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Seismic Analysis of G+15 RC Shear wall multistoried Building With different Shear wall Index

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Abstract: A commonly employed system for resisting lateral loads in buildings is the shear wall system. Shear walls possess notable in-plane stiffness and strength, enabling them to effectively counteract substantial horizontal loads while also providing support for gravity loads. This dual functionality makes shear walls highly advantageous for enhancing the seismic performance of buildings. They play a pivotal role in contributing substantial lateral stiffness, strength, overall ductility, and energy dissipation capacity.
To investigate the impact of shear wall configuration on the seismic performance of buildings, we have introduced shear walls at various locations with different wall indices on the building plan, such as side center shear walls, corner shear walls, and shear walls positioned near the center of the building plan. The primary objective of this study is to assess how the arrangement of shear walls influences the seismic behaviour of buildings. In the present study, our focus is directed towards determining the effect of shear wall configuration on the seismic performance of buildings through the introduction of shear walls at different locations with varying wall indices on the building plan.
Keywords: Shear wall, Shear wall indices, SAP2000, Time history analysis, Storey Displacement.

I. INTRODUCTION

Shear walls are specifically engineered to withstand both gravity and lateral loads. Their incorporation is driven by factors such as the ability to minimize lateral drifts, design simplicity, and a proven track record of excellent performance in past seismic events. With a substantial in-plane stiffness, shear walls effectively limit the lateral drift of a building under lateral loads. Their primary role is to behave elastically during wind loading and, in cases of low to moderate seismic loading, to prevent non-structural damage within the building. While shear walls are designed to exhibit elastic behavior under common loads, it is anticipated that during severe earthquakes of lower frequency, these walls may undergo inelastic deformations. Consequently, shear walls must be engineered to withstand forces causing inelastic deformations while retaining their load-carrying capacity and energy dissipation abilities. During severe earthquakes, structural and non-structural damage is expected, with a primary focus on preventing collapse and ensuring life safety.

Post-earthquake evaluations consistently demonstrate the effectiveness of shear walls in limiting damage. The extent of observed damage depends on the specific building and shear wall configuration. Early design codes for shear walls were primarily strength-based, but stringent detailing requirements led to overly conservative code provisions for most buildings with shear wall systems.

A shear wall is defined as a vertical structural member with a length at least seven times greater than its thickness. Serving as the principal lateral load-resistant components in multi-storey building structures, shear walls have undergone extensive experimental and theoretical studies over the past fifty years.

In the lateral load analysis of building structures featuring shear walls, proper methods are crucial for modeling shear wall assemblies. Shear wall models in the literature can be categorized into two types: those developed for the elastic analysis of building structures and those developed for the nonlinear analysis of building structures.

II. OBJECTIVE

1) Five 3D models representing midrise G+15 storey buildings with varying shear wall ratios were created to assess shear wall indices for reinforced concrete structures.
2) SAP2000 was employed for modal analysis of these model buildings, yielding essential modal information crucial for understanding their dynamic characteristics.
3) Subsequent linear time history analyses were conducted in SAP2000 to obtain data on displacement and inter-storey drift for the modeled buildings.

III. METHODOLOGY

The abbreviations "W," "C," and "B" are used for shear walls, columns, and beams, respectively. Members in the X direction are numbered from left to right, while members in the Y direction are numbered from top to bottom in all models. The letters following "B" designate the storey number where beams exist.

Models are named using a standardized format: "Mi_n_Tx." In this format, "M" stands for "Model," "n" denotes the storey number, and "T" represents shear wall thickness. The letter "i" next to "M" designates the model number, ranging from 1 to 5. The letter "x" next to "T" signifies the wall thickness in millimeters, with values of 150 and 300.

For instance, "M3_15_T150" represents the third model with 15 storeys and a shear wall thickness of 150 mm.

