International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

Design and Analysis of a Monolithic Dome using Staadpro V8i - Review

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Abstract - *Monolithic dome structures were built in the 1970s in Europe and America. These dome structures share common benefits of being cost efficient, earth-friendly, extremely durable, and easily maintained. Monolithic shells are easily constructed and are extremely cost-effective. Monolithic domes respond efficiently to any climate, even to extremely cold or hot temperatures. In terms of utility savings, monolithic domes can cut electricity consumption by up to one-third, thereby saving 60–70% of total energy costs. Moreover, monolithic structures provide the highest survivability rates from destructions. The interior of monolithic domes have perfect, concave shapes to ensure that sound travels through the dome and perfectly collected at different vocal points. These dome structures are utilized for domestic use because the scale allows the focal points to be positioned across daily life activities, thereby affecting the sonic comfort of the internal space. This study examines the various acoustic treatments and parametric configurations of monolithic dome sizes. A geometric relationship of acoustic treatment and dome radius is established to provide architects guidelines on the correct selection of absorption needed to maintain the acoustic comfort of these special spaces.*

Key Words: **Dome, Staad.Pro, Nodal Joint Load, Shear Force & Bending Moments**

1. INTRODUCTION

Monolithic dome structures are enclosed by smooth concave surfaces built in one block. These structures are unsuitable for communication, presentation of speeches, and musical performances. Smooth concave surfaces purely reflect sound energy and do not diffuse this energy properly in space. In most cases, these structures will create focal points and dead spots with different geometrical configurations. Previous work outlined practical guidelines for the proper acoustic design of circular rooms and domes but the general application of common rules to different scales and uses cannot be easily achieved. A recent study outlined remedial actions of sound by focusing on structural deflections of the original concave geometry of domes; however, this approach has limitations because of the structural construction process of monolithic domes. Acoustical behaviour cannot be easily standardized because of variation in the size, shape, and volume of concave domes. Therefore, correct treatments of internal surfaces should be applied to prevent the occurrence of unusual phenomenon in the room and assess remedial strategies against such phenomenon through an accurate acoustic assessment of space handling Monolithic dome structures are constructed for residential spaces. The acoustic phenomena arising from concave shapes will interfere with human activities because the focal points of acoustic energy have the same levels of occupancy. This study examines the acoustic behaviour of residential monolithic dome structures and aims to standardized acoustic treatment strategies related to dome size. Acoustic examination is based on parametric analysis of the acoustic and geometric factors related to subjective evaluation. This study presents the results of acoustic evaluation to improve sound fields through the use of certain parameters.

1.1What is a Monolithic Dome?

Simply defined, the Monolithic Dome is a super-insulated, steel-reinforced concrete structure that can be designed for virtually any use: office or business complex, school, church, synagogue or temple, gymnasium or sports arena, theatre or am phi theatre airplane hangar, factory, bulk storage facility, house or apartment complex, military installation, etc.

1.2Aim

The main objective of this project is to study analysis and design of Monolithic Concrete Dome using Staadpro V8i with substructure of an auditorium. The main objective of the study is to design the structural elements of a dome structure such as shell structure, ring beam, column and footing.

1.3Research objectives

The objectives of this research can be summarized briefly as follows:

1. The main objective of this project is to study analysis and design of Monolithic Concrete Dome using STADD Pro v8i with substructure of an auditorium
2. To study the design of structural elements of a dome structure such as shell structure, ring beam,

column and footing.

3. To analyse the structure for carrying the various load like dead load live load wind load and seismic load.
4. 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

1.4 Need of Study

- It is essential to design urban life spaces in accordance's to the needs of modern time
- This study will be useful where the need for low cost housing in India is large and huge percentage of population is still lingering under poverty.
- The construction of a Monolithic Dome is not restricted by either time or most weather conditions, since majority of the work takes place inside the inflated Airform. Generally, construction can continue around-the snow, eliminating costly work stoppages.
- A Monolithic Dome provides fire protection as well.

