Analysis of a Façade Structure Considering Lateral Load using ETABS

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Abstract
Any building's exterior component is its facade system. Modern designers have advanced toward employing various materials as facades for purely aesthetic reasons. A thorough investigation of the wind load in high buildings with different material facades is done, and the behaviour is predicted and evaluated with various façade systems. In this investigation, various wall systems are explored for the state-of-the-art with regards to looking at the many types of materials used in façades, their operational and strength requirements, as well as their applications and design for wind load in large towers. This paper's research goals are to determine the composite materials used in façade construction and to design and evaluate an elevated building's façade system for wind load. Three distinct façade systems— shear wall, and masonry glass wall—are examined in this research for a G+18 high-rise building. Storey displacement, shear force, bending moment, axial force, and base shear of the structure are all investigated. Modeling and analysis are done using ETABS, an analytical application.
Key words: Architectural Façade, Wind Modeling, Façade, Efficiency, and Aesthetics.

1 INTRODUCTION

It is impossible to exaggerate the relevance of structural facades to research and the construction sector. Although the Façade is an exterior shell made of glass, stone, cladding, and other materials, it nonetheless gives a building its face even when it is not entirely made of bricks and mortar. The material used most frequently in facade systems is glass.

1.2 Façade System

Facade systems are composed of the structural components that provide lateral and vertical resistance to wind as well as other forces, as well as the components of the building envelope that provide weather resistance in addition to thermal, acoustic, and fire resistance..

1.2.1 Masonry Veneer

In Indiana, brick outperforms metal in terms of efficiency and durability. Regardless of the fact that brick is frequently thought of as a predictable option for a façade, we compare it to other materials on almost every project in terms of cost, performance, and aesthetics.

1.2.2 Metal Wall Panel

There are numerous aesthetically pleasing and functional possibilities available with metal panels. Nevertheless, this material frequently charges higher than other resources, which can lead a project's completion to be postponed.

1.2.3 EIFS

A veneer system called EIFS (exterior insulation and finish system) protects despite also providing a wide range of aesthetic choices. Usually, this item is known to as stucco. A drawback of EIFS is its endurance. The stiff insulation's thin EIFS shell is easily damaged. EIFS is the most affordable system per square foot due to the insulating performance it offers. In addition to the surface becoming stained and filthy, colours may fade over time. We typically employ EIFS to cover taller portions of a building because of these characteristics.

2 LITERATURE REVIEW

HardikMandwe et al (2021) This research sought to determine the impact of building height on seismic performance by studying the response of multi-story buildings with shear walls. Powerful software called STADD Pro can calculate nodal deflections against lateral forces and figure out the amount of reinforcement required for any concrete section depending on its load.

MuammerYaman (2021) The purpose of this research was to identify and highlight how building façade types' design and application determinants affect their energy effectiveness in various climate classes. 12 different building façade types in varied climates were studied and analysed using a purposive or judgmental sampling procedure.

AgnieszkaLeśniak and Monika Górka (2020 Based on formative and summative assessments, the research paper gave a stability analysis of the connections and relationships between the variables. Based on quantitative and qualitative studies, the study report gave a structural analysis of the interactions and correlations between the factors.

C. Aiello et al (2019) The major objectives of the study were to increase knowledge of glass curtain wall seismic performance and to enable glazing designers and specifiers, architects, engineers, glazing builders, and construction companies avoid such errors in the future.

3 METHODOLOGY

In this study, the focus was on analysing high-rise structures while taking into consideration three different facade systems: masonry, steel, and shear wall frames. For the study, various facade systems on a (G+18) building were built and evaluated. In order to perform a comparative analysis and find precise answers, various building models with shear walls, steel plates, and masonry infill as facades were prepared at various sites. This will allow for the analysis of an efficient facade system. Base shear, Story Drift, and Displacement at nodes were the criteria used in the comparison analysis.

