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PRISM | ARUP

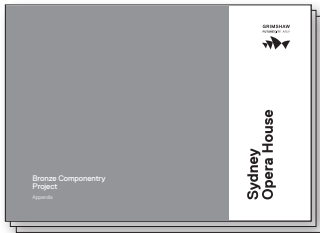
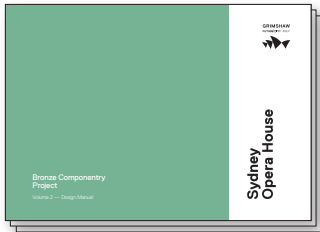
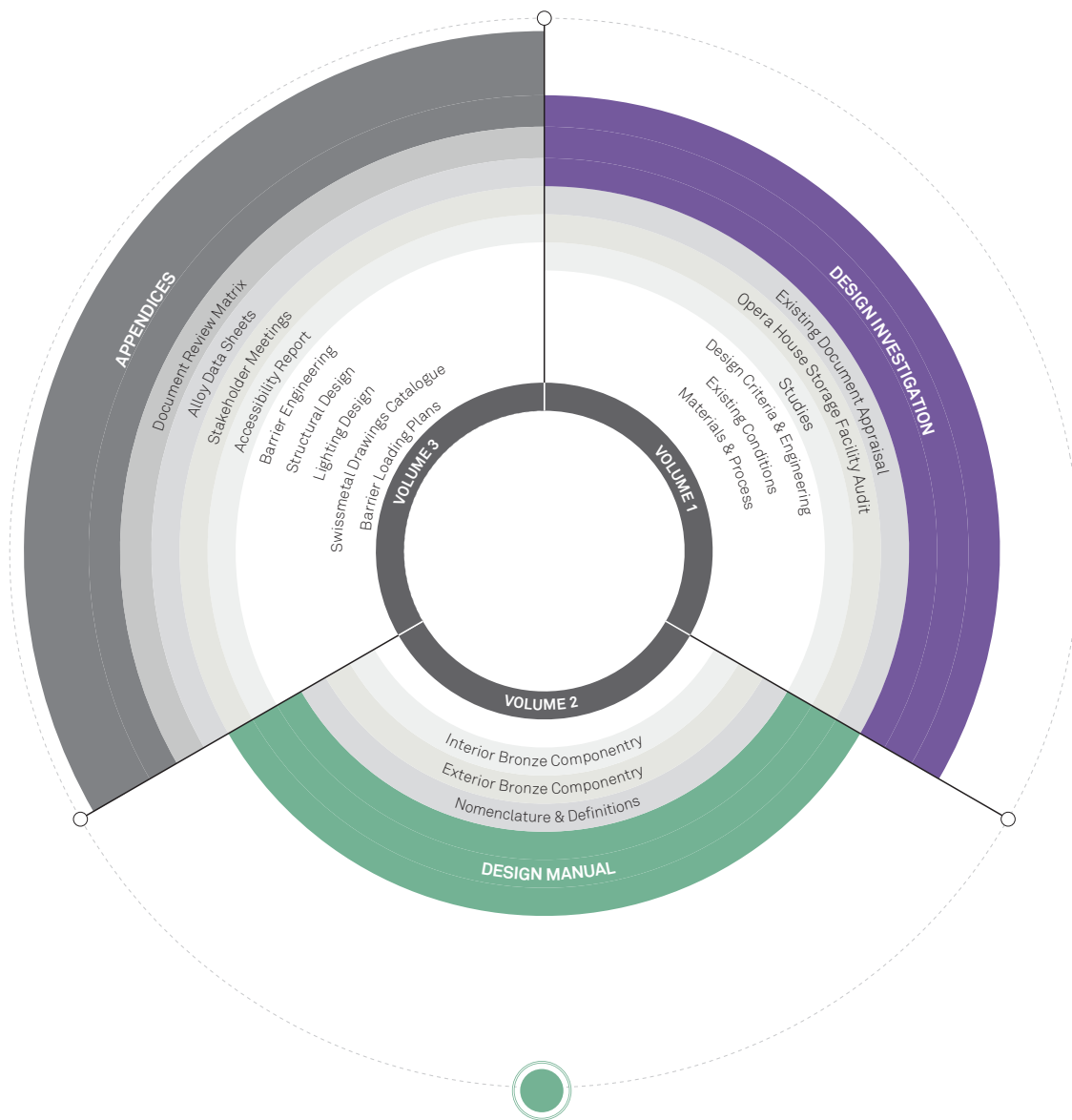


Sydney Opera House

Bronze Componentry Project

Volume 2 — Design Manual (Draft for Review 18/08/2017)

Volume 2 in context



Bronze Componentry Project Reports:
Volume 1: Design Investigation
Volume 2: Design Manual
Appendix

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Volume 2

Design Manual



Introduction

Design Manual

The Bronze Componentry Project (BCP) Design Manual is the accompanying document to BCP Volume 1 Design Investigations. Both documents build on previous industrial design studies, primarily the Handrail and Barrier Master Plan (2014) prepared by the Government Architects Office, which identified over 40 types of barrier and handrail systems in use at the Opera House.

The componentry systems developed within this Manual are fabricated in four main profile types, manufactured in different materials and assembled in different configurations. At the acceptance of the BCP Design Principles by the EAP, Grimshaw engaged with the architectural teams designing the renewal works together with the EAP in a series of design consistency workshops.

The functional requirements of each project were assessed against the BCP Design Principles and the production requirements of architectural bronze extrusion. Due to the high cost of production, the objective of the componentry kit-of-parts is to minimise the number of extrusions required to accommodate the greatest number of arrangements, while honouring Utzon's principle of "pre-fabrication: machine-made components, modular coordination/standardisation, repeated form – supporting a 'kit or parts' construction system for off-site pre-fabrication and ease of maintenance and replacement when required..." [REF: Utzon Design Principles, Sydney Opera House Trust, May 2002]

The BCP also quantifies the full extent of architectural bronze required for renewal works — not only for barriers and handrails etc. these works required the re-creation of the original extrusions to achieve the same appearance and geometries. Site measurements and research of the original die drawings by Austral Crane were used to determine which profiles needed to be extruded and in some cases these original profiles informed the design of new sections. Production of the bronze profiles starts with the review and approval of technical drawings for the fabrication of a master die. Once confirmed test extrusions are made to ensure they are dimensionally accurate with correct tolerances.

Grimshaw reviewed all shop drawings for the barrier and facade elements to ensure consistency across the renewal works projects and provided verification of the completed profiles once they arrived at the Opera House storage facility. Replicating the original extrusion processes will allow the bronze to acquire patina without changing character, weathering and simplicity to match the existing bronze.

The Bronze Componentry Project (BCP) is a necessary part of Opera House renewal due to changes in legislative accessibility standards, building codes, and statutory requirements since the Opera House's completion in 1973. Building projects undertaken as part of the renewal program (2013-2023) present an opportunity to Opera House renewal project has also and a desire to provide a safer more inclusive experience for Opera House artists, audiences visitors and staff.

Grimshaw, and our consultant team, have designed, engineered and certified the BCP barriers, handrails, connections and installation. An integrated lighting design solution has also been developed for each current project and is to be adopted to suit their specific lighting requirements.

Exterior Bronze Componentry

The design methodology has been to build on the established rhythm of the existing barrier and precast granite set building modules, to maintain the orientation and location of the existing barrier posts with a dominant circular top rail referencing the original U-Profile extending the designs of the Utzon Room and Western Concourse. It accommodates stair geometries both vertically and in plan as the barriers and wall mounted handrails wrap around the Forecourt and Podium.

Interior Bronze Componentry

Also developed around the existing barrier and precast granite set building modules the interior components are set out using the existing barrier post locations. The interior circulation performance spaces require a greater range of barriers, freestanding and wall mounted handrails and guardrails.

Nomenclature & definitions

Clarifying terminology

As building performance requirements change, so do their definitions. An example is the use of the term ‘barrier’ on stairs and landings. Recently, the National Construction Code (NCC 2016) has replaced the term ‘balustrade’ in favour of ‘barrier’ to describe a structure that prevents falls from stairs, landings and balconies. It is for this reason that nomenclature and definitions has been included in this Manual, thereby unifying descriptions used by consultant teams to describe bronze componentry, and eliminating potential confusion by the misuse of historical and inaccurate references.

The nomenclature defined on the following pages ensures there is consistency as current and future renewal works are completed. This Manual also recommends that for future projects, all engineering and architectural documentation adopts and builds on the assembly codes outlined herewith (BAR-100, HR-100 etc.) to ensure future deployment of bronze packages continues to reference the correct specification sections.

Definitions are given on the following componentry typologies:

- Barrier;
- Wall mounted handrail;
- Free standing handrail;
- Guard rail;
- Performance space rail; and
- Infill.

Barrier

Barriers are defined in Part D2.16a of the National Construction Code (2016) as:

Barriers to prevent falls. A continuous barrier or other barrier must be provided along the side of any roof to which public access is provided, any stairway or ramp, any floor, corridor, hallway, balcony, deck, verandah, mezzanine, access bridge or the like and along the side of any delineated path of access to a building, if it is not bounded by a wall and if its level above the surface beneath is more than 1m.

Horizontal elements:

For floors more than 4m above the surface beneath, any horizontal or near horizontal elements between 150mm and 760mm above the floor must not facilitate climbing.

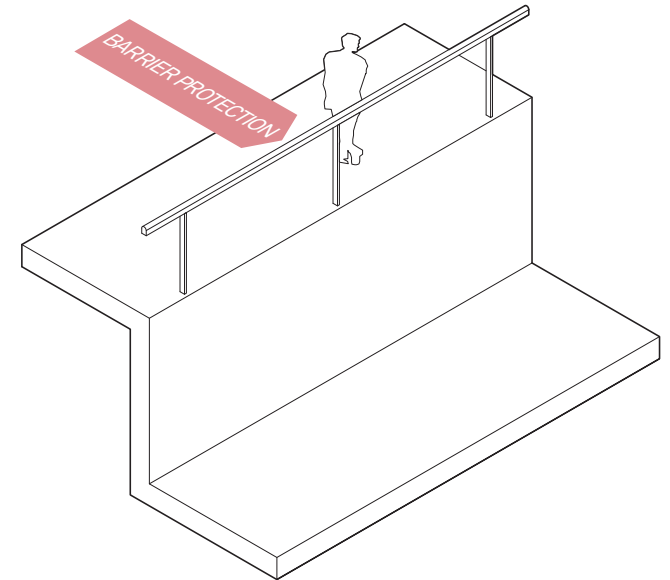
Height:

Class 9a building in NSW requires 1200mm height “when provided externally to the building; and 1m when provided inside the building”.

The height of a barrier must not be less than 865mm above the nosing of an associated stair tread, the floor of a ramp, or the floor beneath an operable window.

The height of a barrier must not be less than 1000mm above any floor, walkway, or landing (unless it is the inside edge of a landing in which case it can be 865mm)

Openings in a barrier must be constructed such that a 125mm sphere is not permitted to pass through it. For stairs, the opening is measured above the nosing line of the stair treads.



Existing Application: Forecourt Perimeter, Lower Concourse
(Source: Grimshaw)

Wall mounted handrail

The requirements for access for people with a disability Table D3.1 Class 9a (NCC 2016) access requirements apply to and within all areas normally used by the occupants. For the Opera House this means that all areas of the building are required to be accessible and designed in accordance with Part 12 of AS1428.1 (It is however, understood that non-conformances are accepted in certain instances where heritage or aesthetic constraints prevent adherence to standards and requirements)

Cross section:

The cross section of handrails shall be circular or elliptical, not less than 30mm or greater than 50mm in height or width for not less than 270mm around the uppermost surface.

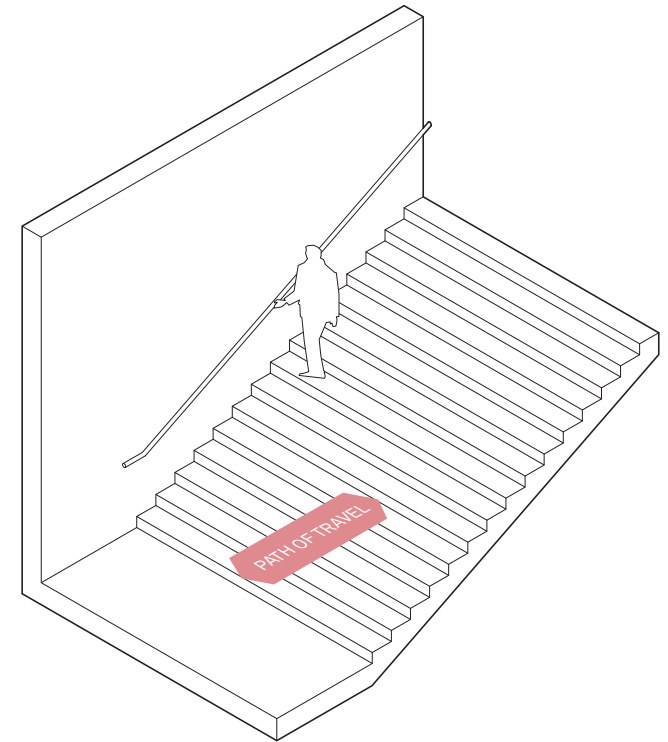
Exposed edges:

The ends and corners of handrails shall have a radius of not less than 5mm.

Height and clearance:

The top of handrails must be between 865mm and 1000mm above the nosing of stairway treads or the plane of the finished floor of the walkway, ramp or landing.

Clearance between a handrail and an adjacent wall surface or other obstruction shall be not less than 50mm. This clearance shall extend above the top of the handrail by not less than 600mm.



Existing Application: Forecourt Perimeter, Lower Concourse
(Source: Grimshaw)

Free standing handrail

Cross section:

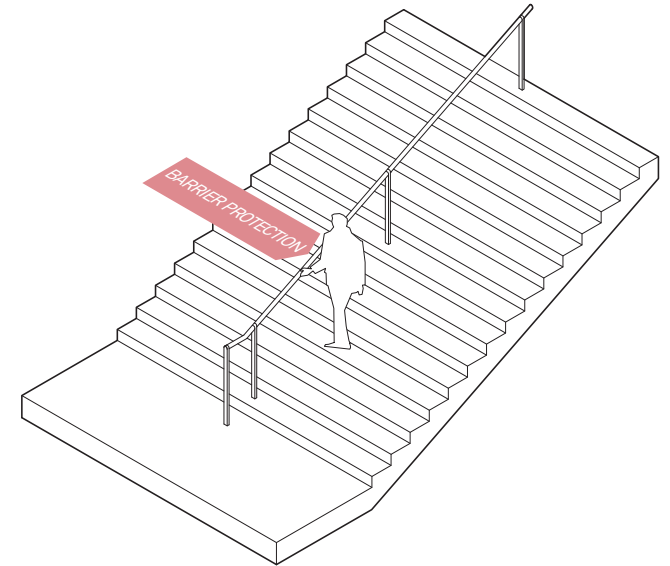
The cross-section of handrails shall be circular or elliptical, not less than 30mm or greater than 50mm in height or width for not less than 270° around the uppermost surface.

Exposed edges:

The ends and corners of handrails shall have a radius of not less than 5mm.

Height and clearance:

The top of handrails must be between 865mm and 1000mm above the nosing of stairway treads or the plane of the finished floor of the walkway, ramp or landing. Clearance between a handrail and an adjacent wall surface or other obstruction shall be not less than 50mm. This clearance shall extend above the top of the handrail by not less than 600mm.

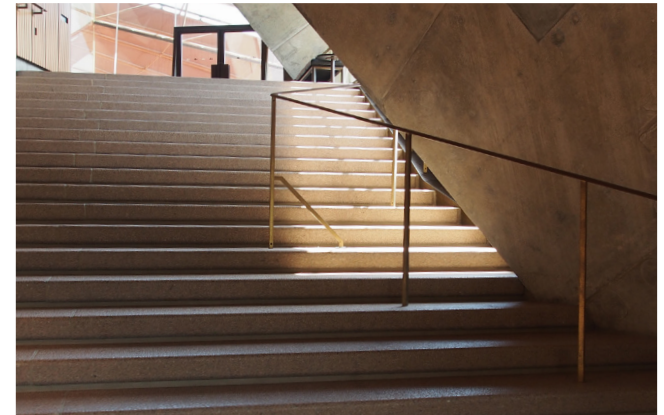
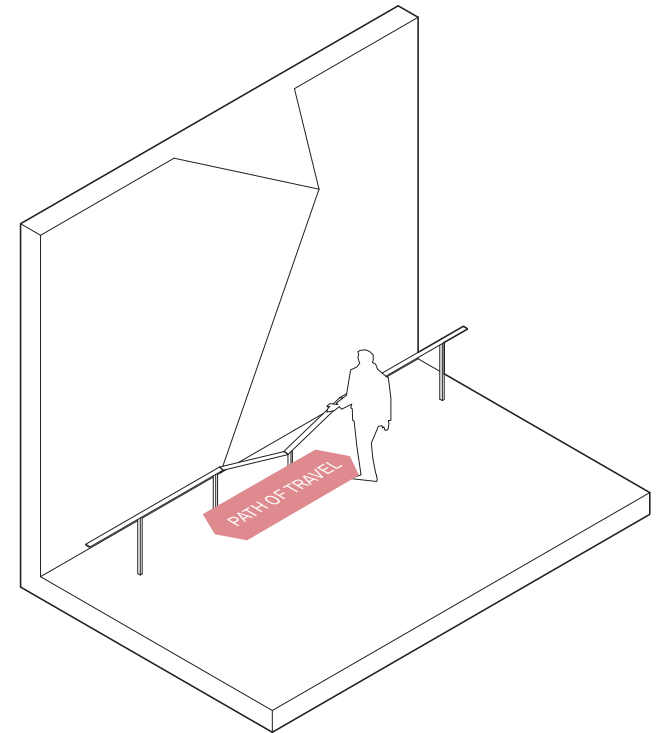


Existing Application: Northern Foyers, East & West Foyers, Southern Foyer, Podium Steps, Lower Concourse (Source: Grimshaw)

Guard rail

When the control of people is required to prevent access or in instances where head height is reduced presenting a hazard (under stairs and overhead projections) the use of guard rails may be required.

Guard rails are not required to have an infill panel, prevent climbing or designed in such a way to resist structural loads i.e. they are not required to resist a full crowd loading category



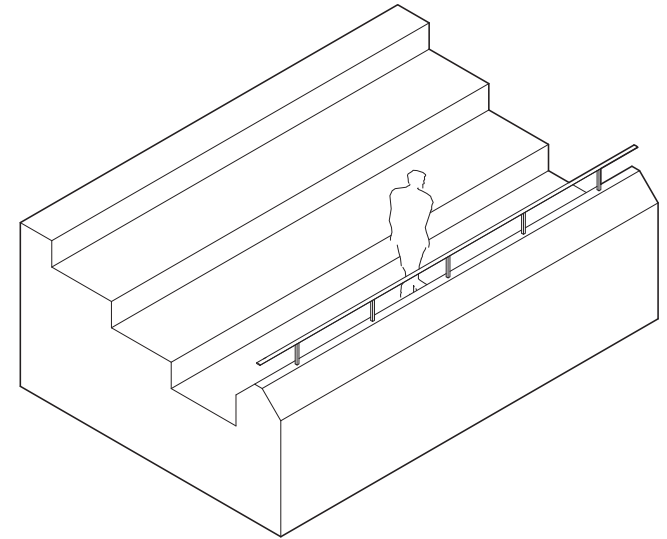
Existing Application: Northern Foyers, East & West Foyers, Southern Foyer (Source: Grimshaw)

Performance space rail

This type refers to a series of different profiles which are designed to minimise the visual impact, and provide protection from falling inside the performance spaces. These types are referred to in the Government Architects Office report 'Handrail and Barrier Master Plan 2014' as follows;

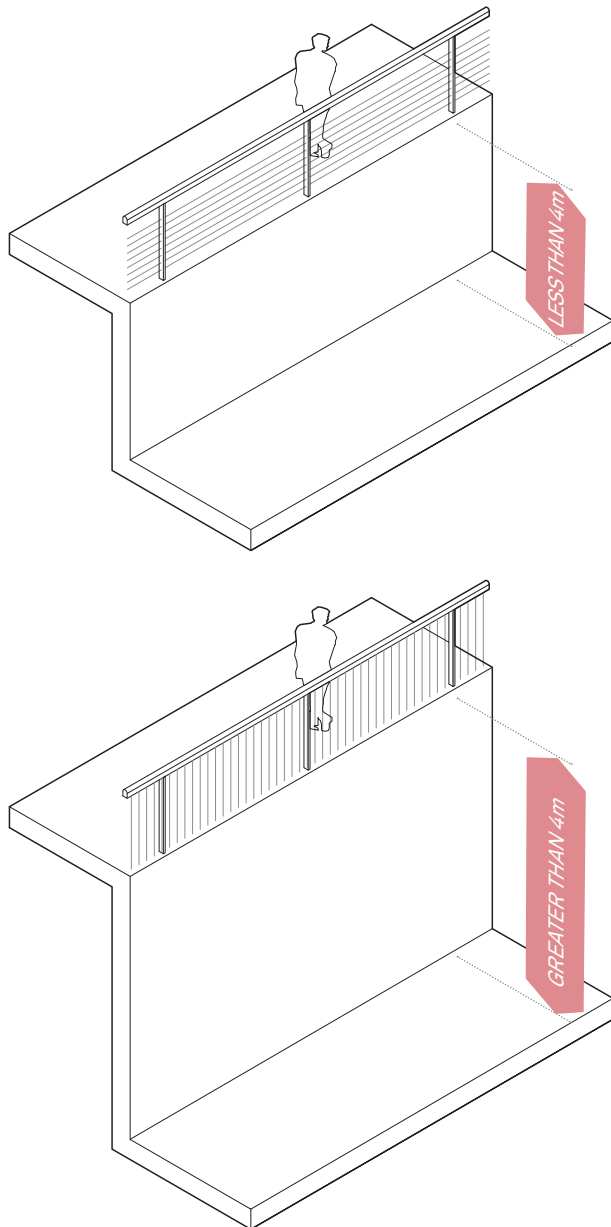
- EB - Elliptical Guardrail
- EH.2* - Elliptical Handrail, Type 2
- SH - Square Handrail
- CHB.1* - Circular Handrail Barrier, Type 1
- CHB.2* - Circular Handrail Barrier, Type 2

Note that none of these types fulfil legislative requirements. They do not have infill and are not designed in such a way as to resist structural loads (crowd loading etc).



Existing Application: Concert Hall, Joan Sutherland Theatre, Studio Auditorium (Source: Grimshaw)

Infill



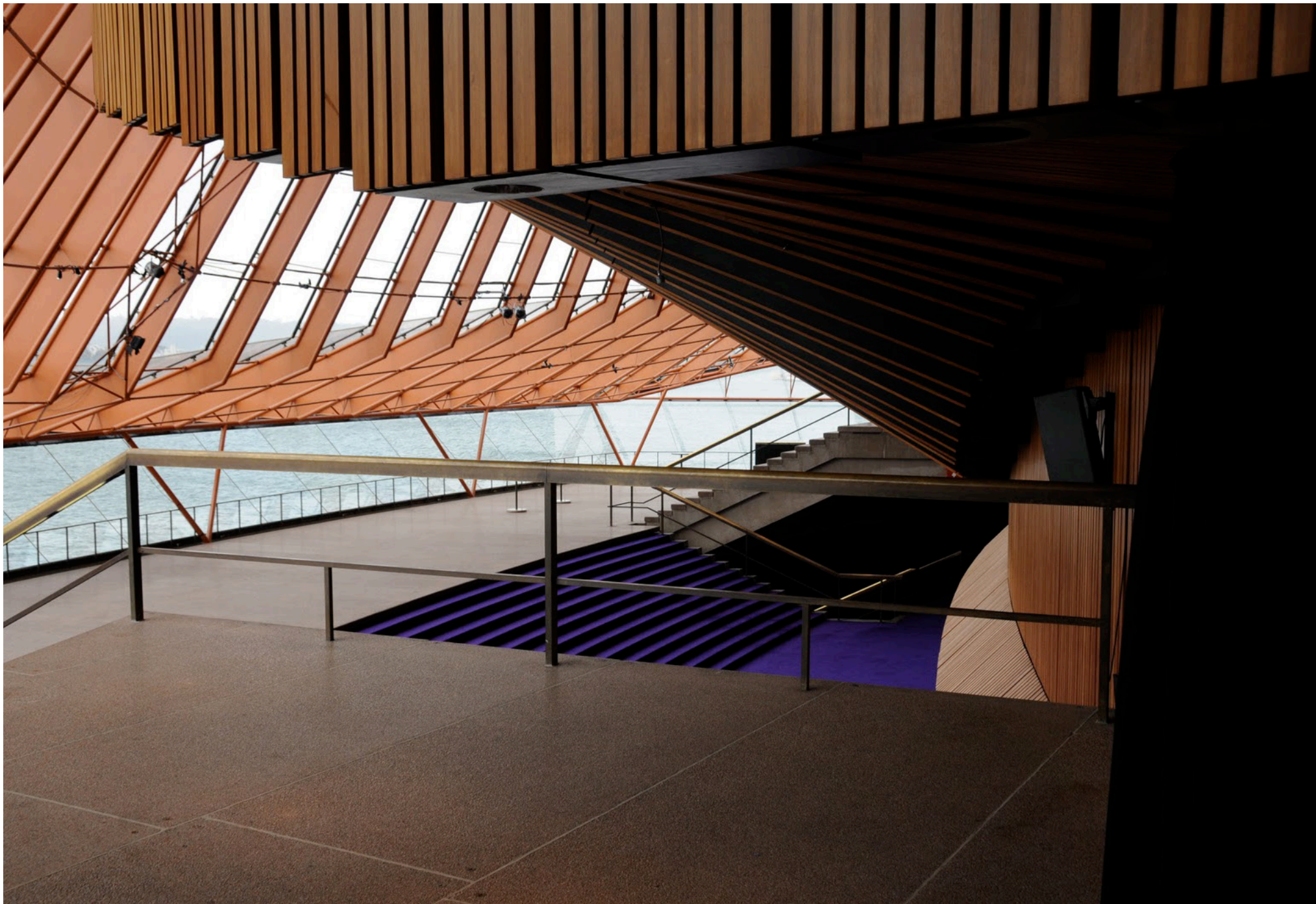
Barrier infills are typically required to be constructed in a manner so that a 125mm sphere is not permitted to pass through it.

The most recent barriers constructed at the Sydney Opera House are the additions to the Western Concourse; here the Opera House has utilised a horizontal wire system. They are deemed to comply when constructed in accordance with the following:

Construction achieves minimum tension values and does not exceed the maximum deflections for the wire size and spacing. For floors more than 4m above the surface beneath any horizontal or near horizontal elements between 150mm and 760mm above the floor must not facilitate climbing.

For non-continuous vertical wire systems, when measured with a strain indicator, must be in accordance with the minimum tension values determined by wire size and spacing, must have wires of no more than 2.5mm diameter (7x7 or 7x9 lay) construction; and changes in direction at support rails must pass around a pulley block without causing permanent deformation to the wire; and must have supporting rails,

constructed with a spacing of not more than 900mm, of material that does not allow deflection that would decrease the tension of the wire under load; and when the wire tension with a strain indicator achieves minimum tension values and does not exceed the maximum deflections for the wire size and spacing.



Chapter 1

Exterior Bronze Componentry



Introduction

Exterior bronze componentry

In addition to the engineering, design and heritage aspirations, statutory accessibility requirements are driving the need and impetus for a new barrier and handrail suite. Inclusion of handrail extensions, down-turns and barrier infills are a departure from the existing exterior fabric however it is important to remember that they are necessary to achieve a compliant barrier solution.

The proposed componentry solutions build on the established placement and rhythm of existing barrier and precast granite sett building modules. This is to maintain the orientation and location of the existing barrier posts in order to minimise the impact of the renewal works within the Opera House Precinct.

The exterior componentry design has been developed with a dominant circular top rail referencing the original U-Profile extending the designs of the Utzon Room and Western Concourse. It accommodates stair geometries both vertically and in plan where each profile is notched and mitred around the 80x40mm post. An essential requirement is to maintain the vertical joint between top rail profiles, allowing the individual sections to be removed, while referencing the vertical alignment of the original U-Profile details.

Of particular interest to the design and engineering team is the span of individual barrier elements to ensure the engineering requirements are met and to provide achievable constraints for the design.

Interior barriers at entertainment venues across NSW must have a top rail height of 1000mm AFFL [BCA 2009 Clause D2.16 (f) NSW Table D2.16a Barrier Construction]. The Opera House includes a range of public spaces which fall into the category of “areas where people may congregate”, therefore based on the specific uses nominated within AS1170.1, barriers which protect a fall at the Opera House will need to be designed to support a crowd load of C5 (see following table).

There are lower loading categories which might initially appear to be applicable for some specific areas (i.e. C1/C2 for stairs), however the higher load criteria requires the Opera House to explicitly include internal and external areas with bars, theatres, auditoria, assembly areas and studios.

Minimum height for exterior 1200mm		Minimum imposed load to top edge			Minimum imposed load to infill	
Type of occupancy for part of the building or structure	Specific Uses	Horizontal (kN/m)	Vertical (kN/m)	Inward, outwards or	Horizontal (kPa)	Any Direction (kN)
C5 Areas susceptible to over-crowding	Theatres, cinemas, grandstands, discotheques, bars, auditoria, shopping malls, assembly areas, studios etc.	3.0	0.75	0.6	1.5	1/5

1.1

Barriers

Exterior barrier: BAR-200

Design application

BAR-200 is the exterior version of interior BAR-100 and is the barrier and handrail for all exterior spaces. Its component parts include top rail, post, and infill vertical tension rods mounted to a concealed cassette in the top rail, down to the granite sets and stair treads.

Nominated locations

All exterior locations, Level 2 Podium, North and Eastern Forecourts, Western Forecourt, stairs, ramps and barriers to the Ground Floor, Concourse and Lower Concourse.

Code requirements

National Construction Code:

- 2016 Building Code of Australia
- Disability Discrimination Act:
- AS1428.1 (2009) Design for Access and Mobility
- Engineering:
- AS 1170.1 (2002) Structural Design Actions;
- AS 1926.1 (2007) Safety Barriers for Swimming Pools; and
- AS/NZS 1680.2.1 (2008) Interior and Workplace Lighting

Specifications

Height: 1200mm

Top rail: 80mm Diameter (C5 3.0 kN/m horizontal, 0.75 kN/m vertical)

Handrail: 47mm Diameter (0.75 kN/m horizontal, 0.75 kN/m vertical)

Maximum Span: 2450mm

Post size: 80x40mm

Infill: vertical tension rods (C5 1.5 kPa horizontal, 1.5 kN/m any direction) mounted from an extruded cassette concealed in the top rail which is fixed to a granite sett.

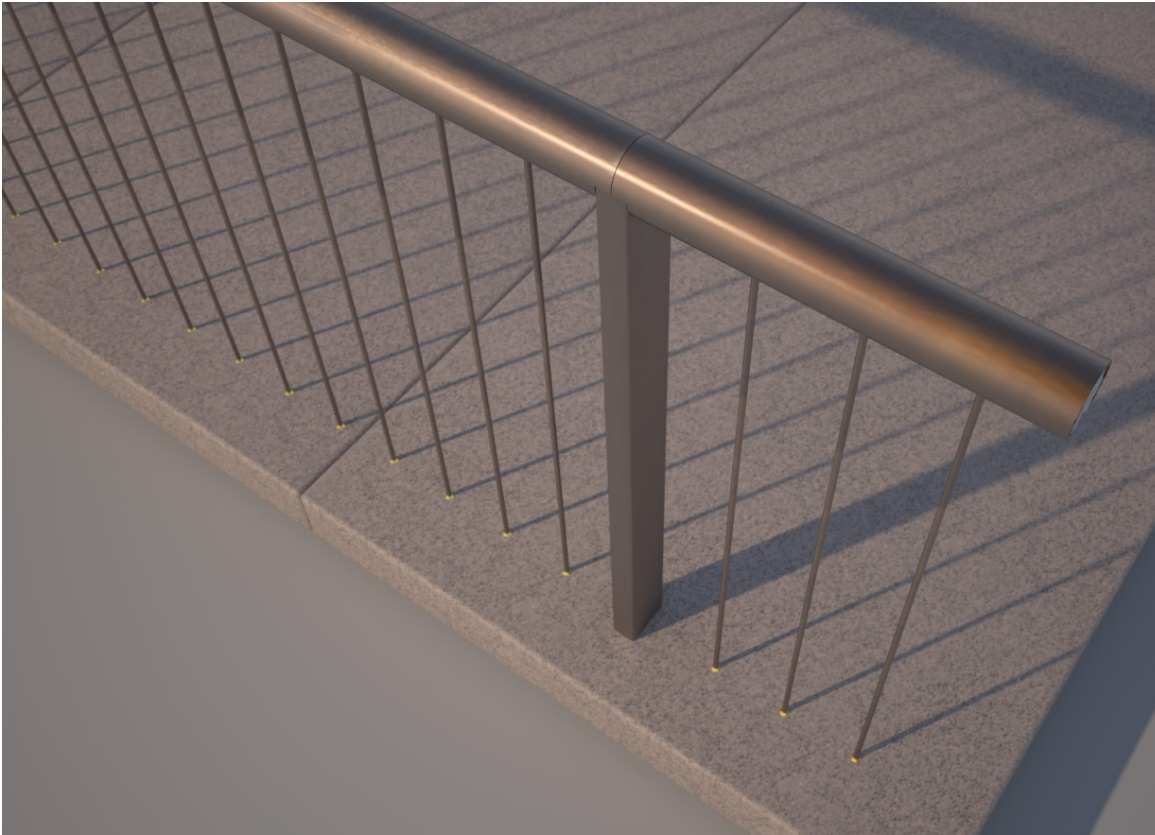
Accessibility: Handrail extensions return and connect to adjacent stairs, handrails used adjacent to stair and ramps, for straight sections on the podium handrail, can be omitted.

Components

- Handrails;
- Kerb; and
- Kick boards

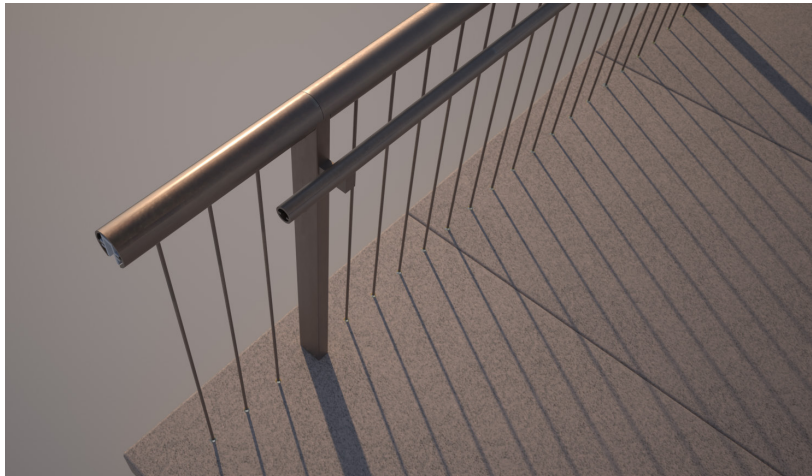
Lighting

To be developed as the exterior barrier designs are implemented. Principal approach is to use the linear LED 20 x 355 mm LED lighting accommodated within the handrail subject to coordination with the overall lighting strategy.

