Review Paper on Comparative Analysis of Circular and Rectangular Building Structures: Load Distribution and Construction Area Utilization

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Abstract - *The choice between circular and rectangular building structures profoundly impacts structural engineering, affecting how buildings look, function, and use resources. This analysis conducts a thorough comparison of these architectural shapes, with a specific focus on how they handle load distribution and utilize construction space. Load distribution is a critical factor, involving a building's ability to support its weight and withstand dynamic forces like earthquakes and wind. Circular buildings, known for their unique shapes, and rectangular structures, admired for their simplicity, respond differently to these challenges. Efficient use of construction space is equally crucial in a world with growing cities and limited land. As urban areas expand, making the most of interior spaces within buildings becomes essential for sustainable growth. This research aims to uncover how load distribution works in circular and rectangular structures, looking at their responses to internal and external forces. It also delves into the spatial advantages and challenges each shape presents, explaining how space allocation affects practicality and overall usefulness. By conducting this Analysis, we intend to provide architects, engineers, and city planners with valuable insights, supporting well-informed decisions in architectural and structural design. This research contributes to the quest for a sustainable and resource-efficient built environment, aligning with the evolving demands of modern urban life.*

Key Words: **Circular Structure, Rectangular Structure, Construction Area Utilization, Load Distribution, Structural Analysis, Staad Pro.**

1.INTRODUCTION

The choice between circular and rectangular building structures is a pivotal decision in structural engineering, with deep implications for functionality, aesthetics, and resource utilization. This study focuses on a comprehensive comparative analysis of these architectural forms, specifically examining load distribution and construction area utilization. Load distribution is a critical consideration, encompassing the capacity of buildings to bear the weight of their structures, as well as withstand dynamic forces such as seismic and wind activity. Circular buildings, with their unconventional shapes, and rectangular structures, known for their angular simplicity, respond differently to these challenges. Efficient construction area utilization is equally vital in a world marked by urbanization and limited space. As cities grow, optimizing interior space within buildings becomes paramount for sustainable development. This research aims to display the difficulty of load distribution mechanisms in circular and rectangular structures, exploring their responses to internal and external forces. Additionally, it seeks to analyze the spatial advantages and challenges essential to each form, explain how space allocation impacts functionality and utility.

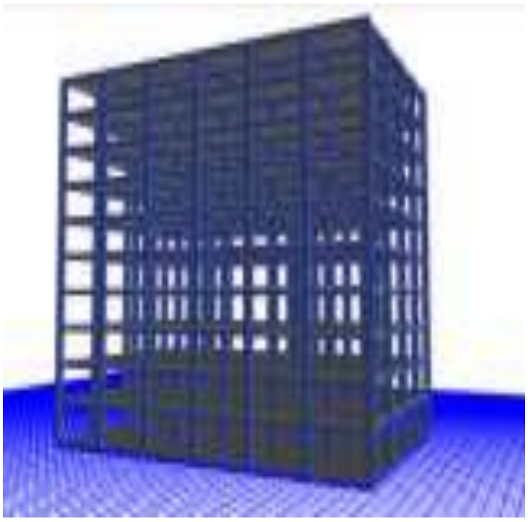

Fig-1: Rectangular Building Structure

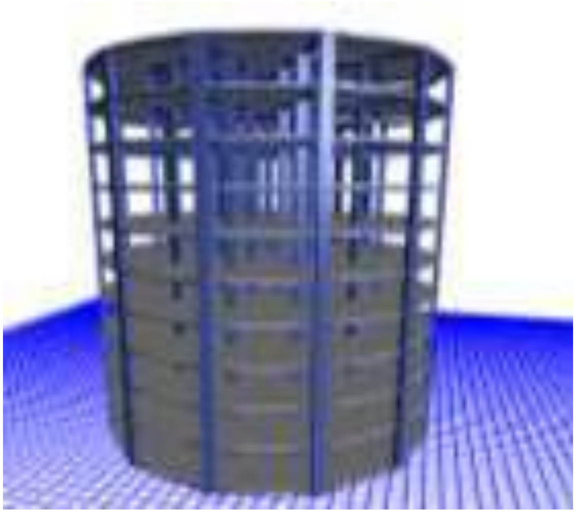

Fig-2: Circular Building Structure

1.1 Problem statement

We don't know enough about how circular and rectangular buildings handle things like weight distribution and the best use of space inside. This lack of understanding makes it hard to decide which type of building is better for different situations. Solving this problem will help us design buildings that work well and use resources wisely.

