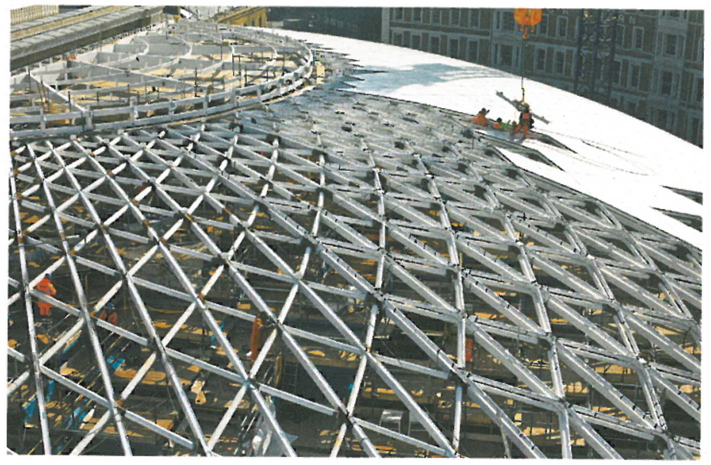
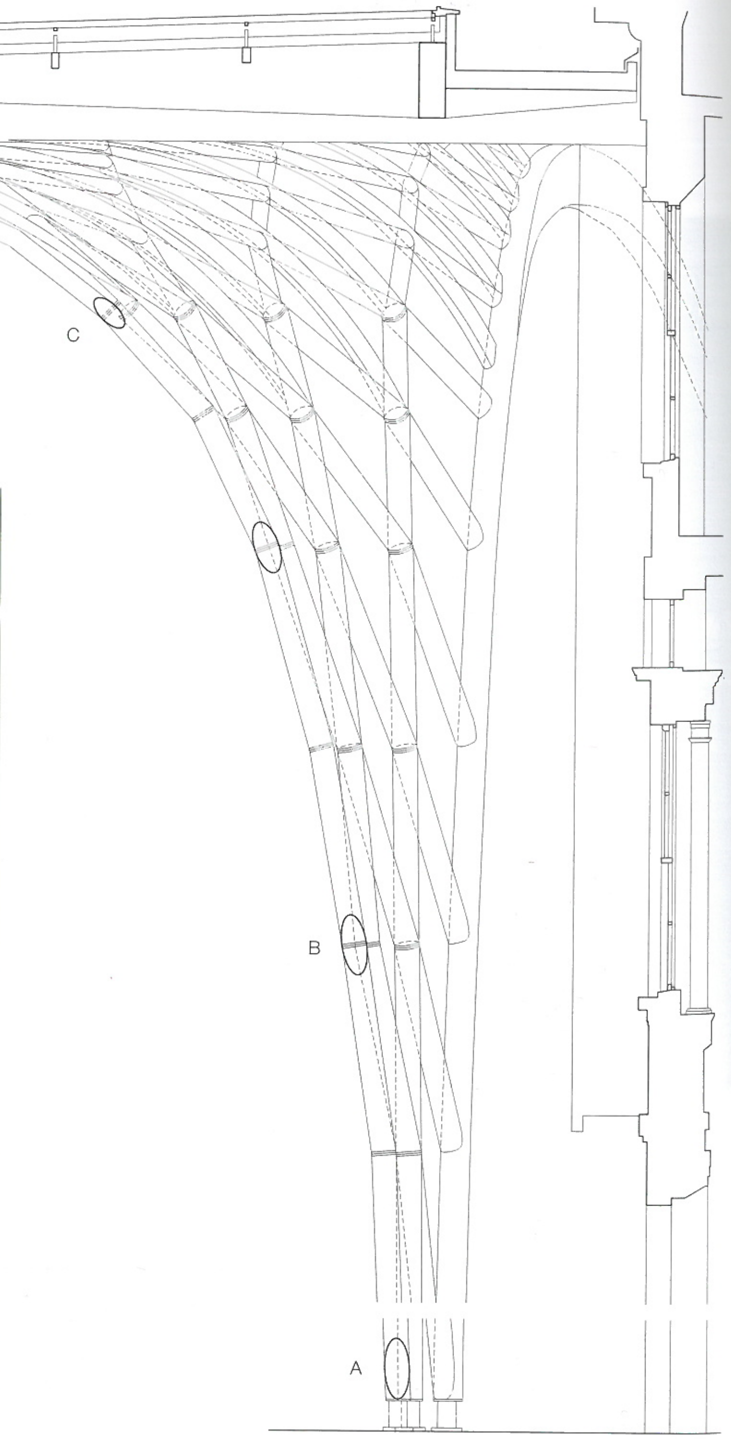
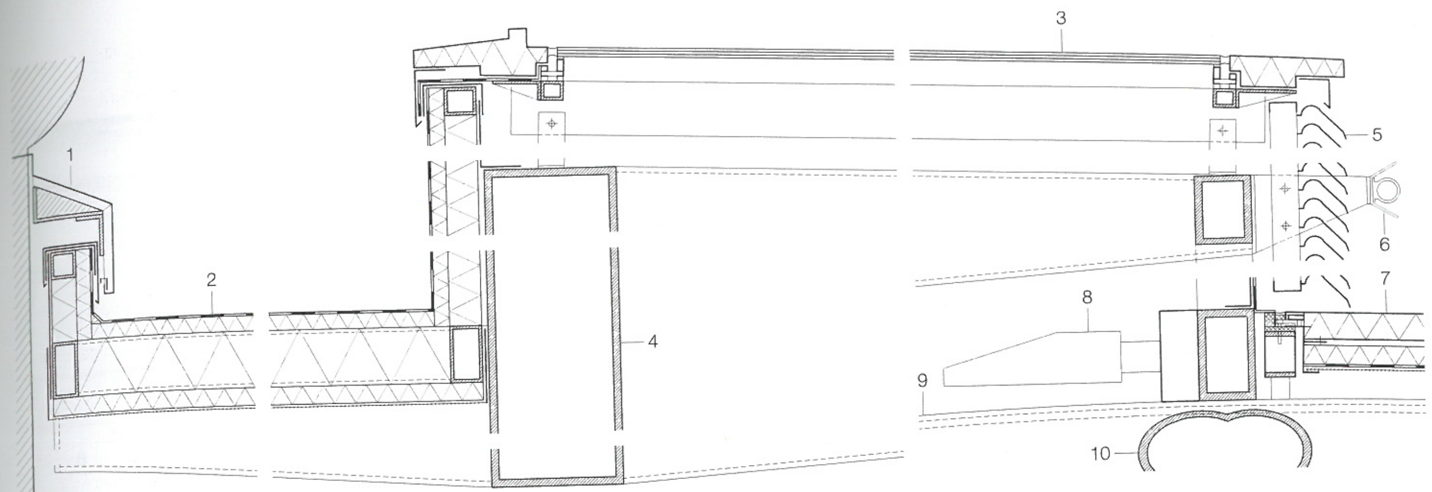
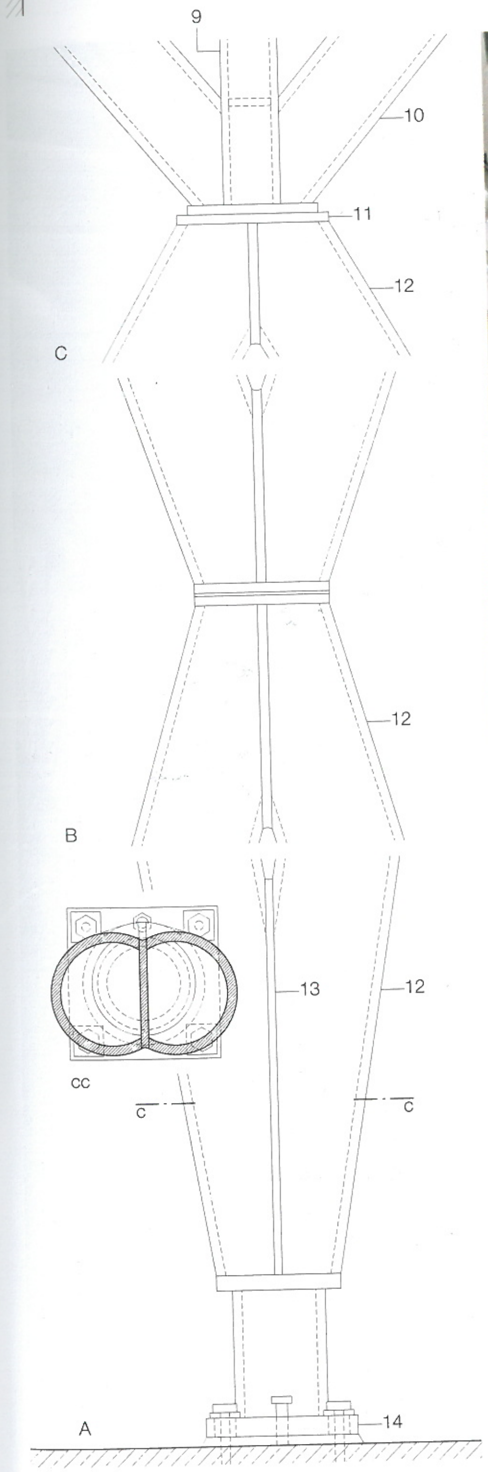


