The Design

Crewe International Airport will be the destination for everyone.

A highly efficient airport with passenger experience, safety and comfort at the forefront of design. This aesthetic design incorporates innovative technology to optimise operational functionality without compromising the requirement of a net zero carbon scheme. Our roof will become an iconic symbol for the community, and will be recognised across the world. Creating heritage is at the heart of design, not only by incorporating the community, but by producing a new way of life for the local area. Whether you're shopping, dining, or playing mini-golf, the Destination Hub is an attraction in its own right. In line with future infrastructural developments, the design will complement HS2 perfectly. Where HS2 links city to city, the airport will link the United Kingdom to the world.

Design Statistics

Predicted passenger numbers	
Total passengers per year	55.7 million
Total passengers (peak hour)	10,500

Construction	
Estimated cost	£10.3 Billion
Estimated time	4 Years

The predicted passenger numbers have been calculated by using those of the airports being replaced. The terminal buildings have been designed using the hourly number of passengers expected during the peak month of August. It is expected that 85% of passengers are flying for leisure and 15% for business. 88% of passenger destinations are international and 9% are domestic. 3% of passengers are using the airport for connecting flights.

Similarly, the cost for the project has been estimated by using knowledge of costs for previous projects, including both airports and large-scale infrastructure.

Further details on the construction time can be found on the Construction & Waste board.

