International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 Impact Factor: 8.176 ISSN: 2582-3930

Comparison and Analysis of Multi Storey Building with or Without Shear Wall Using Staad Pro

Prof. R.V.R. K Prasad[1], Shruti A. Telrandhe[2], Dhanshree R. Padole[3], Devang Mansata[4], Ubaid Ahmad Khan[5], Trupti Sahare[6]

Shrutiatelrandhe.ce@kdkce.edu.in , dhanshreerpadole.ce@kdkce.edu.in, devanghmansata.ce@kdkce.edu.in , ubaidakhan.ce@kdkce.edu.in , truptisshahare.ce@kdkce.edu.in

Associate Professor K.D.K College of Engineering Nagpur, Maharashtra, India (1)
UG Student, Department of Civil Engineering (2,3,4,5,6)
KDK College of Engineering Nagpur, Maharashtra, India

ABSTRACT: Due to the increasing frequency of earthquakes in the past, there has been a growing demand for earthquake-resistant buildings. One way to fulfil this demand is to incorporate shear walls into the building's structure to resist the lateral forces generated by wind, earthquakes, and other sources. Shear walls are typically made of reinforced concrete, masonry, or steel and are placed at strategic locations throughout the building to provide stability and prevent structural failure during a seismic event. In the present work, G+6 story building has been modelled using software STAAD PRO for Zone factor-0.1 in Nagpur, India. The analysis is by carried out of R.C.C building with different posting of shear wall on floor plan of by using STAAD PRO software. The present work presents a comprehensive analysis of reinforced concrete buildings with various configurations, considering factors such as location and thickness of shear walls, to investigate their efficacy in withstanding lateral forces.

INTRODUCTION

Shear walls play a crucial role in ensuring the safety and stability of a building during earthquakes and high winds. These walls are designed to resist lateral forces by providing rigidity and stiffness to the building's structure. Shear walls can be made from various materials, including concrete, masonry, steel, and wood. They are strategically placed in a building to resist the forces that act perpendicular to the wall's plane. The use of shear walls in building design has become increasingly popular due to their effectiveness in reducing damage and collapse during seismic events. The importance of shear walls in building design can be illustrated by analysing the behaviour of a six-story reinforced concrete building. In this case, a comparison study will be conducted to evaluate the structural response of the building with and without shear walls. The study will also assess the impact of different types of lateral loads on the building's behaviour, including wind and earthquake loads.

The building model used in the study has a rectangular floor plan with dimensions of 11.2m x 7.9m. The building model with shear walls will have shear walls located at the corner of the building, spanning the entire height of the building. The shear walls are designed to resist lateral forces and transfer them to the building's foundation. In contrast, the building model without shear walls will have no lateral load-resisting elements. The building's stability will depend solely on the strength of its columns and beams to resist lateral forces. The study will use STAAD Pro software to analyse the behaviour of the building with and without shear walls under different types of lateral loads. STAAD Pro is a powerful structural analysis software that can simulate the response of a building to various types of loads, including seismic loads and wind loads.

The study will assess the structural response of the building with and without shear walls to various types of loads. The response will be evaluated based on several factors, including the maximum displacement, maximum stress, and maximum strain of the building's elements. These factors will be used to determine the role of shear walls in mitigating structural damage and collapse during seismic events. The study's results are expected to show that the building model with shear walls is more resistant to lateral forces than the building model without shear walls. The shear walls provide additional rigidity and stiffness to the building, which increases its ability to resist lateral forces. In contrast, the building model without shear walls is expected to be more vulnerable to lateral forces and more likely to suffer damage or collapse during seismic events. Furthermore, the study's results will demonstrate the critical importance of shear walls in modern building design. The use of shear walls in building design has become increasingly necessary due to the increased occurrence of seismic events worldwide. In regions where seismic activity is prevalent, the use of shear walls is essential to ensure the safety and stability of buildings.

In conclusion, shear walls are an essential component of a building's lateral load-resisting system. They provide rigidity and stiffness to the structure and ensure that the building can withstand lateral forces, such as those caused by earthquakes and winds. The study discussed in this article will evaluate the structural response of a six-story reinforced concrete building with and without shear walls. The results of the study will demonstrate the critical importance of shear walls in modern building design.

LITERATURE REVIEW

Radhika Rajeev, R. Senthil Kumar (2022) [1]

This paper provides an overview of different research works done to improve the performance of shear walls and determine their best position in a building for seismic analysis. Shear walls are rigid vertical diaphragms that transfer lateral forces from exterior walls, floors, and roofs to the ground foundation parallel to their planes, keeping buildings from blowing over during seismic activity or high wind. The paper presents several research studies that analysed the location of shear walls in buildings based on factors such as lateral displacement, story drift, concrete quantity, total cost for steel and reinforced concrete [RC], and percentage of Ast in the middle column. The researchers concluded that constructing buildings with shear walls in short dimensions at corners is more economical and effective in resisting lateral forces. The paper also highlights the importance of shear walls in high-rise buildings and areas with high wind and seismic activity. Additionally, the studies analysed the effect of shear walls on displacement, story drift, shear, story stiffness model period, and frequency on different floors, concluding that shear walls outperform framed structures in earthquake-prone areas. The researchers used software such as ETABS and STAAD. Pro V8i for modelling, analysing, and designing various sections of multi-story buildings.

