Will metal skins replace cable suspended roofs?

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Will Metal Skins Replace Cable Suspended Roofs?

Est-ce que des bâches métalliques remplaceront les toitures en câbles suspendues?

Werden Metallhäute die kabelabgespannten Dächer ersetzen?

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1. Introduction

The characteristic of cable roof structures is the use of primary and secondary members to carry the roof loads. The primary members are high-strength steel cables which span large distances stretching from abutment to abutment. The secondary members are bridging the small distance between the cables and really enclose the space below. Either a steel deck, concrete panels, wood planking or plastics are the materials for the secondary members. (Figure 1).

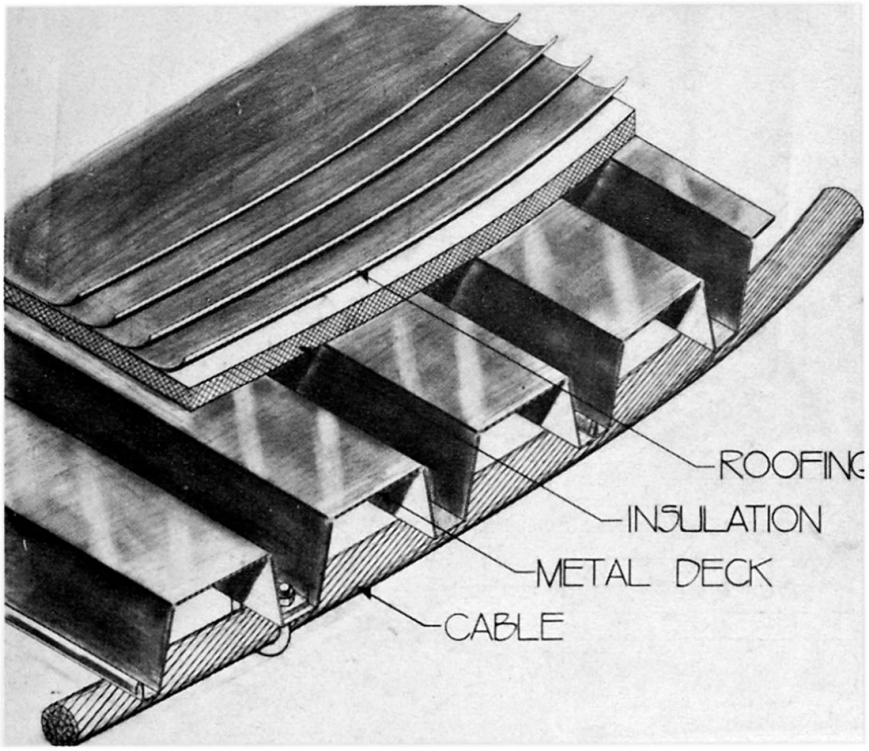

Fig. 1. Conventional Cable Roof Detail

However, if the metallic area of the steel cables is spread to form a thin metal sheet, such a skin could perform both functions of primary and secondary members, of cables and deck. The skin represents simultaneously an infinite number of parallel thin cables carrying the roof load and a metal deck enclosing the space. (Figure 2.) The substitution of the cables by a skin allows straining the material in more than one direction, which without question results in economy.

