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SEISMIC BEHAVIOUR OF RC DUAL FRAME SYSTEM FOR REGULAR STRUCTURE

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Abstract:
From the past study it has been observed that various studies were done on design of shear wall and its behaviour in different seismic zones. In this thesis the study was done on dual structural system for regular building 25 storeys in the earth quake zone-V. Concrete shear wall are used to resist the lateral displacement for earth quake vibrations. First shear wall are placed around the building as periphery walls, then the position of shear wall is being changed with same thickness and study was carried out with this dual system how the building behaves in the form of Time period, displacement, storey drift, and base shear.
Keywords: Dual system, Equivalent static analysis, shears wall, storey drift, Lateral displacement.

Introduction:

As the country's population and economy continue to expand rapidly, India will need to expand its infrastructure to meet the rising demand. The need for land in populated areas is always growing. We must preserve arable land for farming and agriculture. Vertical development is the only viable solution to meeting the land requirement in these areas. Additional lateral stresses from wind and earthquakes pose difficulties for this sort of construction. Because of this, the present structural structure has to undergo modifications in order to stand up to these pressures. The effectiveness of different lateral load resisting systems against deformation and shear imposed by earthquake and wind forces has been the subject of much study.

The idea behind the dual system is to increase the resistance to lateral stress by using two separate systems. In frames and wall systems, when intelracted forces affect shape of shear, deformation shape will be different. The frames help to stabilize the upper wall and limit any movement, which is a great feature of this setup. Frames are less likely to move when propped against a wall.

All structural systems utilized in buildings exist to sustain gravity loads, and this is their principal function. Dead load, live load, and snow load are the three most frequent types of loads caused by gravity's pull. Buildings are not only susceptible to these vertical pressures, but also to lateral loads brought on by the wind or an earthquake, which may lead to the development of excessive stress and, in turn, to lateral sway movement or vibration.

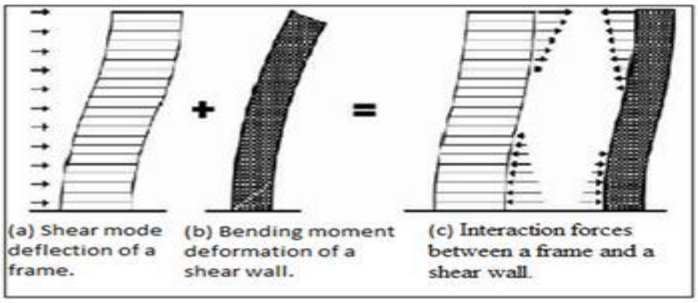


Fig-1 Dual structural system

The shear walls and moment resistant frame of a dual system building. They are constructed to withstand the combined lateral force of their design. High-rise structures often have the necessary stiffness and strength to sustain lateral loads thanks to the combination of shear walls and frames. When combined, 2 systems must be able to withstand the total lateral load in a way that is proportional to their respective rigidities, & moment resistant frames should be able to withstand minimum 25% of base shear.

Classification Of Shear Wall : Cross sections for shear walls may range from the standard square or rectangle to more complex geometries like a T, L, barbell, box, etc. The construction of walls is useful for sectioning off an area and the installation of cores is useful for housing and transporting utilities like elevators. Wall apertures are necessary for windows in outside walls, doors or corridors in interior walls, and lift cores in the center of buildings. Architecturally and practically, apertures may be any size or placed anywhere. In recent years, shear wall structure has been more popular for use in construction of high-rise buildings, such as service apartment or office/commercial towers. Shear walls made of reinforced concrete come in a wide variety of designs.

1. Simple rectangular types
2. Coupled shear wall
3. Rigid frame shear wall
4. Framed wall with In filled wall
5. Column supported shear wall
6. Core type shear wall

In the last 20 years, shear walls' application in mid- and high-rise construction has skyrocketed. Because of their increased vulnerability to lateral loads and seismic stresses, they are of essential importance in tall structures. As a structure rises in height, the importance of its lateral stiffness in withstanding earthquake and wind loads grows. Shear wall construction, where the walls have relatively high in-plane stiffness to withstand lateral stresses, may provide this rigidity.
In the case of tall structures and lifts, the shear wall is the most efficient lateral force-resisting device. Buildings need shear walls to withstand the lateral forces that result from earthquakes.
Over the last two decades, shearwalls' application in mid- and high-rise structures has skyrocketed. Because of their increased vulnerability to lateral loads and seismic stresses, they are of essential importance in tall structures. As a structure rises in height, the importance of its lateral stiffness in withstanding earthquake and wind loads grows. Shear wall construction, where the walls have relatively high in-plane stiffness to withstand lateral stresses, may provide this rigidity.