Axay Thapa, Sajal Sarkar (2017) [2]

This is a technical article about the seismic design of buildings with a focus on the use of reinforced concrete shear walls as a major earthquake-resisting member. The article discusses the importance of evaluating the seismic response of shear walls appropriately and compares the dynamic responses of frame structures with and without shear walls. Three models of varying height with and without shear walls are analysed using static and response spectrum methods in seismic zone V in STAAD. Pro V8i. The article also includes a literature review of related studies on seismic behaviour, dynamic analysis, and the evaluation of the effectiveness of shear walls. The methodology used in this study includes the equivalent lateral force method and response spectrum method. The article concludes with the importance of properly designing structures to resist seismic forces and the advantages of using reinforced concrete shear walls in high-rise buildings.

Sanjeebanee Behera, P. K. Parhi (2017) [3]

The article discusses the importance of shear walls in making a building earthquake resistant. Shear walls are vertical cantilevers that counteract lateral loads caused by wind load and seismic loads. They provide adequate stiffness to the structure and limit lateral drift. The paper presents a comparison of the earthquake behaviour of buildings with and without shear walls using STAAD Pro V8i. The study analyses reinforced concrete buildings by changing the position of shear walls, considering various parameters such as story drift and lateral displacement. The models analysed include a multistorey building frame without shear walls, with shear walls at each periphery, with shear walls at each corner, and with shear walls at the centre. The paper determines the efficient, effective, and ideal location of shear walls in high seismic regions. The study shows that the building with shear walls in the short span at the corner is more economical than the others.

Kirankumar Gaddad, Vinayak Vijapur (2018) [4]

This is a technical research paper that discusses the behaviour of structures during earthquakes. The study focuses on comparing the performance of four models of a G+20 storey building, including a normal building, a floating column structure, a shear wall structure, and both shear walls and floating column’s structure. The seismic analysis of the building is done using both equivalent static and response spectrum methods, with the help of Indian Standard code IS 1893(Part-1) 2002 and ETABS-2016 software. The paper concludes that the shear wall structure performs better than the other three models, with lesser displacements and more strength. The study also explains the concept of floating columns and shear walls and their

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role in resisting earthquake forces. The paper aims to contribute to the understanding of earthquake-resistant structures, which is crucial in a country like India that lies in an earthquake-prone zone.

Mr. Shailesh Patil, Prof. K. K. Tolani (2017) [5]

In conclusion, this paper provides a comprehensive literature review on the design and analysis of shear walls, which are commonly used as lateral load resisting systems in high-rise buildings. The effectiveness of shear walls in resisting seismic loads is highlighted, and the importance of their location in the building is emphasized. The paper presents a problem statement related to the decrease in lateral load resisting capacity of buildings due to the presence of soft stories and proposes a solution to increase the stiffness and strength of the building by introducing shear walls. The main objective of the study is to determine the optimum location of shear walls in RC buildings using STAAD Pro software, which will help structural designers in the design of buildings to overcome the ill effects of earthquakes. Overall, this paper contributes to the body of knowledge on the use of shear walls in structural engineering and provides valuable insights for future research in this field.

Priyanka Kosare, Deepti Hazari (2019) [6]

This passage discusses the importance of shear walls in buildings, especially in seismically active zones where buildings are subject to lateral loads from earthquakes, wind, and blasting. Shear walls are vertical diaphragms that can transfer lateral forces from exterior walls, floors, and roofs to the ground foundation. They are constructed to counteract the effects of lateral loads and are especially important in high-rise buildings subject to lateral wind and seismic forces. The passage discusses the various types of shear walls and their classification, as well as codal provisions for shear walls. The ideal position of a shear wall is in a symmetric position to avoid torsion and bring in a lot of lateral resistance. The role of shear walls is to reduce lateral displacement/storey drift, reduce the time period of vibration of the building, reduce moments and induced torsion during earthquakes, and increase the stiffness of the building. Shear walls are easy to construct and efficient in terms of minimizing earthquake damage.

METHODOLOGY

The methodology section outlines the approach taken to design a multi-storeyed residential building to withstand dead load and live load, earthquake, and wind loads as per Indian Code of Practice. To ensure the building can withstand various loads, the member forces are calculated using load combinations specified in IS 456: 2000. Additionally, seismic provisions are taken into consideration to ensure the building's safety, including the use of a special RC moment resisting frame, response reduction factor, importance factor, and soil type. These provisions are intended to reduce the impact of earthquakes on the building's structural integrity.

Overall, the methodology section highlights the various factors considered in the design of the building, including the location, building type, response reduction factor, importance factor, soil type, and damping ratio, among other factors. The combination of these factors ensures that the building is structurally sound and capable of withstanding various loads and environmental conditions.

Seismic provision for this building:

- Seismic Zone: Nagpur (Z=0.1)
- Types of the frame: Special RC Moment Resisting Frame
- Response reduction factor (R): 5.0
- Importance factor (1): 1.0
- Soil type: medium soil
- Damping ratio: 5%.

