Analysis of a Facade Structure Considering Lateral Load Using ETABS

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Abstract — Facade system is the external part of any structure. Nowadays designers are progressive towards using different materials as facade for the purpose of Esthetic appearance. In tall structures with diverse material facades, a detailed analysis for wind load is conducted and the behaviour will be estimated and compared with different facade system. Different wall systems are explored for the state-of-the-art in terms of examining the many types of materials used in façades, their functional and strength requirements, as well as their applications and design for wind load in tall buildings in this research. The main goal of this study is to identify material composites utilized in façades, as well as to design and analyses a high-rise building's façade system for wind load. This study compares several facade systems for a G+18 high-rise structure using three different facade systems: masonry, shear wall, and glass wall. The structure's storey displacement, shear force, bending moment, axial force, and base shear are all examined. ETABS, an analytical application, is used for modelling and analysis.

Keywords: Structural Façade, Wind Analysis, Façade, Energy, Esthetic Appearance

I. INTRODUCTION

The importance of structural facades in science and the construction industry cannot be overstated. While the Façade is an outside envelope of glass, cladding, stone, and other materials that is not cast long with bricks and mortar but nonetheless creates the building's face. Glass is the most commonly utilised material in facade systems. Glass is a millennia-old material in construction technique that has been used for ages. It is currently employed as a structural component rather than a see-through filler inside a supporting frame assembly. The enhanced quality of glass allowed for a shift in attitudes regarding its use, leading to the discovery of float glass and the thermal fortification (tempering) procedure, as well as the availability of research methodologies. The use of glass in the production of large transparent windows, floors, and roofs has been motivated by the desire for architectural lightness, transparency, and accessibility. Glass is a brittle building material that is unstable under stress due to its non-crystalline molecular structure, which allows it to be employed in a number of applications. Glass serves as a source of solar energy, thermal insulation, acoustic insulation, fire protection, safety, and defence. Despite the fact that it has the drawback of being fragile in terms of material composition, civil engineers are getting more adept at designing within the required safety limitations. Glass as a facade material has a constraint in terms of its capacity to make structural connections. There are numerous tried-and-true solutions on the market today. In addition, ACP, or aluminium composite cladding, is increasingly widely used as part of curtain wall systems. ACP (Aluminum Composite Panel) is designed to be light in weight while yet providing excellent insulation. In India, the ASTM / Euro Codes are typically used to design facade systems, as Indian Codes do not provide such deep concept information. As a result, further structural performance study is needed for the design of aluminium composite panels for use in India. The result of the anticipated learning of aluminium panels through various end situations will be analysed for various loadings and aspect ratios, which will aid the designers.

The structural elements that give lateral and vertical resistance to wind and other forces, as well as the building envelope elements that provide weather resistance as well as thermal, acoustic, and fire resistance, make up facade systems. The sort of façade system utilised is determined by the building's form and scale, as well as local planning rules that may alter the building's appearance in relation to its surroundings. For example, while brickwork is frequently requested for the external façade, light steel wall sections (known as infill walling) have effectively supplanted more traditional blockwork in the construction of the inner leaves.

In a way that no other building system can, the facade blends attractiveness and excellent performance in a way that no other building system can. It is frequently the most essential component of a building's design because it sets the tone for the remainder of the structure. Any largely vertical aspect of a building envelope, such as an external wall, is referred to as a facade. The term 'façade' is sometimes used to refer to the external faces of buildings that have a particular architectural emphasis, such as an imposing design, adornment, the building's main entrance, and so on. Energy-saving facade materials have been developed as a result of technological advancements. These innovative goods capture solar energy and are widely used as a secondary source of electricity generation in many business and residential structures.

The development of sustainable façade materials capable of sheltering buildings from environmental conditions such as heat, wind, and rain is a major driver of demand growth. The type of facade you choose is important in terms of making your building stand out both visually and functionally. Because of the growing need for greater safety measures and ambiance in the corporate and hospitality industries, product demand in commercial buildings is likely to stay high over the next eight years. The various forms of facades for building constructions are listed below.

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Unitised curtain walling systems that are attached to the floors or edge beams of the primary steel structure have been developed for multi-story buildings. Steel and glass are also commonly utilised in façade and roofing systems, with stainless steel brackets serving as local attachments.

A. *Objectives of the study*

- To study the irregularities 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.
- Analyzing structure of parameters of storey displacement, storey drift, storey stiffness and shear force.