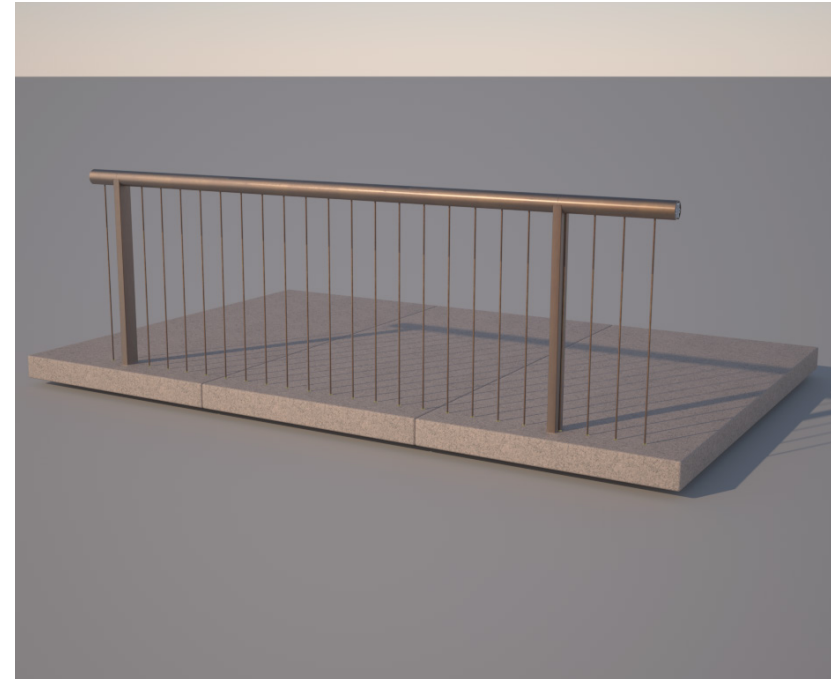


01

- 01 Rendered perspective of the Exterior Podium with vertical tension rod infill (Grimshaw)
- 02 Rendered perspective without handrail (Grimshaw)
- 03 Rendered perspective handrail detail (Grimshaw)
- 04 Rendered perspective with handrail (Grimshaw)



03



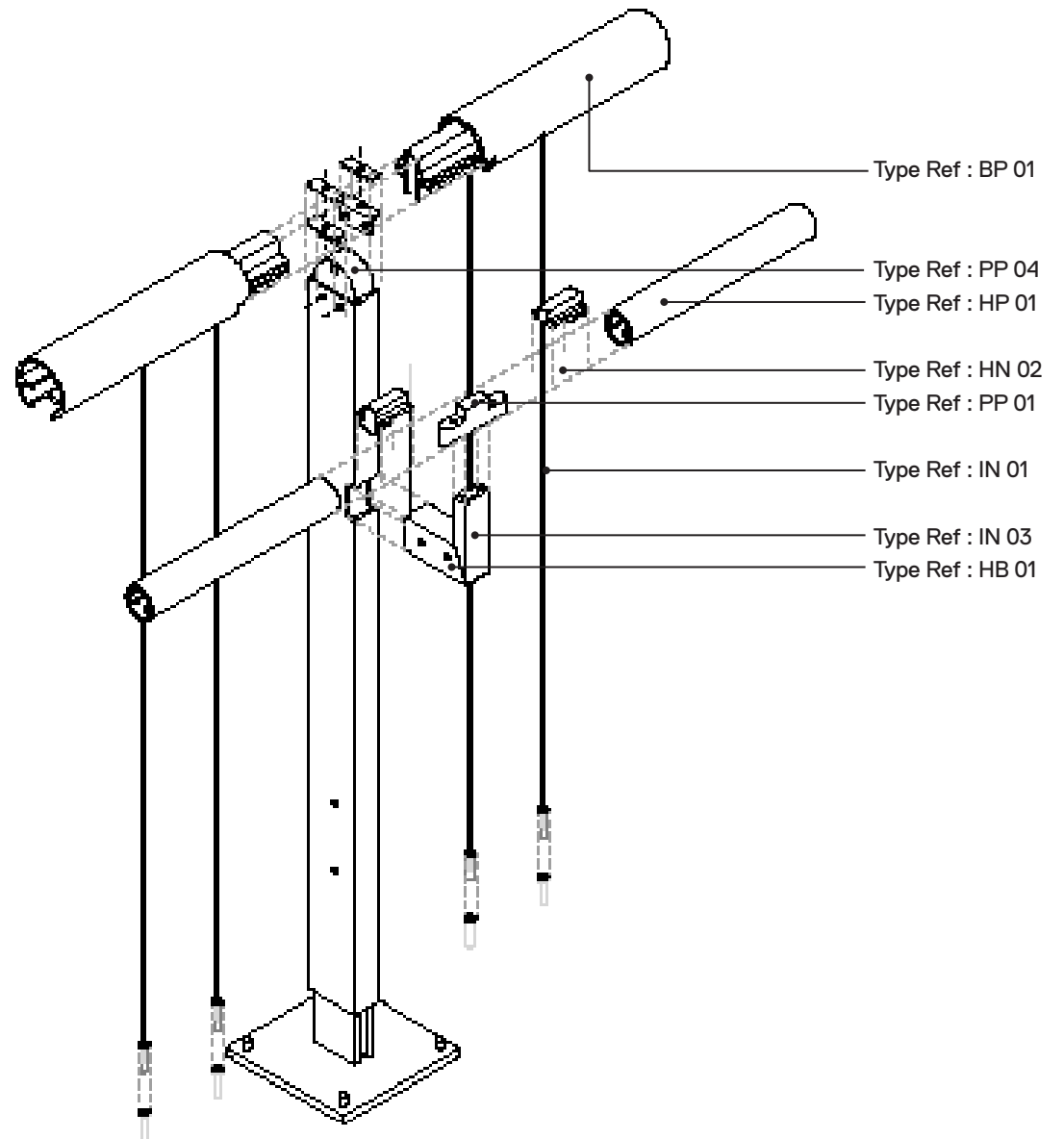
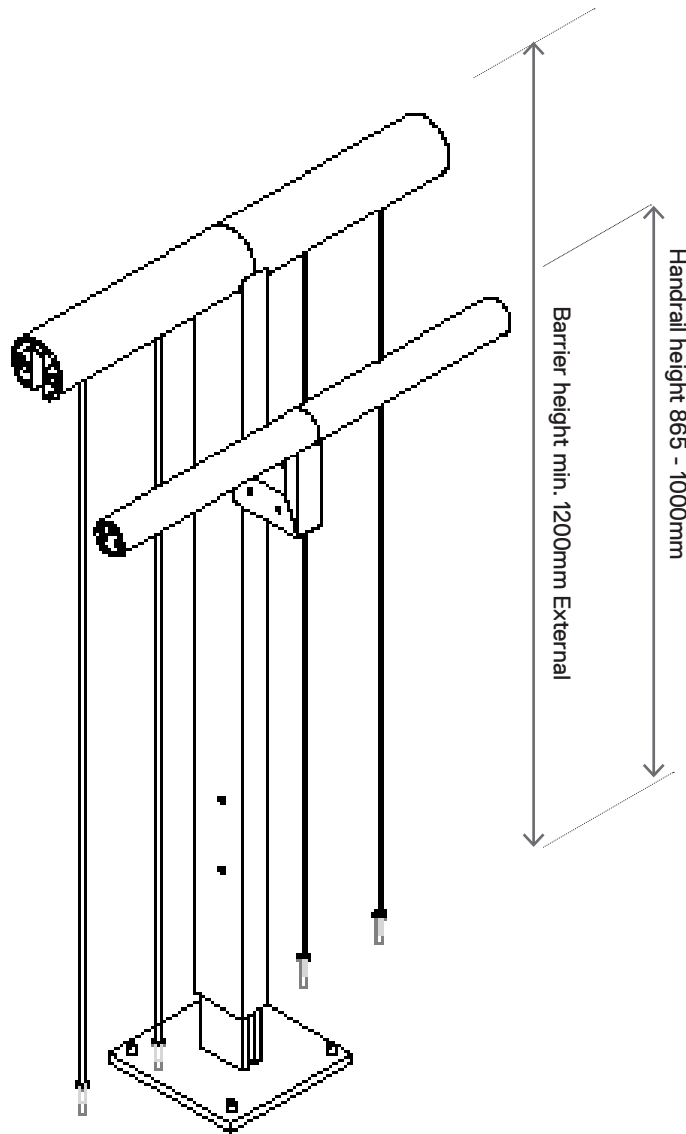
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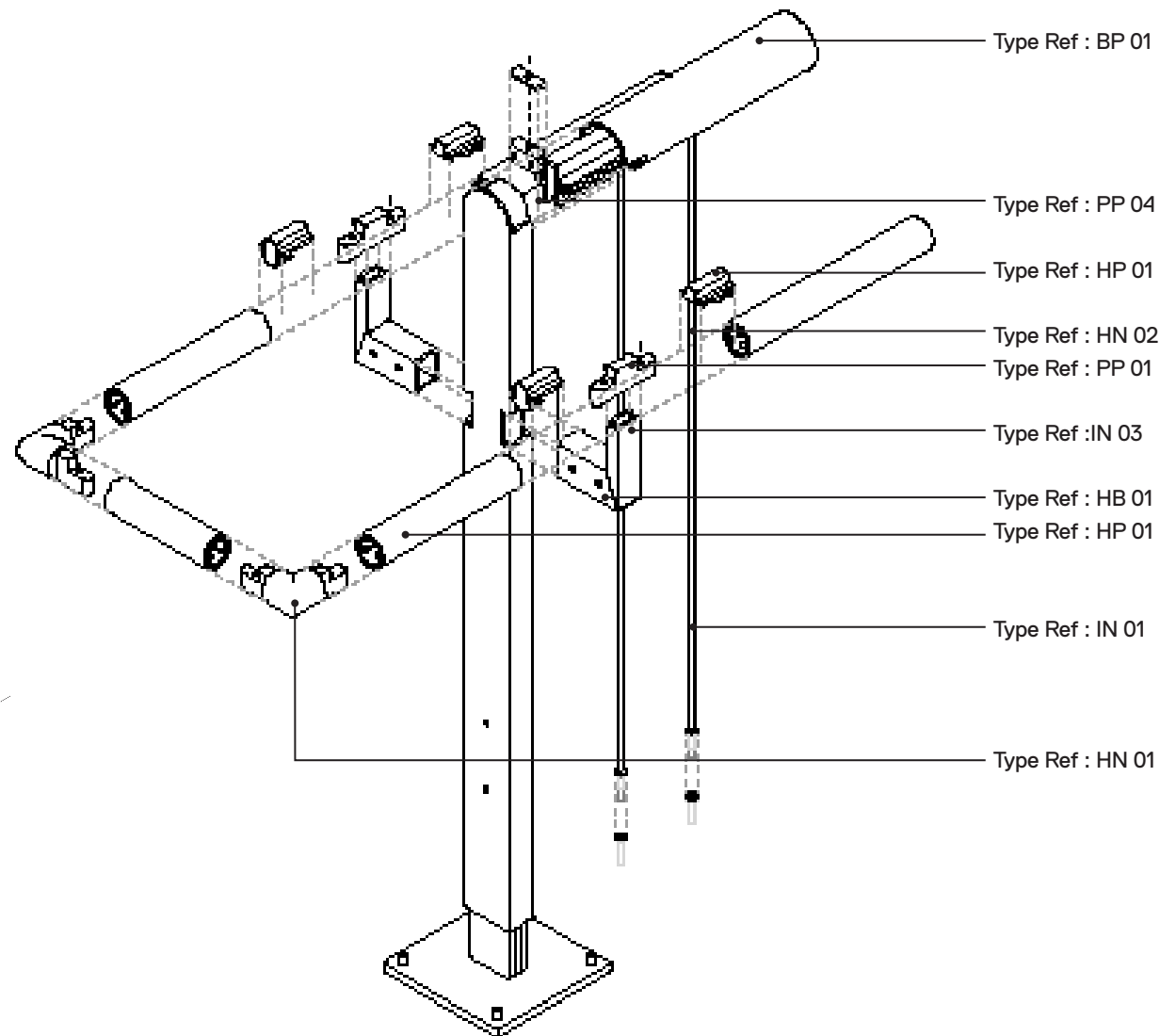
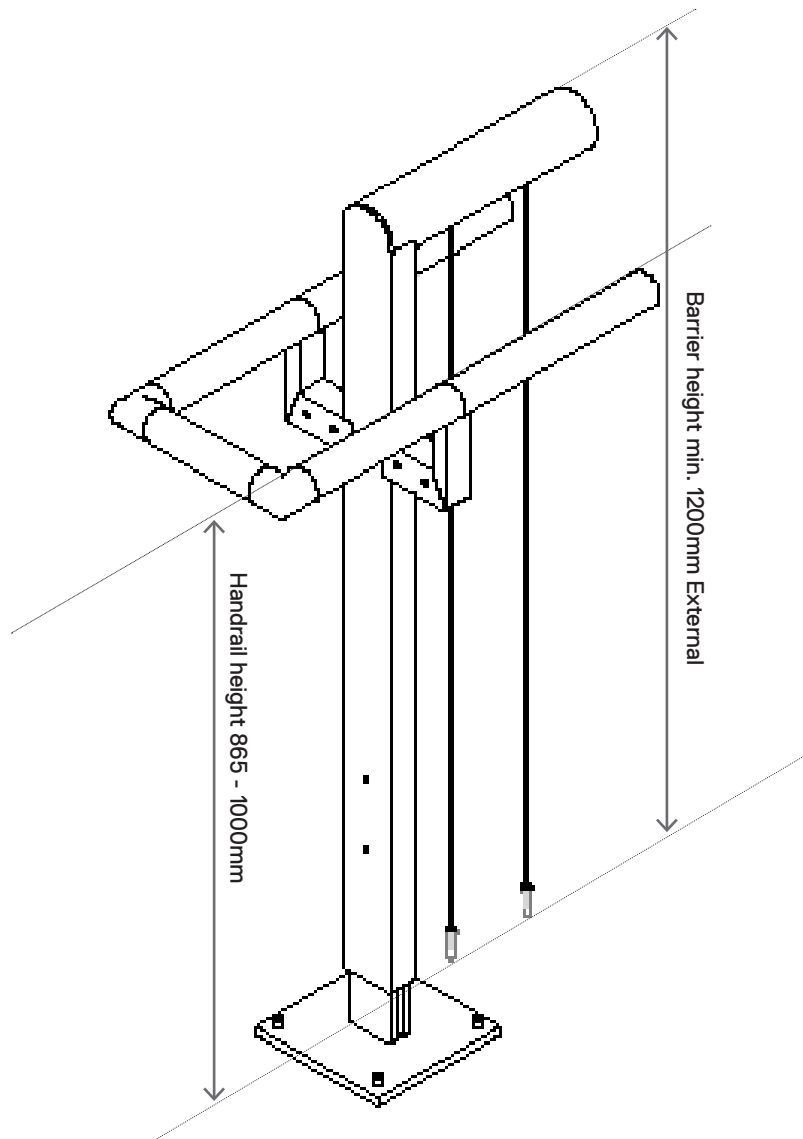
Exterior barrier: BAR-200

Typical details



Exterior barrier: BAR-200

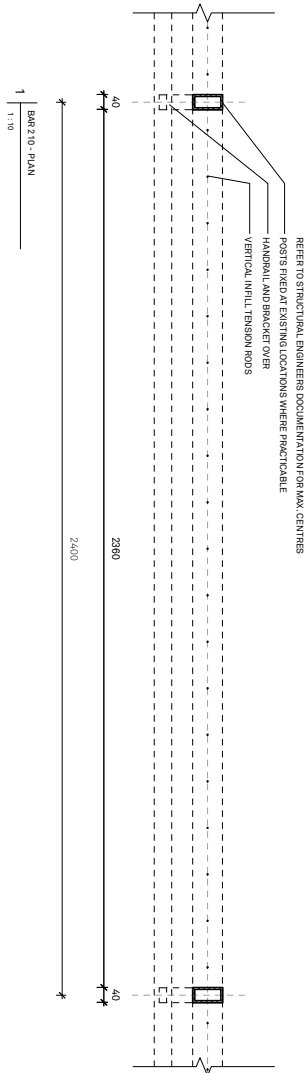
Handrail terminations



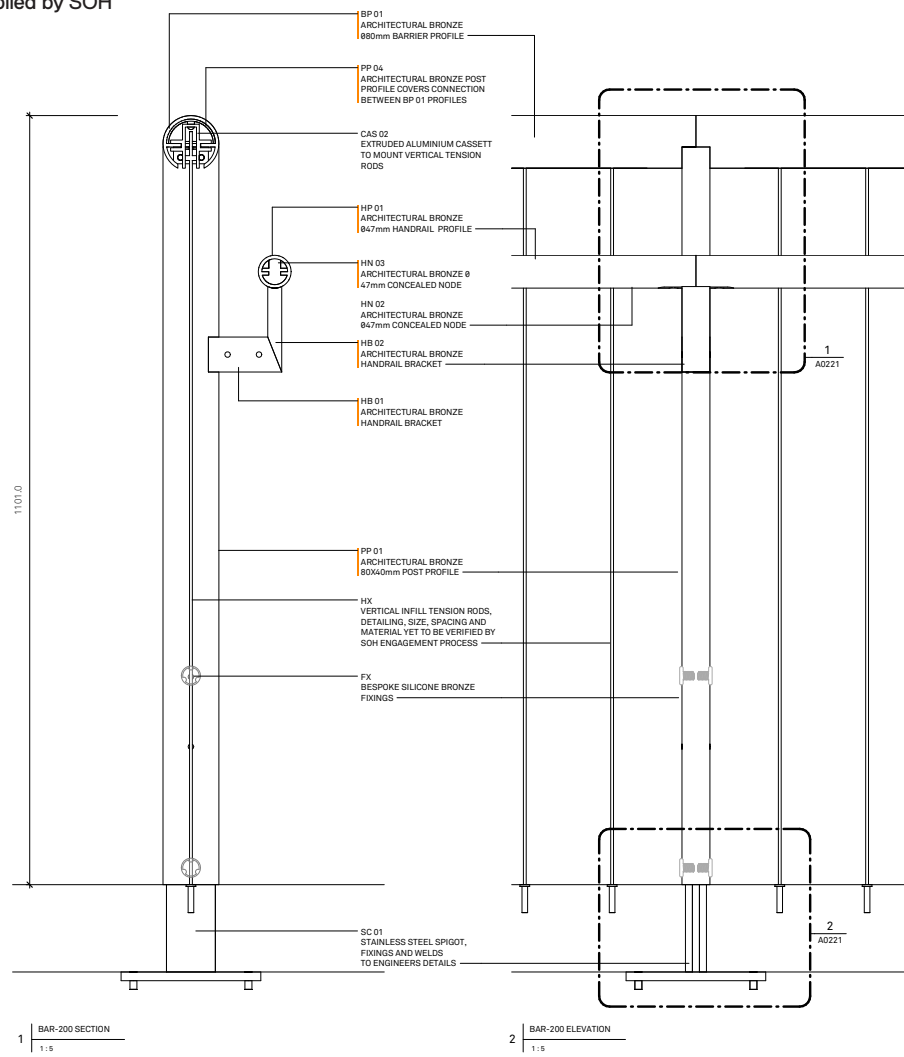
Exterior barrier: BAR-200

Top rail and infill

DWG : 49-BR-GAS01-A0210 - BAR 200 DETAILS



Indicates bronze extrusion
supplied by SOH



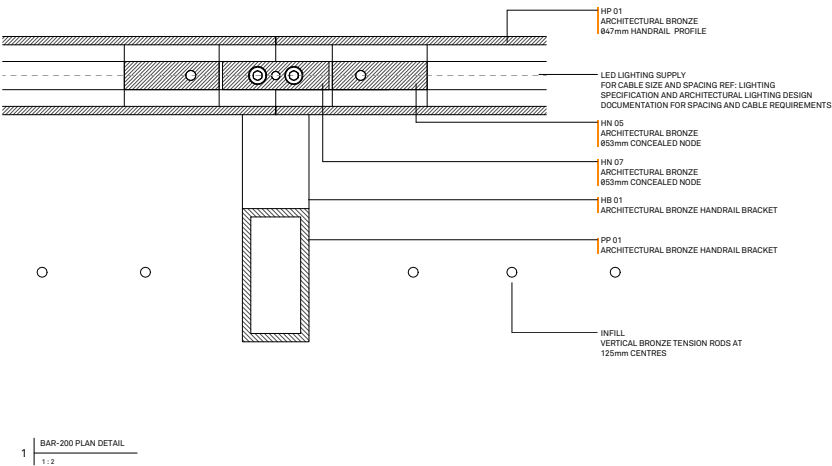
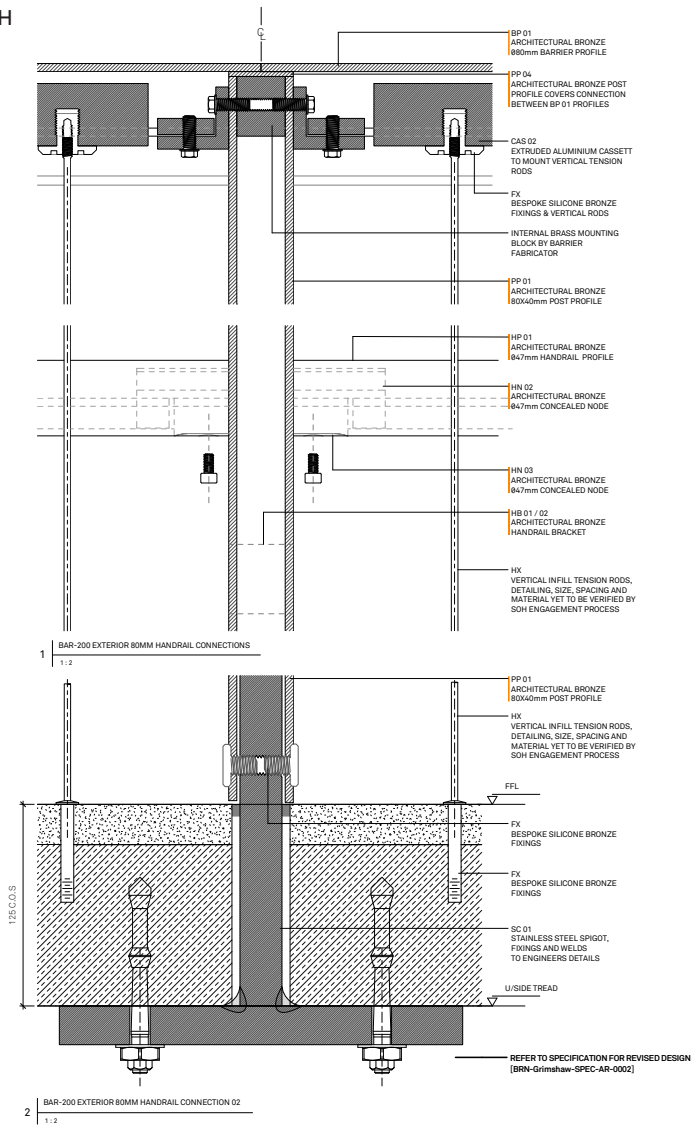
ISSUE - ARCHITECTURAL BRONZE EXTRUSION

DWG : 49-BR-GAS01-A0221 - BAR 200 DETAILS

Exterior barrier: BAR-200

Top rail and handrail sections

Indicates bronze extrusion
supplied by SOH

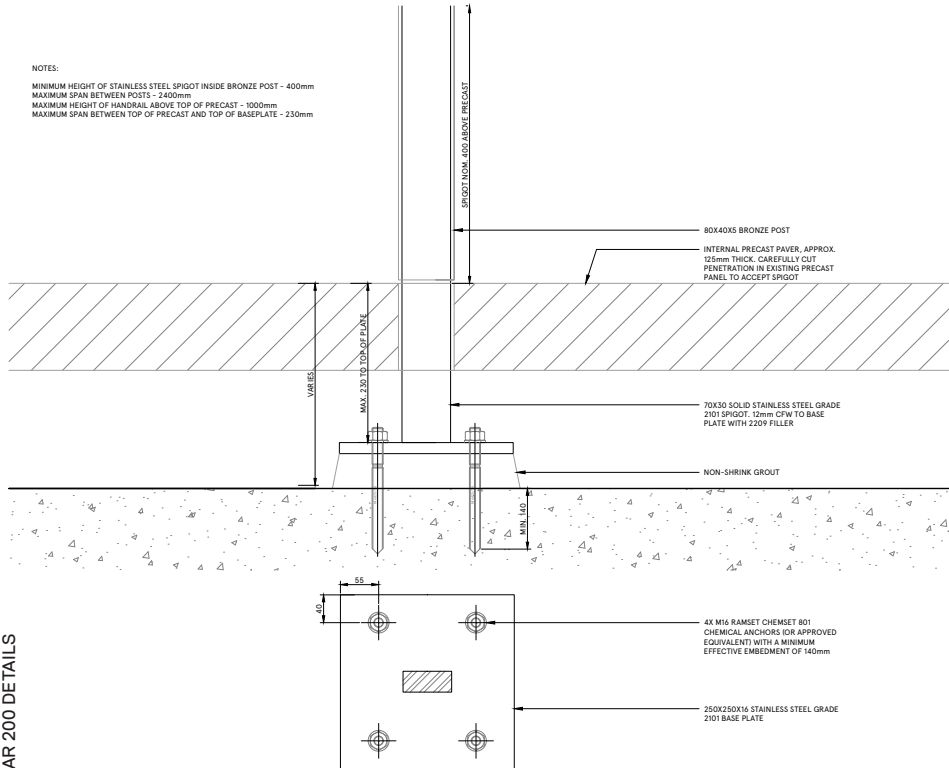


DWG : 49-BR-GAS01-A0221 - BAR 200 DETAILS

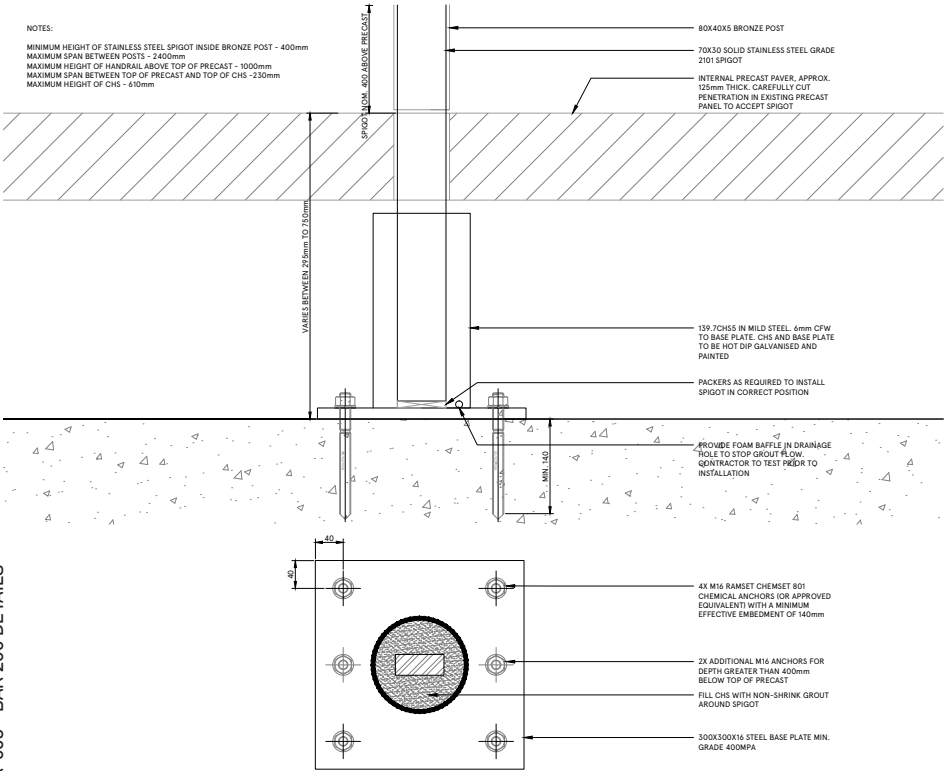
DWG : 49-BR-GAS01-A0223 - BAR 200 DETAILS

Exterior barrier: BAR-200

Structural details



PRISM DWG : FADR-003 - BAR 200 DETAILS

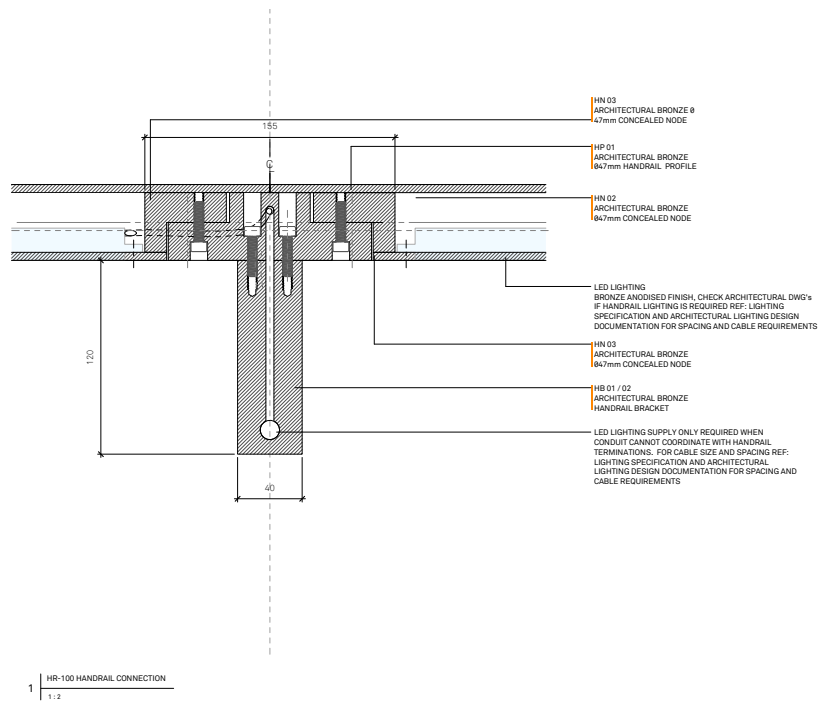


PRISM DWG : FADR-003 - BAR 200 DETAILS

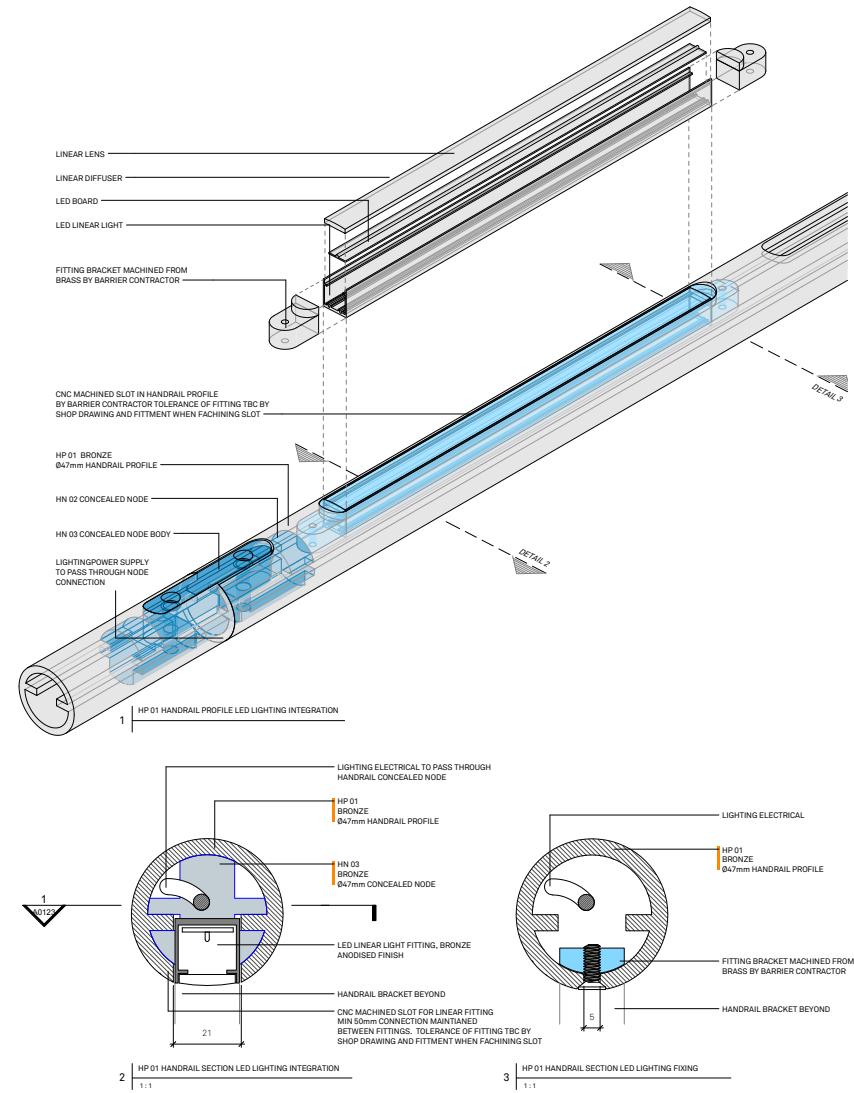
Exterior barrier: BAR-200

Lighting details

PRISM DWG : 49-BR-GAS01-A0721 - BAR 200 DETAILS



PRISM DWG : 49-BR-GAS01-A1210 - BAR 200 DETAILS



Exterior barrier: BAR-200

Common requirements

Accessibility

All barrier designs have been assessed for DDA compliance by Richard Seidman of iAccess Consultants, the full report is attached as Appendix 2. The BAR-200 barrier and handrail is associated with the exterior forecourt Podium, Stairs and Ramps. In accordance with the minimum provision of the accessibility standards, the design of BAR-200 incorporates a 47mm handrail supported from the barrier post.

The detailed design of the BAR-200 handrail at the top of the stair includes a handrail which turns 180 degrees horizontally. This approach has been deemed acceptable by iAccess consultants provided the minimum handrail extension at the top of the stair flight is achieved. The minimum extension at the top of the flight that needs to be achieved is 300mm in accordance with the provisions of Clause 11.2(e) of AS1428.1:2009. The detailing of the handrail at the bottom of the stair flights, where the handrail turns 180 degrees horizontally has been assessed in respect of accessibility compliance. The approach presented is deemed acceptable providing the minimum extension at the base of the stair flight is achieved. The minimum extension at the base of the flight will need to be: stair going(mm) + 300mm which is in accordance with the provisions of Clause 11.2(d) of AS1428.1:2009

When used in ramp or sloped floor conditions, the BAR-200 barrier will require a kerb and/or kick plate located within a protective zone 65mm above the finished floor level (AFFL) to a height of 150mm AFFL. See diagram to the overleaf. Any supportive fixings located in a climbable zone (between 150mm and 760mm AFFL) must not be climbable and fixings may not project more than 10mm.

Lighting

To be developed as the exterior barrier designs are implemented. Principal approach is to use the linear LED 20 x 355 mm LED lighting accommodated within the handrail subject to coordination with the overall lighting strategy.

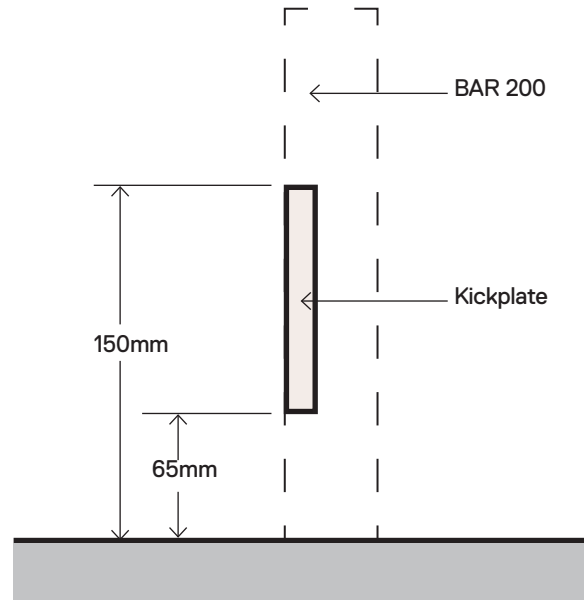
Engineering

Extensive engineering studies were undertaken by PRISM Facades during design development, and these studies in part informed the selection of structural members and connections through the detail design stage. Typically, exterior barriers at entertainment venues across NSW must have a top rail height of 1200mm AFFL [BCA 2009 Clause D2.16 (f) NSW Table D2.16a Barrier Construction], this, combined with C5 Loading requirements as defined in AS1170.1:2002, Table 3.3 and the span between barrier posts of 2450mm, has determined the size of elements. Exterior areas of the forecourt are susceptible to overcrowding and therefore AS1170.1 is applicable. This standard requires that any barriers must be able to resist a horizontal 'C5' live load of 3.0kN/m.

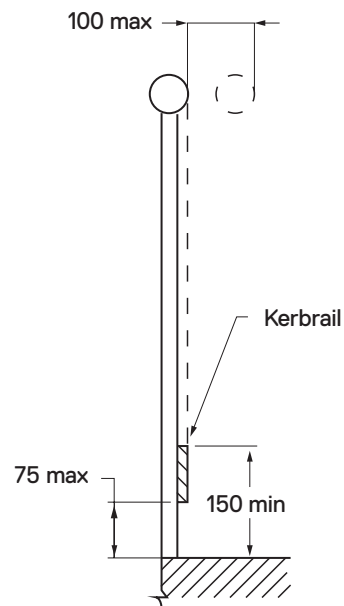
The BAR 200 exterior barrier includes an 80x40 post with a wall thickness of 7mm, the connection spigot at the base is required to have a height of 470mm (minimum). Due to the loads imposed upon this connection, the spigot is unable to be fabricated singularly from bronze and a stainless steel connection has been allowed for (Grade TBC).

The design and compliance requirements for barrier infill which protects from a fall greater than 4m is such that a 125mm sphere must not be able to pass through any opening (NCC D2.16, table D2.16a). Vertical tension rods for the exterior barriers are positioned with a max spacing of 125mm centre to centre with a nominal 15mm diameter and are designed so that they cannot be forced apart enough to allow a 125mm sphere to pass through (NCC D2.16, table D2.16a).

