Aircraft Hangar Superstructure Selection
Identifying Selection Criteria

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By Don McLaughlin, P.E.

Aircraft hangars are commonly referred to as "glorified garages" for airplanes. They can vary from simple "shade" structures that protect the aircraft from the elements to complicated, high-tech, environmentally controlled maintenance facilities. However, a major cost factor of any hangar facility is the hangar superstructure itself. Compared to ordinary buildings addressed by most building codes, the load and serviceability demands placed on the hangar superstructure are unique.

Door Openings

The superstructure must contain large doors that allow aircraft access; therefore, hangars could be described as large buildings with at least one wall missing. The superstructure must withstand all load combinations with these doors open or closed. The open doors verses the closed doors usually require separate wind load analyses. Because of the door openings themselves, plan stiffness eccentricities are created that lead to unconventional load paths. Three-dimensional analysis and design techniques are usually best suited to handle the stiffness eccentricities.

The doors themselves can be free-standing, can be bottom supported and lean on the hangar or actually be supported by the hangar superstructure. The type of door depends on the climate at the hangar site as well as owner preference for operations. The type of door has a major influence on the hangar superstructure framing system.

Serviceability Constraints

Hangars are usually tall, flexible buildings but are still only one-story buildings. Building codes often require the use of loads that consider the hangar a multi-story building because of its height. Design of the hangar long spans and tall heights are usually governed by serviceability constraints and not by member stresses. Serviceability constraints include limiting the deflection and sidesway

160-meter clear-span aircraft maintenance facility for Evergreen Airways in Taiwan, Republic of China. This structure utilizes a space frame roof system with a lateral load resisting system composed of braced frames.

of the hangar so that the doors remain operational under certain load combinations.

Typically, hangar facilities also have space for offices, maintenance shops, warehouses and utility areas. These spaces are generally adjacent to the hangar space and "lean" on the hangar superstructure. Typically the columns in this space are closer together and the multi-story areas feature stiff concrete slabs. Therefore, this space is structurally stiffer than the flexible hangar space, which must be taken into account during design. Again, three dimensional analysis and design is usually the best solution for handling the different stiffnesses.

Unique Requirements

Each hangar design is unique in that client needs, local building codes, site constraints, material availability and the availability of a trained work force are driving factors in the selection of a structural system. Other major factors that may affect the superstructure include:

- Airport clear zone requirements
- Type and number of aircraft
- Preference for positioning the aircraft in the hangar area
- Preferred hangar door type, configuration, and clear opening requirements
- Categories of maintenance to be performed
- Requirements for suspended work docks, telescoping cranes and overhead bridge cranes
- Weight of suspended mechanical and electrical equipment
- Roofing material and roof slope requirements
- Future expansion of the facility

Structural Solutions

In pursuit of cost-effective solutions for long-span hangar design, many concepts for aircraft hangar superstructures have been studied and developed. Some major structure types that have been studied include:

- Rigid Frame Conventional Steel Framing
- Braced Frame Conventional Steel Framing
- Space Frame Construction
- Three-hinged Steel Arches
- Splayed Steel Arches
- Cantilever Trusses
- Suspended Trusses
- Pretensioned Steel Structures
- Post-tensioned Steel Structures
- Fabric Roof Structures
- Concrete Shell Structures
- Numerous Proprietary Systems

As in most engineering solutions, the most cost-effective solution for one system does not necessarily translate into the best solution for all the systems of the project. For example, an efficient hangar superstructure may result in higher overall costs for the mechanical/electrical systems and higher operating costs over the life of the facility.

Cost-Benefit Analysis

Generally, it is best to minimize the exterior surface of the hangar and consequently the volume of the hangar. The smaller the hangar exterior surface area, the less siding, roofing and insulation that will be required and the smaller the magnitude of the windload that must be resisted. By decreasing the volume of the hangar, there are cost savings in mechanical, electrical and fire protection systems both initially and in operating costs over the life of the hangar facility.

This cost benefit must be weighed relative to the hangar's smaller size and suitability for a specific aircraft. Finally, the benefits and costs of each superstructure system should be studied in conjunction with life-cycle costs of the other systems and presented to the client for selection of a structural system.

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