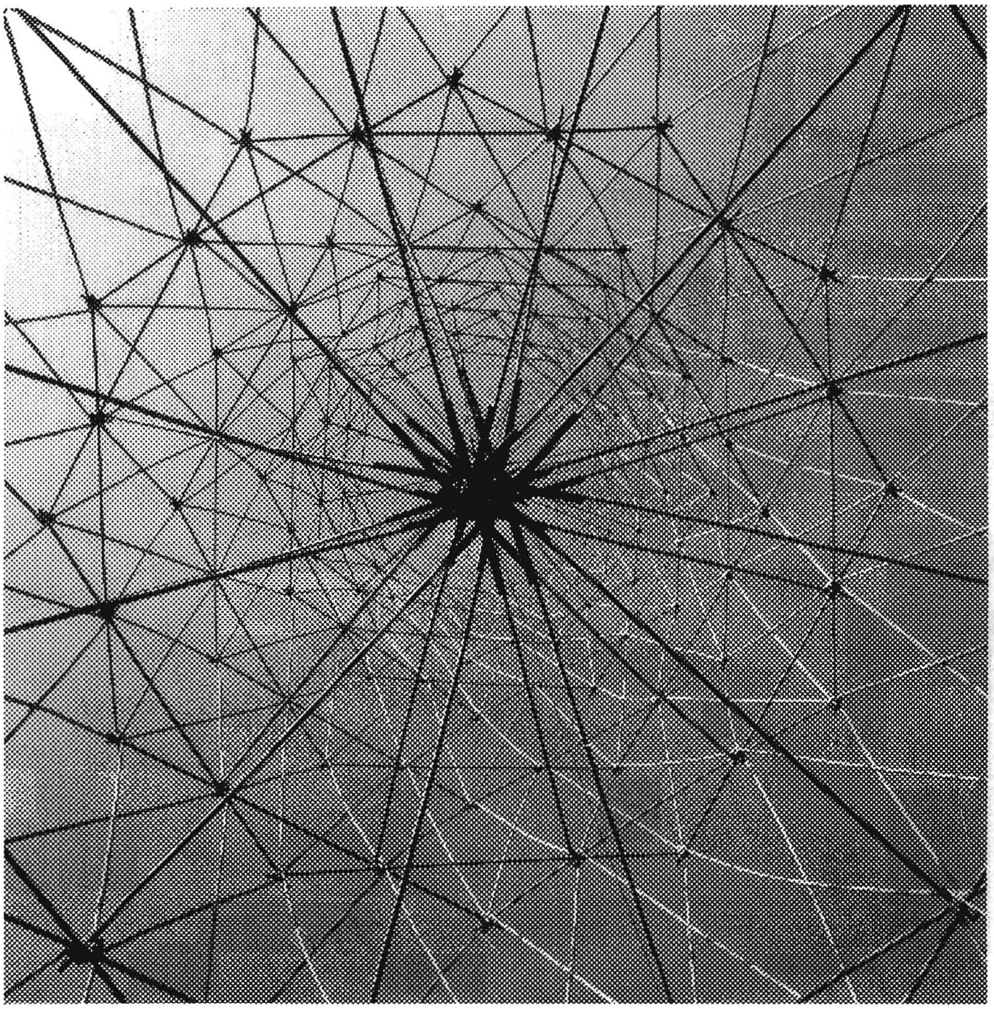
Research on building structures and building physics : proceedings of an interuniverity research seminar, Eindhoven, November 18-20, 1992

RESEARCH ON BUILDING STRUCTURES AND BUILDING PHYSICS
EINDHOVEN 1992



PROCEEDINGS OF AN INTERUNIVERSITY RESEARCH SEMINAR

Eindhoven University of Technology the Netherlands
Wroclaw University of Technology Poland

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WROCLAW POLITECHNIKA

ALCO-DOME
Design and erection of the steelstructure

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ABSTRACT

Recently a single-layer lattice dome of 52m clear span was erected on the grounds of the Eindhoven University of Technology.
This dome has been developed by members of the light weight structures group of the department of Structural Design (BKO) in coöperation with Siemer B.V., Geertruidenberg.
Attention will be paid to some special features of the dome, including the geometry, the node (Adjustable Lattice Connector) and the erection method.