II. LITERATURE REVIEW

Ke Wang et al (2022) A numerical study of composite shear walls with stiffened steel plates and infilled concrete (CWSC) was given in a research paper utilising ABAQUS. The mechanical mechanisms of the web plate and concrete were explored, and parametric analysis was conducted using FE models to determine the law of parameters on seismic behaviour. The hysteresis curves, failure phenomenon, ultimate strength, initial stiffness, and ductility are all well-represented in the finite element (FE) model. The key components for resisting lateral force are the web plate and concrete. The web plate is estimated to generate between 55 and 85 percent of the wall's lateral force. The web plate's corner primarily resists vertical force, whereas the rest of the web plate resists shear force.

According to the results, increasing wall thickness, steel ratio, axial compression ratio, and channel length-to-width ratio improves elastic stiffness and ultimate strength capability. With rising shear span ratio, elastic stiffness and ultimate strength capacity are diminished. Steel ratio, shear span ratio, axial compression ratio, and length-to-width ratio of the channel are all factors that influence CWSC ductility. Steel ratio and shear span ratio have a favourable influence on ductility, whereas axial compression ratio and channel length-to-width ratio have a negative affect.

Anish Lakhera et al (2021) Through the use of non-linear and linear analysis methodologies, the seismic response of an unreinforced masonry building with an arched geometry was reported in this research study. The equivalent frame technique (EFM) was utilised to determine the position and kind of failure caused during the seismic study through the constructed hinges, and the finite element method was used to evaluate the masonry structure to pinpoint the major stress concentration at the target displacement. To account for the arching action in the spandrel, the Equivalent Frame model was presented with an arched geometry beam element, and pushover analysis was then done using the user-friendly programme code SAP2000.

The developed hinges have a strong correlation with the observed damage pattern of the brick wall with an arched entrance, according to the findings. When comparing the demand curve obtained from the curved beam element to an experimental curve, a good correlation was discovered. The proposed approach improves the manner of capturing the arcade system's reaction while reducing computational effort. The comparable frame approach was also shown to be useful for pushover analysis of brick façades with arched openings.

III. METHODOLOGY

Step 1: Different research papers from all across the globe were reviewed to identify the spectrum of research. The research paper are summarized to give a brief about the work done till date and scope of further research, which led this research which presents the comparative analysis of a case study considering three different facade system namely masonry infill, steel plate infill and shear wall and the high rise structure was analyzed for wind analysis

Step 2: First step is to define the metric system in ETABS before modeling any structure. Here the display units are defined as Metric SI and the steel section is considered as per Indian standards with steel design code as IS 800:2007 and concrete design code as IS 456:2000.

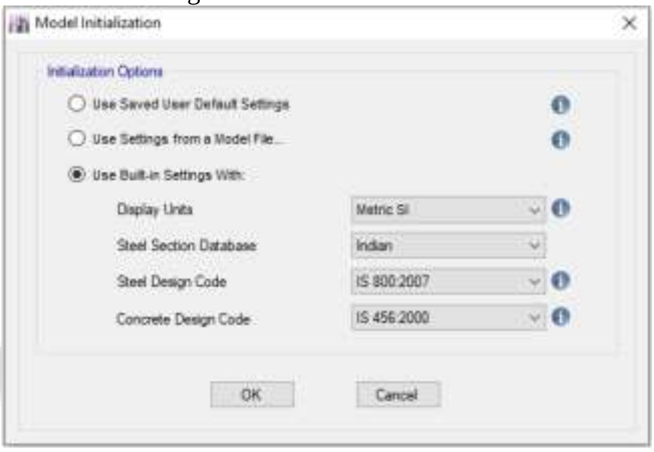


Fig. 1: Model Initialization

Step 3: Grid system is used for designing the structure in X, Y and Z direction from quick templates and the grid can be customized as per the need to maintain gaps in between columns.

