SOUTHERN AFRICAN INSTITUTE
OF STEEL CONSTRUCTION

Elphick Proome Architecture + ARUP (Pty) Ltd

Nelson Mandela Cruise Terminal

THE PROJECT BRIEF

CLIENT: KCT | MSC

ARCHITECTS: Elphick Proome Architects

MAIN CONTRACTOR: Stefanutti Stocks Building KZN

Brief and project overview

After decades of operating cruises out of a rudimentary shed, the Port of Durban and ocean cruise capital of Sub-Saharan Africa now enjoys an energising and catalysing landmark terminal. As a new portal to the Kingdom of the Zulus that welcomes tourists to the province, the terminal is designed to facilitate embarkation and disembarkation of 6 000 passengers per day while converting to a conference centre during the 5 off-season months. To deliver this benchmark the terminal is planned to allow the functions attached to each process to occur with utmost efficiency.

This includes baggage drop-off, reception, waiting and immigration on the outward-bound flow and immigration and baggage collection on the inward bound flow. These areas are supported by both light vehicle drop off zones, light vehicle parking and bus drop off areas as well as future retail facilities. Unlike an airport, a cruise terminal demands large flows of people within short timeframes, so a clear and legible planning solution was fundamental.

Brief and project overview

The seasonal functional flexibility is achieved by allowing the division wall between the arrival's hall and the baggage collection hall to fully slide away, opening the entire floorplate to operate as a fully connected space

The terminal projects a powerful form which displays many layers of metaphor. Dwarfed by docked cruise liners wharf side, the construct asserts itself as a memorable landmark object interfacing harbour and city. Conceived with an overt African identity, the envelope of the terminal draws inspiration from the earthy colours, vibrant textures and traditional triangular motifs displayed in Zulu craft. Its terracotta cladding with variant coloration, wraps all surfaces of the building and unifies its form to offer a powerful image for passengers to view from docked liners' decks above. The African colouration inspired by Zulu artwork, is unique, contextual and demands attention, boldly contrasting the conventional white or grey 'treatment' characterising most transportation buildings globally.

Brief and project overview

Randomly arranged structural columns set on an ‘African grid’ support a vast canopy interfacing an expansive piazza. This over-sailing construct announces the entrance and together with the folded form of the facades and roof, characterise the terminal to generate a simple, yet intricate architectural expression.

The dominant angular enclosure connects tenuously to ground in strategic positions to emphasise the drama of the terminal’s cantilevered overhangs. Where the external envelope angles away, large, glazed expanses promote visual connection to the urban exterior. Crafted external paving arrangements and rich sub-tropical landscaping deliver an exciting and carefully orchestrated pedestrian experience which draws focus to the complex’s public piazza.

Brief and project overview

Effectively a large shed with extensive spans, the terminal's profile envelope is generated by a consistent 1,2m deep primary steel structural zone clad with profiled aluminium sheeting. This technical solution facilitates a very long northern edge cantilever anchored on a single springing point.

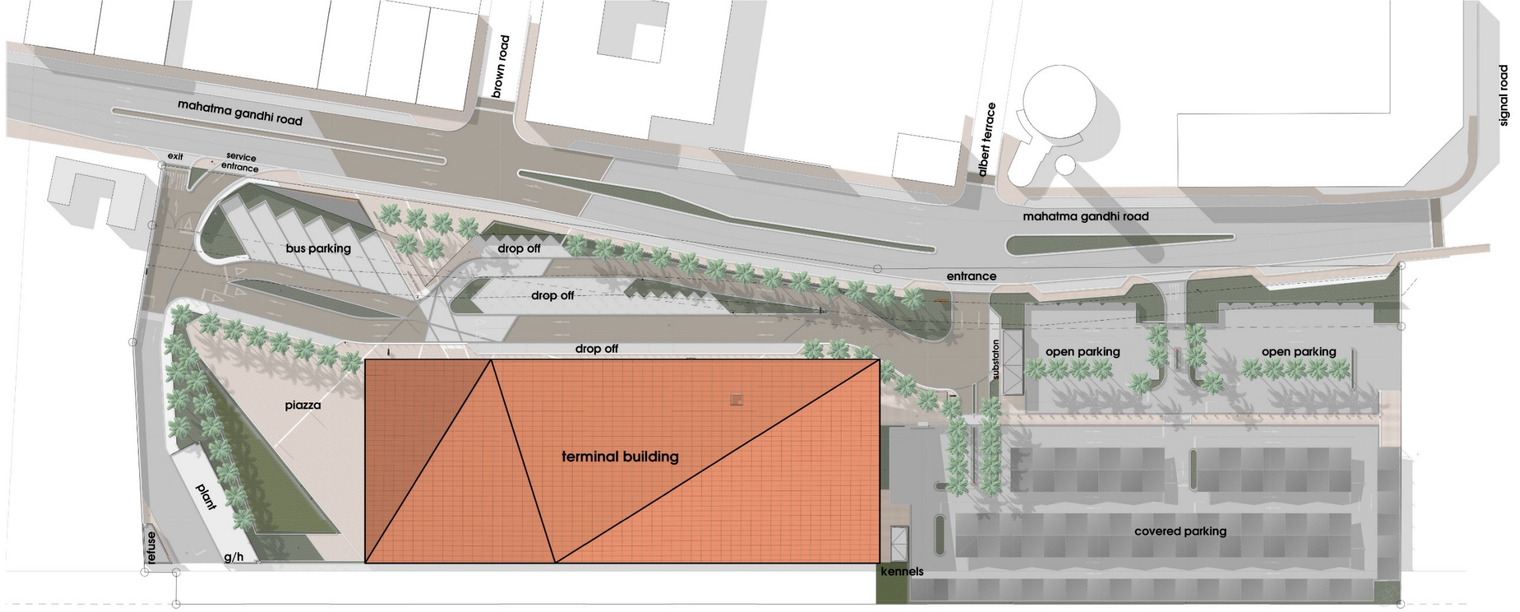
Due to the thermal margins of a sub-tropical climate, the envelope is conceived as a ventilated façade to moderate heat exchange between the internal and external zones. The entire envelope is thus clad with variously configured triangular clip-on fibre cement facade panels. The internal ceiling zones are finished with Birch ply panels in a continuation of the parametric external triangular output. These panels are parametrically generated and disbursed to promote full triangular patterning with no cut panels on the both the roof and connecting facade surfaces.

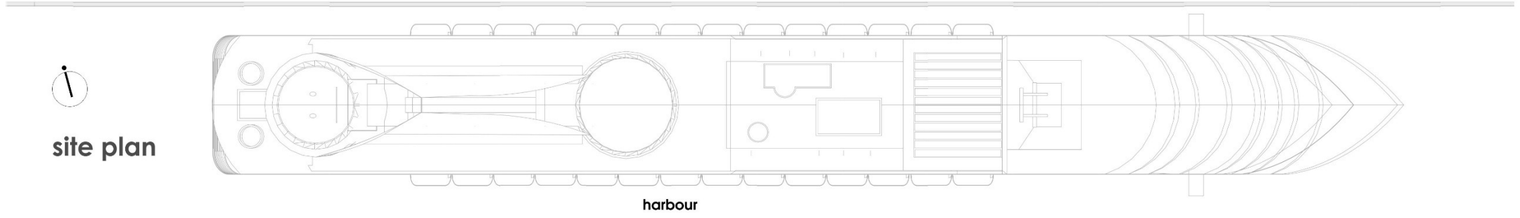
Brief and project overview

The voluminous passenger spaces enjoy broad vistas across the rejuvenated historic precinct beyond. The gently folded roof form is shaped to invite entrance and direct departing passengers' visual attention to the wharf-side. Upon arrival, the opposite is effected, with carefully curated vistas welcoming disembarking passengers to the city beyond.

