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Shear Wall Placement in an Anomaly of Multiple Stories Proves Effective

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Abstract - Challenges have arisen in the pursuit of greater heights and more complex buildings. Building height enhances the importance of the structure's rigidity. The dominance of lateral loads has led to increasingly tall constructions being subjected to peculiar loading effects and extremely high loading values. Tall structures must be designed with durability, functionality, stability, and occupant comfort in mind. This means that practically every designer must solve the issue of providing sufficient strength and stability against lateral stresses, such as wind loads and seismic forces. A shear wall is a plate-like structural element used in a building structure to withstand lateral stresses, such as those caused by an earthquake or high winds. It's useful for construction from the basement up to the roof. At order to make a structure more earthquake-proof, shear walls may be installed in strategic positions around the building's perimeter. The purpose of this work is to compare and contrast three distinct models of 'H'-shaped plans, two of which include shear walls at various locations, with a third that does not include such walls. Based on these comparisons, the best-performing model is determined. ETABS 2016 was used for all the calculations.

Keywords - Shear wall, irregular plan, earthquake forces, ETABS etc.

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INTRODUCTION

Even in supposedly technologically advanced places like Bangalore, India, the population has outstripped the ability of the city's infrastructure to provide for its residents' transportation, water, and waste needs. As revealed in research by the World Bank and the United Nations, by 2050, over 200 million people living in India's urban areas would be vulnerable to natural disasters including storms and earthquakes. Nearly two-thirds of India's population lives in a high-risk zone for earthquakes. Building an earthquake-resistant building using materials with unique properties, such a shear wall, is a minimum need for protecting the lives of these individuals. Shelter for a populous nation requires skyscrapers. For improved speed of construction, resistance to lateral dynamic forces, and security, shear walls have been shown to be the superior choice. However, shear wall construction plays a crucial role in creating earthquake resistant structure in which lateral stability and uniformity of response of structures towards lateral dynamic stress are maintained. If a multistory structure is made of reinforced concrete (RCC), adding a shear wall may greatly improve its performance. A shear wall's effectiveness decreases with increasing size. High-rise buildings benefit greatly from the use of shear walls since they are both practical and cost-effective.

There are numerous competing needs and intricate architectural systems to coordinate, making tall buildings the most difficult to construct. Thinner and more delicate tall structures constructed today may be more likely to waver in the wind than their bulkier forebears. Therefore, it is crucial that the design take into account the effects of wind and seismic forces. Vertical and horizontal loads exerted on reinforced concrete framed structures can be adequately resisted. The installation of a shear wall system is one of the most effective ways to ensure the lateral stability of tall structures in the face of lateral stresses such as wind and seismic forces.

Numerous research in the field of structural health monitoring have spent the past two decades investigating the ways in which modal parameters change. Changes in the values of these parameters, which characterize the dynamic behavior of a structure, may be indicative of aberrant behavior or damage to the structure.

Modal parameters have been demonstrated to vary depending on the severity of structural damage after high-intensity earthquakes in previous research. Modal frequencies, for example, have been shown to exhibit persistent fluctuations from 11% for buildings with little damage (Clinton, Bradford, Heaton, & Favela, 2006) to over 30% for structures with extensive damage.

Shear wall and bracing placement for a structure exposed to pseudo static (seismic) stresses is the primary focus of this article. STAAD-PRO V8i performs a TIME HISTORY analysis on the structure. Examining the maximum bending moment, shear force, and story drift.

