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Artikel: A semi-rigid hanging roof in Wakayama (Japan)

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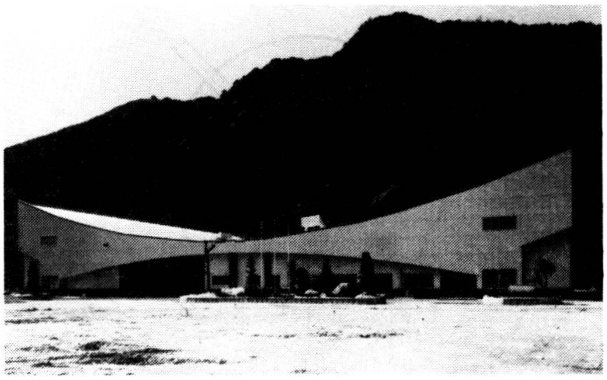
10. A Semi-Rigid Hanging Roof in Wakayama (Japan)

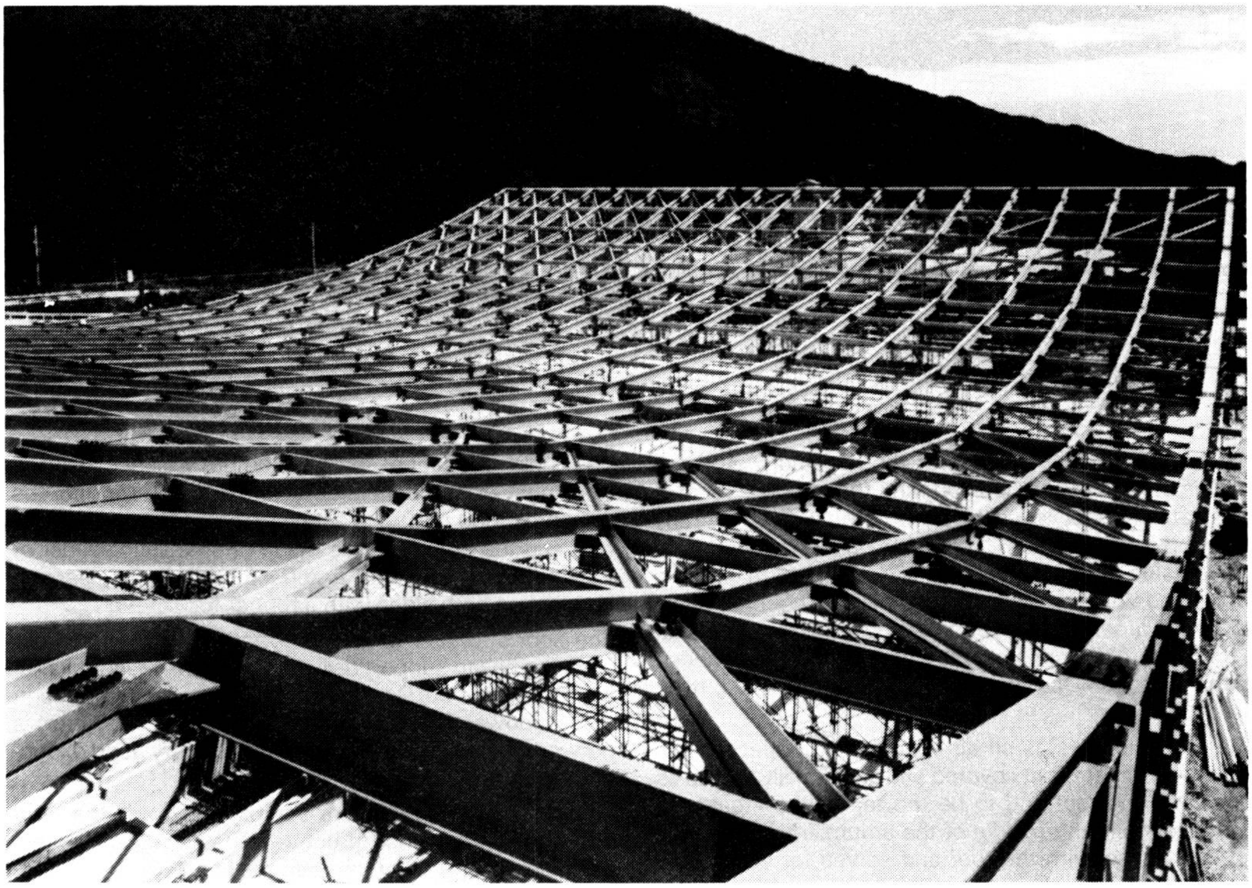
Owner:	*Town of Susami, Wakayama, Japan*
Architect:	*Kuboi Design Office*
Structural Engineer:	*Mamoru Kawaguchi*
Contractor:	*Abe Komuten*
Fabricator:	*Sumitomo Metal Industries*
Total Floor Area:	*3957 m^2*
Height:	*13.3 m*
Total Weight of Steel:	*179 metric tons*
Construction Period:	*11 months*
Service Date:	*March 1985*



General View

Introduction

A hanging roof is said to be rational and economical, since structural members of the roof are stressed only in tension, and they can develop the full strength of the material without any reduction due to buckling. However, this is true only within the boundary of the roof, and how to deal with the big tensile forces which have been carried by the roof members up to the boundary has been one of the greatest design problems of an hanging roof. The most popular way of taking care of the tensile forces at the end of a one-way hanging roof of rectangular plan is the backstay system in which the tensile forces of the roof cables are taken over by bachstay cables at the roof end from where the inclined bachstay cables carry the forces down to anchorages. The backstay system has a sufficient technological background in the field of suspension bridges, and it has also been applied to many examples of hanging roofs. It should be noted, however, that this system has the following drawbacks when it is used for a hanging roof:



Roof Frame Being Erected

1) Extra costs and space are necessary on both sides of the building for the backstay cables and the anchorages.
2) The backstay cables should be treated for corrosion resistance.