MODELING

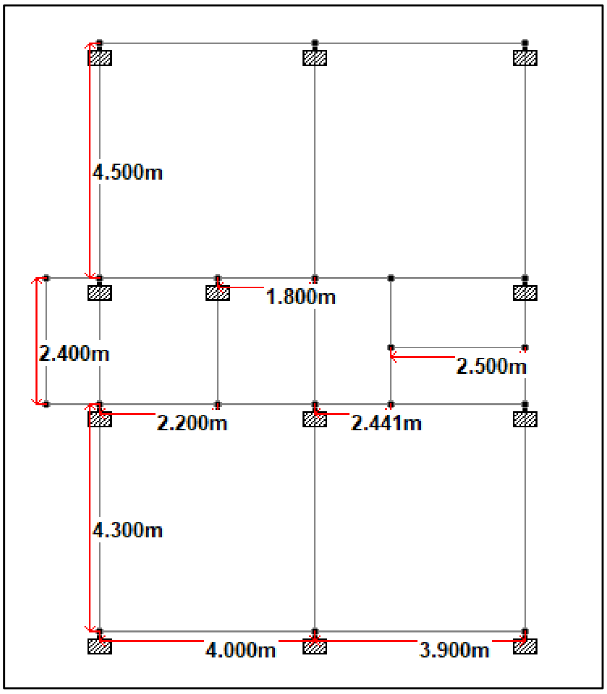
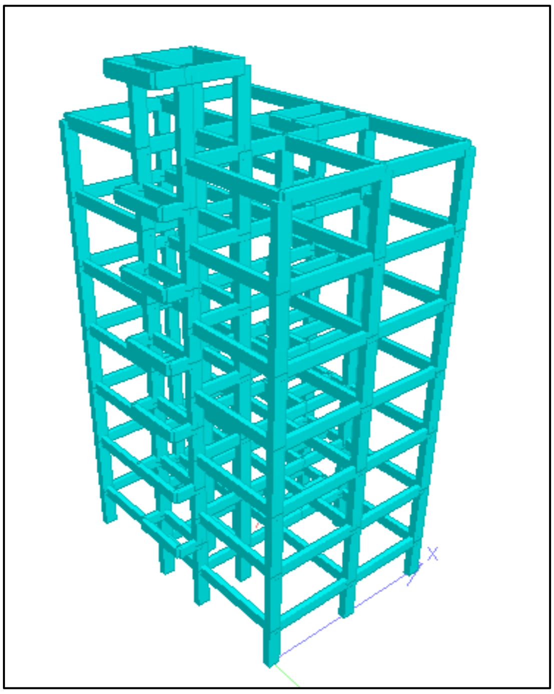


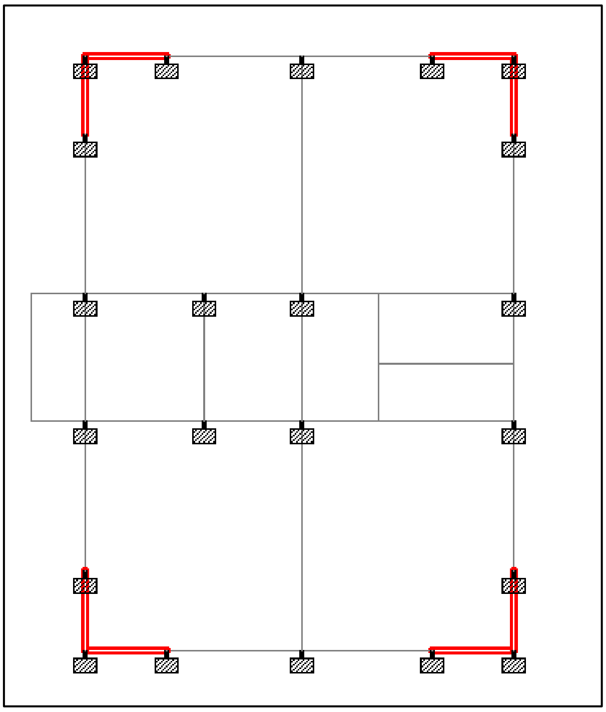
Figure 1: Plan of G+6 Model Without Shear Wall



WITHOUT SHEAR WALL

MAX BENDING MOMENT

Figure 2: Rendered View of G+6 Model Without Shear Wall



WITH SHEAR WALL

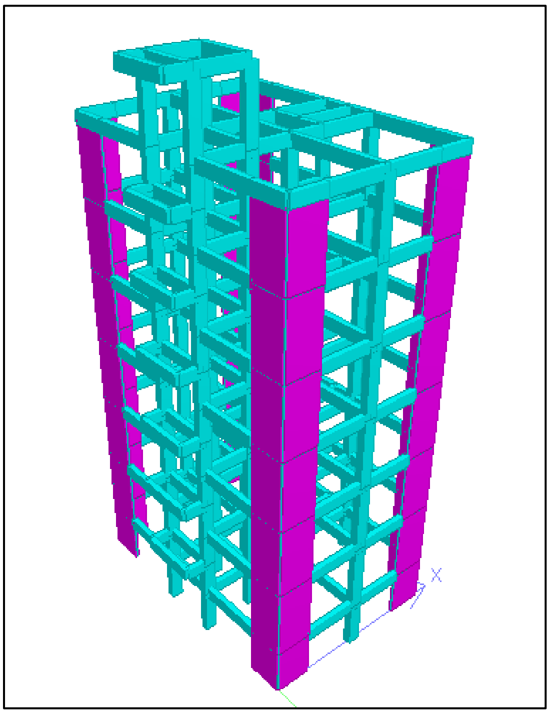


Figure 3: Plan of G+6 Model with Shear Wall

International Journal of Scientific Research in Engineering and Management (IJSREM)
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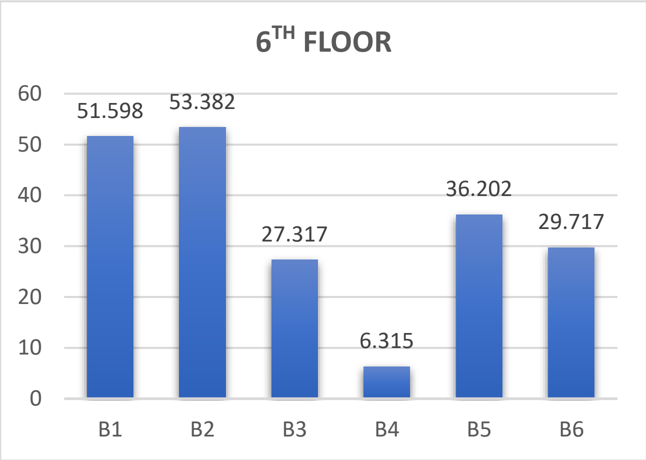