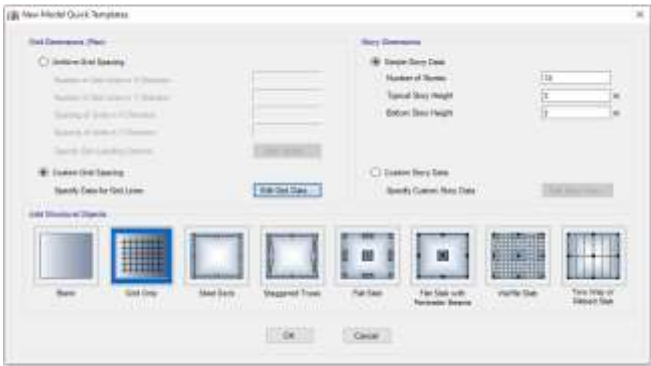


Fig. 2: New Model quick Template

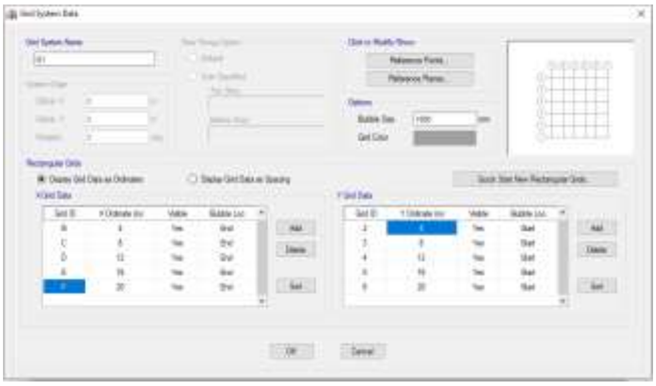


Fig. 3: Grid System Data.

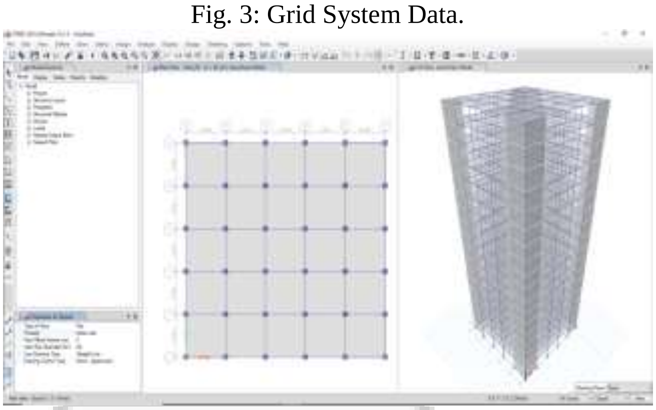


Fig. 4: Plan view of the Structure

Step 4: Defining properties of material for concrete and steel in reinforcement for column, beam and slab and further defining the properties of wall or in thIS research its facade system. Here M30 concrete is considered for the material used in the structure.

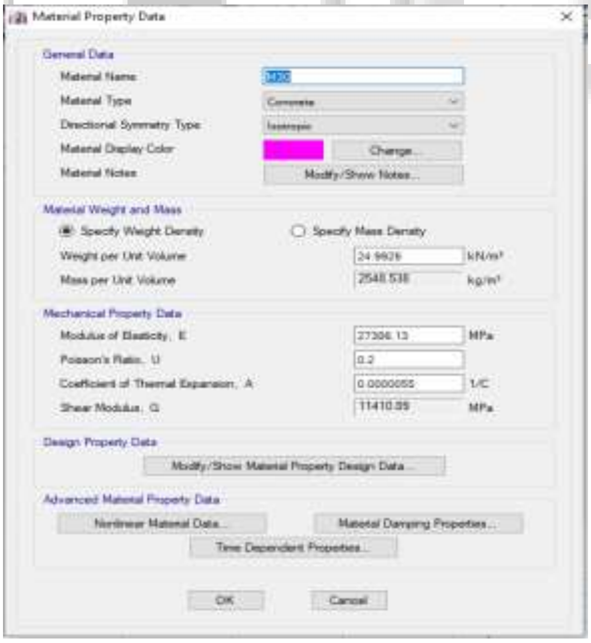


Fig. 5: Defining properties of concrete

Fig. 6: Defining Properties of Rebar

Fig. 7: Defining Properties of Masonry

Fig. 8: Defining Properties of Steel

Step 4: Defining section properties for the structure as size of beam, column, wall and thickness of slab. Here the depth and width of the section is defined for all the elements which together constitute the structure.