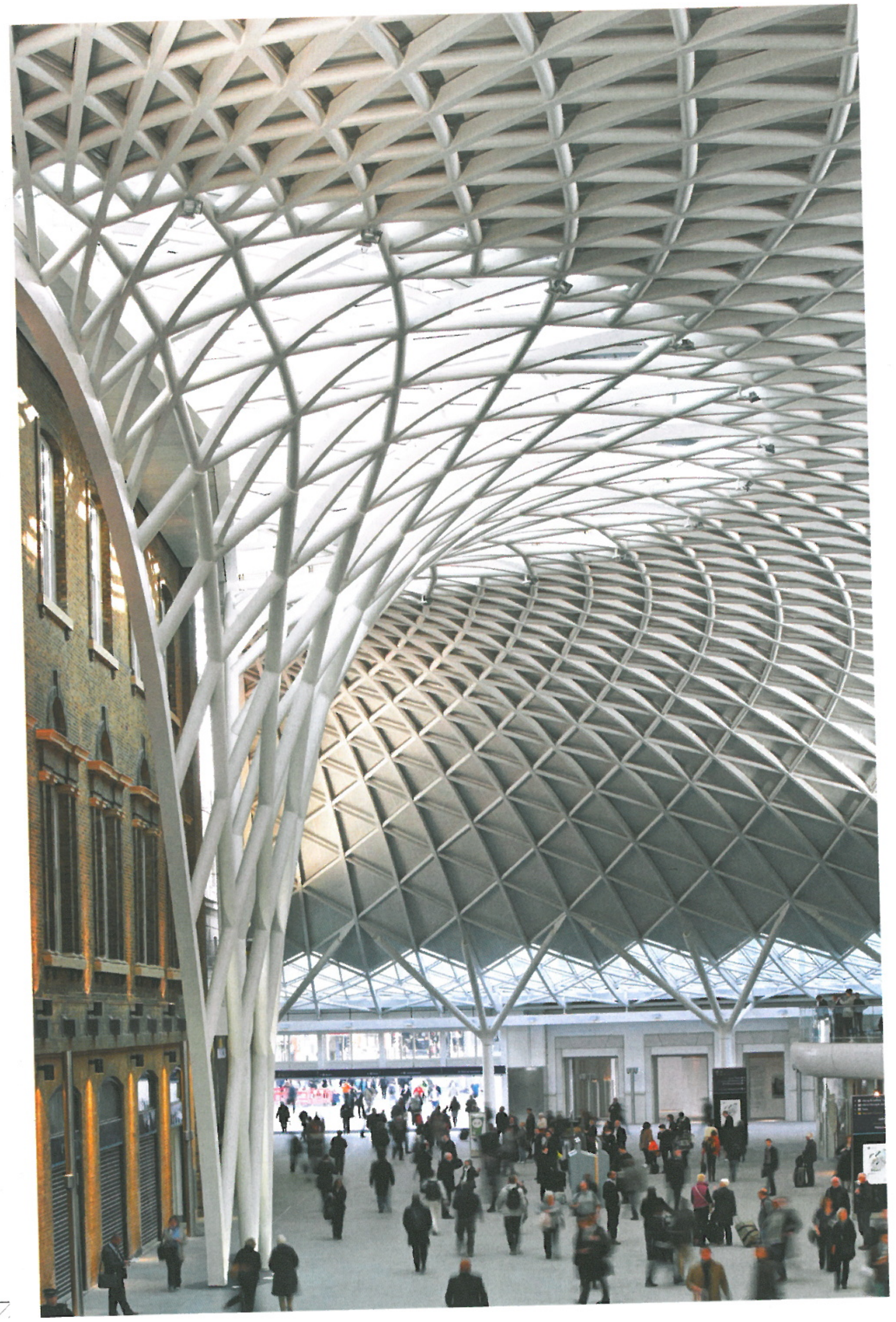
Vertical section
scale 1:100
Section through facade
Load-bearing structure
scale 1:20

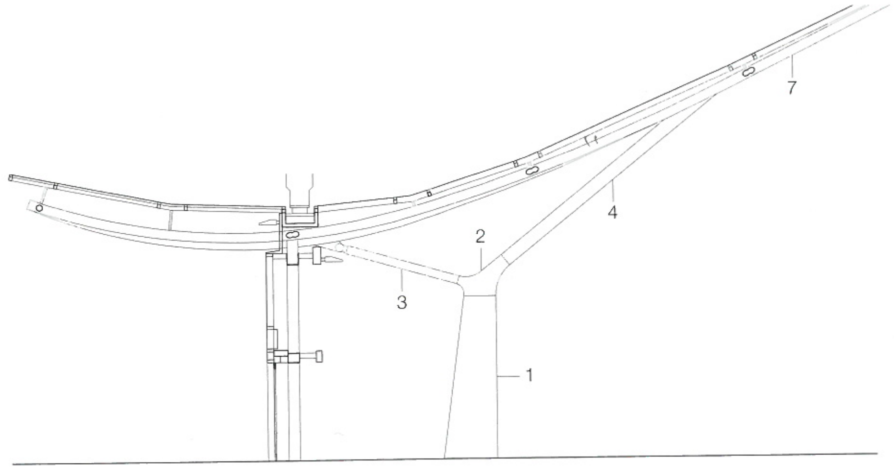
1 2 mm sheet-aluminium flashing to existing building
2 bituminous sheet sealing layer
20 mm EPS insulation, compression resistant
160 mm mineral-wool insulation between 80/120/5 mm steel RHS supporting structure
50 mm mineral-wool insulation
2 mm perforated sheet aluminium cladding
3 13.5 mm laminated safety glass roof light
4 250/800/20 mm galvanized steel RHS, painted
5 stainless-steel ventilation grille
6 fall prevention rail
7 opaque roof element:
2.5 mm anodized-aluminium sheeting
70 mm mineral wool
3 mm galvanized steel sheeting
50 mm mineral wool
vapour barrier
2 mm perforated aluminium sheeting
8 light fitting
9 150/250/20 mm welded steel box beam
10 Ø 244/25 mm galvanized diagonal steel tube, painted
11 25 mm steel plate
12 Ø 323/25 mm steel tube
13 20 mm steel plate
14 400/400/50 mm steel plate

