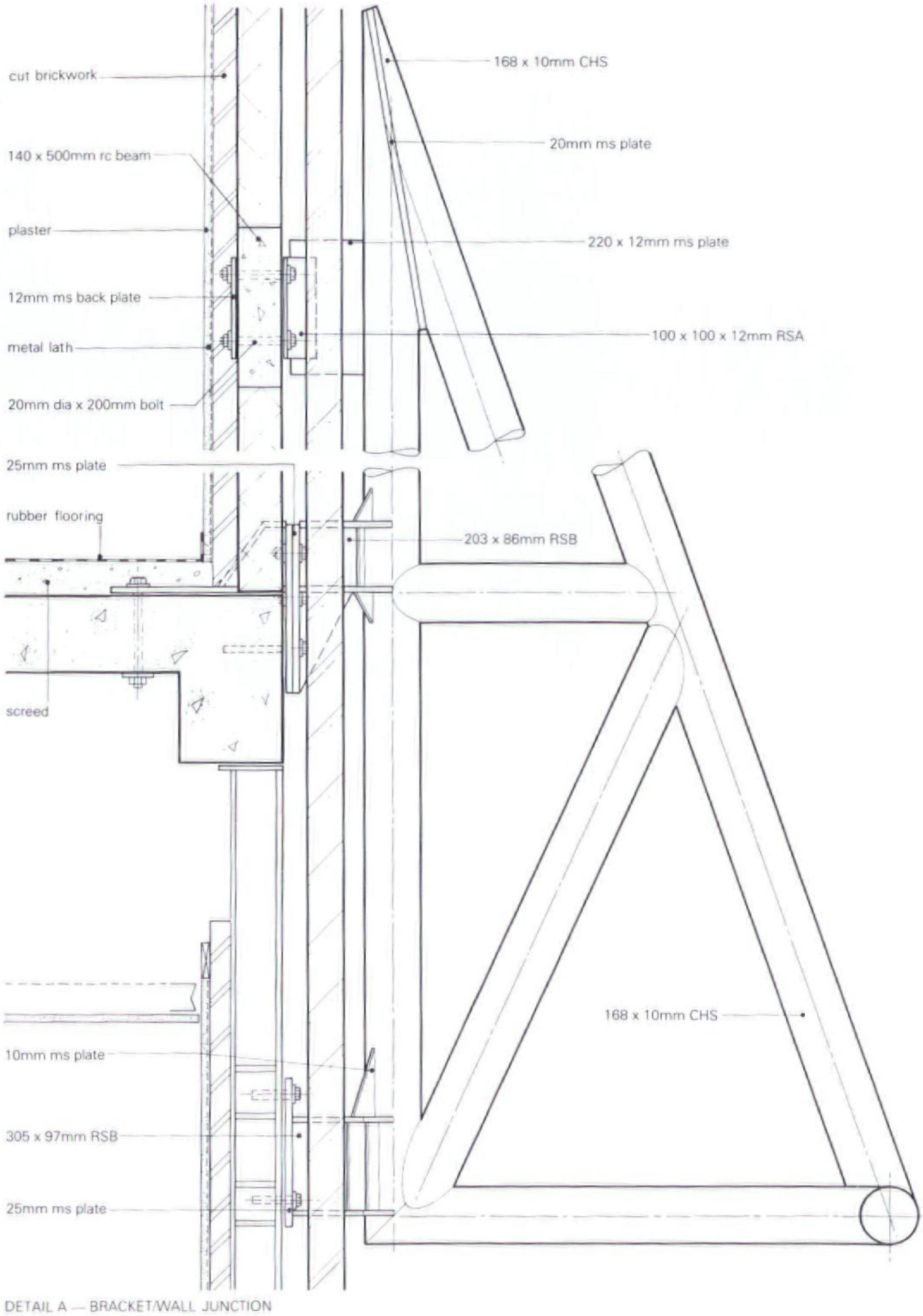

3

2 Internal view of the bridge looking towards the new building.
3 Detail of the structure and glazing fixings.
4 Detail section of the bracket to wall junction.
5 Part elevation, part section.
6 Detail section of the junction of the bridge to the old building and, top right, glass fixing details.