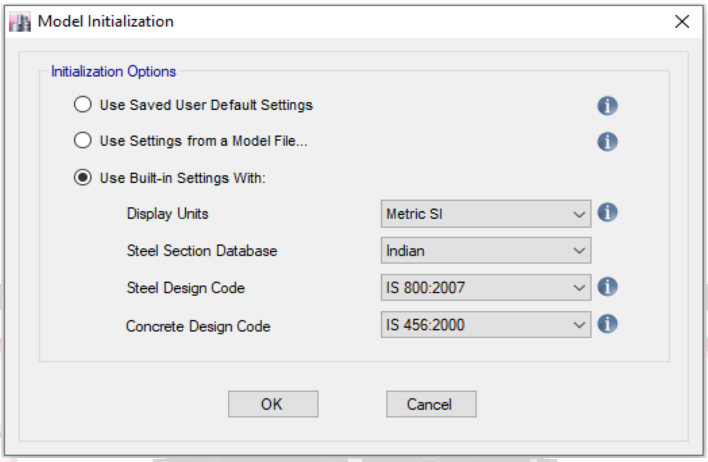

Fig 1 Model Initialization

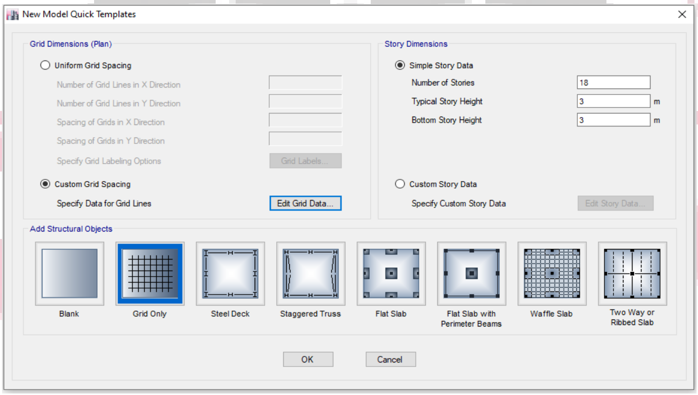

Fig 2 New Model quick Template

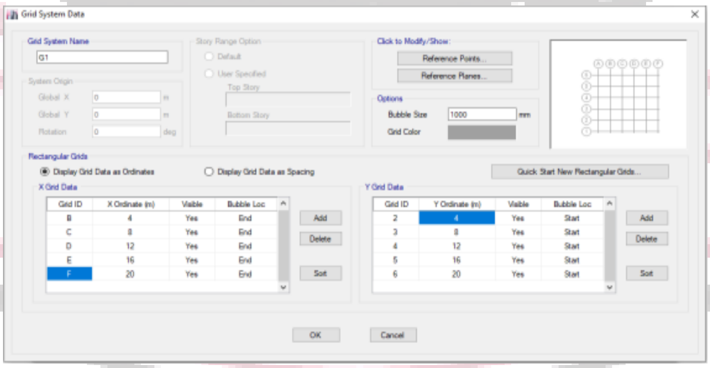

Fig 3 Grid System Data.