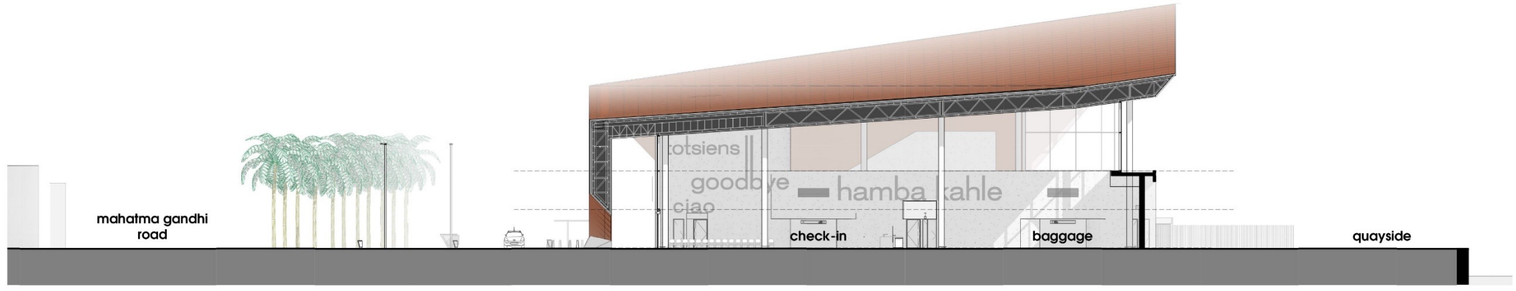
This experiential sequence heightens the conceptual notion of a portal and inherently exemplifies the spirit of the terminal.

