International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

"COMPARATIVE ANALYSIS OF A FACADE STRUCTURE CONSIDERING DISSIMILAR MATERIALS USING ETABS ANALYSIS TOOL"

[1]Karandeep Singh Khanuja, [2]Mahroof Ahmed, [3]Kishor Patil

Sushila Devi Bansal College of Engineering, Indore (452001), Madhya-Pradesh, India

ABSTRACT :

This thesis presents a comprehensive comparative analysis of façade structures utilizing dissimilar materials—shear wall, brick masonry, and steel—using the ETABS analysis tool. The primary objective is to evaluate the structural performance and efficiency of each material when employed as a façade element in a high-rise building. The study employs detailed modelling and simulation techniques to assess key parameters such as lateral stiffness, load-bearing capacity, displacement, and stress distribution.

The research methodology involves creating three distinct models of the façade structure, each corresponding to one of the selected materials. The performance of these models is analyzed under various loading conditions, including wind and seismic loads, adhering to relevant building codes and standards. The ETABS software facilitates the intricate analysis by providing accurate simulations of the structural behaviour, which are critical for assessing the feasibility and reliability of each material.

Results from the analysis reveal significant differences in the performance metrics of the three materials. The shear wall demonstrates superior lateral stiffness and load-bearing capacity, making it highly effective for seismic resistance. Brick masonry, while providing adequate performance, shows higher displacement values, indicating potential concerns in high-stress scenarios. The steel façade, characterized by its high strength-to-weight ratio, exhibits excellent performance in terms of flexibility and resilience, but requires careful consideration of its connections and detailing.

The comparative study underscores the importance of material selection in façade design, providing valuable insights for structural engineers and architects. The findings advocate for a balanced approach, considering both the advantages and limitations of each material, to optimize the structural integrity and overall performance of façade systems in modern construction.

Keywords: Façade structure, Shear wall, Brick masonry, Steel, ETABS analysis, Structural performance, High-rise building, Seismic resistance, Load-bearing capacity.

1. Introduction :

Structural facades are critically important in the fields of science and construction. Facades, the external envelopes of buildings made from materials such as glass, cladding, and stone, play a significant role in defining a building's appearance. Glass is the most widely used material in facade systems. Although glass has been used in construction for centuries, its role has evolved from merely being a transparent filler to becoming a structural element within supportive frames. These innovations have facilitated the construction of large transparent windows, floors, and roofs, driven by the architectural desire for lightness, transparency, and openness.

Glass, despite its brittleness due to its non-crystalline molecular structure, is used in various applications such as solar energy harvesting, thermal and acoustic insulation, fire protection, and safety. Although its fragility poses design challenges, civil engineers are becoming more proficient at creating safe and effective designs. However, glass does have limitations in forming structural connections. Numerous reliable solutions are available in the market to address these challenges. Additionally, Aluminium Composite Panels (ACP) are increasingly popular in curtain wall systems due to their lightweight and excellent insulation properties. In India, the design of facade systems typically follows ASTM or Euro Codes, as Indian Codes lack detailed concepts for such designs. Therefore, further research on the structural performance of aluminium composite panels is necessary for their application in India.

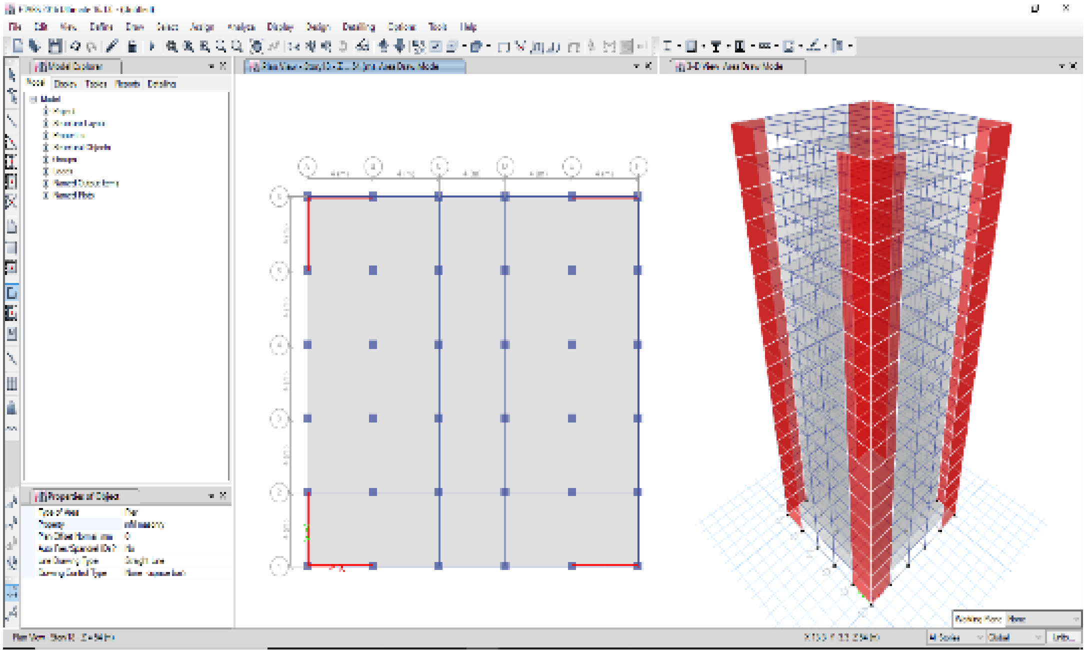
2. Objectives of the study :

● To study the variations in structural analysis and designing of G+18 storey structure as per (IS 875 Part III:2015).

