Design And Analysis Of A Monolithic Dome Using STAAD.Pro V8i

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Abstract - In this paper, we have designed and analyzed the "Monolithic Dome Structure" by using software STAAD PRO V8i. In this study by applying point loads over the nodal joints analysis and design of concrete dome structure will be done using STAAD.Pro. The project is initiated with the collection of information from existing journals, papers called literature review. After collecting the relevant information the project is started. Dead load and live load are assigned as the plate load. The safe loads are found from the design results against various loading cases. We Also Analyse the Seismic load. Axial forces, bending moment, nodal joint load are to be designed by using STAAD.Pro.

***Key Words*: Monolithic Dome, STAAD.Pro, Bending Moment, Safe Load, Dead load, Live Load.**

1. INTRODUCTION

Monolithic Dome is thin wall reinforced concrete shell structure. The structure provides safe shelter for the people in the area with hurricanes and earthquakes. This technique is an effective alternative to conventional methods. A Monolithic Dome is a structure cast in a one-piece form. A curve rotated about a central axis to form a surface, creates a Dome. Monolithic Domes are not only unique and eye catching, but studies have shown them to be exponentially energy efficient. They Use 50% less energy then traditionally built structure of similar size .Domes are designated as tornado shelters. Three brothers David, Barry and Randy built and patented the first monolithic dome in 1975, it was 105 feet (32m) in diameter and 35 feet (10m) high and is still used today. The construction of monolithic dome with proper earth sheltering will withstand bomb blast more effectively. Sizes of domes are very small is 2.5m diameter and very large 80m diameter domes. So, monolithic domes are the most energy efficient and safest buildings that can be built and then can be designed for many uses.

2. AIM AND OBJECTIVE

The main objective of this project is to study analysis and design of Monolithic Concrete Dome which is located at MIT college of engineering, Loni Kalbhor, Pune. Result obtained from staadpro and manual calculations should be equal. To analyse the structure for carrying the various load like dead load live load wind load and seismic load. Also check construction and thermal performance. To study the design of structural elements of a dome structure such as shell structure, ring beam, column and footing. Discuss about advantages and disadvantages of monolithic dome. To design the structure according to Indian standards codal provisions. Following IS code will be used for designing RCC structure.

- IS 456-200
- IS 1893-2002/2005
- IS 875-1987

3. LITERATURE REVIEW

3.1 Analysis and design of spherical dome structure by using STAAD.Pro – R. Madhu Kumar, U. Manivasan, V.S. Satheesh and S. Suresh Babu – International Journal of Modern trends in engineering and research ISSN: 2455-0876

Sections and column sections in substructures on the ultimate PGA and yielding PGA are studied, and the optimized values of the parameters are suggested for structural designing.

Findings - Seismic response, Failure mechanism, Single- layer latticed domes, and Low cycle fatigue IDA. Dome, STAAD.pro, Nodal Joint Load, Shear Force and Bending Moment.

3.2 An evaluation of the monolithic dome construction method for biological containment structures Noel Neighbor, David B. South.

A monolithic dome was built as a residential structure using a previously developed airform technique. The building consisted of an outer airtight form, polyurethane foam insulation, and reinforced concrete. Except for the airform kit, locally available materials were used for construction using several alternatives and options applicable to this kind of building. The process and options were evaluated relative to their application for the production of biological containment facilities. It was concluded that the monolithic dome building technique is an effective alternative to conventional methods.

3.3 Ansa T Varghese, Manju George, "Study on Effect of Diameter, Compressive Strength and Number of Ribs on the Large Concrete Monolithic Dome", International Journal of Engineering Development and Research (IJEDR)

This paper present the study of the effect of diameter, numbers of ribs and compressive strength on the large concrete monolithic dome. Domes have been used in development of silos, residential buildings, school and stadium roof of industries, nuclear reactor, pressure vessel, auditoriums because it is capable of providing safe area, minimum material, easy to erect, heat efficient, membrane action and enable to absorb very large loads with a small thickness. According to the analysis shown that the increasing dome diameters cause increasing in ultimate load capacity while decreasing in ultimate load capacity. Increasing of concrete compressive strength increase in ultimate load capacity while decreasing of concrete cause to decrease in ultimate load. Increasing the number of ribs causes increasing in ultimate load capacity while decrease in all ultimate load capacity.