1.2 Objective of the study

1. To assess and compare the load distribution characteristics of circular and rectangular building structures under various load scenarios, including static and dynamic loads.
2. To analyze and quantify the efficiency of construction area utilization in circular and rectangular buildings, considering factors like interior space layout and functional optimization.
3. To investigate the structural performance of circular and rectangular buildings in terms of their response to seismic forces, wind loads, and other environmental pressures.
4. To identify the advantages and disadvantages of each building shape concerning energy efficiency, sustainability, and resource utilization.
5. To provide design recommendations for architects and engineers when choosing between circular and rectangular building structures, considering load distribution and construction area optimization as key factors.

2. LITERATURE REVIEW

[1] IS 456-2000 "Reinforced Concrete Code of Practice"- Is a cornerstone for research on building structures. In my project, its sections on structural design, concrete mix design, and construction practices were particularly relevant. These guidelines were pivotal in my comparative analysis of circular and rectangular buildings, focusing on load distribution and construction area utilization. This code book is an indispensable resource, ensuring the credibility and accuracy of my research.

[2] IS 1893(Part-1)-2002 "CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES"- has been a pivotal resource for my project. In particular, the section dealing with seismic design criteria and earthquake-resistant construction standards is crucial. This code provides essential guidelines for assessing the seismic performance of both circular and rectangular building structures. It ensures that my research on load distribution and construction area utilization in the context of seismic forces is robust and compliant with industry standards. This code book has significantly enriched the credibility of my project.

[3] This paper discusses the design challenges of circular geometry in residential buildings. It explains that circular houses are more energy-efficient than rectangular houses because there is less dead area for cool air to accumulate and because they have a smaller surface area to volume ratio. However, circular geometry poses challenges for the design of building elements such as walls, roofs, and windows.

[4] The research methodology involving Life Cycle Assessments (LCA) and Material Flow Analysis (MFA) is rigorous and provides a comprehensive foundation for developing environmental design guidelines. These guidelines promote resource efficiency, adaptability, and the use of low-impact biomaterials, all of which are crucial aspects in my research when comparing circular and rectangular building structures.

[5] This research explores the benefits of circular buildings over rectangular buildings in terms of lateral loads, energy efficiency, and acoustic design. The study aims to analyze the advantages of circular buildings and compares them with rectangular buildings. The paper suggests that circular buildings are more durable and better in strength against lateral loads, less embodied energy, energy efficient, and better acoustics. The research emphasizes the importance of sustainable development for smart cities and the need for better infrastructure planning.

[6] This research explores the seismic variation in reinforced concrete buildings by providing shear walls at different locations. The study uses dynamic analysis and Etabs software to analyze three models with shear walls at the outer, mid, and inner walls of the building. The seismic parameters such as lateral storey force, storey displacement, and periods are compared to determine the effectiveness of each model. The study concludes that the placement of shear walls at the mid and inner walls of the building is more effective in reducing the seismic response of the building.

[7] This paper presents a methodology to optimize building core design in tall buildings. It compares the structural floor shape efficiency of circular and square high-rise structures towards lateral loadings and concludes that circular structures are more efficient.

[8] The paper presents a study on the seismic behavior of circular buildings with vertical mass irregularities. The study analyzes the effects of earthquakes on five different models of a circular building with mass irregularity using the Equivalent Static Analysis (ESA) method. The results of the study are presented in terms of storey displacement, storey drift, and base shear. The study concludes that the presence of vertical mass irregularities in circular buildings significantly affects their seismic behavior. The study recommends that engineers should consider the effects of vertical mass irregularities in the design of circular buildings to ensure their safety during earthquakes.

[9] This article studies already constructed contemporary single-family houses on circular plans (and circle derivatives) to create and systematize knowledge about the use of circular plans in housing architecture. It provides examples of circular plans and discusses their advantages and disadvantages.

