Airport Roof & Long-Span Structure Design Guide

1. Why Long-Span Steel Roofs Define Modern Airports

Terminal roofs are the largest single expense item in an airport's structural budget, and they are also the element passengers remember. A typical check-in hall or concourse demands clear spans of 40-120 m above baggage handling, retail, security screening and passenger walkways, with column placement dictated by circulation, not structure. Reinforced concrete and post-tensioned solutions lose economic and technical viability beyond roughly 30-40 m clear span, which is precisely where structural steel takes over.

Steel offers three properties that concrete cannot match in this typology: strength-to-weight ratio, modular fabrication speed, and reversible connection detailing. A market-leading roof structure for a 450,000 sqm airport project can be erected, coated and weather-sealed in phases, allowing interior fit-out to start while peripheral zones are still being framed. This interstitial construction logic is what compresses total programme and, in airport finance terms, accelerates terminal revenue readiness.

> **Engage the structural steel specialist at concept stage, not at tender stage. Roof geometry, node types, transportation module widths and erection sequencing are decisions that become irreversible once the architectural skin is frozen.**

2. Structural Systems Compared

Four families dominate airport roof engineering. The right choice depends on clear span, roof curvature, column grid, local steel availability and site crane capacity. The comparison below summarises typical application envelopes used in practice across projects in China, Europe and the Middle East.

System	Typical span (m)	Steel weight (kg/sqm)	Best suited to
Space frame (bolted or welded sphere)	30-80	28-55	Two-way grids over regular column grids; fast bolted site assembly
Welded truss (triangular or Vierendeel)	40-100	35-70	Linear concourses, curved roofs with constant section
Beam-string structure (tensioned)	60-120	30-55	Long-leaf roofs wishing to minimise depth above glazing
Cable/suspen-dome systems	80-140	25-45	Iconic radial roofs where compression ring + tension membrane is permissible

Table 1 - Indicative envelopes for airport roof systems

For most international terminal projects, the bolted space frame remains the most economic and logistics-friendly option: it ships as flat-packed nodes and members, assembles on-site with torque-controlled bolting, and accommodates tolerance drift between independently erected bays. Welded trusses and beam-string structures buy greater slenderness at the cost of higher fabrication scrutiny and on-site weld inspection volume.

- Regular grid, repetitive bays: bolted space frame (SG series nodes, HS 4.8/8.8 bolts).
- Longitudinal concourse with constant cross-section: welded triangular truss, 3-4 m depth at 40-80 m span.
- Iconic gateway roof with radial geometry: welded sphere space frame or cable-stiffened system-from 60 m to 140 m.
- Roofs above train stations integrated into the terminal: composite steel-concrete deck on frame grid.

3. Loads Every Airport Roof Must Carry

Airport roofs behave differently from industrial sheds. They are large, lightweight, highly exposed structures whose governing loads are almost always wind suction, snow drift patterns and thermal movement - not gravity. Failure to model these three correctly has produced documented roof cladding losses at multiple international airports.

3.1 Wind

Terminals sit on open, flat airfield land with few upstream obstacles, so exposure is high. Cladding zones overhanging check-in facades develop strong negative pressures. Design should follow EN 1991-1-4 (with the UK National Annex where applicable), GB 50009 (China) or ASCE 7-22; the wind tunnel test remains advisable for cantilevered eaves beyond 15 m and any roof with curvature that eludes code pressure coefficients.

3.2 Snow and ice

Snow on airport roofs is frequently redistributed by wind into drifts against parapets, skylight curbs and valley gutters. EN 1991-1-3 and GB 50009 both provide drift coefficients; where roof geometry creates concave valleys, apply a drift factor of 1.5-2.5 to the basic ground snow load over affected modules. Roof-mounted plant platforms and HVAC corridors are additional concentrated load paths that must be communicated to the structural engineer as early as possible.