LITERATURE REVIEW:

2.1 Krishna Mahajan, Ketan Jain: Design of shear walls and their performance in various zones has been the subject of a wide range of studies. In this research, we conduct an in-depth analysis of a dual structural system for a multi-story structure with an irregular design (G+18) in Indore's zone III. To prevent buildings from sliding laterally due to seismic vibrations, engineers use concrete shear walls. Analysis is performed with various shear wall thickness for different models, and shear walls are put as perimeter walls, around the lift core, and next to the stairs. The analysis also pays close attention to the building's structure.
2.2 Sumit Pahwa , et.al: This Project includes a thorough discussion of the structural analysis of a building for explaining application of shear walls in highly seismic areas (zone-5), as well as analysis of a symmetrical frame having a 30-story building with and without shear walls under varying soil conditions. This project uses the building design analysis program STAAD.Pro to create a multi-story structure.
2.3 Rajan Suwal1, et.al: Moment-resisting frame and shear walls, which are vertical walls of reinforced concrete, make up a dual structural system. Elevator cores and stairwells are typical places for shear walls in high-rise structures. The placement, form, quantity, and arrangement of shear walls in a tall structure may take many different forms.
Through a review of the relevant literature, this work aims to determine how factors such as shear wall location, height, and thickness affect the behavior of multi-story structures.
2.4 MS. Kiran Parmar Prof. Mazhar Dhankot: This research examines the differences and

similarities between 3 diverse kinds of dual lateral load resisting systems used in high-rise structures. In this research, we focus on a pair of systems utilized in multi-story buildings to withstand lateral stresses (wind and earthquake).
The results demonstrate the effectiveness of the dual system in resisting lateral loads over a range of building heights. To conduct this analysis, we employ electronic tabulation software. This research examines these systems analytically to see how well they fare against deformation at varying heights.
2.5 Dr. Vijaya G. S, Vinodhini S: In this research, the structural behavior of a multi-story, regular-shaped structure with a connected shear wall and bracings is the primary focus. We do lateral load analysis on regular and mass reduction models, as well as soft storey and linked shear wall models. We take into account a variety of building heights, from 30 to 50 stories. ETABS was used for the aforementioned study. The seismic response, axial force, shear force, bending moment, and soft storey and mass reduction and V and X bracing models for 30, 40, and 50 story buildings are analyzed. As a building's height grows, so does the axial force acting on it. Models with a softer storey or less mass have less axial force. The regular model is the stiffest of the three. The axial forces and bending moments in columns were both significantly decreased by using the V bracing model. Displacements between floors were well within acceptable parameters.
2.6 **Mamatha L, et.al:** The purpose of the present finite modeling research is to analyze the structure with and without floating columns, with both regular and I-shaped horizontal and vertical irregularities, and with both bare moment resisting frames and brick infills considered for shear walls. To investigate how different models react when column flotation occurs due to loadings. And using the same models, we construct and examine thick shear walls made of M25 grade concrete. We compare the results of the study using the response spectrum approach with the linear or equivalent static method. In order to assess the models, we use E-Tabs 2015. Built-in plot graphs record maximum storey displacement, inter-storey drift, and shear at each story.
2.7 P. S. Kumbhare, et.al: The purpose of this project was to look at how efficient RC shear walls are in medium-rise structures. With two different structural systems in mind, we conduct an earthquake analysis of a residential medium-rise structure. Frame system and Dual system, to be specific. Using these four models, we can examine the shear wall's effectiveness in further detail. 1st model is a bare frame system, whereas the next four are dual type systems. We use the popular analysis program ETAB. By switching out the column for a shear wall, we can examine how these models fare over a range of parameters.
2.8 Gajagantarao Sai Kumar, et.al: The primary goal of this study is to assess and construct a building having shear wall, and to locate shear wall such that the building resists lateral pressures as well as possible while experiencing as little movement as possible. Here, we use ETABS to create a model of a seven-story skyscraper with a floor plan of 15 by 20 meters. Manual solution and ETABS verification confirmed the accuracy of the produced model. After that, four unique models of earthquake-prone buildings were constructed in ETABS. These blueprints include four distinct shear wall installations across the structure. These buildings were the subject of seismic, vibration, and response spectrum testing. We used the ETABS model to calculate key characteristics such storey stiffness, storey displacement, and storey drift. We compared them to the results we got from a frame with no shear walls. The optimum design is proposed for this site with the shear wall having least lateral storey displacement and greatest stiffness by comparing the findings obtained at various shear wall positions.
2.9 Ambika-Chippa, Prerana-Nampalli: The purpose of this research was to examine the similarities and differences between seismic analysis and design for RC moment resistant space frames and shear walls. We choose to examine two distinct examples involving moment-resisting frames and dual-system designs. Different heights (G+4), (G+6), (G+8), and (G+10) were considered for both bare and brick-infilled frames of varying bay sizes (2x2), (3x3), (4x4), (5x5), and (6x6), and for the dual system, a (5x5) bay at the (G+8) storey was considered for both a frame with and without a shear wall subject to the same loading. In order to study and design the frame, we used STAAD ProV8i software and