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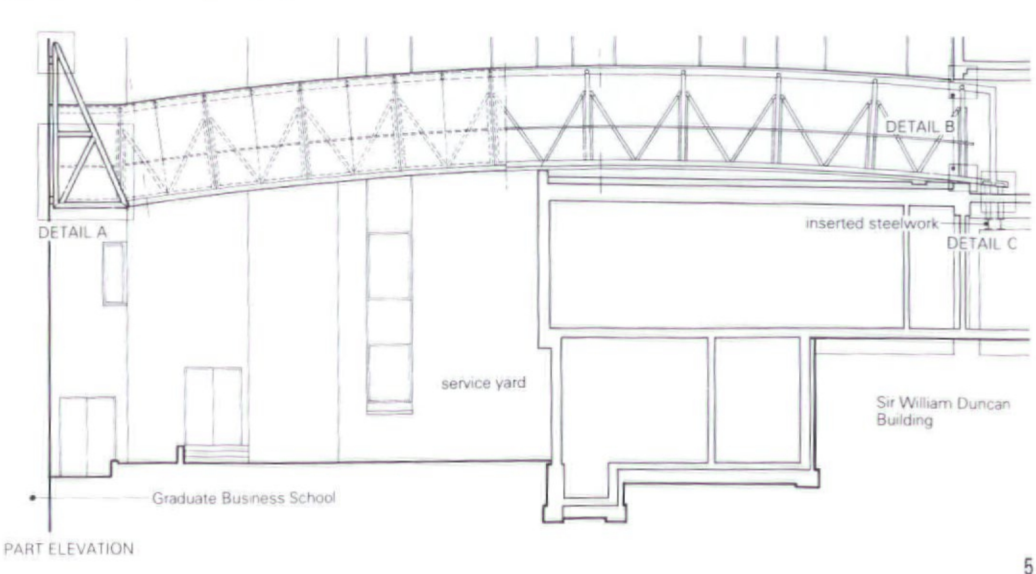

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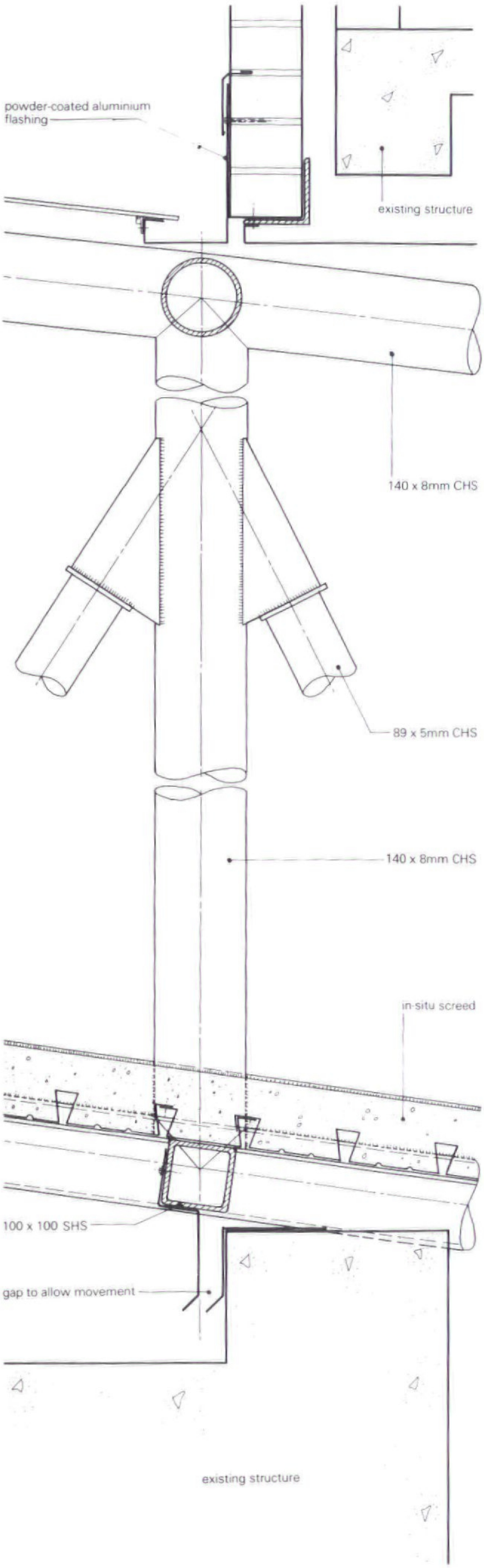
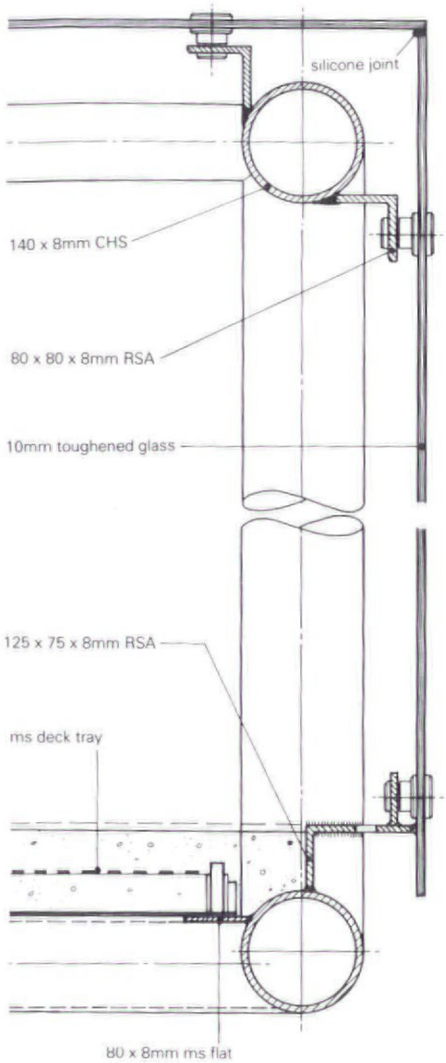
Credits
location Strathclyde Graduate Business School, Cathedral Street, Glasgow
client University of Strathclyde Graduate Business School
project manager University of Strathclyde Estates Office
architect Reiach and Hall: Bob Wallace, Bob Wilson, Shona Wood
quantity surveyor Muirheads
electrical/mechanical engineer The Ian Hunter Partnership
structural engineer Beattie Watkinson & Partners
main contractor GA Construction
subcontractors: link bridge Gray & Dick, **structural steelwork** Bone Connell & Baxter, **mechanical** How Engineering Services, **electrical** Forth Electrical Services