4. PROBLEM STATEMENT

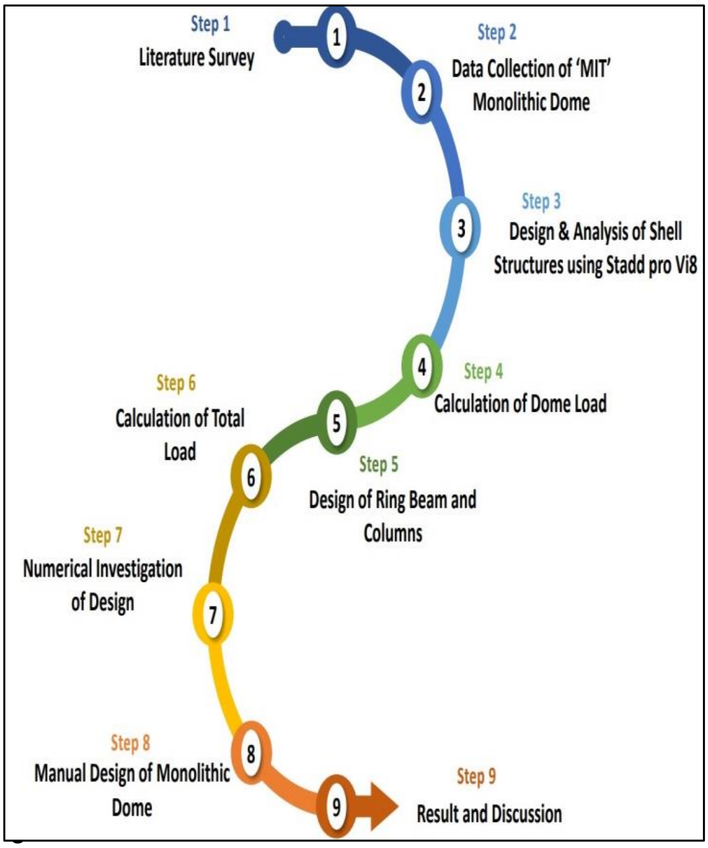
The main need of this study is to improvise new dimensions of domes to analyze the behavior of dome like strength variation and durability. Monolithic domes will helps in studying load analysis. All the study will implement on Staad pro v8i software to calculate the load of structure and implementing the correct sizes of columns, beams.

5. METHODOLOGY

The project study can be described in two stages:

1) The primary data of monolithic dome was taken from a Literature survey, manuals, e-books, research papers and various Indian codes etc.

2) The data regarding dimensions of monolithic dome (MIT college, Loni Kalbhor, Pune) was taken from their professors and students.



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6. COMPARATIVE ANALYSIS OF DOME STRUCTURE

For the analysis of monolithic dome structure, we design one dome structure is Located At MIT College Of Engineering Loni Kalbhor, Pune by analytically and using software (STAAD PRO V8i) and by Design Manually also Statement of the problem is given below: Design a Reinforcement concrete Spherical Dome Structure of 49m base diameter and 52m spherical diameter. The Dome is carry Uniformly Distributed Load of 1kn/m2 of surface area. By Using M30 Grade of concrete and HYSD steel of grade Fe415.

A. Manual Calculation

1. Meridional thrust (T_u) = 255.73KN (C)
2. Meridional thrust (τ_{vt}) = 1.022mpa (C)
3. Hoop force = 141.41KN (T)
4. Hoop stress (τ_{ht}) = 0.565mpa (T)
5. Hoop tension in ring beam = 556.66KN
6. Area of steel reinforcement in each element of dome = 700mm^2
7. 7.Spacing along both lateral and transverse diameter of bar used = 16mm
8. Total area of each ring beam section = 2416mm^2
   spacing of bar in ring beam = 150mm c/c

- Diameter of bar used in ring beam is 8mm and 21 nos.
- Composite area of ring beam = 133000 mm^2
- Size of ring beam adopted = 350mm x 400mm
- Shear reinforcement in ring beam = Area of each section = 101mm^2
- Spacing of stirrups = 200mm
- Diameter of bar = 8mm and 2 legged stirrups