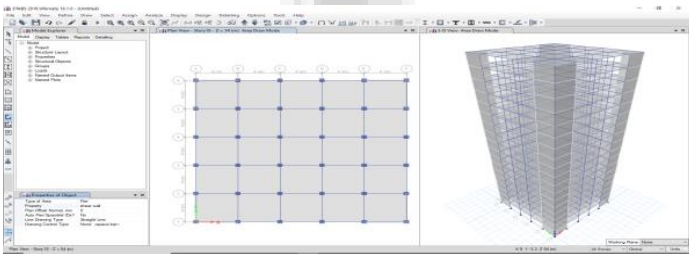

Fig 4 Plan view of the Structure

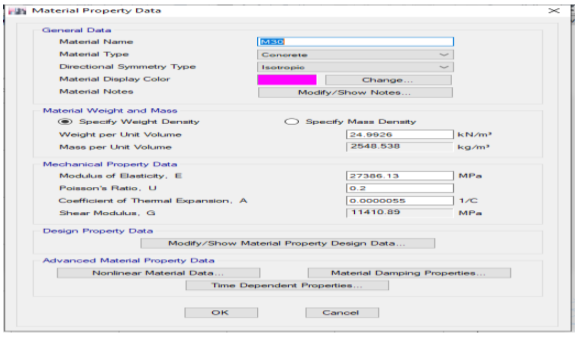

Fig.5 Defining properties of concrete

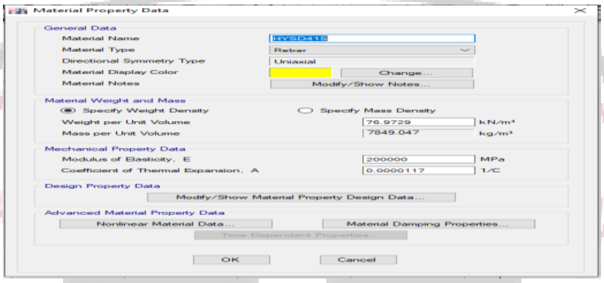

Fig 6 Defining Properties of Rebar

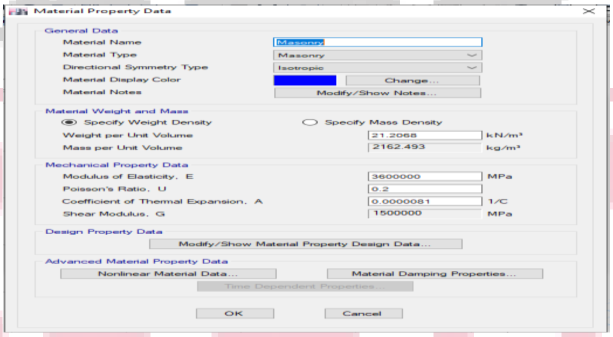

Fig 7 Defining Properties of Masonry

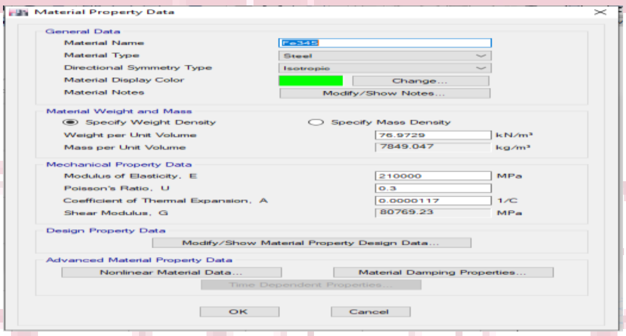

Fig 8 Defining Properties of Steel

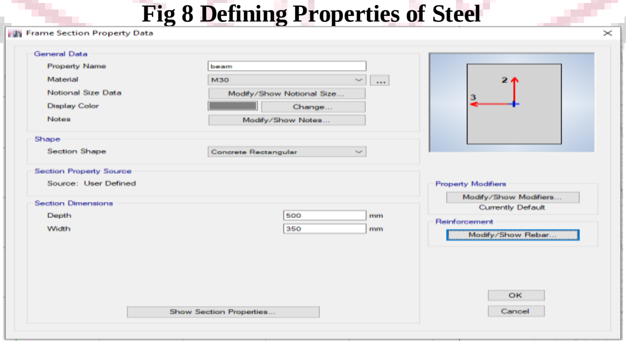

Fig 9 Frame Section Properties for Beam

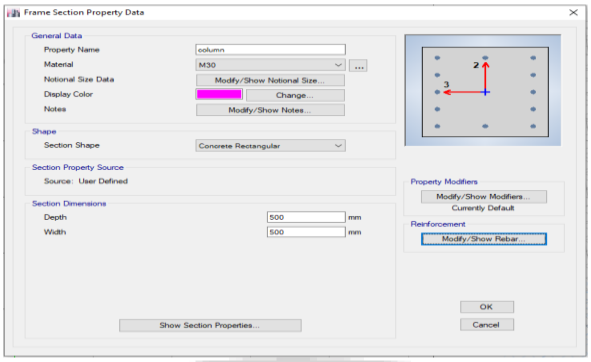