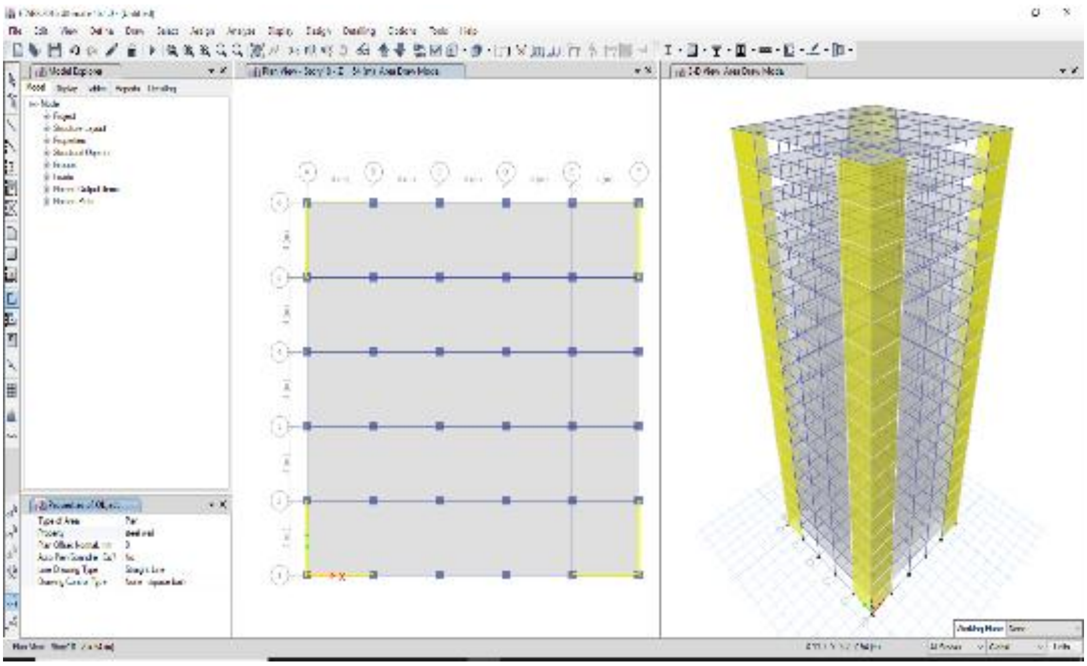
- To study the behaviour of structure with Masonry Facade, Shear Wall Facade and Steel Facade when subjected to wind loads.
- Analysing structure of parameters of Storey Displacement, Storey Drift, Storey Stiffness and Shear Force.

3. Case Study

Case I: G+18 Structure with Masonry Façade.



Case II: G+18 Structure with Steel Plate Façade



Case III: G+18 Structure with Shear Wall Façade

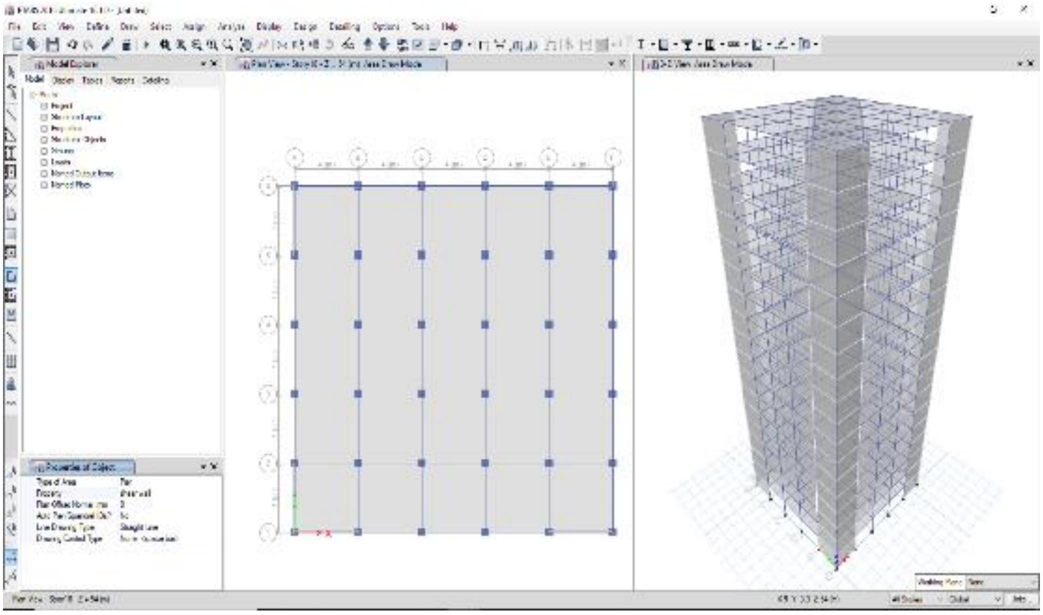


Table 4.1: Geometrical Properties

Specification	**Data**
Storey Height	3.0m
Storey Type	G+18
Bottom Storey Height	3.0 m
Number of Storey	18
Bays along X direction	5
Bays along Y direction	5
Bays length along x Direction	4m
Bays length along Y Direction	4m
Column	500x500mm
Beam	500x300mm
Slab Thickness	200mm