[10] This paper examines seismic analysis of 15-story buildings in seismic zone V, employing various methods such as equivalent static, response spectrum, time history, and pushover analysis. The study compares regular and irregular reinforced concrete frame structures' responses in terms of storey displacement. Irregular structures with mass, stiffness, torsion, and re-entrant corner irregularities exhibit higher displacements and nonlinear behavior during pushover analysis. The findings underscore the importance of adhering to seismic design principles for structures to withstand moderate to strong earthquakes, necessitating dynamic analysis for both regular and irregular buildings.

[11] In this paper the results show that as the height of the building increases, the lateral forces and deflections also increase. The base shear obtained from STAAD Pro was around 5% higher than the manual calculations. The total concrete and steel requirements were calculated. The deflections were checked against code limits. In conclusion, STAAD Pro proved to be an effective tool for analyzing and designing the high rise building. It helped save time and provided accurate results.

[12] The authors performed structural modeling, analysis and design of a multi-storey residential building using STAAD Pro software. They designed and provided reinforcement details for various structural elements like slabs, beams, columns, footings and staircases. And upon completing the analysis and design, they found that the structure satisfies the design requirements.

[13] The project aimed to design a G+5 building in Kalakode using Revit and STAAD.Pro. Revit and AutoCAD facilitated planning through 3D modeling, while STAAD.Pro handled analysis and design. STAAD.Pro's command-based input and CAD-based generators like AutoCAD enabled precise modeling. The process included defining nodal points, specifying supports, applying loads, conducting analysis, and checking for errors. It also involved concrete design per IS 456: 2000. STAAD.Pro's graphical input and reporting tools enhance efficiency in modern multi-story building projects.

2.2 Methodology

1. **Data Collection:** Gather data on existing circular and rectangular buildings, including architectural plans, structural specifications, and construction details.

2. **Structural Modeling:** Create detailed 3D models of circular and rectangular buildings using architectural design software like Revit. Ensure the models accurately represent real-world examples.

3. **Load Simulation:** Apply various types of loads, such as dead loads, live loads, wind loads, and seismic forces, to the structural models. Simulate these loads using structural analysis software like STAAD.Pro.

4. **Load Distribution Analysis:** Analyze how each building shape distributes and handles the applied loads. Focus on factors like load paths, stress distribution, and deformation patterns.

5. **Construction Area Utilization Assessment:** valuate the interior space utilization of both building

shapes. Consider factors like room layouts, partitioning options, and overall functionality.

6. **Statistical Analysis:** Apply statistical methods to analyze and compare the data collected from load distribution and construction area utilization.

7. **Visualization:** Create visual representations of the results, including charts, diagrams, and 3D models, to make the findings more accessible and understandable.

8. **Conclusion:** Conclusions will be drawn regarding Circular and Rectangular Building Structures based on their Load Distribution and Construction Area Utilization.

9. **Report Compilation:** Compile the research findings, analysis results, and recommendations into a comprehensive report that presents a clear and detailed comparative analysis of circular and rectangular building structures with respect to load distribution and construction area utilization

2.3 Numerical Data

For the analysis of two structural models, one in a circular shape and the other in a rectangular shape, the geometry and material property details are provided in Table No. 1 and Table No. 2

Table -1: Data for Rectangular Building Structure

Area of building	750 m2
Hight of Structure	48.60
Size of Beam (M-25)	300 X 500 MM
Size for Column (M-30)	400 X 700 MM
Thickness of Slab (M-20)	150 MM
No of Storey	15 Nos

Table -2: Data for Circular Building Structure

Area of building	754.76 m2
Hight of Structure	48.60
Size of Beam (M-25)	300 X 500 MM
Size for Column (M-30)	400 X 700 MM
Thickness of Slab (M-20)	150 MM
No of Storey	15 Nos

For Seismic zone – V. Earthquake condition for both models zone factor z=0.36, For rocky, or hard soil sites. soft importance factor is 1, response reduction factor = 5.

3. CONCLUSIONS

The comparative analysis of circular and rectangular building structures reveals intriguing insights. In terms of load distribution, circular structures exhibit unique stress patterns, while rectangular structures display more predictable responses. Construction area utilization highlights the efficiency of circular designs in optimizing interior space. The data underscores the importance of considering both load distribution and spatial efficiency in architectural decision-making, providing valuable guidance for engineers and architects.

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