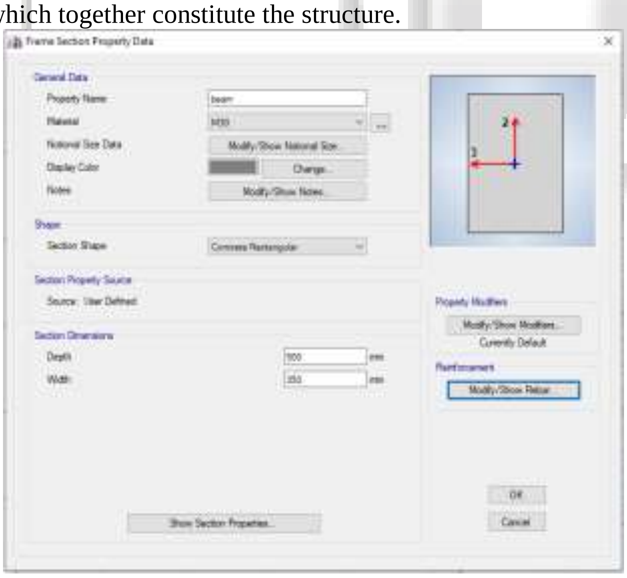


Fig. 9: Frame Section Properties for Beam

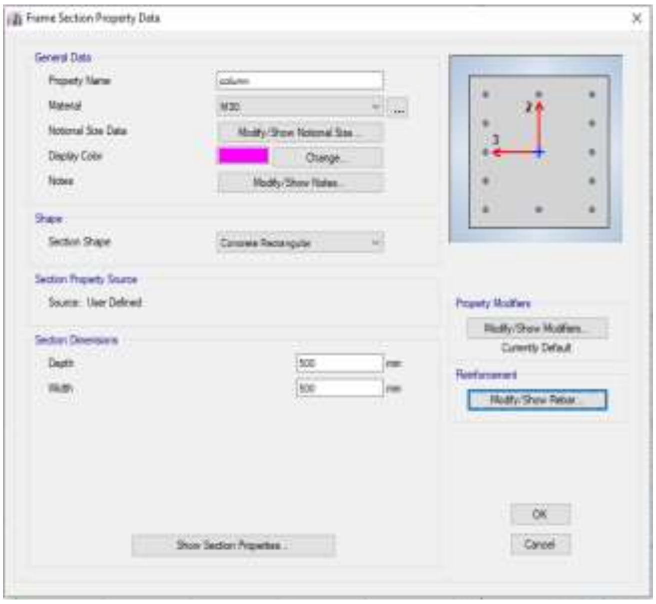


Fig. 10: Defining section properties of Column

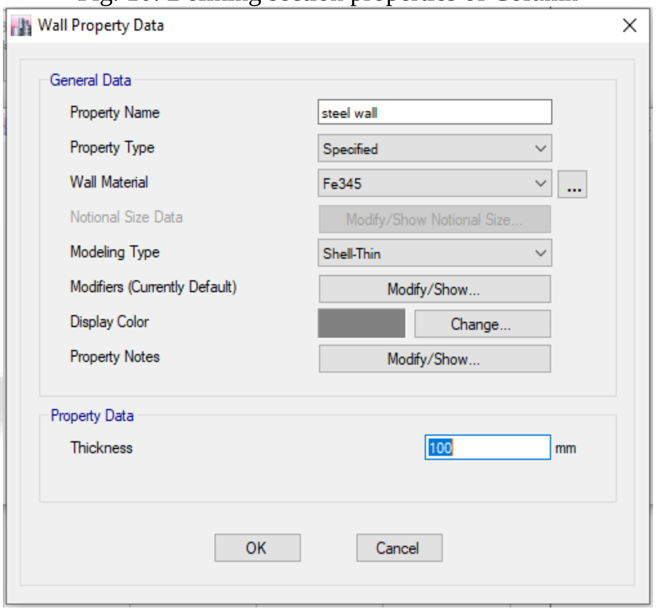


Fig. 11: Defining Property data for steel wall

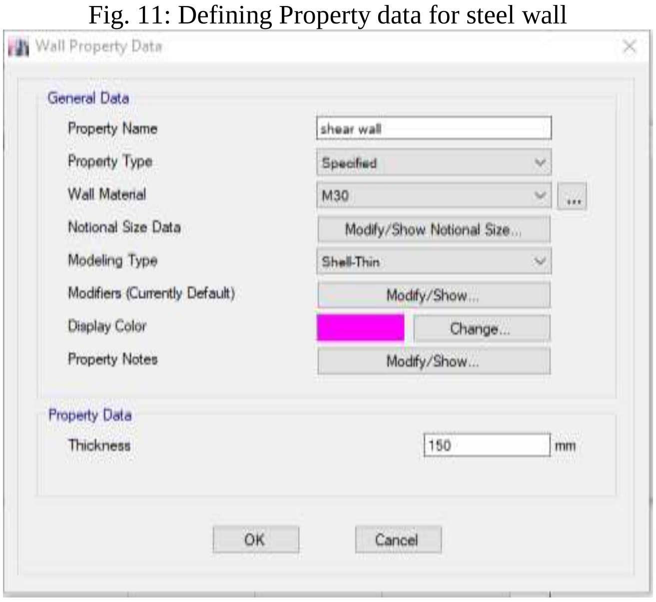


Fig. 12: Defining Property data for Shear wall

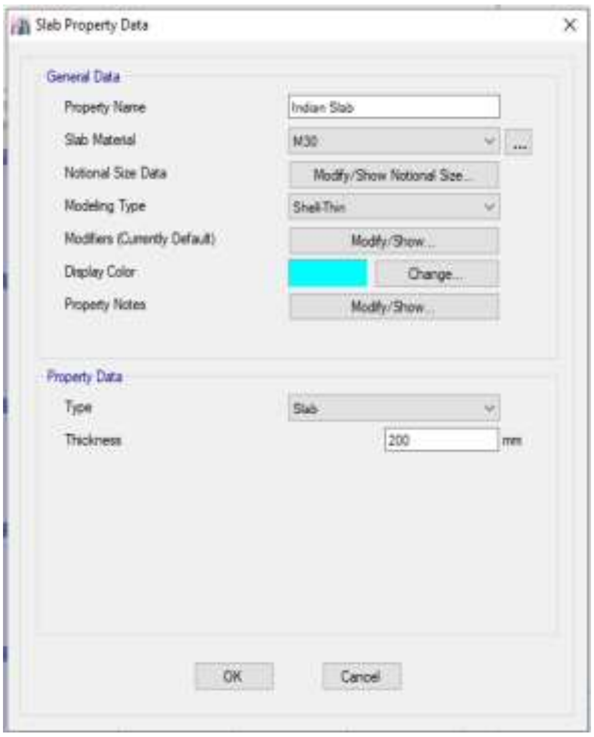