referred to the International Standards (IS) 456-2000, IS: 1893 (Part-1)2002, and IS: 13920-1993. It is possible to determine prices and the underlying economic structure using this information.

2.10 Md mustaq, divya Bharathi: Buildings with the best possible outcomes in terms of optimal sizing and reinforcing of the structural elements, particularly beam and column members in multi-bay and multi-storey RC structures, are gaining importance in the current construction industry landscape. Aside from saving money over more conventional design options, optimum size also takes into account the best stiffness co-relation between structural elements. The term "optimization" refers to enhancing something to its maximum potential.

This work was performed on a G+20 commercial structure, using the following structural systems with and without shear walls:

- Only frame.
- Frame with shear walls.
- Frame with shear walls and shear core
- Frame with only shear core

OBJECTIVES AND SCOPE OF WORK

3.1 OBJECTIVES:

1. The purpose of this research is to: • Understand how a typical building with G+24 storeys reacts to earthquake force in seismic zone-V.
2. Utilizing the Equivalent Static approach, do a seismic study on a G+24 storey building.
3. Evaluate variations in seismic zone-V parameters from a variety of shear wall locations.

3.2 SCOPE OF WORK:

1. RC framed structures were modelled.
2. The infill wall's bulk was taken into account.
3. Using the seismic zone factor in relation to the shear wall's location, we can evaluate to get an overall picture of the seismic event.
4. Each model's behaviour is validated for seismic forces such Base Shear, Time Period, Story Drift, and Story Displacement at every level.
5. Seismic zone V is where the shear wall is most prominent, as seen in the research.

METHODOLOGY

Finding the best location for the shear wall (Dual system) to accomplish this goal of minimizing the building's lateral displacement is the focus of this thesis. In order to do this, we used the following strategy.

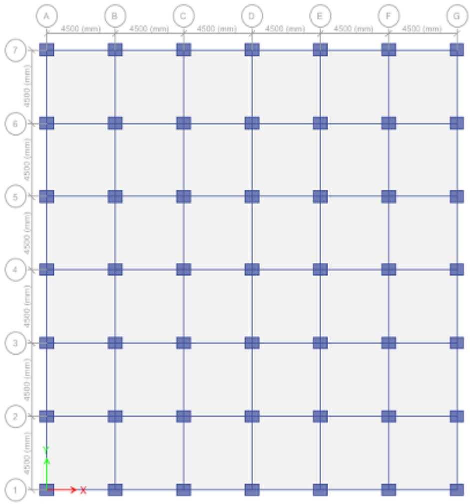
1. The influence of the shear wall's location has been researched in several literatures.
2. To investigate how shear walls affect the behavior of buildings under lateral stress, we use buildings with middle and high rises.
3. We have evaluated many models with and without shear walls. The ideal location for the shear walls is determined by testing them in several parts of the building, such as the central core, the corners, and the perimeter, with the goal of minimizing the lateral displacement of the building.
4. The effects of shear walls in seismic zone V are the primary topic of this research. The use of equivalent static analysis for structural analysis is becoming more common. For modelling, we use Etabs. To determine which structure is the most earthquake-resistant, we may use four parameters—story displacement, story drift, period, and base shear—to evaluate the effectiveness of each model.