The floor plan is rectangular, with a length of 24.5 m in the X direction and a width of 17.5 m in the Y direction, resulting in a total area of 428.5 m² in all models. There are 7 frames in the X direction and 5 frames in the Y direction, each with a span length of 3.5 m. All models are symmetrical in plan with respect to centroidal X and Y axes.

All shear walls have a rectangular cross-section with a length of generally 3.5 m. Shear wall thickness remains consistent for all walls within each model but varies as 150 and 300 mm to achieve different wall ratios.

Considering G+15 Storey buildings with a story height of 3.0 m, the total heights are analyzed to be 30 m and 45 m, respectively. All columns have a square cross-section with dimensions of 0.6 x 0.6 m, and all beams have a rectangular cross-section with dimensions of 0.25 x 0.4 m in all models.

Slabs are modeled as rigid diaphragms in their own planes by assigning joint constraints at each storey level, with a thickness of 120 mm. The concrete class and longitudinal reinforcing steel are chosen as M20 (compressive strength of concrete fck = 20 MPa) and Fe - 420 (f yk = 420 MPa), respectively. The modulus of elasticity of concrete, Ec, is taken as the 28-day modulus of elasticity value of M20 concrete (Ec = 28000 MPa).).

A. Building Parameter

Size of column = 0.6 m X 0.6 m
Shear wall thickness = 0.15 m and 0.30 m
Slab thickness = 0.12 m
Concrete f_{ck} = 20 N/mm^2
Steel f_y = 415 N/mm^2
Floor to floor height = 3.0 m
Number of storey = 10 and 15

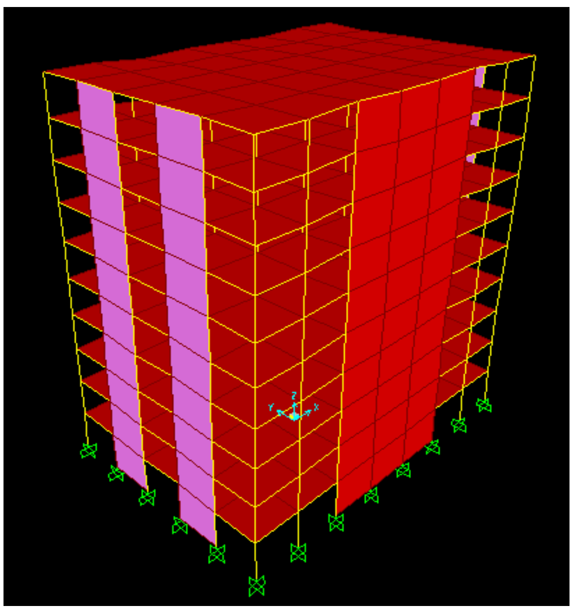
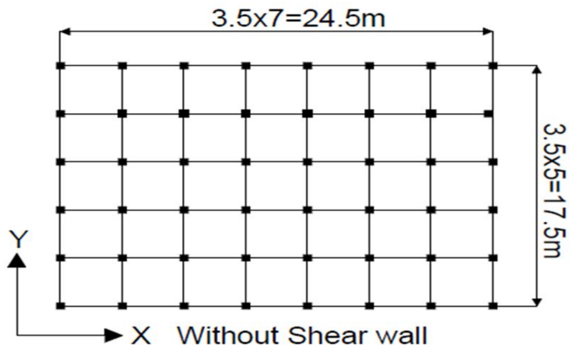
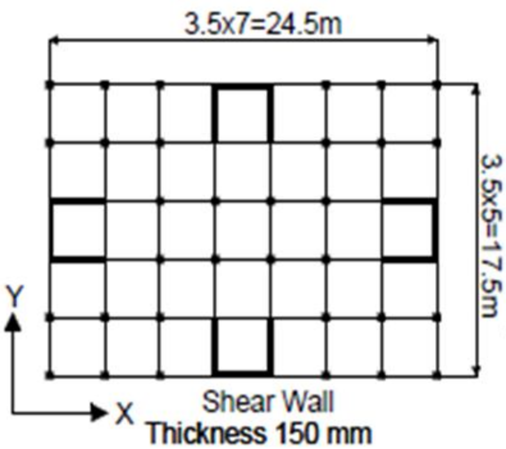
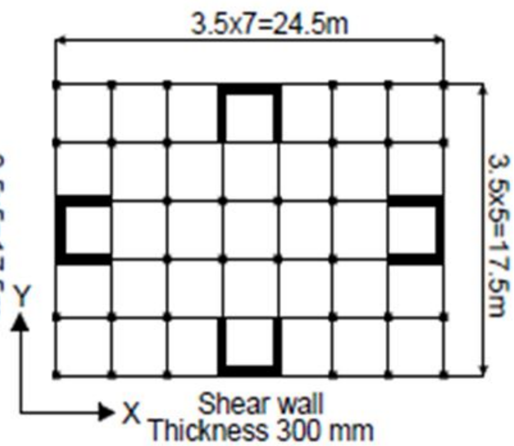
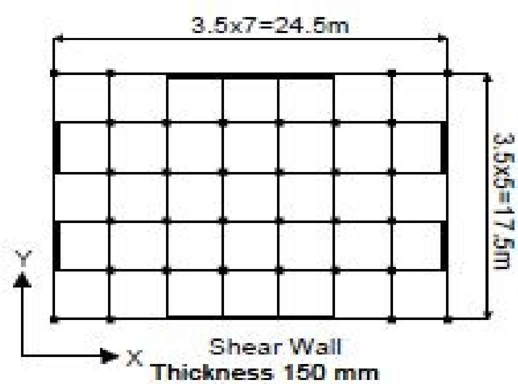


