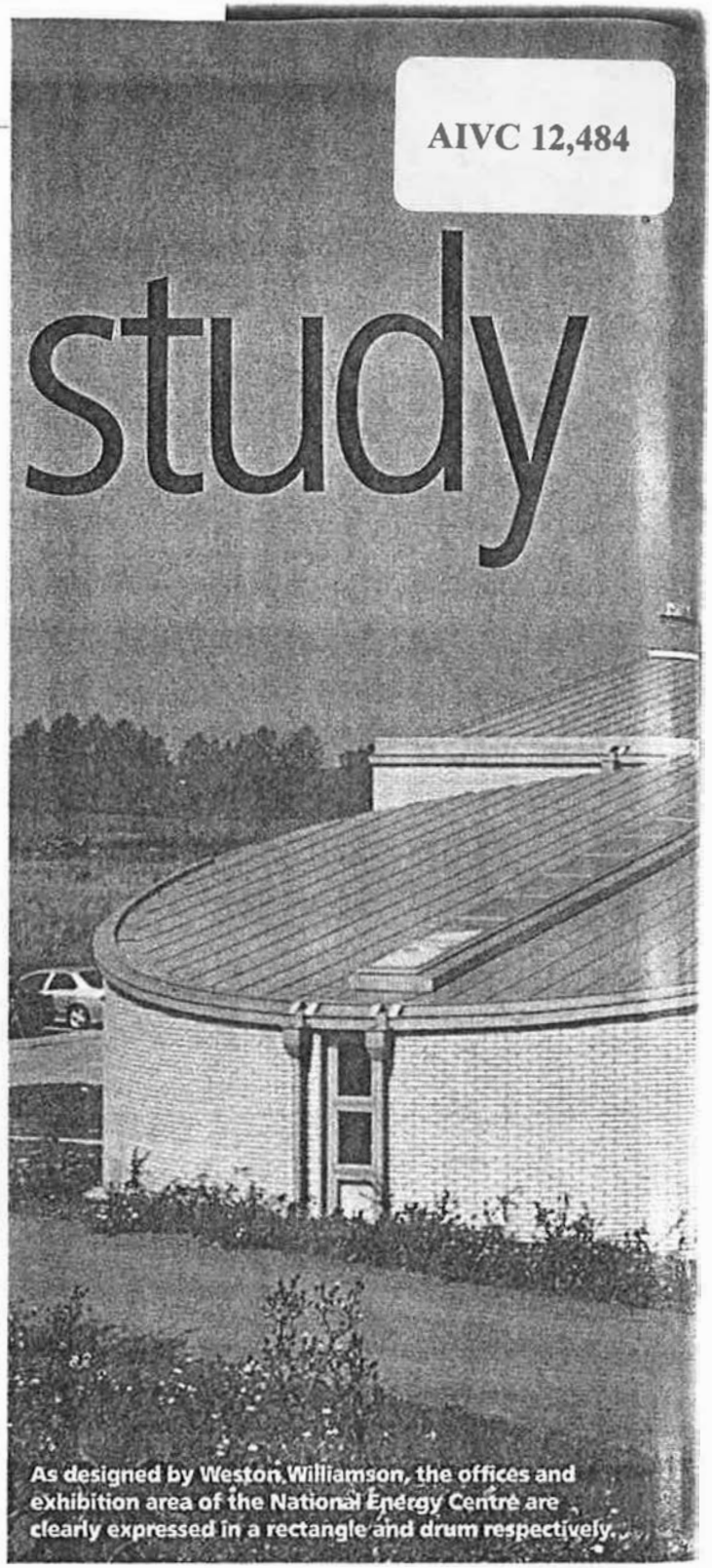
Building 17 September 1999

Cost study

Low-energy buildings usually mean high capital costs. But not the National Energy Centre in Milton Keynes; it was built for nearly £200/m² below the average unit cost for headquarters buildings.

compiled by Weston Williamson, Ove Arup & Partners, and Davis Langdon & Everest



As designed by Weston Williamson, the offices and exhibition area of the National Energy Centre are clearly expressed in a rectangle and drum respectively.