Vertical tension rods transfer their tension and applied infill loads to the extruded bronze top rail + the interior mounting cassette and the precast granite sets at the base and stair treads. A deflection limit of Height/60 in the top rail of the barrier system BAR-200 applies to prevent these cumulative loads visibly deforming the top rail.

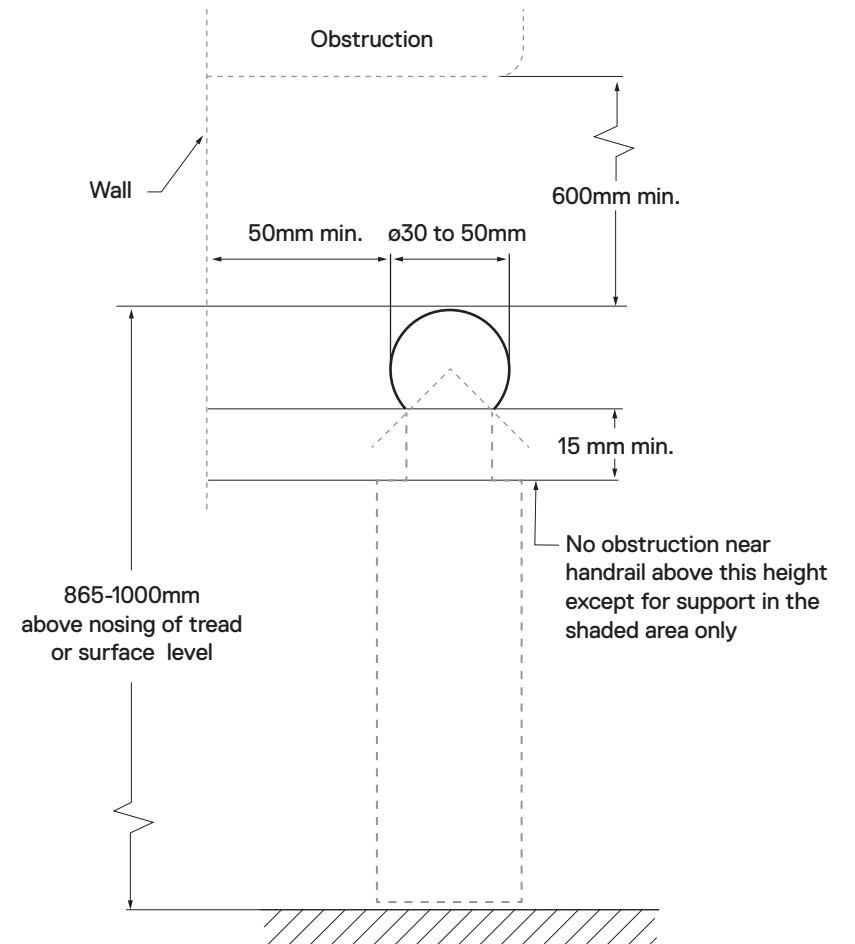


01



02

01 Ramp kickplate / kerbrail dimensions
02 Handrail positioning in relation to the kickplate / kerbrail
03 Handrail clearance diagram adapted from AS 1428.1-2009.



03

1.2

Handrails

Exterior handrail: HR-100

Design application

Throughout the exterior areas of the Opera House - access stairways and forecourt public areas - wall mounted handrails have been designed with a circular profile to suit adjacent environmental commonalities.

Nominated locations

All exterior locations, Level 2 Podium, North and Eastern Forecourts, Western Forecourt, stairs, ramps and barriers to the Ground Floor, Concourse and Lower Concourse.

Code requirements

National Construction Code:

- 2016 Building Code of Australia
- Disability Discrimination Act:
- AS1428.1 (2009) Design for Access and Mobility
- Engineering:
- AS 1170.1 (2002) Structural Design Actions; and
- AS/NZS 1680.2.1 (2008) Interior and workplace lighting

Specifications

Height: 865 - 1000mm

Handrail: 47mm Diameter (0.75 kN/m horizontal, 0.75 kN/m vertical)

Maximum Span: 2450mm

Bracket: 53x20mm

Accessibility: Handrail extensions return and connect to adjacent stairs, or terminate into the adjacent wall finishes.

Components

NA

Lighting

To be developed as the exterior barrier designs are implemented. Principal approach is to use the linear LED 20 x 355 mm LED lighting accommodated within the handrail subject to coordination with the overall lighting strategy.



01

- 01 Rendered elevation of the Exterior wall mounted handrail (Grimshaw)
- 02 Handrail termination option (Grimshaw)
- 03 Rendered perspective of the exterior wall mounted handrail (Grimshaw)
- 04 Handrail termination option (Grimshaw)



03



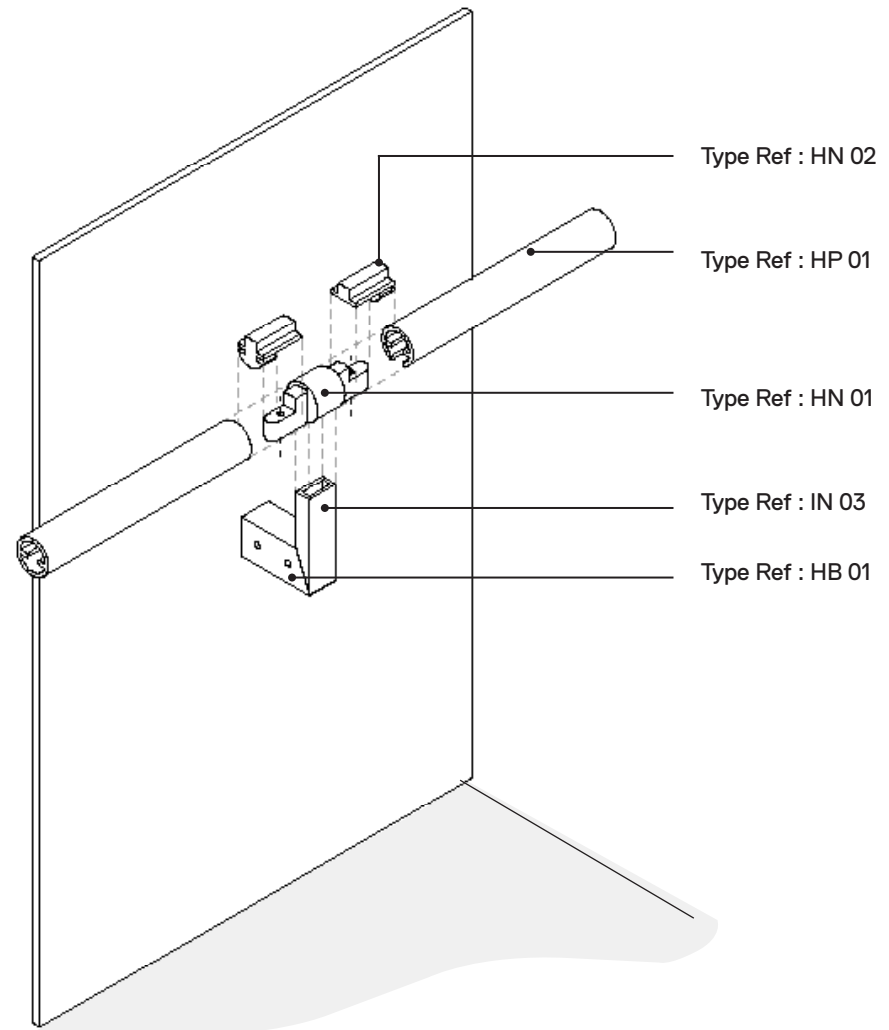
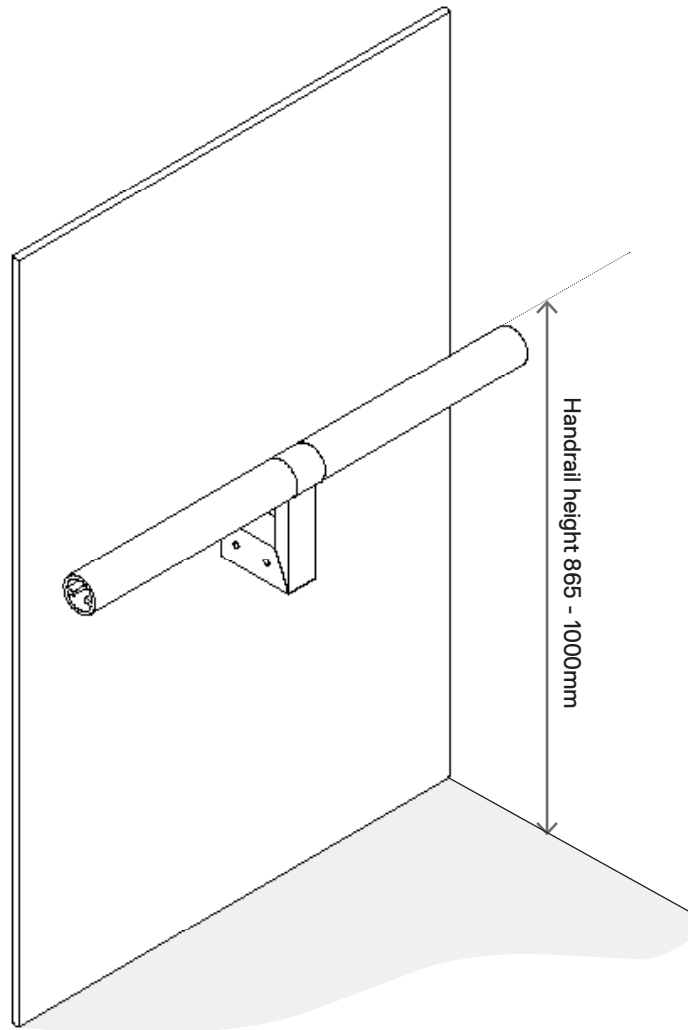
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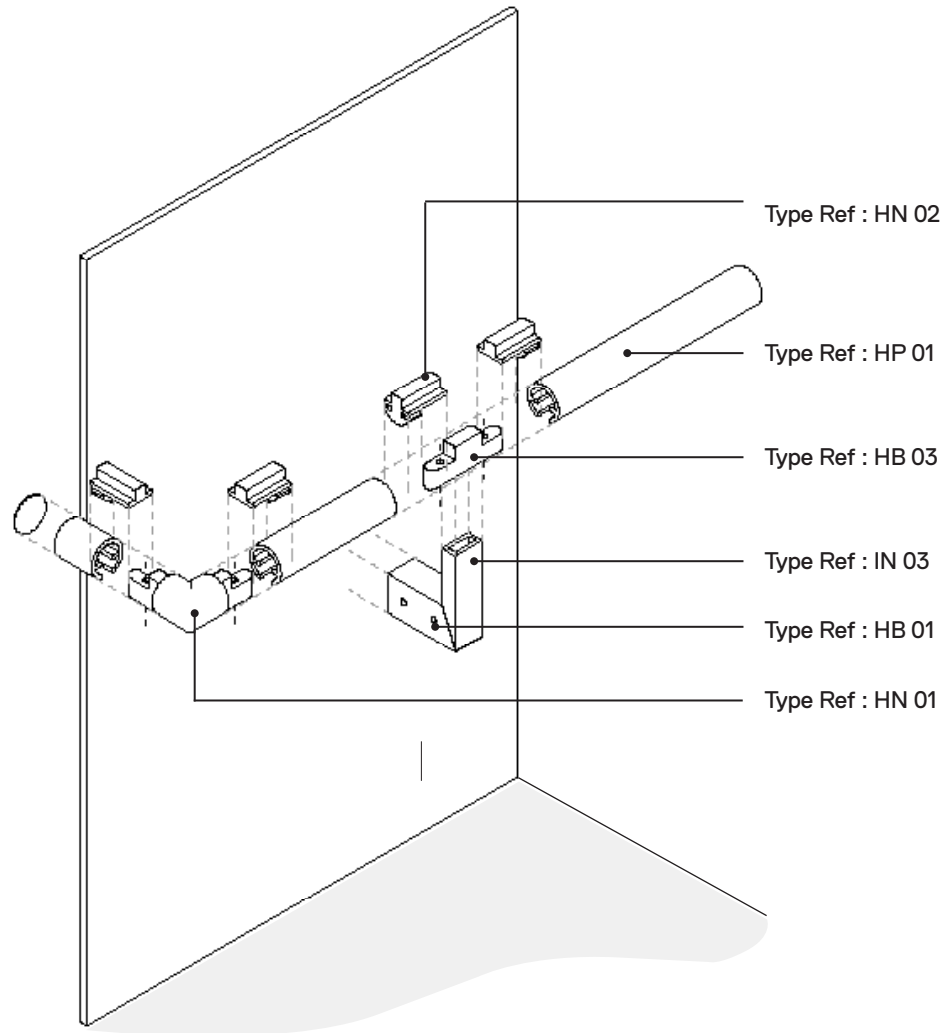
Exterior handrail: HR-100

Typical detail

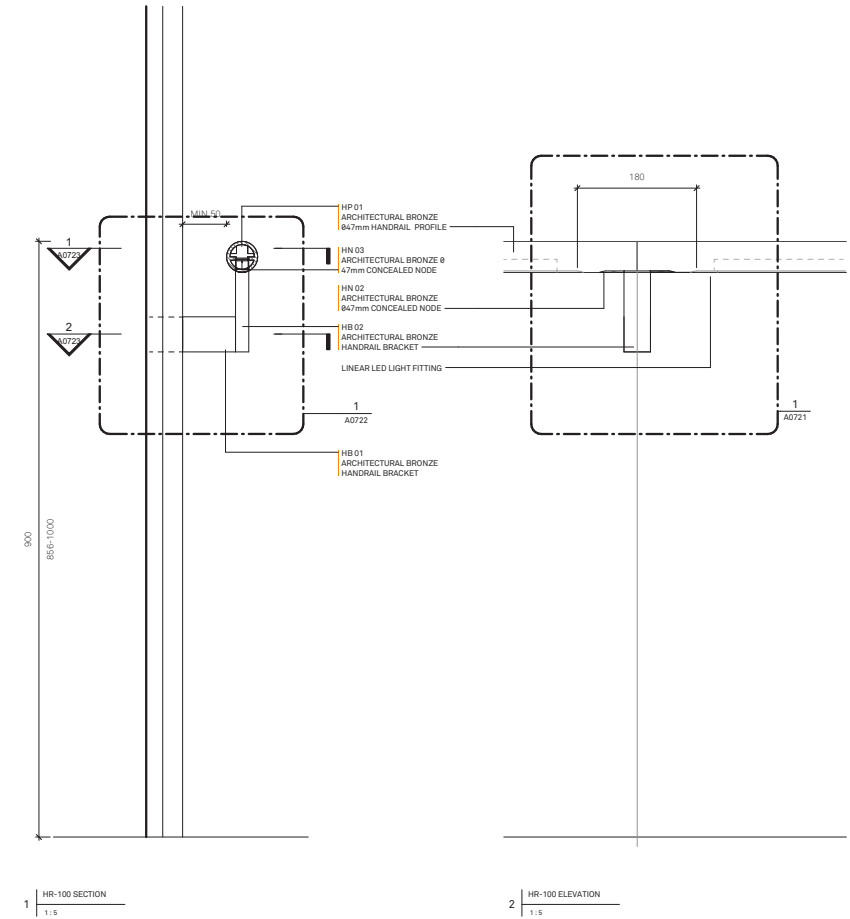


Exterior handrail: HR-100

Handrail termination detail



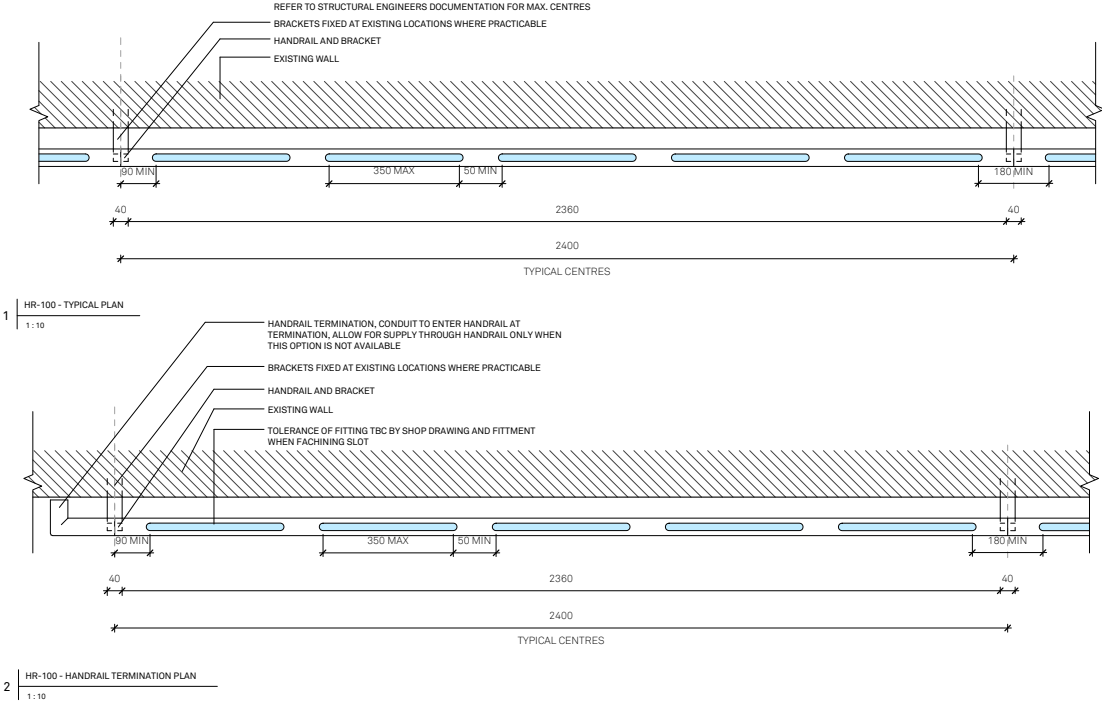
DWG : 49-BR-GAS01-A0711 - HR - 100 DETAILS



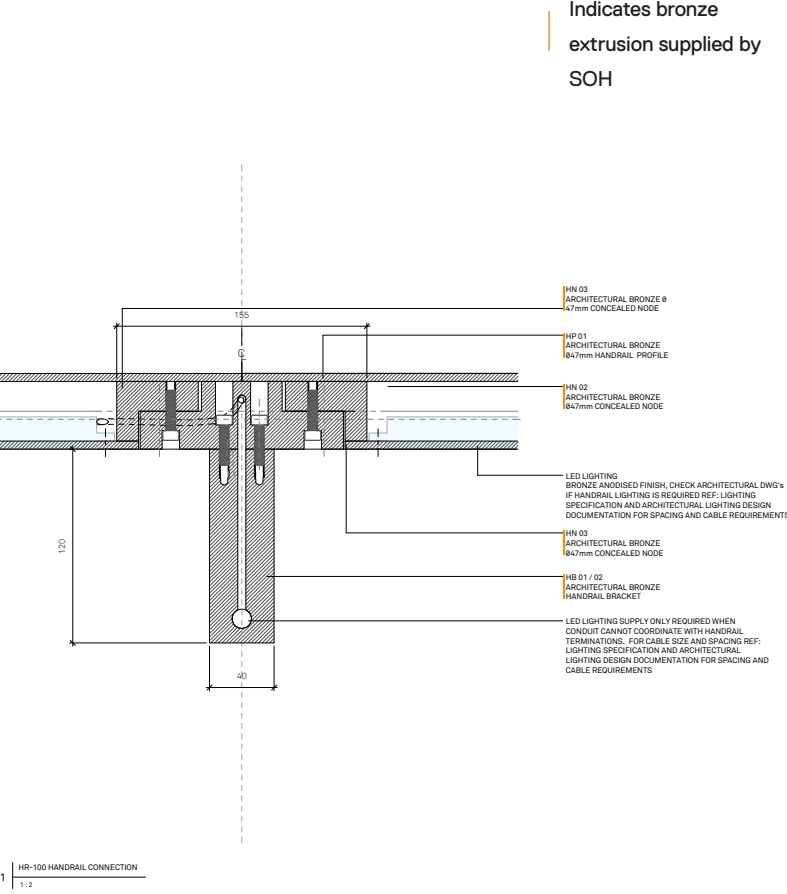
Exterior handrail: HR-100

Handrail plan and section

PRISM DWG : 49-BR-GAS01-A0710 - HR 100 DETAILS



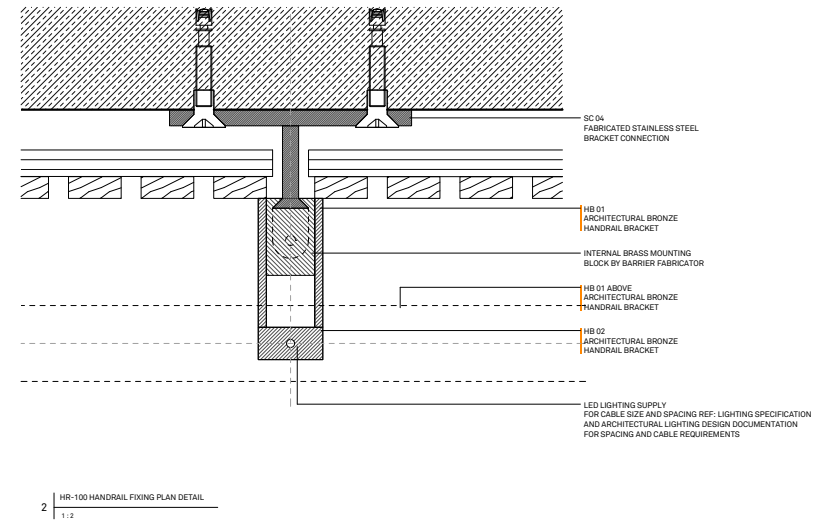
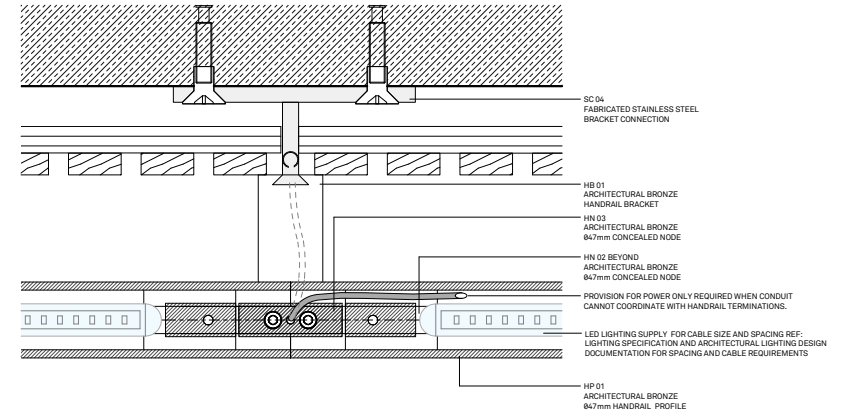
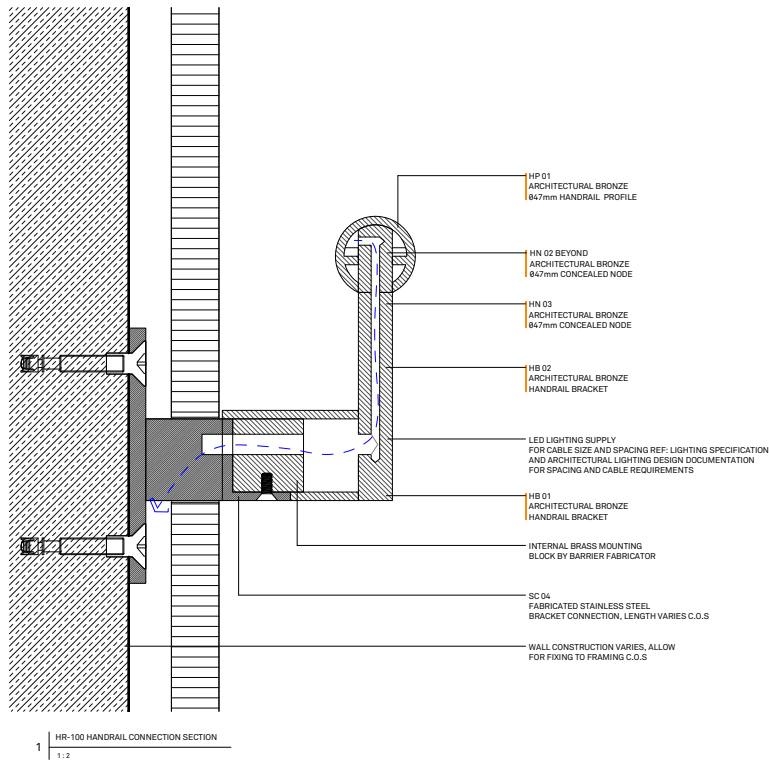
PRISM DWG : 49-BR-GAS01-A0723 - HR 100 DETAILS



Exterior handrail: HR-100

Handrail sections

Indicates bronze
extrusion supplied by
SOH

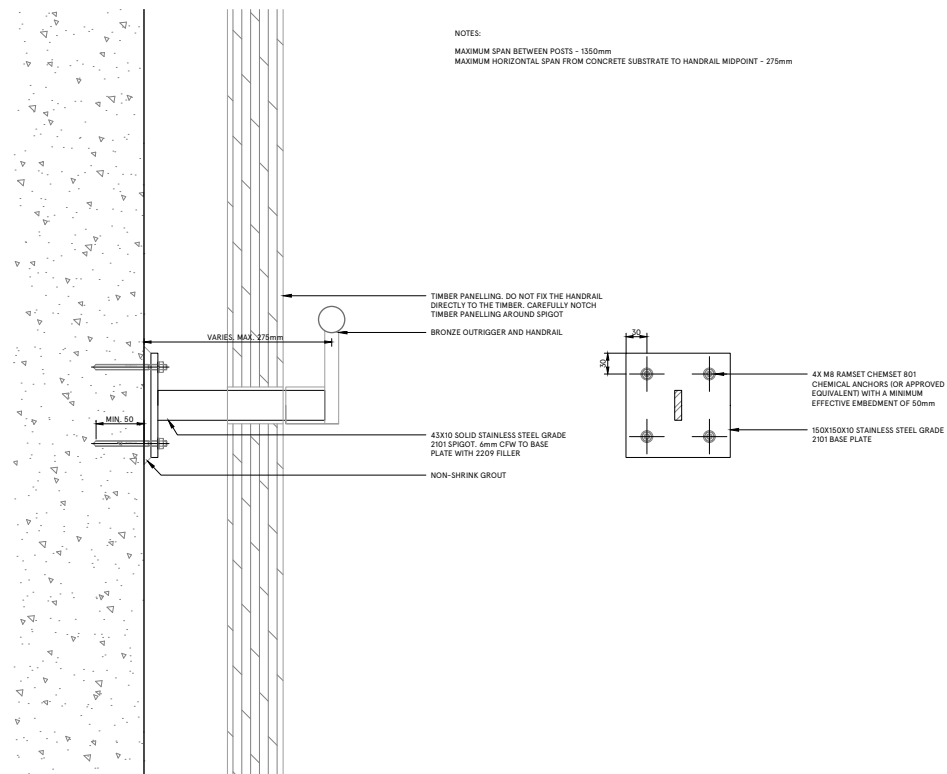


PRISM DWG : 49-BR-GAS01-A0723 - HR 100 DETAILS

PRISM DWG : 49-BR-GAS01-A0723 - HR 100 DETAILS

Exterior handrail: HR-100

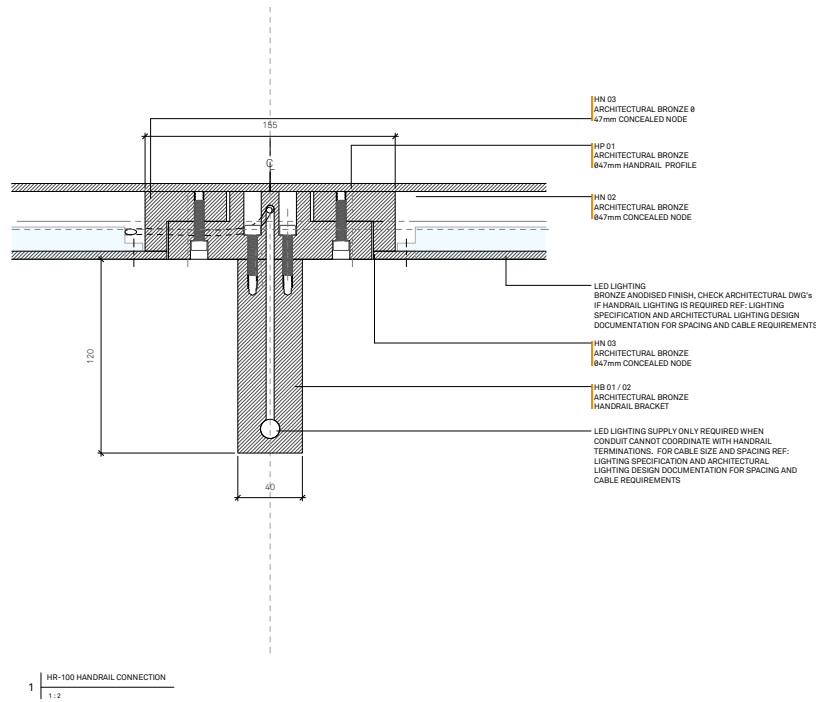
Structural details



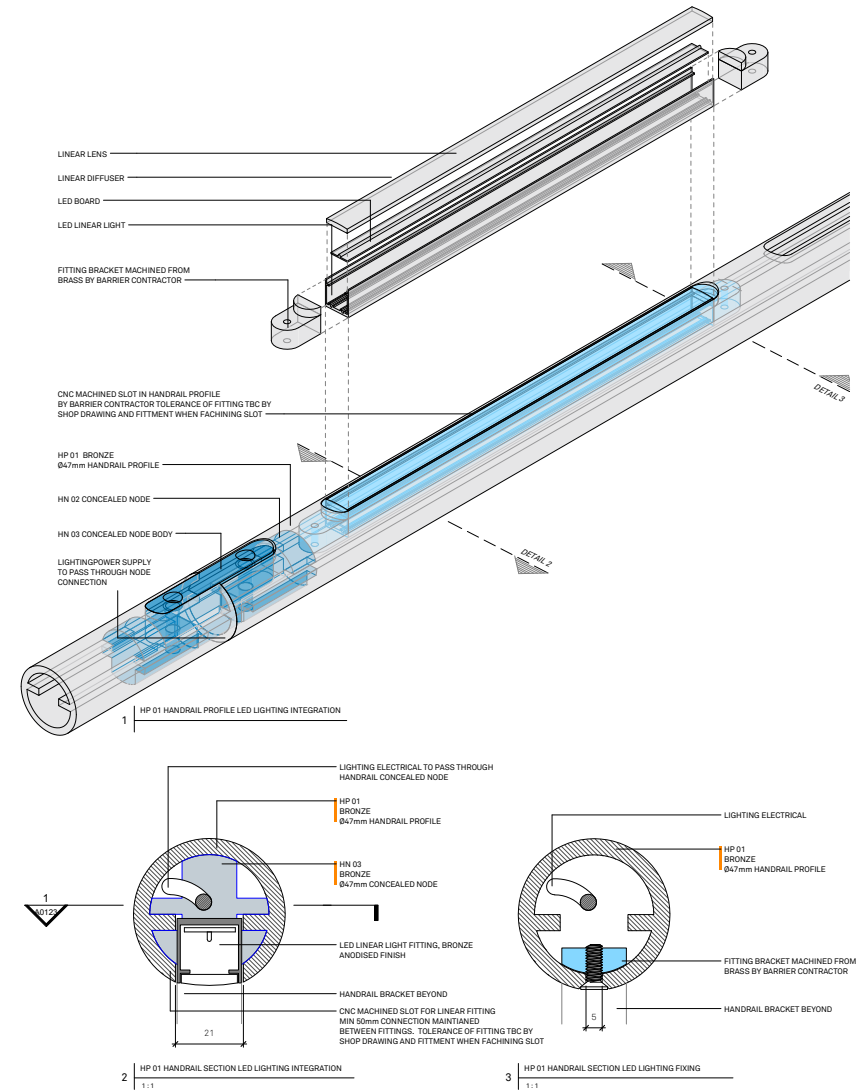
PRISM DWG : FADR-007 - HR 100 DETAILS

Exterior handrail: HR-100

Lighting details



PRISM DWG : 49-BR-GAS01-A0721 - HR 100 DETAILS



PRISM DWG : 49-BR-GAS01-A1210 - HR 100 DETAILS

Exterior handrail: HR-100

Common requirements

Accessibility

All handrail designs have been assessed for DDA compliance by Richard Seidman of iAccess Consultants, the full report is attached as BCP Volume 3 Appendix. The HR-100 wall mounted handrail is associated with exterior stairs where they are affixed to precast granite sets of through granite wall cladding. The design incorporates a 47mm handrail supported from these opaque wall elements. The detailing of the handrail at the top of the stair flights turns the handrail 180 degrees horizontally. This approach is acceptable providing the minimum extension at the top of the stair flight is achieved. The minimum extension at the top of the flight will need to be 300mm in accordance with the provisions of Clause 11.2(e) of AS1428.1:2009

The detailing of the handrail at the bottom of the stair flights turns the handrail 180 degrees horizontally. This approach is acceptable provided the minimum extension at the top of the stair flight is achieved. The minimum extension at the top of the flight will need to be stair going + 300mm in accordance with the provisions of Clause 11.2(d) of AS1428.1:2009. Handrail heights for stairs, landings and walkways occur in a zone 865 to 1000mm this varies depending on the stair geometry and transition zone for horizontal extensions BCA 2009 Clause D2.17 and Clause 12 of AS1428.1:2009. Handrails are required along at least one side of the ramp or stairs, or both sides where the stairs or ramp are wider than 2m BCA 2009 Clause D2.17

The Handrail HR-100 diameter is a 47mm circular profile and connection hardware allows the upper surface to be clear of obstructions or breaks for 270 degrees around the profile.

Lighting

To be developed as the exterior barrier designs are implemented. Principal approach is to use the linear LED 20 x 355 mm LED lighting accommodated within the handrail subject to coordination with the overall lighting strategy.

Engineering

Extensive engineering studies were conducted by PRISM during the design and selection of structural members and connections. No specified loads are nominated within the standards for handrails where there is no fall beyond. Only a serviceability load is necessary to make sure the handrail does not permanently bend under load. This has been an important consideration when accommodating linear LED lighting into the handrail profiles and has determined the maximum length of linear fittings and also the min gap between fittings. To achieve this, PRISM has proposed a serviceability load of 0.75kN/m which is applied to all handrails when they are not acting as a barrier, or where there is a separate barrier beyond. This suits the C1/C2 load nominated in AS1170.1 for areas without obstacles for moving people.

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Chapter 2

Interior Bronze Componentry



Introduction

Interior bronze componentry

The interior barrier design has been developed with a dominant circular top rail in reference the original U-Profile and to extend the designs of the Utzon Room and Western Concourse, it accommodates stair geometries both vertically and in plan where each profile is notched and mitred around the 80x40mm post. An essential detail is to maintain the vertical joint between top rail profiles. This allows the individual sections to be removed and references the vertical alignment of the original U Profile handrails and barrier details.

The design methodology has been to build on the established rhythm of the existing barrier and precast granite set building modules, to maintain the orientation and location of the existing barrier posts; all with the objective of minimising the impact of the renewal works. Of particular interest to the engineering and design team is the span of individual barrier elements to ensure the engineering requirements could be met and to provide achievable constraints for the design. Interior barriers at entertainment venues across NSW must have a top rail height of 1000mm AFFL [BCA 2009 Clause D2.16 (f)NSW Table D2.16a Barrier Construction],

A unique instance associated with the accessibility works is the insertion of passages into the existing stairways to the Eastern Foyer of the CH and Western Foyer of the JST producing a stair cut. The design incorporates a 53mm top rail handrail in order to meet the structural requirements and a performance solution citing functional as well as the provisions of American 2010 ADA Standards for Accessible Design has

been prepared to address the departure from the Australian Standard. This handrail height is 1020mm AFFL and exceeds the max. height for handrails however due to changing stair geometries the min. height for barriers governs. The Sydney Opera House includes a range of public spaces which fall into the category of “areas where people may congregate”, based on the specific uses nominated within AS1170.1, barriers which protect a fall at the Opera House will need to be designed to support a crowd load of C5 (see following table)

There are lower loading categories which might initially appear to be applicable for some specific areas (i.e. C1/C2 for stairs), however the higher load criteria required at the Sydney Opera House explicitly includes internal and external areas with bars, theatres, auditoria, assembly areas and studios.

In addition to the engineering, design and heritage aspirations, the statutory accessibility requirements are driving the need and impetus for a new barrier and handrail suite. Inclusion of handrail extensions, down-turns and barrier infills are a departure from the existing fabric, however, they are necessary to arrive at a compliant barrier solution.