Fig 10 Defining section properties of Column

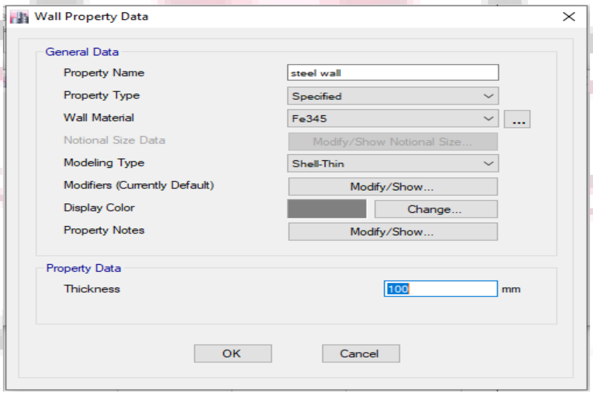

Fig 11 Defining Property data for steel wall

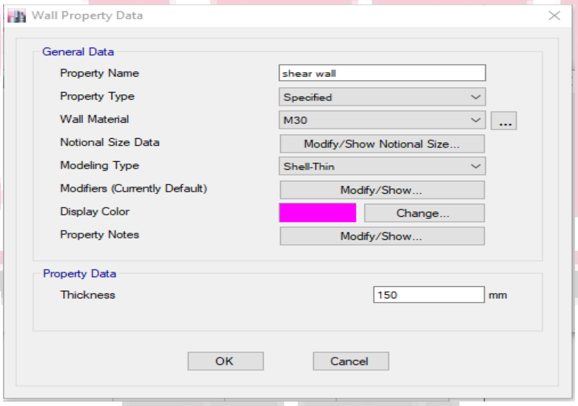

Fig 12 Defining Property data for Shear wall

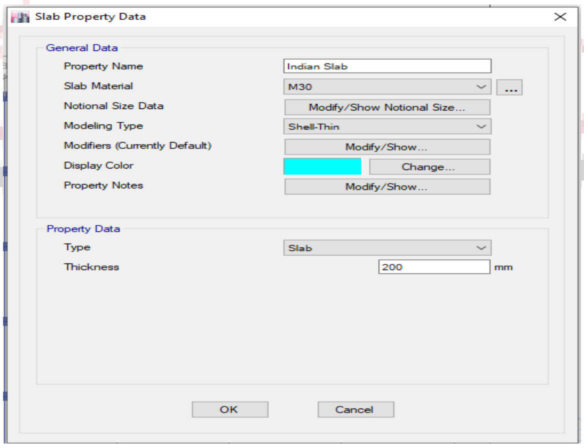

Fig 13 Defining Properties of Slab

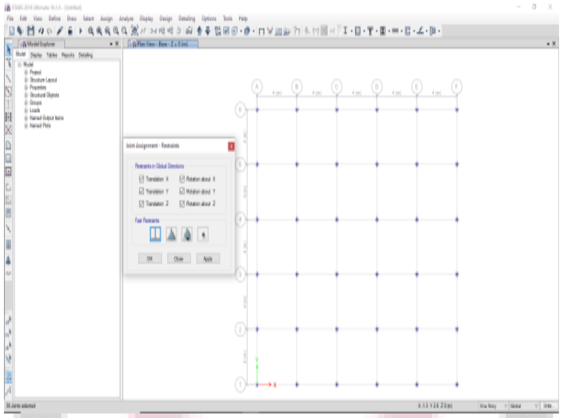

Fig 14 Assigning Fixed Support

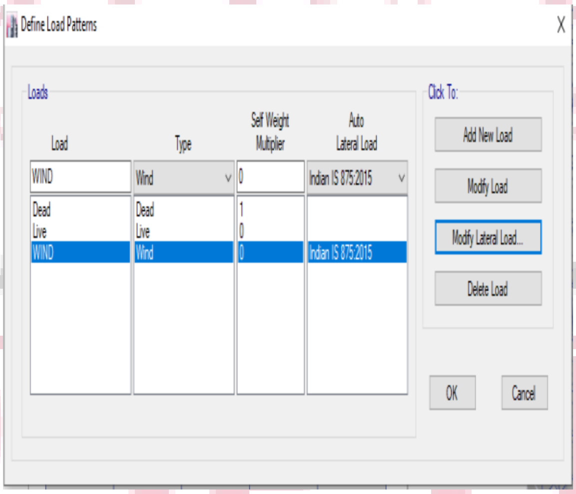

Fig 15 Defining Load Pattern

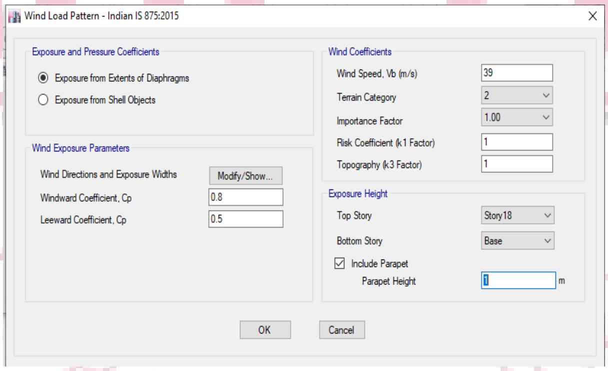

Fig 16 Wind Load Pattern as per IS 875:2015.