At-a-glance guide

National Energy Centre

Project
Budget price low-energy offices and exhibition space of 1000 m²

Client
National Energy Foundation

Location
Davy Avenue, Knowhill, Milton Keynes

Construction cost
£983 590 at £959/m², excluding VAT and fees.
Unit cost of £140-240/m² below HQ building average

Energy features
High insulation, natural ventilation and natural daylight

Cost and procurement constraints
Budget was halved following a change of site, which led to a radical redesign of the original scheme

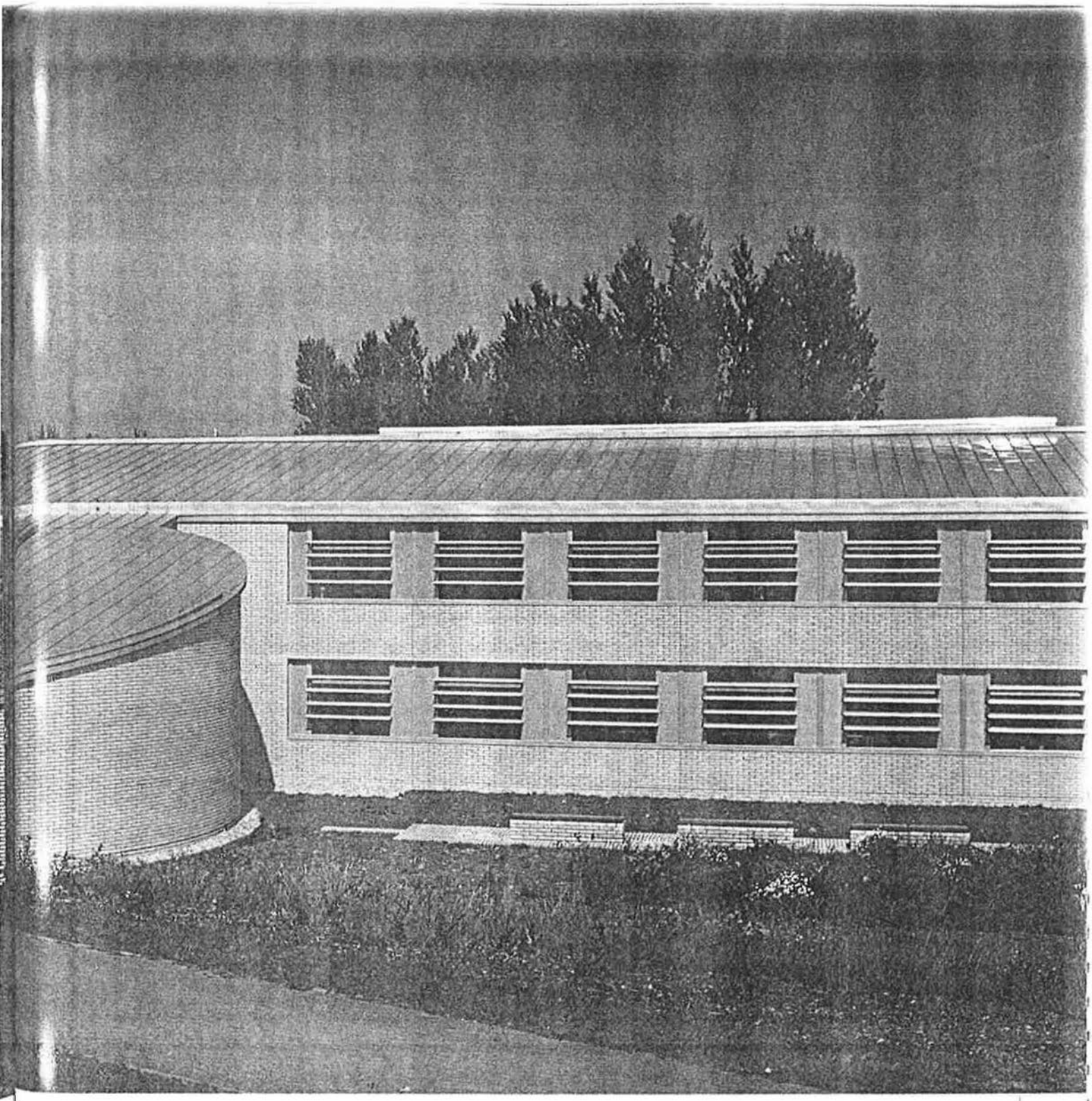
The contract
JCT80 Private Addition with Quantities.
Cost reductions were discussed and agreed with the successful tenderer before starting on site

Client's brief

The original scheme, for which architect Weston Williamson won a limited competition in 1994, was for a 2000 m² building for the National Energy Foundation. It featured a south-facing conservatory intended as a test bed for energy-saving technologies. But there were complications with the site and things went quiet for three years.

