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The European Stainless Steel Development Association

London Underground Stations
Jubilee Line Extension

The last great public project of the 20th century, the £ 3.2 billion Jubilee Line Extension offers a rich tapestry of space, structural invention, and memorable form, through which stainless steel weaves a vital thread.

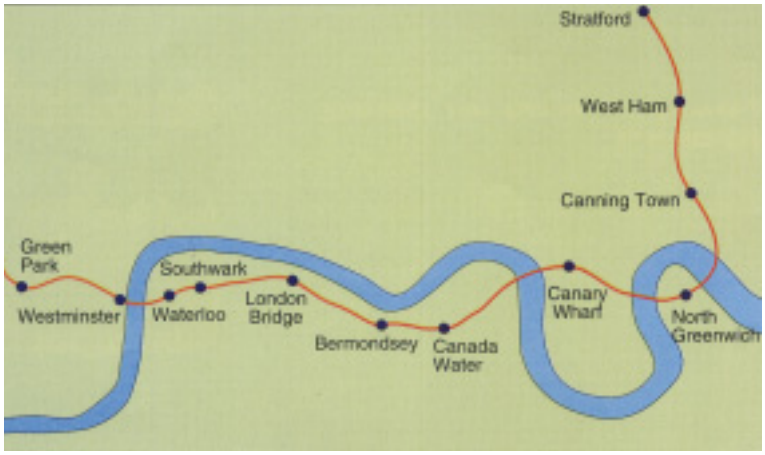
Facts & Figures

- Key dates
  - March 1992: Royal assent granted
  - October 1993: Project approval
  - December 1993: Construction started
  - December 1999: All 11 Stations opened.
- 6 stations completely new – Southwark, Bermondsey, Canada Water, Canary Wharf, North Greenwich, and Canning Town.
- 5 stations enlarged and/or rebuilt – Green Park, Waterloo, London Bridge, West Ham, and Westminster.
- A new fleet of 59 six-car trains was built, able to carry 50,000 passengers per hour. Fast links mean Waterloo Terminal can be reached from North Greenwich in 13 minutes.

As a first for the London Transport Underground System, all JLE stations have stainless steel-framed platform edge doors for reasons of passenger safety and improved station ventilation.

Cover: Southwark Station – Lower Concourse, showing stainless steel wall linings

below: North Greenwich Underground Station Platform



The JLE Route

Each of the 11 stations of the Jubilee Line Extension had its own team of architects.

Architects Design Brief

The need to change claustrphobic passenger routes to bold, airy spaces was primarily achieved by appointing different teams of established architectural practices for each of the 11 stations. They were given freedom to challenge engineering preconceptions, yet were under the overall direction of a London Underground Architect in Charge, Roland Paoletti.

Each station is unique and contributes strongly to its locality, whilst at the same time acknowledging the best and most easily recognised features of the century-old London Underground.

Stratford Station redevelopment – Exterior of main concourse at dusk.

The JLE set a new benchmark for underground railway design by replacing labyrinthine tunnels with bold, user-friendly spaces needing few signs.