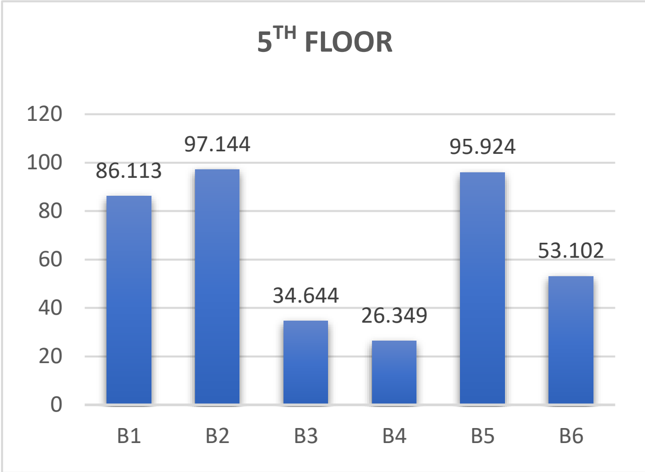

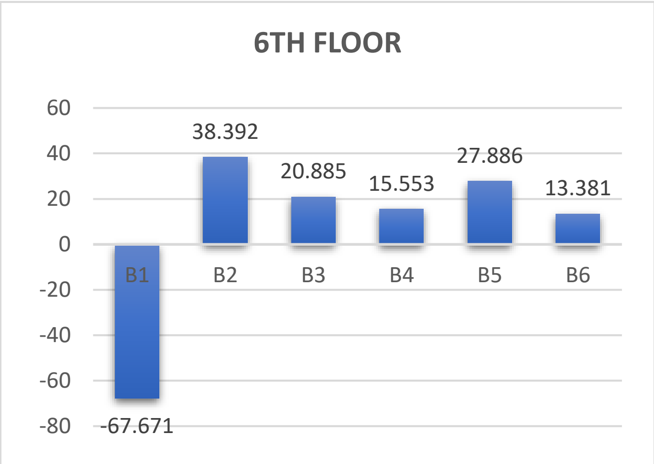

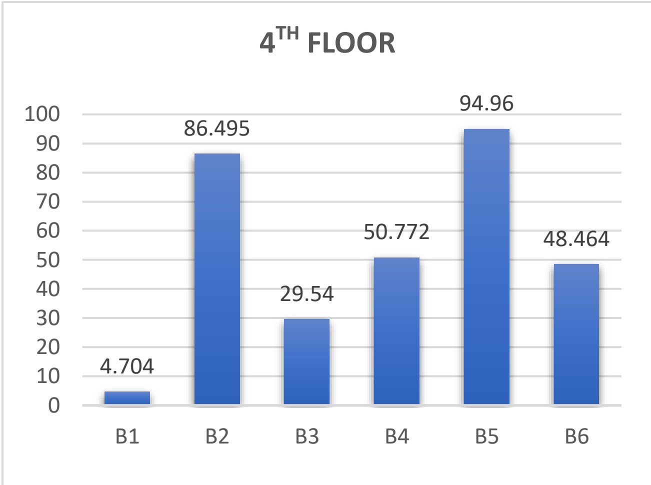

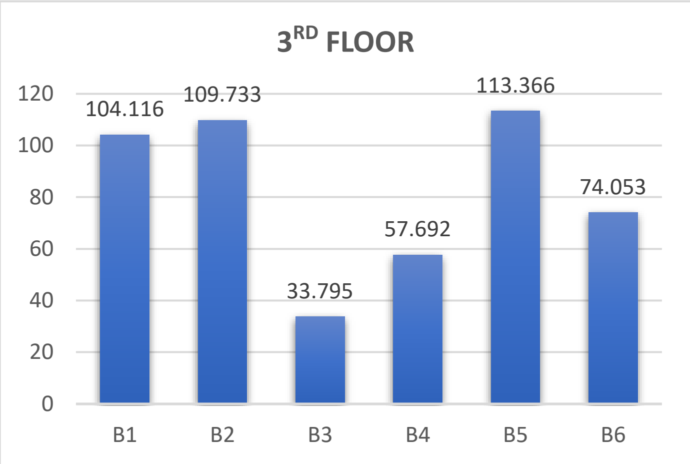
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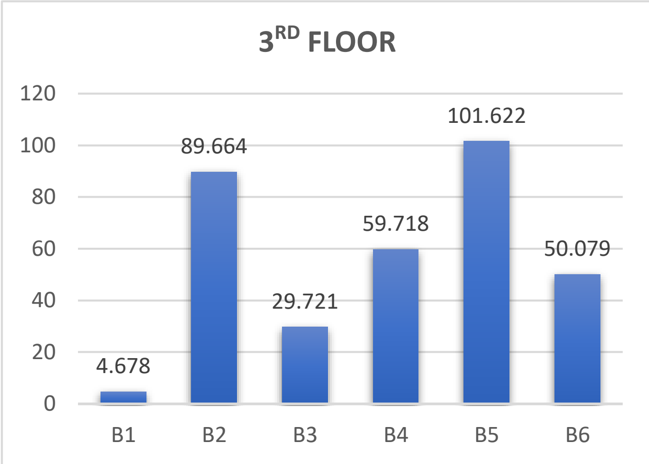
33.795
57.692
113.366
74.053
B1
B2
B3
B4
B5
B6