Fig. 6 3D Structural model with 10 storey


3.5x7=24.5m
3.5x5=17.5m
Y
X
Without Shear wall


3.5x7=24.5m
3.5x5=17.5m
Y
X
Shear Wall
Thickness 150 mm


3.5x7=24.5m
3.5x5=17.5m
Y
X
Shear wall
Thickness 300 mm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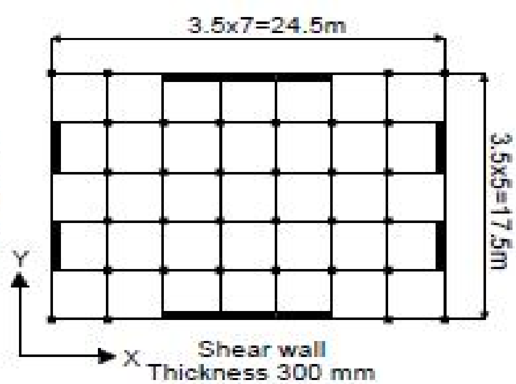
3.5x5=17.5m
Y
X
Shear Wall
Thickness 150 mm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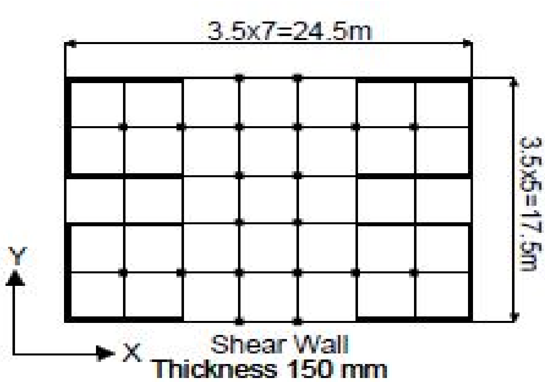
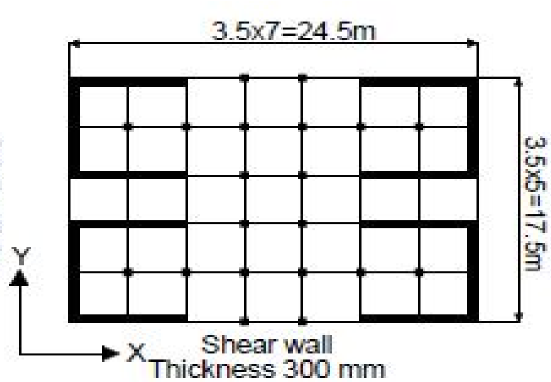
3.5x5=17.5m
Y
X
Shear wall
Thickness 300 mm