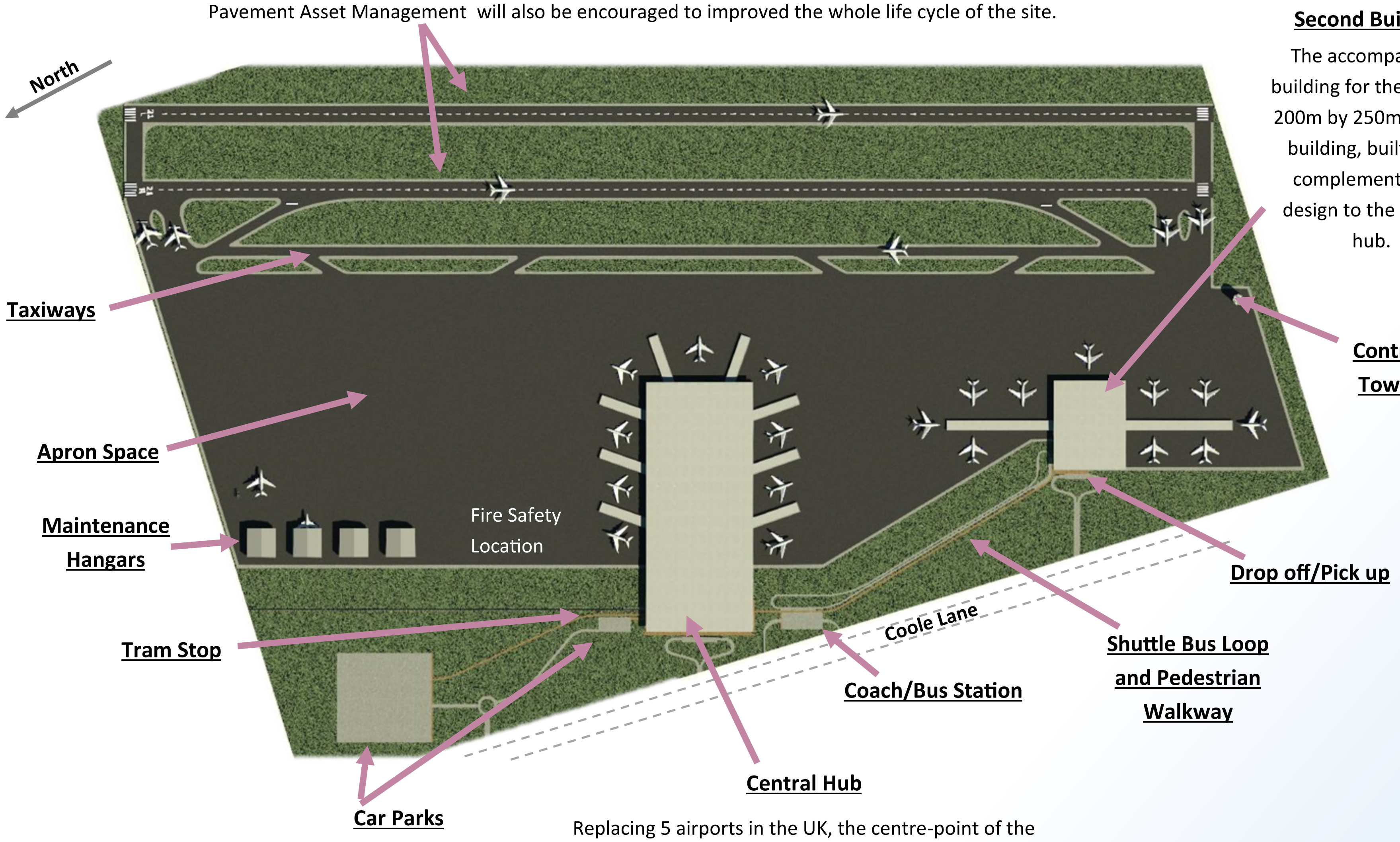
Site Layout

Runways

The site boasts two, 3050m long runways, designed to be operable at the same time and pointing in the south-south-west direction at a bearing of 208°. The orientation of the runways was chosen to utilise the prevailing wind in the UK as much as possible (in the South-West direction), and to also allow an adequate length of runway for the use of all planes required (with a Boeing 747 requiring 3050m), while staying within the bounds of the site. The two runways have a width of 50m, with shoulders either side of 7.5m. Innovative technologies will also be implemented, such as a BBA surfacing as opposed to asphalt (quicker production and less maintenance during use) and the use of cold asphalt recycling during maintenance. The use of asset monitoring of pavements with AECOM's Centre of Excellence for Pavement Asset Management will also be encouraged to improved the whole life cycle of the site.

Second Building

The accompanying building for the site is a 200m by 250m arrivals building, built to be complementary in design to the central hub.



Car Parks

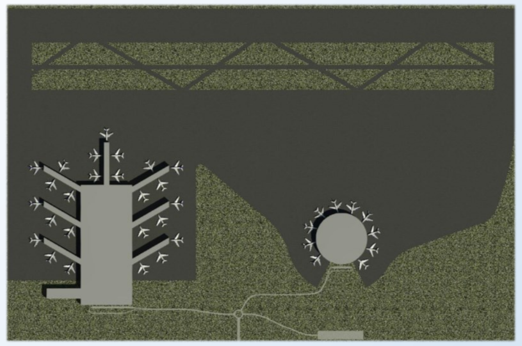
Large Car Park for Visitors and smaller car park for staff.

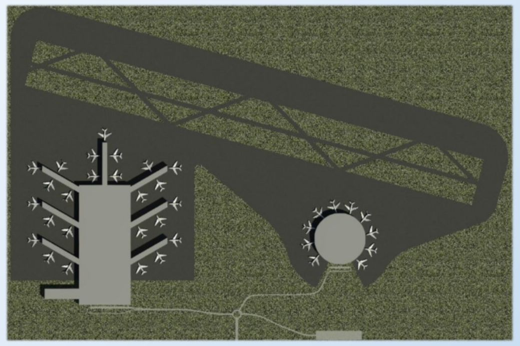
Central Hub

Replacing 5 airports in the UK, the centre-point of the scheme is a 300m by 700m 4 Level central hub building, which has been designed as both the departures building for all of the flights, as well as a destination hub.

Design Development

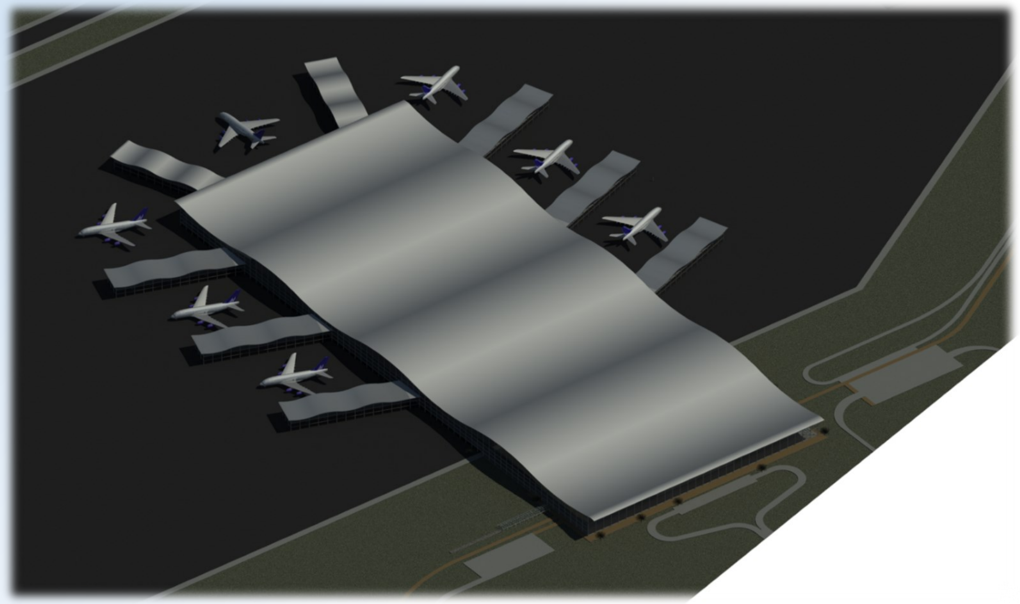
It was decided to have the runways angled on the site, as opposed to parallel with the site, in order to provide better orientation for take-off and landing (by utilising the prevailing south-westerly winds) and to enable the runway to be longer while staying within the constraints of the site. The Destination Hub building was originally to the North of the site, but was moved to be more central, reinforcing it as the primary focal point of the scheme. Multiple access roads were added to the site after consideration was given for the different types, and number, of vehicles entering the site. It was also decided to make the design more consistent by using similar shaped designs for both buildings. The diagrams below show some of the superseded designs.