Conceptual artist impressions





site plan



transverse section

Conceptual artist impressions

THE PROJECT OVERVIEW

PROJECT OVERVIEW

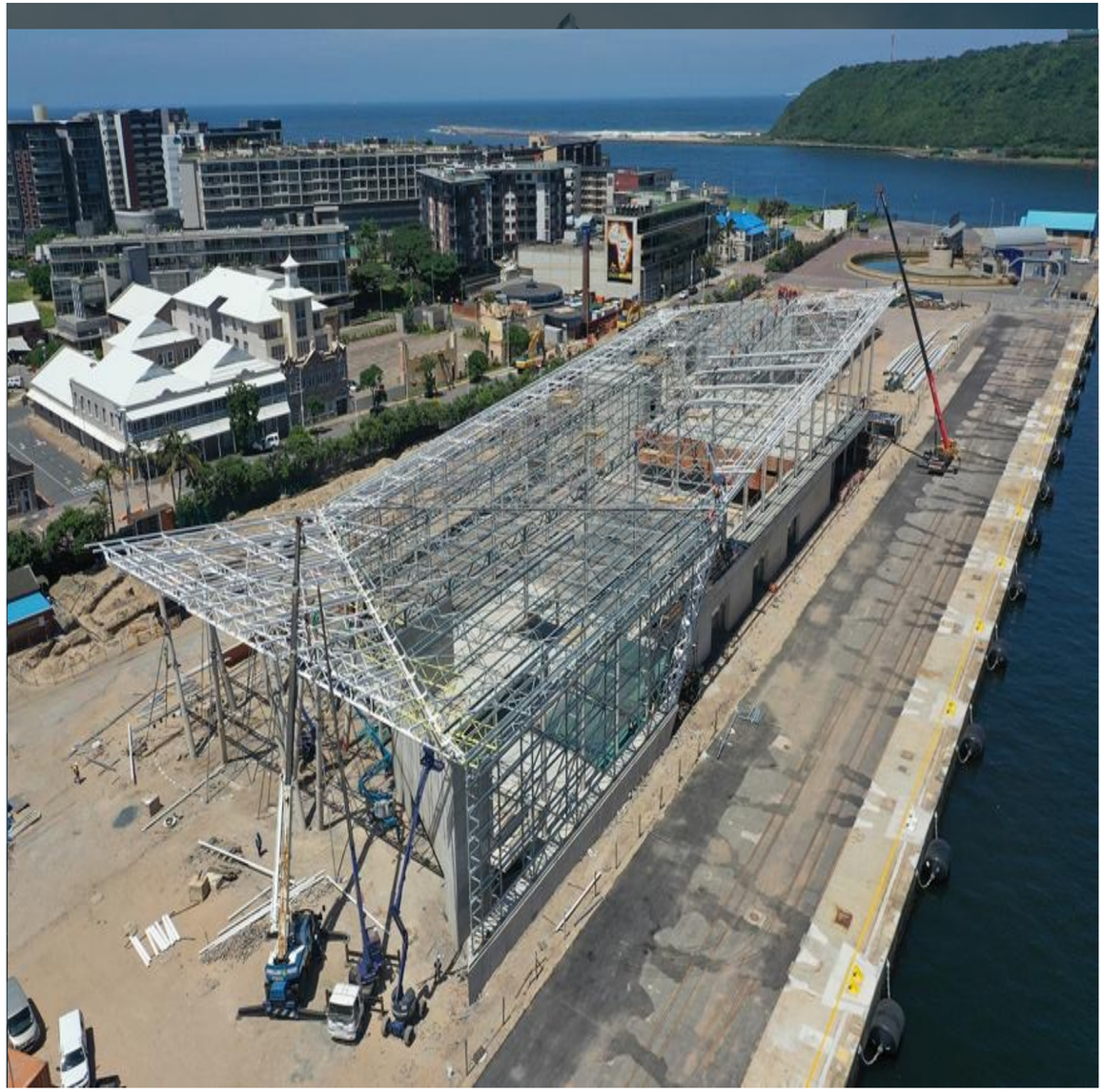
STRUCTURAL STEELWORK

Project Completed: PH 1 - December 2021/Ph 2 November 2023

Steelwork Completed: 2023

Tonnage: 302 Tonnage

Profiles used: SHS – RHS – I beams – U beams - Angles



PROJECT OVERVIEW

STRUCTURAL STEELWORK

Structural Engineer: ARUP (Pty) Ltd

Steelwork Contractor: Avellini Bros. (PTY) Ltd

Steel Detailer: Avellini Bros

Steel Merchant/s: Macsteel / Allied steelrode

PROJECT OVERVIEW

METAL CLADDING AND ROOFING

Project Completed: PH 1 - December 2021/Ph 2 November 2023

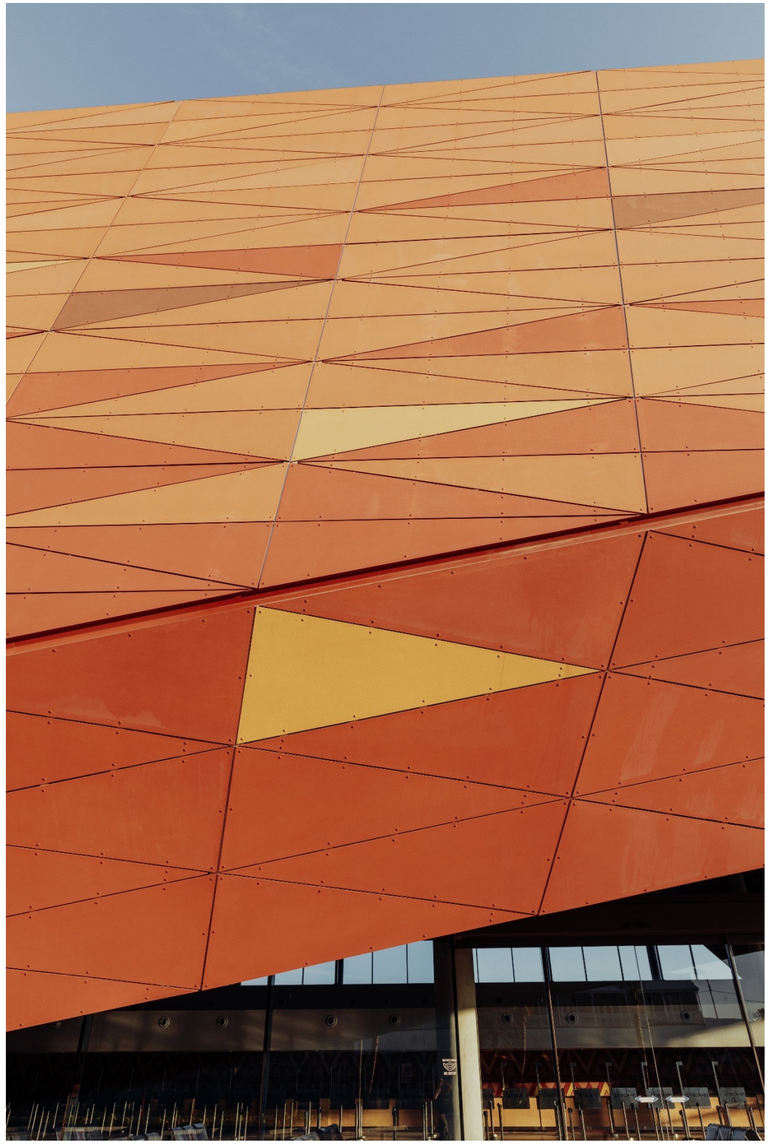
Cladding Completed: November 2021

Cladding Material Used: Mineralis Fibre Cement panels

Cladding Profile: Flat sheet

Cladding Area Coverage: 11 533 m2

Cladding Tonnage: 302 tons



STRUCTURAL FRAMING

STRUCTURAL ENGINEER: ARUP (Ptd) Ltd

STEELWORK CONTRACTOR: Avellini Bros. (PTY) Ltd

STEEL DETAILER: Nathan Deckford

Structural Framing Overview

The structural design of the Cruise Terminal presented many interesting challenges which would not have been feasible without the use of structural steel as the material of choice.

Geometry

- The architectural vision for the project resulted in a complex geometry, the likes of which could not be achieved without advanced 3d modelling.
- The various inclined planes of the roof resulted in fold lines being created which did not necessarily match the rectilinear structural grid below.
- The impact of this resulted in every truss requiring a slightly different geometry depending on where in the fold line it intersected, the same applied to the primary girder trusses.
- The roof structure seamless blended into the perimeter vertical structure with dramatic inclined edges down to the ground floor.

Structural Framing Overview

Entrance columns

- The entrance canopy into the Terminal building is supported by a series of raked RC columns, all at varying angles and heights to meet the roof structure.
- This presented a unique challenge for the contractor as the raking columns had to be set out and cast within tolerance to meet the roof structure above. In addition to this, temporary props were required to support the columns until the roof steelwork and bracing were completed. All out of balance forces were resolved in the roof bracing back to concrete stability elements.

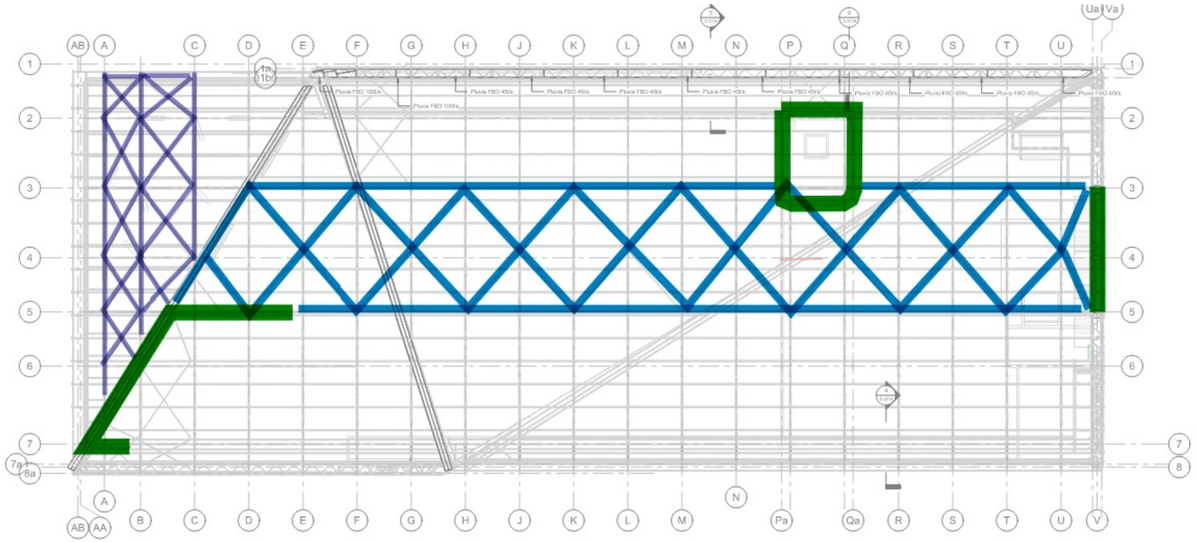
Structural Framing Overview

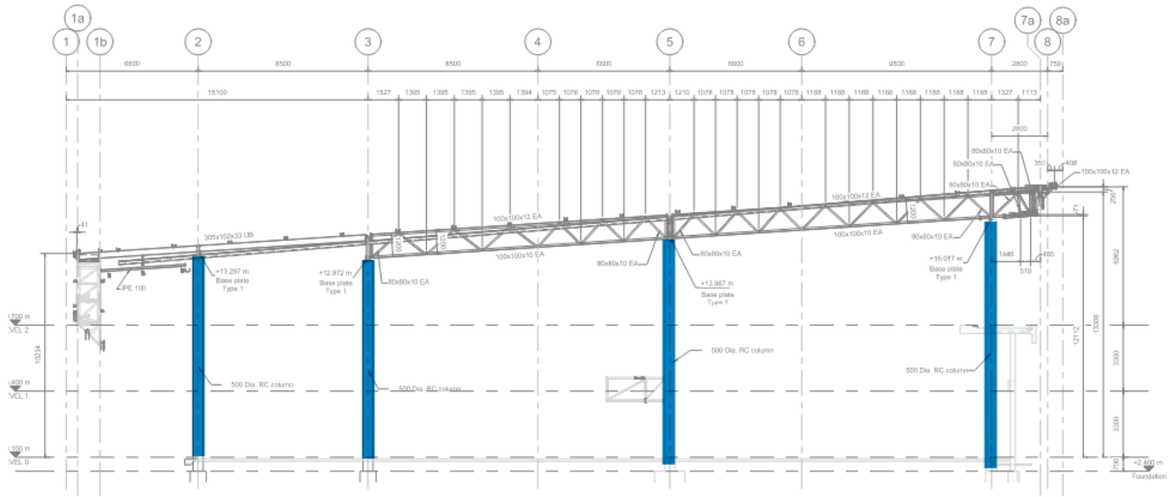
Northern Elevation – ‘Anvil’

- The most interesting challenge was the solution to the Northern elevation. The architectural vision of wrapping the roof down to a singular point at ground floor resulted in a 108m unbalanced cantilever structure that supported the Northern edge of the roof.
- This resulted in large forces having to be resolved at a singular point. In order to achieved this, we worked with the architects to optimize a concrete plinth to transfer these loads to the foundations, but at the same time minimize the dimensions to create the illusion of the structure disappearing into the ground. This plinth became affectionately known as the Anvil due to the final optimized shape that was agreed.
- The loads from the cantilever structures were transferred into the plinth with cast-in-plates due to the large forces involved.

