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STUDY OF THE EVOLUTION OF GEODESIC DOMES FROM THE POINT OF VIEW OF THE STRUCTURES OF DOME SPACECRAFT

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Abstract: Today, with the advancement of science and technology, there are new needs and demands in the field of structural engineering. The time factor in constructing structures has doubled, and this has increased the tendency towards prefabricated structures. Also, with the increase in human populations, there has been a strong interest in having large spaces without the presence of middle pillars. In this regard, from the beginning of the century, a number of experts were attracted to the unique capabilities of spacecraft. With the publication of these results, the field was welcomed more and more day by day, with the passing of several decades, the study of space structures is still at the center of the experts and students of civilization. If the grid is curved in two directions, it is called a dome. Perhaps a dome is a part of a sphere or a cone with multiple joints. In general, domes are highly rigid structures. Examples of domes can be diamonds and gyodecic domes. In this paper, geodesic domes have been analyzed from the point of view of the discussion of structures of dome space spaces in the geodesic dome. A geodesic dome (or a dome constructed with geometric surfaces) has a spherical or semi-spherical shell structure or a grid shell based on a grid of large interconnected (geodesic) loops on its surface. Geodesic domes are formed by subdivisions. Polygons are more stable because they form triangles at any time. The geodesics cut each other to form triangular elements to increase their internal strength and also increase the power of distribution of stress at the level of their structure. With more divisions on the surface, the dome gets smoother and more flexible.

Key words: geodesic, geodetic space, geodesic dome, geodesic structure

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1. INTRODUCTION

A geodesic dome is a spherical spatial frame that transfers the loads through the linear members in a spherical dome to the support, in which all members are in direct stress (tension or pressure). Often, a narrow-bore member (made of plastic or metal) is used to convert the dome into shelter. The best form that can withstand horizontal and vertical forces (wind and earthquakes) is the spherical force. In the event that the number of members of the geodesic dome increases, the dome's resistance will increase against the vertical and vertical loads. The geodesic domes are formed on the basis of four major planetary, quadrilateral, cubic, octagonal, twelve, and twenty-faceted planes. In these five volumes, the lengths of the edges are equal. In such a way, all the vertices are in contact with the atmosphere of the universe. In this paper, geodesic domes from the beginning of the invention to the present day have been studied in terms of design, use and construction.

2. RESEARCH METHOD

After studies in the domain of the dome structure, if the network is curved in two directions, the dome is called. Perhaps a dome is a part of a sphere or a cone with multiple joints. Domes are structures with high rigidity and are used for very large openings up to 250 meters. The height of the dome should be greater than 15% of the diameter of the dome base. Domes are centered. A variety of domes can be a gear-type dome. If the number of gears is high, you should consider the crowded crowd at the top of the dome. To avoid this, it's best to remove some of the gears near the top. There is another dome called the German engineer Osfeldler, many of which were built by Esfeldler and others after the 19th century. The bug of this dome can be seen in the bulk of the members at Vertex, which is the same solution to solve this problem. Another example of domes is the Dome of Lemla. This dome can be considered as a combination of one or more loops that are cross-linked. Of the other examples of domes, one can refer to diamonds and bubbles and geodesic domes. Joints in gear dams and springs are rigid. Regarding the regular play of power, the geodesic, diamond and bubble domes are very suitable. The method of data collection is conducted through research, library and studies, and tried to use the latest and most up-to-date information and resources, and even samples. In this research, after the studies in the field of architecture and nature, the components of natural patterns and bionic architecture are extracted from the documentation, and then the level of approval and education of children is measured using these components in the design of a recreational center for children.

3. HISTORY

Architect and engineer Bakminnster Fuller invented and modernized geodesic domes in 1954, and by inventing these domes, engineers looked at the dome forever. These domes were part of a spherical structure that, instead of a set of arches, consisted of a set of triangles that, using modern technological knowledge, provided buildings with greater efficiency and cost (2). The ideas and plans that Fuller made during the 1950s and 1960s created the idea that such large and giant domes could cover all the cities. Also, Fuller says in his research; "If a Korean with triangles is constructed, it will have unique strengths and capabilities." (Space Designer Regulations, 2010). In the late 1950s, the Kaiser Aluminum Company began producing fuller Geodesic domes, constructed of diamond-shaped panels with hardened edges and cryptic-shaped elements, and created a combination of geodetic frame shells. Despite the attractiveness and efficiency of instruments that have domes of geodesy, but in their construction, there are several executive problems such as the difficulty of waterproofing them, the difficulty of performing openings due to the continuity and the difficulty of using conventional furniture due to their particular internal shape. Perhaps these problems can be overcome in large structures, but in small buildings, these problems overcome the benefits of such systems. Today's geodetic domes are represented by the expansion of dome-shaped and curved domes. Like the Wolverine Dome - Zayes Dywindig. (M. Golabchi, et al, 2015).