Roof Concept: The Wave

Departures Terminal—3D View



The Wave involves a stainless steel wave propped up on the structure via columns above the 4th level. The roof reaches has a maximum apex of 10m above roof level and a minimum height of 0m above roof level.

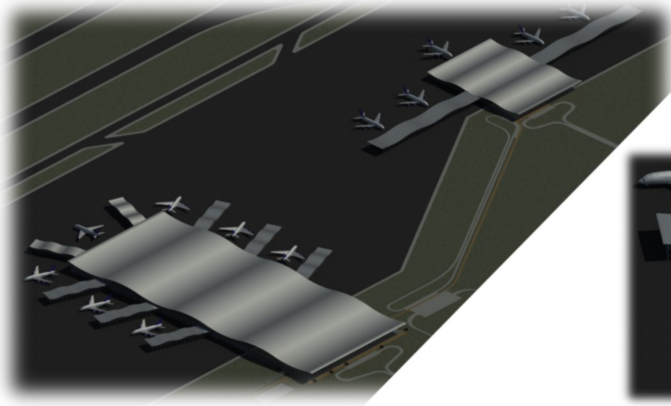
Stainless steel is the best material option for this roof due to its durability, flexibility and aesthetics. Stainless steel is a material that can be easily shaped and molded, this is a critical property that was needed for this chosen shape (wave) in order to achieve feasible construction. The aesthetics of steel are minimalistic, allowing for a professional looking design that fits well with the colors of the surroundings (planes and runways); furthermore, when sun light is at a high level, the reflections on the steel roof will look impressive from above.

One key purpose of the wave is that it is aimed to look impressive at both ground level and from plan view, this is satisfied as the parabolic nature of the roof can be seen the top (viewing from flight) and the sides (boarding gates).

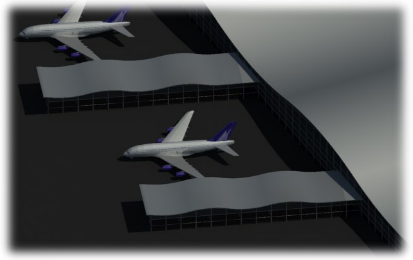
The wall material that forms the skin of the building is external glazing, the purpose of this is to create a sense of openness and prevent a claustrophobic experience by allowing a visible connection with the passenger and the plane throughout their airport visit.

Parabolic Roof—Elevation View

Departures and Arrivals Terminals—3D view



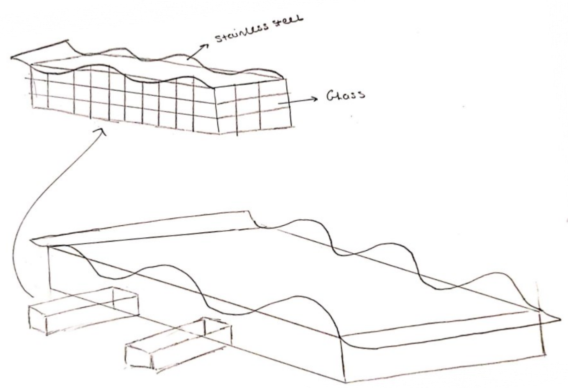
Boarding Gates—3D View



The glass used is specifically tinted float glass. This glass has the same manufacturing process as regular clear floating glass with the addition of metal oxides to create darkness on the glass. Transparency of the glass can be manipulated as the color darkness is proportional to thickness – the transparency will be maximized to allow for visibility from the inside to the outside of the airport throughout the whole boarding process.

The Wave overhangs 11m over the entrance of the airport (as shown on the elevation view), this overhang is curved and has an elevation of 29m - this allows for a visually stunning arrival for the passengers and hopefully a memorable experience.

Initial Sketch Idea

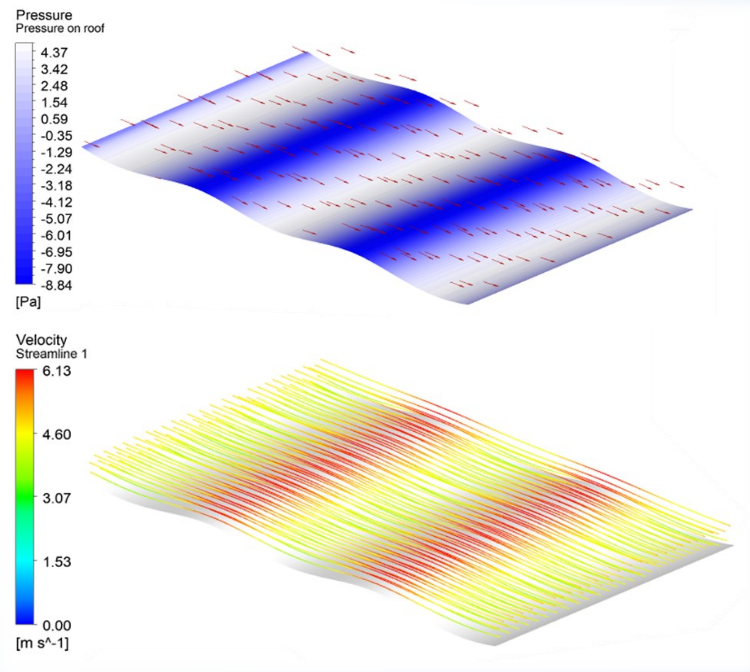


CFD Wind Analysis

By introducing a roof of non-linear geometry, this causes a non-linear wind pressure distribution over the roof. Existing calculations are unable to model this complex situation, therefore CFD analysis is needed to approximate which sections of the roof are critical.