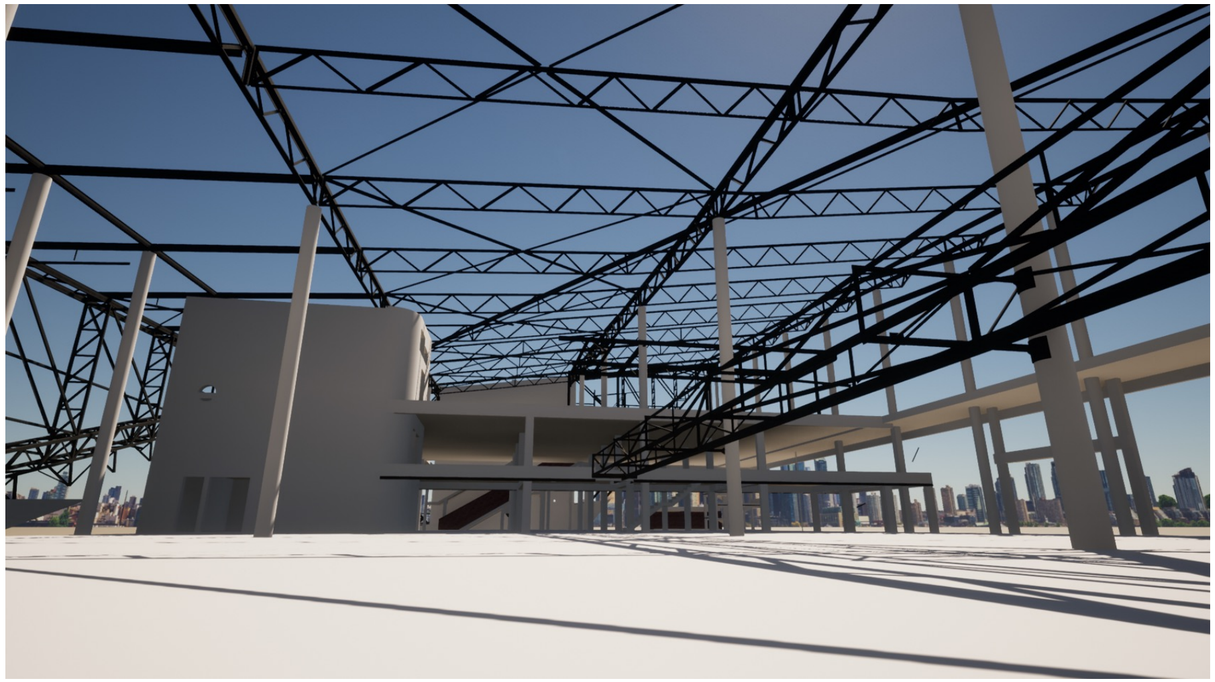
Structural engineering | Framing + stability

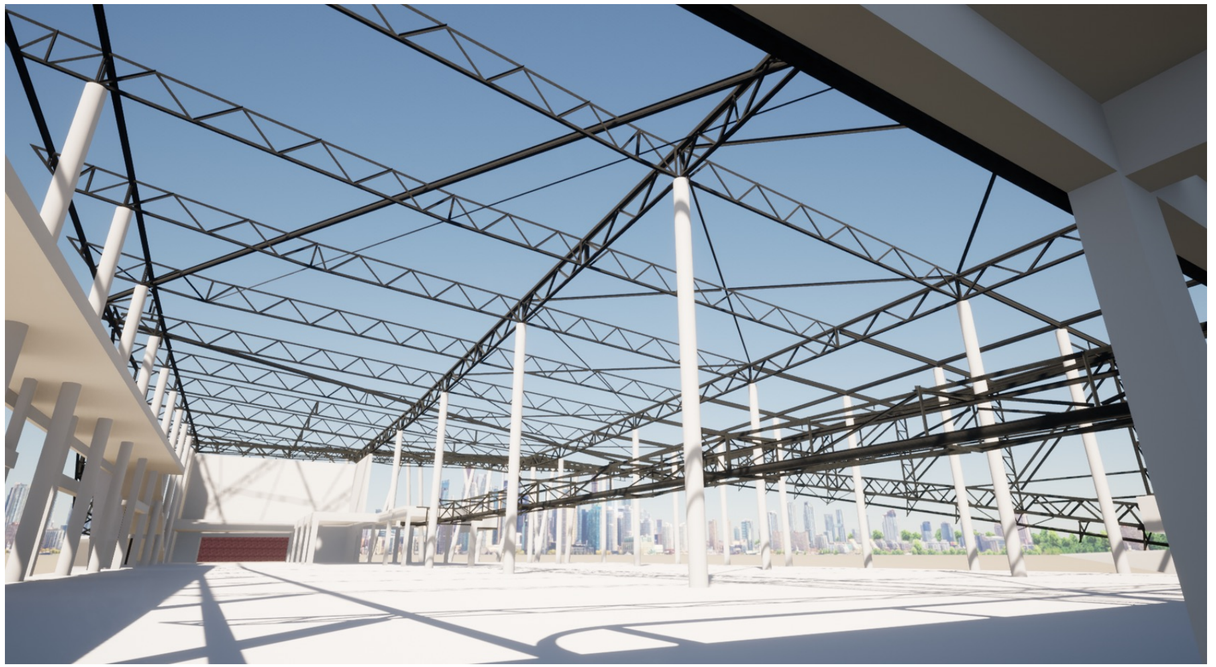
- RC frame
- Stability
    - Core + shear walls
    - Braced structural steel frame.
- Primary and secondary trusses
- RHS as purlins due to long span structural sheeting.





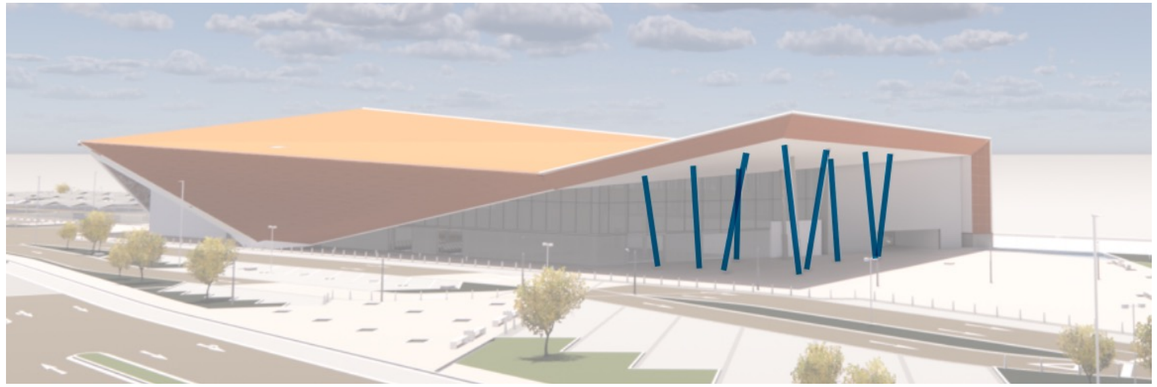
Renders from Arup Revit Structural model