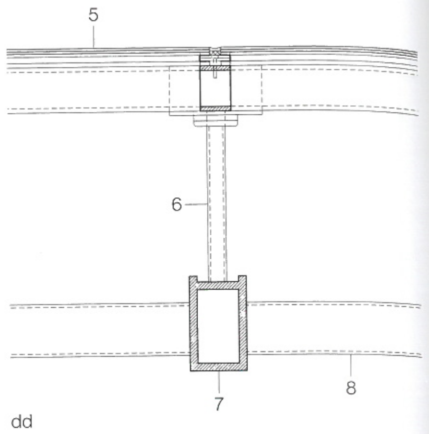


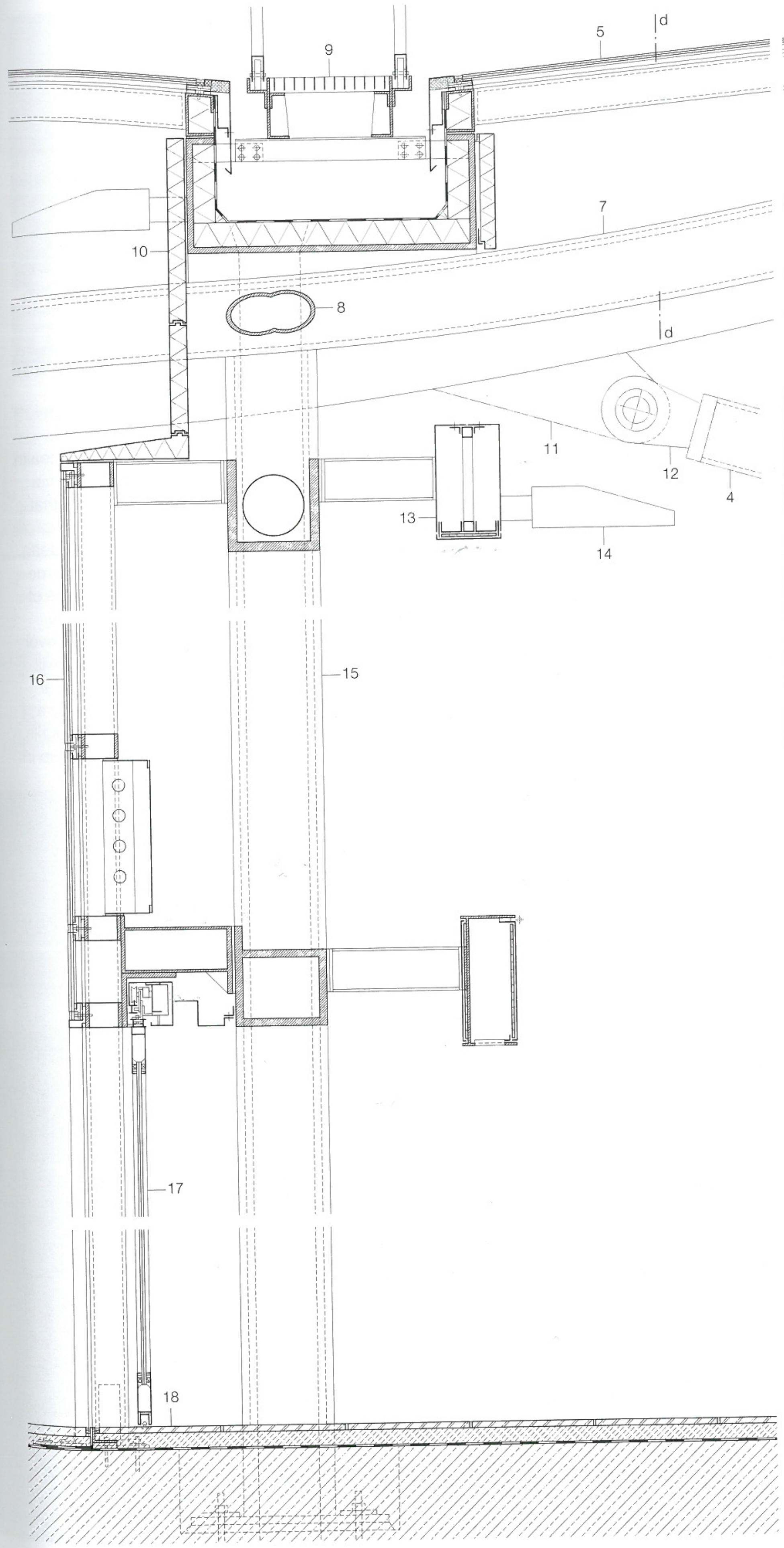










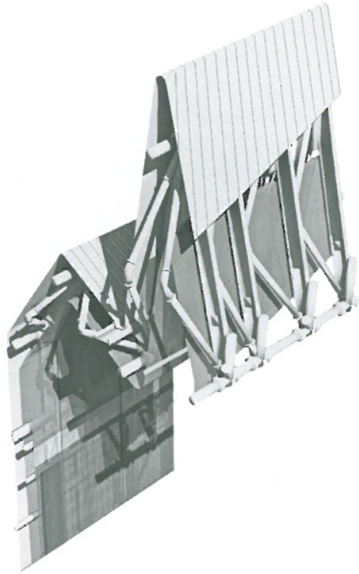


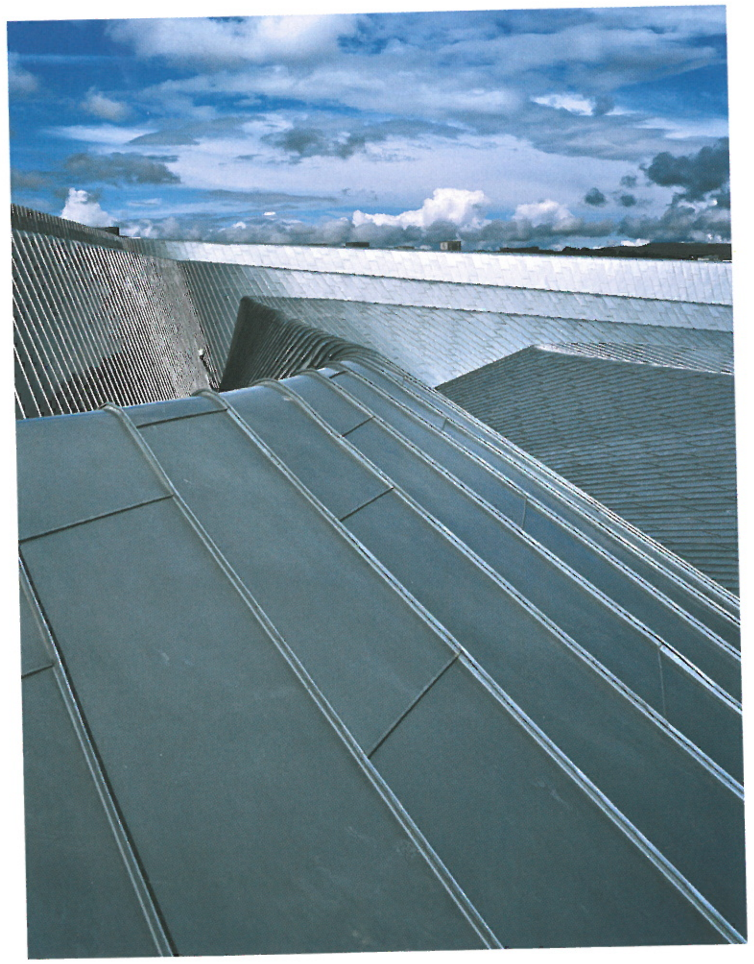
Vertical section
scale 1:200
Sections through facade
scale 1:20