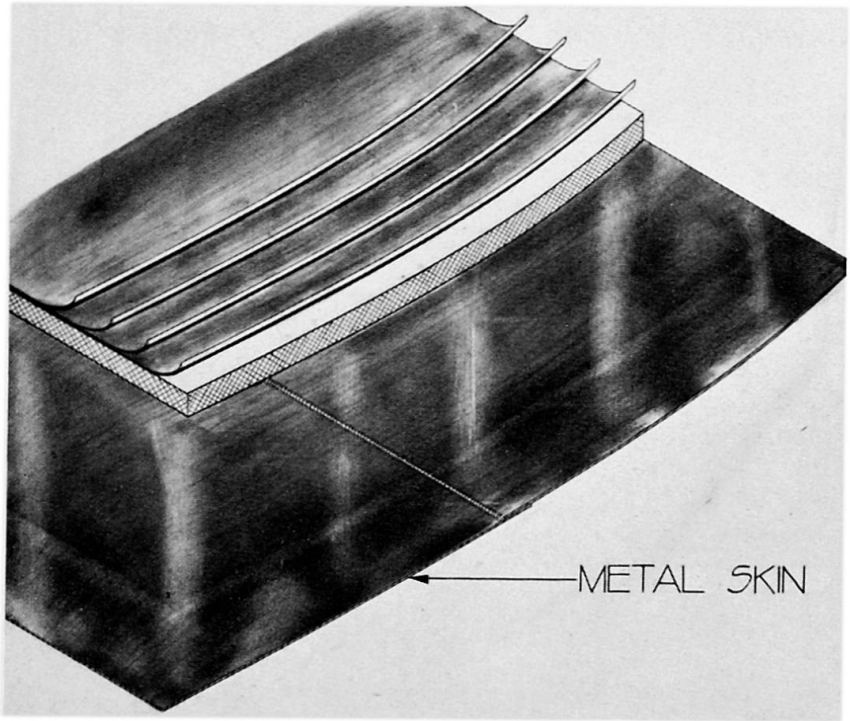

Fig. 2. Metal Skin Roof Detail.

2. Form Stability

It is well known that the major problem in the design of cable roofs is the limitation of their deformation due to non-uniform loading. The stiffness of a cable roof can be controlled by different means, such as weight, guy wires, stiffening trusses, double curvature, or shell action of the roof deck. These methods can also be applied to a hanging steel skin.

However, the continuity of a metal skin allows for more elegant methods of stabilizing a roof. An inside pressure created in the total enclosed space would easily carry the weight of such a skin and would expand it into a dome-like bubble. An under-pressure would preload a hanging skin and stabilize its form, similar to the action of additional weight. The complications of pressurizing a total building finally can be avoided by creating a steel balloon. (Figure 3.)

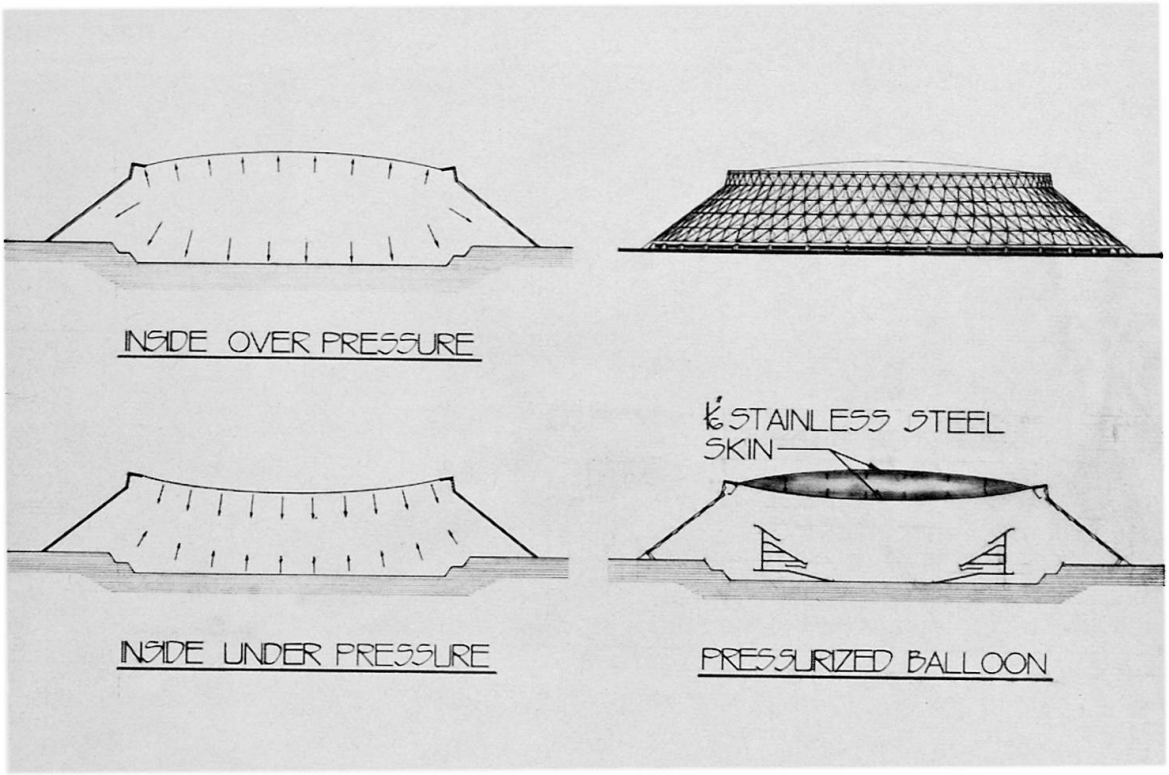

Fig. 3. Stabilization of Metal Skins by Air Pressure.