Then, in March 1997, the architect received a letter from the foundation saying that it had found another site. It said that, although the building size and budget had been cut in half, the funding was in place. It held another limited competition, which Weston Williamson again won.

The new brief was for 1000 m² of mainly office space with an exhibition and seminar area. The building had to act as a visitor centre for individuals and groups wanting to discover more about energy issues. Exhibitions in the building were to continue into landscaped areas. The building was required to achieve a "very good" rating on the Building Research Establishment Energy Assessment Method scale.



RONEN NUMA

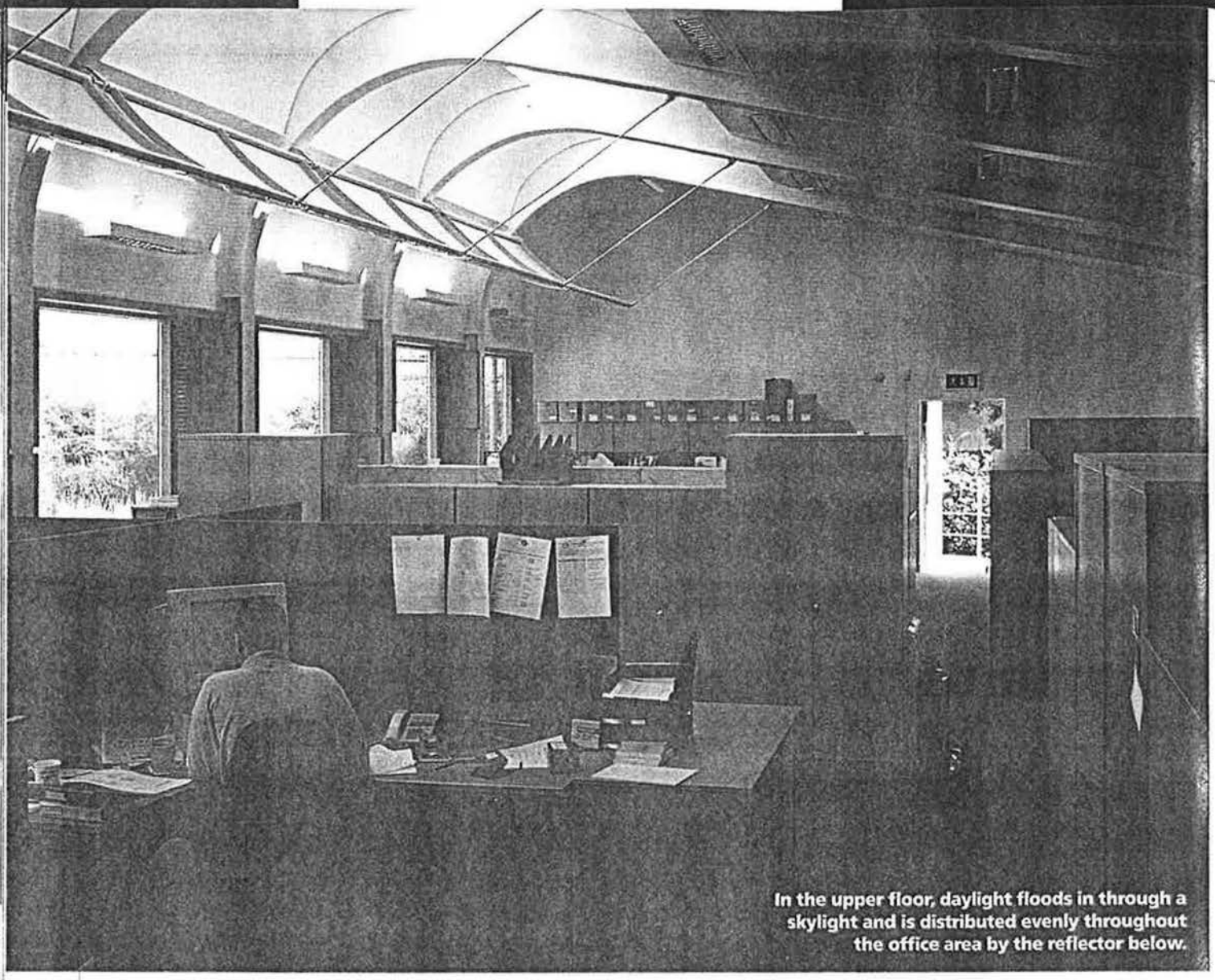
Design

A redesign was needed for the new site and budget. It was no longer economically viable to have such a large expanse of glass on the south facade, as the hoped-for sponsorship from manufacturers evaporated. The revised design does, however, retain the facility for solar cells to be incorporated later.

The emphasis is on efficient planning, with a simple plan and cross-section. One of the first decisions was to express in architectural form the two parts of the building: the offices and the exhibition and seminar space. The offices are contained in a long rectangular block, with the exhibition and seminar area in a circular building facing the entrance. Exhibitions will extend outside and the outside area includes a timber crop that will supply a wood-burning boiler in the future.

Development team

client **National Energy Foundation** architect **Weston Williamson** project manager and fit-out designer **Avebury Project Services**
structural engineer and energy consultant **Ove Arup & Partners** quantity surveyor **Davis Langdon & Everest**
planning supervisor **Gardiner & Theobald** design-and-build contractor **Llewellyn Construction**



In the upper floor, daylight floods in through a skylight and is distributed evenly throughout the office area by the reflector below.

Low-energy features

To achieve a low-energy design, it was necessary to invest in long-life, "passive" building fabric components, rather than short-life "active" mechanical systems. Active mechanical equipment tends to be manufactured using large amounts of energy and other finite resources, and needs replacing more frequently.

The design solution provides a long-life, loose-fit envelope, structure and services, within which frequent fit-out changes can occur. The design thinking also went as far as "future-proofing" the building, by designing its orientation, roof slope and roof-fixing points to accommodate solar energy collectors at a later stage.