Fig. 13: Defining Properties of Slab

Step 5 Assigning Fixed Support at bottom of the structure for X, Y and Z direction.

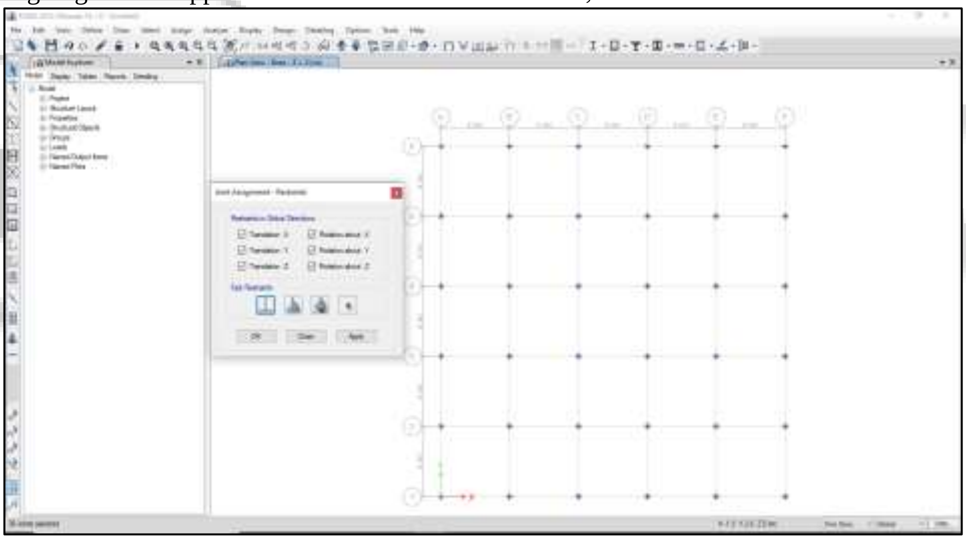


Fig. 14: Assigning Fixed Support

Step 6 Defining load properties to be assigned on all the three models with different facade systems. This research is focused towards analyzing high rise structure G+18 with dead load, live load and wind load as per IS 875:2015.

