

Feasibility Study of Geodesic Dome as Disaster Resistant Structure

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Abstract - Of all structures built from linear elements, a Geodesic Dome has the highest ratio of enclosed volume to weight. Geodesic domes may pave way for economic, sustainable, energy efficient structures with no intermediate supports. Study on these structures is of great importance especially considering it as an environment friendly construction technique. This paper aims at explaining the concepts, modelling, stress analysis and design of geodesic dome as disaster resistant structure. Modelling is done in CADRE Geo 7, analysis and design using STAAD Pro.

Key Words: Geodesic, Icosahedron, Seismic, Sustainable, CADRE Geo 7, STAAD Pro

1. INTRODUCTION

Engineers and architects have always held a special interest for structural systems that enable them to cover large spans with minimal interference from internal supports. It is perhaps no surprise that dome structures, capable of encompassing maximum volume with minimum surface area, are one of the oldest structural forms and have been used in architecture since the earliest times.

Due to the efforts of Buckminster Fuller, the geodesic dome became a vogue form of design. Buckminster Fuller's passion for geodesic structures came from the design's affinity with nature, an effect he described as the "energetic-synergetic" geometry of his domes. "Energetic" refers to Fuller's belief that nature always builds the most economic structures. He claimed that geodesic domes built upon principles embodying force distributions similar to those of atoms, molecules, and crystals, would form the lightest, most efficient forms of construction. Fuller defined synergy as the "integrated behaviors of nature and the behavior of a whole system unpredicted by the behavior of any sub-assembly of its components. Similarly, the geodesic dome exhibits a stiffness and rigidity greater than that predicted based on the sum of the individual components that make it.

There are two possible classes of geodesic subdivision, for Class I subdivision, the dividing lines are parallel to the edges of the primary bracing, in Class II the dividing lines are perpendicular to the primary bracing. Class I subdivision produces geometry where the edges of the triangle lie on a great circle which leads to simple design of a hemisphere

with planar connections, this may not be achieved with a Class II subdivision. Geodesic domes produce extremely light skeleton structures that are very stiff and rigid, enclosing a large area without need for internal supports. Due to the light weight, the round shape of the dome perimeter, and the generally uniform load distribution of geodesic dome structures, deep foundations are not normally required. Construction of shallow foundations allows a considerable saving in time and money over deep foundations.

2. MODELLING

A commercial package called CADRE Geo 7 was used to generate vertices, struts and ties for the proposed geodesic dome. CADRE Geo is a design utility software that can generate a wide variety of 3D geodesic and spherical or ellipsoidal models for import to CAD or other structural analysis applications.

For the analysis, a class I, frequency 6- 20m diameter geodesic dome was modelled.

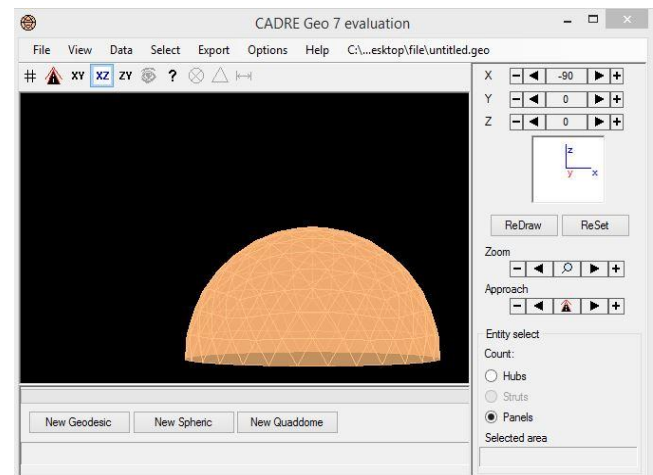


Fig -1: Modelling in CADRE geo 7

3. LOADING

Dead load was calculated by the software based on the materials used. The struts were made of steel and panels using polycarbonate material. Roof load was calculated based on IS 875(Part 2)-1987 clause 4.1.

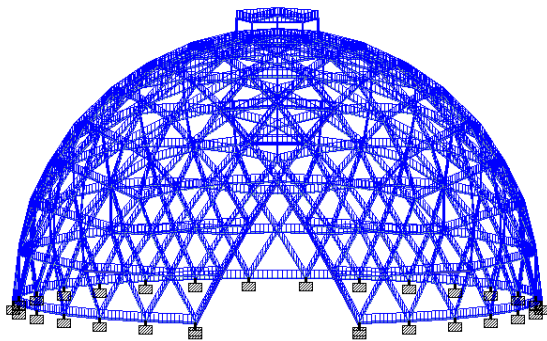


Fig -2: Live load

Wind load was calculated considering super cyclonic storm condition which is the most severe wind condition prevailing in India and the load was calculated as per IS 875 (Part 3) – 1987.