The centre is designed around full passive cooling, natural ventilation, low heating needs and user control.

Cooling is provided by exposed internal surfaces with high thermal capacity. This is the most effective use of passive cooling because it allows the thermal mass to absorb the maximum of both radiated and convective heat.

The slatted facade vents allow natural ventilation to cool the exposed surfaces at night, thus removing the excess heat ready for the following day.

Solar gain is reduced by various means. The glazed south facade is shaded externally with tailor-made horizontal metal louvres, and internally with glare control blinds. Facade vents can be opened at night and closed during the hottest part of the day, achieving a peak internal temperature some 3°C below the external temperature.

An exposed concrete ceiling with high thermal capacity was installed on the ground floor. On the top floor, thermal capacity was provided by two layers of cement-based drylining, spanning a lightweight steel frame. This is protected from the sun's heat by extensive roof insulation.

A simple, almost domestic-style single boiler was all that was needed to heat the building, given the high levels of thermal insulation. The boiler is one of the new generation of "fit and forget" high-efficiency condensing types for wall mounting. It comes with integral variable speed pump and controls, so no other central plant was needed. This package offered the lowest overall capital cost, reduced energy use and low maintenance.

Daylighting has been maximised, as artificial lighting is a major energy consumer in offices. High levels of glare-free daylighting are achieved from light being reflected off internal light shelves on the south wall. Generous north facade windows and light-coloured room surfaces also help maximise daylighting.

The artificial lighting relies on high-frequency luminaires with modest illumination levels and task lighting on desks.

Occupants are given direct control over their immediate environment, to increase comfort. Features include manually operated shutters for natural ventilation, thermostatic radiator valves, manual light switches and glare blinds.

Features that were omitted to meet the stringent budget included luminaire daylight controls, more local switches, testing for envelope airtightness and a laminated timber roof structure.

Key technical data

Roof U-value	0.13 W/m²°C
Walls U-value	0.26 W/m²°C
Window U-value (mid-pane)	1.9 W/m²°C
Heating demand	less than 50 W/m² of floor area
Lighting energy use	less than 10 W/m²
Target carbon dioxide emission	40 kg/m²/year

Cost commentary

The 1000 m² building is predominantly open plan, with only the amenity areas compartmentalised. At £959/m², it represents good value for money for a headquarters.