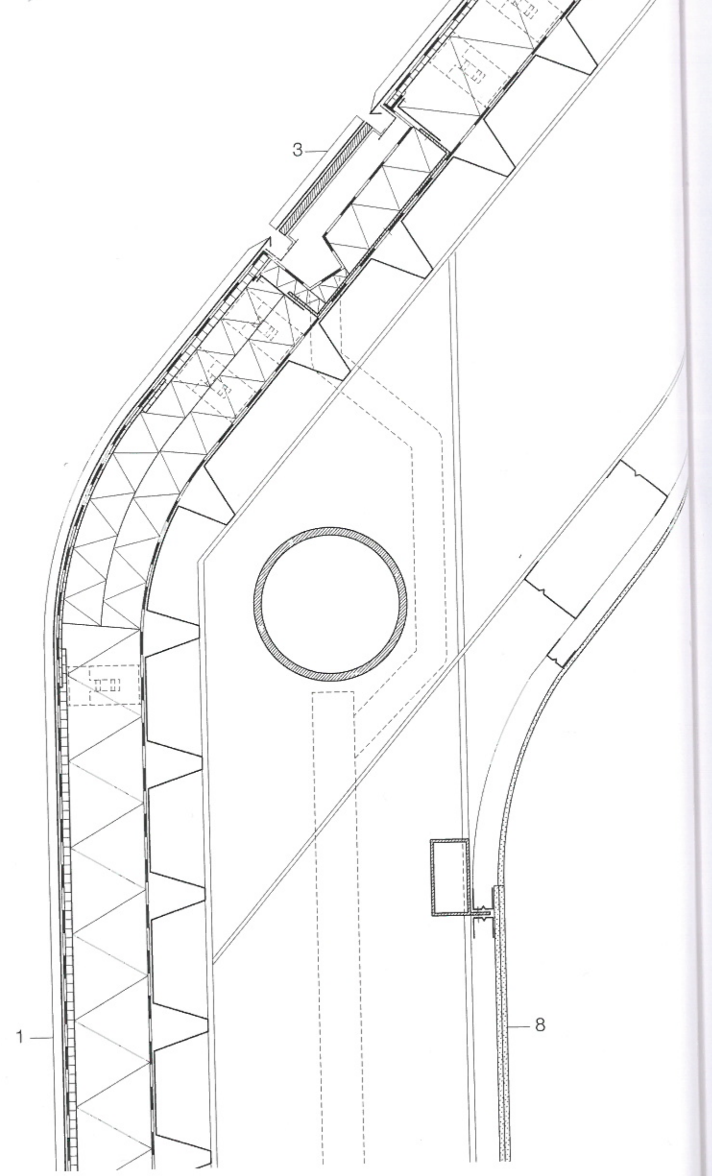
1 galvanized welded steel pier, painted:
2× ∅ 355/36 mm steel tubes;
40 mm and 30 mm steel plates;
6 mm sheet-steel cladding
2 cast-steel node to pier
3 ∅ 219/16 mm steel tube
4 ∅ 355/16 mm steel tube
5 translucent roof element:
13.5 mm laminated safety glass on
120/80/4 mm aluminium RHS
6 ∅ 48/5 mm tubular steel
distance piece
7 250/150/20 mm welded steel
box beam
8 ∅ 139/8 mm diagonal steel tube
9 maintenance walkway:
steel grating
10 60 mm insulated aluminium panel
11 50 mm steel fin
12 2× 25 mm steel plates
13 cable duct
14 light fitting
15 300/300/25 mm steel SHS column
16 13.5 mm laminated
safety glass adhesive fixed to
post-and-rail facade, consisting of
120/80/5 mm aluminium RHSs
17 sliding door:
15.5 mm laminated
safety glass in
aluminium frame
18 20 mm granite flooring
50 mm screed
polythene sheeting
300 mm reinforced concrete

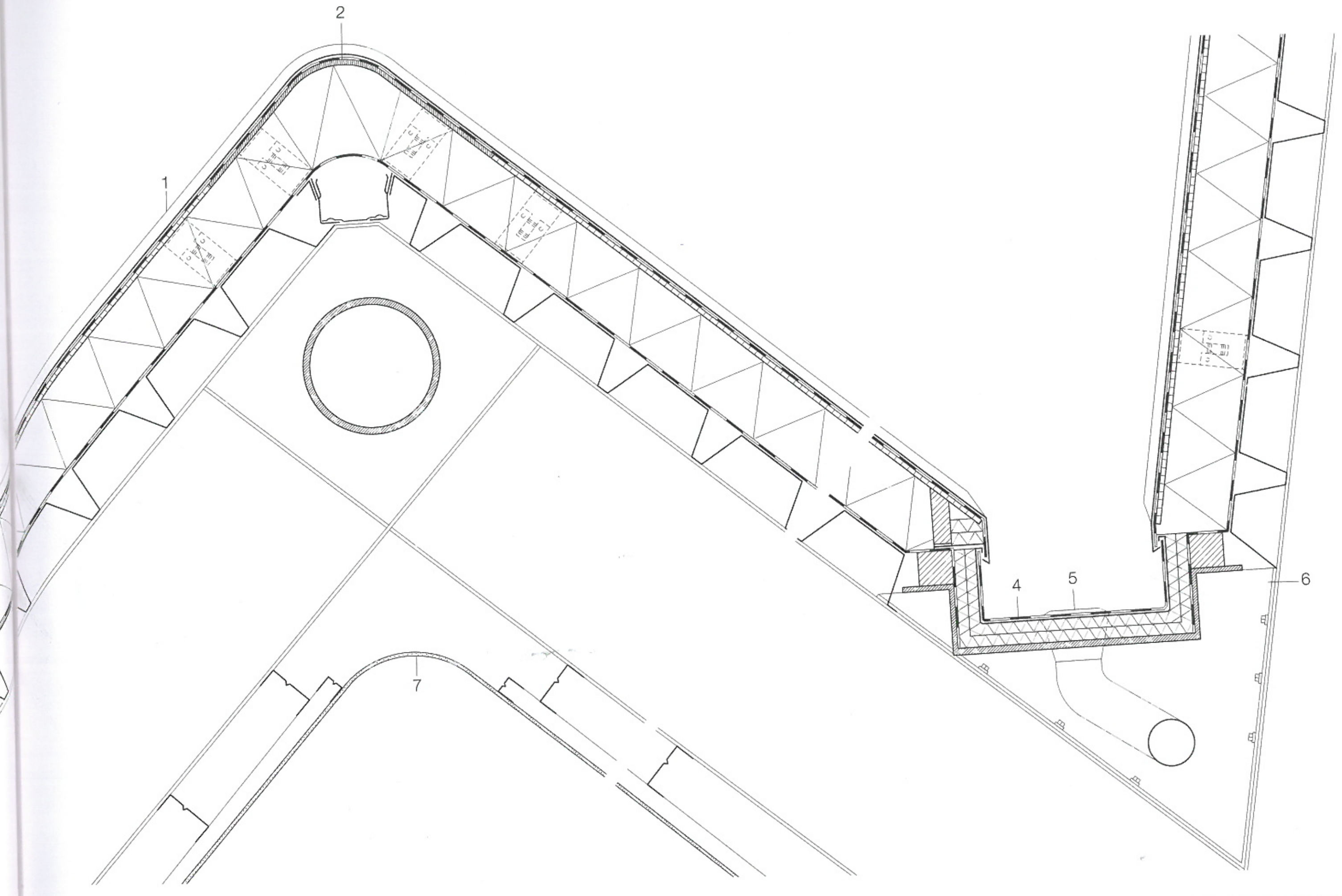
Section
scale 1:20

1 roof/wall construction:
0.8 mm sheet zinc with
25 mm standing seams
polythene separating layer
18 mm plywood
200 mm non-combustible
mineral wool
vapour barrier
trapezoidal-section metal sheeting
140 mm deep on
steel structure
2 18 mm galvanized sheet-steel
bent to shape at ridge
3 340 mm removable element
over eaves drainage:
0.8 mm sheet zinc
with 25 mm standing seams
20 mm galvanized sheet steel
20 mm aluminium section
bent to shape, fixed to
3 mm perforated aluminium angle
1.2 mm foil sheeting
100 mm mineral wool
6 mm galvanized sheet steel,
bent to shape
4 drainage gutter
(to bear foot traffic):
1.2 mm foil seal adhesive fixed to
1.2 mm galvanized sheet steel
60 mm thermal insulation,
compression resistant
20 mm welded steel section
5 drainage outlet with vortex filter
6 sheet-steel reinforcing rib
(according to struct. calculations)
7 10 mm glass-fibre-reinforced
plasterboard on channel sections
8 2× 12.5 mm perforated gypsum
plasterboard on channel sections