LITERATURE REVIEW

Tajzadah, Jawid & Desai, Proff& Agrawal, Vimlesh. (2019) When analyzing and designing tall RCC structures, lateral loads take center stage. Stiffness, rather than strength, becomes more significant than strength when it comes to bearing lateral loads, which rises with building height. The increased in-plane stiffness and strength of a shear wall makes it an efficient structural structure. To lessen the moment and shear demands of different structural parts, it bears the seismic and wind loads by a combination of axial-shear-bending action and draws most of the lateral stresses. Shear wall placement and orientation in a building's structural system is a crucial factor in the system's resistance to lateral stresses during a seismic event. When a building's shear wall is placed incorrectly, it creates eccentricity, which is the primary source of the torsion system. By simulating and evaluating a variety of building configurations with and without shear walls, the authors of this research hope to determine the ideal placement of shear walls in reinforced concrete structures. Using ETABS software, we designed a G+9 RC structure with a variety of shear wall configurations (i.e. shear wall around core, shear walls in inner bays of the building, shear walls at building periphery and the final case is the building corners). Base shear, top-story displacement, wing drift, and time period are some of the metrics that have been examined between each model and the Bare Frame.

Rokanuzzaman, m & khanam, farjana & das, anik & chowdhury, sharmin. (2017) When it comes to high-rise structures, shear wall systems are among the most popular options for resisting lateral loads. Locating the shear wall where it will do the best is crucial. The purpose of this study is to examine how the placement of shear walls in high-rise buildings affects their stability. In this case, we'll be talking about a residential building with a normal floor height of 10 feet, a G+15 (sixteen-story) construction, and a base size of plan 49.25 feet by 49.25 feet. Eight-, ten-, twelve-, fourteen-, and sixteen-story structures were designed in this paper's software, and three models were analyzed for crucial parameters including displacement and base shear under lateral loading, with and without shear walls in the frames. ETABS 9.6.0 was used to do the analysis, and the corresponding static approach was applied to the data. The absence of a shear wall, a shear wall in the center of all four lateral sides, and a shear wall at each of the four vertices of an L-shaped model have all been studied. Results demonstrate that Model 2 (with shear wall situated in the center of four peripheral sides) performs best in terms of both top displacement and base shear.

Dipika N. Khandelwal, Monica S. Mhetre(2017) In seismically active areas, when shear pressures on a structure rise owing to earthquake loads and/or the wing load effect, shear walls are the structural elements intended to resist these lateral forces. Structures that must withstand earthquakes often rely on shear walls for the massive strength and stiffness they give, as well as the deformation capacity they provide. Typically, a building's gravity loads are resisted by a moment-resisting framed structure, while lateral stresses are resisted by RC shear walls. In terms of strength, stiffness, and resistance to in-plane stresses operating along its height, constructions with shear walls have shown to be superior to those without during historical earthquakes. The optimal shear wall height and placement in a tall building construction are analyzed and summarized in this work.

Riya Novlekar, Pratibha Choudhary, Divya Patre, Barkha Verma (2014) Buildings may be made more rigid by the use of shear walls, which offer the required lateral strength and stiffness to withstand horizontal forces. The structural behavior of shear walls under lateral stresses is greatly impacted by their form and placement. Dynamic study of the building's reaction to shifting shear wall positions. IS 1893 (PART-1):2016 Method Analysis Several models have been examined, each with a different shear wall at a different position, all of which are exposed to the same zone IV seismic stress.

BUILDING MODELLING

A regular-in-plan, 50-story structure was designed for this analysis, with each floor being 3.5 meters in height. The Indian Code of Practice for Seismic Resistant Design of Buildings was followed throughout the design process of these structures. It was supposed that the structures were anchored at their foundations. STAAD Pro was used to create the building models. All of the structural models were analyzed in all four zones, contrasting their lateral displacement and base shear.

Model 1 – Framed structure.

Model 2– The building with shear walls one on each side.

Model 3– The building with shear walls on corner.

Model 4– The building with shear walls at Centre.

Table 1: Preliminary data for the building.

No. of stories	50
Floor to Floor Height	3.5 m
Beam size	450x900 mm^2
Column size	900x2000 mm^2

Thickness of slab	200 mm
Thickness of Wall	230 mm
Shear wall	450mm
Grade of Concrete and steel	M40 and Fe500

3-D Models of the buildings.