Headquarters buildings are typically 10 000 m² and cost between £650/m² and £950/m², according to the Building Cost Information Service. The average is £800/m². However, DLEtE's experience is that they vary from £800 to £1650/m², with the average being £1100-1200/m². Tenants' fit-out costs can add £100-500/m² to lettable area costs, depending on existing provision and tenants' requirements.

The foundation wanted its building to use non-toxic, high-quality materials and to have high insulation values in order to cut energy consumption. It also wanted it to have the potential to use solar power and renewable energy resources.

During the design stage, once initial tenders had been received, every effort was made to achieve the least expensive life-cycle solution without compromising the foundation's energy and environmental objectives. A number of potential funding sources could not be finalised in time for construction, so some features had to be omitted. The reduced floor area meant that the southern, sloping, glazed elevation, which formed a full-height "conservatory" circulation space, was dismissed as being economically unviable. Photovoltaic cells and a wood-burning boiler were also left out. However, the design does have facilities to accommodate these features if extra financial support is secured.

Other savings included:

* Cheaper foundations. Formwork to the sides of ground beams and bases was dispensed with and the backfilling material was respecified
* A steel monopitch frame and roof structure was installed instead of laminated timber. Although there were no significant cost differences between the two, improved buildability reduced the overall construction period by three weeks and cut preliminary costs
* Microporous-painted Scandinavian softwood windows were used instead of powder-coated aluminium ones.

Further savings were achieved by changing the specification of the floor finishes, internal light shelves and blinds, light fittings, radiators, water heaters and lighting control system.

The preliminaries, at 13.45% of total cost, are slightly higher than might be expected for a building of this type. This was partly because poor ground conditions meant that greater site supervision was needed for the detailed foundation construction. The high quality of concrete finish and the attention to detail needed with the insulation also pushed up the cost of preliminaries.

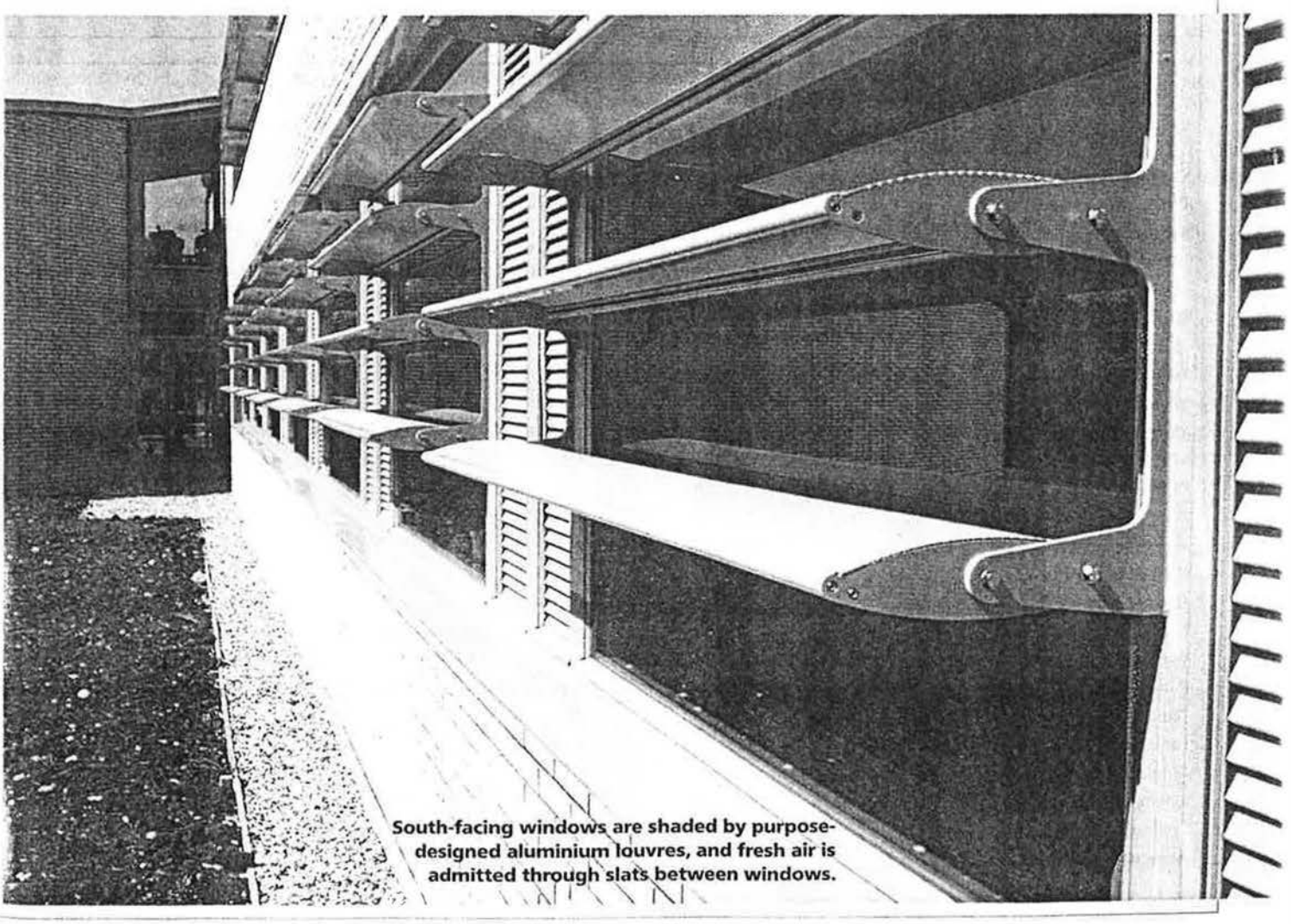
Services installation, at £160/m², is particularly low. This is mainly due to the absence of mechanical air-conditioning and ventilation (except in the WCs). The building has been designed to be naturally ventilated.