Minimum height for interiors 1000mm		Minimum imposed load to top edge			Minimum imposed load to infill	
Type of occupancy for part of the building or structure	Specific Uses	Horizontal (kN/m)	Vertical (kN/m)	Inward, outwards or	Horizontal (kPa)	Any Direction (kN)
C5 Areas susceptible to over-crowding	Theatres, cinemas, grandstands, discotheques, bars, auditoria, shopping malls, assembly areas, studios etc.	3.0	0.75	0.6	1.5	1.5

2.1

Barriers

Interior barrier: BAR-100

Design application

BAR-100 is the barrier and handrail for use throughout all interior spaces. Its component parts include a top rail and post that suspends a cantilevered glass infill above the pitch line of the stair treads.

Nominated locations

All interior locations, Northern and Southern Foyers, stairs, ramps and barriers.

Code requirements

National Construction Code:

- 2016 Building Code of Australia
- Disability Discrimination Act:
- AS1428.1 (2009) Design for Access and Mobility
- Engineering:
- AS 1170.1 (2002) Structural Design Actions;
- AS 1926.1 (2007) Safety Barriers for Swimming Pools; and
- AS/NZS 1680.2.1 (2008) Interior and workplace lighting

Specifications

Height: 1200mm

Top rail: 80mm Diameter (C5 3.0 kN/m horizontal, 0.75 kN/m vertical)

Handrail: 47mm Diameter (0.75 kN/m horizontal, 0.75 kN/m vertical)

Maximum Span: 2450mm

Post size: 80x40mm

Infill: nom 17.76mm toughened 100% heat soaked, low iron glass with non reflective coating (C5 1.5 kPa horizontal, 1.5 kN/m any direction) Glazing clamp concealed within top rail

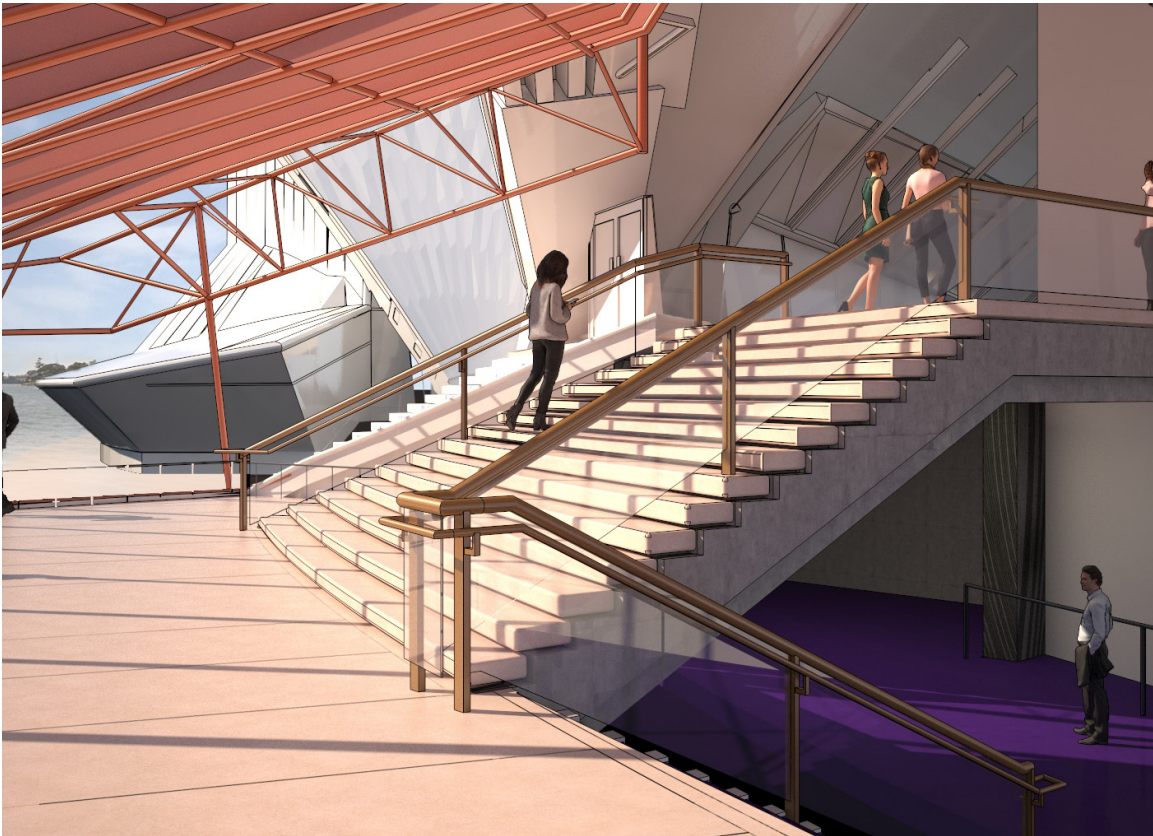
Accessibility: Handrail extensions return and connect to adjacent stairs, handrails used adjacent to stair and ramps, for straight sections, can be omitted.

Components:

- Handrails;
- Kerb; and
- Kick boards

Lighting

Linear LED 20 x 355 mm LED Lighting can be accommodated within the handrail subject to coordination with the overall lighting strategy.

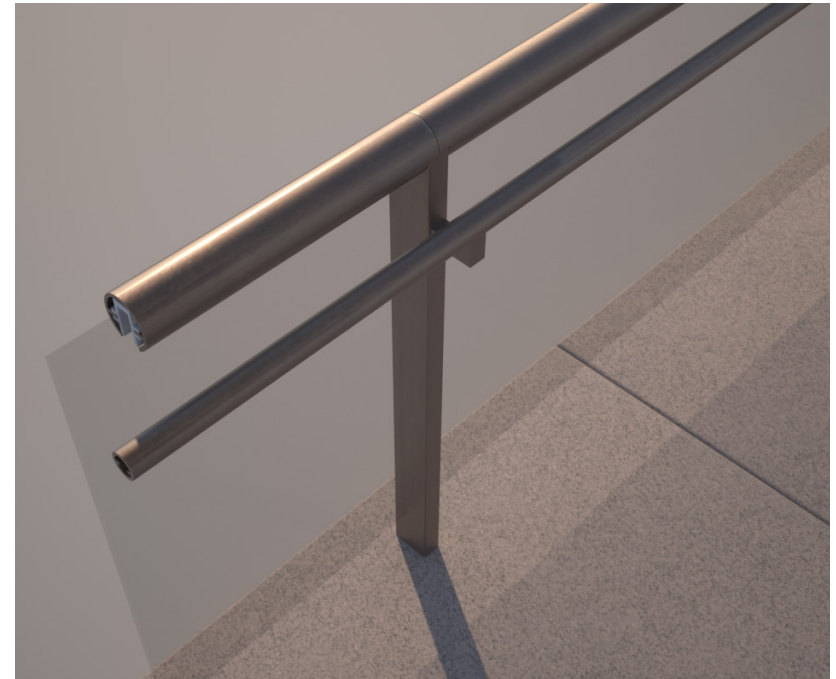


01

01 Rendered perspective of the proposed Northern Foyer (Grimshaw)
 02 Rendered perspective of the glazed infill (Grimshaw)
 03 Rendered plan of the handrail termination (Grimshaw)
 04 Rendered perspective of the handrail termination (Grimshaw)



03



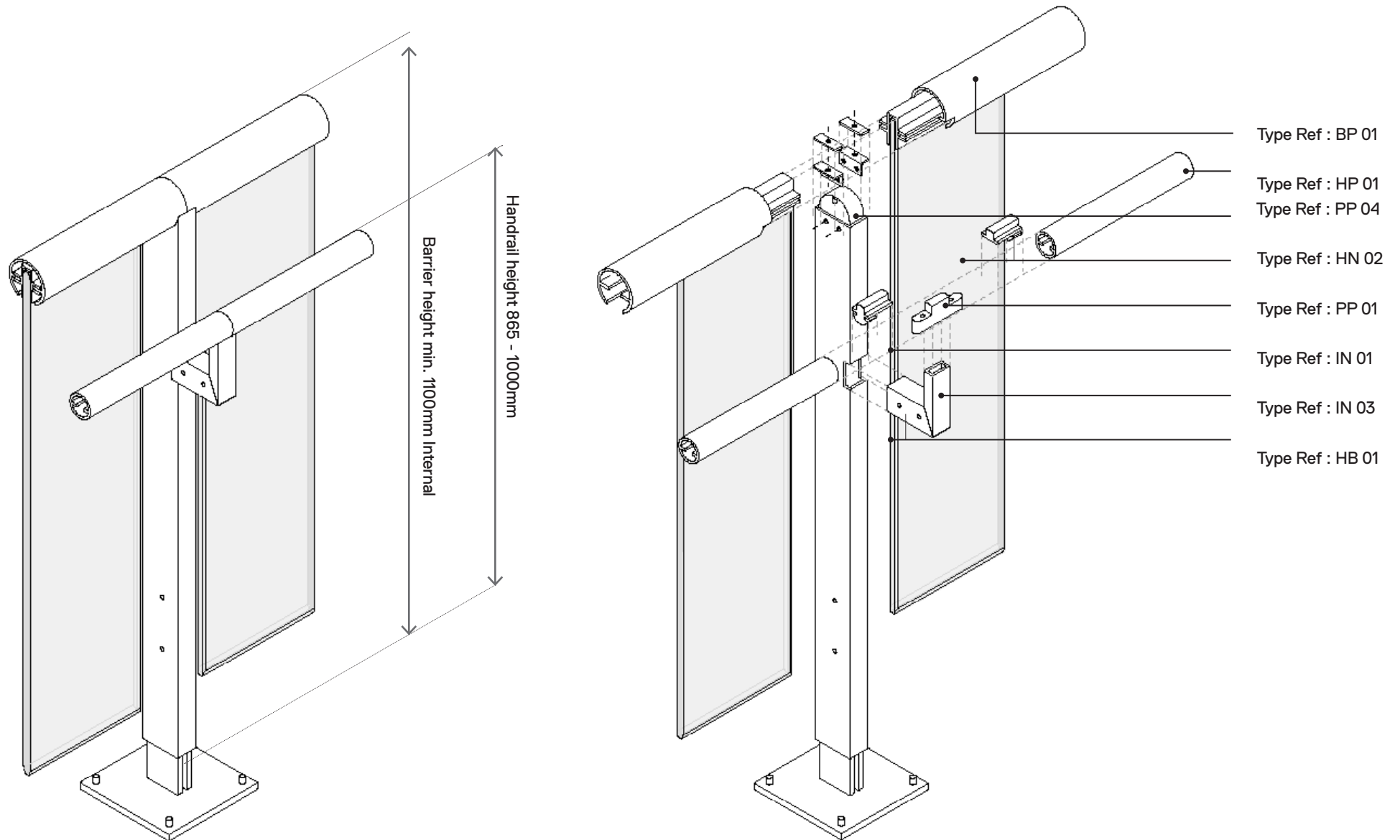
02



04

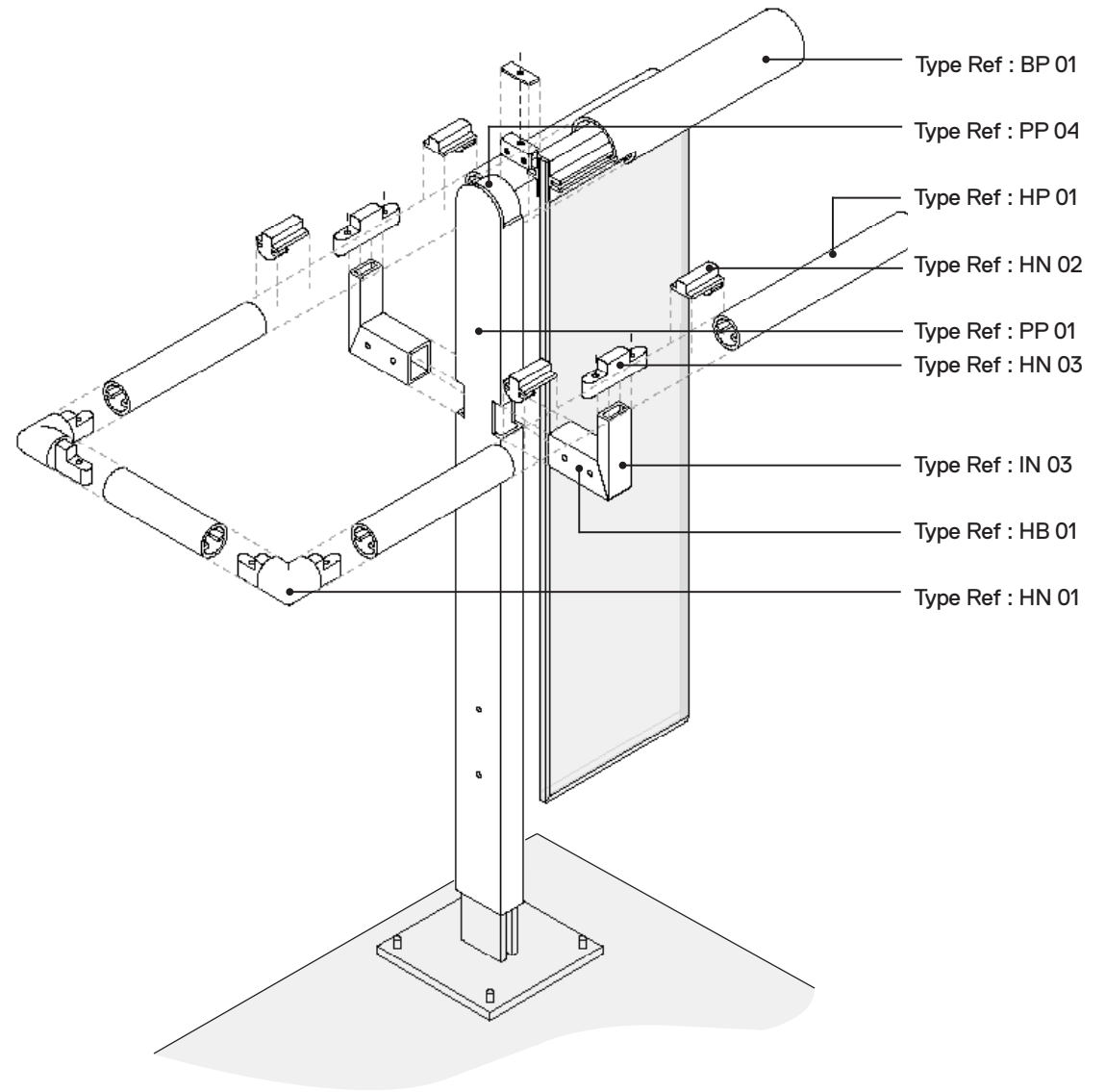
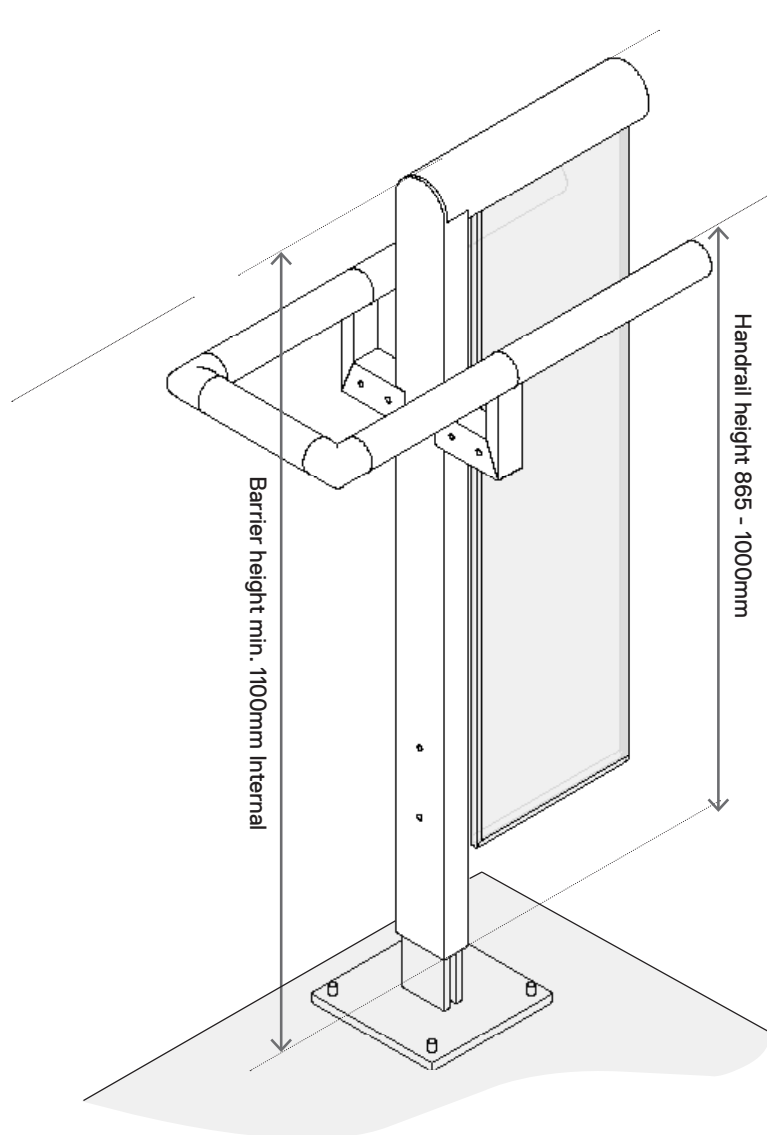
Interior barrier: BAR-100

Typical details



Interior barrier: BAR-100

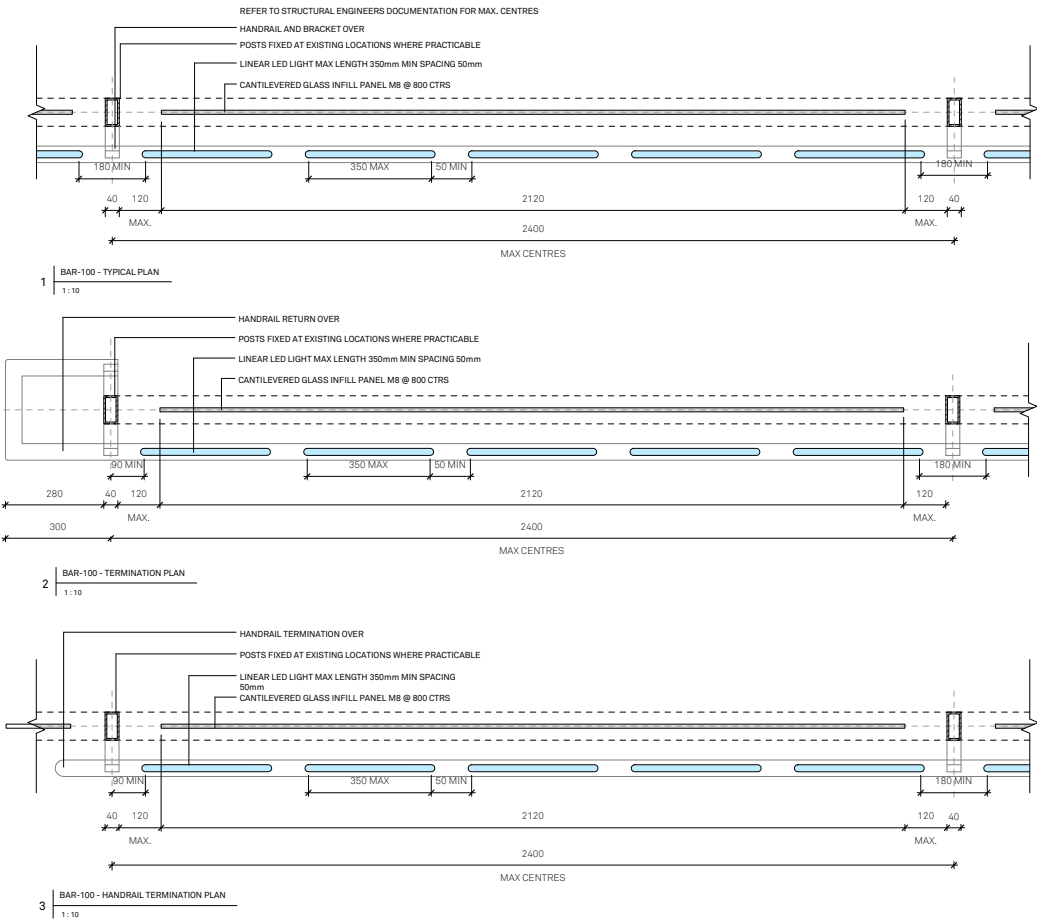
Handrail termination



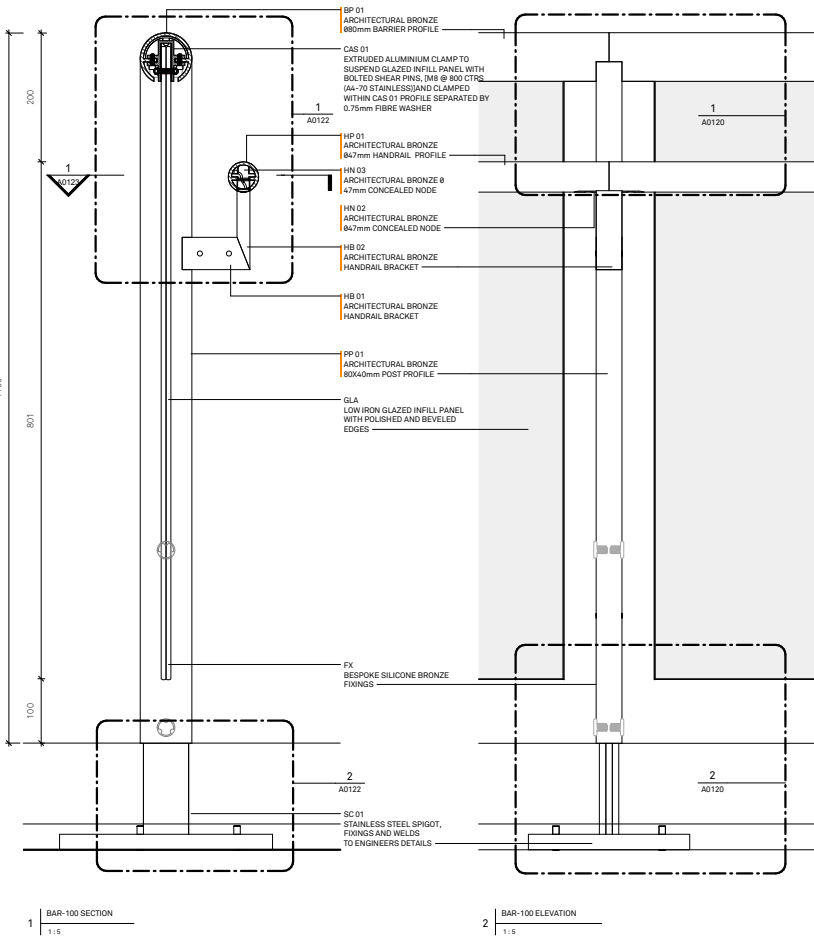
Interior barrier: BAR-100

Typical sections

Indicates bronze extrusion
supplied by SOH



PRISM DWG : 49-BR-GAS01-A0110 - BAR 100 DETAILS

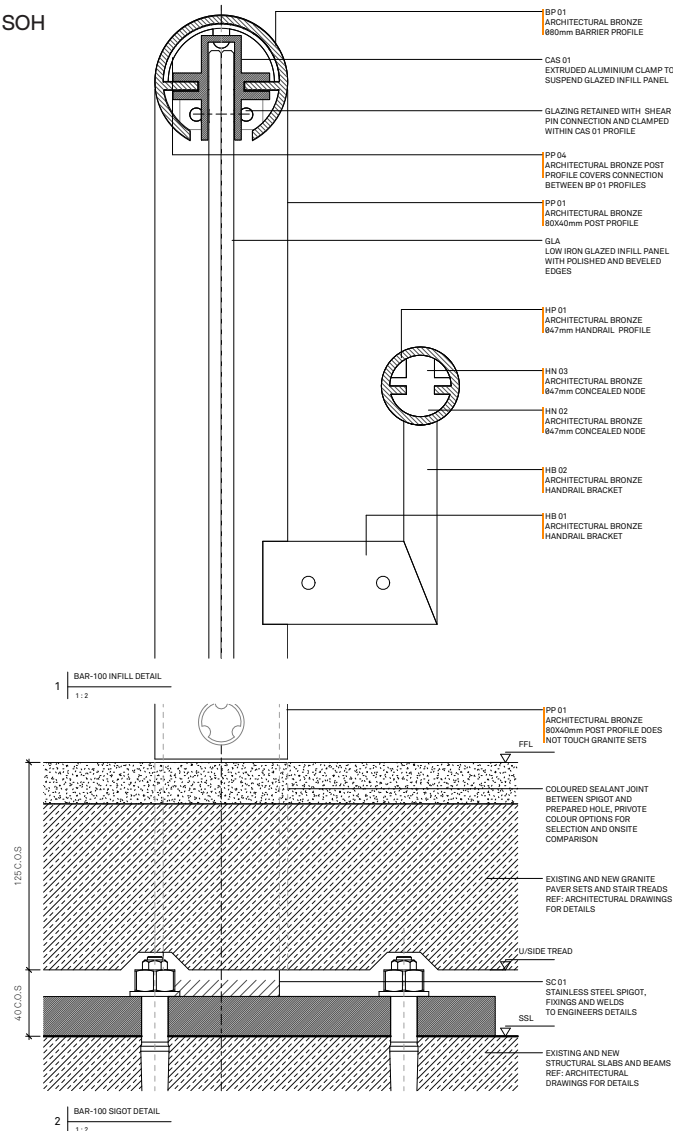


PRISM DWG : 49-BR-GAS01-A0111 - BAR 100 DETAILS

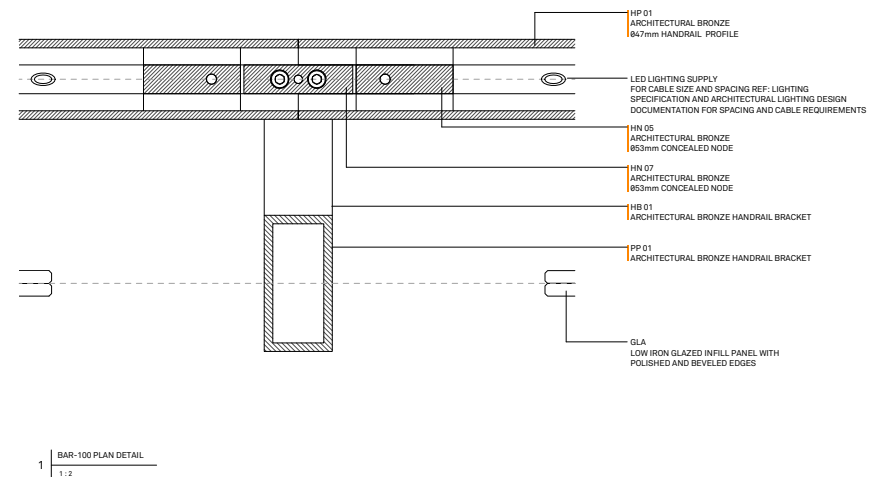
Interior barrier: BAR-100

Handrail sections

Indicates bronze extrusion
supplied by SOH



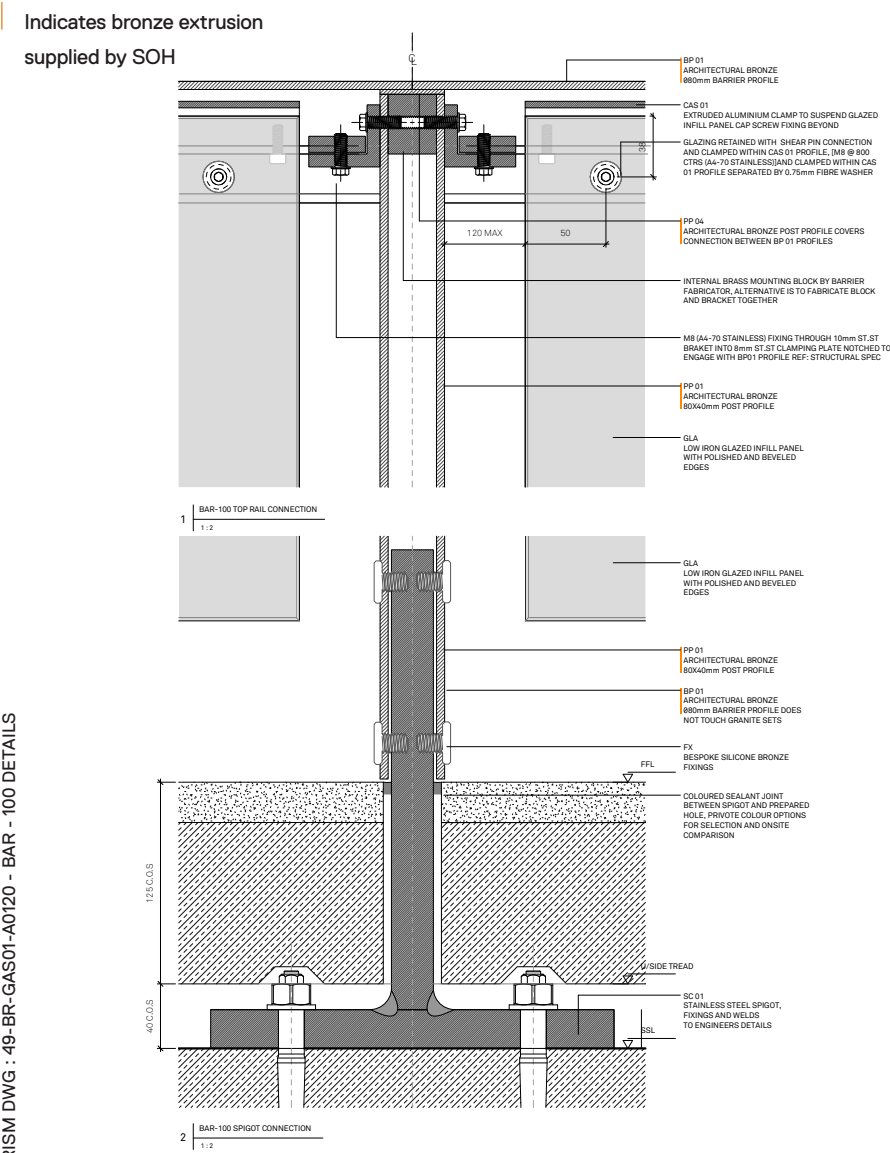
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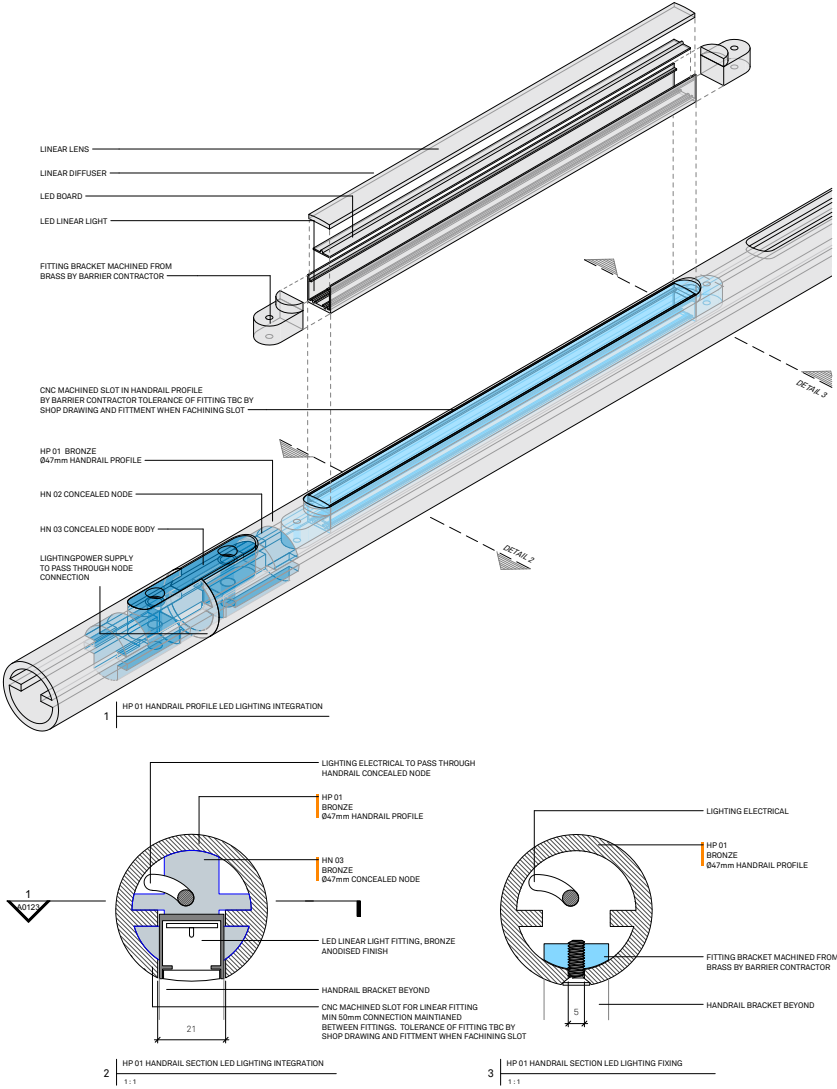
PRISM DWG : 49-BR-GAS01-A0123 - BAR - 100 DETAILS