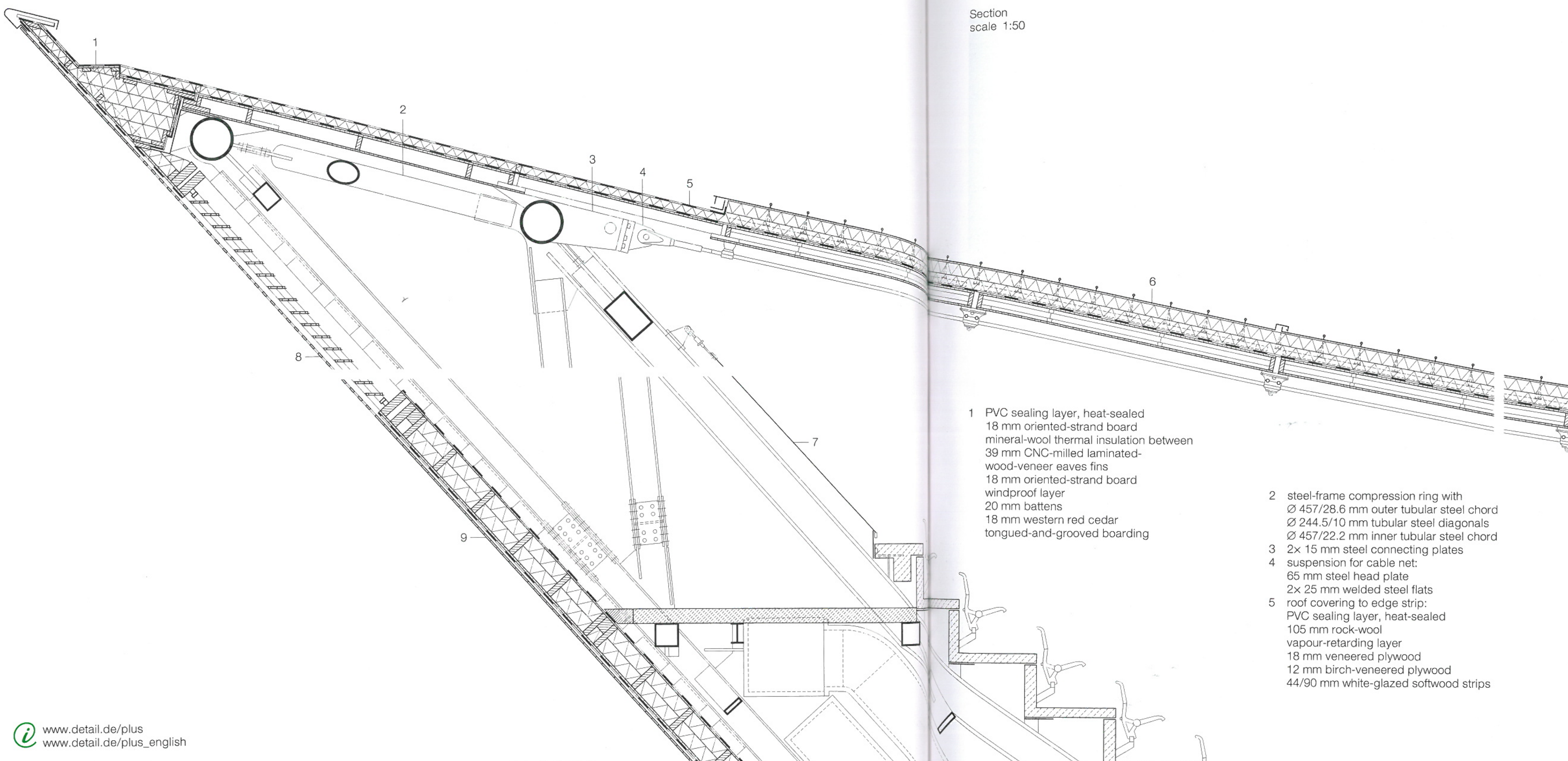


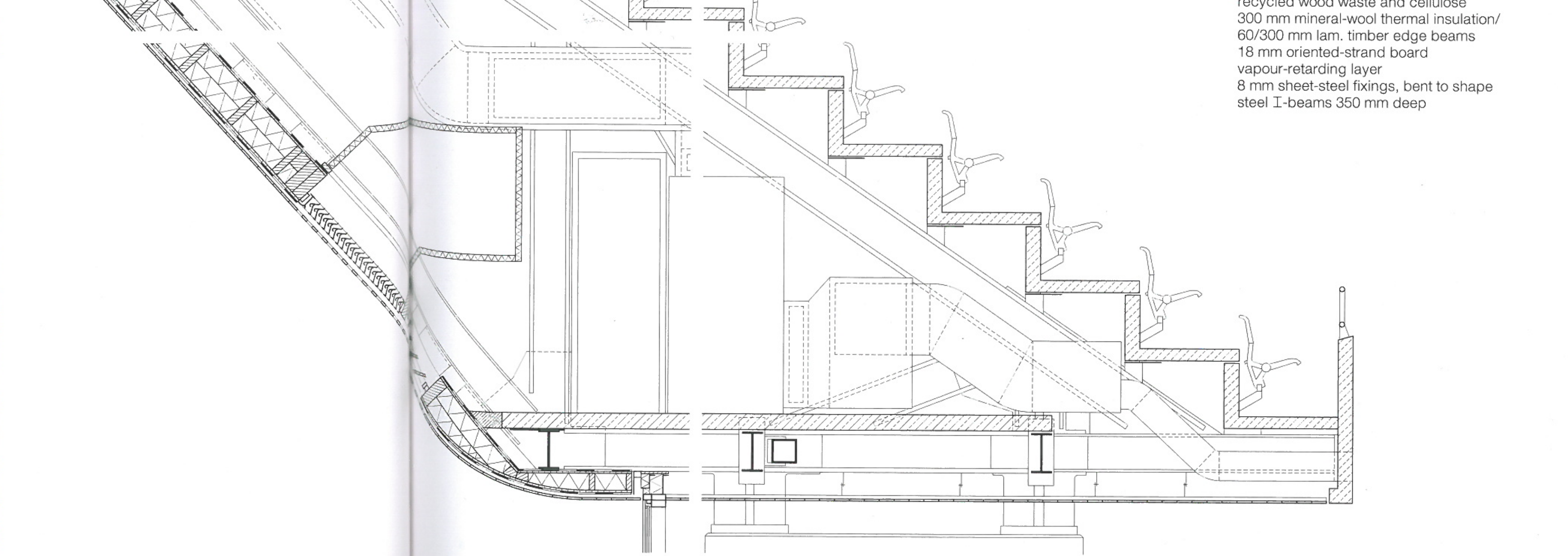






Section
scale 1:50





1 PVC sealing layer, heat-sealed
18 mm oriented-strand board
mineral-wool thermal insulation between
39 mm CNC-milled laminated-wood-veneer eaves fins
18 mm oriented-strand board
windproof layer
20 mm battens
18 mm western red cedar tongued-and-grooved boarding

2 steel-frame compression ring with
Ø 457/28.6 mm outer tubular steel chord
Ø 244.5/10 mm tubular steel diagonals
Ø 457/22.2 mm inner tubular steel chord
3 2x 15 mm steel connecting plates
4 suspension for cable net:
65 mm steel head plate
2x 25 mm welded steel flats
5 roof covering to edge strip:
PVC sealing layer, heat-sealed
105 mm rock-wool
vapour-retarding layer
18 mm veneered plywood
12 mm birch-veneered plywood
44/90 mm white-glazed softwood strips

6 roof construction (see key to drawing pp. 628f.)
7 polyester mesh, PVC-coated on both faces
8 prefabricated facade element with venitilation louvres
9 18 mm western red cedar tongued-and-grooved boarding with 3 mm aluminium separating sections at butt joints
20 mm rear-ventilated cavity/wood battens
neoprene sealing layer
prefabricated facade elements:
22 mm bitumen-bonded slab, consisting of recycled wood waste and cellulose
300 mm mineral-wool thermal insulation/ 60/300 mm lam. timber edge beams
18 mm oriented-strand board
vapour-retarding layer
8 mm sheet-steel fixings, bent to shape
steel I-beams 350 mm deep