3.5x7=24.5m
3.5x5=17.5m
Y
X
Shear Wall
Thickness 150 mm


3.5x7=24.5m
3.5x5=17.5m
Y
X
Shear wall
Thickness 300 mm

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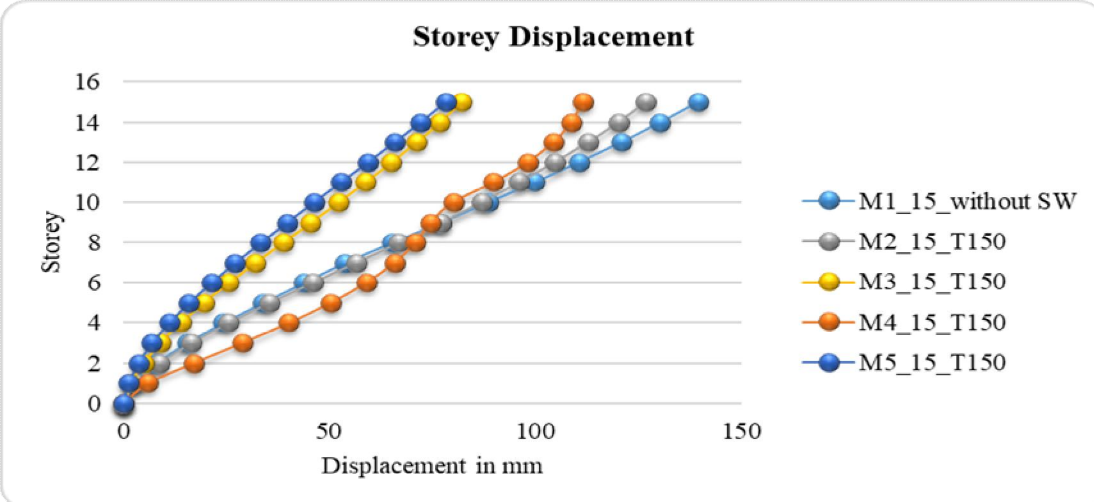
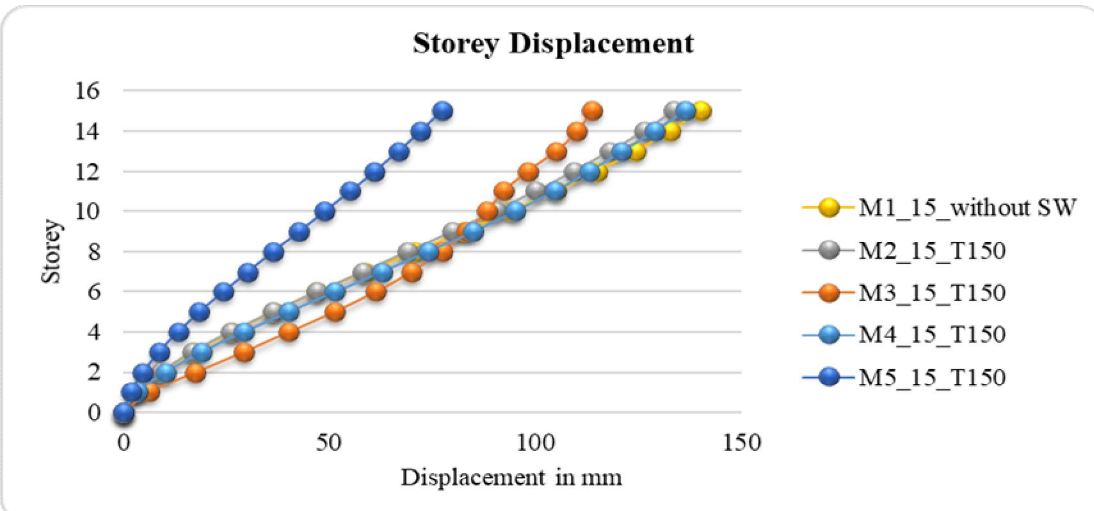
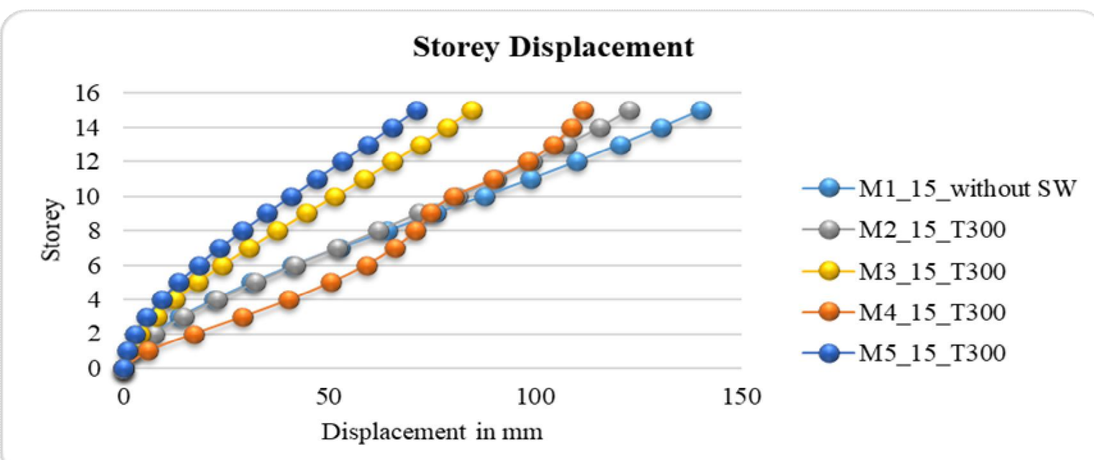
IV. RESULT