Thickness Infill Masonry	150 mm
Thickness Steel Wall	100 mm
Thickness Shear Wall	150 mm

Table 4.2: Material Properties

Concrete	M30
Rebar	HYSD415
Steel Wall	Fe345
Shear Wal Type	Thin Shell
Slab Type	Thin Shell

4. Conclusion :

Maximum Storey Displacement Storey displacement refers to the lateral movement of a floor relative to the building's base. To mitigate excessive lateral displacement, a robust lateral force-resisting system is crucial. In the case of wind loads, the acceptable limit for lateral displacement may typically be set at H/500 (although H/400 is also an option). Storey displacement tends to escalate with the structure's height. In our study, the most significant storey displacement occurred on the 18th floor with a masonry facade wall, showing a 6 percent variance compared to other scenarios.

Maximum Storey Drift The storey drift ratio represents the ratio of storey drift to storey height, where storey drift signifies the lateral displacement of a floor concerning the floor below. In contrast to stable facade systems like steel and shear walls, the masonry wall system exhibited the highest storey drift on the 11th storey, revealing a noticeable peak gap.

Storey Shear The graphical representation illustrating the lateral (horizontal) load, such as wind or seismic force, exerted per storey is referred to as storey shear. Typically, the shear force increases as one moves downwards in the building. Conversely, the plot depicting the resulting displacements per level is termed storey drift. Among the different facade systems, the masonry facade exhibited the lowest storey shear. Notably, as the storey height increased, variations were observed, with the highest storey shear recorded in the steel plate facade at 18523.98 kN and in the shear wall facade at 19127.872 kN.

Storey Stiffness The unit lateral force generating translational lateral deformation within a storey is calculated, where the bottom of the storey is constrained from lateral movement while remaining free to rotate. The maximum storey stiffness was determined to be 4198392 kN for a structure featuring a shear wall facade and 3890499 kN for a structure with a steel plate facade.

Base Shear Base shear, the maximum anticipated lateral stress at the structure's base resulting from seismic activity, is calculated using seismic zone classification, soil type, and relevant formulas outlined in building codes. In comparison to steel plate and shear wall facade systems, the maximum base shear observed for a high-rise structure featuring a masonry facade was 3080 kN.

REFERENCES :

1. C. Aiello, N. Caterino, A. Bonati and A. Occhiuzzi, [The role of details for seismic performance of a full scale glass façade], 4th International Workshop on the Seismic Performance of Non-Structural Elements (SPONSE), May 22-23, 2019.
2. Christopher McGuill and Jennifer Keenahan, [A Parametric Study of Wind Pressure Distribution on Façades Using Computational Fluid Dynamics], Appl. Sci. 2020, 10, 8627.
3. Omid Oliyan Torghabehi and Peter von Buelow, [Performance oriented generative design of structural double skin facades inspired by cell morphologies], Proceedings of the IASS-SLTE 2014 Symposium.

4. Sayali D. Vaidya, Amit Dubli and A.V.Patil, [Study of High Rise Buildings for Varying Wind Pressure & Design of Façade of High Rise Building], International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 06 | June 2020.
5. Agnieszka Leśniak and Monika Górka, [Structural Analysis of Factors Influencing the Costs of Facade System Implementation], Appl. Sci. 2020, 10, 6021.
6. Muammer Yaman, [Different Façade Types and Building Integration in Energy Efficient Building Design Strategies], International Journal of Built Environment and Sustainability, IJBES 8(2)/2021, 49-61.
7. Ecenur Kızılörenli and Dr. Feray Maden, [A Comparative Study on Responsive Façade Systems], 4 th International Conference of Contemporary Affairs in Architecture and Urbanism (ICCAUA-2021) 20-21 May 2021.
8. Ke Wang, Wenyuan Zhang, Yong Chen and Yukun Ding, [Seismic Analysis and Design of Composite Shear Wall with Stiffened Steel Plate and Infilled Concrete], Materials 2022.
9. Anish Lakhera, Ajay Kumar Jain and Deb Dutta Ghosh, [Finite Element and Equivalent Frame Analysis of Masonry Façade; Having an Arched Opening], International Journal on Emerging Technologies 12(2): 92- 97(2021).
10. K Venkatesh and T. Venkatdas, [Study on Seismic Effect of High rise Building shear wall/ wall without shear wall], International Journal of Civil Engineering and Technology (IJCIET), Volume 8, Issue 1, January 2017.