Passengers entering train at Westminster Station

Background to the project

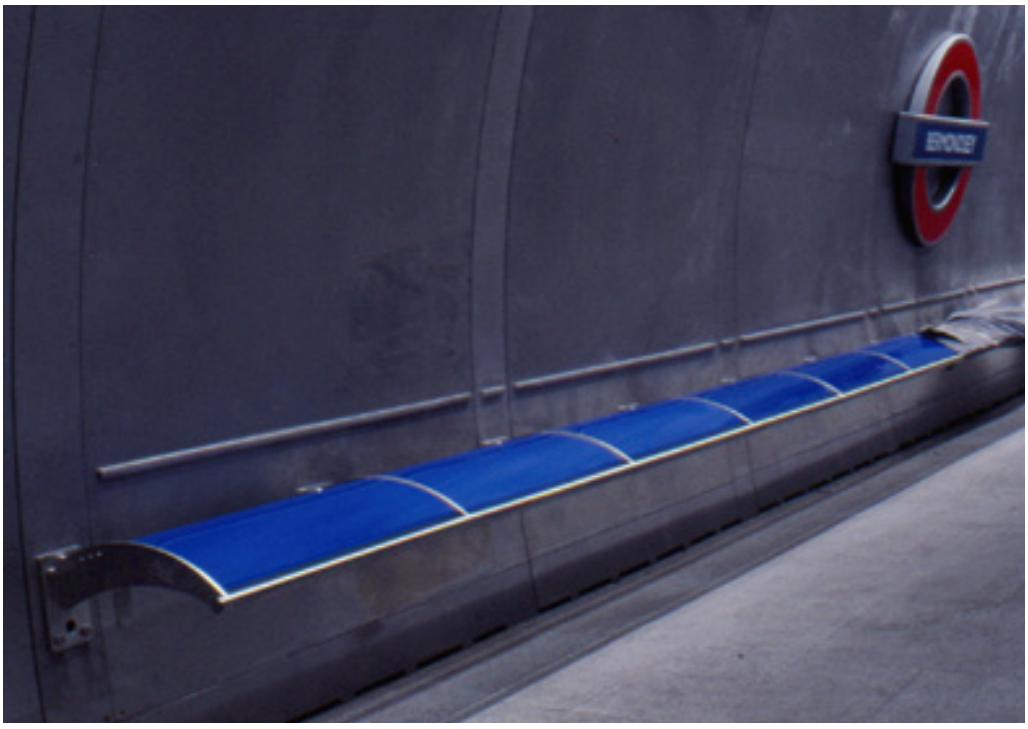
Completed just in time for the Millennium at a cost of over £3 billion, the 16 km extension to the Jubilee Line in Central London is the culmination of half a century of strategic transport planning. An underground railway heading east from Westminster was first proposed in 1943, but not until the 1960's were plans for the Fleet Line to New Cross finalised. However, after renaming it the Jubilee Line in 1979, the offer to create 150,00 new jobs in London's Docklands plus private funding led to a change of plan. The Jubilee Line Extension has since become one of the worlds most sophisticated urban transport systems.

The early impetus for development came from constructing the Docklands Light Railway. However, the JLE serves more than London's Thames Docklands. It is an important link to the east and west of London which relieves traffic congestion, whilst opening areas of south-east London to the established Underground network.

Architectural Philosophy

The route and station extensions effectively link the existing Victorian construction with modern visions and propel both into the future. Whilst the Jubilee Line ticket halls were carved from the vast 19th century vaulted undercrofts of the Waterloo and London Bridge stations, some like Bermondsey, Southwark, and Canary Wharf have been built from new using advanced architectural concepts.

Each of the 11 stations is unique in execution. Nonetheless, stations are immediately recognisable with the best hallmarks of the



Bermondsey Station Platforms use blue glass for seats with laser cut stainless steel plate for the support and edging structure.

Electropolished lattice wire structure in stainless steel for the North Greenwich Station bench seats.

A satin finish, press-formed sheet design with flat bar elbow supports was used for the stainless steel seats at Stratford Station.

London Underground. The outcome is a series of stations responding to the needs of their local communities whilst being connected by a common philosophy.

Throughout the project the priority was established to provide safety and abundant escape routes. Consequently, elaborate finishes with their attendant fire hazard potential were to be avoided and civil work left exposed where possible. Alongside the other durable, uncoated construction materials like concrete and glass, stainless steel was therefore to figure strongly in the architecture of all the stations.

The resulting station architecture, though dramatic, is very simple and should feel as right in 50 years as it is now.

Each station was designed as an individual entity, linked to the others by common principles. This is seen for example in the variety of station seat designs in stainless steel using bold shapes and colours.

Escalators

Bermondsey Station

Architect: Ian Ritchie Architects, London

General Design

Bermondsey is the smallest of the new JLE stations, occupying a compact site on a busy arterial road, in an area previously poorly served by public transport.

Architects Focus

The designers were concerned to ensure that surfaces should be friendly to touch, handle, and lean upon at all places where the public make contact with the building. As a consequence different finishes were selected for the stainless steels.