3.3 Seismic

Light steel roofs attract low seismic forces, but the connections, not the members, govern. A bolted space frame with ductile node behaviour and no weak-axis eccentricity typically outperforms rigid welded structures under seismic demand. For projects in seismic zones, follow EN 1998-1 or GB 50011 with a response modification factor appropriate to the connection ductility achieved in the shop drawings.

3.4 Thermal movement and deflection

A 300 m long terminal roof will expand and contract some 80-120 mm between a −20 degC winter night and a +45 degC summer day. Sliding bearing supports, expansion joints every 60-90 m, and connection detailing that tolerates rotation without fatigue are non-negotiable. Serviceability deflection limits for airport roofs are typically span/250 under live load, with stricter limits for glazed interfaces.

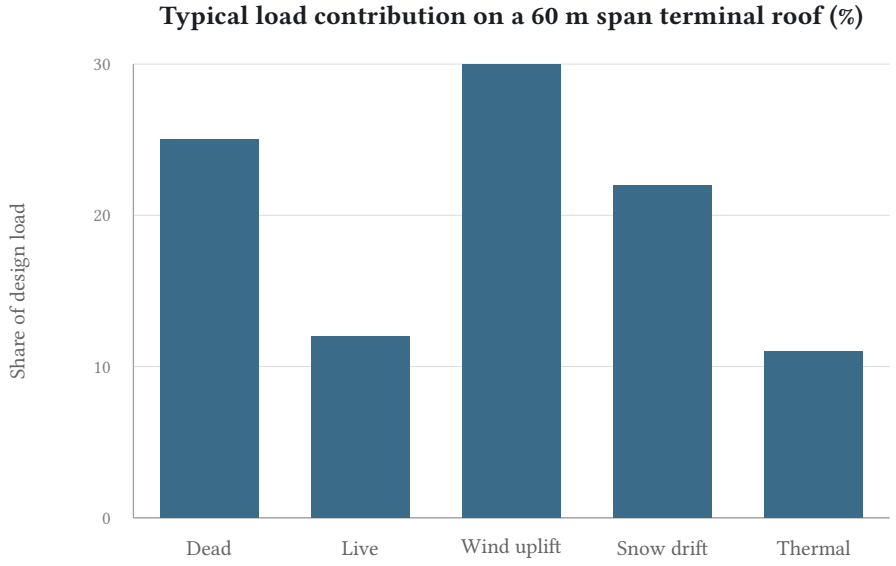


Figure 1: Figure 1 - Indicative load composition, long-span concourse roof

4. Materials, Grades and Standards

Material selection drives both cost and delivery certainty. For export projects, the fabricator's mill-sourced grades must map cleanly to the design code used in the host country. The most common mapping used on airport projects is summarised below.

Design code	Typical grade mapping	Notes
EN 1993-1-1	S355JR / S355J2 / S355K2	J2/K2 for weld-loaded exposure; charpy 27J at −20 degC
GB 50017	Q355B / Q355C / Q355D	C/D grades for cold regions; matches S355 performance envelope
AISC 360	ASTM A992 / A572 Gr.50	Primary wide-flange members
Bolts	HS 8.8 / 10.9 (GB/T 1228); 8.8/10.9 (EN 15048-2)	HV high-strength with torque control for space-frame nodes

Design code	Typical grade mapping	Notes

Table 2 - Grade mapping across commonly used codes

For airport roofs in corrosive coastal or high-humidity environments, hot-dip galvanizing to ISO 1461 (typical Zn mass 600-1000 g/sqm depending on section thickness) is strongly preferred over shop primer for external elements, with the corrosion category verified against ISO 12944-2 and a maintenance painting schedule included in the O&M manual.

5. Fire Protection: Balancing Life Safety and Steel Economy

Airport codes demand long evacuation times for large single-storey terminals, which translates into required steel temperatures of around 350-550 degC for 60-120 minute fire resistance. Blanket protection of every member is expensive and rarely necessary. Standard practice is a performance-based strategy: protected primary members and unprotected secondary members, validated by structural fire analysis per EN 1993-1-2 or GB 51249, with intumescent coating limited to zones genuinely governed by the fire scenario. Keep coating thickness assumptions in the tender documents; changes here are a notorious source of variation orders.