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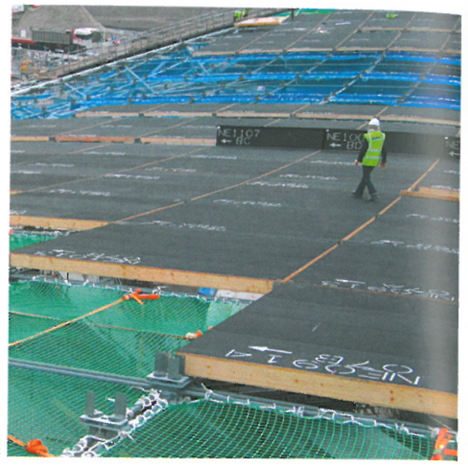
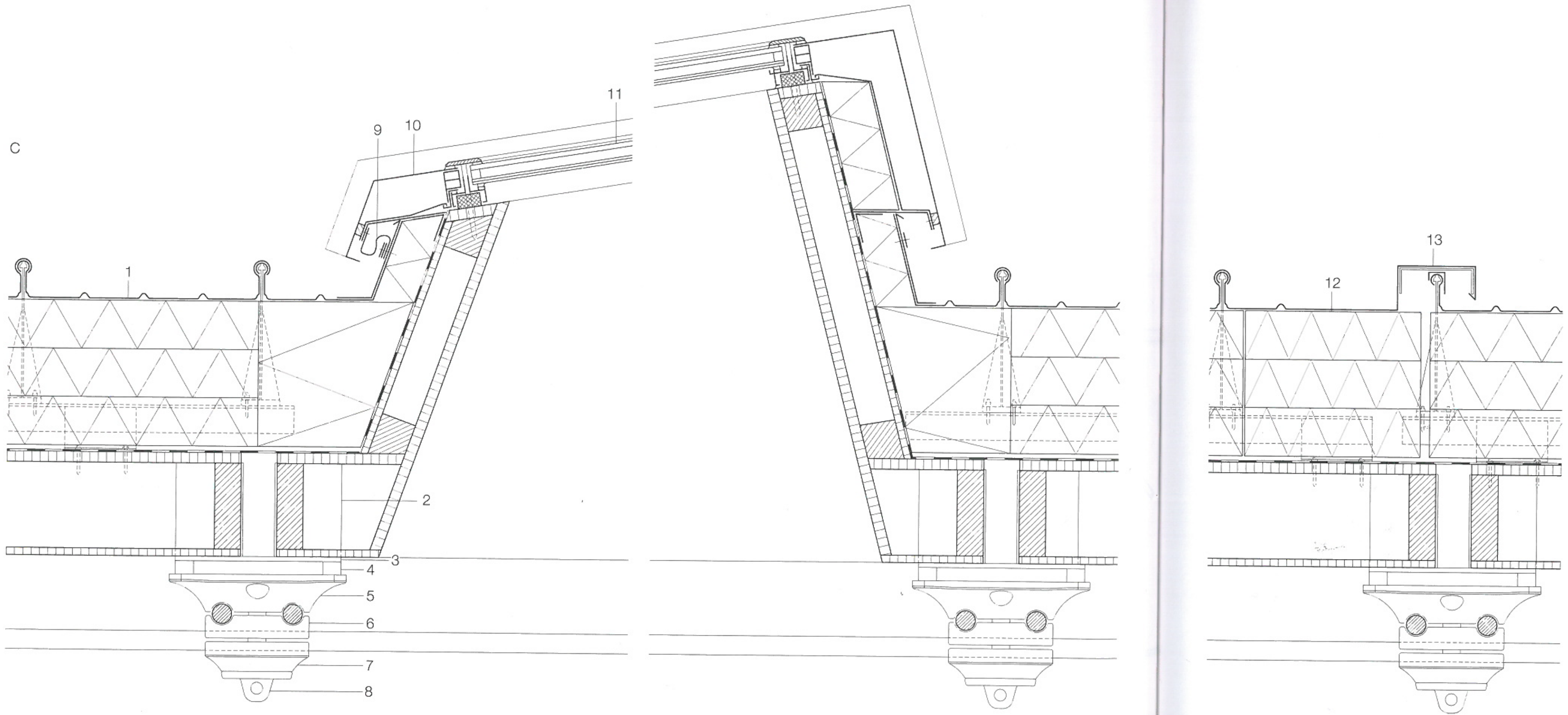
a