Special natural ventilation features include:

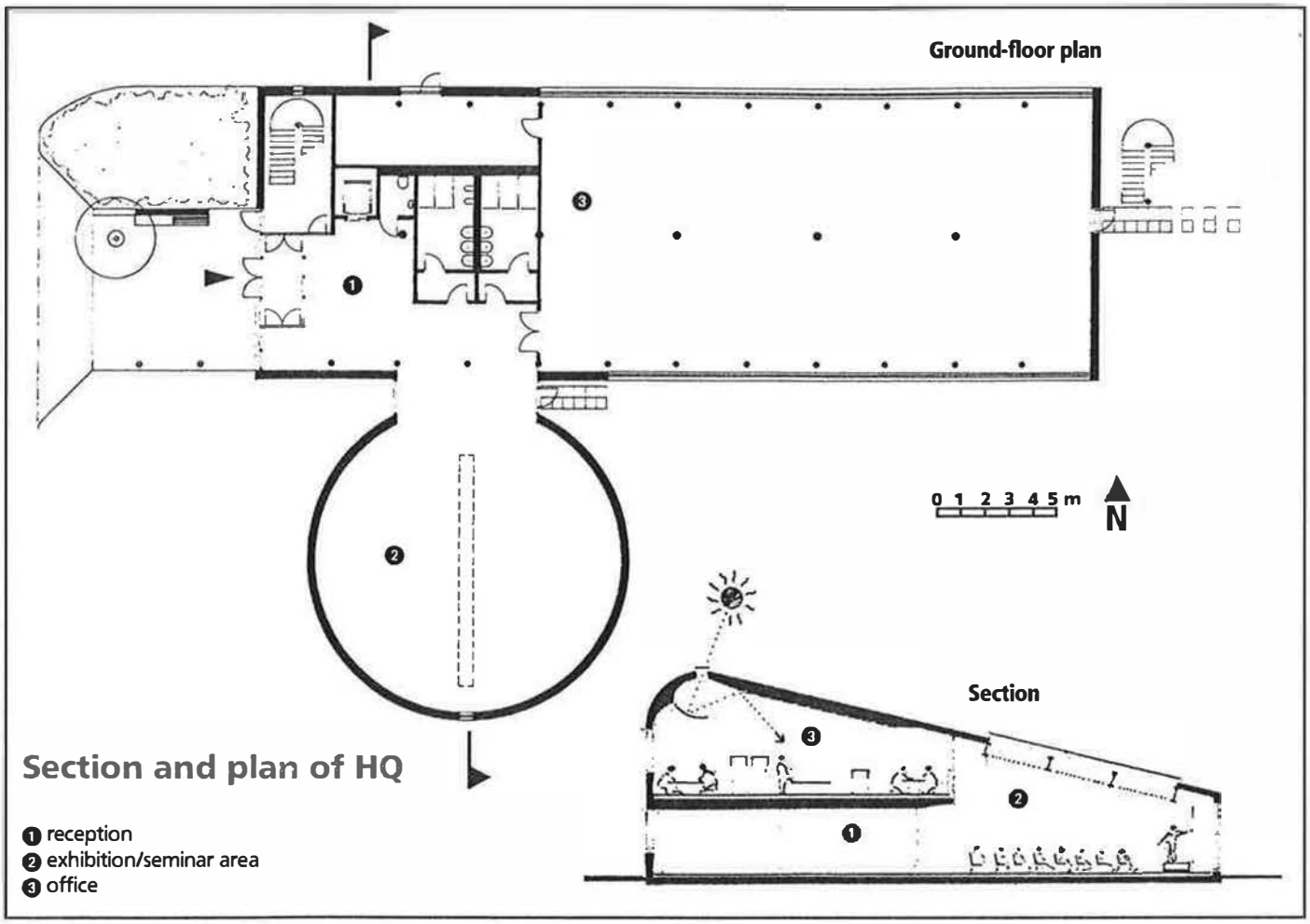
* External powder-coated curved sun louvres @ £250/m²
* Internal powder-coated light shelves @ £315/m
* Two layers of Cape Pyroc fibre-cement boards to ceilings @ £32/m².