DESCRIPTION OF MODELS:

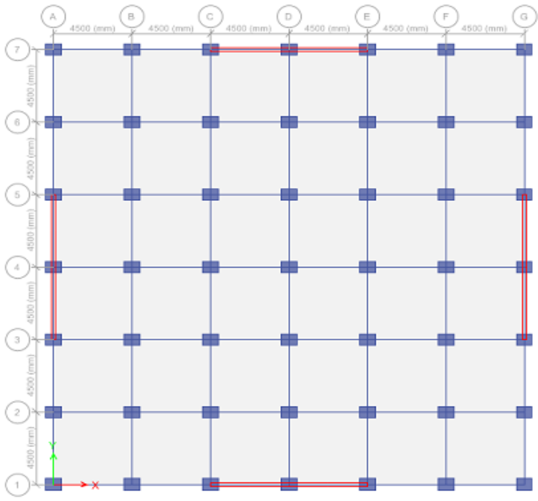
A total of 6 models were prepared for seismic study of RC regular.
Model-1: A RC framed building without dual system.
Model-2: A RC framed building with dual system (Position of shear wall at periphery)
Model-3: A RC framed building with dual system (Position of shear wall at periphery and inside)
Model-4: A RC framed building with dual system (Position of shear wall at centre)
Model-5: A RC framed building with dual system (Position of shear wall at centre and corner)
Model-6: A RC framed building with dual system (Position of shear wall at periphery, corner and centre)

4.2 Modelling different types of model using Etabs

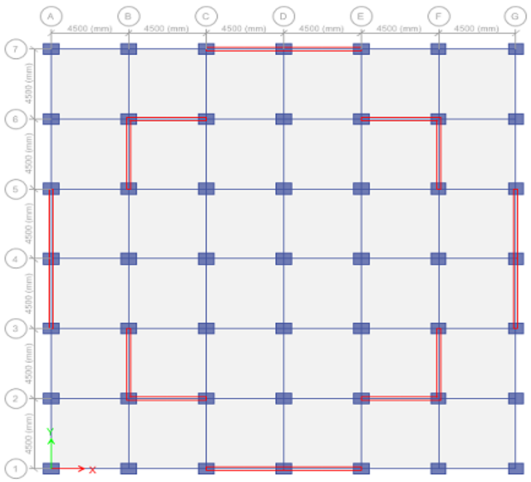
Model-1: A RC framed building without dual system



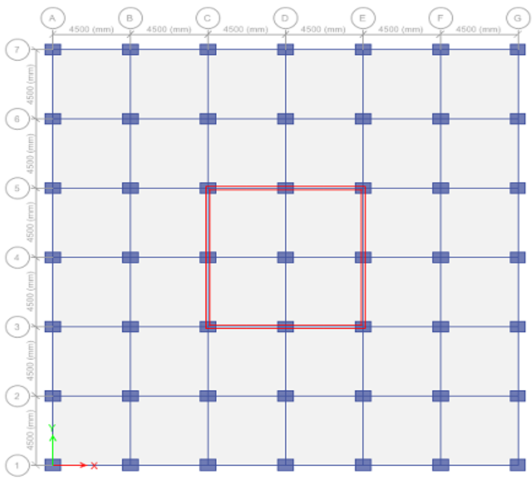
Model-2: A RC framed building with dual system



Model-3: A RC framed building with dual system



Model-4: A RC framed building with dual system (Position of shear wall at centre)