Technical data

Clear span	:	52m
Height	:	15m
Diameter sphere	:	60m
Design load	:	- windspeed: 144 km/h - snowload: 50 kg/m² - safety factor: 1,5
Bars	:	300 steel tubes ϕ152,4 x 4mm 6 HEA 140 (entrances) 25 different length's between 4,5 and 7,5m
Reducers	:	cast steel
Nodes	:	30 adjustable, 61 fixed, 33 semi-spherical aupports and 6 entrance supports.
Foundation	:	concrete ringbeam 500 x 800mm

Introduction

The existing laboraties for building research at the Eindhoven University of Technology do not offer the possibility of large full-scale experiments.
A current housing project requires shelter for the next three years for a three story experimental module and some other extensive experiments are awaited.
Renting or buying a temporary structure proved to be very expensive, so it was decided to use some results of the research and development by the light-weight structures group of the department of structural design and Siemer B.V.
A single-layer lattice dome with a prestressed fabric skin

inside and a retractable roof structure were proposed and the first one was chosen.

Geometry

The geometry of the dome is based on the conditions given by a new type of low-cost covering for dome structures developed by Siemer B.V.
This will probably be tested on the dome in the future and subsequently reported.
The structure is a segment of a sphere with a centre angle of 120º and a diameter of 60m.
The segment is divided in six mainly equal parts; three of them contain an entrance. The segment borders are meridians and divided in six equal parts.
Five sets of steel ring bars are not horizontal (except the first ring around the top) but segmentwise vertically curved, while the sixth ring, the concrete ring beam, is horizontal.
To create an entrance, two bars, emerging from the central support node of three segment parts, are omitted and replaced by vertical HEA 140 posts, which stiffen the by the left-out tubes weakened area around the entrance.
These posts connect the dome nodes on top of the door with an inserted piece of foundation, as can be seen in picture 1.
A special detail has been developed to prevent stress-concentrations near the post top.
This quite unusual entrance solution was chosen not only for aesthetic reasons but also for erecting considerations as will be explained later on.

Nodes

It is a well-known fact that lattice domes can't be made from indentical bars and identical nodes, except the icosahedron dome, which is only suitable for relatively small spans and hardly can be considered as a spherical structure.
The dome at issue requires 22 different nodes, including the support nodes.
This number increases rapidly for larger domes with higher 'frequencies'.
So it is very attractive to try to find a universal node which fits all over the structure.
The first author developed an Adjustable Lattice Connector (ALCO) which indead fits everywhere and guarantees a centric connection of the bars in all positions.
Thirty ALCO's were fabricated by the Central Technical Service of the University and spread over the dome structure to test the suitability.
The main body of all the nodes is spherical.
In order to minimize the node it is necessary to reduce the diameter of the tubes.

This reduction is archieved by cast steel reducers, welded to the end of the tubes.
In the surface of the dome stiffness is ensured by triangulation of the geometry so a large reduction from ϕ152,4 to only 50mm is possible.
In the given special dome configuration this results in a node diameter of only 175mm.
Perpendicular to the surface the reduction was limited up to 100mm in order to obtain sufficient bending stiffness in view of the erection method.