1) Reinforcement summary of Dome Slab

Portion	Main steel	Distribution steel
Meridian	#16mm @290mm c/c	#16mm@290mm c/c
Hoop	#16mm@290mm c/c	#16mm@290mm c/c

2) Reinforcement summary of Ring Beam

Portion	Main steel	Shear reinforcement
Ring beam	21nos #8mm @150mm c/c	8mm-2 legged @200mm c/c

B. By using Staadpro:

Reinforcement detailing of ground beam:

1) Meridional stress (z_{vt}) = 1.27mpa (T)
2) Hoop stress (z_{ht}) = 0.394mpa (T)

C. Comparison between Manual and Staadpro Stresses

Description	Stress as per manual design (N/mm2)	Stresses as per Staadpro v8i design (N/mm2)
Max stress	1.022 (C)	1.27 (C)
Min stress	0.565 (T)	0.394 (T)

D. Comparison between Manual & Staadpro Reinforcement

Ring beam	Reinforcement as per manual design	Reinforcement as per Staadpro design
Main steel	20nos-#8mm @150mm c/c	21nos #8mm @150mm c/c
Shear reinforcement	8mm-2legged @200mm c/c	8mm-2 legged @150mm c/c

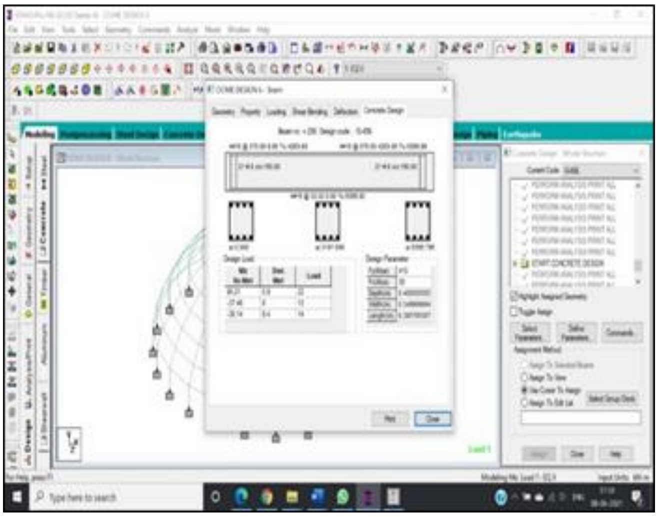

Fig 6.1: Reinforcement Detailing

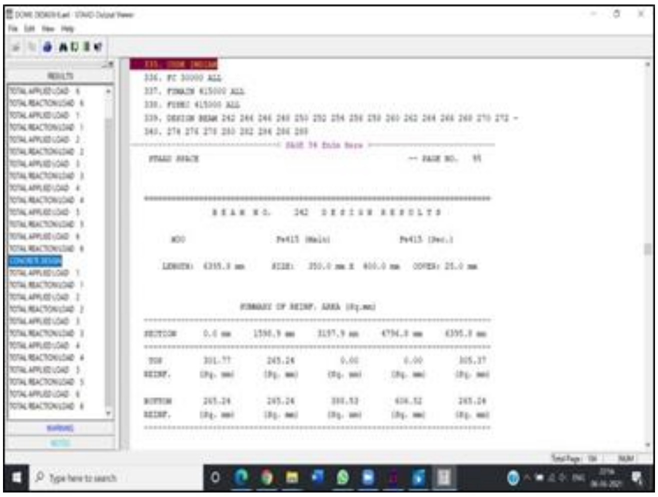

Fig.6.3 Element Design Summary

E. Comparison between areas of reinforcement in dome slab & ring beam by manual by manually & staadpro

	Manual	Staadpro
Dome slab	700mm²	560mm²
Ring beam	2500mm²	2660mm²
Equivalent area of ring beam	133000mm²	140000mm²