Using an approximate wind velocity of 4.8 m/s, based on the peak wind velocity in the UK over the last 20 years, CFD analysis was carried out on the roof to demonstrate the effects of the shape on the wind velocity and the pressure exerted on the roof.

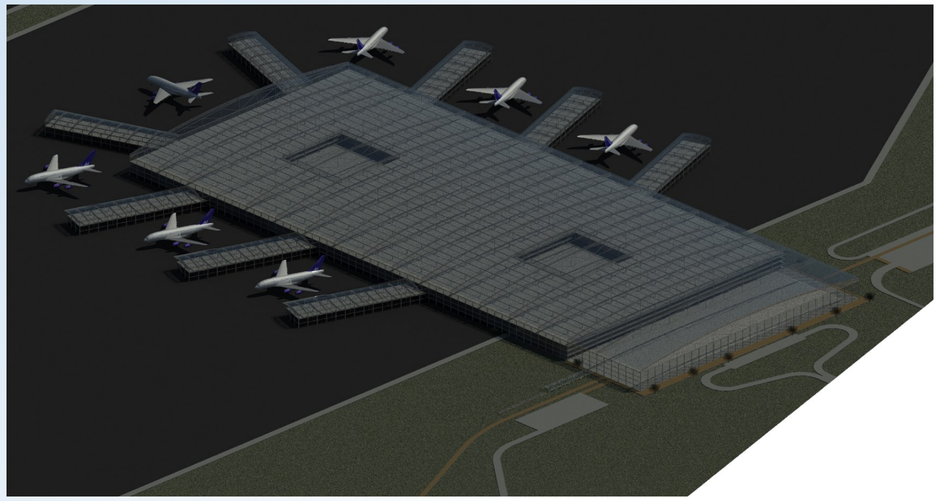
The least favourable condition was at the apex of the roof curves.



Pros	Cons
Aesthetics - Fits with control tower design	Challenging acoustics
Quicker construction (prefabricated roof)	High embodied carbon content
Lighter roof and reduced loading	Requires more columns to provide uplift restraint

Roof Concept: The View

Departures Terminal—3D View



The main focus of the wave is nature and its integration with modern construction. The roof, although constructed with steel structural members, is multiple large glass panes that rest on a truss structure to form one complete mesh.

Glass is the primary material for this idea as it maximizes the natural light throughout the whole structure; allowing for a natural feel while travelling, as well as minimizing lighting costs. The boarding gates are a scaled down model of the main roof, with a smaller truss structure to support it.

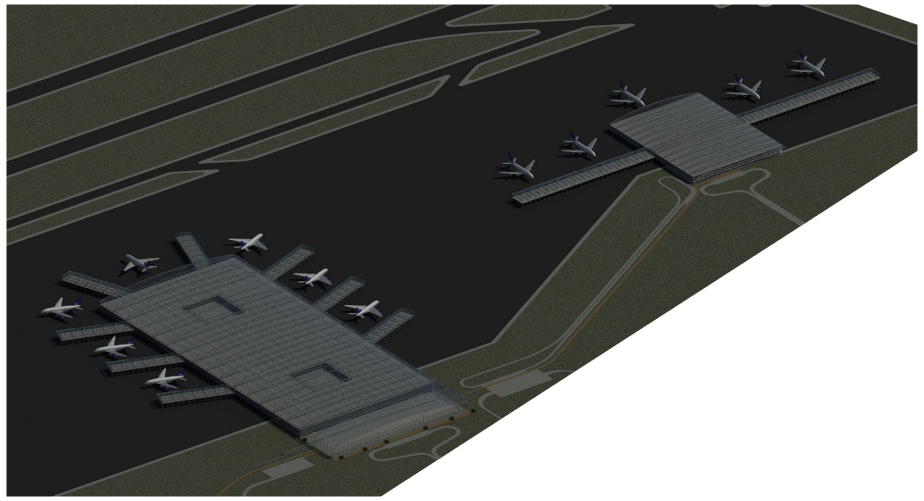
One main purpose of the view is to enhance the experience of the two atria located inside the departures terminal. Passengers will be able to see the scale of the glass roof and truss structures while also seeing the sky via the transparency of the roof; the natural light allowed by the roof with further improve the experience.

The glass mesh is supported by a fink roof truss (as shown on the elevation view), this is a simple webbed truss design that provides the most economical solution for a truss transferring roof loads. The impressive scale of this truss structure is able to be seen while in the atria located in the terminal, and while airborne also.