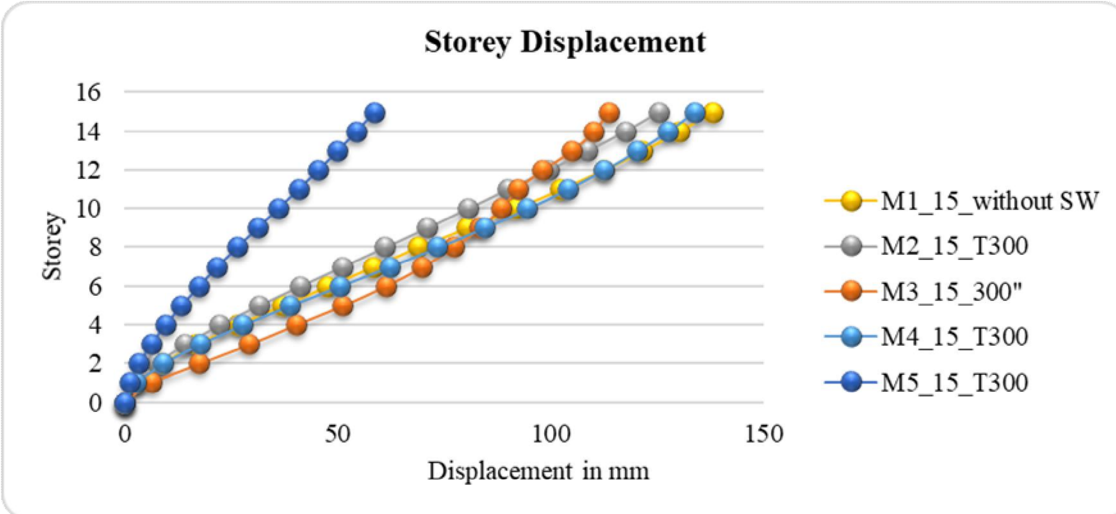
Graph 1 Storey Displacement in X-direction for Shear wall thickness of 150 mm *for G+15 Storey Building*