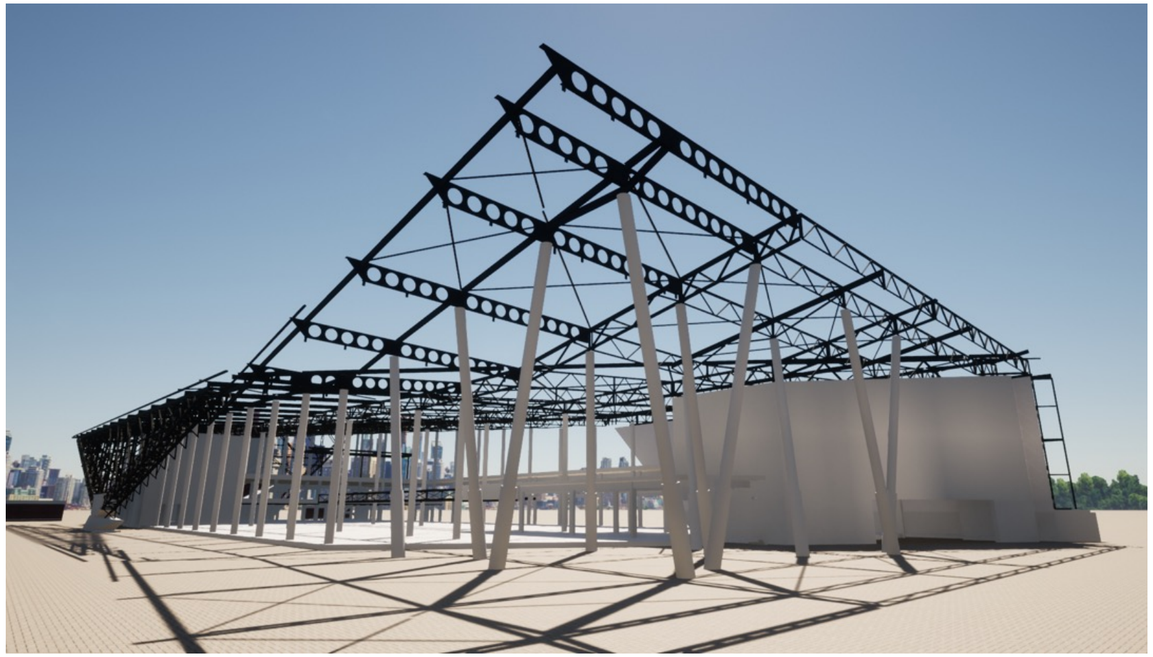




Structural engineering | Entrance raking columns

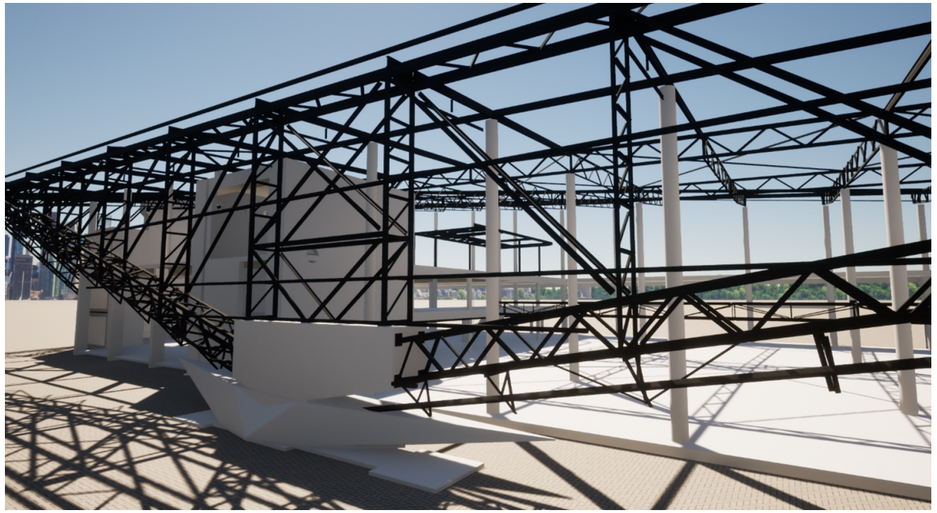
- Complex arrangement of raking RC columns.
- Required propping until SS and bracing erected.
- Roof bracing resolves out of balance loads back into stability system.

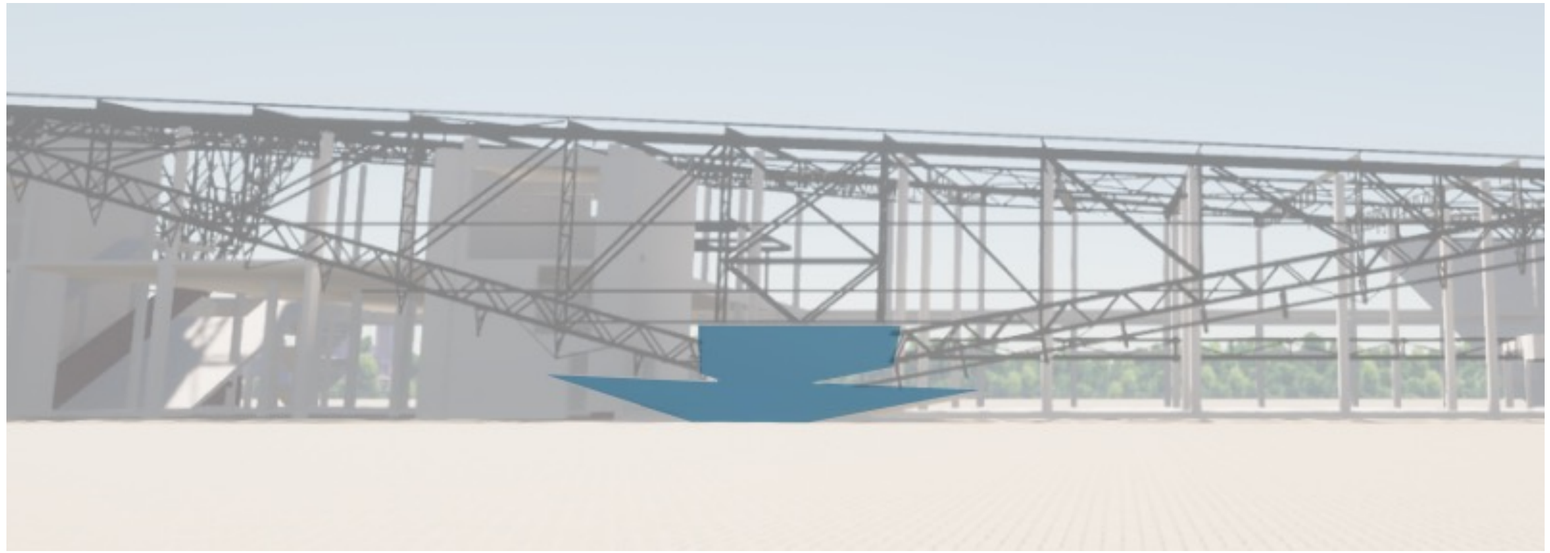


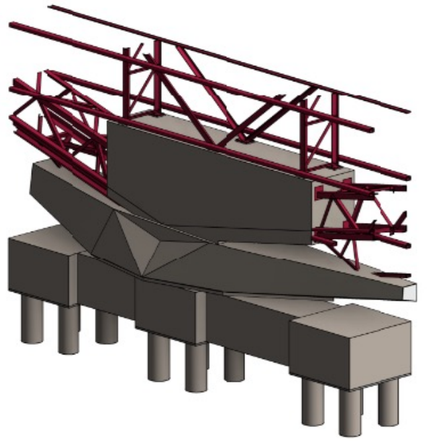


Structural engineering | The ‘Anvil’

- 105m unbalanced cantilever.
- Loads transferred to singular RC plinth… the ‘Anvil’.
- CiPs to transmit forces into plinth







3D View - North Wall Plinth

METAL CLADDING/ ROOFING

CLADDING MANUFACTURER: EQUITONE® Façade Solutions

CLADDING ROLL FORMER / PROFILER: EQUITONE® Façade Solutions

CLADDING/ ROOFING SUPPLIER: MRC Group

CLADDING/ ROOFING CONTRACTOR: MRC Group

MSC CRUISE TERMINAL
ON-SITE ROLLED STRUCTURAL TRAY

MSC CRUISE TERMINAL
AXIAL FAÇADE SUPPORT SYSTEM

MSC CRUISE TERMINAL
EQUITONE MINERALIS

MSC CRUISE TERMINAL
DURING

MSC CRUISE TERMINAL

AFTER (DAY)

MSC CRUISE TERMINAL
AFTER (DAY)

MSC CRUISE TERMINAL
AFTER (DAY)

MSC CRUISE TERMINAL
AFTER (NIGHT)

MSC CRUISE TERMINAL
AFTER (NIGHT)

MSC CRUISE TERMINAL
AFTER (NIGHT)