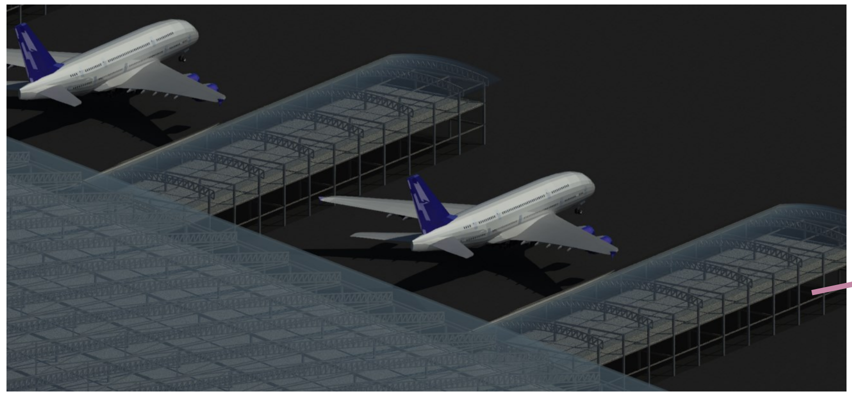
The glass material will be tinted anti-sun glass, this involved tinting the outer pane with a low-e soft coat to give the added benefit of reducing solar heat gain in the summer months at a reasonable cost. The tinted material will still allow sufficient natural light into the airport whilst creating a minimalistic design.

Safety is the critical factor with overhead glazing, and becomes increasingly more important the larger the roof height. Current building regulations suggest that a glass roof larger than 1m should use glass where the lower pane is laminated. The material used on this concept roof is a triple-glazed unit where the outer pane is toughened glass for stability and the lower pane is laminated glass.

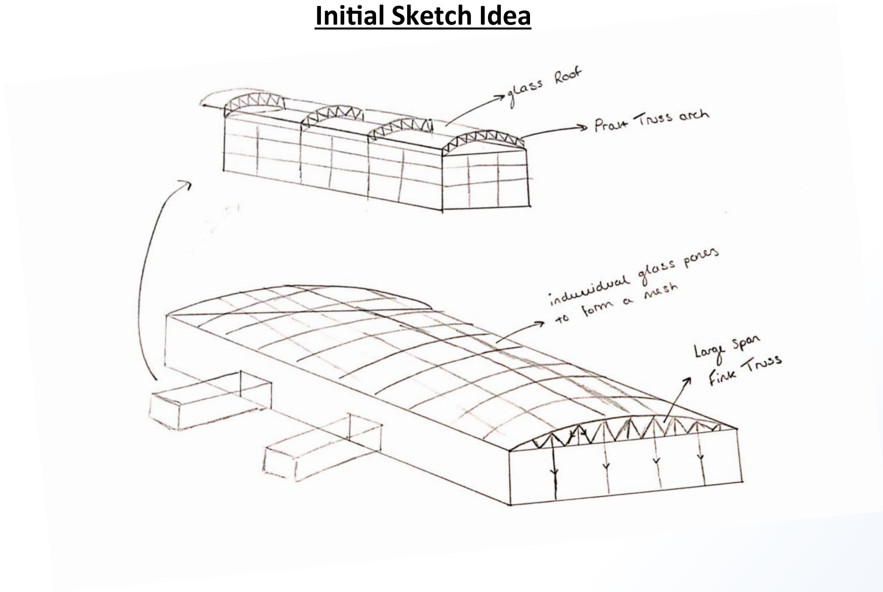
Departures and Arrivals Terminals—3D View



Boarding Gates—3D View



Initial Sketch Idea

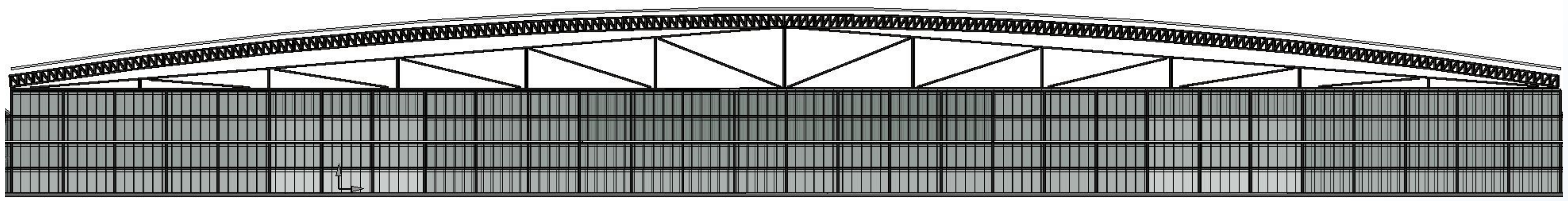


Living walls

With the focus of this roof being nature and the roof already constructed with glass. The walls that form the skin of this airport will be living walls, with glass panes at consistent intervals along the perimeter of the airport. The combination of the glass dome roof and the living wall structure aim to create a greenhouse-like aesthetic to the project.

