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Research Study on Evaluation of Lateral Stiffness of Different Forms Shear Walls Against Lateral Loadings for Steel Frames

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Abstract- **The capacity of the structure to withstand variations in seismic and wind loads is one of its most crucial features. Lateral stiffness has a significant impact on the sample's exposure to natural light. The primary seismic elements used in the seismic design of buildings are concrete slabs or shear walls. Wall panels can bear external loads and offer a strong support system. It is crucial to assess the wall's seismic reaction since the building's response is dependent on the seismic shear wall's characteristics. This work employed response spectrum analysis to assess the elastic stiffness factor, natural moment, and maximum central shear force of a two-dimensional steel frame under various lateral loading systems. In this study, seismic load analysis of a (G+15) storey steel structure in which shear walls with different functions were used was carried out.**

Keyword: Stiffness, Steel Frame, Design Check, response spectrum, Time History, ETABS.

I. INTRODUCTION

Any seismic event, whether it be man-made or natural, can be referred to as an earthquake. Geological fault ruptures are a common source of earthquakes, but they can also be brought on by other occurrences including volcanic activity, mine explosions, landslides, and nuclear testing. Because their primary constructions do not adhere to contemporary seismic requirements, many buildings sustain significant damage during earthquakes. India is classified into four zones based on seismic activity, according to the ISIS seismic zonation map: 1893-2002. Region II, Region III, Region IV, and Region V are these. It may be necessary to create complete models, conduct thorough testing, produce hundreds of the identical models, then analyse and design depending on the test findings in various sectors. Unfortunately, the construction sector does not have access to this alternative, making it impossible to launch a large-scale firm. Indian Standard Code 456:2000 is the design standard for much of the country's currently standing buildings, however to make them earthquake-resistant, buildings should follow IS 1893-2002.

These constructions typically only have vertical loads, which results in elastic structural behaviour. Severe seismic occurrences, however, may expose buildings to stresses that exceed their elastic limitations. as of that moment. Since many concrete structures have suffered major damage or have collapsed as a result of the earthquakes that have occurred over the past four years, it has become clear that ready-for-use buildings and structures require precise seismic analysis. Identification of the structures that will sustain damage is crucial for this reason. The straightforward linear elasticity approach is ineffective for achieving this objective. As a result, the design model represents a novel way for design and seismic programming that uses nonlinear techniques and performance models.

A. Shear Wall

A shear wall is a type of support that can withstand earthquake and wind-induced shear stresses. Shear is a force operating vertically on building components (columns, beams, etc.) that causes the building to sway back and forth in civil engineering. Shear walls protect the structure from tilting or collapsing by transmitting the weight to the base and stabilising the building. Although all curtain walls have the same goal, their construction might vary based on their material (such as stone, steel, or wood), thickness, length, and location, necessitating the use of particular building techniques. Shear walls absorb the stresses from the building's weaker parts, such as the exterior walls, floors, and roofs, and transfer them to the foundation when outside factors, such as storms, harsh weather, or earthquakes, cause damage. Shear walls offer an external force that protects the structure from trembling or collapsing. Similar to load-bearing walls, shear walls also act as a means of transmitting forces and loads from one point to another—the foundation. Shear walls support the building like load-bearing walls but do not take on vertical loads. Instead, shear walls provide horizontal protection for both sides of the building.

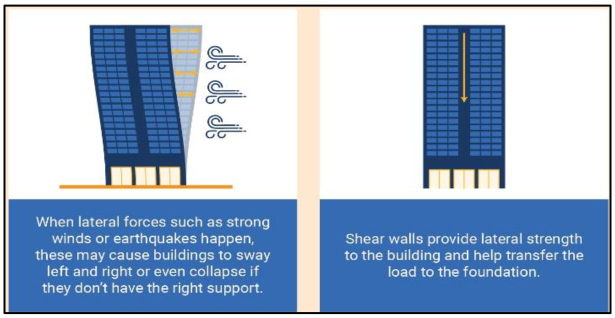


Fig 1 Building with Shear wall

B. Stiffness

To put it simply, hardness refers to how stiff a thing is. In other terms, it refers to a material's capacity to retain its shape while not deforming under force. The harder the product is, the better it is in resisting deformation. Despite the fact that there are several ways to define stress, Hooke's rule says that the force is defined as the capacity to match the force operating on the object. The coefficient of hardness, sometimes known as this, may be calculated using the formula below.;

$$K = F / D \qquad (1)$$

K stands for the object's energy, D for the outcome of the change, and F for the applied force. Therefore, equation (1) states that there is a connection between external mobility and stiff structures.