1.5 Future Scope

This study is undertaken only for an auditorium in Pune. Same study can be done on other type of structures in different locations.

1.6 Advantages of Monolithic Dome Structure

- Cost of a dome is less.
- Require less maintenance.
- Circulation of air and heat is very good, to climate these structure are very cold.
- Protects from fire.
- Survives from earthquakes, tornadoes, hurricanes.

1.7 Disadvantages of Monolithic Dome Structure

- Wasted space in narrow corners.
- Lack of seams.
- Building permits may be difficult to obtain if local officials are not familiar with the monolithic dome.

1.8 Limitation of Study

In this study we cannot take the particular research paper for comparison of results. The location of every structure is different so the wind speed varies according to locations and this results in different value in load calculation.

1.9 Expected outcome

The dome should be safe against bending moment, axial force etc. The dome should be design in such a way that there should not be any error in software for the dimensions we have choose.

2. Literature Review

2.1 Numerical Study of Concrete Dome Structure using ANSYS 17.0- Bincy Baby, Lakshmy G. Das

Dome structures are space structures which cover large area with minimum surface. It is a doubly curved shell structure. Dome is stronger, stable and durable than any other singly curved shell structures which can be applicable to many civil engineering structures like auditorium, exhibition hall, industrial structures top covering of circular water tank etc. This paper deals with numerical analysis of dome structure made of four different geometries where finite element analysis is carried out using ANSYS 17.0 software.

Fig.1 Dome shapes of Algeciras Market dome

Structural analysis is probably the most common application of the finite element method. We can perform different types of structural analysis. Such as Static Analysis, dynamic analysis etc. Here Static structural analysis and Topology Optimization were carried out. In this study the analysis determines deflection, maximum principle stress and crack pattern of the different models created.

Findings: Doubly- curved shell, Semi-spherical dome, Tori-spherical dome, Elliptical dome, ANSYS.

2.2 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.

The structure remained sound following completion. No major cracks formed in the dome shell. More cracks occurred in the slab than in the shell. The airform remained in about the same condition as when new, not showing any noticeable deterioration from the weather.

2.3 Acoustic of monolithic dome structures – MostafaRefat Ismail, HazemEldalyn (2017), Frontiers of Architectural Research (2018)

The author researched on the Acoustic of monolithic dome structures. Which describes the Analyse monolithic structures including being cost-efficient, earth-friendly, extremely durable, and easily maintained. Regarding climate, the monolithic domes are easily constructed and are cost effective on constructing. The main aim of the paper by the author is to examine the various acoustic treatment sand parametric configurations of monolithic dome sizes. Destructions of these structures provides the highest survivability rates. These dome structures are utilized for domestic use because the scale allows the focal points to be positioned across daily life activities. Monolithic structures cast from one piece to form a homogeneous structure. Acoustical Analyse cannot be easily standardized because of variation in the size, shape, and volume of concave domes. Author studied that Monolithic dome structures are constructed for residential spaces. Further is the figure showing a typical residential unit constructed out of monolithic domes.

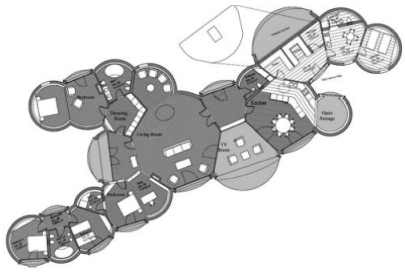


Fig.2A typical residential unit constructed out of monolithic domes

Findings: Behavior of monolithic structure, Configuration of monolithic dome sizes, survivability rates.

2.4 Analysis and design of spherical dome structure by using STAAD.Pro - R.Madhukumar, 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.