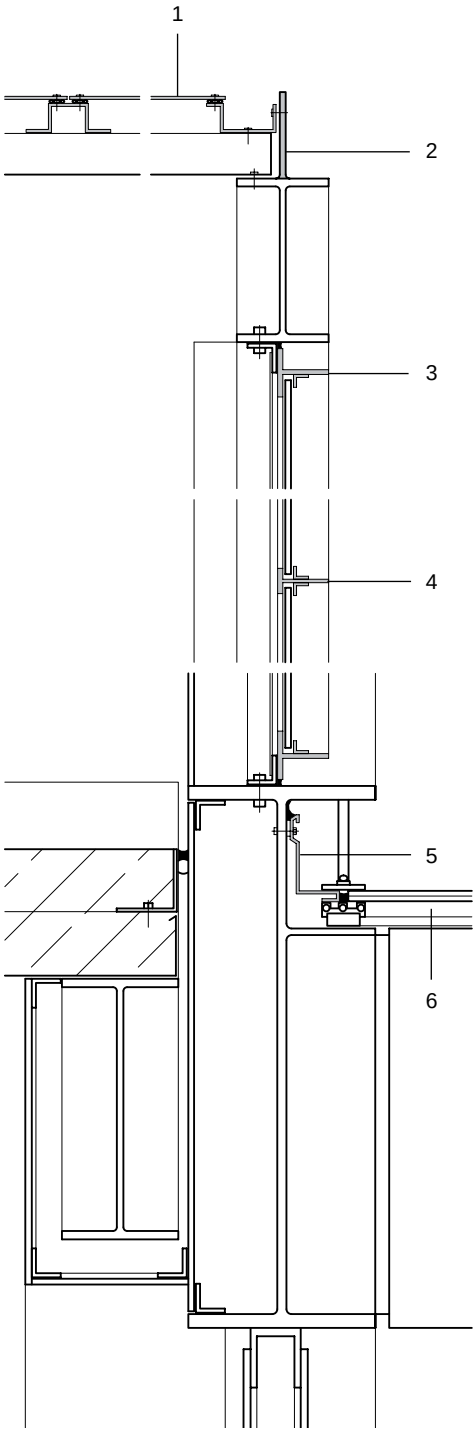
The aim was to create a seamless integration of civil engineering and architecture, exploiting natural light to create a clear, spatial experience and a legible route between platforms and main entrance at Jamaica Road. The station is covered by a translucent roof, which allows the sun's rays to reach the rail platforms beneath. At the west end of the station a ventilation and escape shaft has been inserted beneath gardens and garages at Ben Smith Way.

Following the Fenel Report on an earlier fire at London Underground's Kings Cross Station, all materials were selected for low combustibility and low smoke, low toxicity characteristics. Hence civil work was to be left exposed where possible and potentially hazardous secondary finishes were to be avoided. As a consequence, uncoated stainless steels were specified for many of the building assemblies.

Ticket hall gateline

Stainless Steel Architectural Details

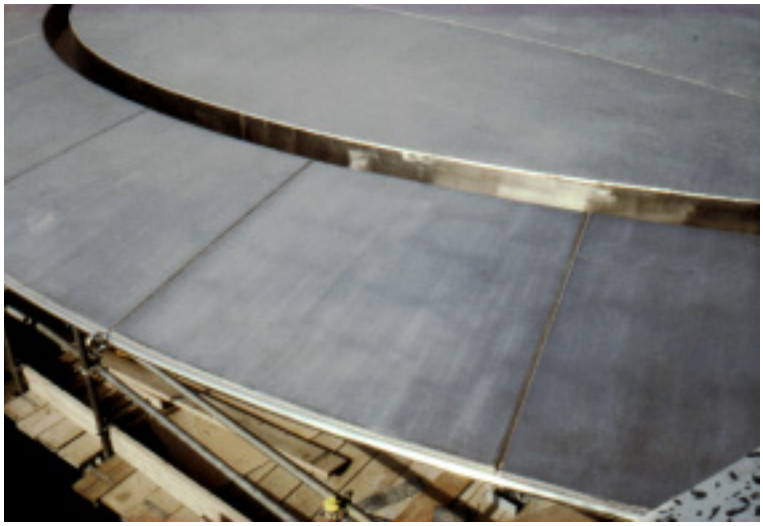
· Single Curvature Roof with Integral Gutters