3. Stainless Steel Balloon

The feasibility of such a stainless steel balloon roof has been studied in our office analytically. Model tests and weld tests with stainless steel were performed by the International Nickel Co., New York. (Figure 4.)

4. Erection

The erection of steel skins must be studied very carefully. There is no question that the fabrication of large steel ballons must be done on the site. In order to avoid scaffolding it is reasonable to assemble the structure on the ground and hoist it in place after completion. Because of the extremely light weight, approximately one-tenth of a conventional steel roof, the hoisting into place does not represent any difficulty.

If a steel skin is used for a tent-like structure with a rather complicated geometry, then plates can be welded on pre-erected ribs, as shown in Figure 5 and Figure 6.

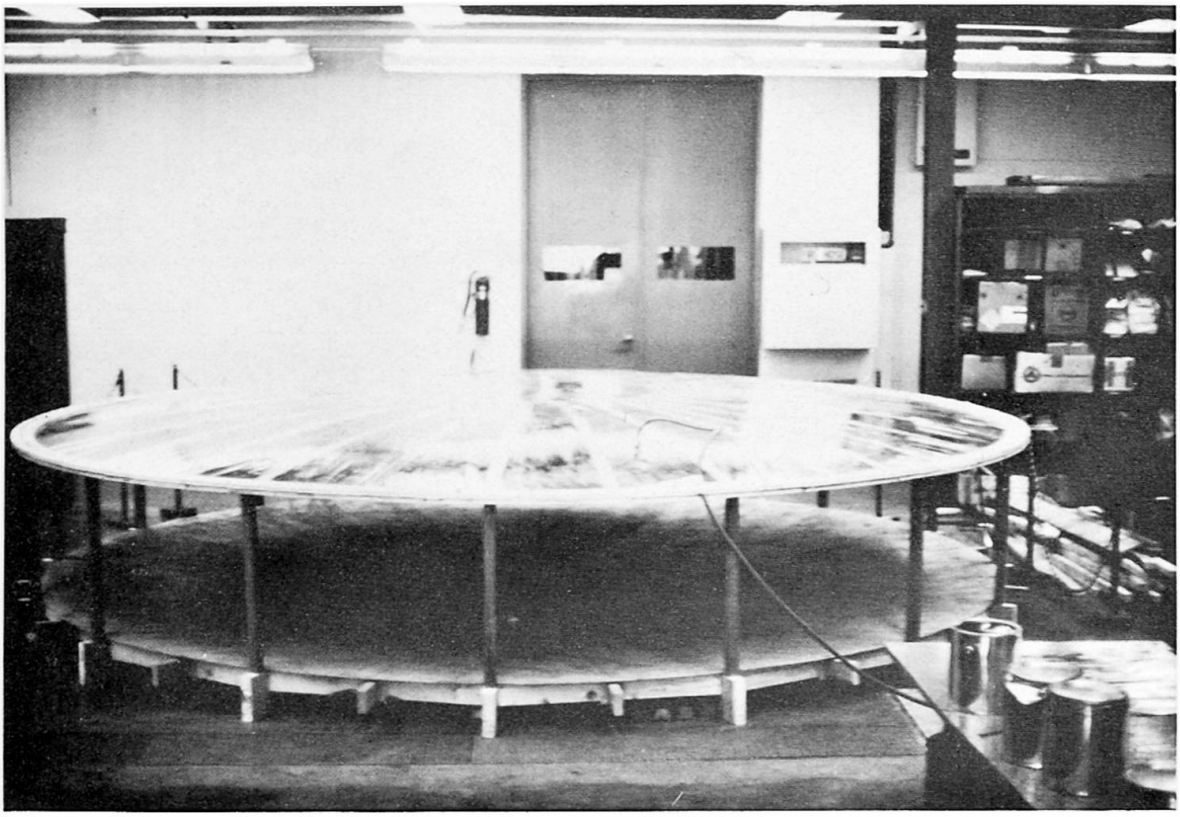

Fig. 4. Model Test of Stainless Steel Balloon Roof.
International Nickel Co., New York, N.Y.