6. Roofing, Drainage and Acoustics

The roof envelope is where airports fail most visibly in service. Standing-seam metal roofing on 57-70 mm composite or double-skin insulated panels provides the acoustic absorption terminals need beneath the structural zone, while vapour barriers must be detailed to the local dew-point regime. Roof drainage should assume a 1-in-50 year storm with gutters sized for 150% of theoretical flow; valley gutters need emergency overflow scuppers. Acoustic design targets for terminal concourses typically sit at 0.5-0.6 noise reduction coefficient in the finished ceiling, which favours perforated liner trays with acoustic infill under the structural spanning members.

7. Fabrication and Erection Logistics

A 40,000-50,000 tonne terminal steel package is erected in 12-24 months with 4-8 tower cranes and, for roof zones, crawler or telescopic cranes working around the building perimeter. The fabrication

schedule must reverse-engineer erection sequences: steel is delivered to match site progress, not warehouse stock. This requires the fabricator to commit to a phased release plan - typically monthly batches of 2,000-5,000 tonnes - with pre-shipment inspection points, photographic documentation and agreed tolerance regimes for interface surveys. Trial assembly (mock-up) of a representative roof module is strongly recommended before mass production begins.

8. Long-Term Maintenance and Inspection

Airport roofs are inspected on walkways, not from cherry pickers. Provide permanent access catwalks and inspection gantries at every expansion joint, roof-level plant zone and glazed interface. Maintenance planning should schedule: annual coating surveys per ISO 12944-8, torque audit of a sample of high-strength bolted connections every 5 years, and ultrasonic inspection of critical welded nodes on a 10-year cycle. The O&M manual, delivered in the language of the owner's maintenance crew, is part of the structural contract deliverable.

9. Reference Projects and Measured Performance

The following completed projects illustrate the span range and structural systems discussed. These are drawn from public project records and serve as benchmark references for owners developing their own brief.

Project	Scale / span	System deployed
Guangzhou Baiyun Airport Terminal 3 (China)	450,000 sqm / 42,000 t steel	Large-span space frame + multi-storey steel frame
Zhengzhou Xinzheng Airport (China)	Terminal + multi-level interchange	Welded space frame concourse
Qatar airports and FIS hub buildings	Medium spans 40-70 m	Bolted space frame, galvanized external
Frankfurt AirRail Centre (Germany)	Station roof over rail platforms	Lattice truss + composite deck

Table 3 - Benchmark airport roof references

> **Project references are cited from public records for benchmarking. For a proposal-grade case study matched to your span, budget and climate, request the engineering department's project dossier.**

10. Owner's Design Checklist

1. Freeze terminal functional zones and column grids before structural tendering; structure follows circulation, not the reverse.
2. Commission a wind tunnel study for any roof with eaves beyond 15 m, curvature, or exposed perimeter canopies.
3. Agree the steel grade mapping to the host-country design code at tender stage; document substitution rules.
4. Define fire-resistance strategy (performance-based vs prescriptive) and coating thicknesses in the contract.
5. Require a phased fabrication release plan with pre-shipment inspection and photographic evidence per batch.
6. Mandate trial assembly of a representative module before mass production.
7. Specify permanent access catwalks and an inspection schedule matching ISO 12944-8 and local statutory requirements.
8. Negotiate change-order rules for coating, node types and erection sequencing before signature.

11. Standards Referenced

Standards referenced

[1] EN 1991-1-3: Actions on structures - Snow loads

[2] EN 1991-1-4: Actions on structures - Wind actions

[3] EN 1993-1-1 / 1-2: Design of steel structures / fire

[4] EN 1998-1: Design of structures for earthquake resistance

[5] GB 50009 / GB 50011 / GB 50017 (China load, seismic, steel codes)

[6] ISO 1461 & ISO 12944: Hot-dip galvanizing and coating systems

[7] EN 15048 / GB/T 1228: Structural bolting

[8] ASCE 7-22: Minimum design loads, USA