3RD FLOOR
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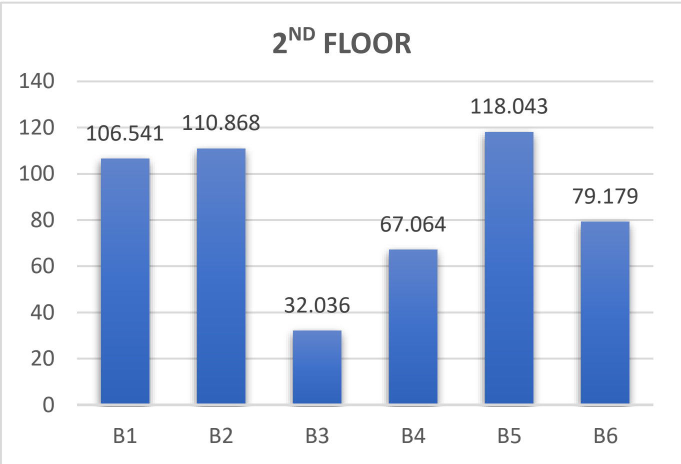
29.721
59.718
101.622
50.079
B1
B2
B3
B4
B5
B6


2ND FLOOR
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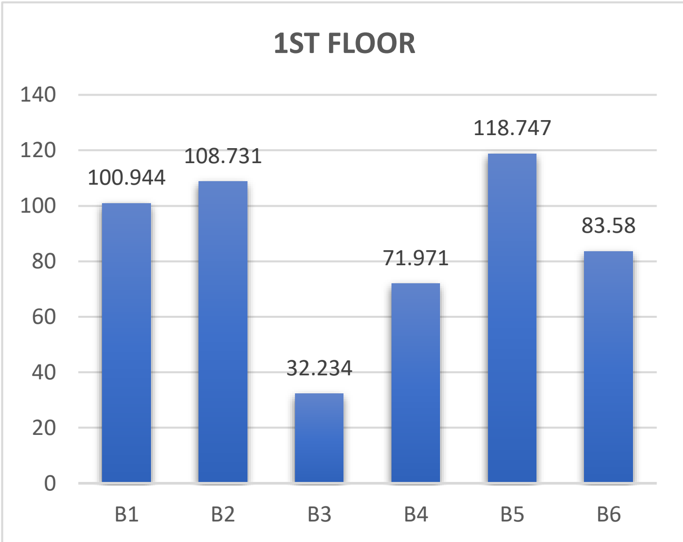
110.868
32.036
67.064
118.043
79.179
B1
B2
B3
B4
B5
B6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32.234
71.971
118.747
83.58
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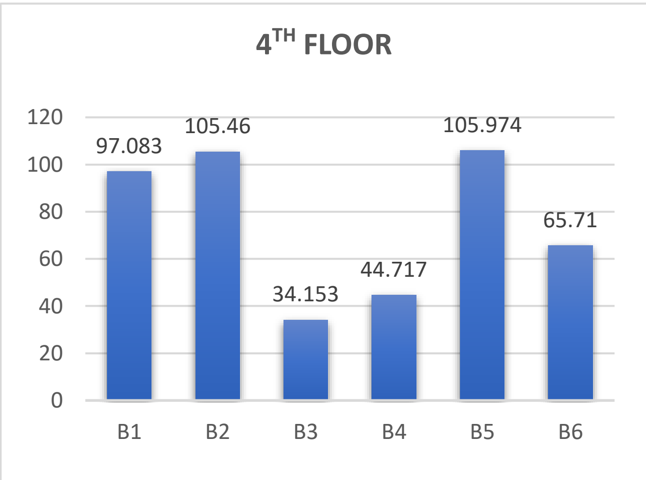
B2
B3
B4
B5
B6


4TH FLOOR
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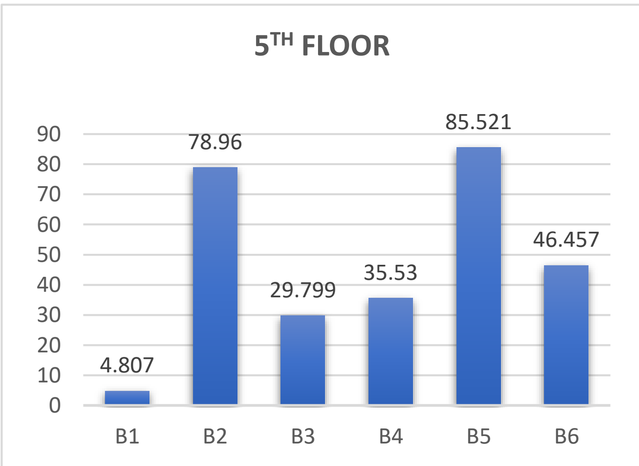
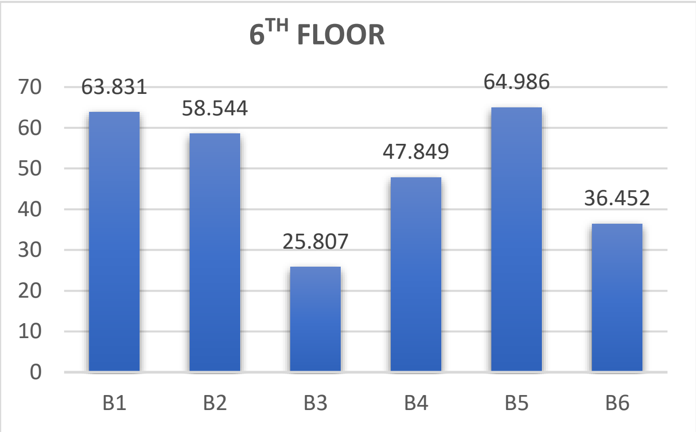
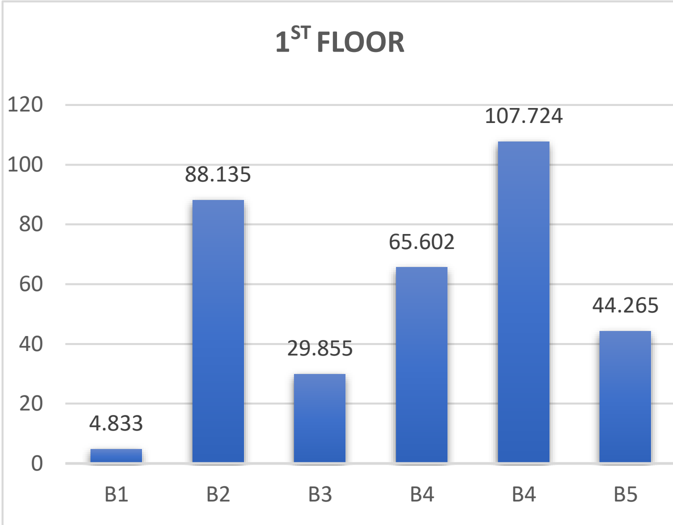
34.153
44.717
105.974
65.71
B1
B2
B3
B4
B5
B6