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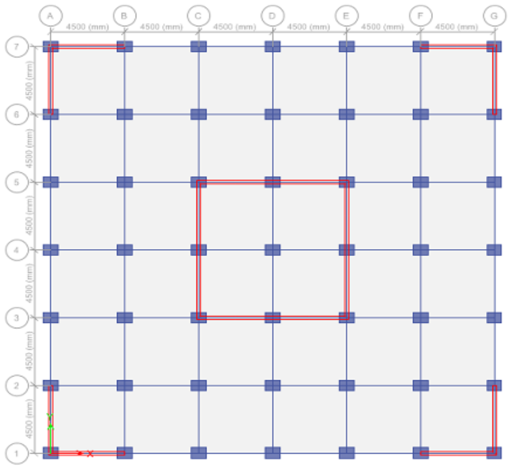
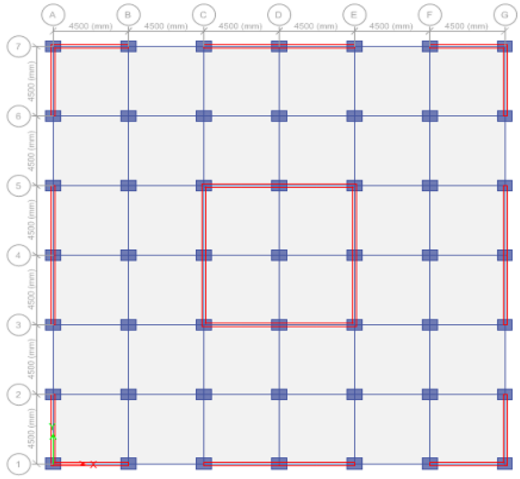
Model-5:A RC framed building with dual system (Position of shear wall at centre and corner)



Model-6:A RC framed building with dual system (Position of shear wall at periphery, corner and centre)



4.3 DETAILS OF STRUCTURE:

Building type	Commercial Building
Frame type	Reinforced Concrete moment resisting
Area of building	729SQM
Total storey	25 (G+24)
Each storey height	3.3 m
Bottom storey height	2.7m
Total building height	81.60m
Wall thickness	230mm
Shear wall thickness	230mm
LL	3KN/m^2 (As per IS-875-Part-II)
FF	1.0 KN/m^2
Wall load	11.80KN/m
Concrete grade	M30
Steel grade	Fe-500N/mm^2
Brick masonry density	18 KN/m^3
Size of column	C-700 x 900 mm
Beam size	230mm x 600mm
Slab thickness	150mm
Seismic Zone	V
Soil type	Medium
Response reduction factor	5 (SMRF)
Importance factor	1.0
Damping ratio	5%

METHODS OF SEISMIC ANALYSIS

It is possible to classify certain seismic analysis techniques as either linear or non-linear. Some examples of linear procedures include the linear static method, the equivalent static force method, and the linear dynamic and response spectrum methods. Here are a few instances of this:

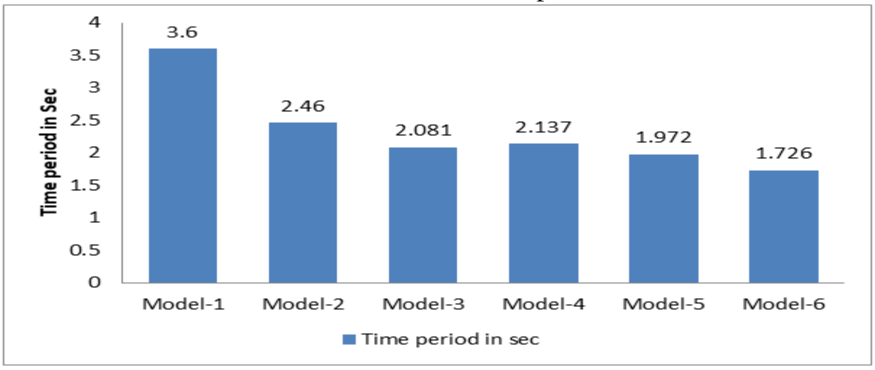
1. Equivalent static analysis

2. Response spectrum analysis
3. Pushover analysis
4. Time history analysis

Equivalent Static Method:
This method is considered easy since it focuses only upon formulae mandated by code of practice. Calculating design base shear with entire specified platform is necessary prior to spreading base shear throughout structure height.