Erection method

The usual erection method for single-layer domes, as for most other structures, starts at the foundation and works gradually to the top.
Only "high frequency" domes can be built this way without temporary supports because of the relatively short members.
With members up to 7,5m in this case these supports are necessary.
People working at increasing heights with heavy parts and tools means a sertain safety risk.
In order to increase safety in the first place and secondly to avoid temporary supports in the successive mounting steps the procedure was turned upside down. Starting with the top and working to the foundation, by lifting the finished part by means of a central mast and adding members and nodes at ground level, both aims were reached.
Double-layer domes, like for example Temcor domes can be built this way quite easily because of their relatively high stiffness perpendicular to the surface of the sphere in the free-edge situation.
Naturally single-layer domes are very weak in this respect.
That's why the reducers are shaped as mentioned before.
To allow mounting of the crown of the dome at first, a two-legged mast was positioned on a ball-bearing in the centre of the dome, so the top node could move between the legs.
The mast was stayed in three directions by cables anchored to the foundation.
To prevent the dome from meeting the stays during lifting three temporary bucks were places on the inserted entrance foundations.
The stags were attached to the top of the bucks, thus giving enough space for the dome to rise, and subsequently anchored to the ringbeam.
This was a major design consideration for the choice of the dome geometry and the solution for the entrances.
Fig. 1 shows the dome during construction just before the final lift of about 4,5m.
At that moment the diameter of the finished part is 46m and the weigth about 200 kN.
60 Bars are waiting to connect this part to the concrete ring beam.
Fig. 2 shows the suspension of the dome during erection and gives an impression of the nodes.

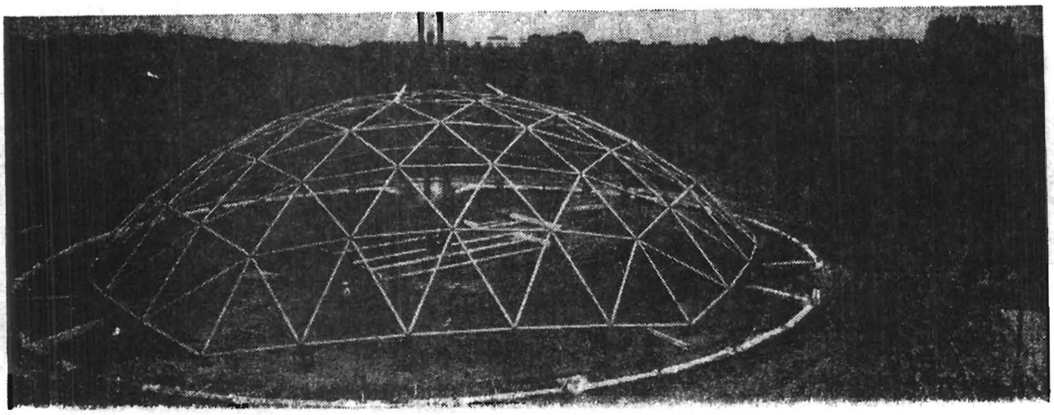

Fig. 1: Just before the final lift.

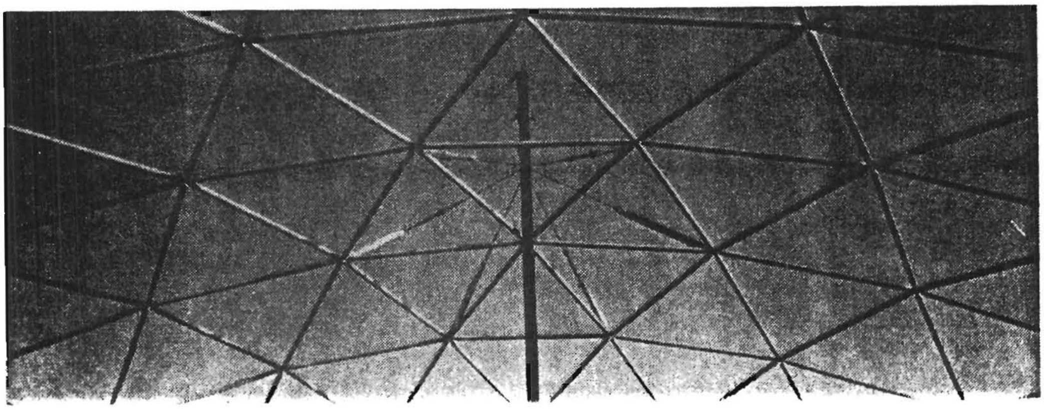

Fig. 2: Suspension during erection.