FABRICATION

STEELWORK CONTRACTOR: Avellini Bros (PTY)LTD

FABRICATION

STEELWORK CONTRACTOR: Shospec

PREFORMED LSF PACK

RAW STEEL STRUCTURE

FLAT PACK LSF

LSF Y-CLUB SUB GRID

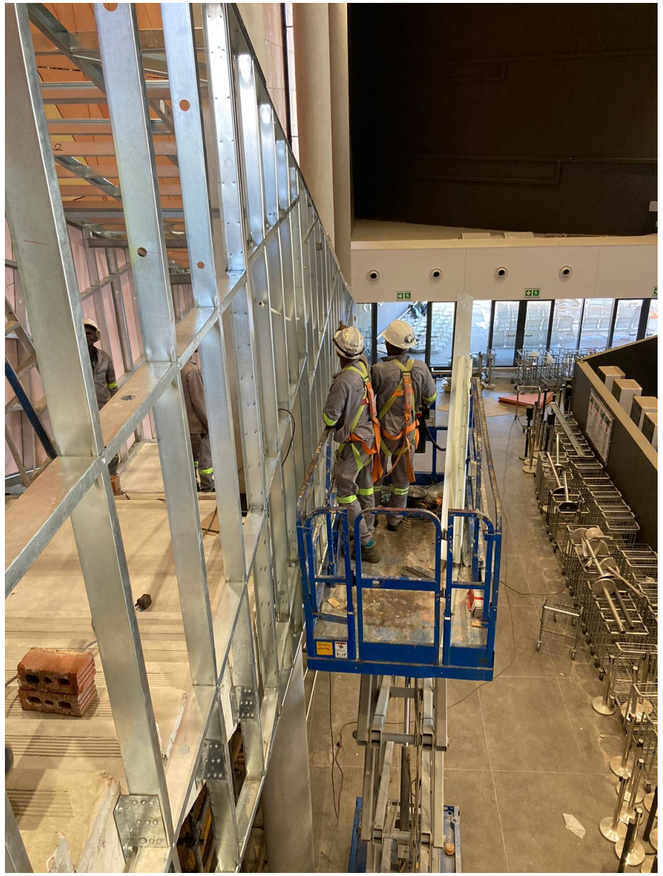
LSF SUB GRID

LSF SUBGRID 2

LSF SUBGRID 3

LSF SUBGRID CLOSE UP

LSF,SUB GRID,LSF BULKHEAD



FIRE STAIR ENCLOSURE 2

ERECTION / CONSTRUCTION / INSTALLATION

CONTRACTOR: Avellini Bros. (pty) ltd

Avellini Bros. (pty) ltd

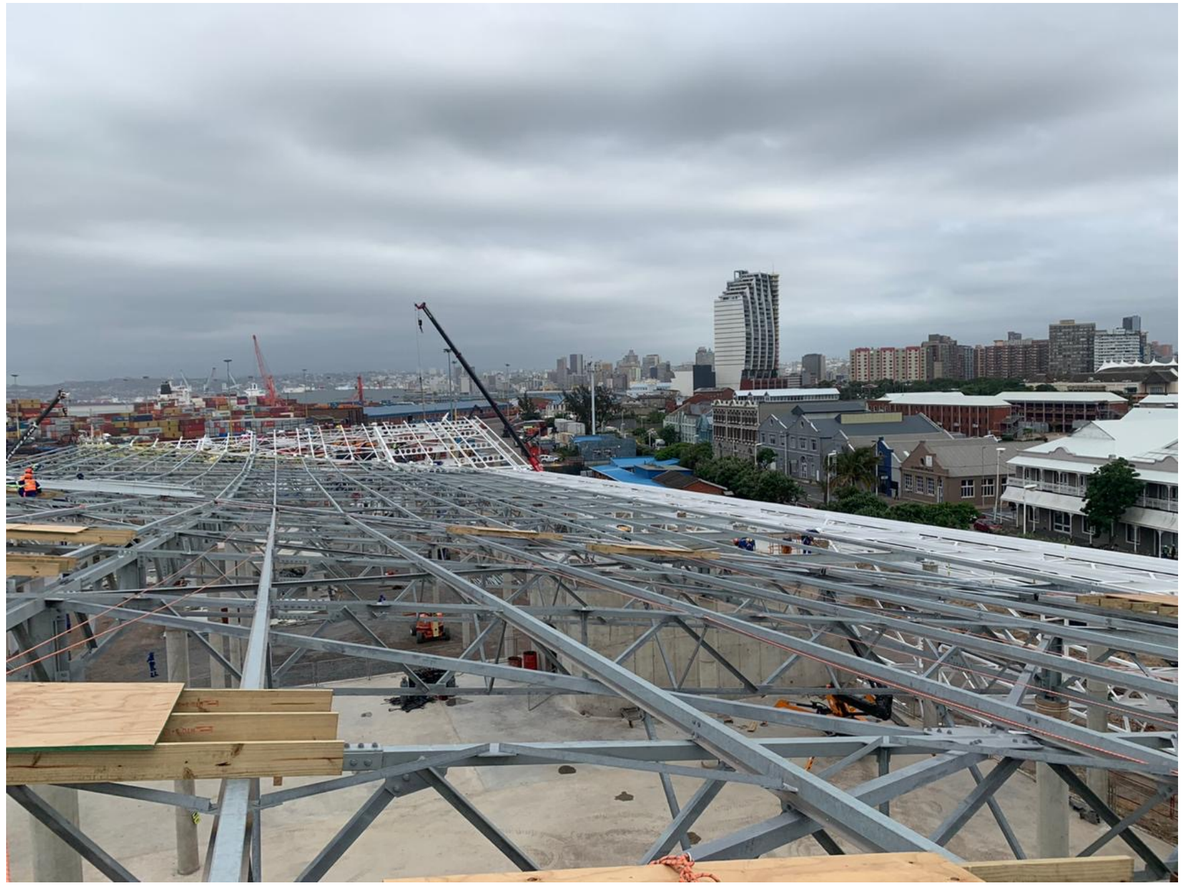
PRIMARY STEELWORK – MAIN BUILDING

PRIMARY STEELWORK – INTERNAL SLIDING DOORS

PRIMARY STEELWORK – ANGLED COLUMNS

PRIMARY STEELWORK – ANGLED COLUMNS

PRIMARY STEELWORK – SIDE WALL



PRIMARY STEELWORK – ROOF STRUCTURE

ERECTION / CONSTRUCTION / INSTALLATION

CONTRACTOR: Shospec

Overview – Shospec - ERECTION AND CONSTRUCTION

- Light steel frame 90x40x0,9m LSF sub grid 10 KM of steel 4500m2
- High level Wiza ply decorative ceiling with triangular patten 4500m2 comprising of 3500 triangle shapes and over 1600 boards fitted with mostly non-visible fixings
- light trough box ceiling transition 150lm
- Acoustic ceilings ,flush plastered ceilings and bulkheads approx. 2000m2
- Folding stacking doors 36 doors over 45 lm of opening , all doors were CNC grooved and custom manufactured .
- LSF Stacking door services bulkhead structure above doors approx. 45 lm