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Figure. 1 and Figure. 2: Geodesic dome by Bummins Fuller (M. Golabchi, et al, 2015) and Kaiser dome of the Vicarage Center in Virginia (Kaiser Aluminum Manufacturing Co. -1950)

With more divisions of geodesic domes, domes are more flexible and damp. Realistic geodesic domes have been created from the development and completion of dentures that have been restored. Loads in the geodetic domes are transmitted through the axial forces (tension and pressure) of the frame members to the piers. All members located at the top of the semicircular dome (45 degrees) underneath the uniform load, under pressure, and all the lower members under stress, and members close to the perpendicular line. The shape of the dome for the reciprocating force follows the determinant role (M. Golabchi, et al, 2015).

4. ADVANTAGES

The most important advantage of geodetic domes is the proper seismic behavior due to their weight and uncertainty. Other features of this type of structures are the following, (Space Designer Regulations, 2010):

- These structures are able to cover large openings with the least amount of consumable materials.
- Used steel in geodesic domes is one third less than other conventional structures.
- Due to prefabricated components, the speed of assembly and installation is very high and economical.
- This dome has a low weight and has a handy movement capability.
- The geodesic dome exhibits greater resistance to dynamic loads such as earthquakes, explosions and winds compared with other conventional structures.
- Between two layers of space in dual geodesic domes can easily be used for electrical and mechanical applications.
- The geodesic dome is very beautiful in terms of appearance and does not require the use of a false ceiling in this structure. Its low level needs less materials.
- A surface exposed to cold during the winter and exposed to heat in the summer. Because the sphere has the lowest surface area per unit volume of the structure.
- The inner concave surface of the sphere creates a natural airflow that flows through the air duct through the airflow through the duct.

5. GEOMETRY

Geodesic domes spread through smaller divisions of one or more Platonic volumes. Octagonal and polygonal, due to the fact that they are formed of triangles, are inherently more stable and are used as the main elements in most lattice domes in buildings. Polygons are more stable because they are formed on each side of the triangles. The most well-known form of such domes is a soccer ball that comes from three-tier divisions of a twenty-tenth volume.

Figure 3: The geometry of the geodesic domes is inspired by the sea coral, and the soccer ball is derived from the reciprocating triangular divisions of a twenty-eyed. (2)

Arrangement of members: Geodesic domes are made in the form of a layer and double layer. Single-layer domes are used for smaller openings and double-sided domes for large openings. The dome of a maximum span layer is 35 meters in length and the two-layer domes are newly constructed, or, in other words, their structure is space structures. (M. Golabchi, et al, 2015) The arrangement of members is in the form of five and regular hexagons..

Figure 4: Two-layer geodetic dome (right, Missouri Climatological Botanical Garden) and a geodesic dome of a solar layer (left, corn cobwebs of Norway houses)

6. CONNECTIONS

Typically, due to the functions of the links and connections in the spacecraft structure, the way of transferring tensions through the links is complex, and in cases where there is no adequate information about their behavior, analytical studies and design with the aid of the test should be considered. Due to the importance of the links, the type of connection of most commercial systems, the turning point of the system is counted and recorded. Steel fittings and joints can be made from high-strength, pressed, hot-formed steel, pressed or cast-fitted steel. Spacecraft structures are often connected with screw or welding devices (F. Moore, 2012). The type of bonding behavior, the flexibility of the connections, the continuity or non-integrity of the members will have a significant significance in the behavior of the spacecraft structure and should be realistically modeled and analyzed. Also, the amount of flexibility or fitting strength is important in members' resistance to bending, as well as the effective length and buckling strength of the members (F. Moore, 2012). Geodetic domes, fittings include several methods as follows:

- Single-unit connection system: In single-unit systems, repeating units that make up the grid are separately produced at the factory and built by connecting them to each other at the site of the workshop, a geodesic dome. Most of these connections are screw driving. Members of each unit may be connected using different links or directly.

-Combination system: Combined methods are systems that are not part of single systems, or come from a combination of several types of connection systems.

- Linked Linking System: In link systems, members and links are created separately at the factory, and then a geodesic dome is established at the workshop by connecting the members to the links.

1. COMPONENTS OF DOME (AND GEODESIC) STRUCTURES

Knot: A solid steel knot that is produced by forging on resistant steel alloys and after machining is ready for installation on the grid. The task of this section is to connect the main members of the trunk trusses to each other and transfer the load. This piece is based on the loads loaded on it and the geometric conditions in the architectural form of the structure of different sizes and to be resistant to atmospheric conditions as well as to obtain The beauty is before the installation of the plating.