b


c

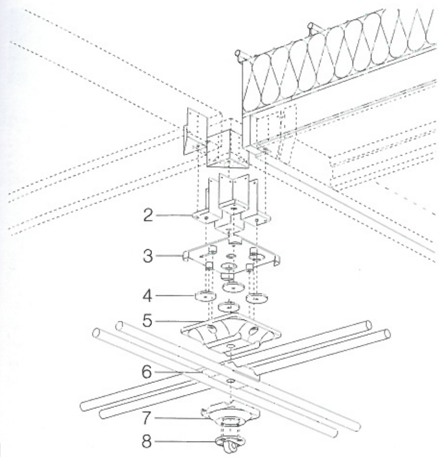
C



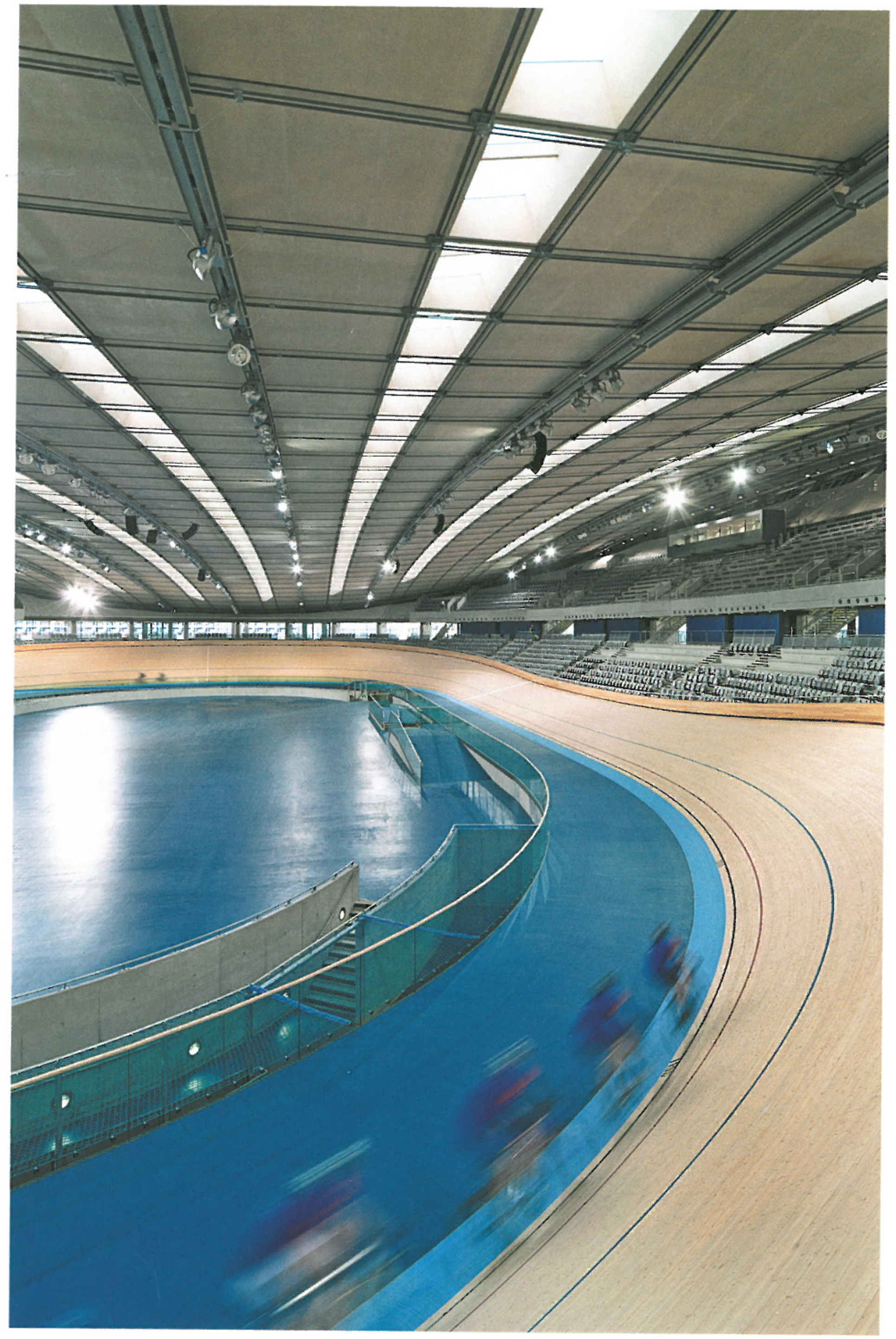
Vertical section
scale 1:10

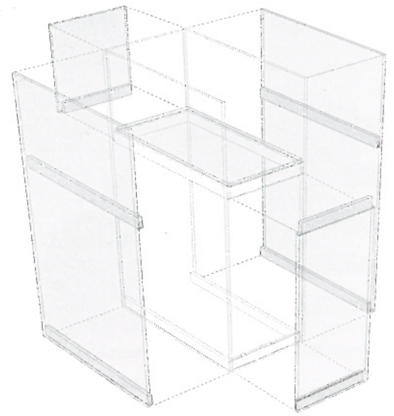
1 roof construction:
sheet-aluminium roofing (standing seams 65 mm high, strips 403 mm wide, 6 m long) welded at ends
mineral-wool thermal insulation compressed from 300 to 260 mm, with system fixing clips to
80 mm sheet-steel supporting structure
vapour-retarding layer
temporary neoprene sealing layer
panel: 18 mm oriented-strand board with softwood edge sections 145 mm deep
12 mm birch-veneered plywood
pairs of Ø 36 mm steel cables in two layers
2 powder-coated welded-steel fixing angles for roof panel, with PTFE slip coating on underside
3 connecting plate with one borehole, one slot and two outsize borings, with PTFE slip coating on both faces
4 8 mm steel collar Ø 88
5 wrought-steel upper cable clamp
6 wrought-steel intermediate cable clamp
7 wrought-steel lower cable clamp
8 closing plate with fixing for light fitting
9 concealed expansion joint to absorb changes in length in roof skin
10 sheet-aluminium covering
11 low-E glazing in aluminium frame:
8 mm toughened glass with heat-insulating coating (self-cleansing) + 16 mm cavity + 2× 4 mm toughened glass with white PVB foils
12 three-layer rock-wool block (each layer 85 mm) as base for aluminium covering next to expansion joint
13 expansion joint in aluminium covering next to roof lights: 50 mm sliding aluminium ties at 400 mm centres

a The cable network is tensioned by hydraulic presses to the point where the cable ends can be connected to the tensile bracing joined to the compression chord of the primary load-bearing structure.
b Each of the cables was preassembled and marked for the node points in such a way that in a tensioned state orthogonal roof bays were created with a 3.60-metre grid dimension. Wrought-steel clamps tie together two pairs of intersecting cables (at right angles to each other) and support the bearings for the roof skin.
c The load-bearing layer of the roof is formed by panels in a timber-frame construction. The joints between elements, which are 6 cm wide on average, absorb movement from the inherently soft form of construction.
d Only one in every four panels is rigidly fixed to the node by means of a bearing angle and a connecting plate; one panel can move in a single direction by means of a slot; and two panels can move in both directions via large borings.

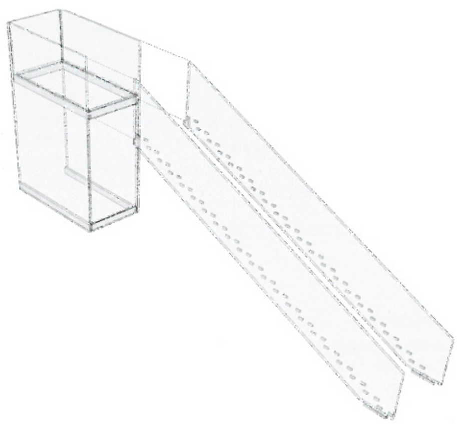


d

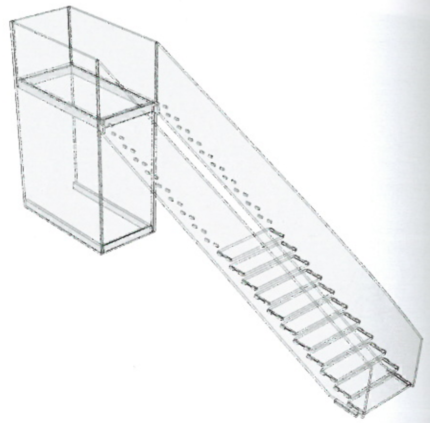




5a



c

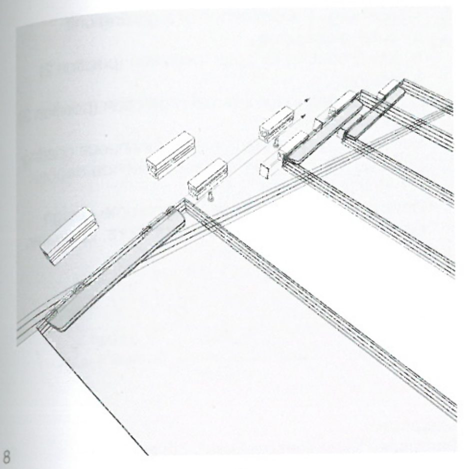


e

Each string is made up of three continuous, jointless panes of 15 mm float glass, laminated into structural units with SG foils in the same way as the 12/12/12/8 mm panes of float glass in the steps.
All the steel fittings required for the joining points of the staircase are also laminated in or on using SG foil. The staircase demonstrates very well not only the wide span that can be achieved with laminating, but also the potential of this technique for load-distributing point details in structural glass.
The stresses acting on the strings are of two main types: firstly that of a hinged single-span girder under vertical load with a span of 7 m and secondly that of a fixed railing with a horizontal load. The bending stresses on the strings around the strong axis are not critical because of the great structural height.
Considerably more complicated, both structurally and in terms of the construction issues involved, is achieving the necessary fixing of the strings in the exclusively horizontal treads. To avoid peak stresses arising from a fixed joint, the connection between the steps and the strings allows for movement. All the horizontal bracing of the staircase comes from the sheet action of the steps.
This is achieved via two fixing points on the ends of each step, which in this example oppose the moment applied from the horizontal load with a lever arm of approx. 9 cm. The fixing points therefore transfer not only the vertical bearing loads, but also the opposite forces of tension and compression, as the controlling load. One of the key questions during the entire design phase was whether any transverse vibration would impair its use as a bridge. Resonant frequencies of around 4 Hz under dead weight and 3 Hz under full load were anticipated in the calculations. Undesirable effects were generally not foreseen with a resonant frequency of below 3.5 Hz.
Measurements on the built staircase confirmed the calculations, as no vertical or horizontal vibrations were felt even when the bridge was in full use during the fair. In designing the joint detailing for the staircase, there were three main areas to resolve: the upper and lower bearing points for the strings and the connection between the treads and the strings. The detailing of the latter is a principal feature of the overall design of the staircase. The loads acting on the joints between the treads and the strings are the vertical bearing loads from the steps and the tension and compression forces for stabilising the strings, as described above.
Easy replacement of damaged steps was an important part of the concept, taken into account in the final design in the form of fittings laminated onto the inner side of the string and steel sheet laminated in between the glass panes making up the steps. Structural calculations dictated that there should be a geometrically symmetrical direction of tension and compression forces into the fitting components to achieve as even a distribution of stresses as possible in the adhesive layer.
Essentially by spreading the forces through the adhesive connections, the distribution of stresses is much improved as compared to drilling point fixings which involve damaging the glass as a result of the mechanical processing. For the final construction, stainless-steel fittings were chosen, made of 15 mm flat steel, 100 × 39 mm in size. A groove was milled out on the step side of each of these pieces to take the tread connections. The way in which each step is fixed to the string, via a total of four laminated brackets (two each end of the step) even allows for one of these adhesive joints to fail, without causing the step to collapse. Extensive FE calculations and test series were carried out in the process of designing the details.
For the firms involved, the manufacture and assembly of such large-format glass components was a great challenge.
In this case, in addition to the actual assembly at the trade fair itself, the trickiest parts were mastering the lamination process in the autoclaves and in the geometrically precise placement of the 42 fitting components per string, without a single adhesion point failing.