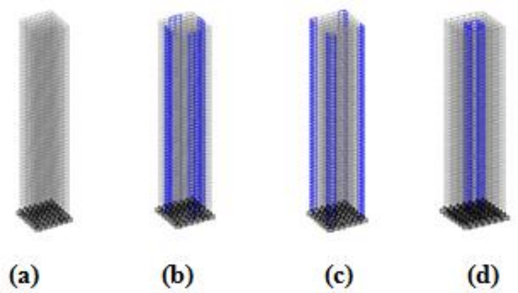

Figure 1: (a) model (b) model-2. (c) model-3 (d) model-4

METHODOLOGY

As specified by IS 875. 1987, both dead and live loads are applied to the structure. This multi-story home must be designed to withstand earthquake and wind forces in accordance with Indian Code of Practice IS 1893 (Part 1): 2002 and IS 875 (Part 3): 1987. We use the load combination specified by IS 456: 2000 to determine the forces acting on the members. The irregular multi-story "H" form plan was adopted for this study. In the case of a tall, uneven structure, the time history approach produces the most accurate results. Using real ground acceleration data in the "X" and "Y" direction during earthquake analysis with time history analysis enables a more accurate and rapid evaluation of the building's condition. So, it was decided to use this approach of analysis.

ANALYSIS RESULT

Below, you'll find the results of a study performed on every model that accounts for every possible placement of shear walls. Researchers looked examined the effects of several variables on building behavior when subjected to seismic stimulation. When considering time period, base shear, and narrative rigidity.

Table 2: Natural Time Period

Mode no	Model 1 sec	Model 2 sec	Model 3 sec
Mode 1	3.677	2.66	2.615
Mode 2	3.572	1.877	2.553
Mode 3	3.44	1.626	1.784
Mode 4	1.219	0.756	0.631
Mode 5	1.183	0.465	0.626
Mode 6	1.139	0.375	0.373
Mode 7	0.701	0.362	0.272
Mode 8	0.688	0.277	0.272
Mode 9	0.662	0.242	0.159
Mode 10	0.49	0.222	0.159
Mode 11	0.481	0.219	0.155
Mode 12	0.463	0.218	0.108

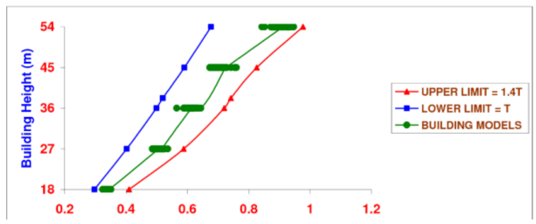

Figure 2: Natural time period V/S Mode

Maximum values for natural times were found in Model 1 and lowest values in Model 3 (see picture above), where stiffness was shown to be inversely related to the square root of natural times. Natural time period drops from Model 1 to Model 3 due to the increased stiffness of the structure caused by the shear wall.

Table 3: Story Displacement

Story	Model 1 mm	Model 2 mm	Model 3 mm
Story20	168.055	127.542	117.795
Story19	165.711	122.504	111.313
Story18	162.302	117.17	104.686
Story17	157.875	111.488	97.916
Story16	152.539	105.405	90.992
Story15	146.401	98.907	83.924
Story14	139.563	92.007	76.735
Story13	132.121	84.739	69.462

Story12	124.167	77.155	62.149
Story11	115.787	69.319	54.854
Story10	107.061	61.311	47.642
Story9	98.063	53.218	40.584
Story8	88.861	45.143	33.762
Story7	79.519	37.202	27.262
Story6	70.092	29.526	21.181
Story5	60.63	22.271	15.621
Story4	51.179	15.616	10.694
Story3	41.76	9.776	6.522
Story2	32.294	5.013	3.239
Story1	21.657	1.656	0.998