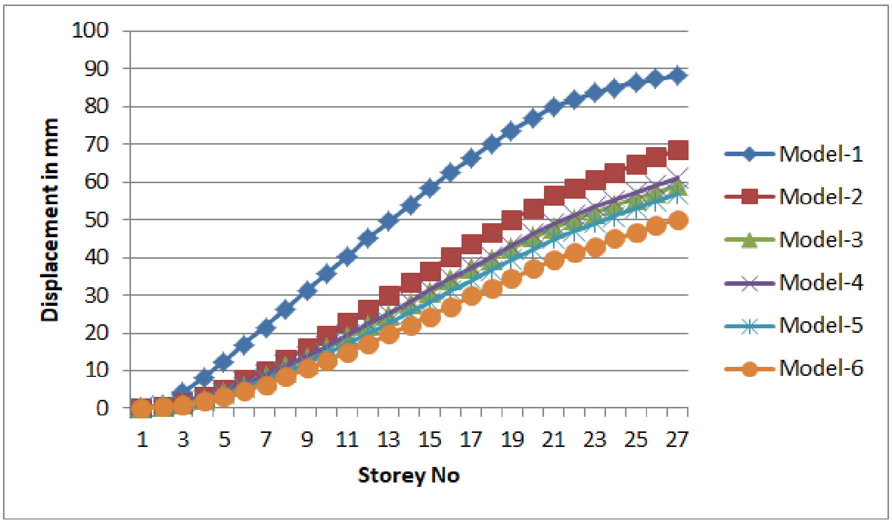
Seismic Base Shear (Vb):
During a seismic event, one may calculate seismic base shear (Vb) in any of the main directions using the following relationship.
Vb= Ah x W
Ah = Acceleration in the Horizontal Plane Spectrum Value is a method of analyzing vibrations and spectra that makes use of the basic natural period (T) as an indirection.
Ah=(ZIS$_a$/2Rg)
Z=seismic zone factor
I=Importance factor
R=Response Reduction factor
Sa/g= Response Acceleration Coefficient
W=Seismic weight of the structure

RESULT AND DISCUSSION
6.1 Time period: It is the amount of time that must elapse for one whole Vibration cycle to finish.



Graph-6.1: Time period for all models
From the graph above, we can deduce that the time period is shortest for model 1, at 3.6 seconds; it then reduces by 31.66% for model 2; and it lowers by 42.19% for model 3. Model 4 sees a 40.63 percent reduction in time, model 5 sees a 45.22 percent reduction, and model 6 sees a 52.05% reduction in time from model 1.

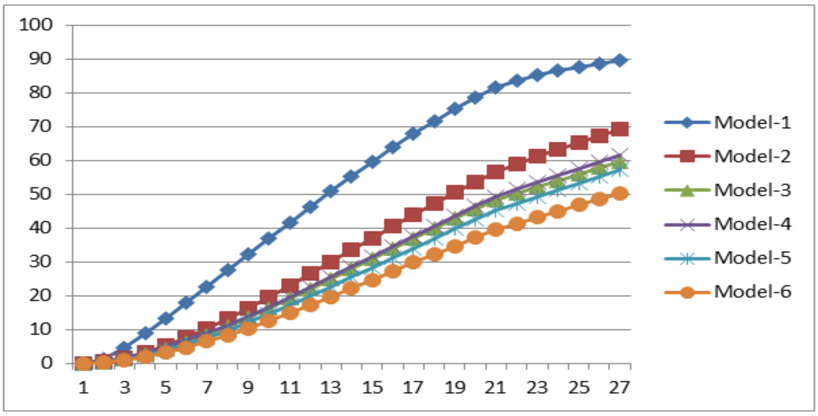
6.2 Displacement: The term "storey displacement" refers to the vertical movement of a building's uppermost level in relation to the ground below.
According to clause 7.11.1.2 of IS 1893 Part 1, permitted bending radius is 163.20mm (0.1632m).



Graph-6.2: Displacement in mm for all models due to ESM along-X direction

According to the data shown above, model-1 (without dual system) exhibits the greatest amount of displacement. The displacement reduces by 22.24 percent as we go from model-1 (central shear wall) to model-2 (peripheral shear wall). Model 3 has a reduced displacement of 32.91 percent due to the shear wall's peripheral and interior locations; model 4 has a reduced displacement of 30.76 percent due to the shear wall's central location.