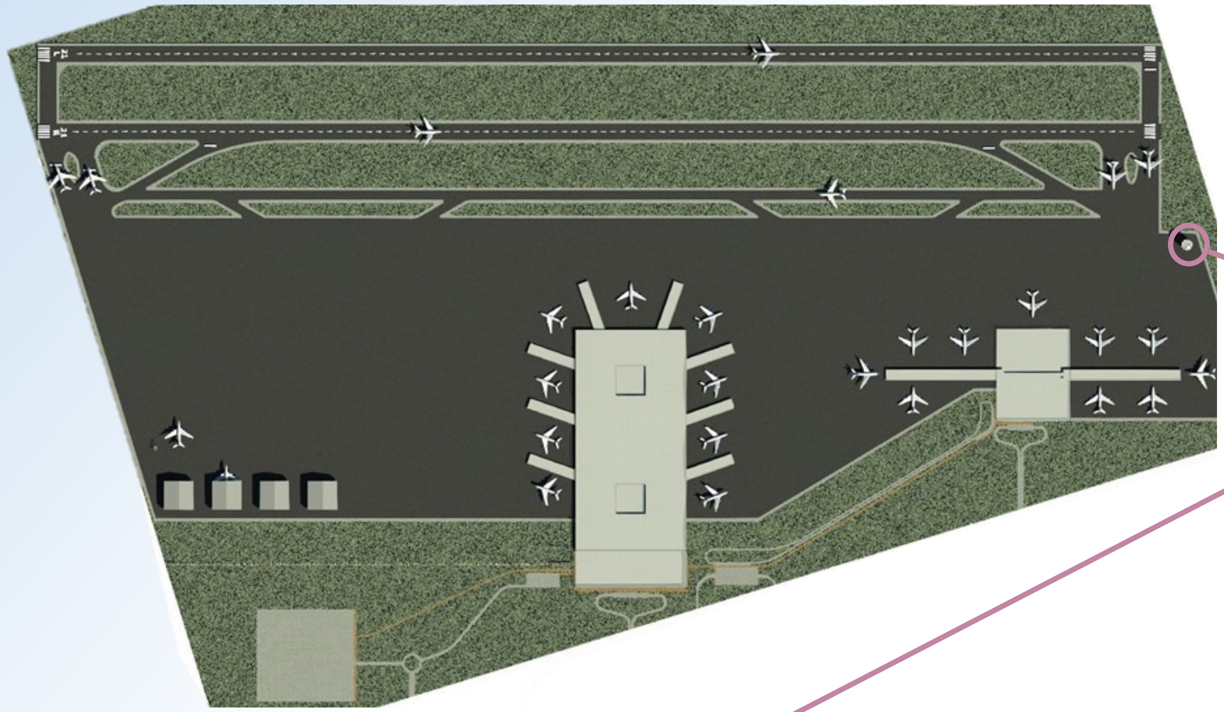
The living wall will have to be carefully maintained all year round, jobs will be created for specialist maintenance work on the walls; if this is not done, then then purpose of the whole structure is damaged.

Curved Roof and Truss—300m Elevation View

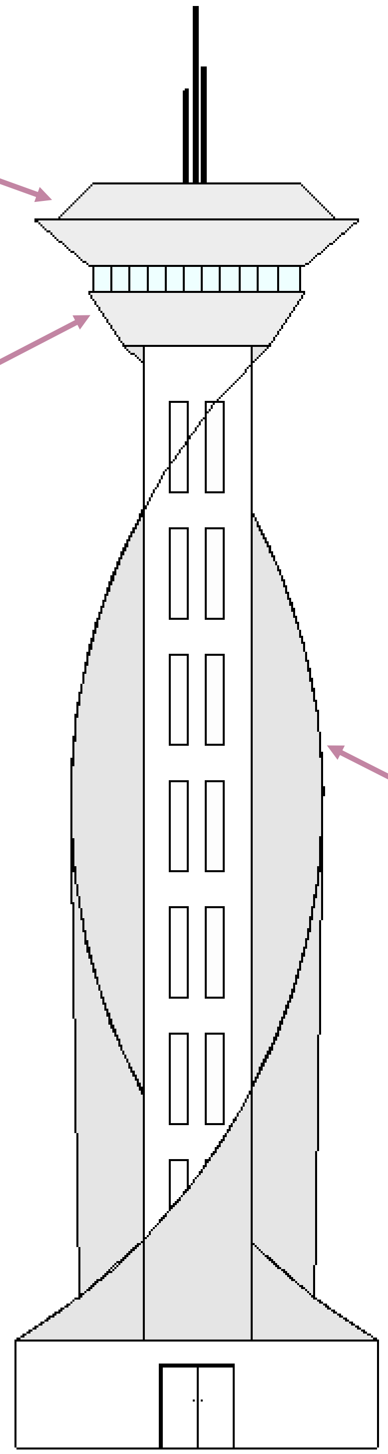


Pros	Cons
Well insulated due to glazing	Overheating in summer
Natural lighting maximized	More complex construction
Impressive visuals within the building	More expensive

