International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

Modelling & Validation of Single Layer Geodesic Dome with various Height to Span Ratios

Swapnil Waghmode[1], D.B. Kulkarni[2]

[1]M. Tech. student, Dept. of Civil-structural Engineering, RIT, Maharashtra, India
[2]Professor, Dept. of Civil-structural Engineering, RIT, Maharashtra, India

---***---

Abstract - Dome is one of the most efficient structure for the larger area which can be construct without interruption of columns. Modeling and analysis is one the critical part for these type of complex structures. Ribbed dome, Schwedler dome, lamella dome, diamatic dome, geodesic dome these are some types of domes but geodesic dome is one of efficient dome. Geodesic dome consists of triangles, which are joined together to form dome like structures, since the triangular shape is very stable and the deformations under the action of forces is very less. This part of work includes the geometrical details and analytical investigation and it includes the detailed geodesic dome modelling. It also includes the validation of software using existing literature results. The modeling work is done in CADRE pro 6 evaluation and validation work is done in SAP2000.

Key Words: Geodesic dome, Modeling, software validation, CADRE pro 6 evaluation, SAP2000.

1. INTRODUCTION

A Geodesic dome is a hemispherical thin-shell structure i.e. latticed shell based on a geodesic polyhedron. Geodesic dome consists of triangles, which are joined together to form dome like structures, since the triangular shape is very stable and the deformations under the action of forces is very less. This concept makes this type of domes very strong. Minimum amount of materials are required for the construction of geodesic domes when compared to ordinary domes. Elliptical geodesic domes have the advantage that they can cover elongated or irregular shaped spaces that vary in elevation. Transportation is easy because of their light weight. They are lightweight, strong and require no interior supports. There are a lot more uses of geodesic domes to make buildings of sheer beauty. Applications of Geodesic domes are residential homes, greenhouses, warehouses, water reservoirs and entertainment spots. Buckminster Fuller's geodesic model was based on the sphere subdivision of an icosahedron. An icosahedron is a regular polyhedron with 20 sides, each of which is an equilateral triangle, and at each vertex, 5 triangles meet.

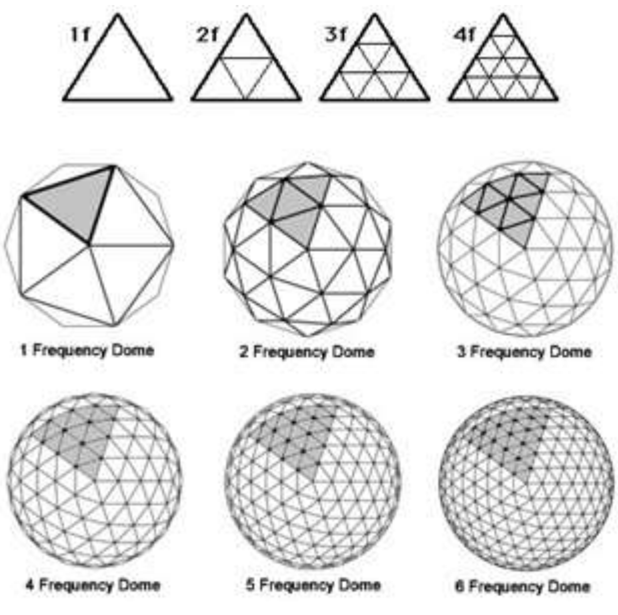

Fig 1.1: Geodesic dome geometries

Fig 1.2: Icosahedron (source-Pacific Domes, 2011)

Frequency is defined as the number of parts or segments into which a principle side is subdivided. For instance, 2ν means the edge of the principle triangle is equally divide into 2 segments, 3ν means 3 equal segments. There are two classes of geodesic subdivision as shown in following fig. class 1 subdivision dividing lines are parallel to edges of principle triangle and in class 2 subdivision dividing lines are perpendicular to the edges of principle triangle.According to Ramaswamy (2002) Using class 1 subdivision we can built both even and odd order frequency domes but class 2 subdivision can only be achieved by even number of frequency.