II. PROBLEM STATEMENT

This project's main goal is to assess the seismic performance of steel structures with shear walls in various locations. This involves assessing the behaviour of the building using the equivalent static analysis approach. Additionally, a response spectrum analysis was carried out to look at the dynamic behaviour. Using the ETAB programme for modelling and analysis.

1) Response Spectrum Analysis
2) Time History Analysis
3) Pushover Analysis

MODEL -1	SHEAR -WALL AT CORNER
MODEL -2	SHEAR -WALL AT BUILDING FACE
MODEL -3	SHEAR -WALL AT CORE
MODEL -4	WITHOUT SHEAR -WALL

III. METHODOLOGY

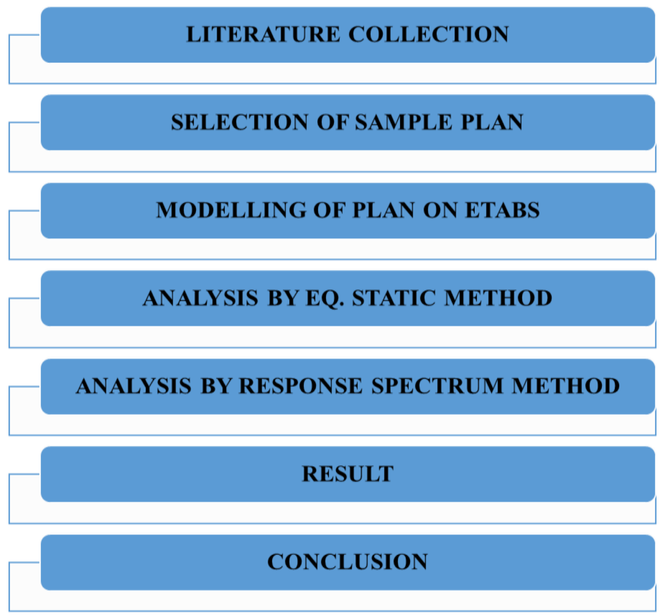


Fig 2 Flow Chart

IV. MODEL DESCRIPTION

Table 1 Model Description

Stories	G+15
Total Height	49.5m
F to F Height	3 m
L And W of building	18m X 18m building size
Size of Beam	ISMB 500
Size Of Column	ISMB 600
Slab Thickness	S150 mm
Shear Wall Thickness	W200 mm
Location	Pune
Seismic Zone	Zone IV
Basic Wind Speed	39 Km/h
Response Reduction Factor	5.0
Importance Factor	1
Grade Of Concrete	M 30
Grade Of Steel	Fe345
Density Of Concrete	25 KN/m3
Supports at base	Fixed
Diaphragm	Semi Rigid
Load Description	DL-Dead Load LL-Live load SDL- Super Dead load EQX- Earthquake in X direction EQXN- Earthquake in X Negative direction EQY- Earthquake in Y direction

	EQYN- Earthquake in Y Negative direction Response spectrum Time History Analysis Pushover Analysis