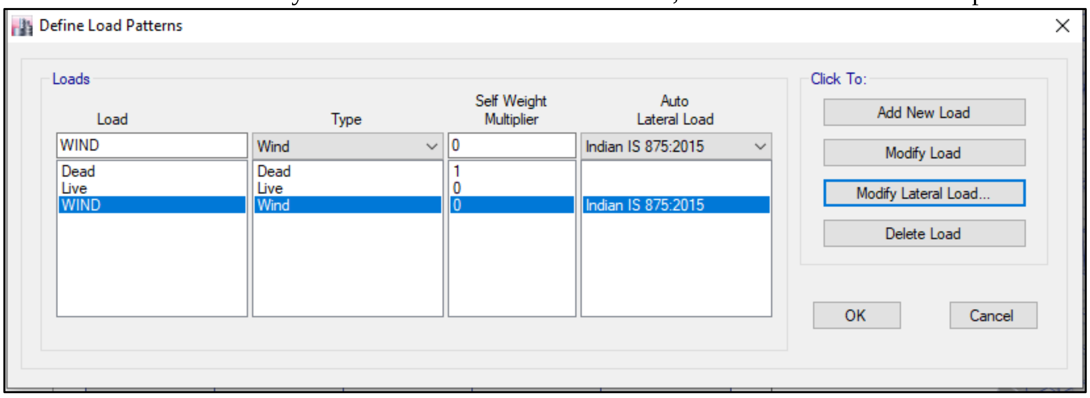


Fig. 15: Defining Load Pattern

Fig. 16: Wind Load Pattern as per IS 875:2015.

Step 7 Analyzing the structure with quick model check where the joints are analyzed

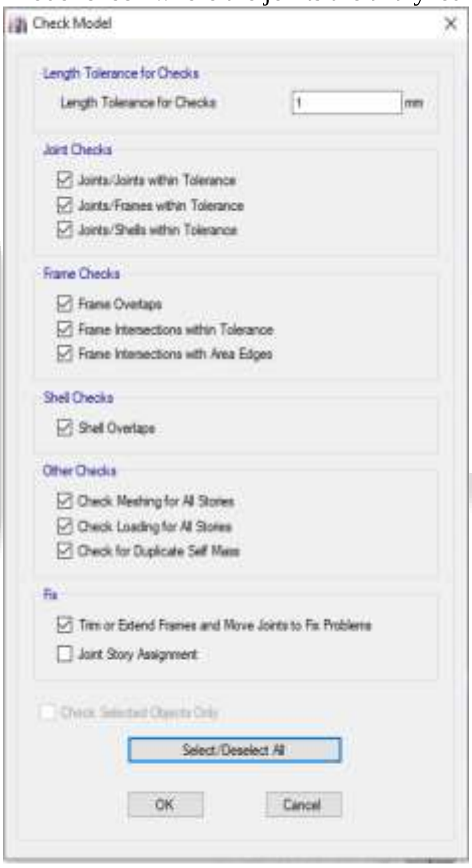


Fig. 17: Quick Model Check

Step 8 Analyzing the structure on parameters of Storey displacement, shear force, axial force, bending moment and wind analysis.