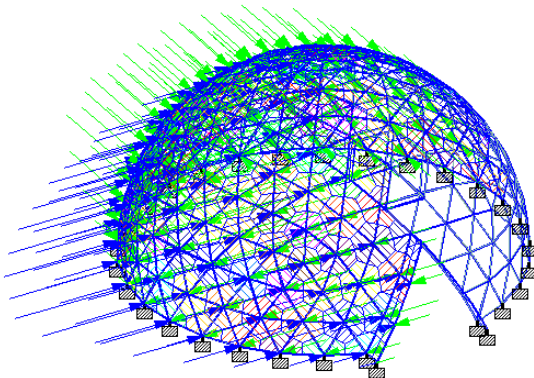


Fig -3: Wind load

Earthquake load was also imposed on the structure as per IS 1893-1 (2002).Zone V region was selected for analysis.

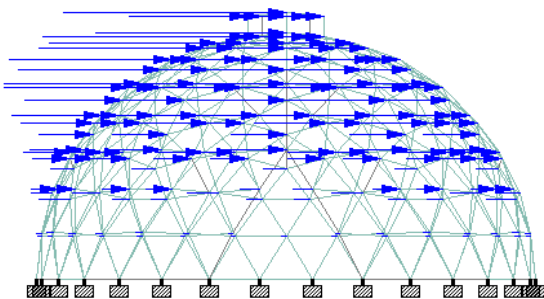


Fig -4: Earthquake load

4. ANALYSIS AND DESIGN

The structure was analyzed and designed using STAAD Pro software. After the application of loads the structure was analyzed. None of the members failed during the design. Smaller tubular section TUB48482.9 was used for struts. The provided section was the smallest section which can be used for struts in the structure.

5. RESULTS

Tonnage, plate stress and beam stress were analyzed using the software. Also the structure was designed using the software to check whether all the members were able to transfer the load without failing.

STEEL TAKE-OFF

PROFILE	LENGTH (METE)	WEIGHT (KN)
ST TUB48482.9	1155.94	44.577
TOTAL =		44.577

Fig -5: Steel takeoff

The total weight of the steel structure was just 44.577 kN, considering the size of 20 m diameter, area of 314.15m² and extreme loading conditions, the structure is very light weight and is highly economic.

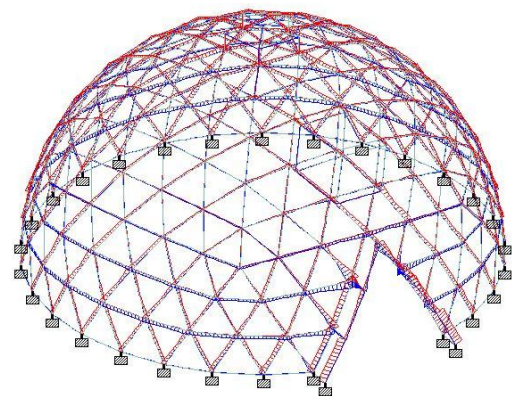


Fig -6: Beam Stress

Stress is evenly distributed over the whole structure. The forces in a geodesic network are an equilibrated combination of tension and compression. Tension forces are global and continuous, while compression forces are local and discontinuous.

Plate stress was found slightly concentrated near the openings but still the values are not much higher since the

size of the panels are reduced by increasing the frequency of the structure.

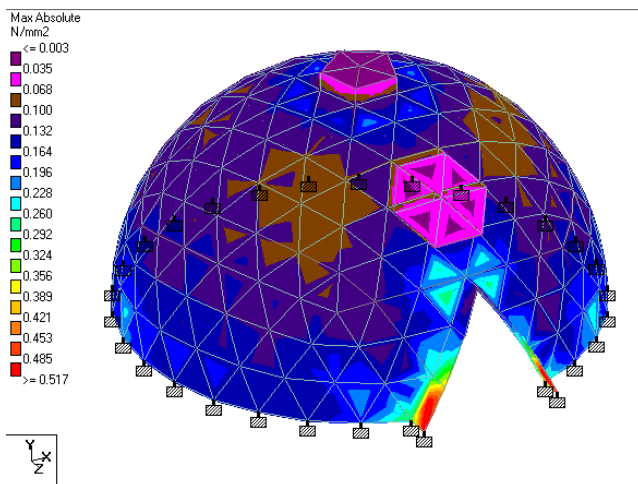


Fig -7: Plate Stress

6. CONCLUSIONS

From the analysis it is clear that geodesic dome can be utilized as a disaster resistant structure. In this case, extreme disaster conditions were provided and none of the members was found failed. The structure was made with frequency 6 which helped to reduce the member size and also the weight of the structure considerably. Also the division of members made the load transfer much more effective. The structure proved to be very strong, even with such smaller sections the structure was able to withstand higher loads.

Hence geodesic dome proved to be an economic structure for construction of important disaster resistant buildings.

ACKNOWLEDGMENTS

The Author(s) wish to express their special gratitude to Dr. P. G. Bhaskaran Nair, PG Dean, Sree Narayana Institute of Technology, Adoor, Above all the author(s) thank GOD Almighty for His grace throughout the work.

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