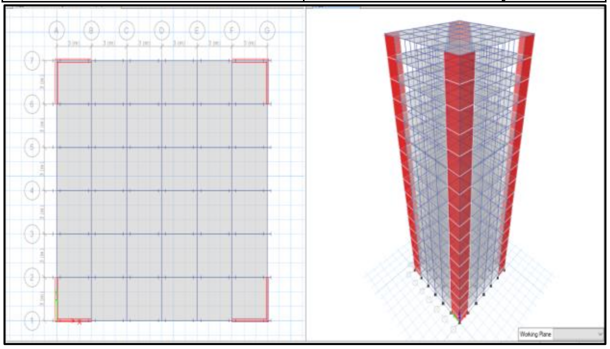


Fig 3 Model 1 - Shear Wall At Corner

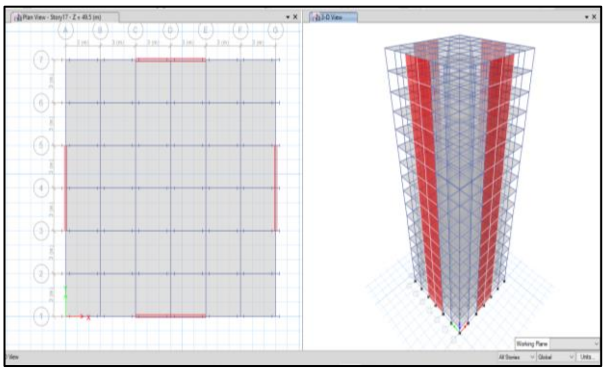


Fig 4 Model 2 - Shear Wall At Building Face

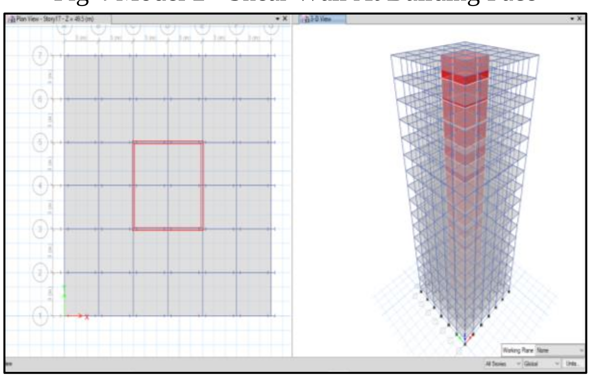


Fig 5 Model 3 - Shear Wall At Core

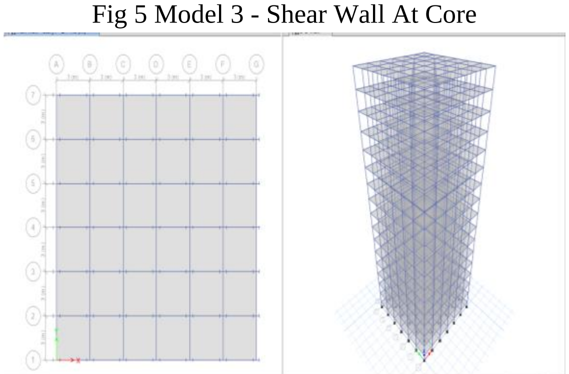


Fig 6 Model 4 – Without Shear Wall

V. RESULT AND DISCUSSION

1) Results for Response Spectrum Analysis

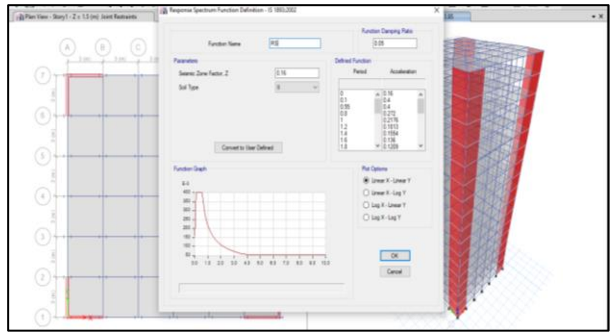
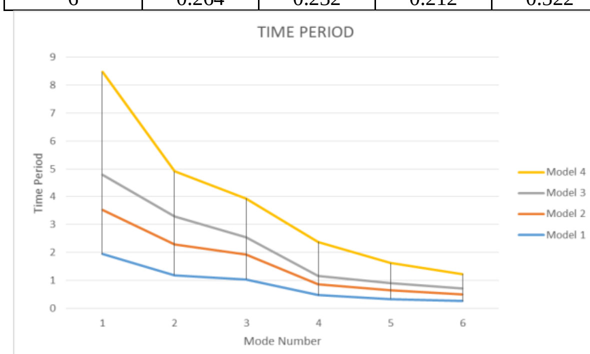