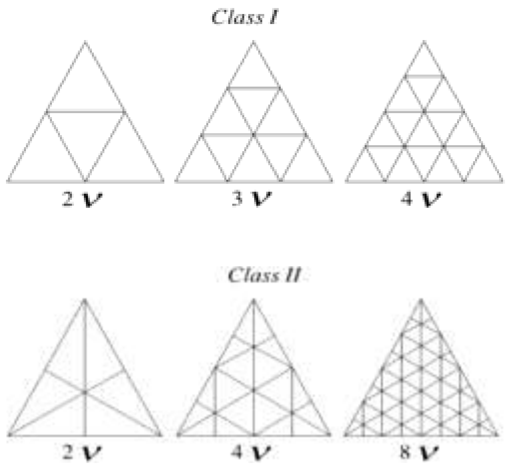

Fig.1.3: Geodesic subdivision class and frequency

2. Modeling:

Geometrical Details of Models:

Six models have been developed using Geodesic dome modelling software for the study of geodesic geometry. These models are developed for different height to span ratios for different frequencies. Span of dome is fixed with reference to previous literature studies as 20m and as per height to span ratios height of dome varies. Class 1 subdivision is adopted for 4V and 6V Frequencies. From modelling we found out number of elements, number of rings, number of supports, number of surface nodes of geodesic dome.

Table 2.1 Geometrical details of geodesic dome models

H/S ratio	Frequency	No. of elements	No. of rings	No. of supports	Surface nodes
1/2	4V	250	6	20	91
1/3	4V	250	6	20	91
1/4	4V	250	6	20	91
1/2	6V	555	9	30	196
1/3	6V	555	9	30	196
1/4	6V	555	9	30	196

Geodesic dome models:

Model-1: 4V,1/2 H to S Geodesic dome
Polyhedron type = Icosahedron Frequency = 4V
Class = I
Breakdown Method -1
H/S Ratio- 1/2
Radius = 10m

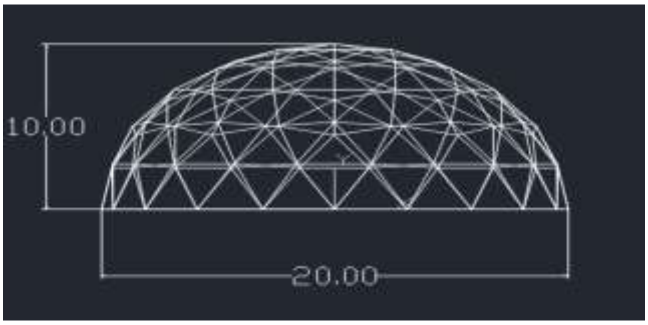

Fig.2.1: 4V,1/2 H to S Geodesic dome

Model-2: 4V,1/3 H to S Geodesic dome
Polyhedron type = Icosahedron
Frequency = 4
Class = I
Breakdown method-1
H/S Ratio- 1/3
Radius = 10

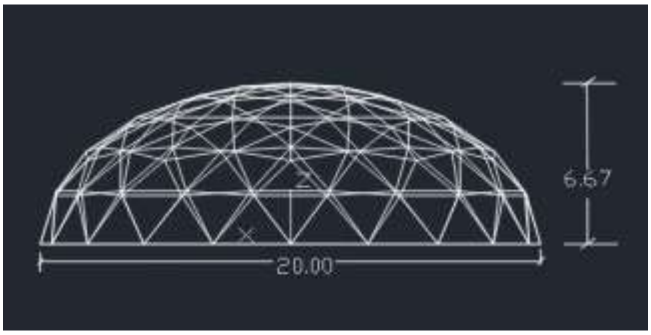

Fig.2.2: 4V,1/3 H to S Geodesic dome

Model-3: 4V,1/4 H to S Geodesic dome Polyhedron type = Icosahedron Frequency = 4
Class = I
Breakdown method-1 H/S Ratio- 1/4 Radius = 10

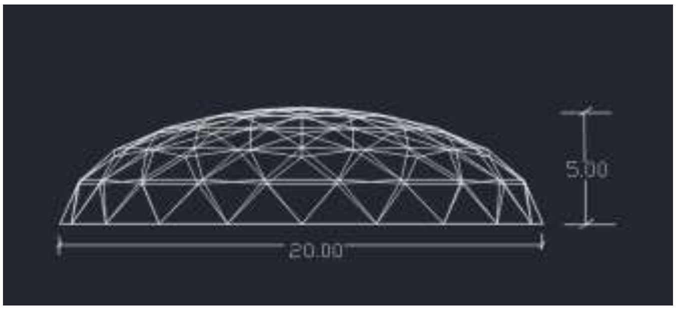

Fig.2.3: 4V,1/4 H to S Geodesic dome Model-4: 6V,1/2 H to S Geodesic dome

Polyhedron type = Icosahedron
Frequency = 6V
Class = I
Breakdown Method -1 H/S
Ratio- 1/2
Radius = 10m