Roof and facade section

1 2B finish stainless steel roofing sheets on stainless steel top hat sections
2 Stainless steel top hat section end piece bolted through predrilled holes in flange
3 80 x 80 mm stainless steel section top and bottom with 20 x 20 mm stainless steel glazing bead fixed to 40 x 40 mm galvanized steel
4 Horizontal transom of 40 x 80 mm stainless steel T-section with 20 x 20 mm stainless steel glazing beads
5 Stainless steel glazed roof flashings
6 Glazed roof

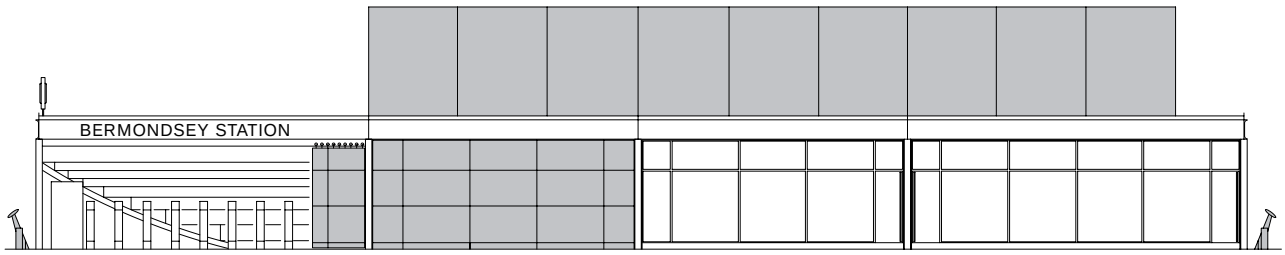
The roof in 3 mm 2B finish 1.4401 (X5CrNiMo17-12-2) sheet was rolled to form an attractive 6 m radius covering. The roof panels are supported on stainless steel top hat sections and include a recessed 2mm thick stainless steel gutter. Stainless steel screws secure the roof panels, which are made watertight by a sealant in the form of a double strip gasket.



Roof Detail

Two continuous stainless steel quadrants with removable panels form the enclosure to the roof plant zones and air intake/exhausts to the station track and tunnel fans.

· Facades to External and Internal Passenger Services



Jamaica Road Elevation

Each cladding panel module in 3 mm shot-peened 1.4401 (X5CrNiMo17-12-2) grade incorporates the appropriate fire separation, thermal insulation, and ballistic resistance properties. These modules are attached to, and electrically isolated from a galvanized carbon steel primary framework via a secondary framework of stainless steel hot rolled angles and 'T' sections.

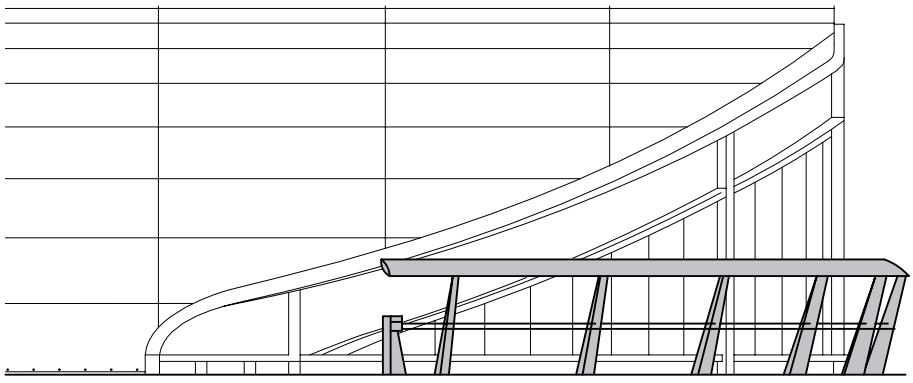
Station entrance

· Leaning Pads and Cable Barriers

The inherent strength and tactile appeal were the key attributes in specifying stainless steel for these for these highly visible safety components.