External works costs were quite high, as the overall site area is 5437 m² – nine times the building footprint.

The contract was let as a competitive tender, with post-tender negotiations held with the lowest bidder to achieve the target price. The contract was completed in 43 weeks. The cost analysis, which is based on the final account, is within 5% of the negotiated contract sum.



South-facing windows are shaded by purpose-designed aluminium louvres, and fresh air is admitted through slats between windows.



Section and plan of HQ

1 reception
2 exhibition/seminar area
3 office

Elemental cost analysis

	Total cost of element (£)	% of total cost	Cost/m² of 1026 m² gross floor area	Quantity	Unit cost of element (£)
Preliminaries	132 330	13.45	128.98	–	–
Substructure	116 530	11.85	113.58	595 m²	195.85/m²
Frame	62 460	6.35	60.88	1 026 m²	60.88/m²
Upper floors	47 400	4.82	46.20	431 m²	109.98/m²
Roof	87 100	8.86	84.89	748 m²	116.44/m²
Stairs	9 450	0.96	9.21	2 nr	4 725.00
External walls	41 530	4.22	40.48	557 m²	74.56/m²
Windows and external doors	59 600	6.06	58.09	235 m²	227.96/m²
Internal walls and partitions	24 760	2.52	24.13	497 m²	49.82/m²
Internal doors	9 640	0.98	9.40	21 nr	459.05
Wall finishes	13 470	1.37	13.13	1285 m²	10.48 m²
Floor finishes	41 060	4.17	40.02	1014 m²	40.49/m²
Ceiling finishes	42 070	4.28	41.00	1073 m²	39.21/m²
Fixtures and fittings	16 190	1.65	15.78	–	–
Sanitary appliances	13 860	1.41	13.51	–	–
Disposal installation	1 170	0.12	1.14	–	–
Water installation and heat source	51 090	5.19	49.80	–	–
Electrical installation	80 130	8.15	78.10	–	–
Gas installation	5 000	0.51	4.87	–	–
Lift installation	12 940	1.32	12.61	–	–
Builder's work	4 300	0.44	4.19	–	–
External works	78 610	7.99	76.62	–	–
Drainage	32 900	3.34	32.07	–	–
Amount of final account	**983 590**	**100.00**	**958.66**	–	–

The drum-shaped exhibition area is lit by a central rooflight. The ceiling of dense fibre-cement boards helps absorb fluctuating temperatures.