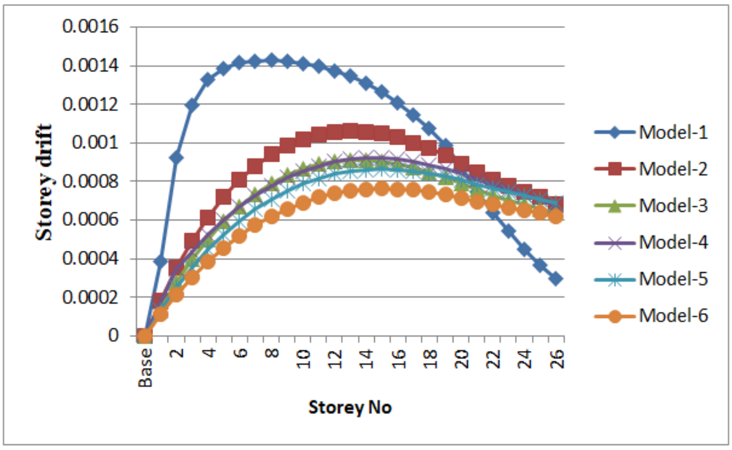
Model 5's shear wall is located in the center and a corner, resulting in a 35.41% reduction in displacement from model 1, while model 6's shear wall is located in the center, a corner, & periphery, resulting in a 43.13% reduction in displacement from model 1.



Graph-6.3: Displacement in mm for all models due to ESM along-Y direction

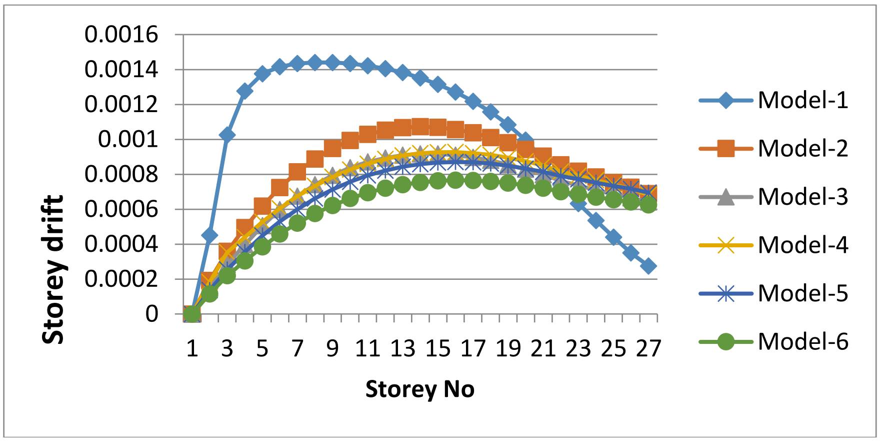
Based on the data presented, it is clear that model-1 experiences the greatest amount of displacement. Since the displacement falls by 22.68 percent when switching to model 2 (shear wall located on the perimeter), we can conclude that including a shear wall will mitigate the problem. Model 3 adds shear walls to the building's exterior and interior, decreasing displacement by 33.51% and further strengthening the structure. Model 4 has the shear wall in the center, resulting in a 31.285% reduction in displacement; model 5 has shear walls in the center and corners, resulting in a 36.08% reduction in displacement; this is a modestly larger reduction in displacement than in earlier models. Finally, the comparable static approach greatly reduces the amount of displacement along the Y-axis in model-6, where the shear wall is located at the perimeter, corner, and center.

6.3 Storey drift: Floor to floor movement is known as storey drift, and the storey drift to height ratio is the amount of storey drift expressed as a percentage of the total storey height.