2.5 Design and analysis of geodesic tunnel dome for an auditorium - Arya Abhishek, PhadtareShubham, Patil Pratik, TipareHarshal, ReetikaSharan- International Research Journal of Engineering and Technology (IRJET)

The study shows the result of static analysis and design of geodesic tunnel dome. The authors collected the dimension of an auditorium, the length is 40m & width of the inner side is 20m with the height of the crown is 10.63m. They built the model required for the project. They also calculated the forces acting (i.e. Wind load, Dead load, Live Load &, etc.) on each panel of the structures for designing purpose, this load is resisted by two hinged arches which are further transferred to the RCC column to soil strata through the foundation. Wind intensity as per (IS 875-1987 part-3) is 44 m/s.

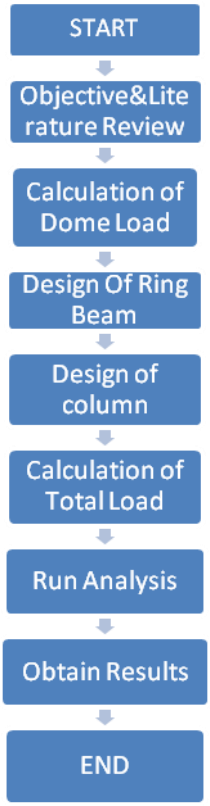
Findings : Geodesic Tunnel Dome, Heavy Wind Load, Arch Truss, Aesthetic View, Energy Efficient, Economical, Steel tubes.

3. Problem Statement

The demand of monolithic domes is increased in variety of residential, commercial and industrial projects. 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 Staadpro v8i software to calculate the load of structure and implementing the correct sizes of columns, beams.

4. Methodology

The project study described two stages. The primary data was taken from a Literature survey targeted by web searches and review of ebooks, manuals, codes and journal papers. After review the problem statement is defined and the selected dome model are taken up for detail study and analysis purposes. This project execution follows the flow chart given below:



4.1 Autocad 2018

This software was used for sketching the plan, section, elevation and reinforcement details for the proposed project.

4.2 STAAD PRO v8i

This software was used for analysing the structure and calculating the moments and loads coming on the structure. There by, designing the components of the structure for the safe loads acting on them. The displacement at the nodes in the structure is found using this software and it is checked whether it is within the safe limits.

4.3 Planning

Planning of the monolithic concrete dome plays a very important role in designing the structure. The plan of the dome, elevation is drawn in Auto cad with the considerations for an auditorium. The architectural plan selected for this analysis is shown as follows

4.4 Modeling Problem Statement

A RC circular dome has internal diameter of 10m and height of 7.25m (including slab of 0.25 m). It is supported on RC staging consisting of columns at bottom levels. The lowest level is at 3m above ground level. Staging conforms to ductile detailing as per IS 13920. Staging columns have isolated rectangular footings at a depth of 2m from ground level. Dome is located on soft soil in seismic zone III. Grade of staging concrete and steel are M25 and Fe415, respectively. Density of concrete is 25 kN/m3.

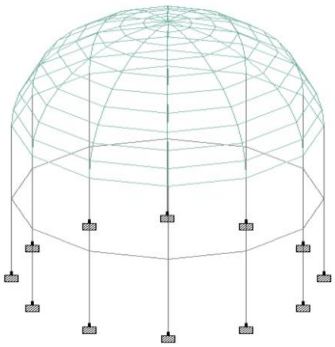


Fig: Side view

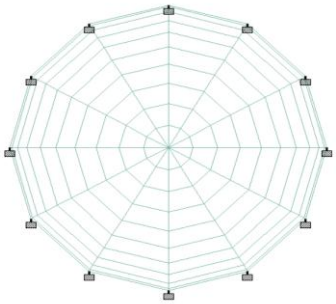


Fig: Top view

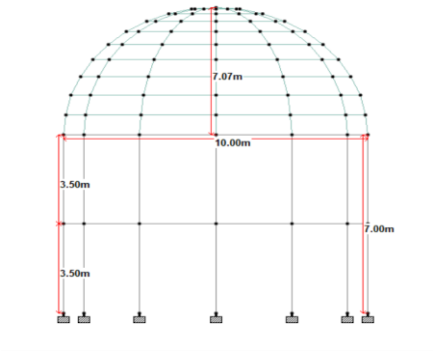


Fig: Front view

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