Interior barrier: BAR-100

Handrail sections and lighting details



PRISM DWG : 49-BR-GAS01-A0120 - BAR - 100 DETAILS

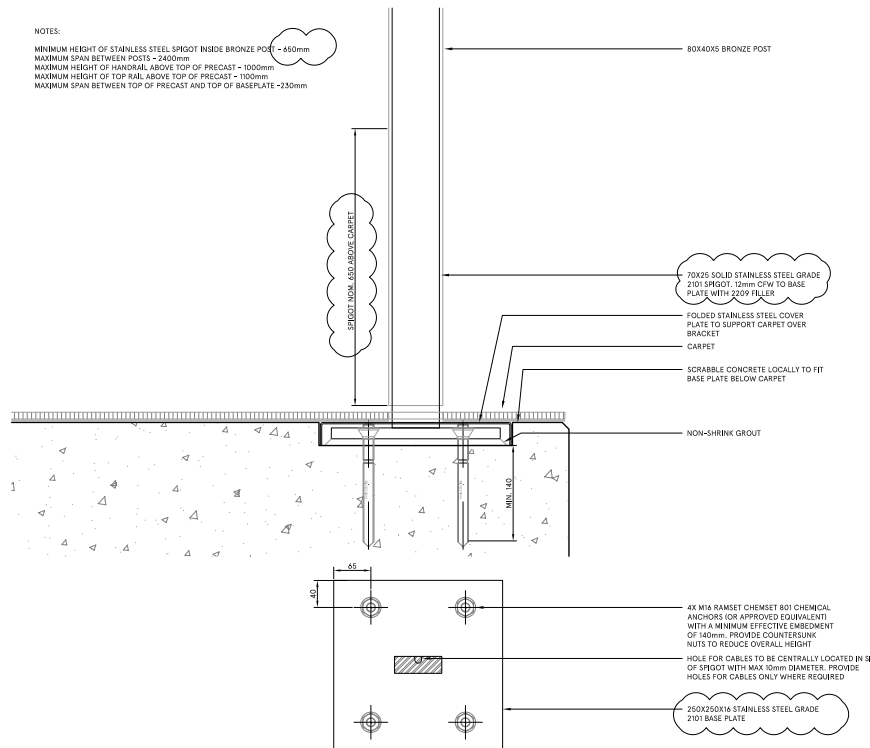


PRISM DWG : 49-BR-GAS01-A1210 - HR 100 DETAILS

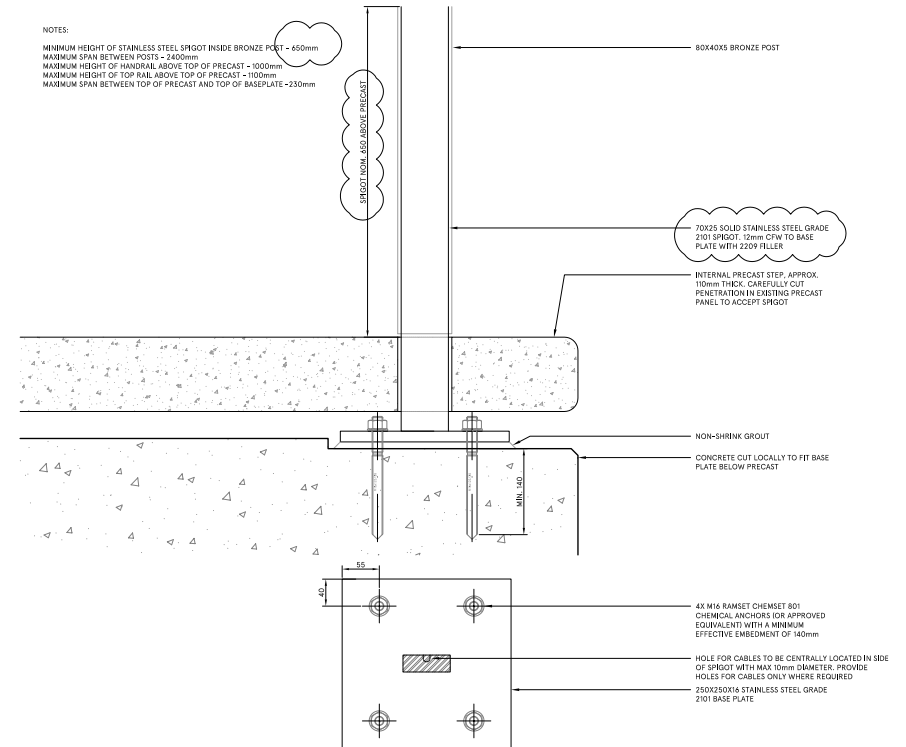
Interior barrier: BAR-100

Structural connections

PRISM DWG : FADR - 006 - BAR - 100 DETAILS



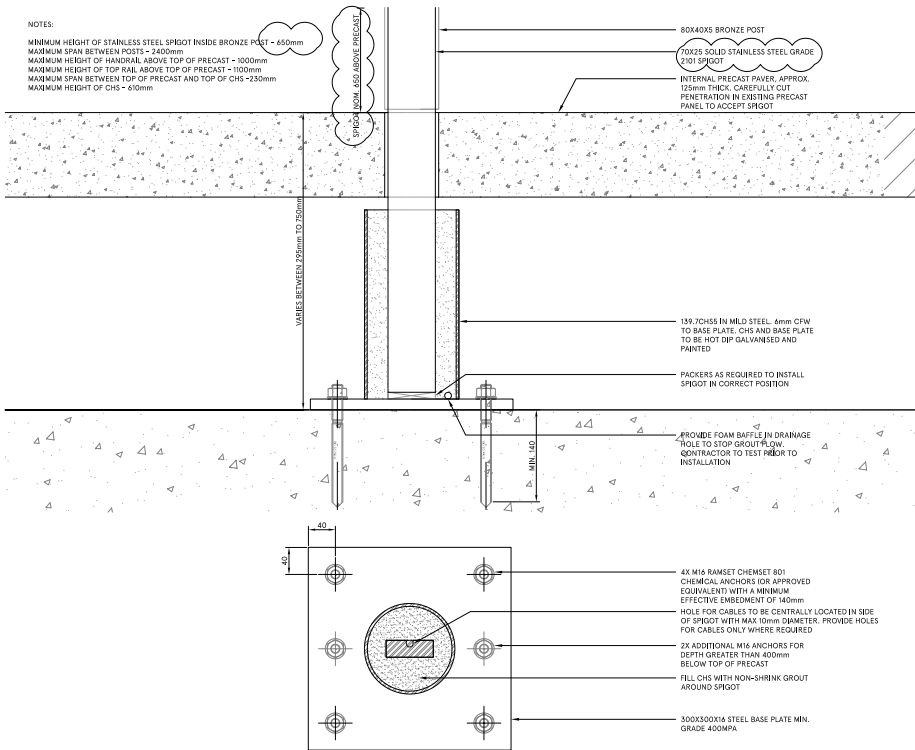
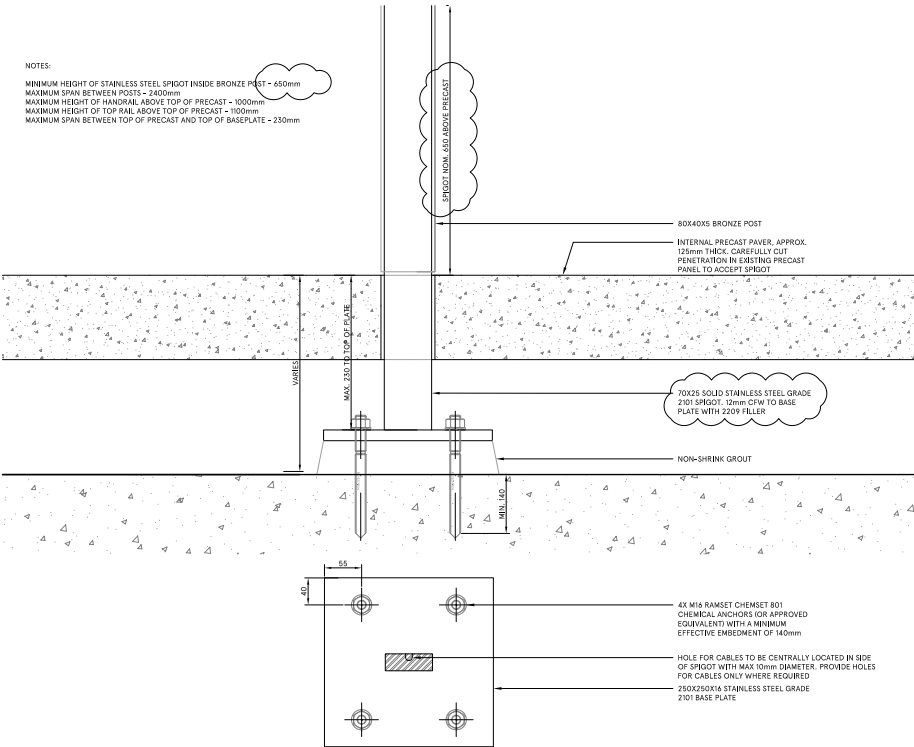
PRISM DWG : FADR - 005 - BAR - 100 DETAILS



Interior barrier: BAR-100

Structural connections

PRISM DWG : FADR - 003 - BAR - 100 DETAILS



PRISM DWG : FADR - 004 - BAR - 100 DETAILS

Interior barrier: BAR-100

Common requirements

Accessibility

All handrail designs have been assessed for DDA compliance by Richard Seidman of iAccess Consultants, the full report is attached as Appendix 2.

The BAR-100 barrier and handrail is the primary design for all interior spaces. The design incorporates a 47mm handrail supported from the barrier post. The detailing of the handrail at the top of the stair flights turns the handrail 180 degree horizontally. This approach is acceptable providing the minimum extension at the top of the stair flight is achieved. The minimum extension at the top of the flight will need to be 300mm in accordance with the provisions of Clause 11.2(e) of AS1428.1:2009.

The detailing of the handrail at the bottom of the stair flights turns the handrail 180 degrees horizontally. This approach is acceptable providing the minimum extension at the top of the stair flight is achieved. The minimum extension at the top of the flight will need to be stair going + 300mm in accordance with the provisions of Clause 11.2(d) of AS1428.1:2009

Handrail heights for stairs, landings, walkways occur in a zone 865 to 1000mm and this varies depending on the stair geometry and transition zone for horizontal extensions BCA 2009 Clause D2.17 and Clause 12 of AS1428.1:2009. Handrails are required along at least one side of the ramp or stairs, or both sides where the stairs or ramp are wider than 2m BCA 2009 Clause D2.17

Lighting

In order to meet safety objectives the illumination level for interior staircases and landings are to comply with AS/NZS 1680 which is 80 lux. In the calculation model prepared by ARUP the handrail height has been set to 860mm. The overall results show the lighting level of both staircase and landing to achieve a horizontal average of 80 lux for a width of 1m from the handrail.

Linear LED fittings have been designed to be concealed within the BAR-100 handrail which has a diameter of 47mm. Although the selected fittings can be manufactured in long lengths, the barrier engineering requirements determined by PRISM have prevented fitting longer than 355 mm from being used. This is consistent with the replacement of the original T5 florescent tube fittings which are a similar length and are also spaced 45mm apart.

Engineering

Extensive engineering studies were conducted by PRISM Facades during the design and selection of structural members and connections. Interior barriers at entertainment venues within NSW must have a top rail height of 1200mm [BCA 2009 Clause D2.16 (f) NSW Table D2.16a Barrier Construction], this combined with C5 Loading and the span between vertical posts of 2450mm has determined the size of elements.

All interior locations, Northern and Southern Foyers, stairs are susceptible to overcrowding and therefore AS1170.1 requires that any barriers be able to resist a horizontal 'C5' live load of 3.0kN/m. The BAR-100 interior barrier has an 80x40 vertical post with a wall thickness of 7mm, the connection spigot at the base is required to have a height of minimum 430mm. Due to the loads at this connection the spigot is unable to be fabricated from bronze and a stainless steel connection is required, grade 316.

The infill for the interior barriers is glazed infill panel. the infill barrier load of 1.5kPa is transferred through the glass and resisted by the top rail in torsion though to the vertical posts..

Interior barrier: BAR-300

Design application

Stair cuts within the Eastern Foyers are a new architectural typology at the Opera House. The EAP has approved a new dual-function top rail barrier and handrail as stair width is restricted in these locations.

Nominated locations

Insertion of passages into the existing stairways to the Eastern Foyer of the Concert Hall and Western Foyer of the Joan Sutherland Theatre producing a stair cut.

Code requirements

National Construction Code:

- 2016 Building Code of Australia
- Disability Discrimination Act:
- AS1428.1 (2009) Design for Access and Mobility
- Engineering:
- AS 1170.1 (2002) Structural Design Actions;
- AS 1926.1 (2007) Safety Barriers for Swimming Pools; and
- AS/NZS 1680.2.1 (2008) Interior and workplace lighting

Specifications

Height: 1020mm

Maximum Span: 1355 mm

Post size: 80x40mm

Glazing bar: 50mm overall (20mm edge engagement)

Glazing Support: Profile cut deadload bracket

Glazing Infill: nom 15.76mm toughened 100% heat soaked, Low Iron glass with non reflective coating (C5 1.5 kPa horizontal, 1.5 kN/m any direction)

Accessibility: Handrail extensions turn down to the floor with 53 x 20mm rectangular profile.

Components

- Handrails

Lighting

PUK LED 16mm light fitting at 300mm centres can be accommodated within the handrail subject to coordination with the overall lighting strategy.

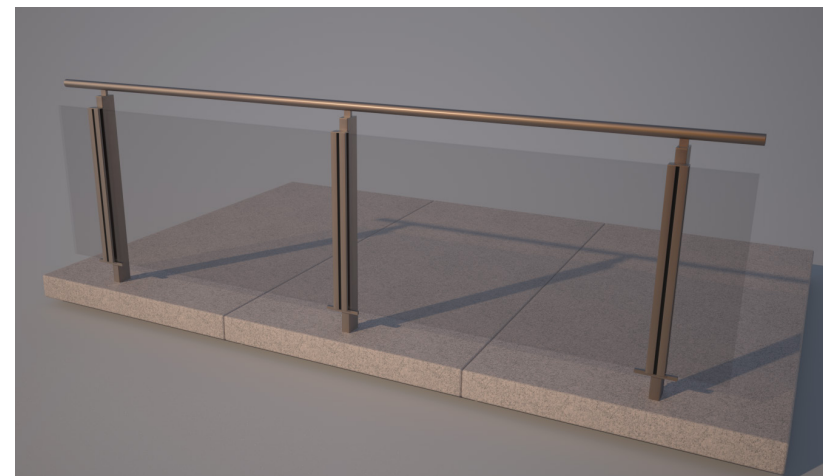


01

- 01 Rendered perspective of the proposed Eastern Foyer stair cut (Grimshaw)
- 02 Rendered perspective of the Exterior Podium (Grimshaw)
- 03 Rendered perspective of the Exterior Podium (Grimshaw)



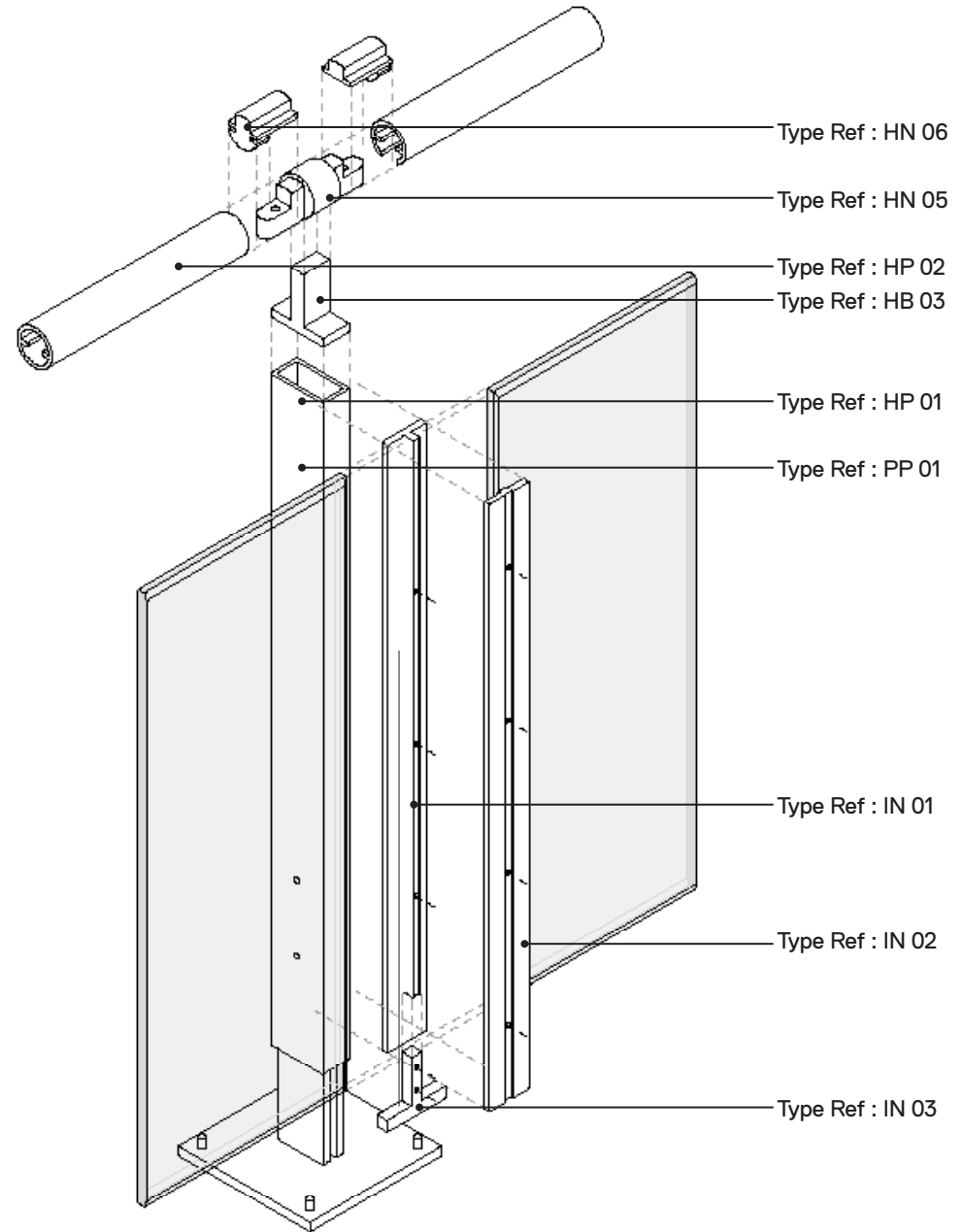
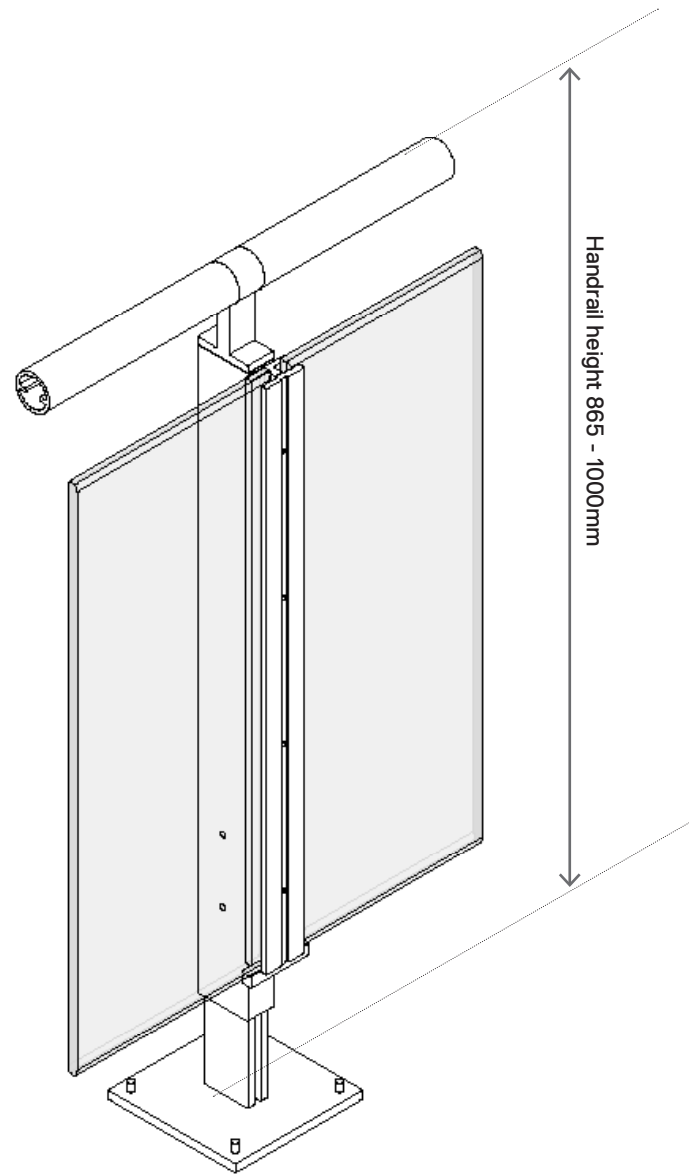
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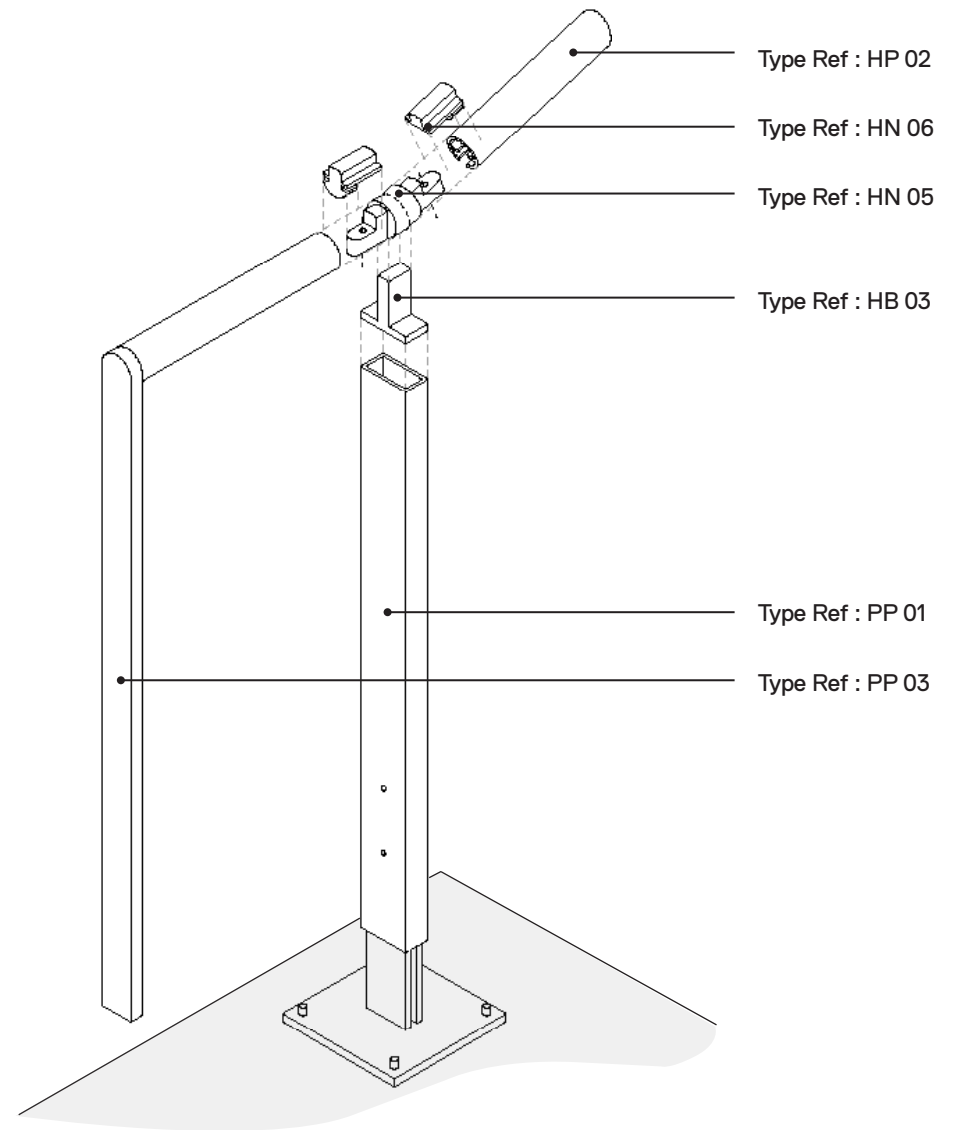
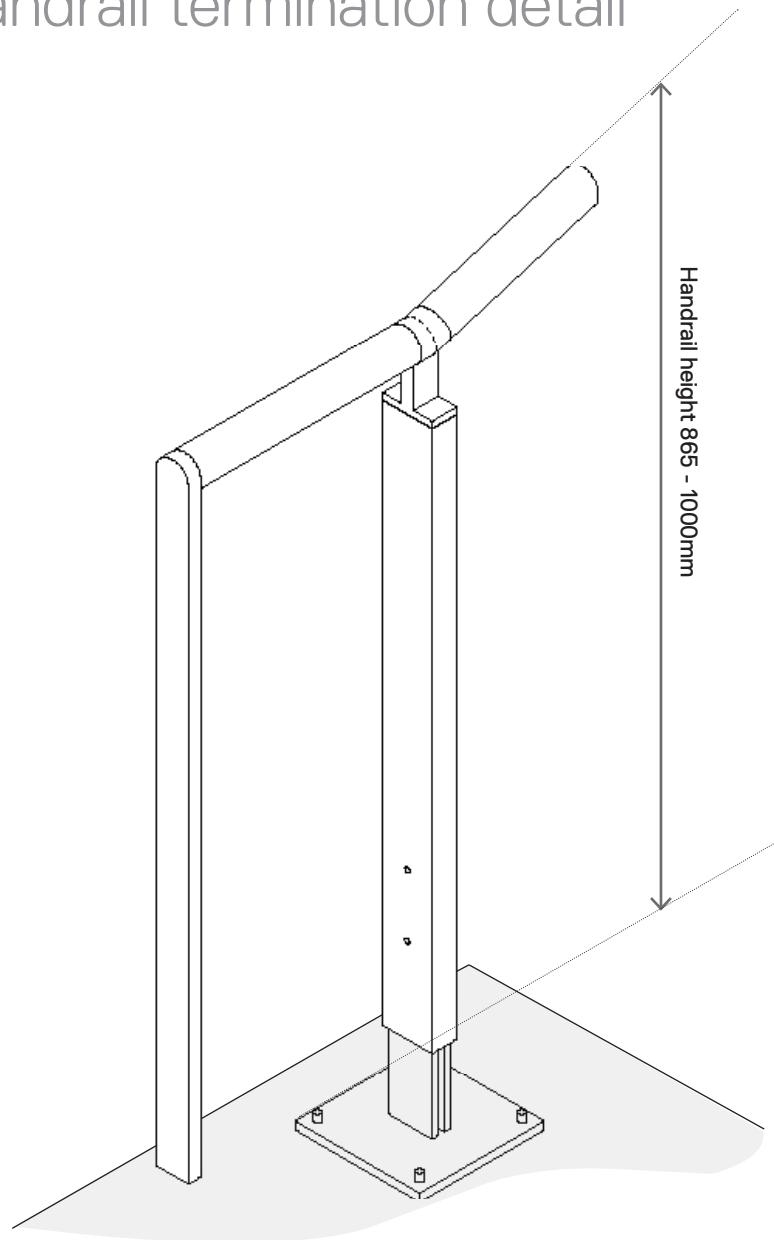
Interior barrier: BAR-300

Typical details



Interior barrier: BAR-300

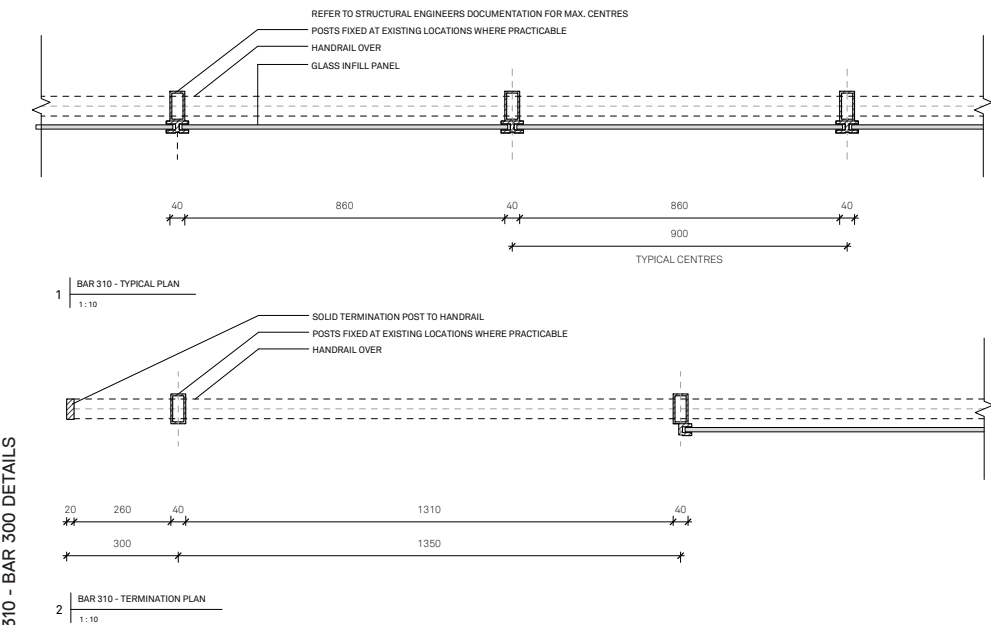
Handrail termination detail



Interior barrier: BAR-300

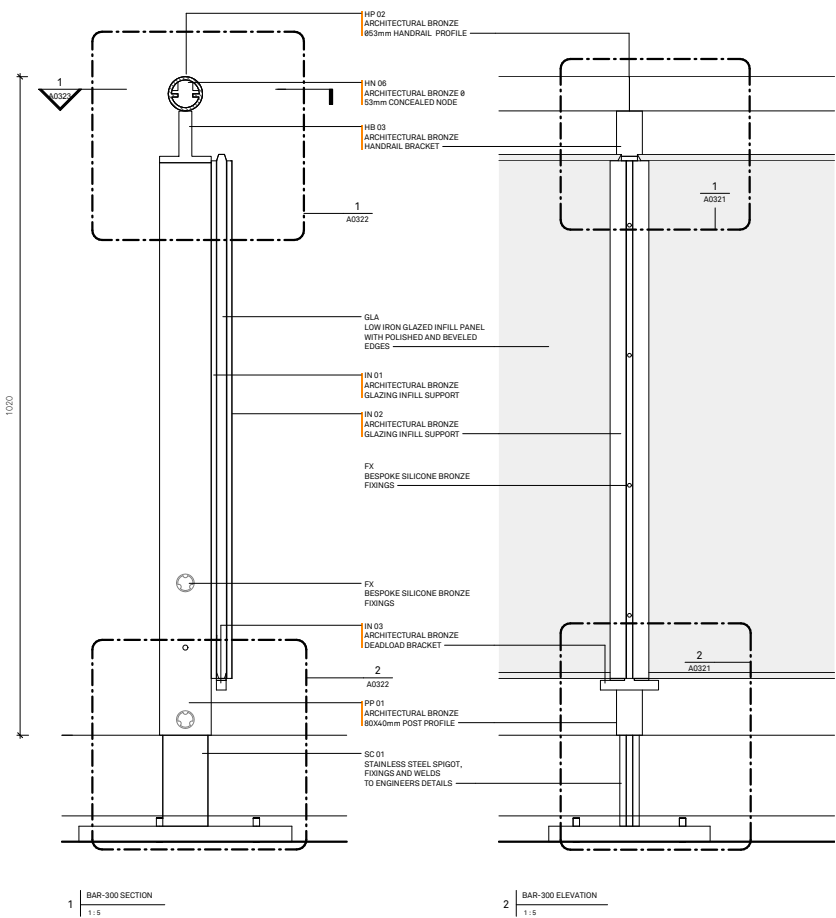
Typical sections

Indicates bronze extrusion
supplied by SOH



PRISM DWG : 49-BR-GAS01-A0310 - BAR 300 DETAILS

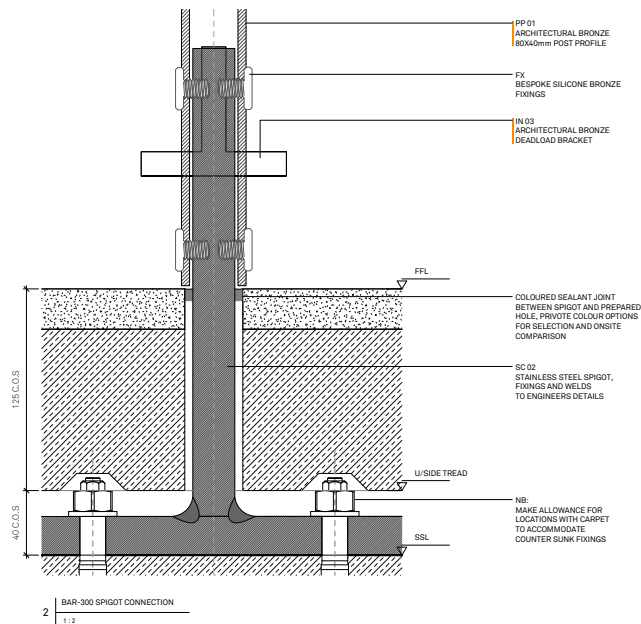
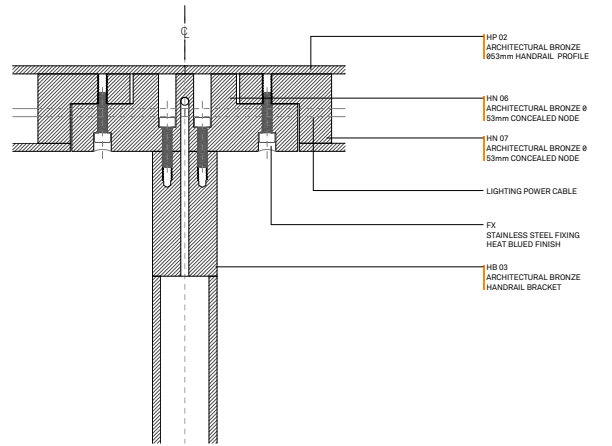
PRISM DWG : 49-BR-GAS01-A0311 - BAR 300 DETAILS



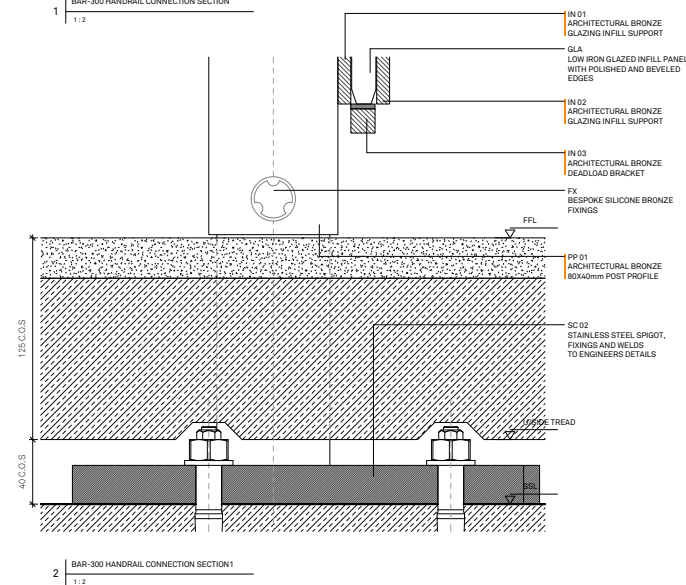
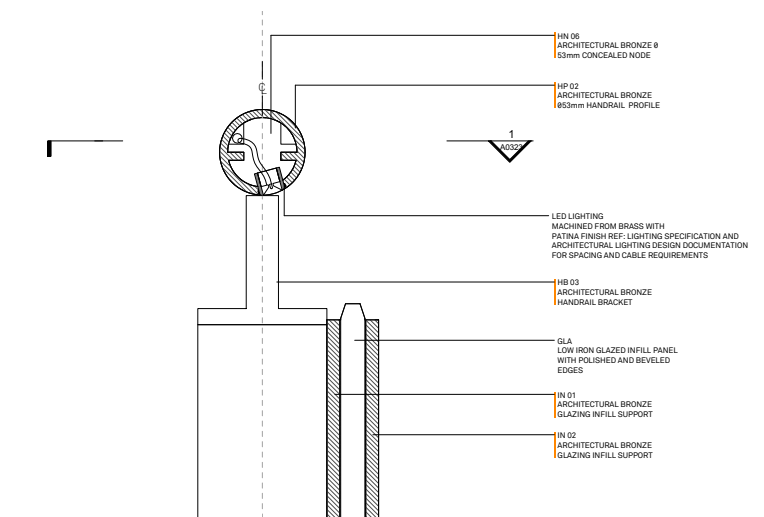
Interior barrier: BAR-300

Handrail sections

Indicates bronze extrusion
supplied by SOH



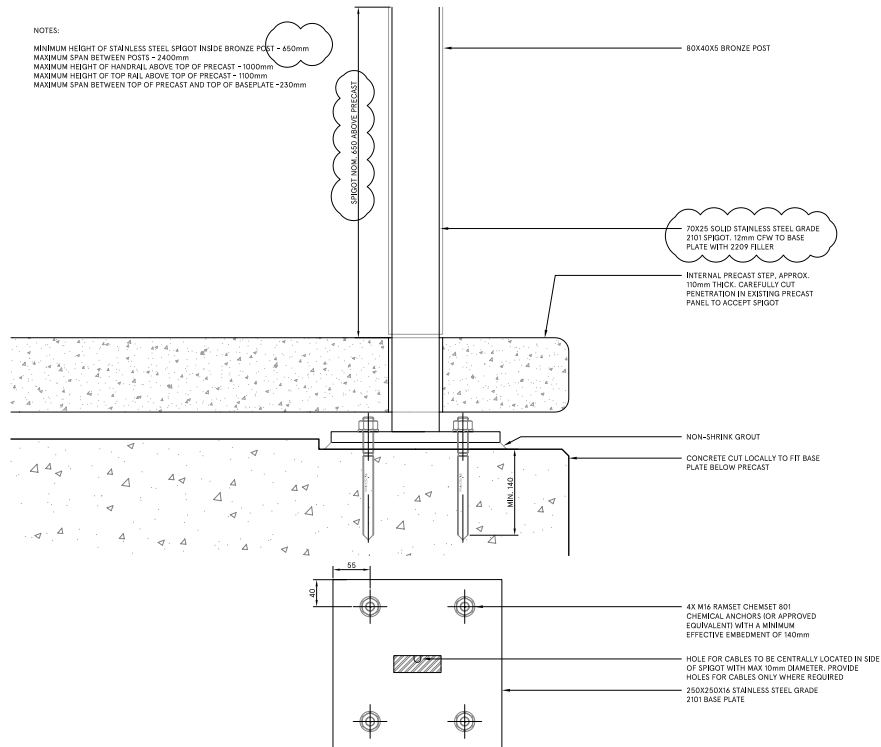
PRISM DWG : 49-BR-GAS01-A0321 - BAR 300 DETAILS



PRISM DWG : 49-BR-GAS01-A0322 - BAR 300 DETAILS

Interior barrier: BAR-300

Structural connections

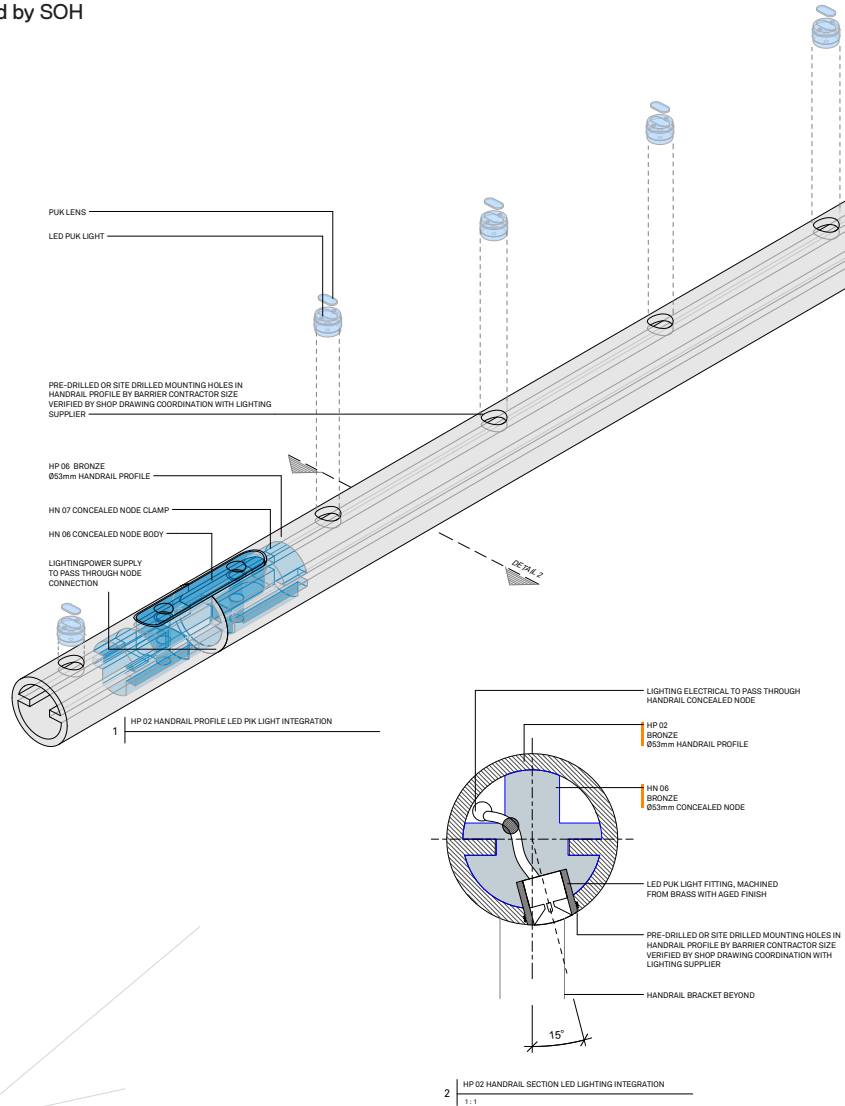


PRISM DWG : FADR - 005 - BAR -300 DETAILS

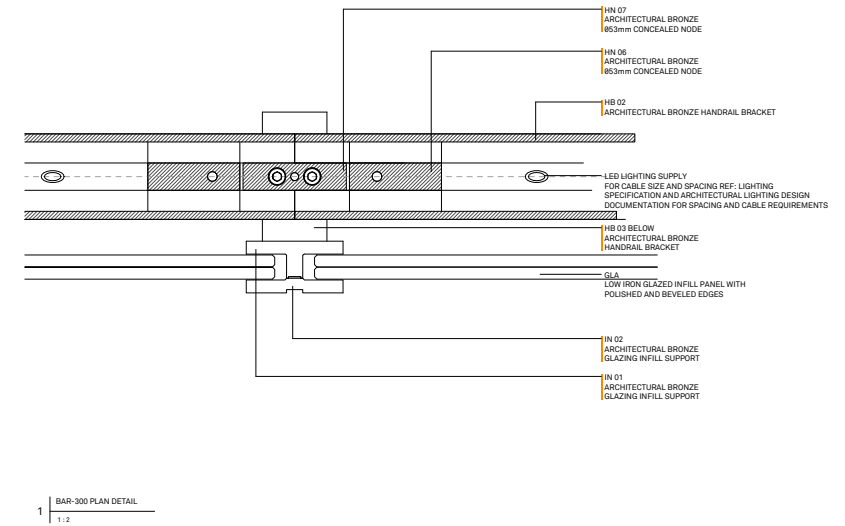
Interior barrier: BAR-300

Handrail section and lighting details

Indicates bronze extrusion
supplied by SOH



DWG : 49-BR-GAS01-A1211 - BAR 300 DETAILS



DWG : 49-BR-GAS01-A0323 - BAR 300 DETAILS

Interior barriers: BAR-300

Common requirements

Accessibility

The barrier designs have been assessed for DDA compliance by Richard Seidman of iAccess. His full report along with an alternative solution for a 53mm handrail diameter is attached as appendix XXX. The BAR 300 barrier and handrail is associated with the insertion of passages into the existing stairways to the Eastern Foyer of the CH and Western Foyer of the JST producing a Stair Cut. The design incorporates a 53mm top rail handrail supported directly above the 80x40mm barrier post with a glazed infill introducing a new profile to the suite of handrail sections within the Sydney Opera House.