Conclusion
Thanks to new processing techniques and new finishes, glass continues to offer tremendous scope for innovation. But it also involves exacting new challenges for the architect, engineer and the construction firm, in terms of design, manufacturing and assembly. Extensive experience and state-of-the-art technology are required to master the complex geometries, and achieve a successful result in steel and glass processing, lamination and assembly.
Neither the "Brücke 7" at glasstec 2008 nor the glass staircase at glasstec 2006 should be regarded as "products" in the conventional sense, but as design and technology experiments that point the way towards future applications in structural glass and facades.

6



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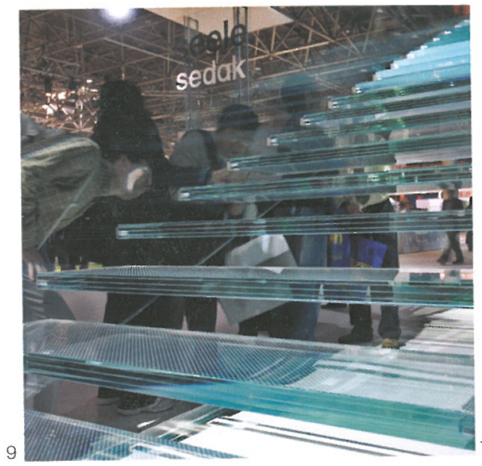

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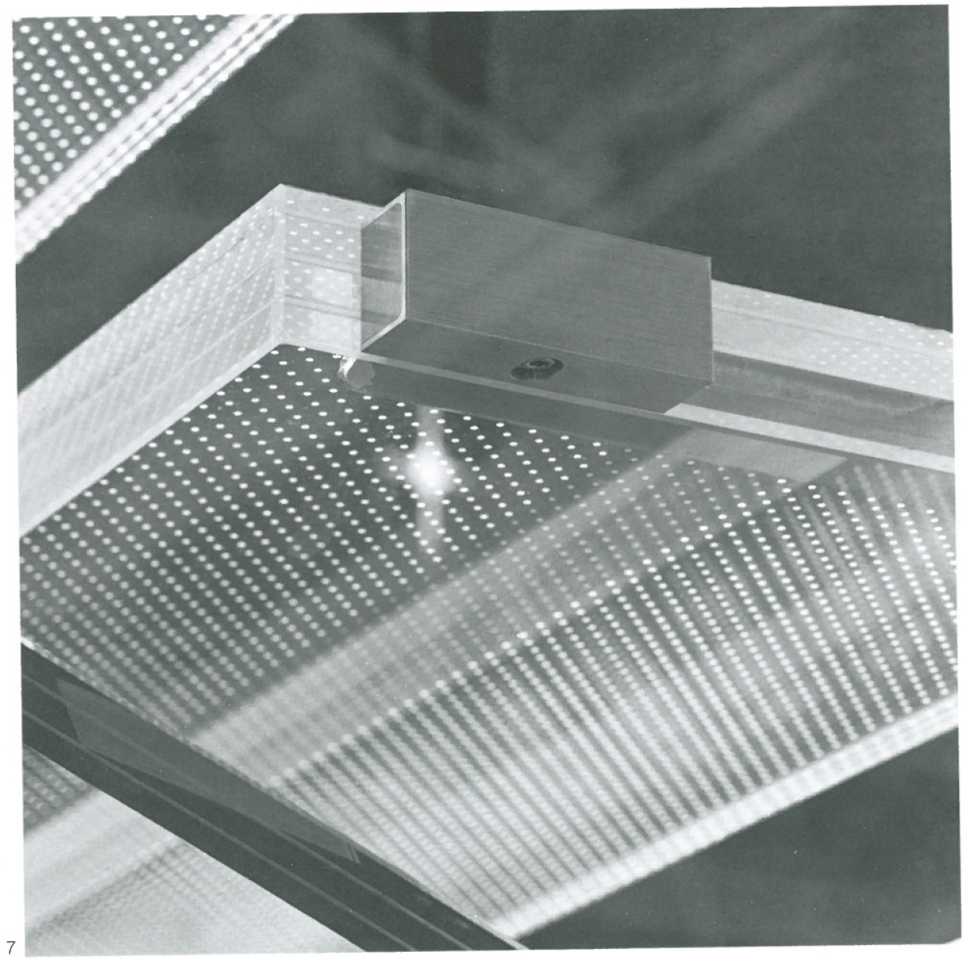

7

5 Production stages for staircase:
a glass elements in support, non-positive joint to laminated-on connectors
b fitting the strings
c fitting the treads
6, 7, 9 Glass staircase at glasstec 2006
8 System sketch
10 Fitting the treads

Taking a Second Look: Glass Pavilion at Broadfield House in Kingswinford

Christian Schittich

1,2 Condition in 1994

Architects:
Design Antenna, Richmond
Brent G. Richards, Robert Dabell
Structural engineers:
Dewhurst Macfarlane and Partners, London
Tim Macfarlane, Gary Elliot, David Wilde
see Detail German Edition 1/1995, p. 59

50 years DETAIL

Over the course of fifty years, DETAIL has portrayed countless noteworthy buildings, each with a story of its own. Some have not changed at all since day one, others have been altered beyond recognition. In many of them, the structure that was experimental in its day has stood the test of time; in others, after a certain period of time, the planners and users have had to admit that things did not turn out quite as intended. Because the buildings are normally published shortly following their completion, data on how they withstand wear and tear are not yet available. DETAIL's 50th Anniversary provides the editors an occasion to take a second look at outstanding buildings from the last five decade. How have the concept and the structure held up? And what has become of the technological developments that sparked these buildings at the time? Corresponding to this issue's topic, the first article in the series is the glass pavilion at Broadfield House in Kingswinford.

The museum pavilion, completed in 1994 in Kingswinford in western England, is the physical manifestation of a recurrent dream: the desire to completely dissolve the building envelope and to thereby achieve total transparency. For centuries this has been a theme in architecture, and by no later than the early stage of modernism in the 1920s, it had become something of a sought-after myth.
Inspired by poets and philosophers such as Paul Scheerbart of Berlin, who goes so far as to see dematerialized structures as the foundation of an open society, the avant-garde architects of the era – including Mies van der Rohe and Bruno Taut – came up with crystalline designs, which, however, for lack of technological support, remained visions on paper.
But during the second half of the twentieth century, glass technology experienced a tremendous boost in its development, and by the early 1990s it had attained a level in which nothing seemed beyond reach. What had once been a brittle, delicate substance is now a high-performance building material for audacious, airy structures which, when necessary, can also bear loads and, thanks to the sophisticated coatings that are for the most part invisible, can also function as climate control.
During this era, the development of glass architecture resembled a race to set records. Following the development of the spectacular glazed grid shells and tensile structures of the late 1980s, many of the leaders in the field sought to do away with every last metal connection component – even the very smallest of them.
In no time at all, the first glass beams and columns turned up, first in smaller private projects, but shortly thereafter in roofs subject to greater loads and buildings accessible to the public.
Then, in the mid-1990s, at the height of this development, the completely de-materialized entrance pavilion at this glass museum in England made the rounds in the press and attracted the attention of the profession. Despite its modest dimensions (11.0 × 5.7 × 3.5 m), it is to this day the largest all-glass structure ever erected. It was also the first of its kind to be realized for a public building. An all-glass structure is composed of no other building material whatsoever than the transparent matter itself – in particular, no point-fixing or other metallic connections – and the necessary adhesives.

Metaphor for the fascination with glass
Planned as an addition to a glass museum – the collection contains items of applied arts made of glass dating to the seventeenth and eighteenth centuries – the pavilion was intended as a modern counterweight to the historic building, a Georgian manor and the corresponding historic collection.
At the same time, the architects and engineers wanted to showcase modern glass technology. They stated that their aim was


1

2