Fig 6 Response Spectrum Analysis

Table 2 Time Period

TIME PERIOD				
MODE NO	Model 1	Model 2	Model 3	Model 4
1	1.95	1.585	1.253	3.679
2	1.189	1.115	0.995	1.608
3	1.047	0.879	0.634	1.378
4	0.48	0.395	0.289	1.224
5	0.343	0.309	0.253	0.727
6	0.264	0.232	0.212	0.522



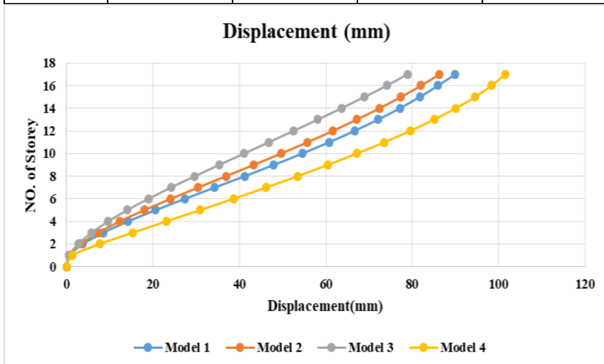
Graph 1 Time Period

We can see from the table and graph above that model 3 has fewer % variance for time period for response spectrum analysis than models 1 and 2. The model with the Shear Wall at the Core is shown to have a 10-15% lower variation than the other 2 models.

Table 2 Displacement (mm)

Displacement (mm)				
Storey	Model 1	Model 2	Model 3	Model 4
0	0	0	0	0
1	0.633	0.583	0.532	1.296
2	3.723	3.25	2.665	7.618
3	8.424	7.288	5.746	15.207
4	14.177	12.302	9.583	23.058
5	20.586	17.983	14.02	30.904
6	27.362	24.093	18.92	38.628
7	34.287	30.443	24.169	46.157
8	41.199	36.887	29.664	53.443
9	47.972	43.308	35.316	60.453
10	54.511	49.613	41.048	67.16
11	60.742	55.728	46.793	73.528
12	66.61	61.594	52.492	79.515

13	72.078	67.169	58.099	85.062
14	77.131	72.431	63.603	90.095
15	81.744	77.38	68.935	94.549
16	85.956	82.028	74.093	98.353
17	89.891	86.275	78.857	101.524

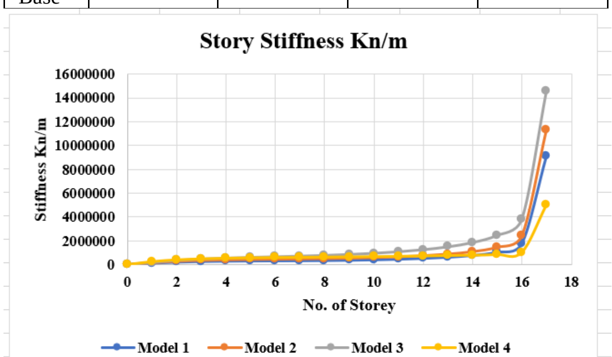


Graph 2 Displacements (mm)

The percentage change of the model 3 response spectrum analysis is less than that of the models 1, 2, and 4, as shown in the table and figure above. Compared to the other 2 models, the core shear wall model's variance is 5–10% lower.