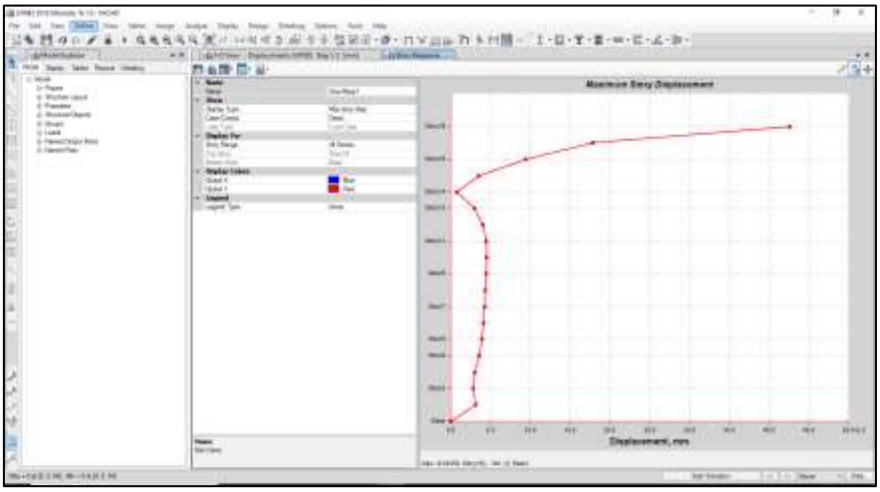


Fig. 18: Maximum Storey Displacement

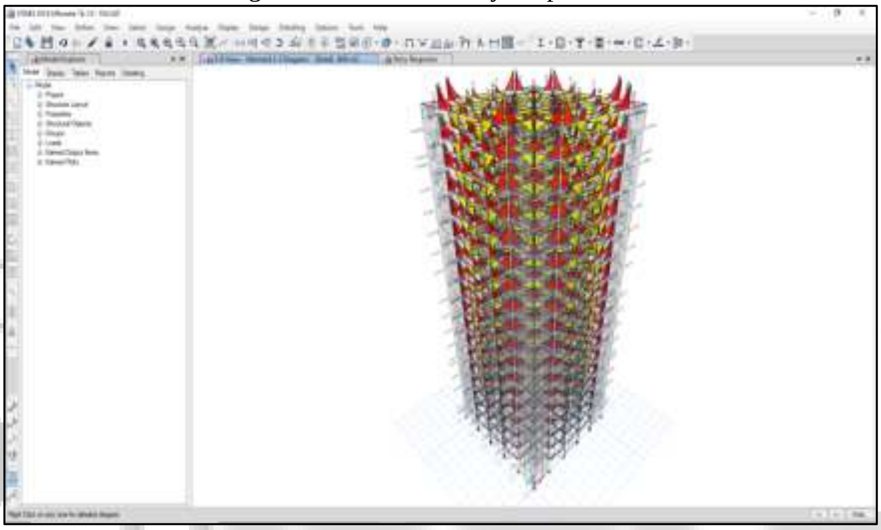


Fig. 19: Storey Response of the structure.

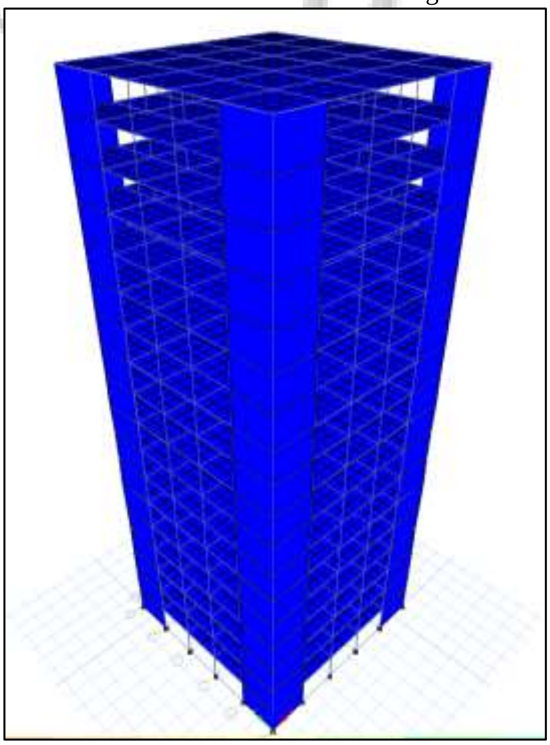
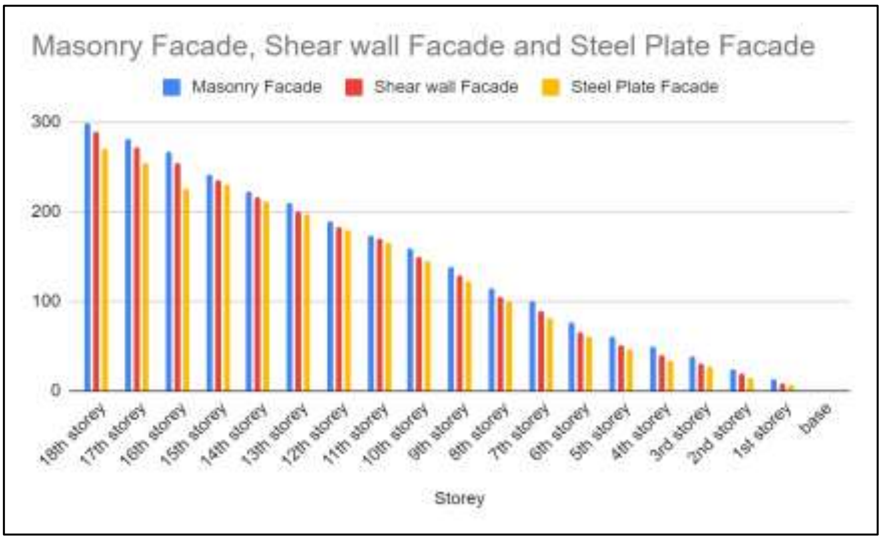