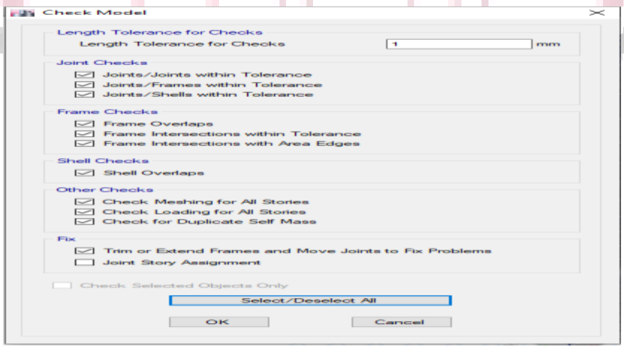

Fig 17 Quick Model Check

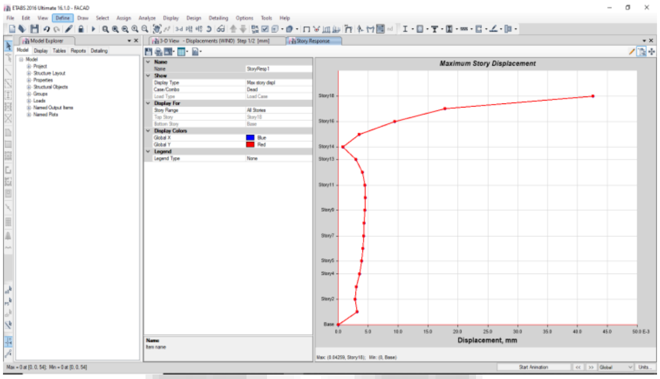

Fig 18 Maximum Storey Displacement

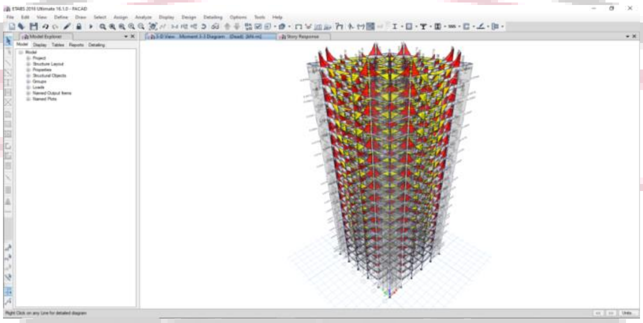

Fig 19 Storey Response of the structure.

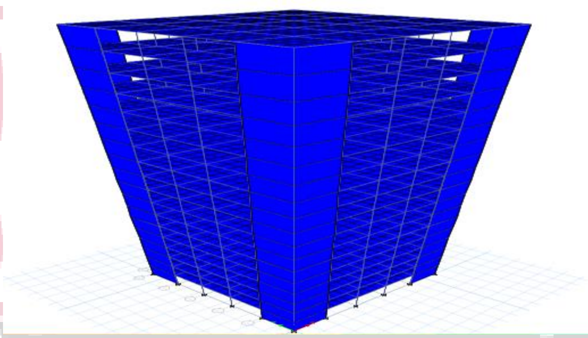

Fig .20 Analyzing the structure

4 PROBLEM STATEMENT

The analysis and design of the three examples under examination were performed using the geometrical specification and the codal provision described in this chapter. On a G+18 high rise structure, a comparison of the masonry facade, steel facade, and shear wall facade system is made here while taking wind loads into account.

Codal Provision

The codal regulations are described in the Indian Standards (Third Revision) of IS:875 (Part 3), which was authorised by the Indian Standards Bureau on (Date) and was written by the Section of Structural Safety Committee with the aid of the Civil Engineering Division Council.

