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The New Airship Hangar in Germany

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1. Summary

Currently, a new generation of airships, the CargoLifter CL 160, is developed. Therefore a new hangar for two airships is going to be built. With a span of 210 m, a height of 107 m and a length of 363 m it will be the largest hall in Germany. The central part of the hangar is of a cylindrical shape consisting of five steel arches covered with a textile membrane. At both ends of the building are the doors which consist of two fixed and six moving elements. They form a semicircle in plan and a quarter-segment of a circle in elevation.

2. Introduction

Six decades ago the golden age for the airships - succeeded by air planes- seemed to have died forever. But the global market and ecological needs require the search for new forms of transportation. Currently, a new generation of airships (helium filled, carbon fibre structure, length 260 m), the CargoLifter CL-160 is prepared. This airship allows transporting a pay-load of 160 t over a distance of up to 10.000 km with a speed of 80-120 km/h. For more information see http://www.cargolifter.de.

In the middle of 1997 the CargoLifter AG commissioned the design for an airship hangar in Germany to house two new airships. The site is an airfield in Brand, about 50 km south of Berlin. With a span of 210 m, a height of 107 m and a length of 363 m it will be the largest hall in Germany (Fig.1). Currently, the detailed design is taking place and most of the building structure should be ready in 1999.

3. Description of the airship hangar

The structural concept distinguishes two main parts of the building. The central part is of a cylindrical shape consisting of five steel arches at 35 m centres - each of the four bays being covered with a textile fabric - and at both ends of the building are the doors which consist of two fixed and six moving elements. Both doors form a semi-circle in plan and a quarter-segment of a circle in elevation. The shape of the building is oriented closely on the clearance diagram for two airships. In addition, this solution is suitable to avoid excessive wind turbulence. The structure has been designed using steel grade S355.

The arches of the cylindrical part have a structural height of 8 m and span over 225 m. The top chords (diameter 559 mm) are at 3,441 m centres and the bottom chords (559 mm) at 2,0 m centre. All the chords of the truss-arch are brace-connected to each other by diagonals (355 mm) and posts (273 mm), with the exception of the two bottom-chords; these are connected by only straight members (355 mm) at 4,135 m, forming a Vierendeel-system.

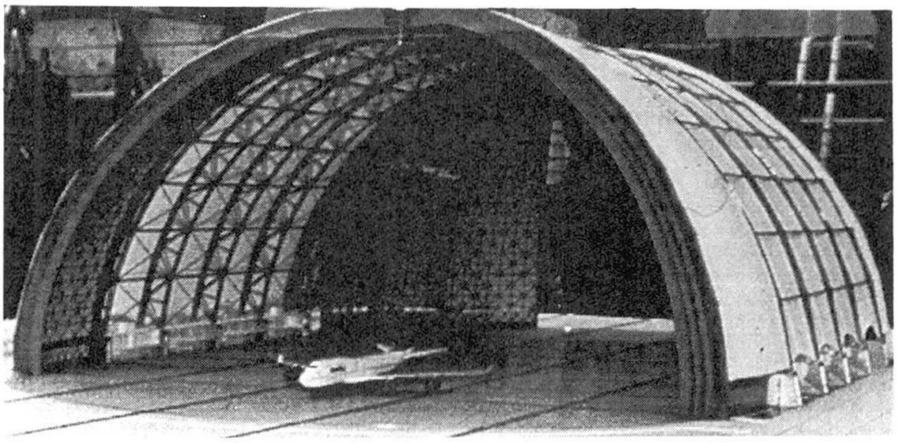
Fig. 1 Perspective of the hangar (model SIAT)

All elements are tubular hollow sections, used because of their high torsional resistance and their good buckling performance. The section thickness varies between 10 and 95 mm. The tube connections have been modelled as fully fixed joints. Currently, analyses are done to investigate the influence of semi-rigid connections on the buckling behaviour of the arches.

The wind bracing is pinned to the bottom chords at each intersection of two arch-polygon segments and pretensioned by 50 kN. At the same intersection between the top chords, external props restrain any torsion in the arches, induced by the eccentrically connected membrane.

At their ridge the arches are longitudinally connected by a four chord, 8 m deep truss, similar to the structure of the arches. This ridge beam enables the connection of the membrane and the valley cable at the top, and takes up the large compression force between the two end arches, generated by the doors.

The hangar entrances are located at both ends of the central part of the building. They consist of a shell structure with a spherical surface. The quarter shells, thus formed, are subdivided into 8 parts. The two fixed bays adjacent to the cylindrical part are more or less continuously connected at one side to the end arches. For these sections, a reticulated structure of 9 by 6 m^2 of HE500A-sections form the structural system. The other six bays of the sphere form the moveable door segments.

The door weight strongly influences directly and indirectly the hangar costs so that minimising the door tonnage was a main aim. The lightest structure was achieved by adopting a shell principle. The inner part of a door segment consists of a spherically shaped frame structure, realised by identical horizontal, vertical and diagonal elements (HE 240A sections), which are rigidly connected in their joints. The cladding spans between the horizontal elements. The side beam dimensions are 3000x800x30x10 [mm], with T90 stiffeners in a 3 by 1 m^2 grid against local buckling. More likely, the edge beams will be manufactured as trapezoidal corrugated web profiles (TWP) with dimensions 3000x800x30-40x5 [mm]. Although the webs are only 5 mm thick due to their folding no additional stiffeners are required. The shell is eccentrically connected to the side beams: at one side to the top flange and at the other side to the lower flange. Hence, a horizontal section through a door shows an approximate Z-shape, allowing for the overlapping of doors underneath each other. At the bottom the shell joins the lower horizontal beam (2300x800x20x15 [mm]) concentrically.

The building enclosure is achieved using a stressed coated polyester fabric type V membrane spanning between the trussed tubular arches in the warp direction and between the ridge truss and the 65 mm edge cable attached to the arch bases in the weft direction By adopting a 65 mm valley cable midway between the arches and by form finding the surface with an increased prestress in the weft direction, the warp span is decreased and the surface stiffened in the weft direction even though the overall curvature is decreased. This way inversion of the outer membrane under wind loading can be controlled.

In addition to the large amount of steel, large amounts concrete are also used for the hangar, about 20.000 m^3 in total. The main concrete elements are the foundations of the arches and the doors, and the floor slab. Between the concrete bases of the arches a two storey high office area is planned with an office height of 3.96 m. Single slab foundations are used for the arches in the cylindrical part.

Detailed information about loading, analysis and design is given in the full-length paper.