Overview – Shospec - ERECTION AND CONSTRUCTION

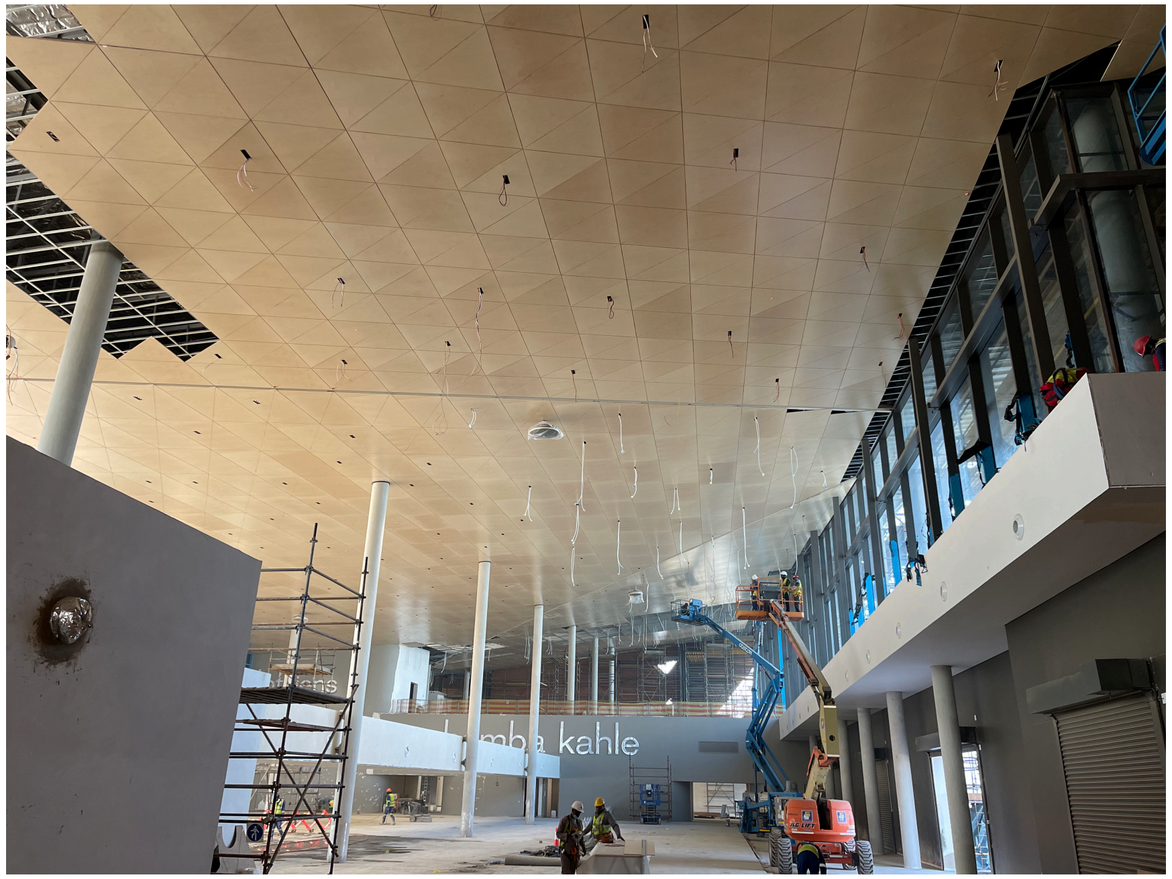
- Fire walls and 450 lm of ceiling fire baffles
- Fire escape stairs enclosure LSF -Light steel frame 30lm fire rated fire escape enclosure from 1 st floor departure lounge
- New yacht club lounge and waiting are LSF light steel frame sub grids , bulkheads walls , and acoustic sound baffle ceiling detail .
- Interior fitout and Toilet cubicles .

SUB_GRID_CEILING

FULL LSF SUB GRID

CEILING GRID AND WIZA INSTALLATION

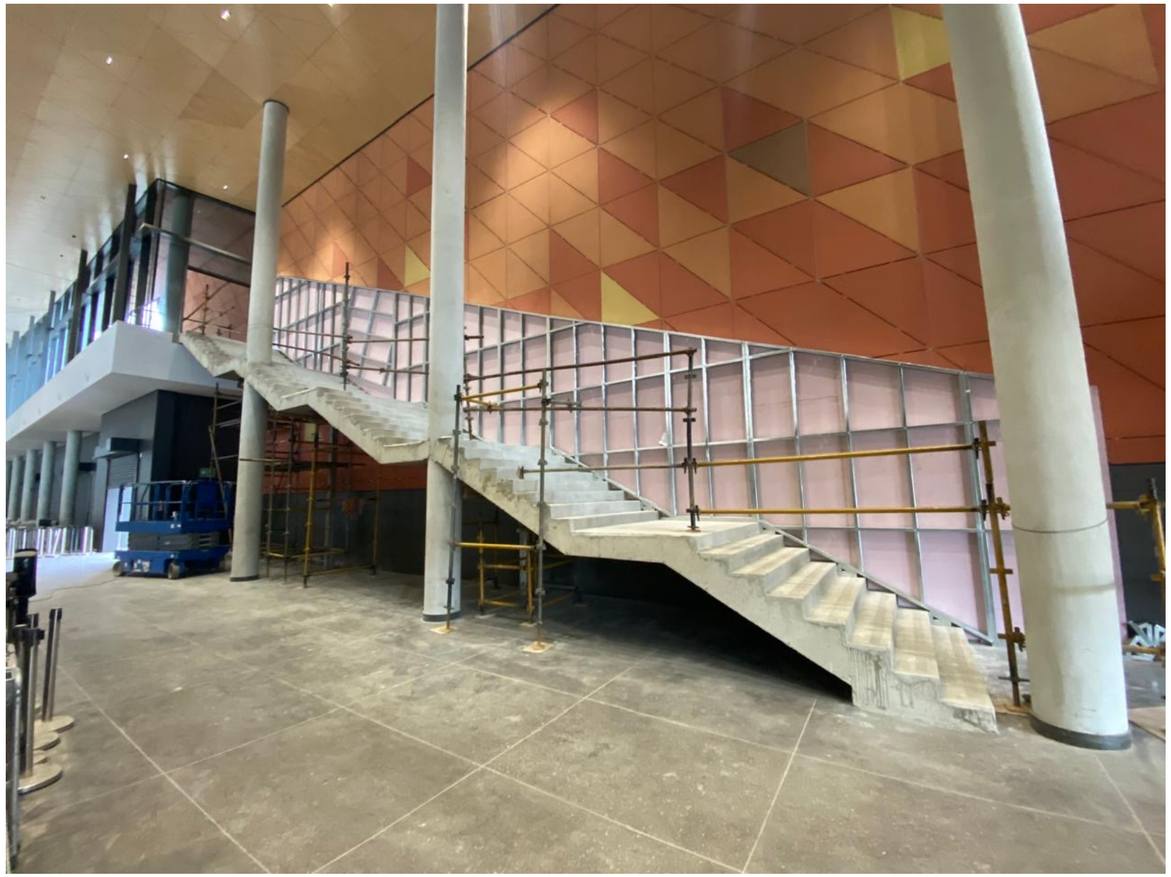
WIZA PLY INSTALLATION



WIZA PLY CEILING CLADDING

COMPLETE CEILING

LSF FIRTE ESCAPE 2



LSF FIRE ESCAPE 1

Y-CLUB LSF BULKHEAD CURVED

Y-CLUB BULKHEAD COMPLETE

CHALLENGES AND SOLUTIONS

Avellini Bros. (Pty) ltd - CHALLENGES AND SOLUTIONS

- The installation of the multiple-angle roof posed significant challenges due to the intricate steelwork involved. Each angle and intersection required careful planning and execution, making the process increasingly complex.

- Moreover, the lattice box girders, essential components of the structure, necessitated the use of rigging aids to ensure precise installation and welding onto the cast-in plates. This meticulous approach was crucial for maintaining structural integrity and safety standards.

- Given the project's location, which likely exposed it to harsh environmental conditions, ensuring corrosion protection became paramount. As a result, stringent measures had to be implemented, leading to extended timelines for completion. While this may have prolonged the project, it was essential for ensuring the longevity and durability of the structure in the face of potential corrosion threats.

Avellini Bros. (Pty) Ltd - CHALLENGES AND SOLUTIONS

- Fabrication of the structure presented its own set of challenges, particularly due to the complexity of the design. Each truss and rafter was unique, requiring specialized fabrication jigs for accurate construction. This level of detail and customization underscored the intricacy of the project and the need for precise engineering and manufacturing processes.

- Overall, the construction of this structure demanded a high level of expertise, attention to detail, and adherence to stringent standards to overcome the various complexities involved and ensure its successful completion.

Shospec - CHALLENGES AND SOLUTIONS

- **Working at very high levels** from 15 to 20 m heights to underside of roof structure this was overcome mostly by using cherry pickers, scissor lifts with over 5 units on site at times and some scaffolding in places. Height access and OHS regulations were a major concern and all relevant OSH training and checks were strictly implemented .

- **Size off the structure** approx. 45lm x 100lm .4500M2 at very high levels and 3 raked ceiling plains of various pitch angles .Very little set out tolerances and forgiveness was allowed, and most ceiling lines interconnected with each different zone intersection or the exterior façade .

- **Set out and co-ordination** -Due to the fact that the internal ceiling triangle lines needed to line up with the exterior fade lines as per architectural design .It was a complicated task due to one trade not following the other but working independently at the same time .Furthermore the tight project timeline had no allocations for working one trade after the other but concurrently only .

Shospec - CHALLENGES AND SOLUTIONS

- The recommended solution was to 3D scan the structure and the façades layout , Setout points . Once this was achieved the surveyed co-ordinates points were transferred to the ceiling layout and around 60 Setout point where then surveyed and marked out on the floor slab and transferred up to the ceiling levels .
  From this we were able to modulate set out grids for the ceiling boards .