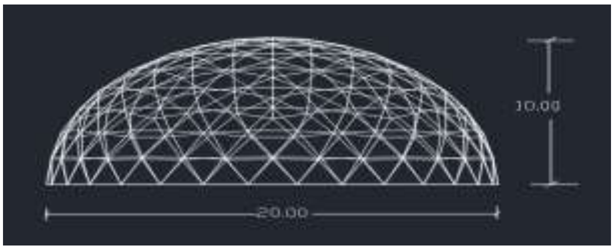

Fig.2.4: 6V,1/2 H to S Geodesic dome

Model-5: 6V,1/3 H to S Geodesic dome
Polyhedron type = Icosahedron Frequency = 6V
Class = I
Breakdown Method -1 H/S
Ratio- 1/3
Radius = 10m

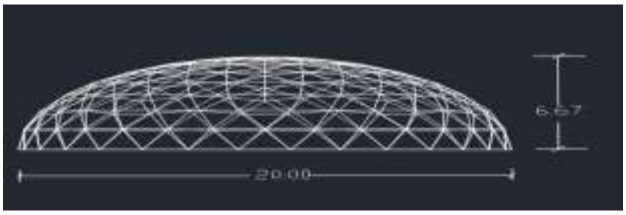

Fig.2.5: 6V,1/3 H to S Geodesic dome

Model-6: 6V,1/4 H to S Geodesic dome
Polyhedron type = Icosahedron
Frequency = 6V
Class = I
Breakdown Method -1 H/S
Ratio- 1/4
Radius = 10m

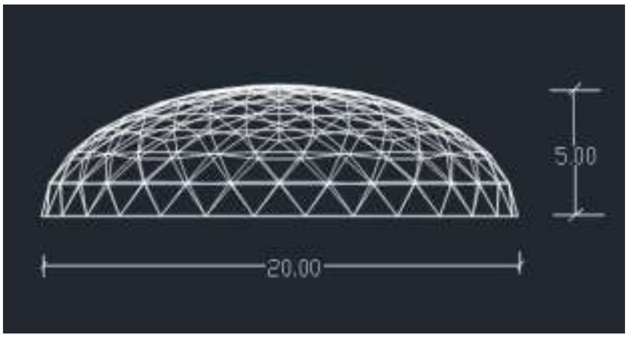

Fig.2.6: 6V,1/4 H to S Geodesic dome

3. Validation of Software by existing literature studies: In this part previous literature study has been studies and result comparison is done for validation purpose. Paper titled 'Comparative study for geodesic dome of class 1 subdivisions' is taken for the existing literature study and validation, published in Journal of Emerging Technologies and Innovative Research (JETIR),May 2016, Volume 3, Issue 5.In this paper comparative study for geodesic dome of class1 subdivision is done. Modelling of geodesic dome is done in modelling software and analysis design is done using STAAD-PRO software. Dome is modelled for different frequencies keeping span constant and compared weights for different frequencies. For Validation purpose we have taken same problem and analysed and designed it in SAP 2000 software.

Problem statement:

Model Details:

Dome diameter-20m Frequency-4V
Subdivision method- class1 Breakdown method- method 1 Polyhedron type- Icosahedron H/S Ratio – ½

1) Dome is modelled in modelling software and for analysis and design imported to SAP 2000 software.
2) After importing model, supports are assigned as reactions restrained in 3 global direction and no moments will be there and material is given.
3) After material assignment group formation like ring1, ring2, top pentagon and bottom is done for the easement of application of section properties
4) After group formation section properties are defined and assigned for each group.Ring 1 - PIPE3239H,Ring 2 - PIPE3239H,Top Pentagon - PIPE2191L,Bottom - PIPE1937H
5) In order to calculate self weight of structure only dead load is applied with factor and analysis is done
This procedure is implemented in SAP2000 software and weight calculation is carried out for different frequencies of domes and results are interpreted.

4. RESULTS AND DISCUSSION

Result & Discussion:

This work has described a study of modelling of geodesic dome and validation of dome with existing literature study.