Passers-by are protected from the voids beyond by stainless steel leaning pads, which act as convenient armrests to view activities in the station and encourage passive surveillance. The continuous pad sections provide protection up to crowd loadings of 3 kN/m, and are constructed from 3 mm thick 1.4401 (X5CrNiMo17-12-2) type open stainless steel oval section with a shot peened surface.

Both leaning pads and cable barriers are supported on inclined 'T' section stanchions made from matching 1.4401 stainless steels.



The east and west facades of the station are protected from vehicle impact by barriers consisting of two pairs of 19 mm diameter pre-stressed and pre-tensioned 1.4401 (X5CrNiMo17-12-2) type stainless steel cables, fastened to their bases by similar grade anchor blocks.

· Anti-climb Barriers and Mesh Panelling

This is a novel yet effective method of allowing public visibility with permanent security from climbers. It uses spirally wound wire mesh in frames, which link visually with the roof profiling. The barrier includes letterbox apertures for maintenance purposes.

Similar thinking was behind the mesh panelling to the ticket hall bridge link, where mesh panels were selected to provide visual transparency, perceived security, and passive surveillance on an important public route over a 16 m wide void.

Here 1.8 m wide spirally wound mesh panels are mounted on 80 by 8 mm thick stainless steel flats on both vertical edges and fixed to cantilevered, galvanized steel support frames.

Ticket Hall Bridge Walk

The 1.8 m wide electropolished panels are held in shot-peened 'T' section cantilevered frames. All products are in 1.4401 (X5CrNiMo17-12-2) stainless steel.

Schematic barrier sketch
1 Electropolished stainless steel panels
2 Shot-peened stainless steel T-section cantilevered frames

Ben Smith Way.
Balustrades & Cargo Net

The 80 sq.m cargo net forms a secure, maintenance-free covering to the horizontal air intake and extraction unit, and provides a high free area (70%) for smoke discharge. The grille successfully negotiates the undulating geometry and is made from interwoven stainless steel cables and chains.

· Seat Support Brackets

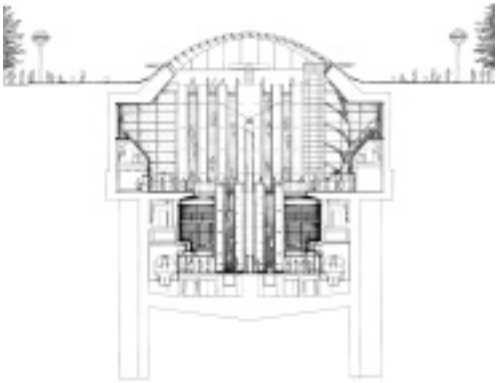
Profiled 1.4401 (X5CrNiMo17-12-2) stainless steel brackets were selected to provide the strength of support and for the visual harmony between the blue glass platform seats and the frieze panelling of the station platforms. They provide adjustment in two dimensions through horizontal slots in the brackets. These are fastened to toothed stainless steel halfen channels concealed behind the platform cladding.

Platform seat bracket

Platform seat

Brackets are made from welded assemblies of laser cut 1.4401 (X5CrNiMo17-12-2) plate, with a bead-blasted and electropolished finish.

The roof of the station is laid out as a leafy landscaped park, creating Canary Wharf's principal public re-creation space. Only the swelling glass domes of the canopies covering the three entrances give any visual evidence to the station below. These structures draw daylight deep into the station concourse, thereby enhancing human orientation and minimising the need for direction signs.



