Volume : 1 | Issue : 3 | December 2011 ISSN - 2249-555X

Research Paper Civil Engineering

Step-By-Step Method Of Fabrication And Erection Of Geodesic Dome From A4 Size Waste Papers

* V. K. Dogra

* M. Tech. (Structures), Fellow IAStructE, Assistant Professor, SALD, Shri Mata Vaishno Devi University, Katra

ABSTRACT

Geodesic Domes are of great interest to Architects, civil engineers and the students studying in these disciplines. These can be planned from basic platonic solids or modified platonic solids. Archimedes, Euler, and many others have worked and contributed on the shapes and properties of the platonic solids. R Buckminister Fuller was the first to create large size geodesic domes based on theses geometries. This paper presents a very simple step-by-step procedure to fabricate and erect geodesic dome from A4 size papers and based on the geometry of truncated icosahedron.

Keywords : Geodesic dome, platonic solids, icosahedron and truncated icosahedron.

Introduction

Icosahedron is a platonic solid with twenty equilateral triangular faces, twelve vertices and thirty edges. Five equilateral triangles meet at each vertex of the icosahedron. All the vertices of icosahedron are equidistant from the centre and therefore a sphere can be drawn touching all the vertices of the icosahedrons. By truncating the vertices of the icosahedrons, in such a way that each triangular face changes into a regular hexagon, truncated icosahedrons is formed. Twelve vertices get truncated to form twelve regular pentagons. The length of sides of the hexagons and the pentagons, is the same. The photograph of the truncated icosahedrons is as shown in figure 1. It may please be noted that each vertex of truncated icosahedon is also equidistant from its centre and therefore, a sphere can be drawn touching all the vertices of truncated icosahedrons.

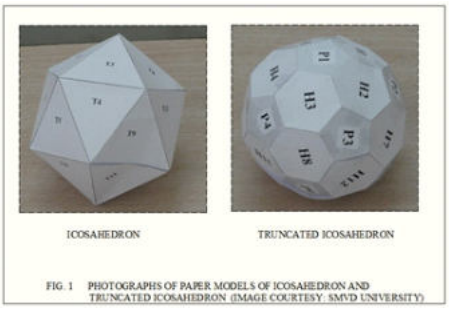

FIG. 1 PHOTOGRAPHS OF PAPER MODELS OF ICOSAHEDRON AND TRUNCATED ICOSAHEDRON (IMAGE COURTESY: SMVD UNIVERSITY)

Each hexagon can further be divided into six triangles as the first subdivision, twenty four triangles as second subdivision, ninety six triangles as third subdivision and so on, as shown in figure 2. Similarly, each pentagon can further be subdivided into five triangles as first subdivision, twenty triangles as second subdivision, eighty triangles as third subdivision, and so on. The additional points (vertices) generated due to the subdivisions of the hexagons and pentagons are then projected on the surface of the geodesic sphere.

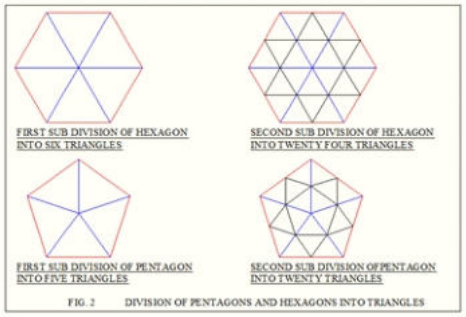

FIG. 2 DIVISION OF PENTAGONS AND HEXAGONS INTO TRIANGLES

The lengths of the sides of these triangles are worked out and geodesic sphere is fabricated. This paper describes the step-by-step procedure to fabricate the geodesic sphere using A4 size papers. The geometry is based on the second subdivision of the hexagons and the pentagons of the truncated icosahedrons.

Lengths of Members

This paper describes the geodesic sphere based on the second subdivision of the pentagons and the hexagons of truncated icosahedron. The lengths of the sides of the triangles after projecting additional points on the surface of the geodesic sphere are given in table 1. The location and marking on the members are shown in figure 3.

Table 1 C/c lengths and number of members required

S. No	Member Identification No.	Length (mm)	No. of Members
1	S_{11}	263.7	180
2	P_{11}	227	120
3	P_{12}	266	60
4	P_{13}	231	120
5	H_{11}	269.5	240
6	H_{12}	268	120
7	H_{13}	273.8	240

Fabrication of Geodesic Sphere

Geodesic sphere made from A4 size papers can be fabricated in following five simple steps:

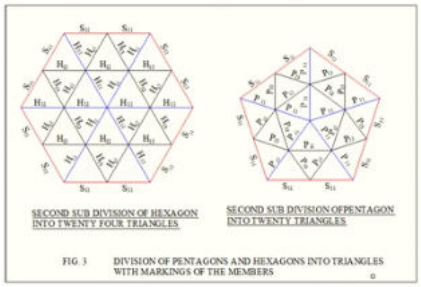

FIG. 3 DIVISION OF PENTAGONS AND HEXAGONS INTO TRIANGLES WITH MARKINGS OF THE MEMBERS

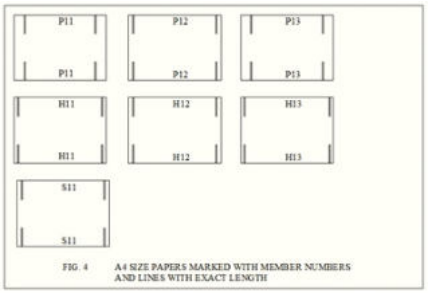

FIG. 4 A4 SIZE PAPERS MARKED WITH MEMBER NUMBERS AND LINES WITH EXACT LENGTH

Step-1 (Marking Papers)