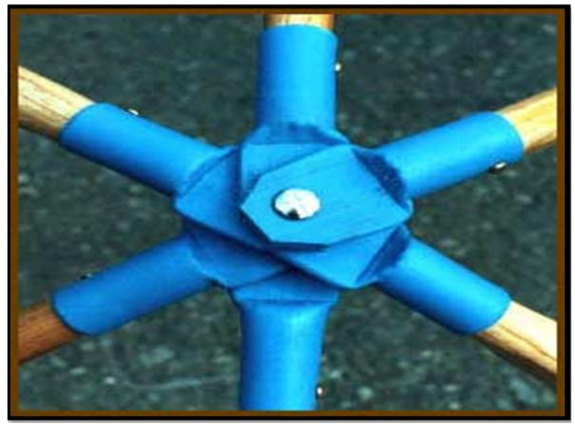

Figure **5:** Example of a single ion-bat type connection

- Location: Geodetic domes are widely used in ceilings. It is also possible to use these structures seamlessly as structural floors and walls.

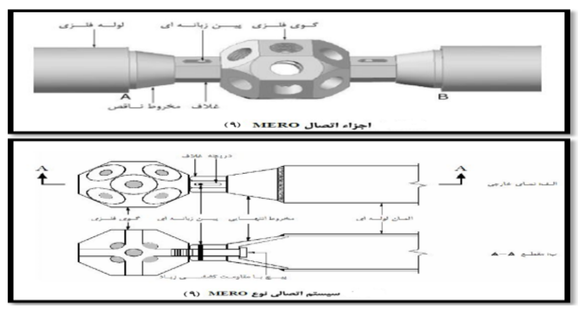

Figure **6:** METRO system and components

Orb: A steel bead that is multifaceted and used for communication between three dimensional members. In the space structure, the balloons make it possible for themselves and their respective members to be placed in a constant position and create a balance between the forces of the members of the structure. The holes have holes in which the members of the structure are machined on the holes they are sitting and screwed up

The special arrows of Sarveston are partly cylindrical and partly spherical. Orders are divided into three categories:

- Ordinary Orbits have 18 holes with 45 degree communication angles;
- Standard arrays used for specific angles;
- Spherical cylindrical and special spiral arrows.

8. INTERFACE COMPONENTS BETWEEN NODES

These components act as the main members of the loader and the loader from the place it enters to the support, which consists of four parts:

A) Pipe: The tubular profile is a geometric view of the best cross-section for carrying axle loads, which is designed based on loads loaded on it and its diameter and thickness are calculated accordingly. This set has straight tubes, the two ends of which are cut and fitted with semiautomatic welding by means of a cone that allows connection to other parts.

B) Tile: A cone-shaped piece that connects to the pipe through welding operations and is responsible for reducing the dimensions of the tubes in the node.

C) Screw: Connection of pipes to knots is done by closing the screw in the thread formed in the knots, which size and sex of this piece are also designed according to the type and amount of load involved.

D) Nut: The connection of the screws to the knots is done by a nut engraved by a thorn with a screw. This piece is also designed according to the type and length of the load involved and has different dimensions.

E) picket of the slope: To create a slope on the plane surfaces of the space structure and the necessary connection to install the ceiling pillars, similar components of variable-length connecting components are used, in the form that one end is connected to the nodes and the other ends of the necessary connecting surfaces Provides pearls.

F) Pearl: To provide the necessary levels for the installation of various types of coating on a space structure, profiles of different sections are used. These profiles can have different sections, such as cans and studs.

2. DESIGN BASICS

Like spacecraft structures, in the initial design, the tables in building codes or rules of thumbnail are often used. Ultimately, the calculations of standard geodesic domes should be completed for the final design. In the past, a large number of members used in geodetic domes needed much time for engineering calculations and were used in very simple shapes. But today, with the help of the computer, the calculations can be carried out at a great rate, which has increased the freedom of form for designers. If existing and standard forms are used, many of these final calculations are easily completed using widely available standard computer software. Putting mechanical and electrical systems in geodetic domes is another issue that makes architecture so easy.

9.1. Build and run

Among the features of how to build geodesics are:

- Repeat production
- Installation speed
- Need for space and heavy equipment
- the need for low manpower
- Coverage

Geodetic domes can physically withstand vertical and horizontal forces; therefore, they are widely used in large openings. Also, with the development of computer software, it is possible to calculate them accurately, and since construction speed is very important for builders, and due to the pre-made elements of it, these domes can be constructed shortly (M. Golabchi, et al, 2015).

3. CONCLUSION

All types of geodesic domes are capable of covering large openings. So it is widely used for the roofs of large showrooms, greenhouses, temporary exhibitions, planes like Sabina in Spain, residential buildings and Stansted airports in London. Due to the lightness of the geodesic domes and the formation of them, small members can be separated from each other in any place. Because they are resistant to weak winds and have little dead load, they can also be used for radio and television towers, which in this type of use of lean towers are sometimes secured by cable against lateral forces.

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