Project data
contract JCT 80
site start date May 1990
completion date March 1992

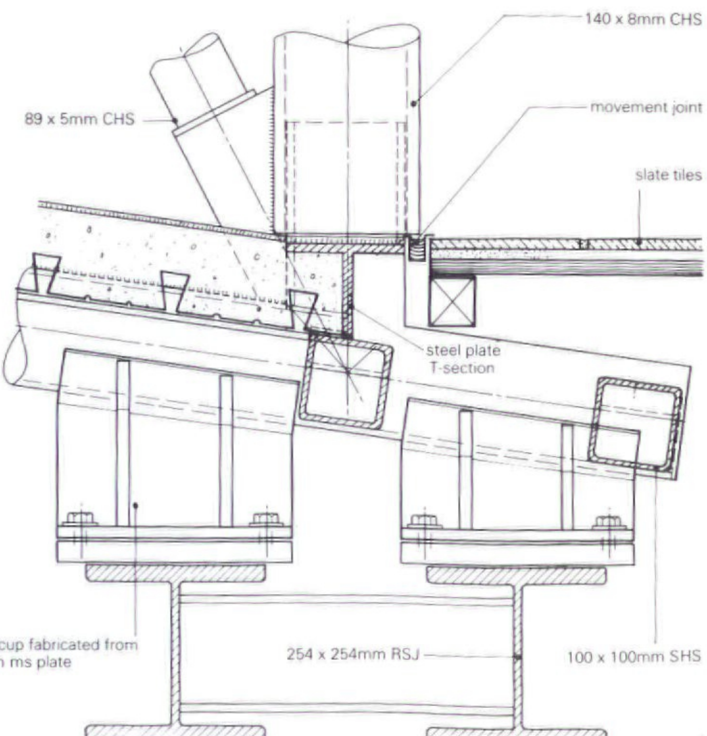
Photo credit
Photographs by Dennis Gilbert



DETAIL B — BRIDGE/WALL JUNCTION



GLASS FIXING DETAILS



DETAIL C — BRIDGE SUPPORT SHOE

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