Table 3 Story Stiffness Kn/m

Story Stiffness Kn/m (x10^5)				
Storey	Model 1	Model 2	Model 3	Model 4
17	116462.77	155499.88	187717.02	249718.28
16	201850.41	274325.68	348672.19	399316.33
15	250946.76	347553.74	462056.28	482392.17
14	278662.21	391952.96	539503.77	533076.62
13	295437.38	422912.75	600923.00	566082.72
12	305325.63	445203.82	653715.73	589532.63
11	315266.07	467043.75	707673.85	608438.93
10	330414.27	494023.49	769788.40	626454.99
9	354377.24	530457.89	847120.94	646167.95
8	390354.84	580457.35	946651.51	668985.30
7	441398.38	648647.89	1076154.3	695082.61
6	511153.25	741632.66	1248147.5	723802.20
5	608717.25	873615.11	1487381.2	754613.89
4	758660.90	1079357.5	1846369.9	789348.44
3	1031518.5	1455658.7	2457840.3	842485.68
2	1745213.2	2405328.4	3798401.2	1027638.5
1	9072532.	11283217	14584030.3	5026508.54
Base				



Graph 3 Story Stiffness Kn/m

We can observe from the aforementioned table and figure that model 1's response spectrum analysis resulted in a lower percentage change in floor stress than models 2 and 3. Compared to the other two models, it has a 5–10% smaller change.

2) Time History Analysis Results

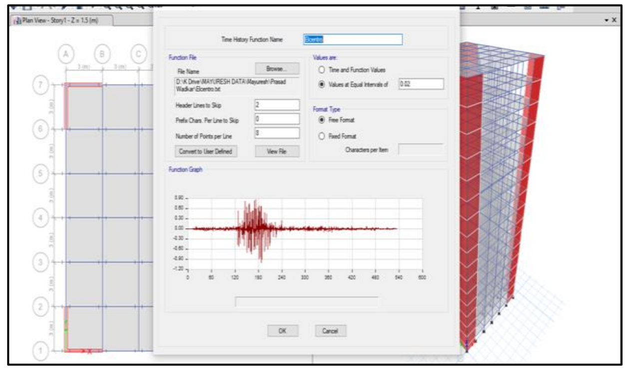
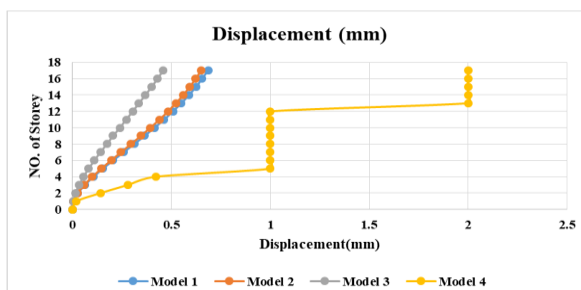


Fig 7 Time History Analysis

Table 4 Displacement

Displacement (mm)				
Storey	Model 1	Model 2	Model 3	Model 4
0	0	0	0	0.00
1	0.005	0.00475	0.003	0.02
2	0.027	0.02565	0.015	0.14
3	0.062	0.0589	0.033	0.28
4	0.105	0.09975	0.055	0.42
5	0.153	0.14535	0.081	1.00
6	0.205	0.19475	0.11	1.00
7	0.258	0.2451	0.141	1.00
8	0.311	0.29545	0.173	1.00
9	0.364	0.3458	0.205	1.00
10	0.414	0.3933	0.239	1.00
11	0.463	0.43985	0.271	1.00
12	0.508	0.4826	0.304	1.00
13	0.55	0.5225	0.336	2.00
14	0.589	0.55955	0.368	2.00
15	0.624	0.5928	0.4	2.00
16	0.655	0.62225	0.43	2.00
17	0.685	0.65075	0.458	2.00



Graph 4 Displacement

Model 3 has smaller displacements for Time History Analysis than Models 1 2 and 4. The model with Shear Wall at Core is shown to have a variation that is 5–10% lower than the other 3 models.