- All ceiling levels were at a rake and basically followed the shopfront levels there were 3 different raking plain areas A,B & C that were split by 150 lm light box trough at their various points of intersection

- **WIZA PLY ceiling boards**- supply and delivery was ex-factory and shipped from Finland EU- Factory delays ,shipping ,lead times and Covid-19 all added additional stresses to this process and lead times . Noting we received 2 x 40 ft containers with approx. 1800 Wiza ply boards .

Shospec - CHALLENGES AND SOLUTIONS

- **Ceiling LSF Sub grid** -Originally the design was based on a steel structure with a timber and shutter ply roof system and a timber sub grid for the Wiza ply ceiling boards .This design was proven to be complicated and impractical .We as Shospec proposed a new engineered Light steel frame 0,9mm AZ 150 steel sub grid solution rolled by our Framecad roll formers .

- The solution allowed for a lighter modular structure pre formed and flat pack . Again, the big concerns was if timber was actually the correct product fit for purpose. This along with concerns of timber quality ,durability and concerns of warping and bending and finally the concerns for future insect infestation .

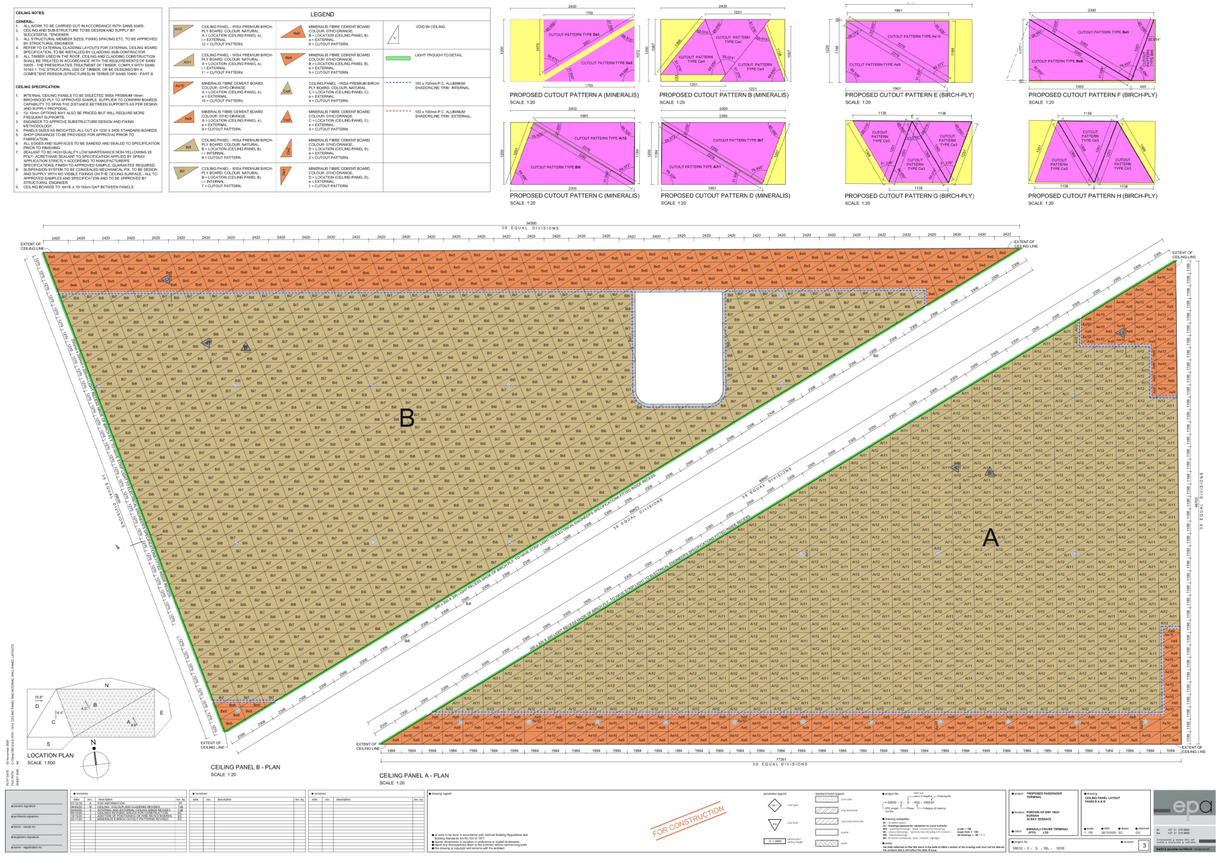
- Ceiling panel tolerances – The design and triangular pattern Wiza ply ceiling panels only allowed for a very tight 2 mm tolerance gap between boards . Creep was a big concern due to the tight layout parameters .To eliminate any mistakes a special 2 mm tile spacer and locating wedge was used to gauge each

Shospec - CHALLENGES AND SOLUTIONS

- Each panel and joint consistently , these spacers were designed to break out after installation to allow the gaps to work as expansion joints. Over 13 tons of LSF sub grid were used with special noggin anti tilt bars spaced at 2,4 m centres over 10 km of LSF steel were used .

- **Ceiling triangular patten** . Originally the ceiling was designed with 3 ceiling zones A,B & C Comprising of 3500 independent single triangles and this would have been hugely complicated regarding labour and practicality of set out and tolerances .

- This was resolved by value engineering and waste reduction by combining the tringles into 2 or 3 per board.Then CNC cutting the boards and routing the patten into a full board rather than independent single triangles . By doing this we reduced the independent tringle qty of single combined pattern boards by over 50% due to combining the triangles. Effectively reducing fitting to around 1600 boards.We further reduced board cut-off waste on the project by a further 30% by implementing this solution and it obviously contributed to significant cost and installation time savings .



SAMPLE CEILING LAYOUT

SAMPLE MODELING

HEIGHT ACCESS

HEIGHT ACCESS 2

RAW STRUCTURE

CEILING ALIGNMENT AND RAKES

THE BENEFITS OF STEEL IN THIS APPLICATION

BENEFITS OF STEEL

Due to the large expanses and complex form of the building, combined with the need for a ventilated facade solution to moderate thermal margins, a steel structure was the only viable option for this project.

Steel construction methods were preferred over wet trades to ensure structural integrity, create spacious interiors, and allow for effective thermal regulation through the ventilated facade. This approach also facilitated faster construction times and greater precision, enhancing overall project efficiency.

WHAT WE'RE PROUD OF

Avellini Bros. (pty) ltd – What We are Proud of

Avellini Bros, boasting a rich 75-year-old legacy, exudes pride in their involvement in a flagship project. This endeavor serves as a testament to the power of collaboration and teamwork, showcasing what can be achieved when individuals unite towards a common goal.

With decades of experience under their belt, Avellini Bros are not just equipped with the necessary skills and resources but also possess a mindset primed for tackling and successfully executing diverse projects. Their longstanding presence in the business world reflects their adaptability and readiness to take on challenges, ensuring that they remain at the forefront of innovation and excellence in their field.

Shospec – What we are proud of

- The opportunity to have been chosen to be involved in the MSC CRUISE TERMINAL project and being part of the technical and solution driven team from design to construction. In the end helping to build an award winning landmark architectural masterpiece and structure
- The quality , finish and meticulous detailing and setting out to achieve the stunning effects of the triangles and lines along with the exterior MRC cladding and our interior ceilings
- The amazing solution driven finish and technical aspects for all members and trades on the build
- We are extremely proud to have had the opportunity to showcase a once in a life time project and solutions on a very unique design request .The architects mentioned to ourselves “This how we envisage what we want but have no idea how you could create this “ Well that’s when in it all started
- And today we get to enjoy an awesome product, finish and a mind-blowing result and architectural landmark

WIZAPLY CEILING 4500M2

WIZA PLY CEILING LINES

WIZAPLY CEILING 4500 M2

36 SLIDING DOORS BULKHEAD

SLIDING DOORS AND BULKHEAD

VIDEO-MSC CEILING FLY AROUND CEILINGS