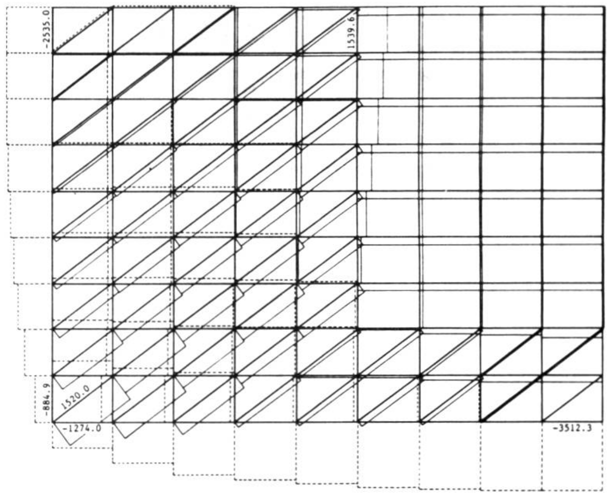
The structure presented here is the second example to have been achieved of a semi-rigid hanging roof which can do without backstays. The first one was realized in Kagoshima City in 1983 on a smaller scale.

Structural Features

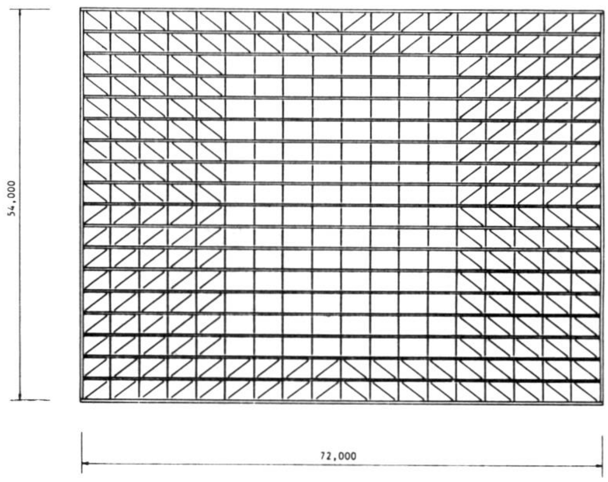
The structure is a hanging roof covering a rectangular plan of 54 m × 72 m. The structural system of the roof may be best illustrated by the roof plan and the elevation. The roof is constituted in the following manner:

1) The roof frame is composed of the hanging, the transverse and the diagonal members, the last being provided in the outer area of the roof. The hanging members are given a continuous bending rigidity in the vertical plane.
2) The peripheral members with increased sectional areas constitute a boundary. They are supported by posts at an appropriate distance.

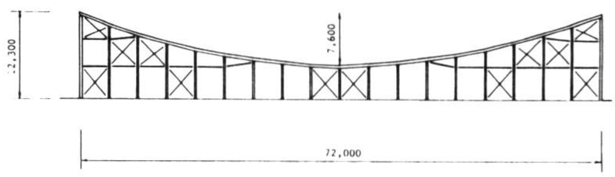
When roof is subjected to a distributed vertical load, tensile forces are produced in the hanging members in the central area. These tensile forces are then automatically led to the corners of the roof by means of the diagonal members. This load-transferring process is possible in this roof system without producing any excessive deformation, since the hanging members are provided with a continuous bending rigidity, which is not the case with «pure» hanging roofs. The tensile forces transmitted toward the corners produce big compressive forces in the peripheral members. In other words the peripheral members constitute a kind of «compression ring» in a rectangular form. Small amounts of compressive forces are produced even in the roof area, but they are easily resisted by members of reasonable size. All these forces are shown in the figure. The big compression in the peripheral members does not cause any economical problems, because these members are restrained at an appropriate distance in the vertical as well as horizontal direction. The compressive forces in the curved peripheral members produce downward forces, which are supported by the posts. The total weight of the roof is mainly supported by this effect. One of the structural features of the system is that it constitutes a «closed» force system in the horizontal equilibrium, and can be supported simply on top of the posts arranged along the periphery of the building. The character of the system is highly hybrid, since while it keeps the merits of a «pure» hanging roof, its low bending rigidity is indispensable for a convenient force flow in the plane of the roof any excessive deflections being produced.



Axial Forces in Roof (in kN)



Floor Plan



Wall Elevation

Reference

Study and Realization of a Hybrid Hanging Roof, by M. Kawaguchi, et al., IASS Symposium Dortmund, 1984.

(M. Kawaguchi)