Structural Cross section View

Canary Wharf station – View from 30 The South Collonade at dusk

Architects Focus

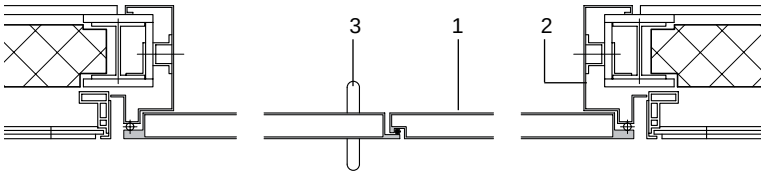
Foster and Partners used a simple palette of hard-wearing constructional materials – unadorned concrete, glass, and stainless steels. This robust aesthetic is most pronounced at platform level, where satin finish stainless steel clads the oval-section columns in a critical damage-prone area.

View of Western Canopy and Escalators at night

Stainless Steel Architectural Details

· Ticket Hall Facades, Doors, and Counters
Contractor – Ticket Hall Cabin Cladding: Harty Holdings Ltd

Administration offices, ticket kiosks and other amenities are sited on the plane flanks of the ticket hall. This has left the main station space free, creating a sense of clarity and calm. The door and wall cladding is designed to accommodate future technological changes through a modular system which includes the ticket cabins as well as plug-in ancillaries such as fire hose reels.

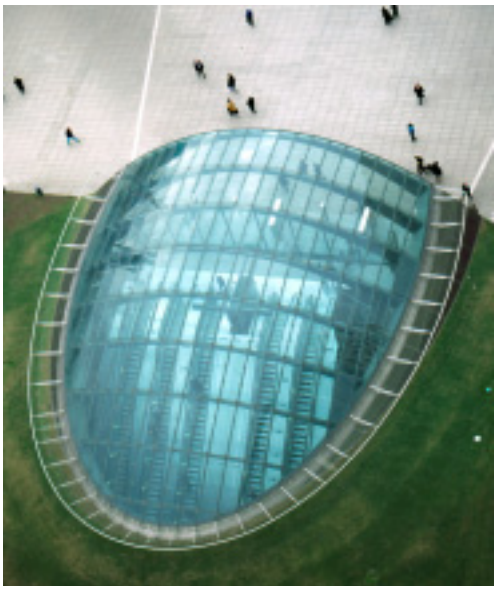


Panel Type H Doors (4 module high)
1 Solid core flush panel stainless steel door
2 2 mm thick stainless steel brake pressed cladding
3 19 mm stainless steel pull handle

Brake pressed panels use satin finished grade 1.4432 (X2CrNiMo17-12-3), in thicknesses of 2 and 3 mm. The secret fix cladding and doors are flush fitted. Doors have hidden hinge pivots and are 1 hour fire resistance rated through the use of panels which are backed by a quilt of mineral wool.

Ticket Gateline

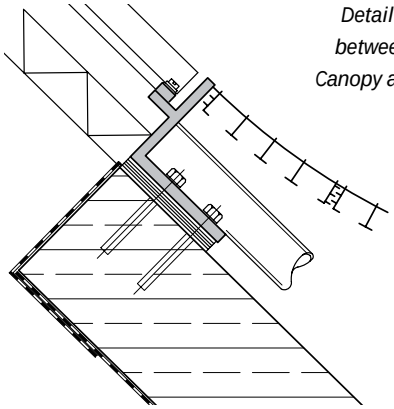
The architect wanted to use bare concrete structures where possible. Durable facing materials are used where surface protection is essential, for ease of cleaning, or where replacement facilities may be required in the future. The outcome of this intent is that all surfaces of the ticket counters and doors, which can be touched and brushed by passengers, are flush fitting modules in stainless steel and glass.