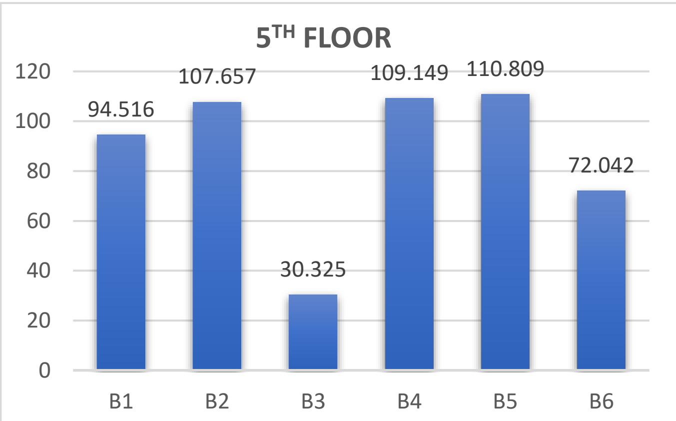

5TH FLOOR
4.807
78.96
29.799
35.53
85.521
46.457
B1
B2
B3
B4
B5
B6

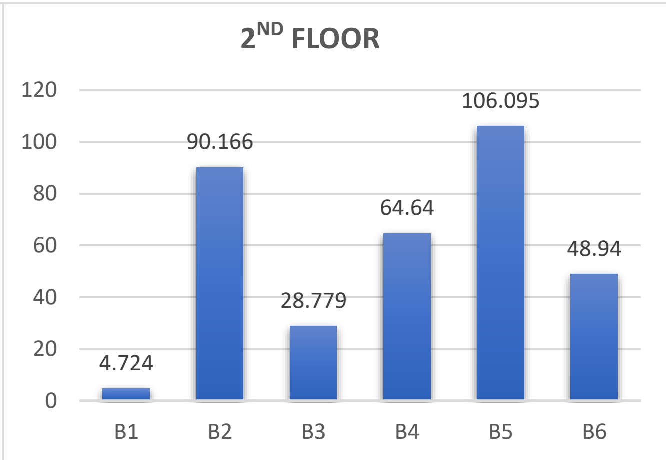
MAX. SHEAR FORCE

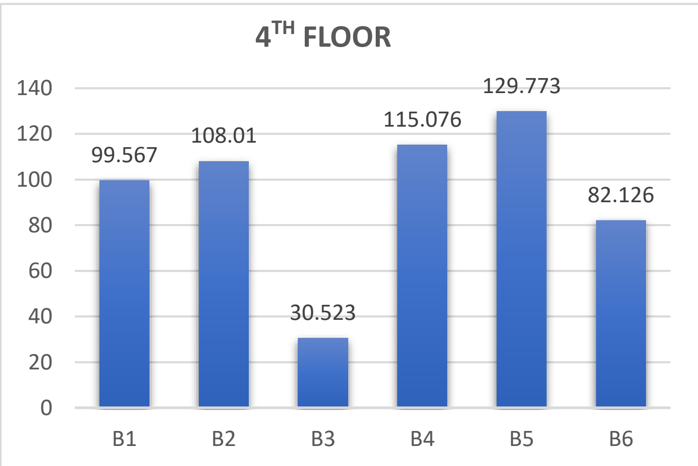
WITHOUT SHEAR WALL



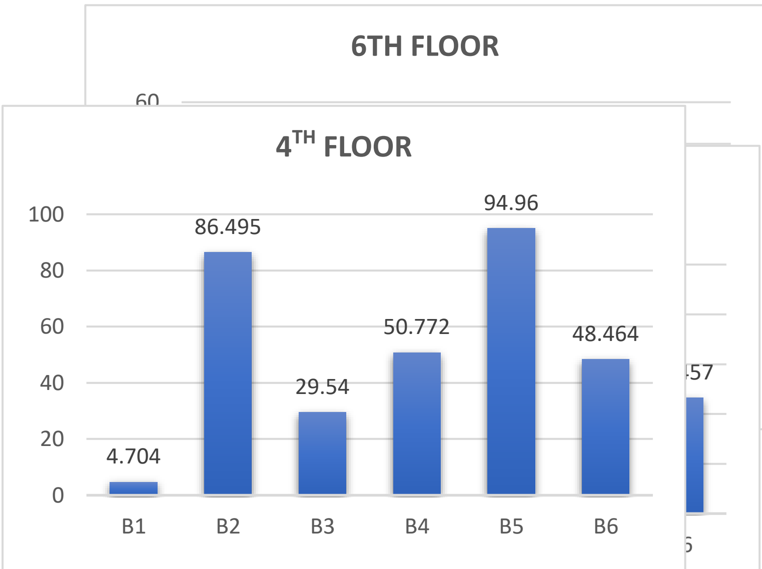


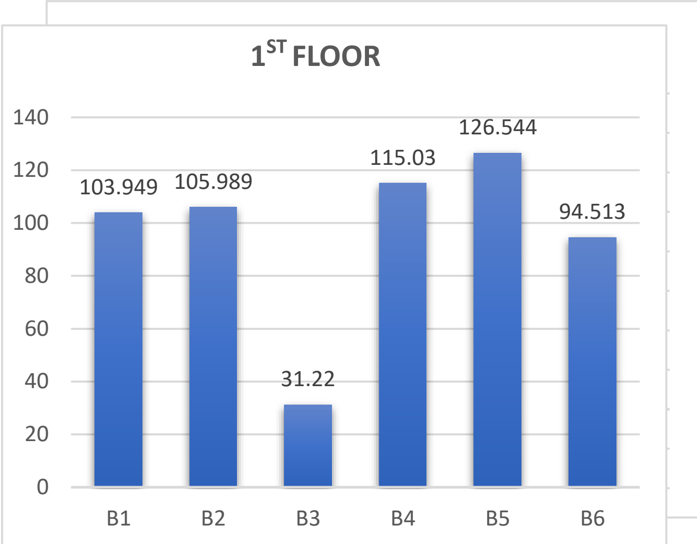






WITH SHEAR WALL




1^{ST} FLOOR
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120
100
80
60
40
20
0
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105.989
31.22
115.03
126.544