Fig. 20: Analyzing the structure

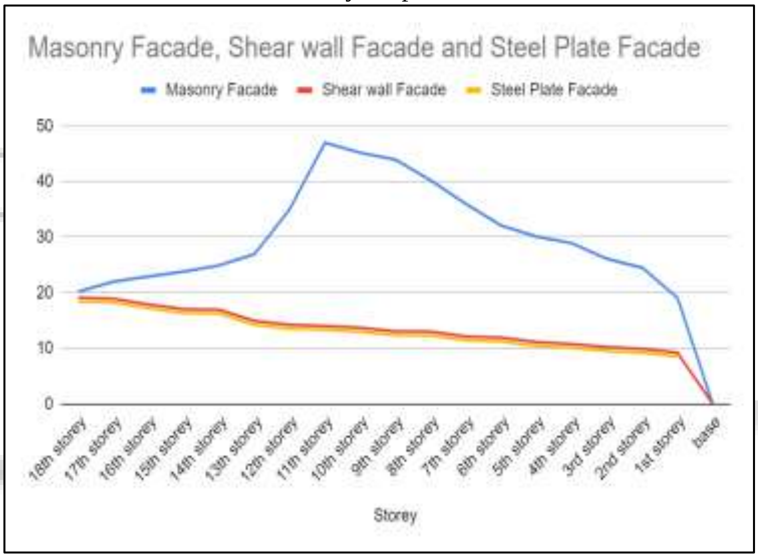
Specification	Data
Storey Height	3.0m
Storey Type	G+18
Bottom Storey Height	3.0 m
Number of Storey	18
Bays along X direction	5
Bays along Y direction	5
Bays length alog x Direction	4m
Bays length along Y Direction	4m
Column	500x500mm
Beam	500x300mm
Slab Thickness	200mm
Thickness Infill Masonry	150 mm
Thickness Steel Wall	100 mm
Thickness Shear Wall	150 mm

Table 1: Geometrical Properties

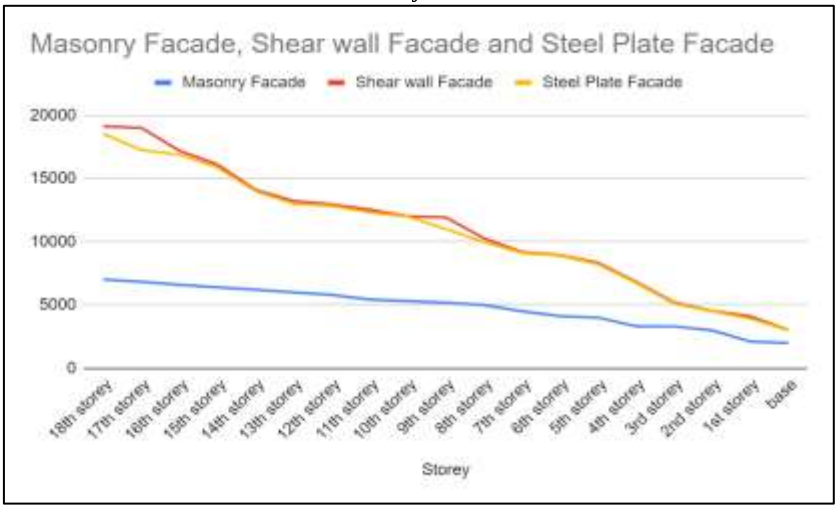
IV. ANALYSIS RESULT:



Maximum Storey Displacement in mm



Storey Drift



Storey Shear in Kn

V. Conclusion:

A. Maximum Story Displacement

The lateral displacement of the storey in relation to the basis is known as storey displacement. The building's excessive lateral displacement can be limited by the lateral force-resisting system. For a wind load situation, the acceptability lateral displacement limit might be H/500 (others may choose H/400). Storey displacement increases with the structure's height, and in this study, the largest storey displacement was found in the 18th storey with masonry facade wall, compared to other examples, with a 6 percent variation in the results.

B. Maximum Storey Drift

The storey drift ratio is the storey drift divided by the storey height. Storey drift is the lateral displacement of a floor relative to the floor below. In comparison to other facade systems such as steel wall and shear wall, which were proven to be stable, storey drift was highest in the 11th storey with a masonry wall system with a peak gap apparent.

C. Storey Shear

The graph depicting how much lateral (horizontal) load, such as wind or seismic, is acting per storey is known as storey shear. The shear grows higher the lower you go. The plot of the resulting drifts per level, on the other hand, is known as storey drift. The masonry facade system had the least storey shear, and the variance was noticed as the storey height increased, with the highest storey shear in steel plate being 18523.98 kN and shear wall facade being 19127.872 kN.

D. Storey Stiffness

The lateral force producing unit translational lateral deformation in that storey is estimated, with the bottom of the storey prevented from moving laterally, i.e., only translational motion of the bottom of the storey is restricted while it is free to rotate. The maximum storey stiffness was 4198392 kN for a structure with a shear wall facade and 3890499 kN for a structure with a steel plate façade.

E. Base Shear

The maximum expected lateral stress on the base of the structure owing to seismic activity is called base shear. It's estimated using the seismic zone, soil material, and lateral force formulae from the building code. In compared to steel plate and shear wall facade systems, the maximum base shear for a high-rise structure with masonry face was 3080 kN.

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