Accuracy in the lengths of the members is very important for proper fitting of the members and proper shape of the geodesic dome. A total of 1080 A4 papers are required, for erection of a geodesic sphere, as given in table 1. All these papers are marked with the member identification number and lines with exact length, preferably using computer and printer. If desired papers of different colours may be used for different members. Two lines, 2mm on either side of the exact length of the member, are also drawn on the papers, so that the distance between the twin lines is 4mm. Thus the distance from the centre of 4 mm diameter hole punched between these twin lines on either end of the paper is the exact length of the member. The marking on either side is done for convenience, so that the marking is always on the outer side irrespective of the rolling started from the upper or lower side of the paper. Sample A4 size papers with identification numbers and twin lines on the left and right ends are shown in figure 4.

Step-2 (Rolling of A4 Papers and Formation of Tubes)

Now the papers are required to be rolled to form paper tubes. The outer end of the paper tube is glued so that the tubes are stable and do not open up. Care needs to be taken that the diameter of all the tubes is nearly the same and the markings are visible on the outer side of the tube. It is desirable to wrap transparent tape on twin lines on either side of the paper to provide extra strength around holes to be punched in step-3.

Step-3 (Punching Holes and Cutting of Extra Length)

In this step holes of 4mm diameter are punched with the help of a puncher. Care needs to be taken that the holes on the paper tube are in the same plane. Extra length of the tubes are cut using scissors and removed. Nearly 10 to 15mm of extra length is sufficient on either side of the twin lines. Members are now ready for fabrication. These tubes with different identification numbers are stacked separately for convenience.

Step-4 (Fabrication of Pentagons and Hexagons)

Twelve pentagons and 20 Hexagons are fabricated by joining the paper tubes together in the pattern as shown in figure 3 with the help of 4mm diameter steel bolts and nuts. Since the sides of the pentagons and hexagons are common, adjustment needs to be done and members 'S11' need to be fitted to pentagons and hexagons accordingly, so that there is no duplication of 'S11'. Photographs of rolled tube, pentagon and hexagon are shown in figure 5.

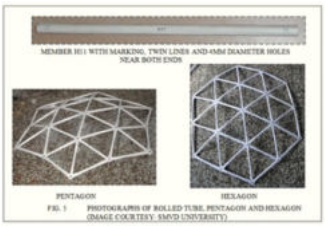

FIG. 5 PHOTOGRAPHS OF ROLLED TUBE, PENTAGON AND HEXAGON (IMAGE COURTESY: SMVD UNIVERSITY)

GEODESIC DOME ERECTED WITH 6 PENTAGONS 5 HEXAGONS AND 5 HEXAGONS OF HALF SIZE

GEODESIC DOME ERECTED WITH 6 PENTAGONS AND 10 HEXAGONS

FIG. 6 PHOTOGRAPHS OF GEODESIC DOME AT DIFFERENT STAGES OF ERECTION (IMAGE COURTESY: SMVD UNIVERSITY)

Step-5 (Fabrication Geodesic Dome from Pentagons and Hexagons)

In this step the pentagons and hexagons are joined together to form the geodesic dome. This is done by lifting and holding a pentagon at a higher level and attaching five hexagons on five sides of this pentagon. These hexagons shall also get attached together along their adjacent edges to form a stable domical shape capable of resting on the ground. Again this dome is lifted up from all five sides and five pentagons are fitted in the slots and the domical shape is again stable and can rest on the ground on five sides of the pentagons just attached. The height of the dome keeps on increasing with every attachment from below. The process of lifting is kept on repeating till all the hexagons and pentagons are attached from below. A geodesic sphere of 2.60m diameter is obtained.

Photographs of a rolled member with holes, pentagon and a hexagon fabricated from the rolled members are shown in figure 5. Photographs of the dome at different stages of erection are shown in figure 6 and 7. Truncated Icosahedron and divisions of pentagons and hexagons of

FIG. 7 PHOTOGRAPH OF GEODESIC DOME WITH AN OPENING (IMAGE COURTESY: SMVD UNIVERSITY)

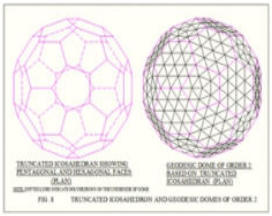

FIG. 8 TRUNCATED ICOSAHEDRON AND GEODESIC DOMES OF ORDER 2

truncated icosahedron are shown in figure 8. Photographs of geodesic sphere fabricated from A4 size waste papers is shown in figure 9.

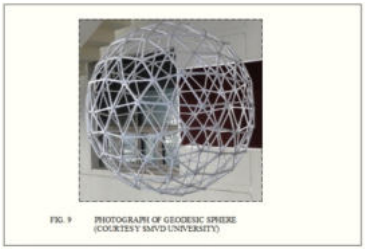

FIG. 9 PHOTOGRAPH OF GEODESIC SPHERE (COURTESY SMVD UNIVERSITY)

REFERENCES

Book Extract "Architectural Geometry" Architecture + DESIGN February 2009, 110 124.