In order to meet the structural requirements and C5 loading a 53mm diameter handrail was developed which exceeds the maximum size permissible by Clause 12(b) of AS1428.1:2009. A performance solution citing functional as well as the provisions of American 2010 ADA Standards for Accessible Design has been prepared to address the departure from the Australian Standard by Richard Seidman of iAccess.

The handrail height documented is 1020mm above the leading edge of the going of the stairway. This nominated height exceeds the provisions of NCC Clause D3.33(a)(ii) and Clause 12(d) of AS1428.1:2009 where the top of the handrail is nominated to be located between 865-1000mm above the leading edge of the stair nosing.

As the handrail also acts as the top rail of the barrier which has a minimum height of 1000mm the additional 20mm allows for changes and variation in the existing stair geometry. This relationship between the depth of the tread goings and the angle of the line of the handrail which is not perpendicular to the edge of the tread (Scott Carver installation at the Western Foyer of the JST). The detailing of the handrail at the bottom of the stair flights turns the handrail 180deg horizontally. This approach is acceptable provided the minimum extension at the top of the stair flight is achieved.

The minimum extension at the top of the flight will need to be stair going + 300mm in accordance with the provisions of Clause 11.2(d) of AS1428.1:2009 The handrail extension terminates with a vertical bronze profile 53x20mm connecting the handrail to the flooring.

Lighting

In order to meet safety objectives the illumination level for interior staircases and landings are to comply with AS/NZS 1680 which is 80 lux. In the calculation model prepared by Arup the handrail height has been set to 860mm. The overall results show the lighting level of both staircase and landings achieve a horizontal average of 80 lux for a width of 1000mm from the handrail. Linear LED fittings cannot be used with the BAR 300 barrier type due to the engineering requirements of the combined top rail and handrail, therefore individual LED light fittings or PUK's have been designed to be concealed within the BAR 300 handrail which has a diameter of 53mm.

The spacing and location of PUK fittings to achieve 80 lux are 300mm centres positioned within the handrail profile at a 15 degree angle from vertical. This can increase glare from the fitting therefore the final selection of the diffuser needs to be carefully considered for each installation.

Engineering

Extensive engineering studies were conducted by PRISM Façades during the design and selection of structural members and connections. As the stairways to the Eastern Foyer of the Concert Hall and Western Foyer of the Joan Sutherland Theatre are susceptible to overcrowding, AS1170.1 requires that any barriers be able to resist a horizontal 'C5' live load of 3.0kN/m. The BAR-300 stair cut barrier has an 80x40 baluster with a wall thickness of 7mm positioned to a max spacing of 1355 mm, the connection spigot at the base is required to have a height of min. 290mm.

Note: due to the loads at this connection the spigot is unable to be fabricated from bronze and a stainless steel connection is required, grade 316.

The infill for the exterior barriers is vertical tension rods with a max spacing of 120mm centre to centre. Vertical tension rods transfer their tension and applied infill loads to the top rail and precast granite sets at the base and stair treads. A deflection limit of Height/60



2.2

Handrails

Interior handrail: HR-100

Design application

Throughout the interior performance spaces, corridors and stairs, wall-mounted handrails have been designed with circular profiles to suit adjacent environmental commonalities.

Nominated locations

All interior locations, East and Western Foyers, stairs, ramps and barriers. Within the Joan Sutherland Theatre and Concert Hall.

Code requirements

National Construction Code:

- 2016 Building Code of Australia
- Disability Discrimination Act:
- AS1428.1 (2009) Design for Access and Mobility
- Engineering:
- AS 1170.1 (2002) Structural Design Actions; and
- AS/NZS 1680.2.1 (2008) Interior and workplace lighting

Specifications

Height: 865 - 1000mm

Handrail: 47mm Diameter (0.75 kN/m horizontal, 0.75 kN/m vertical)

Maximum Span: 2450mm

Bracket: 53x20mm

Accessibility: Handrail extensions return and connect to adjacent stairs, or terminate into the adjacent wall finishes.

Components

NA

Lighting

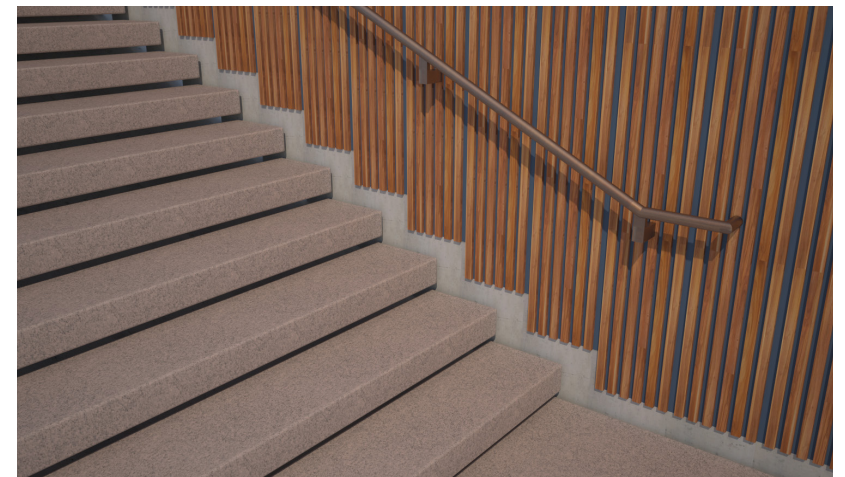
Linear LED 20 x 355 mm LED lighting can be accommodated within the handrail subject to coordination with the overall lighting strategy.



01



02

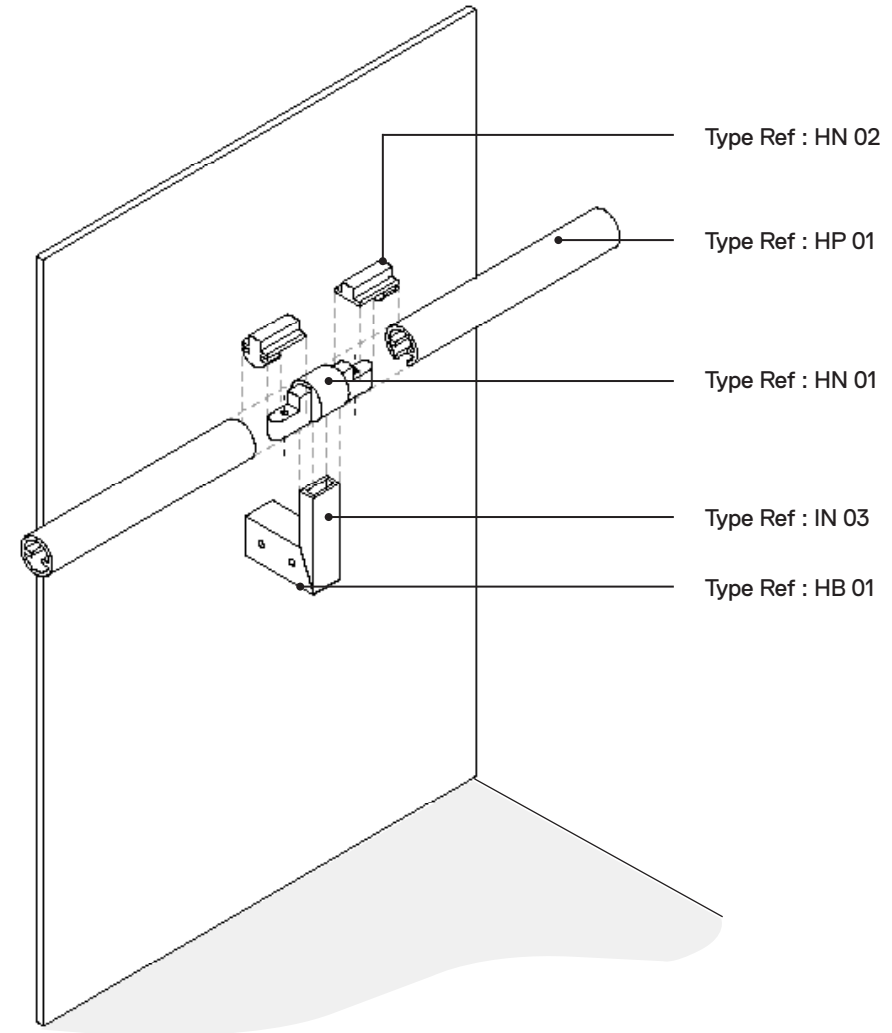
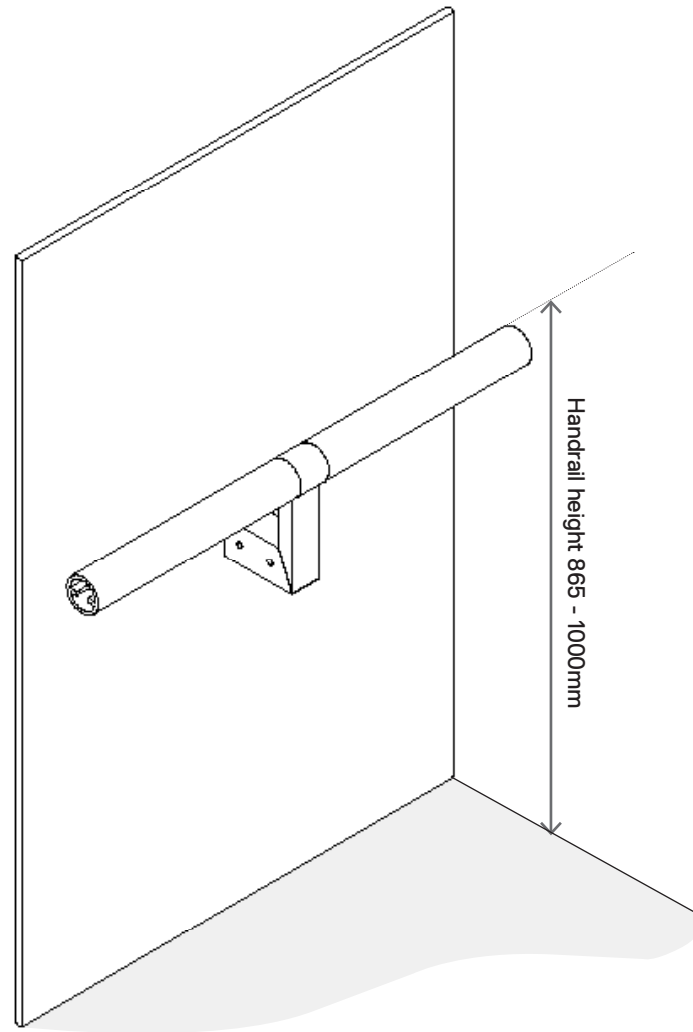


03

- 01 Rendered perspective of the interior wall mounted handrail (Grimshaw)
- 02 Rendered perspective of the handrail termination (Grimshaw)
- 03 Rendered elevation of the interior wall mounted handrail (Grimshaw)

Interior handrail: HR-100

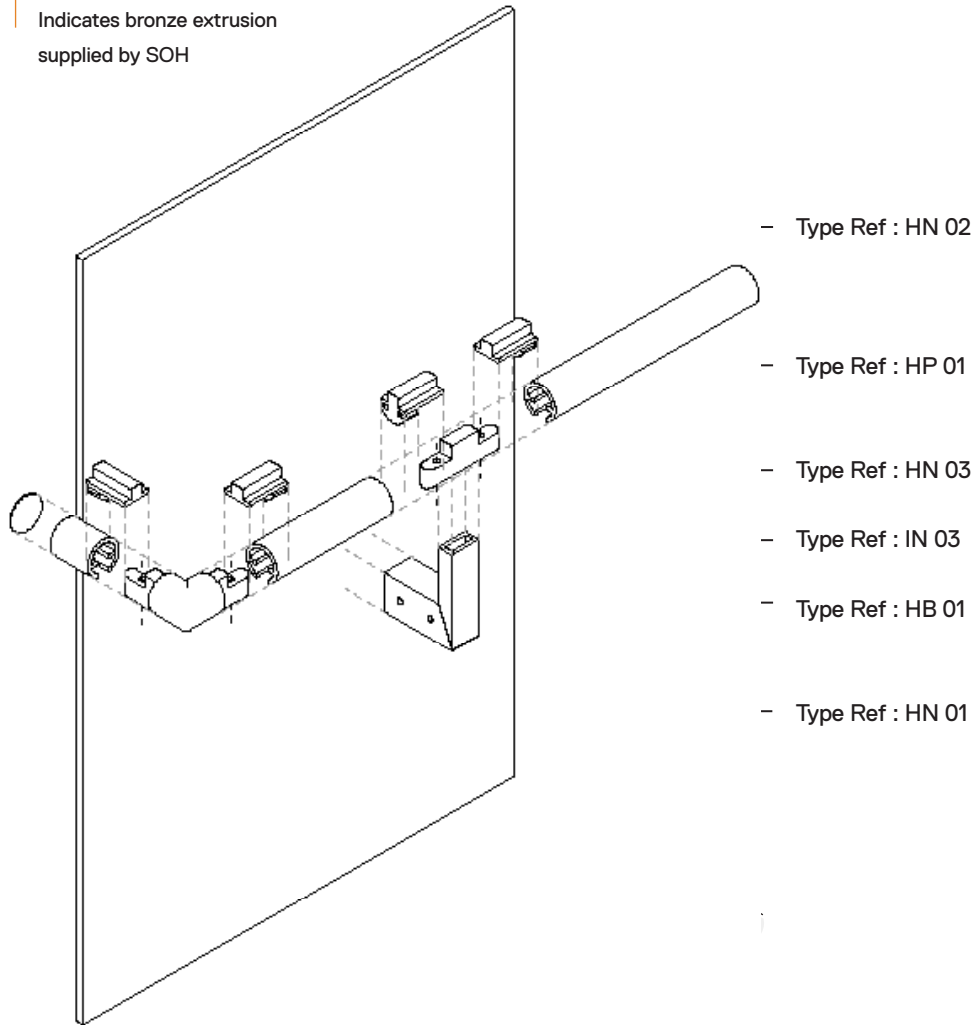
Typical details



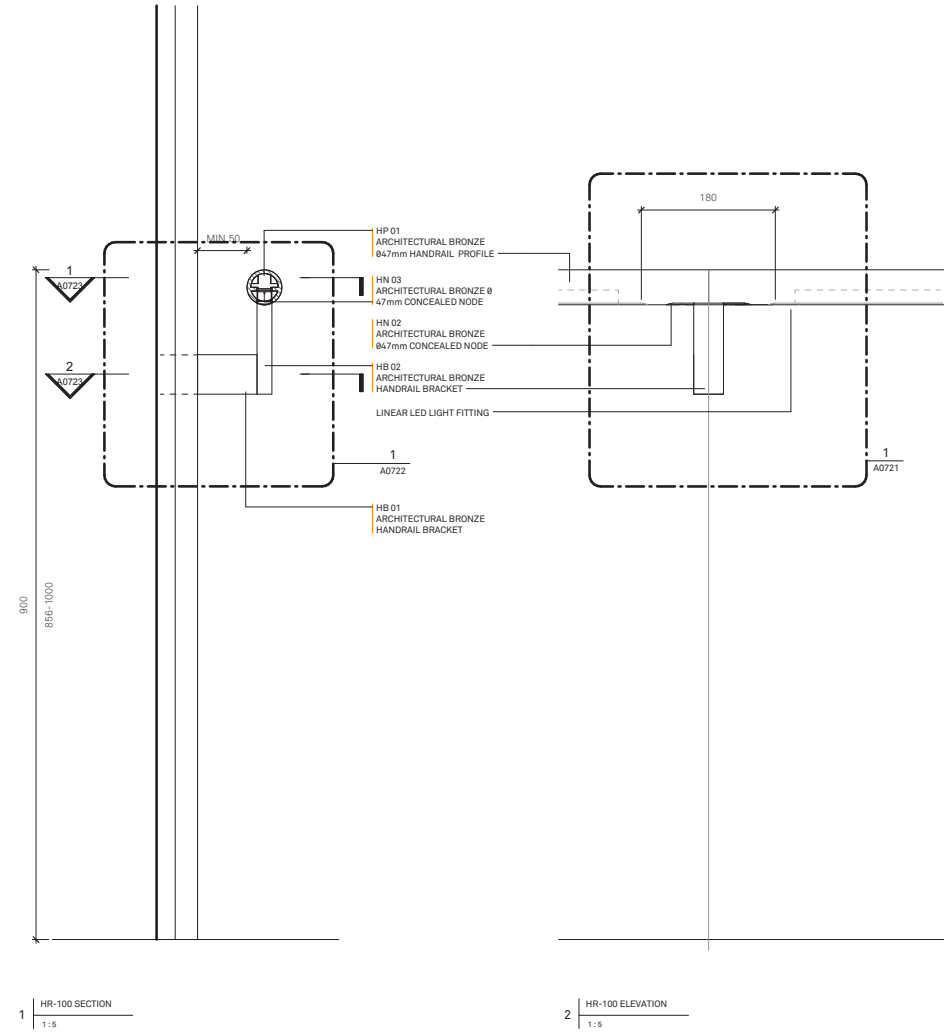
Interior handrail: HR-100

Handrail termination and section

Indicates bronze extrusion
supplied by SOH



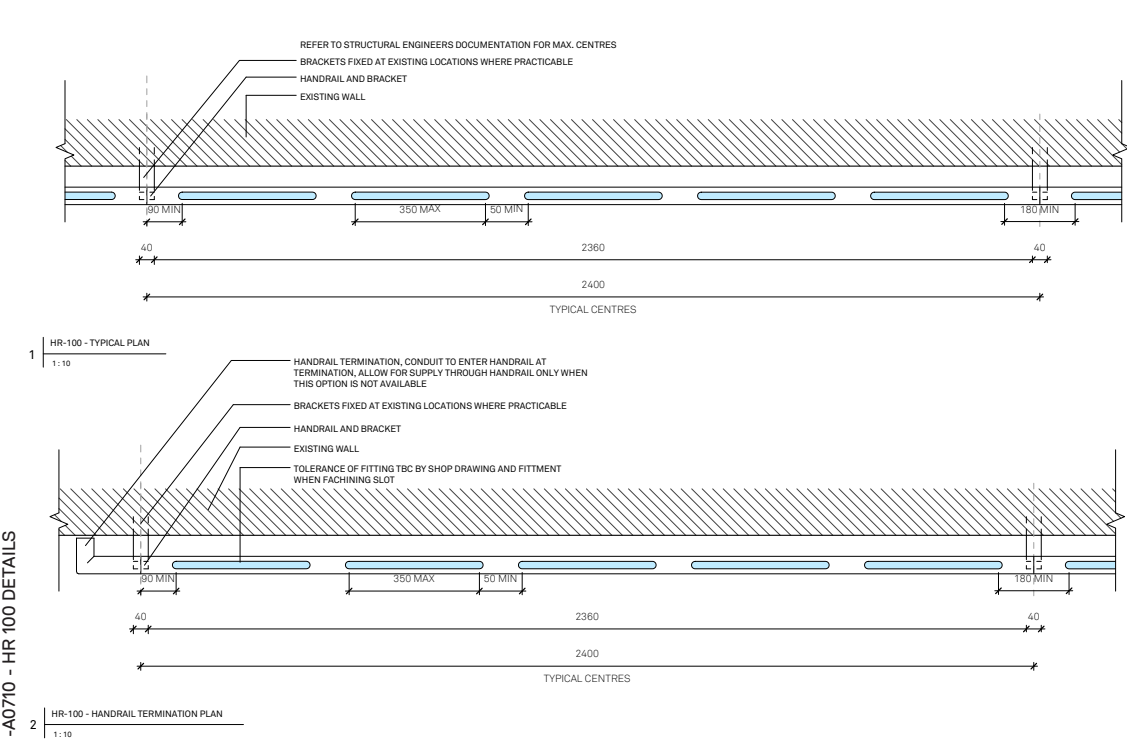
PRISM DWG : 49-BR-GAS01-A0711 - HR - 100 DETAILS



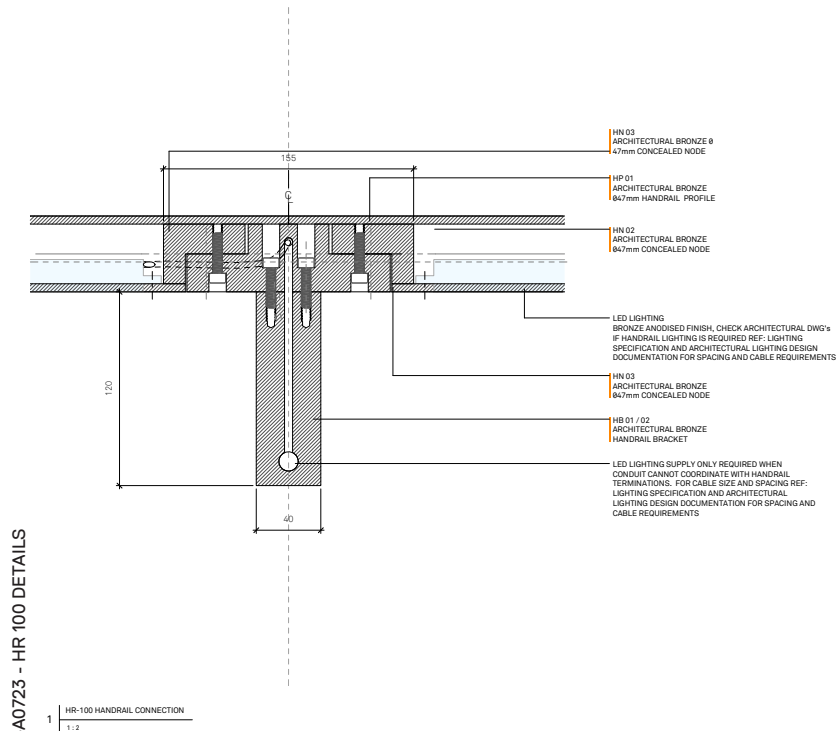
Interior handrail: HR-100

Handrail plan and section

Indicates bronze extrusion
supplied by SOH



PRISM DWG : 49-BR-GAS01-A0710 - HR 100 DETAILS

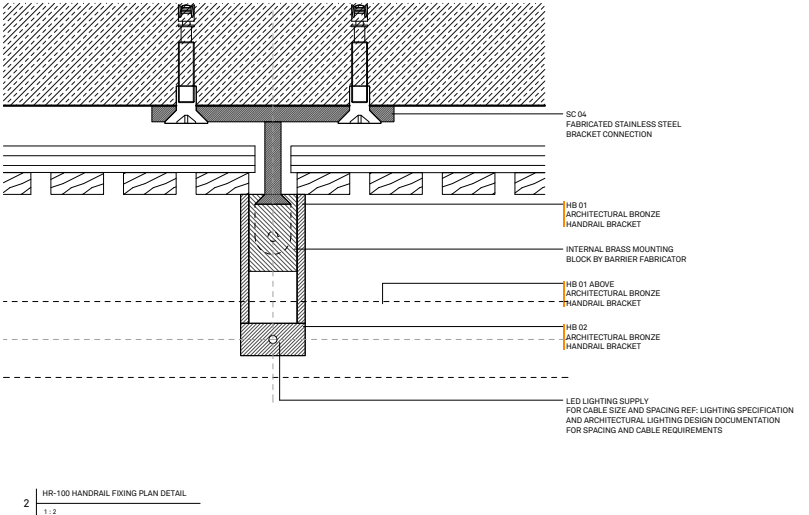
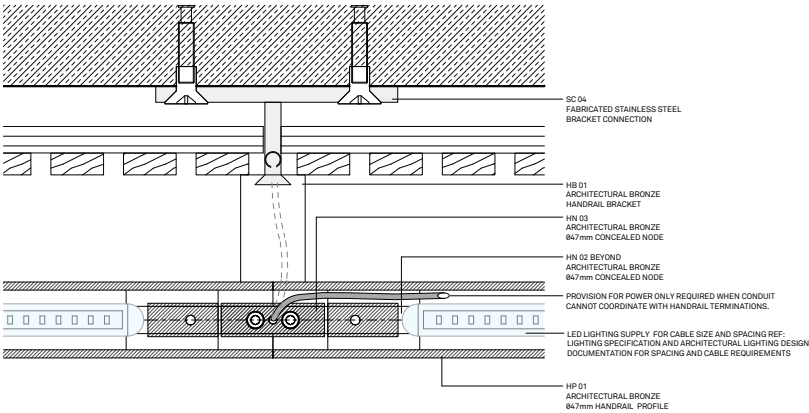
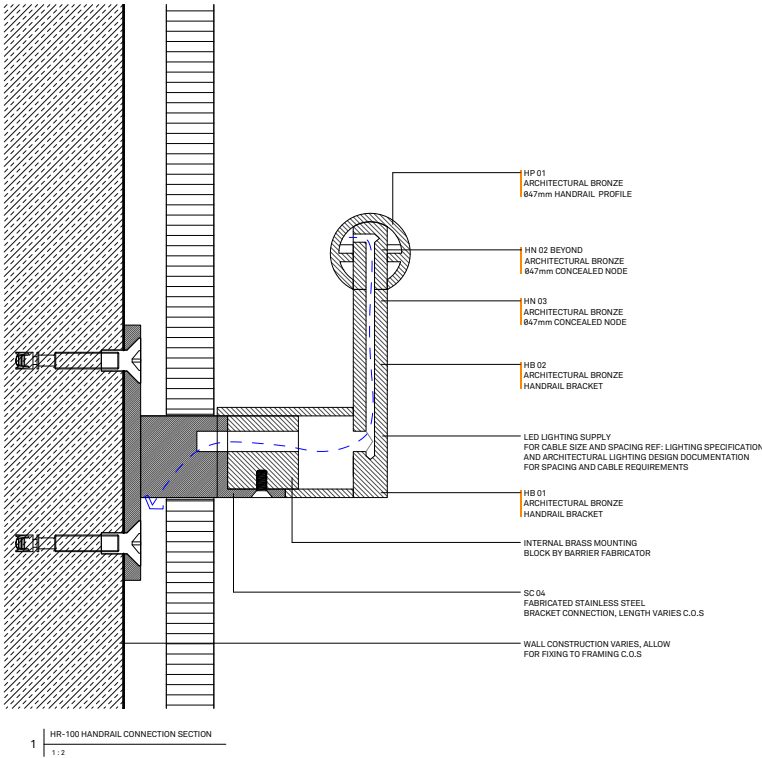


PRISM DWG : 49-BR-GAS01-A0723 - HR 100 DETAILS

Interior handrail: HR-100

Handrail sections

Indicates bronze extrusion
supplied by SOH



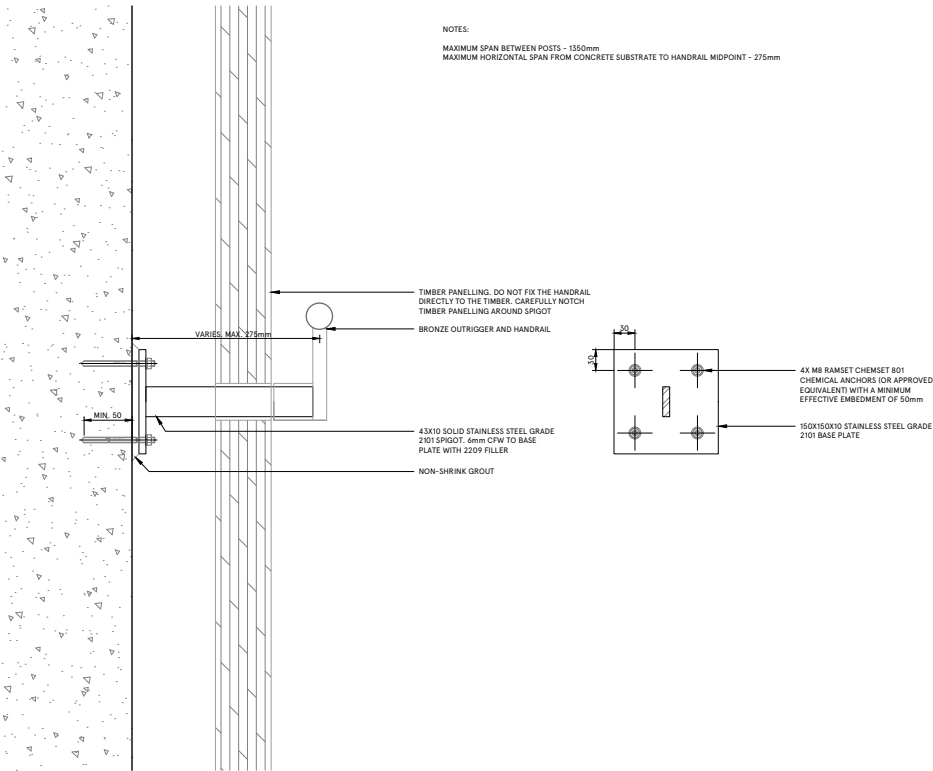
PRISM DWG : 49-BR-GAS01-A0723 - HR 100 DETAILS

PRISM DWG : 49-BR-GAS01-A0723 - HR 100 DETAILS

Interior handrail: HR-100

Structural details

PRISM DWG : FADR-007 - HR 100 DETAILS

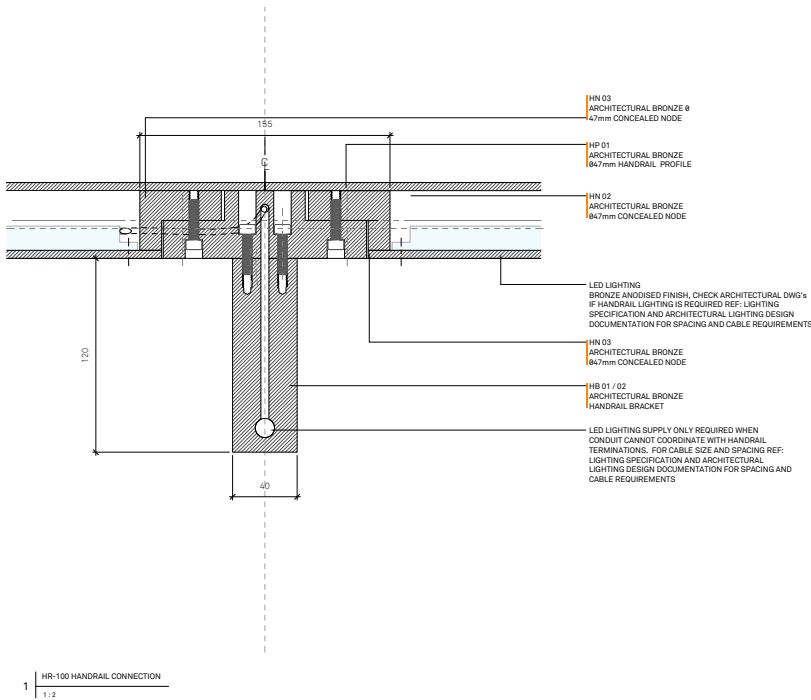


Interior handrail: HR-100

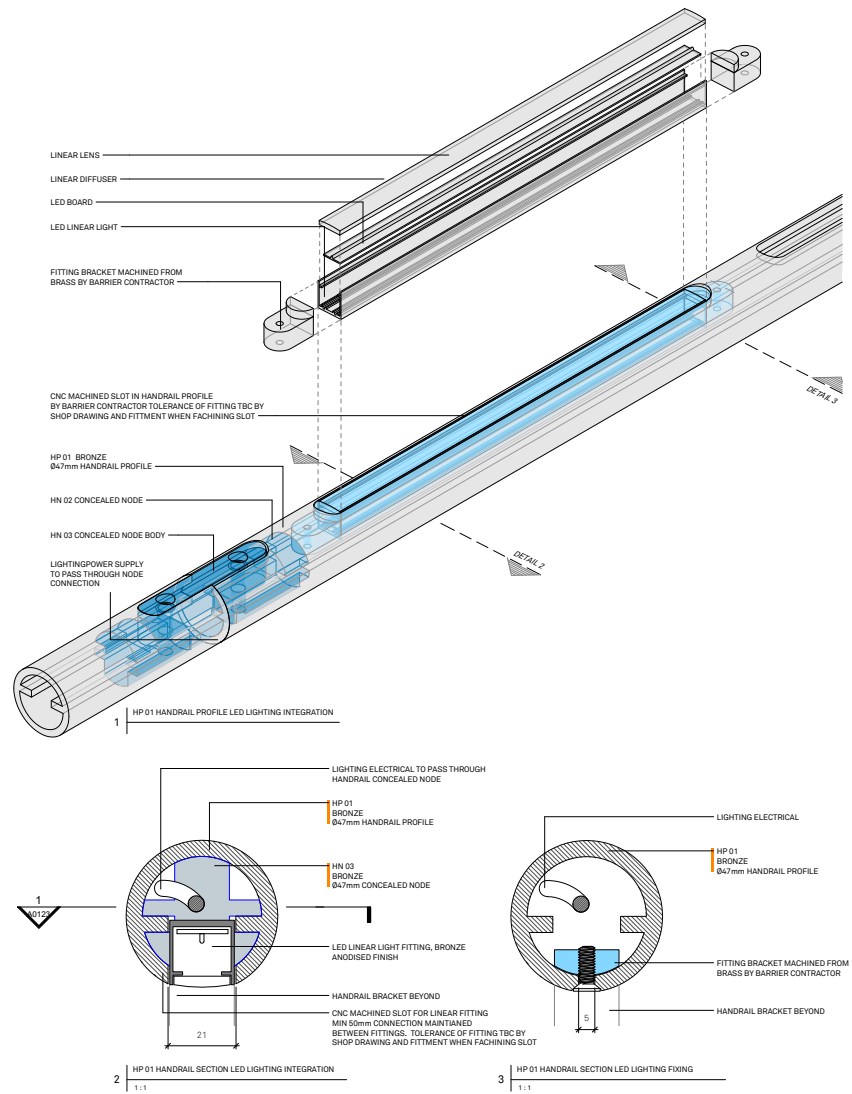
Lighting details

Indicates bronze extrusion
supplied by SOH

PRISM DWG : 49-BR-GAS01-A0721 - HR 100 DETAILS



PRISM DWG : 49-BR-GAS01-A1210 - HR 100 DETAILS



Interior handrail: HR-300

Design application

Throughout the interior performance spaces, corridors and stairs, existing elliptical wall mounted handrails and free standing guardrails are common throughout the interior performance spaces corridors and stairs. The BCP has reproduced the elliptical profile to suit adjacent environmental commonalities.