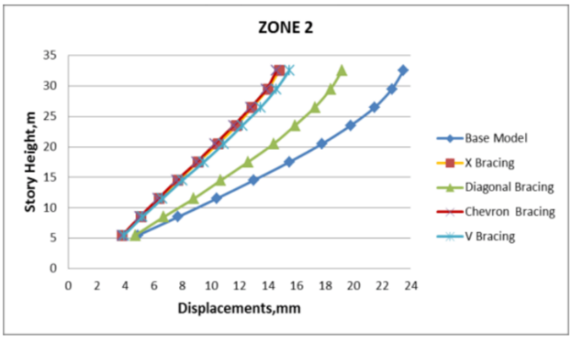

Figure 3: Comparison of maximum story Displacement

The greatest amount of movement shown in Model 1. Model 1 failed in story displacement because the sum of the maximum story displacements from stories 1 through 4 was more than the maximum value permitted by the code. Model 3 showed the least amount of movement; hence it is expected to function best during seismic excitation.

Table 4: Story Stiffness

Story	Model 1 kN/m	Model 2 kN/m	Model 3 kN/m
Story 20	220533.9	137834.5	141797.4
Story 19	296823	246216.1	272392.4
Story 18	329166.7	333054.2	383411.8
Story 17	347507.7	396464.7	473492.5
Story 16	359406.2	441268	546784.8
Story 15	367850.5	473195.6	606734
Story 14	374261	496609.5	656900.4
Story 13	379417.8	514758.5	700553.1
Story 12	383790.9	530095.5	740660.9
Story 11	387686.4	544591.3	780047.7
Story 10	391318.4	559976.6	821637.6
Story 9	394846.9	578098.7	868786.7
Story 8	398399.6	601182.7	925815.4
Story 7	402084.7	632392.4	999044
Story 6	405993.2	676797.9	1098696
Story 5	410168.5	743512.8	1243315
Story 4	414136.9	851296.2	1471295
Story 3	413628.5	1049171	1877362
Story 2	368344.6	1516874	2816446
Story 1	181258.1	2710758	6182560

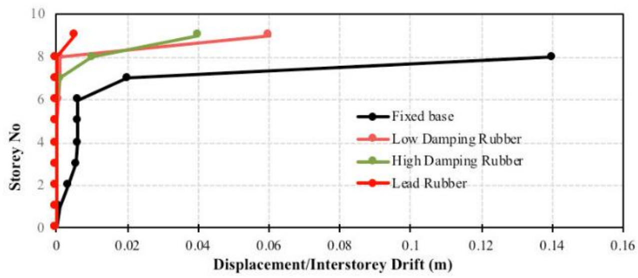

Figure 4: Comparison of maximum story stiffness

With the exception of Model 1, all of the other models met the required level of torsional stiffness as specified by the IS code, as seen in the chart above. In this instance, model 1's 11th-story soft tale situation arises. Model 3 has the highest measured stiffness, making it the most responsive.

CONCLUSION

This research was conducted to evaluate and contrast the seismic resistance of two different 20-story H-shaped irregular R.C framed building plans.

Model 1's value for the natural time period is the highest observed; model 3's is the lowest. Model 1 takes 1.4 times as long to complete as Model 3. If this is true, then Model 1 construction is more adaptable than previous methods. Model 1 is the only one where the value of the story displacement above the maximum allowed by the IS 1893 regulation. From the ground floor to the fifth floor, model 1's values are too high. According to IS 1893, the stiffness of a structure determines how flexible or rigid a given narrative is. The stiffness of stories also behaves differently while moving from the top tale to the bottom story. An empty storey structure and one with shear walls in various locations were examined. The above result demonstrates that Model 1 has a larger top displacement than the other models. Having shear barriers in situ may help limit vertical movement. In earthquake zone 2, the top displacement of Models 2 and 4 is each 3 percent less than that of Model 1 and 18 percent smaller than that of Model 4.

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