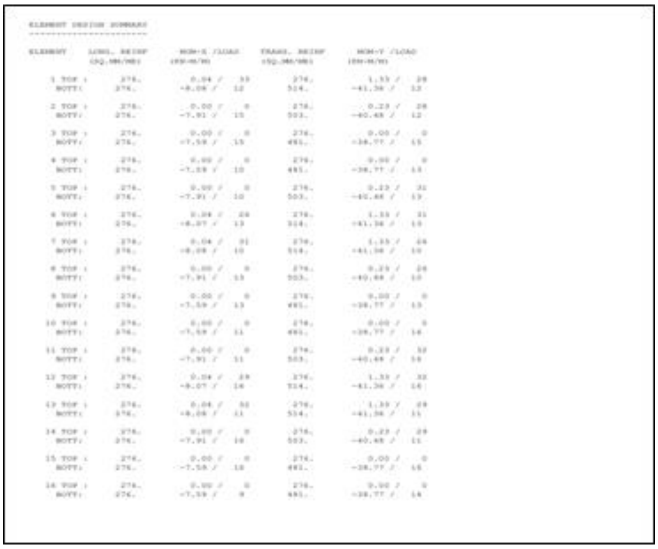

Fig. 6.2 Summary of Reinforcement Area

7. Design Results

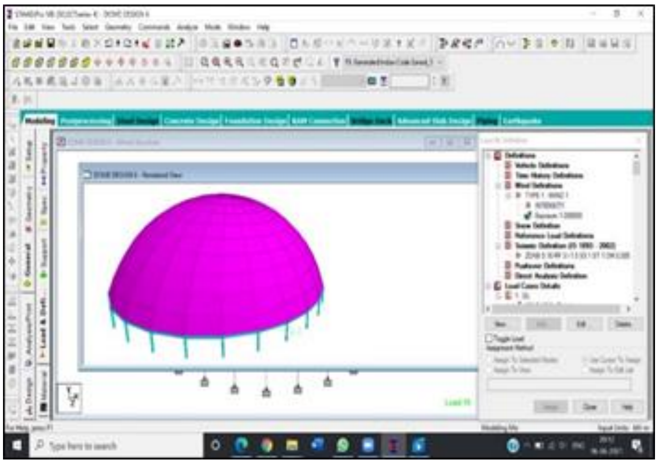

Fig.7.1 3D view of dome structure

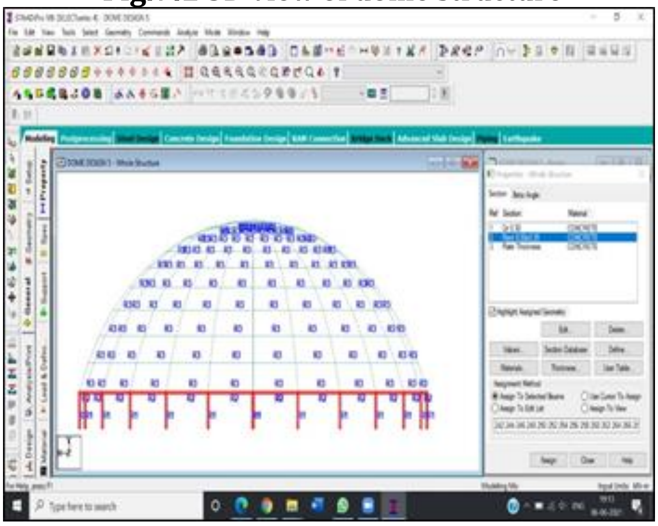

Fig.7.2 Showing Details of Monolithic Dome

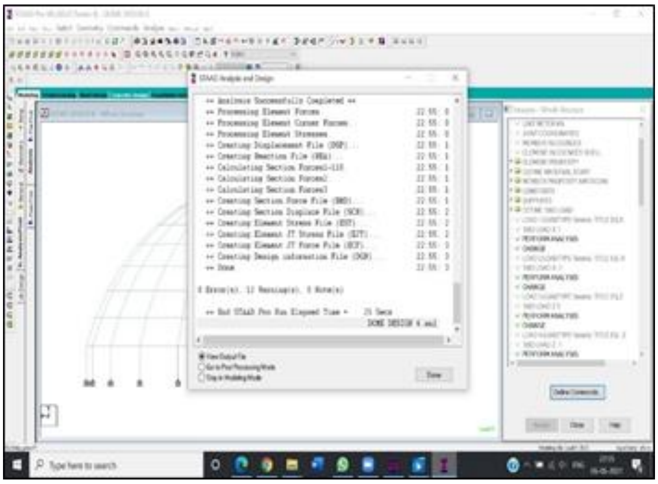

Fig. 7.3 Complete Analysis Result

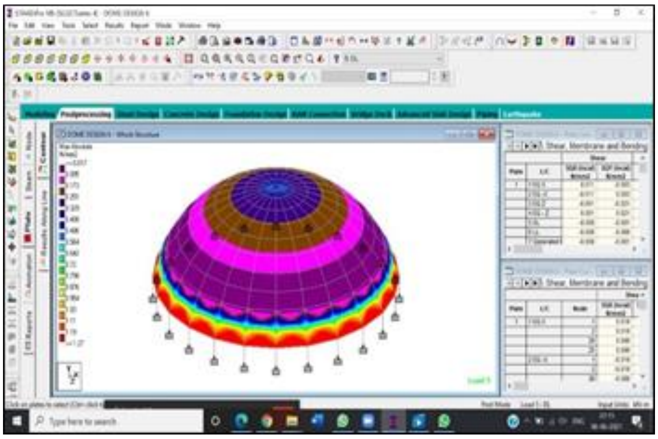

Fig. 7.4 Max Absolute Plate Stresses.

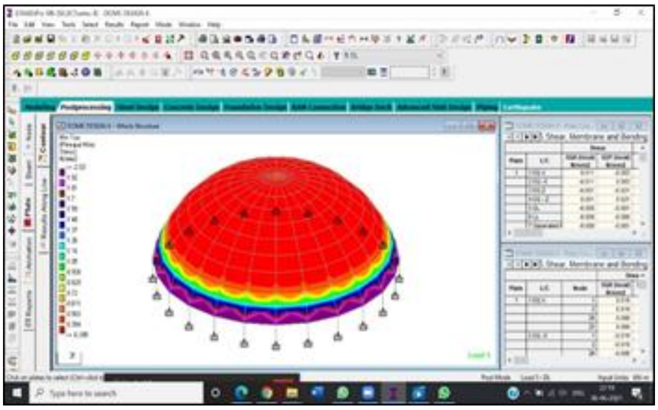

Fig. 7.5 Min Absolute Plate Stresses.

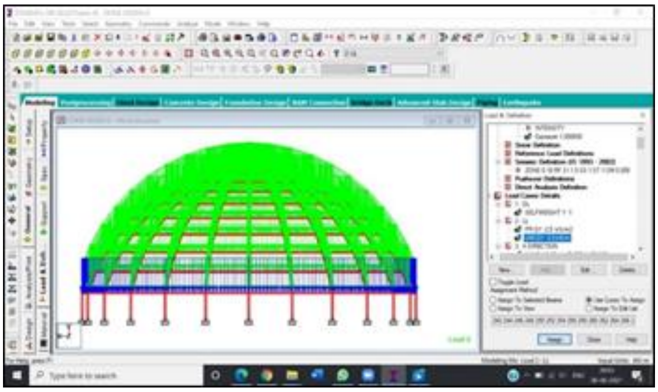

Fig.7.6 Assigning Loading

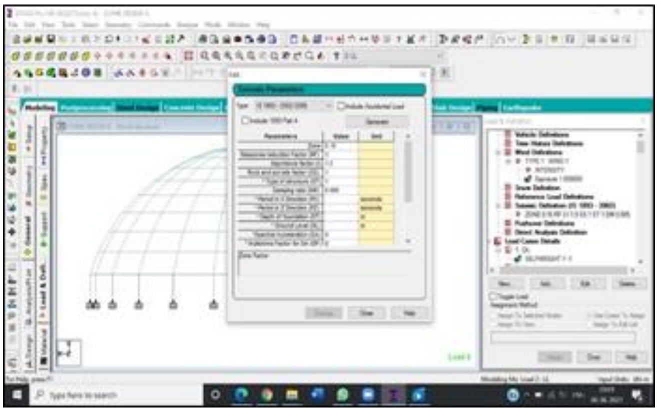

Fig.7.7 Generation of Seismic Zone

8. CONCLISION

In Monolithic Dome method we can use the industrial waste fly ash to replace 15-20% of cement used in construction which also helps to save the environment and cost of construction. We can use composite hallow circular columns replaced by rectangular columns. Structural behavior is studied of RC dome using STAAD.Pro v8i. The assumed dimensions of beam is 350mm x 400mm, column of diameter 500mm & plate thickness is 250mm are safe for carrying various load. For the applied load cases and combination structure comes under safe zone.

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