Nominated locations

All interior locations, East and Western Foyers, stairs, ramps and barriers. Within the Joan Sutherland Theatre and Concert Hall.

Code requirements

- National Construction Code:
- 2016 Building Code of Australia
- Disability Discrimination Act:
- AS1428.1 (2009) Design for Access and Mobility
- Engineering:
- AS 1170.1 (2002) Structural Design Actions

Specifications

Height: 865 - 1000mm

Handrail: 55 x 15mm elliptical (0.75 kN/m horizontal, 0.75 kN/m vertical)

Maximum Span: TBC

Bracket: 53x20mm

Accessibility: Handrail extensions return and terminate into the adjacent wall finishes.

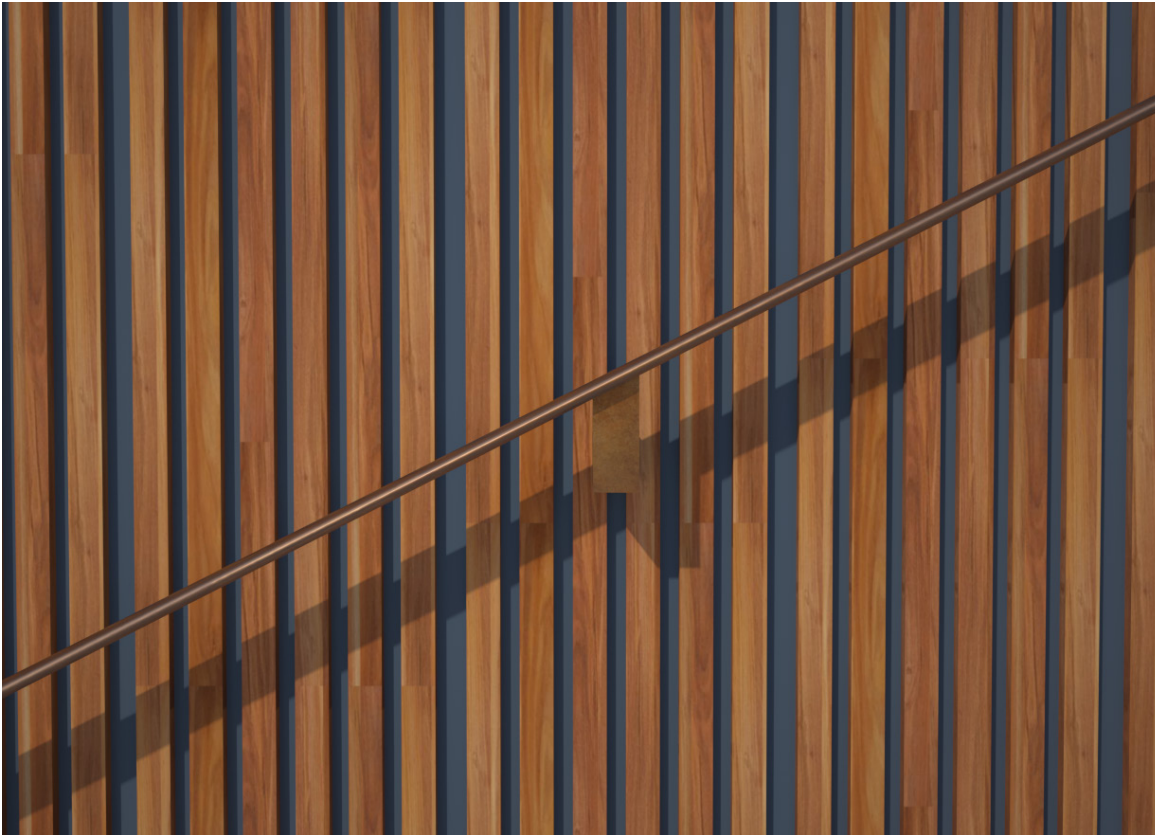
Components

Brazing: Visible portions of silver solder are common in existing installations where sections of continuous profile are joined and are a feature of bronze materiality.

Extensions: In some existing instances, sections of elliptical profile mitre and change direction either horizontally or vertically.

Lighting

Not applicable, lighting cannot be accommodated with this profile.



01

01 Rendered elevation of the interior wall mounted elliptical handrail (Grimshaw)

02 Rendered perspective of the elliptical handrail termination option (Grimshaw)

03 Rendered elevation of the interior wall mounted elliptical handrail (Grimshaw)

04 Rendered perspective of the elliptical handrail termination option (Grimshaw)



03



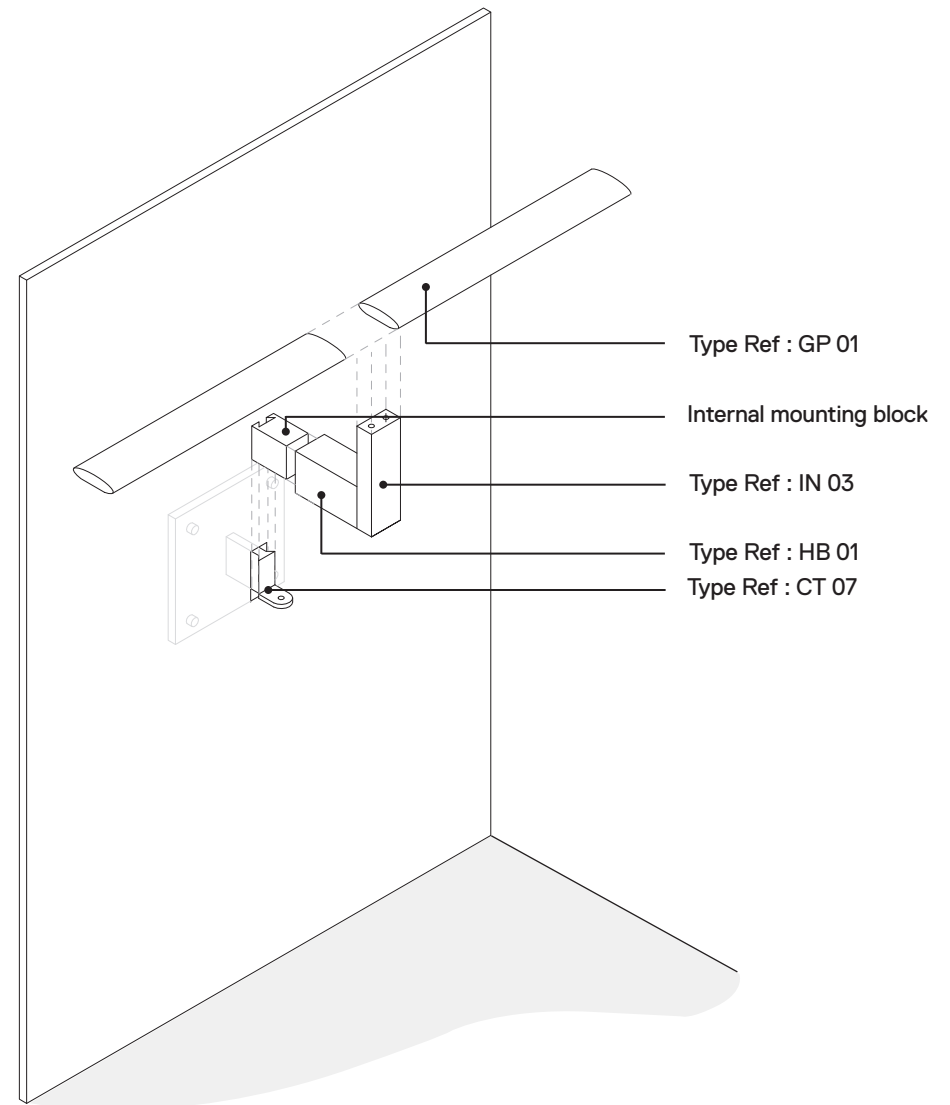
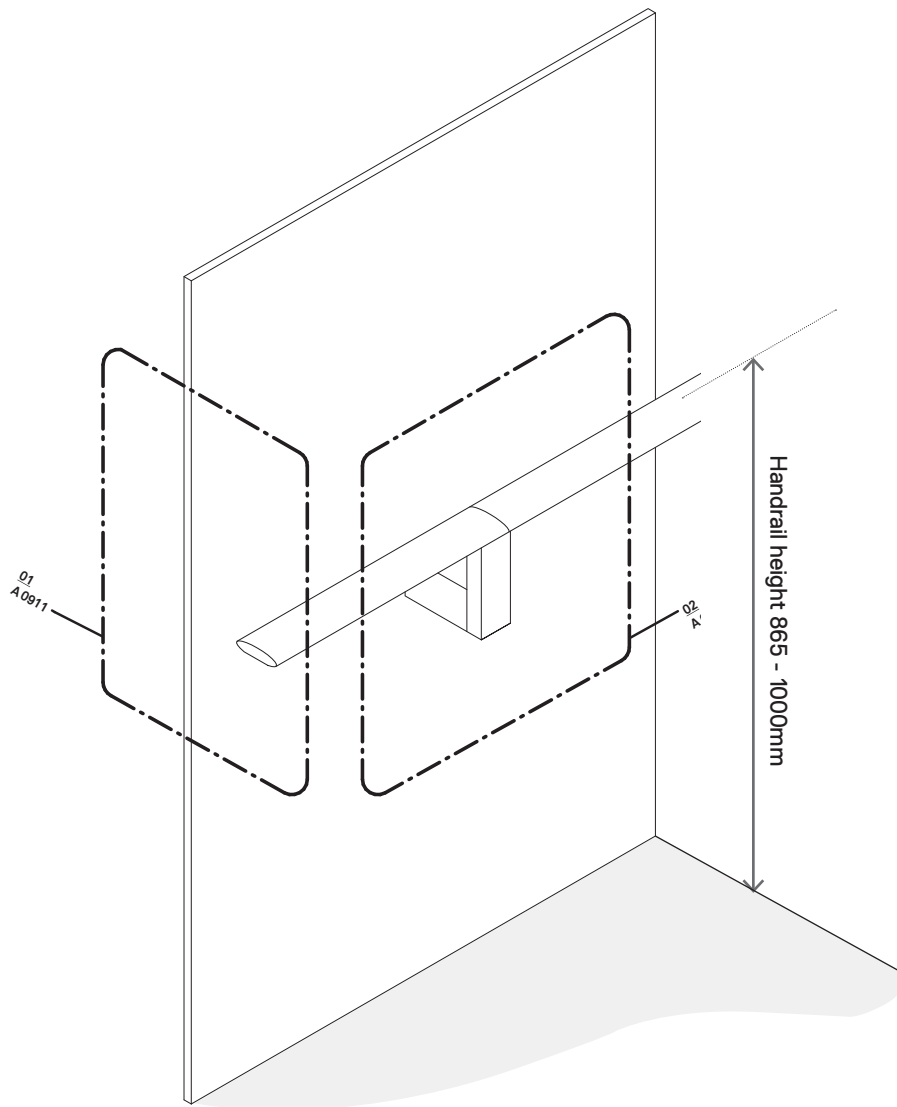
02



04

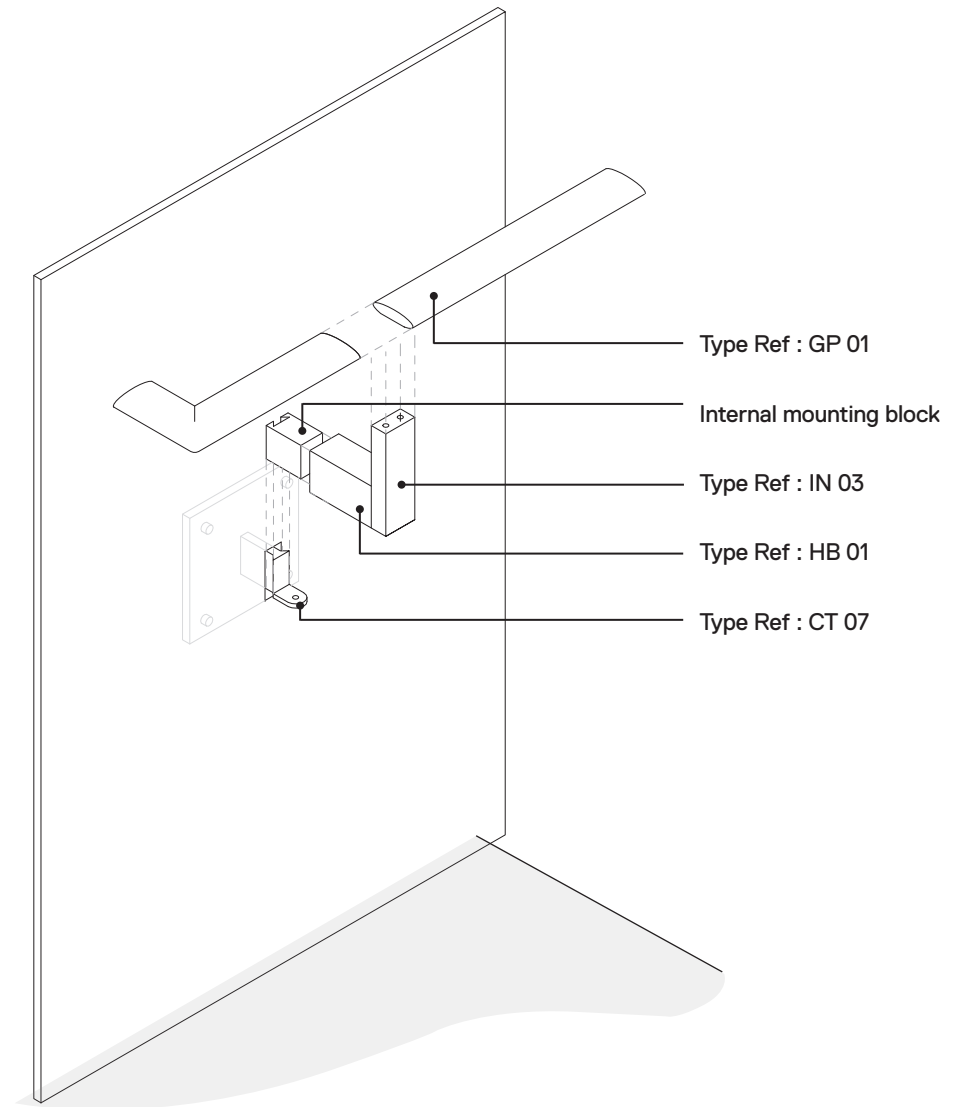
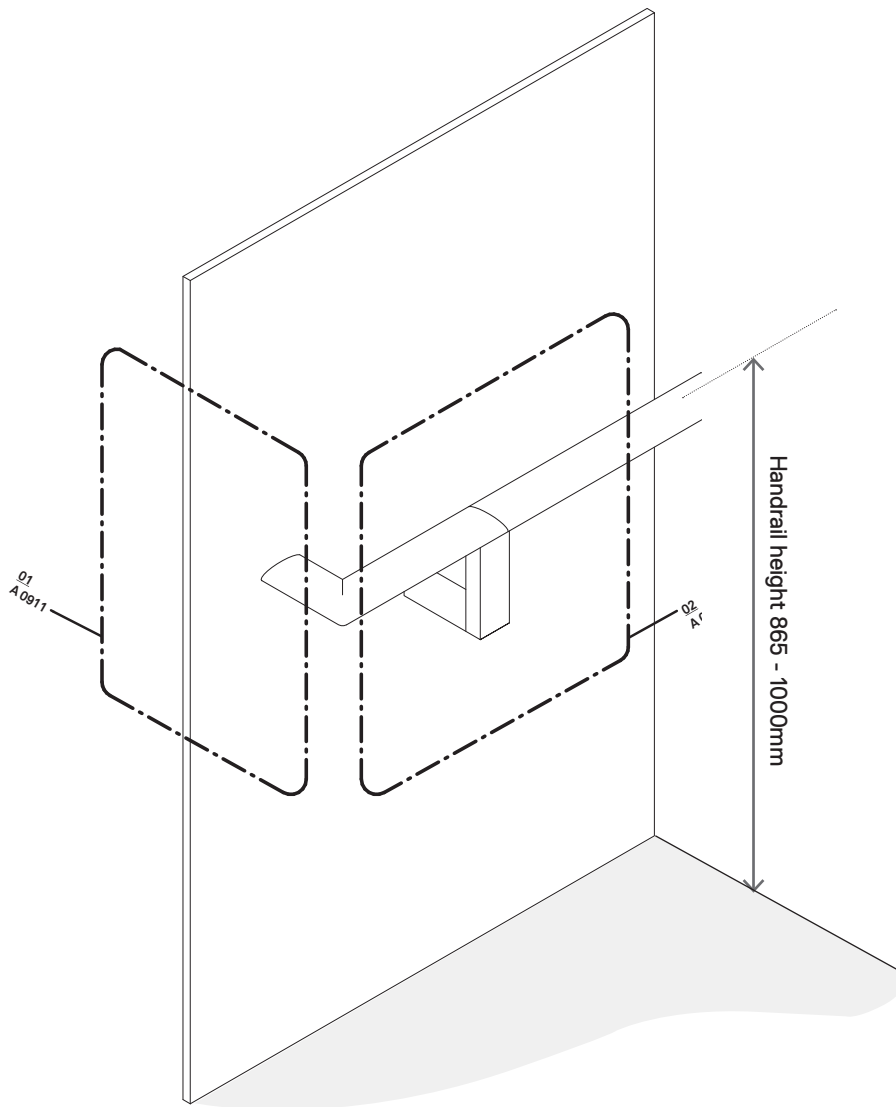
Interior handrail: HR-300

Typical details



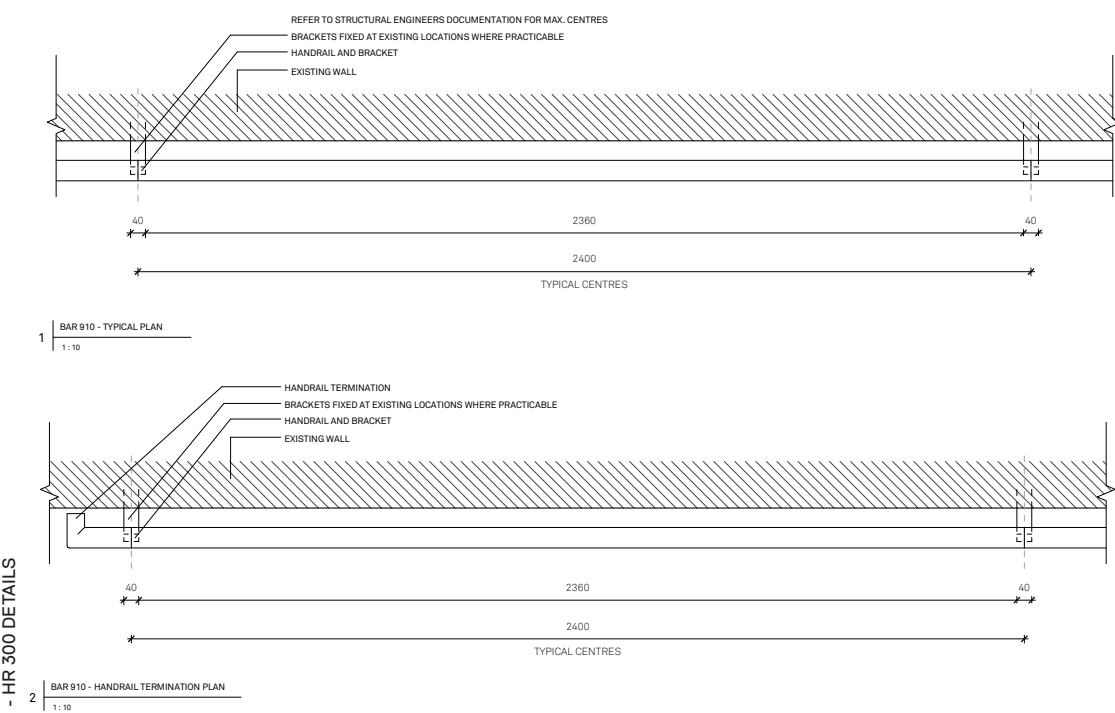
Interior handrail: HR-300

Handrail termination and section

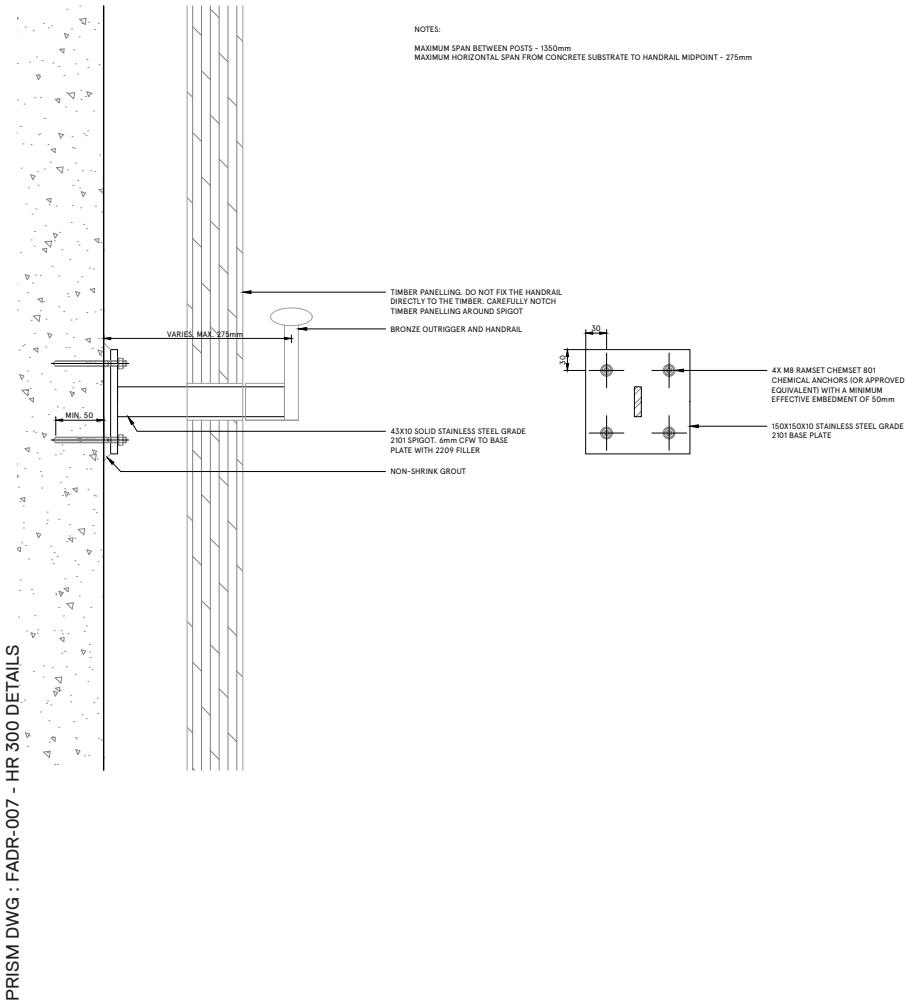


Interior handrail: HR-300

Handrail plan and structural details



PRISM DWG : 49-BR-GAS01-A0910 - HR 300 DETAILS

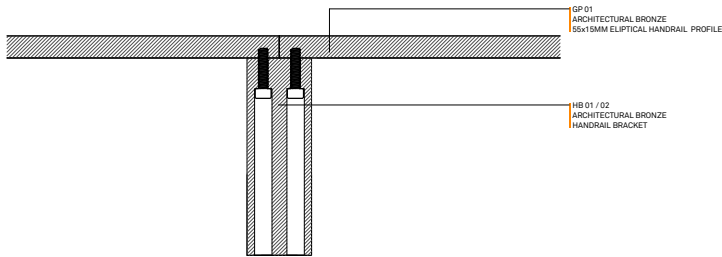


Interior handrail: HR-300

Section details

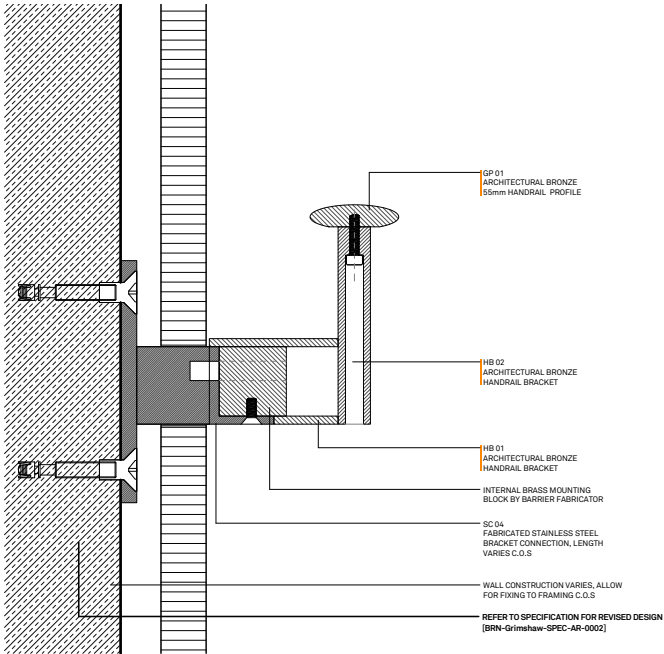
Indicates bronze extrusion
supplied by SOH

PRISM DWG : 49-BR-GAS01-A0921 - HR 300 DETAILS



1 | HR-300 ELEVATION DETAIL
1:2

PRISM DWG : 49-BR-GAS01-A0922 - HR 300 DETAILS



1 | HR-300 SECTION DETAIL
1:2

Interior handrail: HR-300

Common requirements

Accessibility

The handrail designs have been assessed for DDA compliance by Richard Seidman of iAccess. His full report is attached as appendix 2. The HR-300 wall mounted handrail is associated with installation of accessible seating platforms within the JST and CH, interior stairs, aisles and passageways where they are affixed to precast granite sets, through box brush wall cladding and future wall claddings as future renewal works determine. The design incorporates a 55mm elliptical (HR 300) handrail types supported from opaque wall elements.

The use and reproduction of the existing elliptical 55 x 15mm (HR-300) rail mounted along the interior JST and CH aisle way is acceptable. There is no NCC requirement for the provision of handrails to be provided along the aisle ways of NCC Class 9b Special Use Buildings. Noting this, the proposed use of handrail HR-300 will satisfy the design criteria noted in the American 2010 ADA Standards for Accessible Design which permits the use of an elliptical handrail with a maximum width of 57mm.

The heights of the handrail types have been agreed between iAccess and Group DLA (PCA for the current renewal works). Handrail extensions and terminations are in accordance with the provisions of Clauses 11 and 12 of AS1428.1:2009 are not required to be satisfied in this location. However when the HR-300 profile is used in non aisle way applications the detailing of the handrail at the top of the stair flights is required to turn the handrail 180deg horizontally.

This approach is acceptable provided the minimum extension at the top of the stair flight is achieved. The minimum extension at the top of the flight will need to be 300mm in accordance with the provisions of Clause 11.2(e) of AS1428.1:2009. The detailing of the handrail at the bottom of the stair flights turns the handrail 180 degrees horizontally. This approach is acceptable provided the minimum extension at the top of the stair flight is achieved. The minimum extension at the top of the flight will need to be stair going + 300mm in accordance with the provisions of Clause 11.2(d) of AS1428.1:2009

Handrail heights for stairs, landings, walkways occur in a zone 865 to 1000mm and this varies depending on the stair geometry and transition zone for horizontal extensions BCA 2009 Clause D2.17 and Clause 12 of AS1428.1:2009. Handrails are required along at least one side of the ramp or stairs, or both sides where the stairs or ramp are wider than 2m BCA 2009 Clause D2.17. Handrail diameters are 55mm elliptical (HR 300) and connection hardware allows the upper surface to be clear of obstructions or breaks for 270 degrees around each of the profiles. The wall mounted handrail bracket exceeds the min. 50mm clearance to the wall AS1428.1:2009 fig 29.

Engineering

Extensive engineering studies were conducted by PRISM during the design and selection of structural members and connections.

No specified loads are nominated within the standards for handrails where there is no fall beyond. Only a serviceability load is necessary to make sure the handrail does not permanently bend under load. The HR-300 elliptical profile has a depth of 15mm and requires the wall mounted handrail brackets to be positioned closer than the usual 2400mm.

To achieve this PRISM have proposed a serviceability load of 0.75kN/m is applied to all handrails where they are not acting as a barrier, or where there is a separate barrier beyond. This matches the C1/C2 load nominated in AS1170.1 for areas without obstacles for moving people.

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2.3

Guard Rails

Interior guard rail: GR-100

Design application

Throughout the Northern Foyers free standing guard rails are located centrally on stairs, these provide lighting to the stairs to improve the uniformity of lighting conditions.

Nominated locations

All interior locations, Northern and Southern Foyers, stairs, and ramps.

Code requirements

National Construction Code:

- 2016 Building Code of Australia

Disability Discrimination Act:

- AS1428.1 (2009) Design for Access and Mobility

Engineering:

- AS 1170.1 (2002) Structural Design Actions

Specifications

Top rail: 53mm Diameter

Handrail: 53mm Diameter

Post size: 53x20mm

Glazing: None

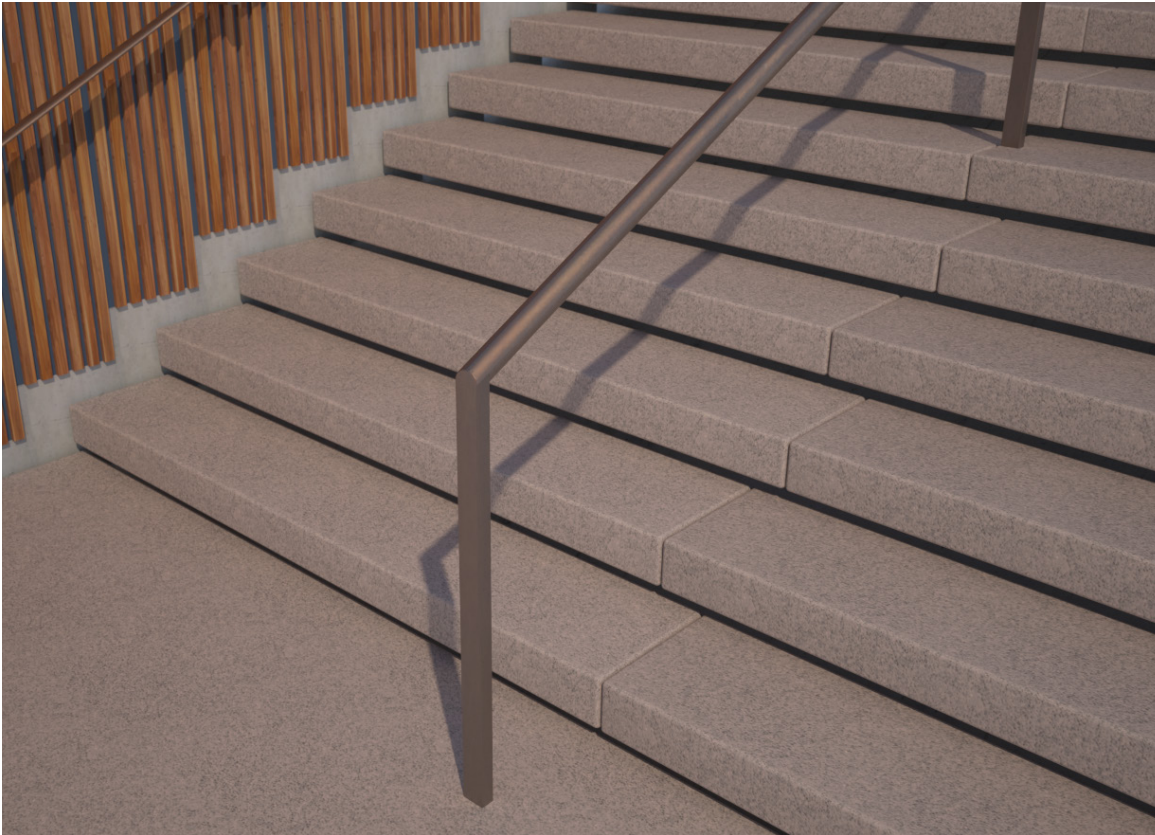
Accessibility: Handrail horizontal extensions have been omitted from the guard rail as they do not form part of the accessible path.