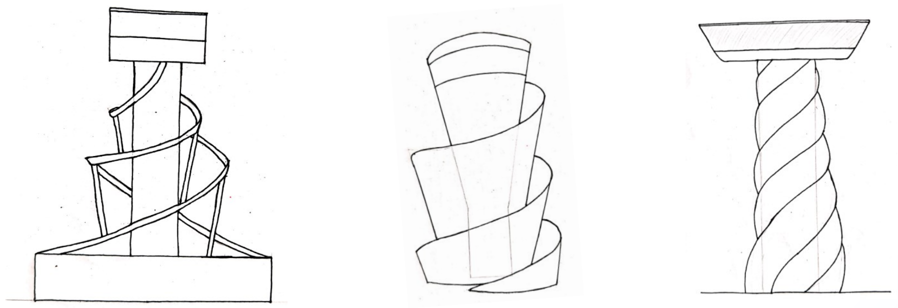
Air Control Tower Design



Control Tower—Elevation View



Initial Sketches and Rejected Ideas



During the concept building of the control tower, aluminum spirals were the focus of the design ideas. 10 different variations of a control towers with aluminum spirals were sketched (the best 3 shown above) and the left model was chosen. This model looked more symmetrical and impressive as the spirals looked the best in elevation in comparison to the others. Furthermore, the left model was chosen as it seems the most constructible due to the more defined structural geometry. It is clear to see the how the chosen sketch has been transformed into the final model.

Control Cab Visibility

A circular control cab room was preferable over squared in order to enhance 360° visibility of the entire runway. The radius of the control tower at the apex is 12m, this provides sufficient space for the workers in the control cab.

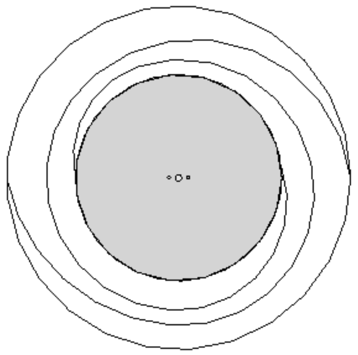
No structural elements will be in the middle of the control cab to maximize space, and windows are located all around the circumference to provide 360° visibility range.

The ceiling of the control cab will slope upwards at the perimeter of the area, this will enhance upwards visibility which is important for when planes take off.

The glazing will not be at perpendicular to the room, it will slope outwards at 15° from the vertical axis in order to eliminate reflections that could reduce visibility.

The base of the tower is allocated for offices and entry, a radius of 20m will provide enough space and produced a solid base for the structures stability.

Control Tower—Plan View



Control Tower Height

The height of the control tower is determined by the "visibility principle", this states that the height is mainly determined by the 1° angle visibility requirement. The required visibility of the runway for our layout is 3500m.

$$Minimum\ height = 3500\ \times\ \tan(1) = 61m$$

So for safety, the control tower is assumed to be 65m.

Architecture

The main feature of the control tower is the non-structural aluminum spiral that encases the control tower. Two separate spirals of identical geometry will be erected as shown on the elevation view, to give the impression they are one with the structure.

Aluminum is one of the only viable metal options that is fit for purpose in this idea. Because of its ductility, aluminum can be easily formed into many shapes and profiles such as a non-linear spiral. The metallic aesthetic to the aluminum matches well with the wave concept, and will in general look impressive due to its reflective nature.

The main core of the control tower will be constructed with concrete composed with WOPC (white ordinary Portland cement), and although more expensive, the high degree of whiteness will improve the overall visual aspect of the control tower.

Structural Design

The building is designed to a 10m x 10m grid system, primary beams will span 20m between two columns along the 700m length of the building and secondary beams span the 10m between primary beams creating 10m bays. As the diagram below shows.

Diagonal bracing will be placed between the 10 m spans, as shown in the Elevation View.

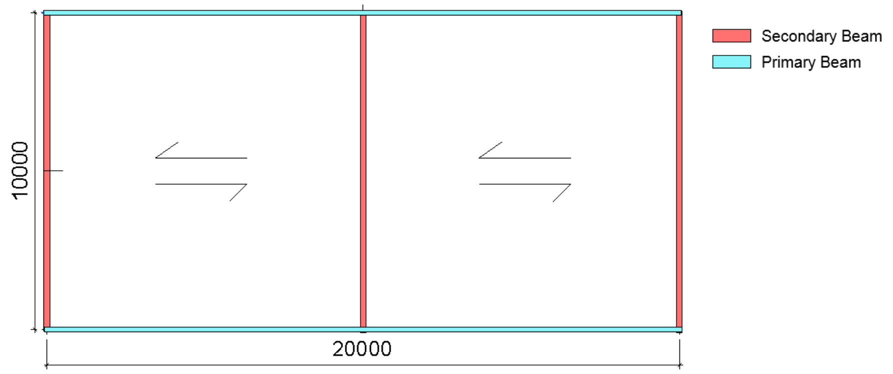
For the initial design it was assumed that the floor load was worst case and therefore was designed as though MEP loading would be acting over the entire building.

The table below details the member sizing for each structural element.