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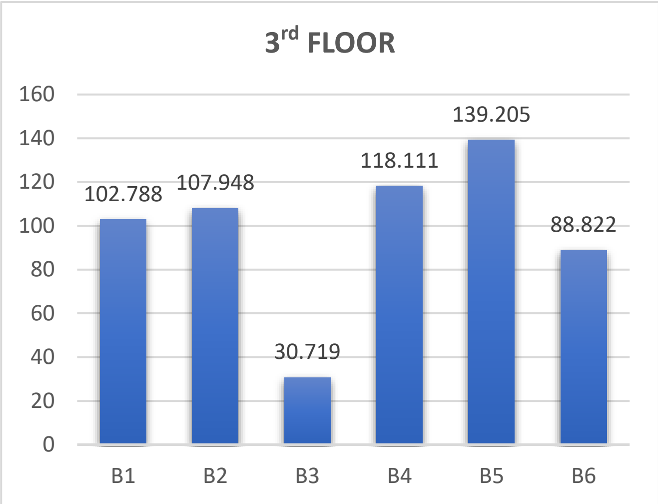
B1
B2
B3
B4
B5
B6


3^{rd} FLOOR
160
140
120
100
80
60
40
20
0
102.788
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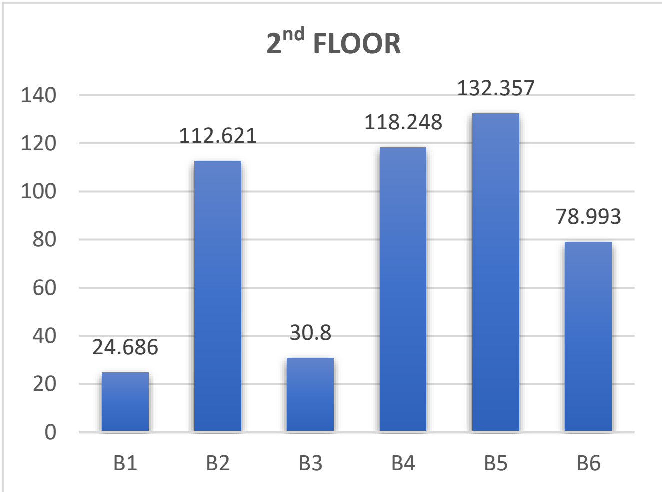
B4
B5
B6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120
100
80
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40
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30.8
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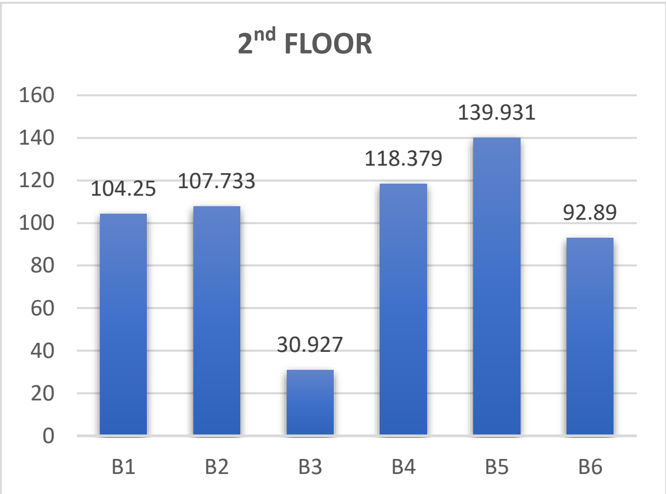
B3
B4
B5
B6