Components

NA

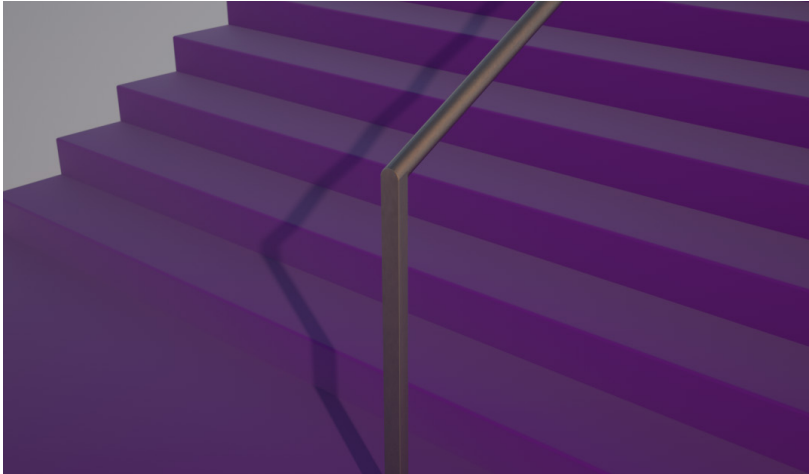
Lighting

Linear LED light fittings, maximum length when integrated into handrail 355 mm

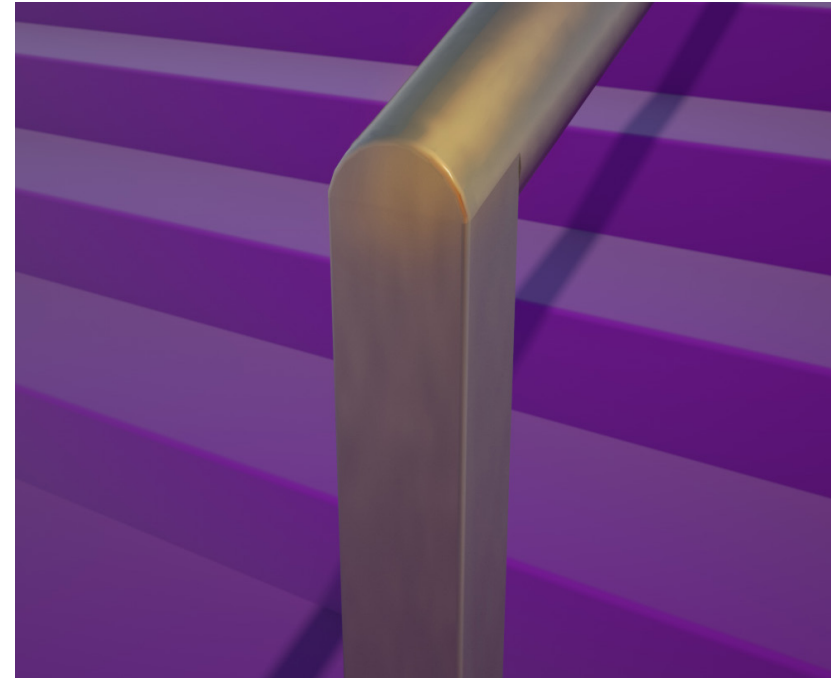


01

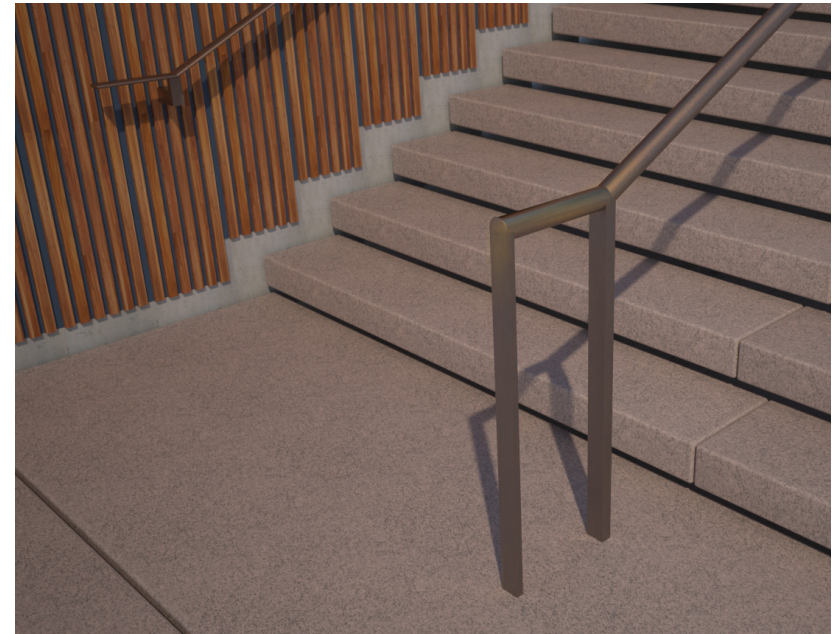
- 01 Rendered perspective of interior guard rail (Grimshaw)
- 02 Rendered connection detail (Grimshaw)
- 03 Rendered perspective of the guardrail termination option (Grimshaw)
- 04 Rendered perspective of the guardrail termination option (Grimshaw)



03



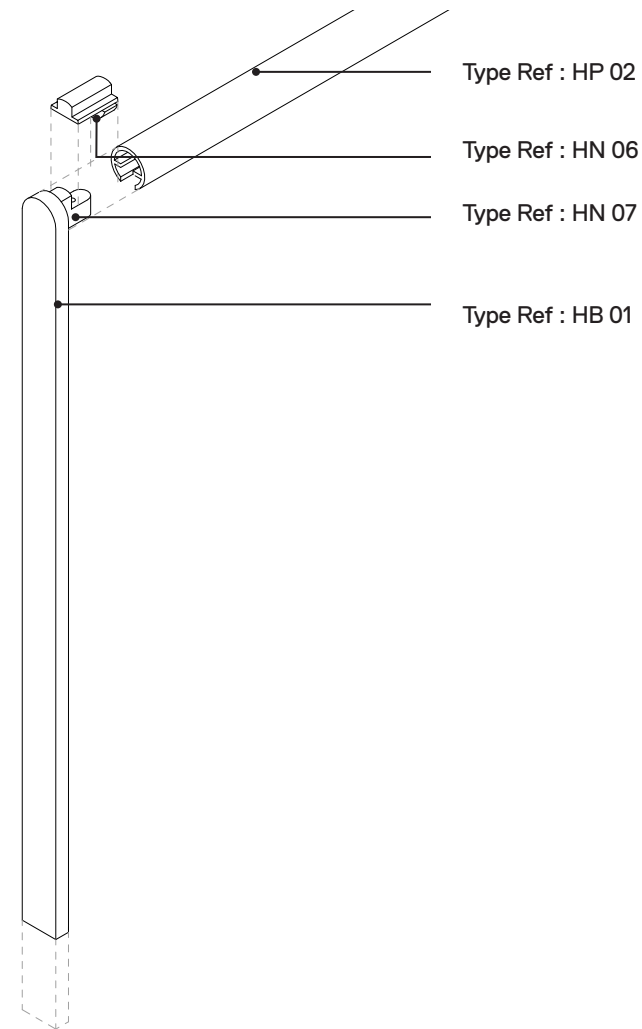
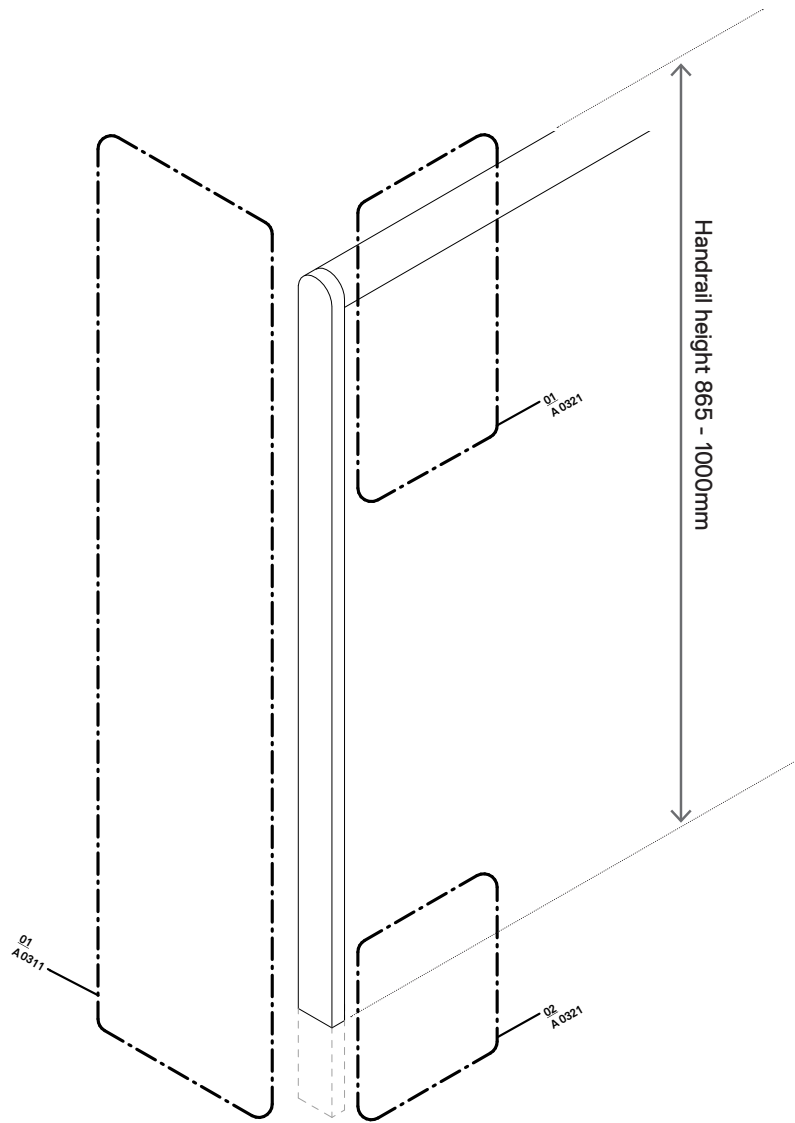
02



04

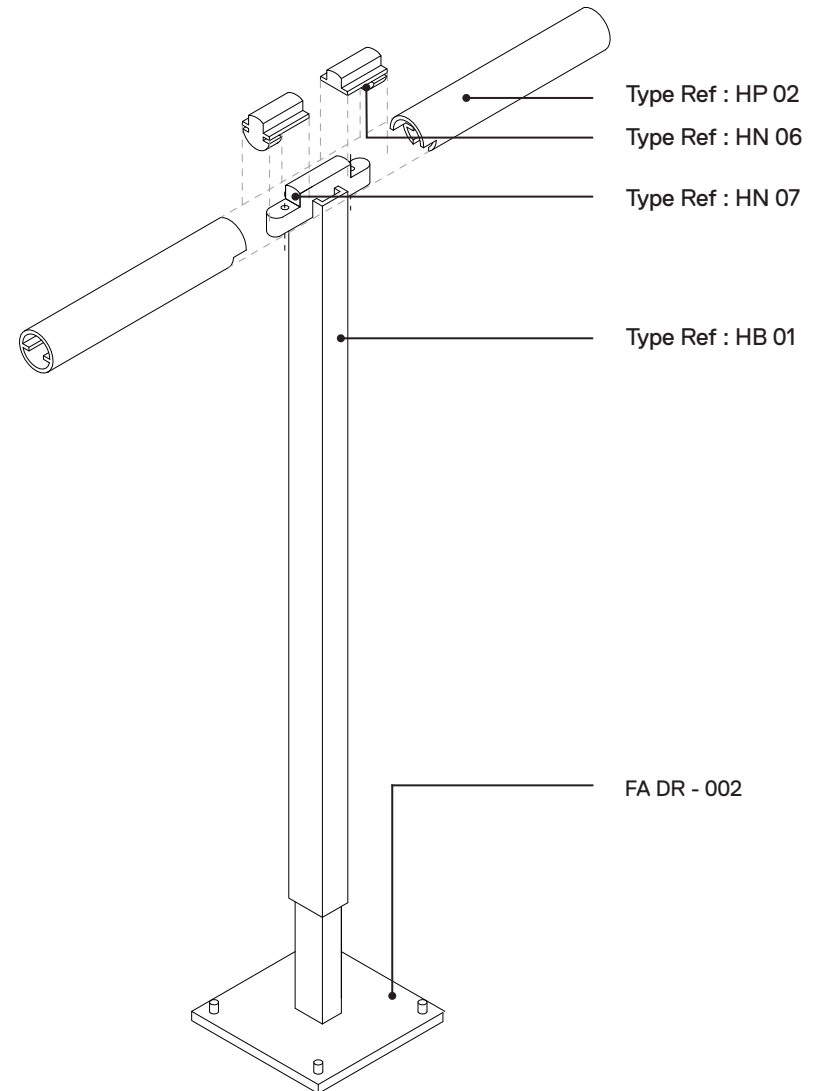
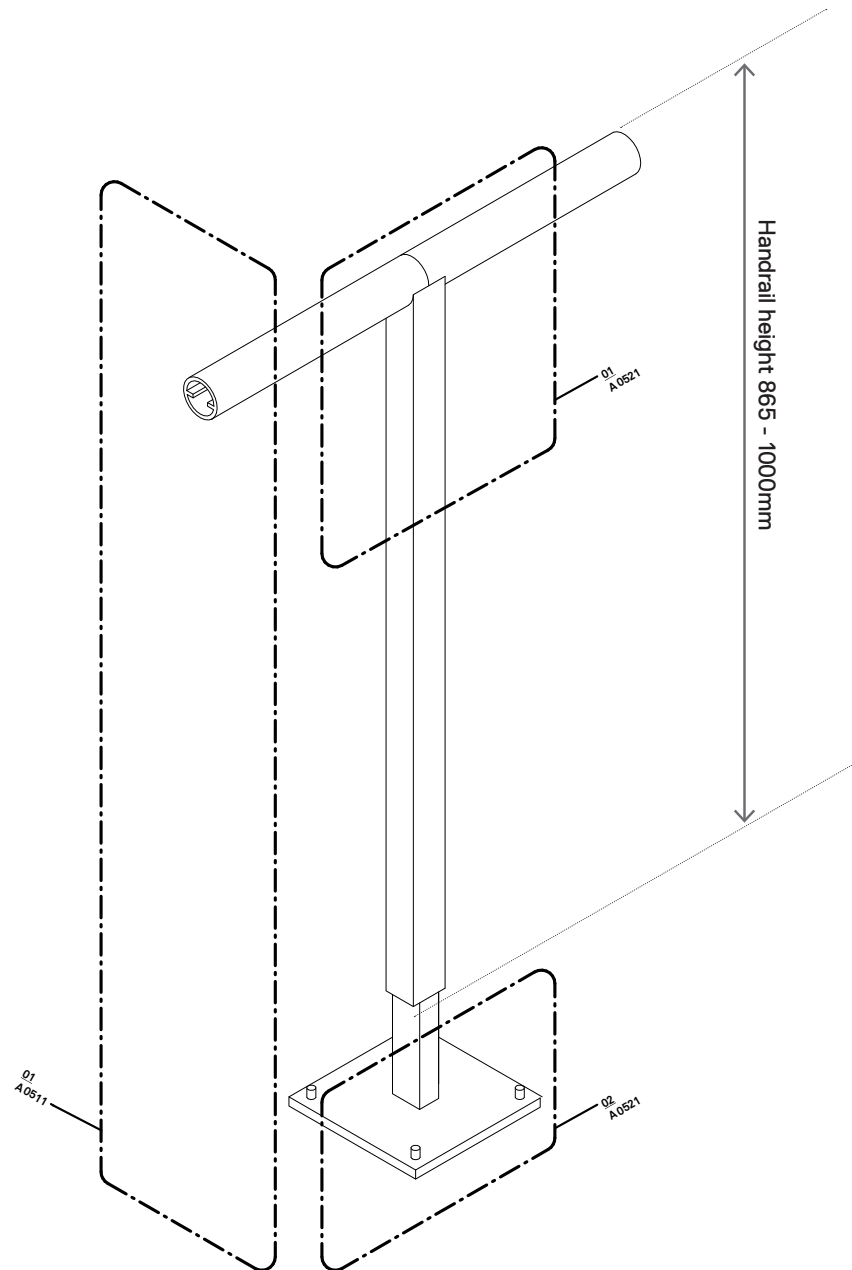
Interior guard rail: GR-200

Handrail termination



Interior guard rail: GR-200

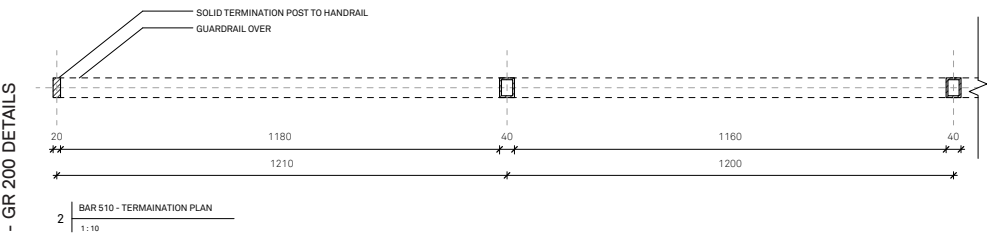
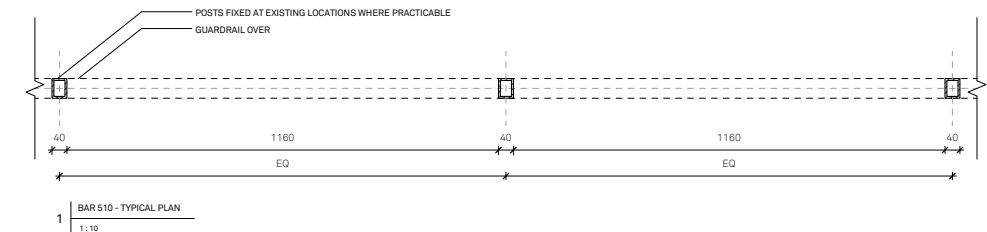
Handrail termination



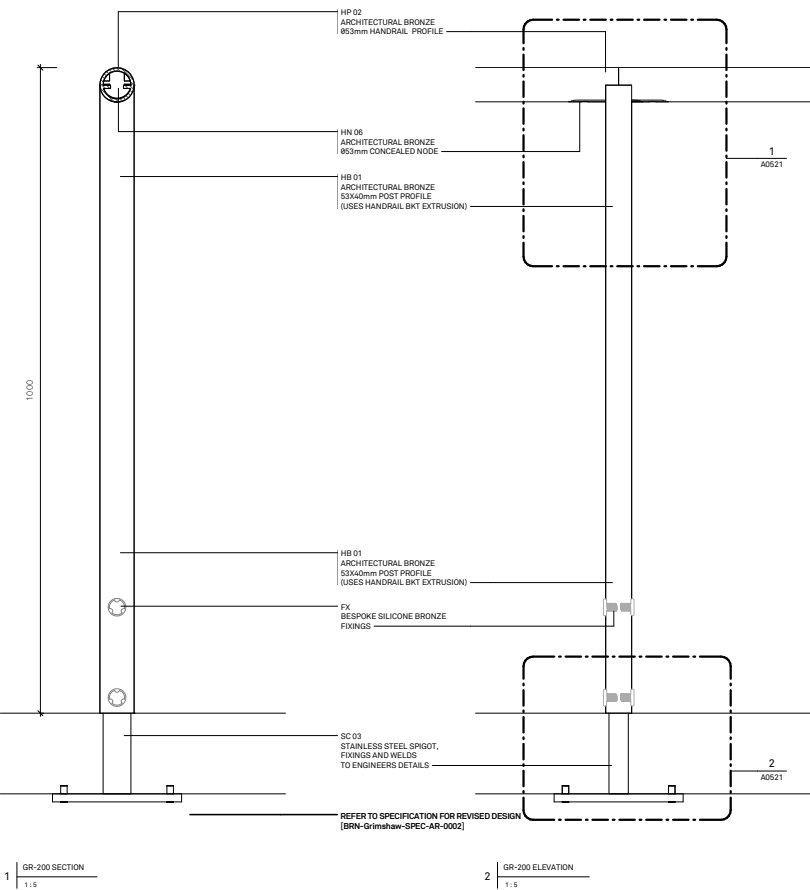
Interior guard rail: GR-200

Typical section

Indicates bronze extrusion
supplied by SOH



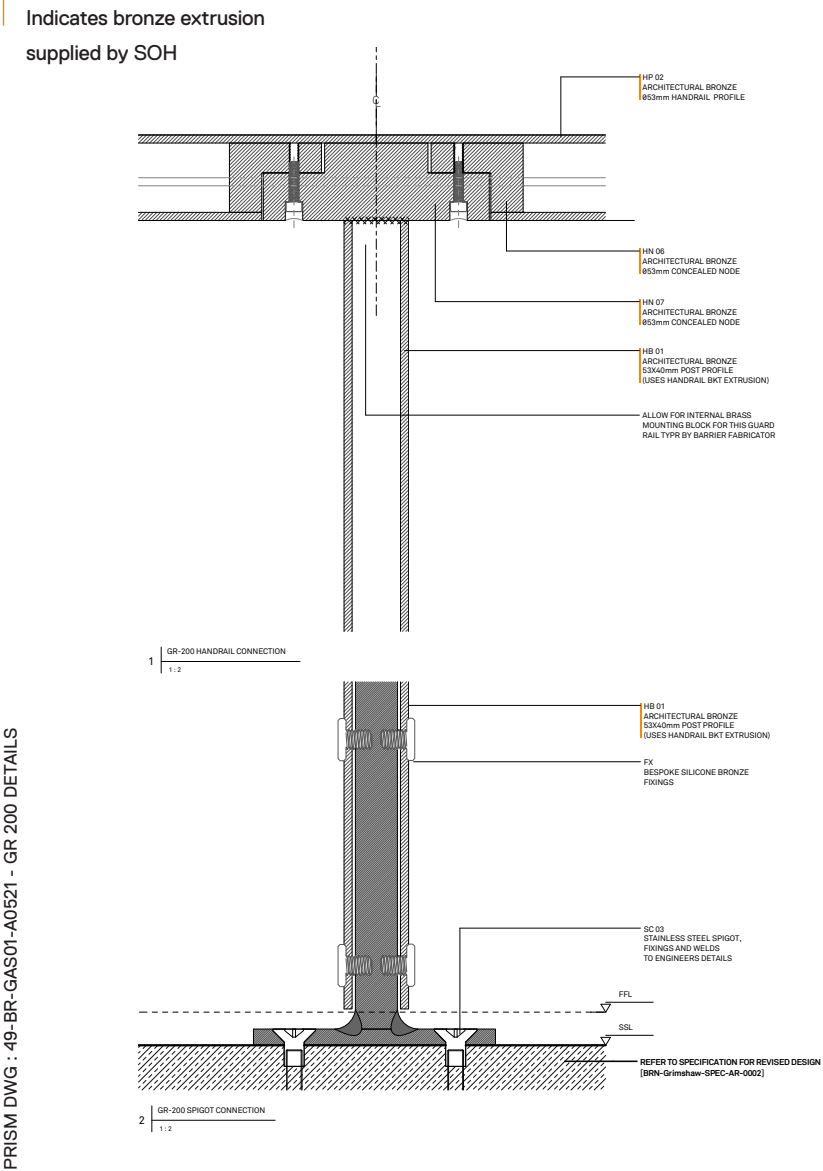
PRISM DWG : 49-BR-GAS01-A0510 - GR 200 DETAILS



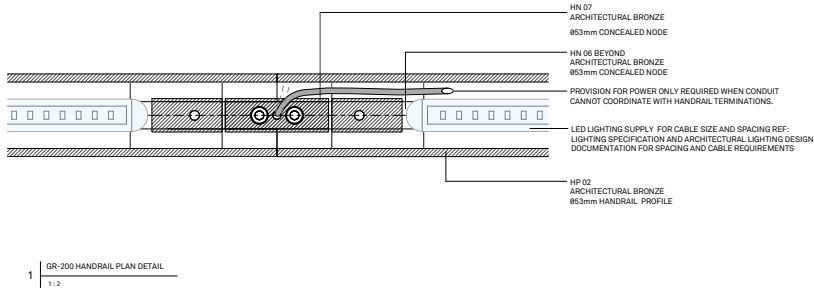
PRISM DWG : 49-BR-GAS01-A0511 - GR 200 DETAILS

Interior guard rail: GR-200

Typical section



PRISM DWG : 49-BR-GAS01-A0521 - GR 200 DETAILS

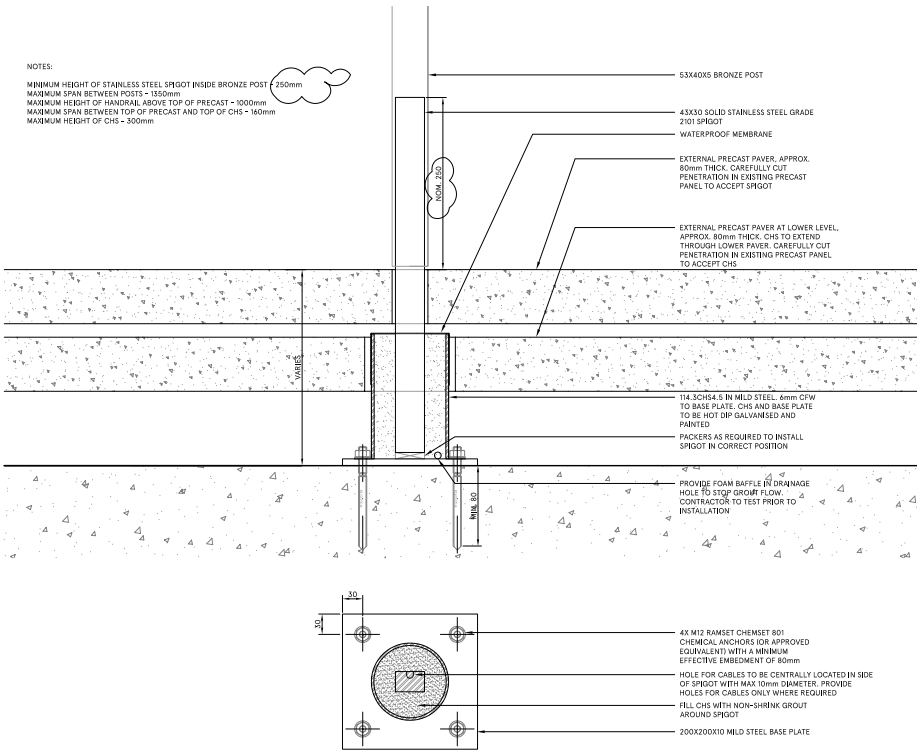
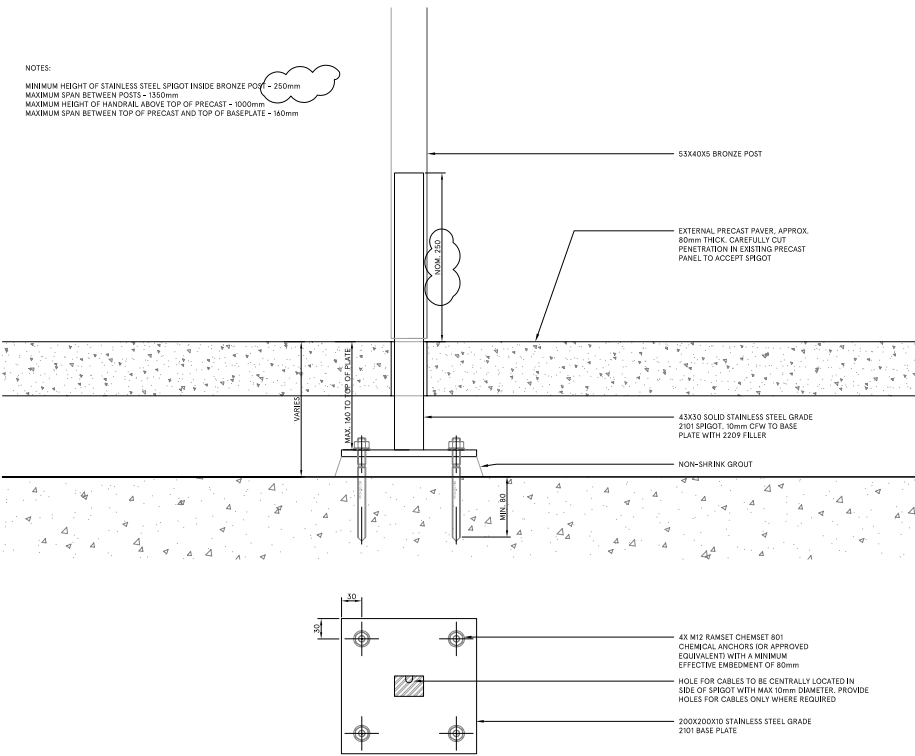


PRISM DWG : 49-BR-GAS01-A0523 - GR 200 DETAILS

Interior guard rail: GR-200

Structural details

PRISM DWG : FADR-002 - GR 200 DETAILS

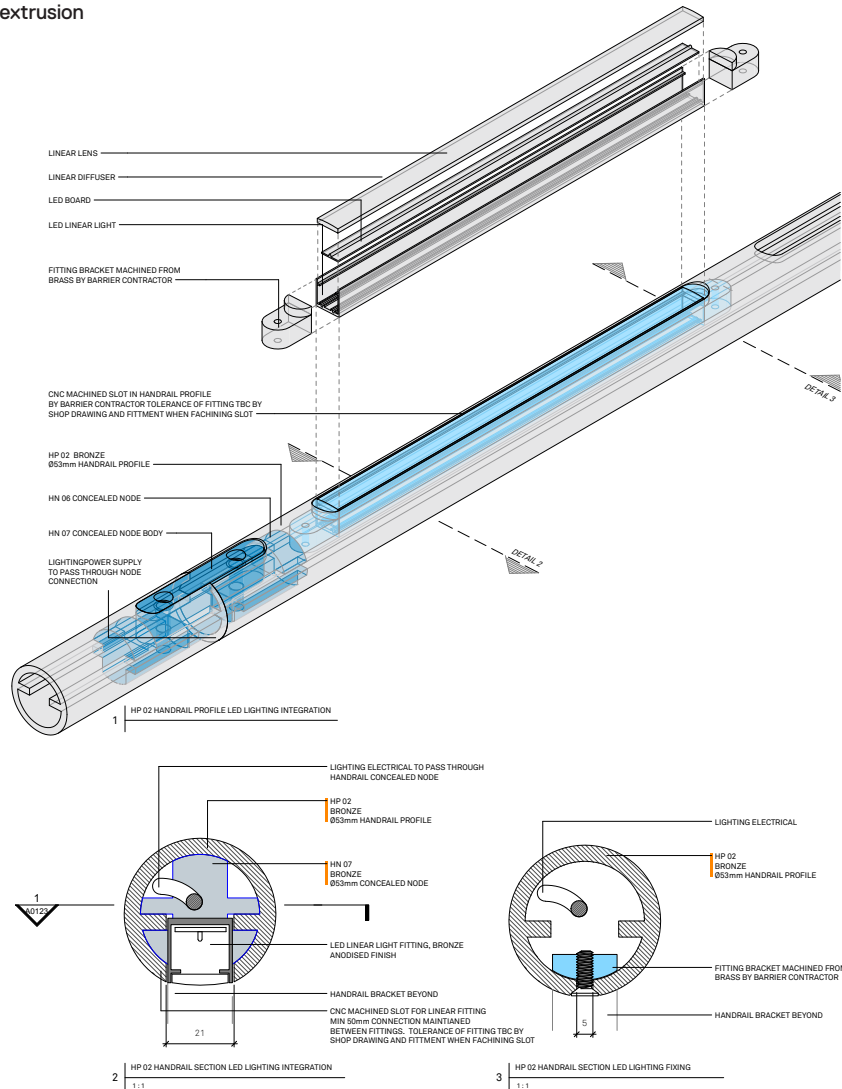


PRISM DWG : FADR-007 - GR 200 DETAILS

Interior guard rail: GR-200

Lighting details

Indicates bronze extrusion
supplied by SOH



PRISM DWG : 49-BR-GAS01-A1210 - GR 200 DETAILS

Interior guard rail: GR-200

Common requirements

Accessibility

The handrail designs have been assessed for DDA compliance by Richard Seidman of iAccess. His full report is attached as appendix 2. The GR-200 free standing guard rail is associated Northern Foyers and the Western Foyer to the CH as stair dividing rails. They are affixed to precast granite sets and to the concrete structure in carpeted areas and future floor coverings as future renewal works determine. The design incorporates a 53mm circular (GR-200) handrail types supported on free standing vertical posts. The heights of the handrail types have been agreed between iAccess and Group DLA (PCA for the current renewal works)

GR-200 can accommodate extensions and terminations in accordance with the provisions of Clauses 11 and 12 of AS1428.1:2009 are not required to be satisfied when used as a free standing guardrail. However when the GR 100/200 profile is used in non aisle way applications the detailing of the handrail at the top of the stair flights are required to turn the handrail 180 degrees horizontally. This approach is acceptable provided the minimum extension at the top of the stair flight is achieved. The minimum extension at the top of the flight will need to be 300mm in accordance with the provisions of Clause 11.2(e) of AS1428.1:2009. The detailing of the handrail at the bottom of the stair flights turns the handrail 180deg horizontally. This approach is acceptable provided the minimum extension at the top of the stair flight is achieved.

The minimum extension at the top of the flight will need to

be stair going + 300mm in accordance with the provisions of Clause 11.2(d) of AS1428.1:2009. Handrail heights for stairs, landings, walkways occur in a zone 865 to 1000mm this varies depending on the stair geometry and transition zone for horizontal extensions BCA 2009 Clause D2.17 and Clause 12 of AS1428.1:2009. Handrails are required along at least one side of the ramp or stairs, or both sides where the stairs or ramp are wider than 2m BCA 2009 Clause D2.17

Guardrail diameters are 47mm circular (GR 100) and 53mm circular (GR 200) profiles and connection hardware allows the upper surface to be clear of obstructions or breaks for 270 degrees around each of the profiles. The wall mounted handrail bracket exceeds the min. 50mm clearance to the wall AS1428.1:2009 fig 29.

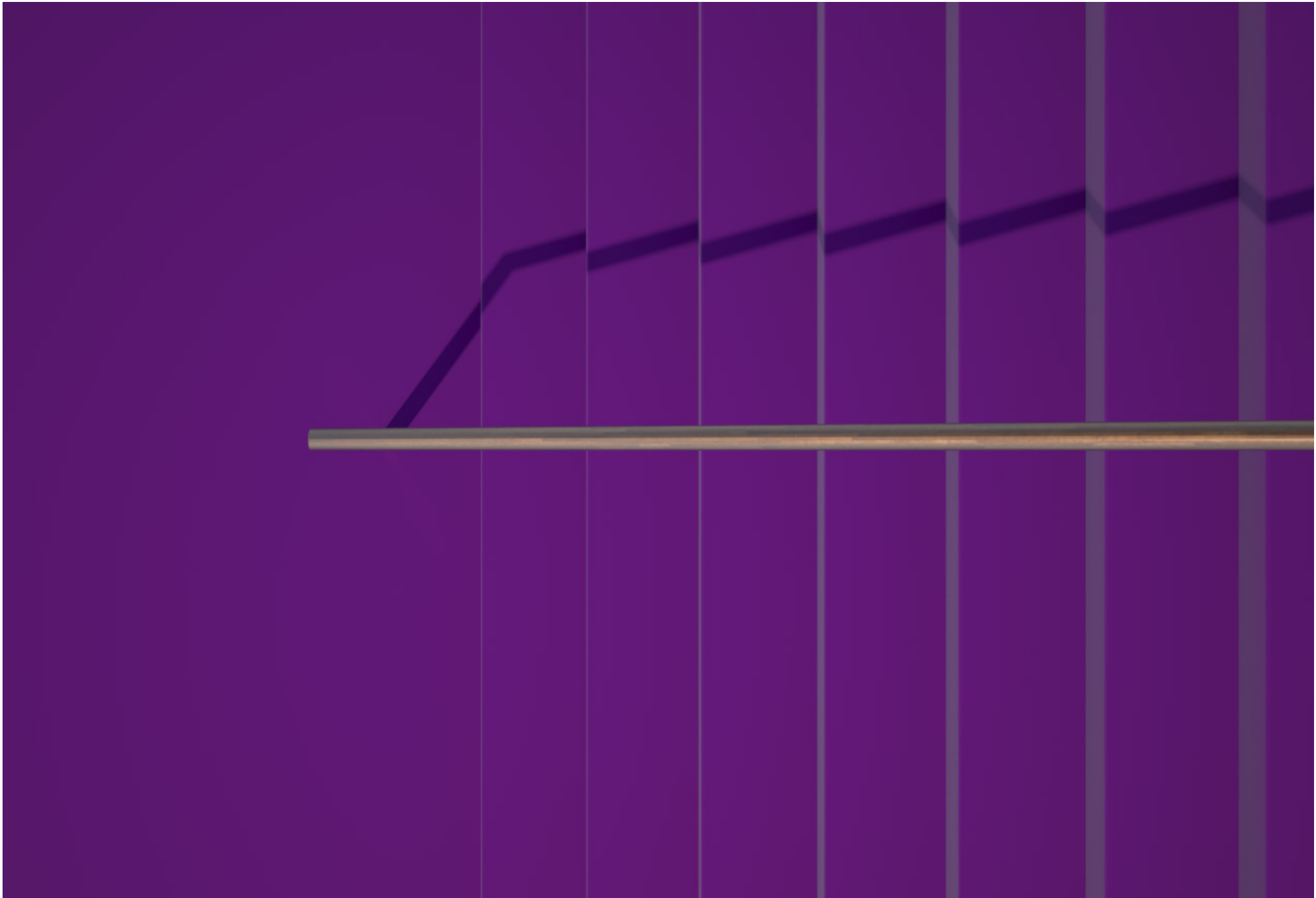
Lighting

In order to meet safety objectives the illumination levels for interior staircases and landings are to comply with AS/NZS 1680 which is 80 lux. In the calculation model prepared by Arup the handrail height has been set to 860mm. The overall results show the lighting level of both staircase and landing to achieve a horizontal average of 80 lux for a width of 1m from the handrail. Linear LED fittings have been designed to be concealed within the GR-100 handrail which has a diameter of 47mm and GR-200 handrail which has a diameter of 53mm.

Although the selected fittings can be manufactured in long lengths, the barrier engineering requirements determined by PRISM have prevented fitting longer than 355 mm from being used. This is consistent with the replacement of the original T5 florescent tube fittings which are a similar length and are also spaced 45mm apart.

Engineering

Extensive engineering studies were conducted by PRISM during the design and selection of structural members and connections. No specified loads are nominated within the standards for handrails where there is no fall beyond. Only a serviceability load is necessary to make sure the handrail does not permanently bend under load. This has been an important consideration when accommodating linear LED lighting into the handrail profiles and has determined the max length of linear fittings and also the min gap between fittings. To achieve this PRISM has proposed a serviceability load of 0.75kN/m is applied to all handrails where they are not acting as a barrier, or where there is a separate barrier beyond. This matches the C1/C2 load nominated in AS1170.1 for areas without obstacles for moving people.



Team acknowledgments

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Arup

Tim Carr Australasia Leader, Lighting

Delvin Saputra Lighting Designer

GRIMSHAW

PRISM | ARUP