Graph-6.4: Storey Drift for all models due to ESM along-X direction

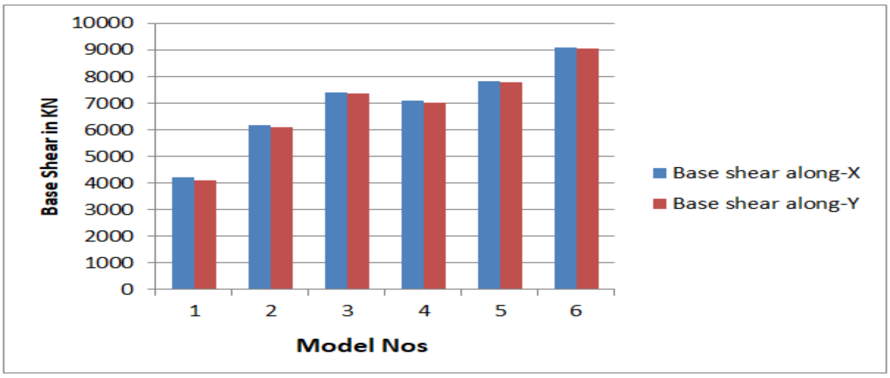
The preceding chart clearly shows that model-1 has the least amount of drift between floors. Model 2 has a 55.88% higher storey drift compared to model 1. The drift between floors grows by 53.125% as we get to model 3. Compared to model-1 along the X axis, the storey drift rises by 55.88% when we transition to model-4, by 56.52% when we switch to model-5, and by 51.61% when we switch to model-6 owing to ESM.



Graph-6.5: Storey Drift for all models due to ESM along-Y direction

The preceding chart clearly shows that model-1 has the least amount of drift between floors. The amount of drift between floors grows by 59.42% as we go from model 1 to model 2. Model-3 has a 56.25% higher storey drift than model-2. Compared to model-1 along the Y-axis, the storey drift rises by 58.82% when we switch to model-4, by 60% when we switch to model-5, and by 55.55% when we switch to model-6 owing to ESM.

6.4 Base Shear: It is a prediction of the greatest lateral stresses acting on a building's foundation as a result of seismic ground motion.



Graph-6.6: Base Shear in KN for all models due to ESM along-X &Y direction

The accompanying graph shows that model-1 without a dual system has the lowest base shear. The

base shear is 31.74 percent higher in model 2 than in model 1 due to the addition of the shear wall at the perimeter. The base shear increases from model-1 along the X axis by 43.21% in model-3 with the shear wall in the periphery and interior, by 40.62% in model-4 with the shear wall in the center, by 46.18% in model-5 with the shear wall in the center and corner, and by 53.68% in model-6 with the shear wall in the periphery, corner, and center.
The Y-direction seems to be where model-1 without a dual system has the least amount of base shear, as seen in the above graph. The base shear is 32.92 percent higher in model 2 than in model 1 due to the addition of the shear wall at the perimeter. Base shear increases from 44.40% in model-3 to 41.77% in model-4, 47.30% in model-5 to 47.30% in model-6 along the Y-direction, and 54.64% in model-6 to 47.30% along the Y-direction due to ESM.

Observation and Conclusion

Observations:

1. When comparing buildings with and without dual systems, it is clear that the latter experience far more displacement.
2. The dual system in the building reduces the amount of displacement.
3. The use of a dual system in construction shortens the schedule significantly.
4. When a building has a dual-system layout, the drift from the top floor to the lower floors rises.
5. The added weight of a dual-system building is a major drawback to using such a system. Therefore, the dual system has a higher base shear than the single system.
6. Shear walls (dual systems) have a major impact on buildings because of this.
7. For a normal structure, the storey drift is greatest at floor nine and gradually decreases from there. In contrast, the greatest storey drift occurs at level 12 in dual-system buildings.
8. Lower-level comparisons show that the presence of a shear wall reduces storey drift.

Conclusions:

1. Shear wall should be located strategically inside the structure to provide an effective lateral force-resisting system that limits lateral displacements caused by seismic loads.
2. Comparing the performance of several shear wall placements, we find that the peripheral, corner, and central positions provide the greatest results in minimizing displacement.
3. As per IS 1893, when verified with h/500, all storey displacement was within the allowable range.
4. Utilizing a dual system cuts down on construction time.
5. Because of the building's multiple systems, model-6 has far less storey drift at lower levels than model-1 does.
6. Base shear in model 6 with a dual system is much higher than in model 1.
7. We find that the dual-system building significantly reduces displacement.

Scope for further study:

1. This current effort caters to a 24-story G+ building. Adding floors allows for more space and productivity.
2. The current effort takes earthquake factors into account. Additional effort may be required for wind loading.
3. Currently, we are working with medium soil. Thinking about soft soil for future work may be useful.
4. The authors of this paper use a dual-system approach. But in the future we may also add bracing, damper, etc., to the dual system.

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