2^{nd} FLOOR
160
140
120
100
80
60
40
20
0
104.25
107.733
30.927
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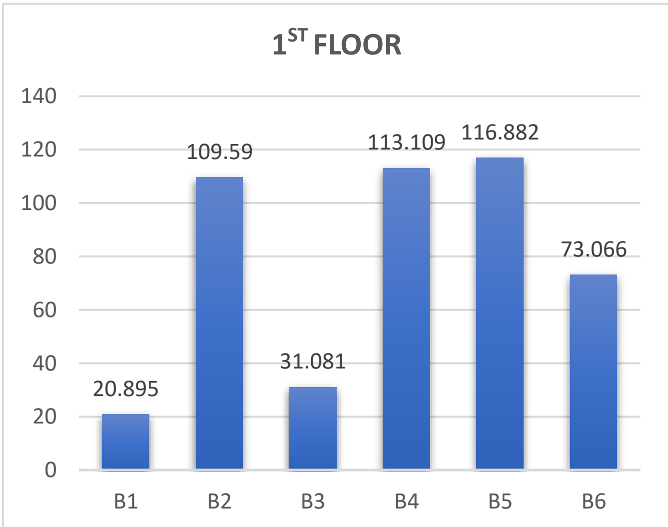
B3
B4
B5
B6


1^{ST} FLOOR
140
120
100
80
60
40
20
0
20.895
109.59
31.081
113.109
116.882
73.066
B1
B2
B3
B4
B5
B6

MAX. BENDING MOMEMNT ON COLUMN

WITHOUT SHEAR WALL

Beam	L/C	Bending Moment [M1]	COLUMN NO
36	34	31.037	C1
37	29	24.904	C2
38	29	26.514	C3
113	25	55.659	C4
80	34	30.08	C5
114	20	63.506	C6
115	20	56.586	C7
70	34	38.459	C8
79	20	32.468	C9
71	29	38.664	C10
72	29	44.409	C11
107	20	49.389	C12
108	20	53.294	C13
109	25	51.802	C14

WIT SHEAR WALL

Beam	L/C	Bending Moment [M1]	COLUMN NO
		SHEARWALL	SH1
37	29	13.689	C2
		SHEARWALL	SH2
113	25	39.079	C4
80	34	18.313	C5
114	20	49.074	C6
115	20	32.23	C7
70	34	28.835	C8
79	20	21.202	C9
71	29	23.132	C10
72	29	27.516	C11
		SHEARWALL	SH3
108	20	45.296	C13
		SHEARWALL	SH4

Beam	L/C	Bending Moment [M2]	COLUMN NO
36	23	43.545	C1
77	23	59.302	C2
118	23	57.506	C3
33	18	46.768	C4
80	27	63.386	C5
74	32	53.686	C6
115	23	71.109	C7
30	18	46.685	C8
79	27	64.158	C9
71	32	53.959	C10
112	23	70.094	C11
27	32	42.912	C12
68	23	59.008	C13
109	23	58.474	C14

Beam	L/C	Bending Moment [M2]	COLUMN NO
		SHEARWALL	SH1
77	23	40.932	C2
		SHEARWALL	SH2
33	18	37.886	C4
80	27	51.247	C5
74	32	44.084	C6
115	23	68.392	C7
30	18	38.02	C8
79	27	52.283	C9
71	32	44.545	C10
112	23	67.292	C11
		SHEARWALL	SH3
68	23	41.962	C13
		SHEARWALL	SH4

MAX. AXIAL FORCE ON COLUM

WITHOUT SHEAR WAL

Beam	L/C	Axial Force (KN)	COLUMN NO
36	19	1146.812	C1
37	7	1511.981	C2
38	18	1408.9	C3
33	22	1336.796	C4
40	21	1224.46	C5
34	23	1617.383	C6
35	23	1569.731	C7
30	22	1314.042	C8
39	20	1173.842	C9
31	18	1484.07	C10
32	18	1523.957	C11
27	22	1118.071	C12
28	25	1440.923	C13
29	23	1126.572	C14

WITH SHEAR WALL

Beam	L/C	Axial Force (KN)	COLUMN NO
		1764.832	SH1
37	7	1014.886	C2
		2136.204	SH2
33	22	1144.928	C4
40	21	1108.829	C5
34	23	1543.989	C6
35	23	1341.002	C7
30	22	1130.823	C8
39	20	1060.957	C9
31	18	1414.168	C10
32	18	1304.981	C11
		1789.758	SH3
28	25	1035.531	C13
		1844.355	SH4

CONCLUSION

The present research involved the use of STAAD pro software to design a G+6 building with seismic loading. The software was used to model the building as a 3D space frame, and various loads such as dead load, live load, wind loads, and seismic loads were calculated based on the Indian standards, IS 875(Part 1Part 2 Part 3): 1987 and IS 1893:2002.

The study considered two models - a building frame without a shear wall and a building frame with a corner shear wall. The results showed that without a shear wall, medium to high-rise multistorey buildings experienced high lateral displacement. Additionally, the axial load and bending moments on the columns were found to be maximum.

However, the inclusion of a shear wall was found to be effective, economical, and easy for construction as it is made of reinforced concrete. As such, the study concluded that shear walls provide lateral strength and stiffness to the building, improving its performance under seismic forces. Furthermore, the study identified the corner portion of the building as the ideal location to install the shear wall, making the building more resistant to earthquakes.

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