Specification

Substructure
250 mm reinforced concrete suspended slab with perimeter beam; 33 400 × 400 mm reinforced concrete columns; strip foundations and isolated bases averaging 2.5 m deep; granular material backfill; 100 mm thick Floormate insulation.

Frame
40 reinforced insitu concrete columns with fine, fair finish formwork generally: 22 with diameter of 250 mm, five with diameter of 300 mm, nine with area of 200 × 500 mm, four with area of 540 × 600 mm; 150 mm thick reinforced insitu concrete lift shaft.

Upper floors
300 mm thick reinforced concrete suspended slab with fair, fine finish formwork.

Roof
Rheinzinc 0.7 mm thick long-strip roofing with pre-weathered standing-seam joints at 500 mm centres on 25 × 125 mm treated softwood boarding on 50 × 75 mm treated softwood noggins with 300 mm thick Rockwool insulation and breather membrane.

Stairs
One two-flight painted-steel 4.63 m high internal staircase with half-space landing including handrails and balustrades; one 4.63 m high two-flight galvanised steel external staircase with half-space landing including handrails and balustrades.

External walls
Ibstock Cattybrook Cheddar Gold metric facing bricks; 90 mm thick thermal blockwork inner leaf; 200 mm wide cavity, with 160 mm thick Rockwool High Performance Batts.

Windows and external doors
Rationel Scandinavian softwood double-glazed windows and doors with low-emissivity glass and 14-18 mm cavity, depending on window size; 600 mm wide McKenzie Martin Ventura double-glazed non-vented powder-coated framed continuous rooflight.

Internal walls and partitions
140 mm thick blockwork (41.5 m²); Rationel Scandinavian softwood double-glazed screens and doors (44 m²), Thrislington WC cubicles and duct panel system.

Internal doors
30 mm thick hardwood veneered solid-core flush doors in painted softwood linings.

Wall finishes
13 mm thick Hardwall plaster with three coats emulsion paint (1244 m²); glazed ceramic wall tiling in toilets (41 m²).

Floor finishes
Quiligotti raised-access flooring (868 m²); Burmatex Cordiale carpet tiles (494 m²); Rawson Rivera carpet tiles (366 m²); Altro Safety flooring (11.5 m²); Jaymart PVC backed coir matting (7 m²); painted screed in plant room (32 m²).

Ceiling finishes
Two 40 mm thick Cape Pyroc fibre cement boards to sloping areas (389 m² @ £32.05/m²); six Gypsum Glasroc to curved areas (165 m² @ £22.14/m²); 12.5 mm plasterboard and skim (101 m²); Gyproc M/F suspended ceilings in toilets (63 m²); painted concrete (355 m²).

Fixtures and fittings
Perforated powder-coated steel curved internal sun blinds (40 m² @ £250/m²); perforated powder-coated steel 900 mm wide light shelves (28 m @ £31.5/m).

Sanitary appliances
Armitage Shanks WCs, twin urinal sets with Barflo water-saver units, sinks, basins and disabled packs, stainless steel toilet roll holders, soap and towel dispensers, handrails and electric hand dryers.

Disposal installation
100 × 200 mm zinc gutters with 100 and 150 mm diameter down pipes, PVCu soil and waste pipes internally.

Water installation and heat source
Low-pressure hot-water heated by combination boiler; wall-mounted radiators with thermostatic valves and floor trench finned tube convectors in the seminar area; one electric Diffusion overdoor heater, two Solectra water heaters; low-speed extract fan ventilation to toilets.

Electrical installation
Low-voltage switchgear and distribution board, lighting with Erco fittings, emergency lighting, fire-alarm system with type M notifier, power supply in underfloor ducts, PVCu-covered copper-tape lightning protection.

Lift installation
One eight-person/630 kg disabled model hydraulic lift by Schindler serving two floors.

External works
65 mm thick Charcon Europa concrete blocks to road and car park area (938 m²); Ibstock Cattybrook Cheddar Gold brick paving (103 m²); Iroko slatted seats, zinc-covered plywood seats and copings on brick walls; grading levels, shrub planting, grass seeding.

Drainage
100, 150 and 225 mm diameter vitrified clay drain pipes in trenches averaging 1500 mm deep (286 m), seven precast concrete manholes, one petrol interceptor.