Table 4.1: Result comparison

Span (m)	Frequency	Weight in tonnage(KN) Existing literature(Staad-pro)	Weight in tonnage(KN) in SAP 2000	Variation in results(%)
20	4V method 1	217.38	218.857	0.541%
	4V method 2	238.328	238.755	0.170%
20	6V method 1	234.706	235.060	0.154%
	6V method 2	240.185	240.972	0.326%

5. CONCLUSIONS

From modeling and validation of geodesic domes for different height to span ratios following conclusions are drawn.

1. For 4V frequency & 20m span model, method1 variation in results by analysis with both the software is differ by 0.541% only.
2. For 4V frequency & 20m span model, method2 variation in results by analysis with both the software is differ by 0.170% only.
3. For 6V frequency & 20m span model, method1 variation in results by analysis with both the software is differ by 0.154% only.
4. For 6V frequency & 20m span model, method2 variation in results by analysis with both the software is differ by 0.326% only.
5. As the results by both the software are almost same, hence SAP2000 is proving as feasible as STAAD-PRO.

ACKNOWLEDGEMENT

I extend my sincerest gratitude to my parents, my Guides, head of program, head of dept., and my well-wishers who helped me in all situations whenever needed during this project completion.

REFERENCES

[1] Davis, T. (2011). Geodesic Dome, *Pacific Domes*, California.

[2] Haitao, Z., Yigang, Z., Feng, F., Eng. C., M., Jinzhi, W.(2018). “Progressive Collapse Analysis of Reticulated Shell Structure under Severe Earthquake Loading Considering the Damage Accumulation Effect.” *Journal of Performance of Constructed Facilities (ASCE)*, 32, 04018004-1 to 04018004-10.

[3] Hosseini, M., Hajnasrollah, S., and Herischian, M. (2012). "A Comparative Study on the Seismic Behavior of Ribbed, Schwedler, and Diamatic Space Domes by Using Dynamic Analyses." *Proceedings of the 15WCEE, Lisbon,*24-28.

[4] Huidong, Z., Qinghua, H., Yuanfeng, W., and Yan, L. (2016). "Explicit modeling of damping of a single- layer latticed dome with an isolation system subjected to earthquake ground motions." *Engineering Structures (Elsevier)*, 106, 154-165.

[5] IS (Indian Standard). (2002). "IS 1893 (Part 1):2002. Criteria for Earthquake Resistant Design of Structures."*Bureau of Indian Standards (BIS),* New Delhi.

[6] IS (Indian Standard). (2007). “IS 800 : 2007, General Construction in Steel - Code of Practice.” *Bureau of Indian Standards (BIS),* New Delhi.

[7] Li, Y.G., Fan, F., Hong, H. P. (2017).“Reliability of latticed dome with and without the effect of using small number of ground motion records in seismic design.” *EngineeringStructures (Elsevier)*, 151, 381- 390.

[8] Wenjiang, K., Zhihua, C., Heung, F., Lam, b., Chenran, Z. (2003). “Analysis and design of the general and outmost-ring stiffened suspen-dome structures.” *Engineering Structures (Elsevier)*, 25, 1685–1695.

[9] Zhi, X. D., Nie, G. B., Fan, F., and Shen, S. Z. (2012). "Vulnerability and Risk Assessment of Single-Layer Reticulated Domes Subjected to Earthquakes.",*Journal of Structural Engineering(ASCE)*, 138, 1505-1514.

[10] Zhiwei, Y., Shuiming, L., Dagang, L, Chen, L., and Jian, L. (2016).“Failure Mechanism of Single-layer Steel Reticular Domes with Reinforced Concrete Substructure Subjected to Severe Earthquakes.” *International Journal of Steel Structures (*Springer*)*, 16, 1083-1094.

[11] Zhu, N., and Jihong, Y. (2014).“Structural Vulnerability of a Single-Layer Dome Based on Its Form.”*Journal of Engineering Mechanics (ASCE),* 140, 112-127.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

BIOGRAPHIES

	Mr. Swapnil M. Waghmode, PG Student, M.Tech, Structural Engineering, at Rajarambapu Institute of Technology, Rajaramnagar. Graduated from Savitribai Phule Pune University, Pune.
	Associate Prof. D.B. Kulkarni is presently working as Associate Professor at Rajarambapu Institute of Technology, Rajaramnagar.