3) Pushover Analysis Results

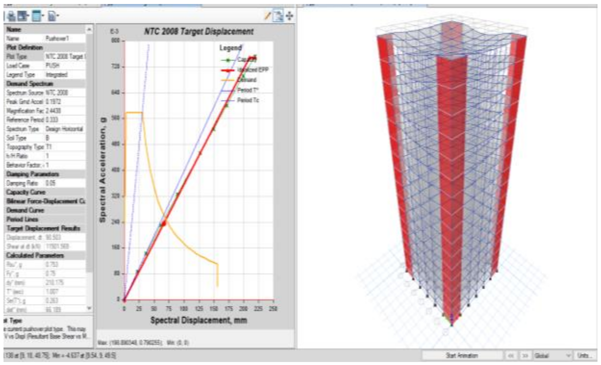


Fig 8 Model 1 - Pushover Analysis Results

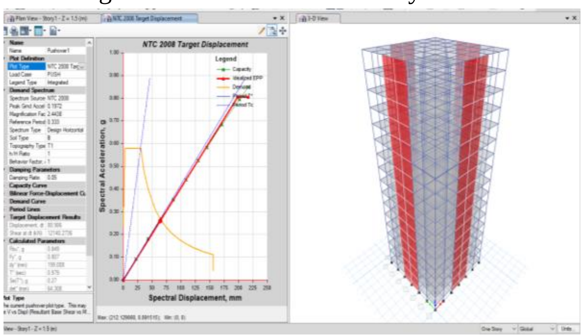


Fig 9 Model 2 - Pushover Analysis Results

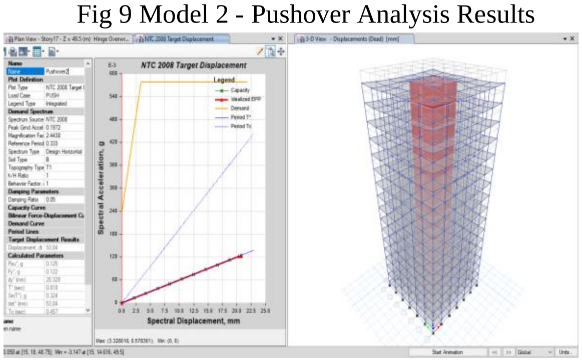


Fig 10 Model 3 - Pushover Analysis Results

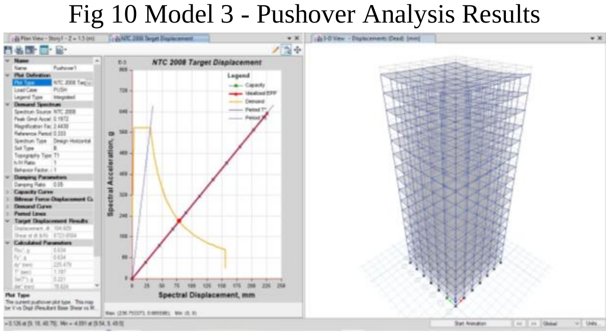
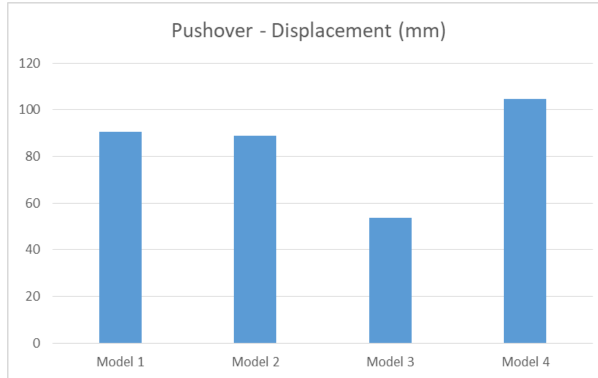


Fig 10 Model - Pushover Analysis Results

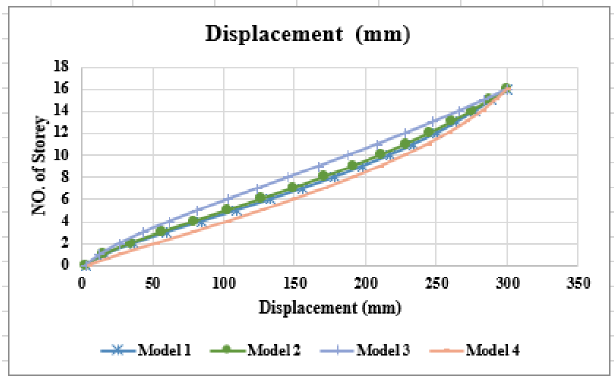
Table 5 Pushover - Displacement (mm)