Element	Primary Beam	Secondary Beam	Column	Bracing
Size	1016 x 305 x 494	838 x 292 x 226	356 x 406 x 393	168.3 x 8 CHS

Loading Conditions		
Screed	Permanent	1.2kN/m^2
Ceiling and Services	Permanent	0.5kN/m^2
Slab	Permanent	4.4kN/m^2
Floor Load	Permanent	2kN/m^2
	Variable	7.5kN/m^2
Roof Load	Permanent	4.5kN/m^2
	Variable	1kN/m^2

Structure—Plan View



	Span	Deflection	Shear	Moment
Primary Beam	20m	93.5mm	1434kN	7801kNm
Secondary Beam	10m	34.7mm	1259kN	3148kN

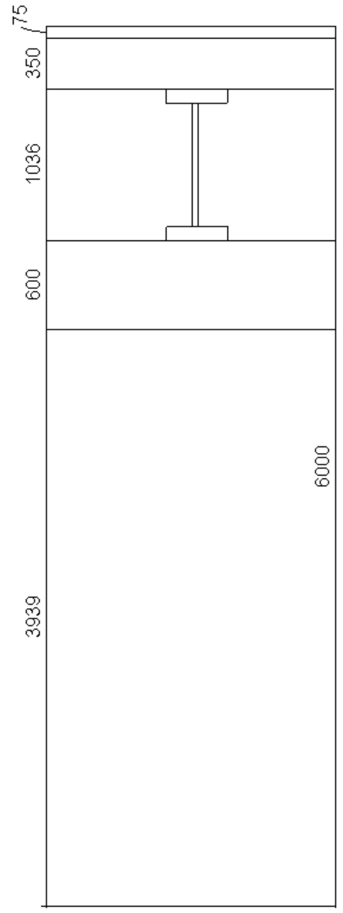
Column Height	
Floor to Ceiling	3.939 m
Screed	0.075 m
Beam Depth	1.036 m
Slab Depth	0.350 m
Ceiling and Services	0.600 m
Column Height	6.00m
Building height	24 m

Where two primary beams connect there is a column which also supports two secondary beams.

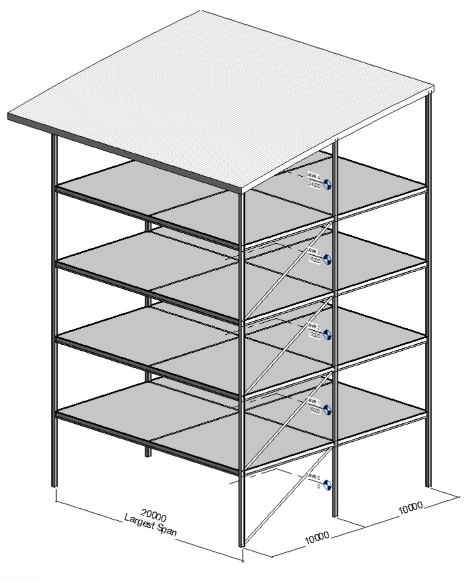
For The Wave roof concept, there is an extra column above roof level that props up the stainless steel wave. These columns vary in length depending on the elevation of the roof above level 4.

The most critical column is the ground floor, analysis has been done and the column **356 x 406 x 393** has been chosen.

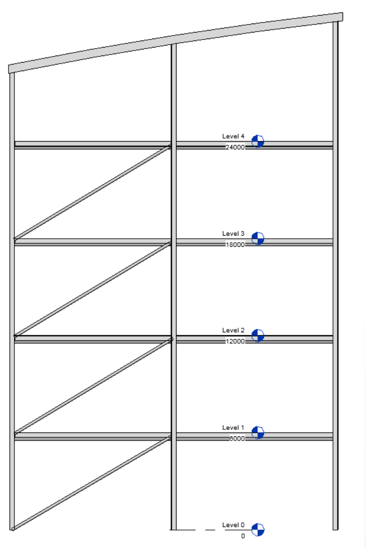
Floor to Floor Diagram



Structure—3D View



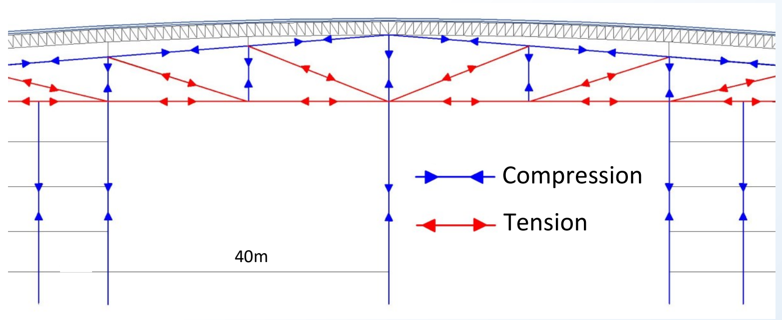
Structure—Elevation View



Column Loading	
Ground Floor	2409.34 kN
Floor 1	2409.34 kN
Floor 2	2409.34 kN
Floor 3	2409.34 kN
Roof	757.50 kN
NEd	11600 kN

Longest Roof Span

The longest roof span will be 40m, across the atria. This will be supported by columns as shown in the diagram. By positioning the greatest span here, the roof and columns become an aesthetic focal point within the atria.



Initial Foundation Design

The foundations for this airport will be piled, specifically a pile group. The pile cap will be **3m x 3m x 1.8m** which is sufficient to prevent cracking via shear.

The pile group will consist of 4 piles of **700mm diameter** acting in a group. It is estimated they will need to be between 5-7m deep to provide full moment resistance.

Foundation Dimensions	
Pile Diameter	4 x 700 mm
Pile Cap Dimensions	3m x 3m x 1.8m