Aerial view of main arch canopy

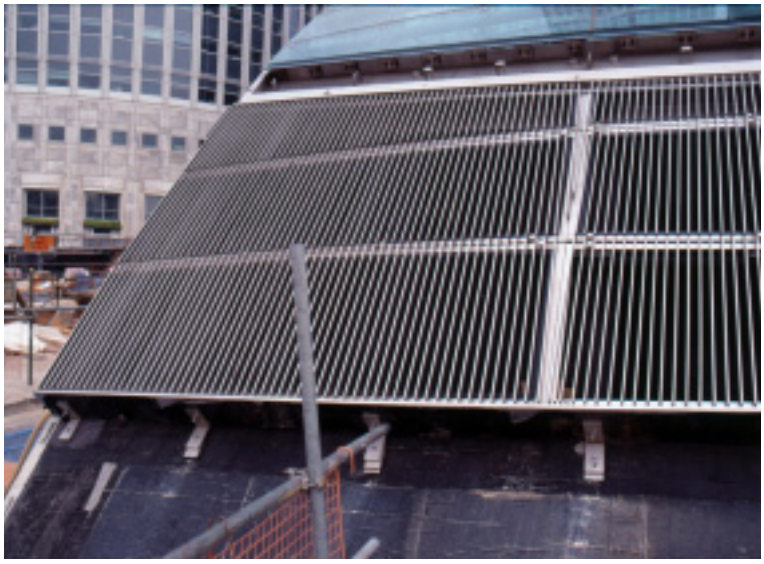
· Main Canopy Structure: Ground Supports, Louvres, Gutters, and Glazing
Contractor – Entrance Canopies: Mero (UK) plc

This arc structure operates in a fairly aggressive saline environment adjacent to the river. For the distinctive canopy an 80 year minimum lifespan meant that the material selection possibilities were limited to stainless steels, glass, and concrete for exposed features.



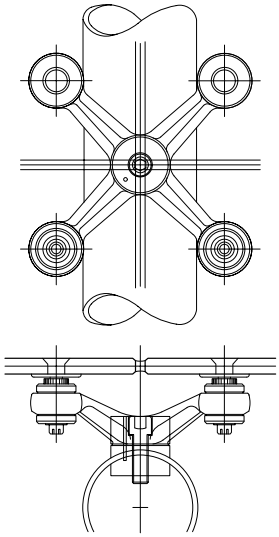
Detail at Junction between Entrance Canopy and Ground

The stainless steel angle section 240 by 250 by 20 mm thick supports the structure through size M20 stainless steel bolts to BS EN 3506, and is curved to match the canopy profile. Satin finished 1.4432 (X2CrNiMo17-12-3) is used for the section, which connects to the louvre grilles above via anti-theft wheelnut fixings, and is concealed by a loose fill at ground level.



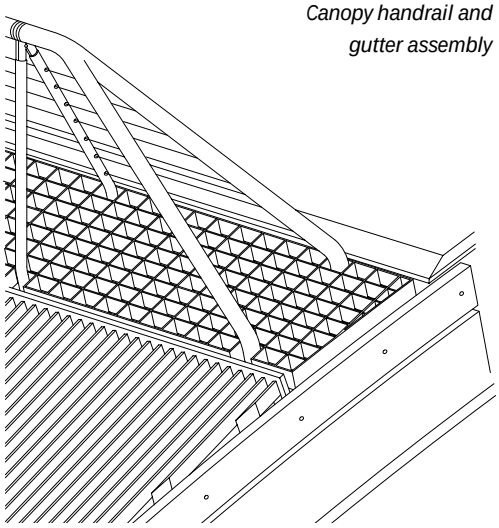
Canopy supports at gutter base level

Strength requirements of the plate assemblies at base level were also needed.



Four point canopy structural glazing spider

Glazing fixings and spider connections for the canopy are also in grade 1.4432 (X2CrNiMo17-12-3), and join the 25mm thick glazing via 'planar' fasteners. The distinctive four point glazing spiders 170 mm square are made as lost wax castings and finished with a bead blasted satin finish.



Canopy handrail and gutter assembly

Below the handrail support, box sections made from 10 by 60 mm 1.4432 (X2CrNiMo17-12-3) stainless steel flats make up the ventilation louvres for the semi-marine environment and are welded to the 6 mm by 80 mm plate which form the gutter grilles.

Lifts have transparent glass sides to enhance passenger security and deter vandalism. Fire resistant requirements (zero gas emission tolerance), as well as scuff resistance were the guiding considerations in specifying stainless steels for the lift panels and escape route gantries, in 2 mm thick type 1.4401 (X5CrNiMo17-12-2).

· Gantries and Lifts
Contractors:
Escape Route Gantries: Jordan Engineering,
Escalators & Lifts: Kone

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