Displacement (mm)			
Model 1	Model 2	Model 3	Model 4
90.5	88.98	53.84	104.6



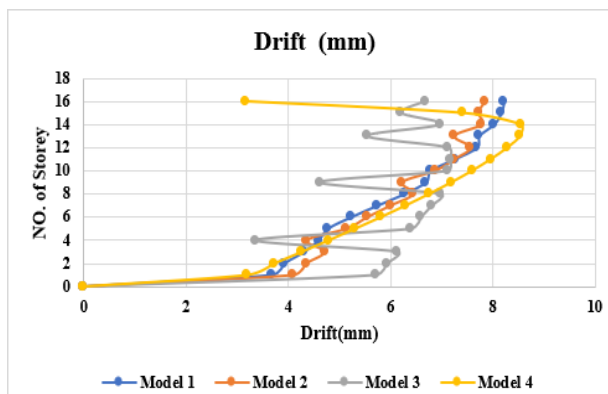
Graph 5 Displacement

Model 3 has lower displacements for the pushover analysis than Models 1, 2 and 4th. Compared to the other 3 models, the variance is shown to be 25–30% lower for the model with a shear wall at the core.



Graph 5 Pushover - Storey Displacement (mm)

Model 3 has lower displacements for pushover analysis than Models 1, 2 and 4. Compared to the other 3 models, the variance is shown to be 40–45% lower for the model with a shear wall at the core.



Graph 6 Pushover - Story Drift (mm)

Model 3's Story Drift for Pushover Analysis is lower than that for Models 1, 2, and 4. Compared to the other 3 models, the variance is shown to be 20–25% lower for the model with a shear wall at the core.

VI. CONCLUSION

The project's primary goal is to assess the seismic performance of steel structures with shear walls at various sites. To do this, the behaviour of the structure is assessed using a dynamic approach of study. The response spectrum technique of analysis is also used to examine the dynamic behaviour. Various shear wall sites, including shear walls at corners, building faces, and cores, are used in modelling and analysis utilising the ETAB programme. The floor share results for all scenarios were maximal for the first level and minimal for the top floor, according to the FEA data. The first floor showed the least amount of drift and displacement, which in all cases increased at the top floor. The research leads to the conclusion that models 3 (shear wall at core) are each more effective than models 1, 2, and 4, respectively. According to our study and IS: 1893-2016, a floor is considered to be a "soft story" if its stiffness varies by 30% from neighbouring floors. When all models were evaluated, no soft tales were discovered. All findings from the debate that follows are completed:

- Compared to Models 1, 2, 3 and 4, Model 3 has a lower percentage variance for the time period for the response spectrum study. For the model with the shear wall at the core, the variance is determined to be 10-15% lower than for the other 3 models.
- Compared to models 1, 2, 3 and 4, model 3 has a lower percentage fluctuation of displacement for the response spectrum analysis. Compared to the other 3 models, the shear wall model's variation is shown to be 5–10% lower.
- Compared to models 1, 2, 3 and 4, model 1's response spectrum analysis tale drift % variation is lower. The model with the shear wall at the corner is determined to have a variance that is between 5 and 10% less than the other 3 models.
- Compared to Models 1, 2, 3 and 4, Model 1 has a lower percentage variance in narrative stiffness for reaction spectrum analysis. The model with the shear wall at the corner is found to have a variance that is 5–10% lower than the other 3 models.
- Compared to Models 1, 2, 3 and 4, Model 3 has reduced displacement for time history analysis. The model with the shear wall at the core is found to have a variation that is 5–10% lower than the other 3 models.
- Compared to models 1, 2, 3 and 4, model 3's tale drift for time history analysis is lower. The model with the shear wall in the core is shown to have a 10-15% lower variation than the other 3 models.
- Model 3 has less displacement for pushover analysis than Models 1 and 2. Compared to the other 2 models, the variance is shown to be 25–30% lower for the model with the shear wall at the core.

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