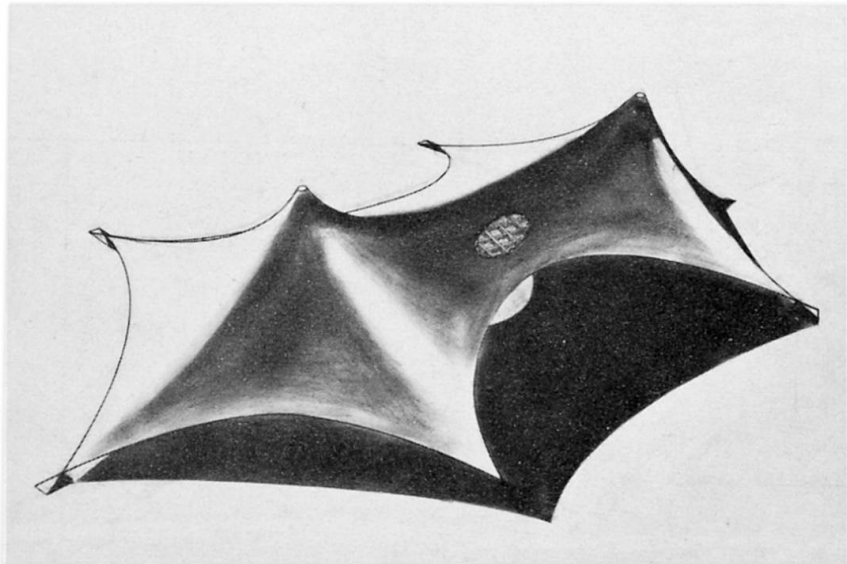

Fig. 5. Free Form Steel Skin Tent.

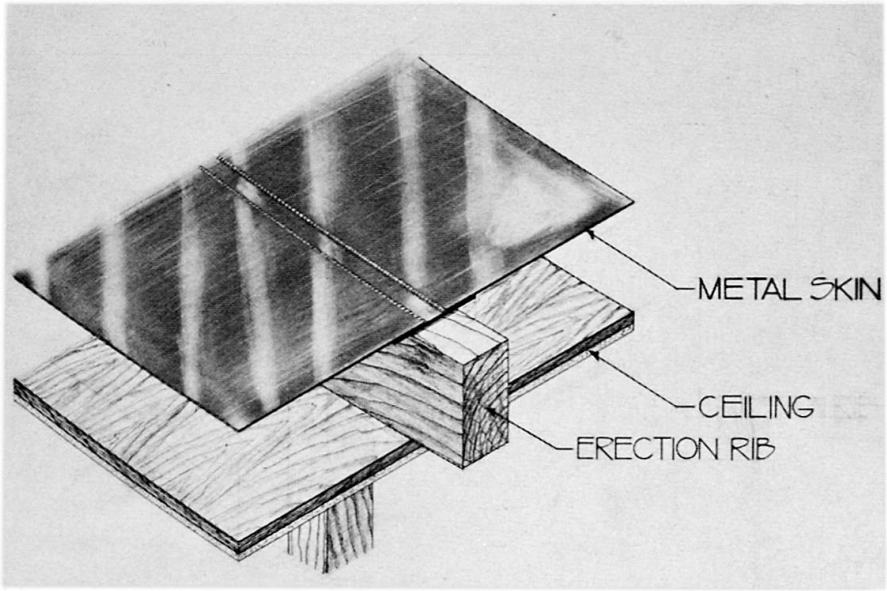

Fig. 5. Erection Detail

5. Permanence

Membrane roofs made of plastics or similar materials have a very serious disadvantage because of the very limited life expectancy of such materials. It is obvious that a stainless steel skin with its unlimited corrosion resistance eliminates completely the more temporary character of membrane roofs existing until now.

Summary

The further development of cable supported suspended roofs to metal skin membranes is discussed. The characteristic of the uniformity of such skins is used to stabilize their shapes by air pressure. Calculations and model tests prove the feasibility of such structures. The use of stainless steel guarantees permanence.

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