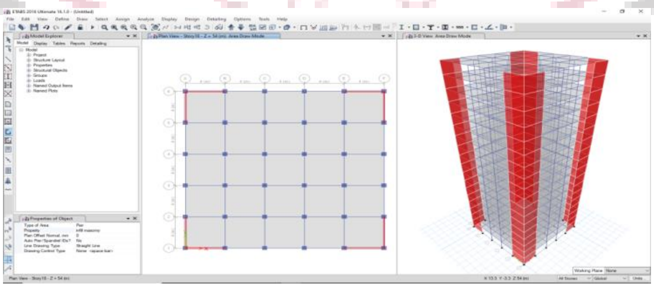

Fig 21 High rise structure with Masonry Facade

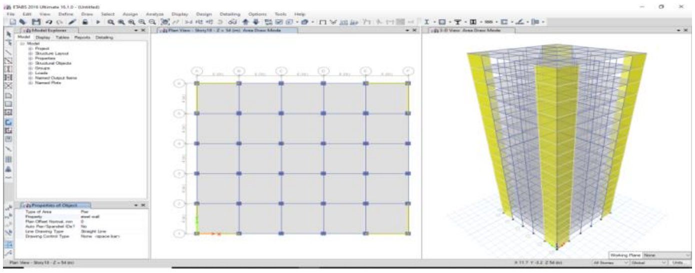

Fig 22 High rise structure with Steel Plate Facade

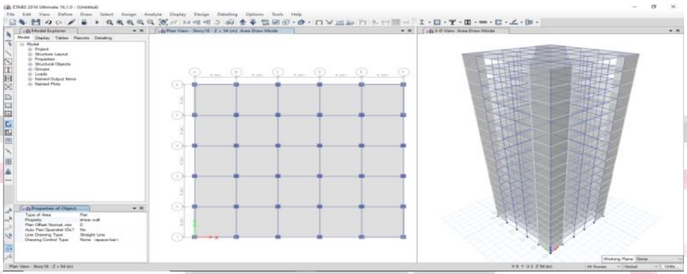

Fig 23 High rise structure with Shear Wall Facade

Table 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 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 2: Material Properties

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

Table 3: Wind load properties

Wind Speed Vb(m/s)	39
Terrain Category	2
Important Factor	1
Risk Coefficient	1
Topography	1
Windward Coefficient	0.8
Leeward Coefficient	0.5

5 RESULT AND DISCUSSIONS

The values-optimized structural behaviour of a high rise structure is shown in this section while taking into consideration three different facade systems, including masonry, steel plate, and shear walls. All of the models are subjected to the same loads, and ETABS is used to do the analysis. his part analyses the model and presents the findings in tabular and graphical form for the parameters of storey displacement, storey stiffness, base shear, and storey drift.deflection,

Table 4: Maximum storey displacement in mm

Maximum Storey Displacement in mm			
Storey	Masonry Facade	Shear wall Facade	Steel Plate Facade
18th storey	299.021	289.192	269.921
17th storey	281.89	271.261	254.921
16th storey	267.009	254.092	226.176
15th storey	241.932	235.932	230.093
14th storey	222.983	216.026	210.82
13th storey	209.92	200.098	196.929
12th storey	190.002	182.932	179.409
11th storey	173.929	171.021	165.201
10th storey	158.93	150.021	144.211
9th storey	138.902	129.043	123.002
8th storey	114.926	105.093	100.181
7th storey	99.973	89.093	80.991
6th storey	76.973	65.092	60.092
5th storey	60.926	51.094	47.092
4th storey	49.932	39.893	34.122
3rd storey	37.937	30.982	26.91
2nd storey	24.873	19.973	15.202
1st storey	12.976	8.274	6.092
base	0	0	0

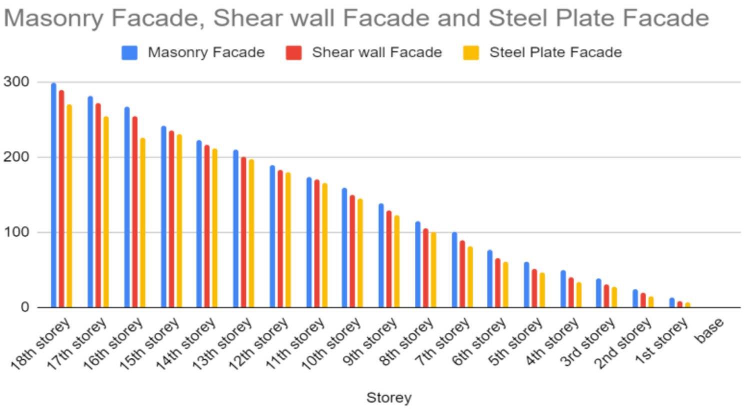

Fig 24 Maximum Storey Displacement in mm

Table 5: Storey Drift

Storey Drift			
Storey	Masonry Facade	Shear wall Facade	Steel Plate Facade
18th storey	20.177	19.099	18.409
17th storey	21.982	18.923	18.233
16th storey	22.912	17.87	17.18
15th storey	23.819	17.021	16.331
14th storey	24.921	16.932	16.242
13th storey	26.921	14.902	14.212
12th storey	35.021	14.21	13.52
11th storey	47.001	13.999	13.309
10th storey	45.202	13.698	13.008
9th storey	43.921	13.023	12.333
8th storey	40.21	12.98	12.29
7th storey	35.982	12.09	11.4
6th storey	32.09	11.89	11.2
5th storey	30.092	11.11	10.42
4th storey	28.92	10.732	10.042
3rd storey	26.09	10.201	9.511
2nd storey	24.48	9.892	9.202
1st storey	19.09	9.209	8.519
base	0	0	0

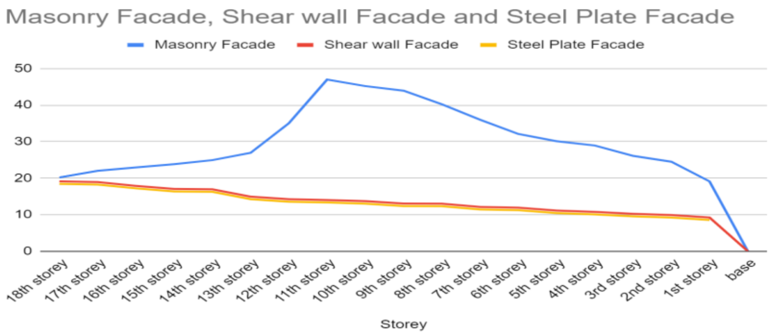

Fig 25 Storey Drift

Table 6: Storey Shear in kN

Storey Shear in kN			
Storey	Masonry Facade	Shear wall Facade	Steel Plate Facade
18th storey	7011.001	19127.947	18523.983
17th storey	6827.83	18992.937	17253.92
16th storey	6592.945	17192.723	16,875.56
15th storey	6389.1	16093.938	15864.398
14th storey	6199.405	14093.927	13987.409
13th storey	5992.932	13221.946	13001.121
12th storey	5793.21	12947.928	12832.35
11th storey	5428.332	12539.937	12321.549
10th storey	5298.93	12012.928	11987.409
9th storey	5167.93	11923.93	11001.213
8th storey	4983.828	10266.839	9976.09
7th storey	4498.092	9178.927	9099.659
6th storey	4109.273	8947.929	8889.65
5th storey	3984.93	8328.028	8211.98
4th storey	3309.829	6829.93	6732.82
3rd storey	3298.926	5193.092	5099.836
2nd storey	2984.927	4525.094	4498.828
1st storey	2098.937	4100.829	3909.092
base	1988.927	3022.929	2988.929

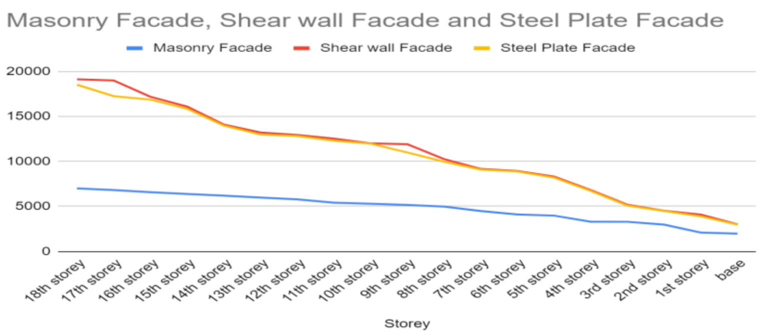

Fig 26 Storey Shear in kN

Table 7: Storey Stiffness in kN

Storey Stiffness in kN		
Masonry Facade	Shear wall Facade	Steel Plate Facade
605982	4198392	3890499

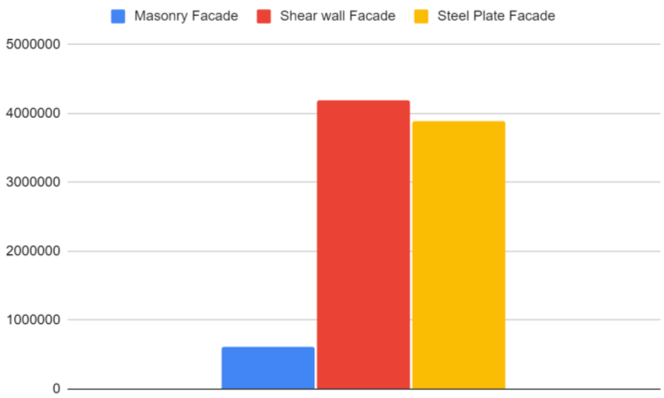

Fig 27 Storey Stiffness in kN

Table 8: Base Shear in kN

Base Shear in kN		
Masonry Facade	Shear wall Facade	Steel Plate Facade
3080.596	1835.91	1928.773

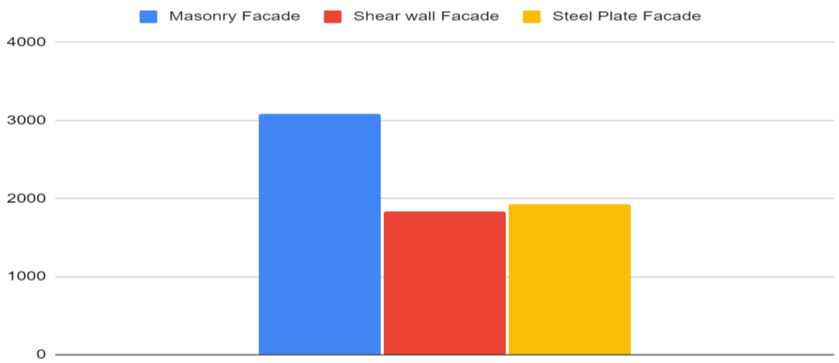

Fig 28 Base Shear in kN

CONCLUSION

This research analyzes various facade systems using a G+18 high-rise building as three case studies for masonry, shear walls, and glass walls. Storey displacement, shear force, bending moment, axial force, and base shear are the parameters used to analyse the structure. ETABS, an analytical software, is used to perform the design and simulation.

Maximum Story Displacement

Storey displacement is the lateral displacement of the storey with reference to the base. The lateral force-resisting system can reduce the excessive lateral displacement of the building. The acceptable lateral displacement limit for a wind load scenario may be H/500 (others may opt for H/400). In this study, the 18th storey with a masonry facade wall had the biggest storey displacement when compared to other samples, with a 6% difference in the outcome. Storey displacement grows as a function of the structure's height.

Maximum Storey Drift

The product of storey drift and storey height is known as the storey drift ratio. The lateral movement of a floor in relation to the floor below is referred to as "storey drift." Story drift was greatest in the 11th storey with a masonry wall system with a peak gap noticeable in comparison to other facade systems, such as steel wall and shear wall, which were demonstrated to be stable.

Storey Shear

Storey shear is the graph that shows the amount of lateral (horizontal) load applied on each storey, such as from seismic or wind waves. The shear increases as you descend. Storey drift, on the other hand, is the graph of the resulting drifts per level. The greatest storey shear in steel plate was 18523.98 kN and the highest storey shear in shear wall facade was 19127.872 kN. The masonry facade system had the least storey shear, and the difference was noticeable as the storey height grew.

Storey Stiffness

The bottom of the storey is prevented from moving laterally, indicating that only translational motion of the storey is restricted while it is free to rotate, and the lateral force producing unit translational lateral deformation in that storey is calculated. A building with a shear wall facade had a maximum storey stiffness of 4198392 kN, while a structure with a steel plate façade had such a maximum storey stiffness of 3890499 kN..

Base Shear

Base shear relates to the greatest anticipated lateral tension caused by seismic activity on the base of the building. It is calculated utilising the building code's lateral force, soil type, and seismic zone formulas. The maximum base shear for a high-rise structure with masonry face was 3080 kN, which was higher than that of shear wall and steel plate facade systems.

FUTURE SCOPE

- This study focused on the linear dynamic analysis of wind excitation. The frame structure, however, can also be subjected to non-linear dynamic analysis for more accurate outcomes evaluation. As a result, nonlinear time history analysis is also possible. Furthermore, seismic analysis tools may be provided.
- We can get accurate insights for a comparative analysis by evaluating the outcomes utilising SAP 2000 with several slab systems.

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