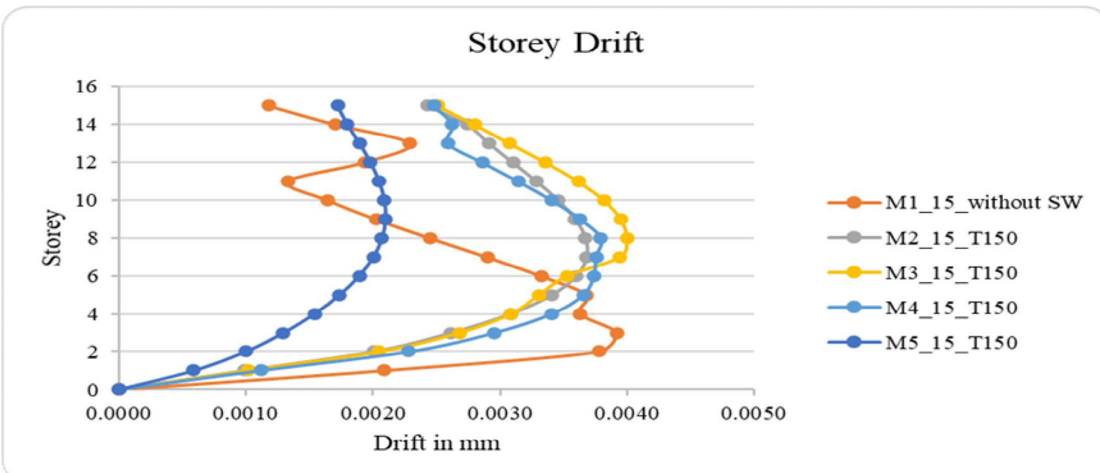
Graph 2 Storey Displacement in Y-direction for Shear wall thickness of 150 mm for G+15 Storey Building



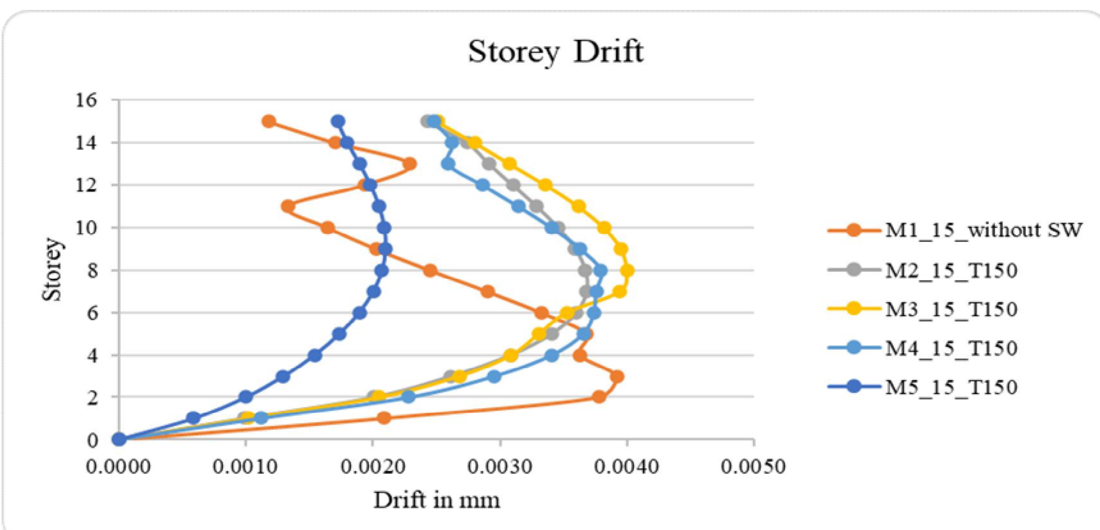
Graph 3 Storey Displacement in X-direction for Shear wall thickness of 300 mm for G+15 Storey Building



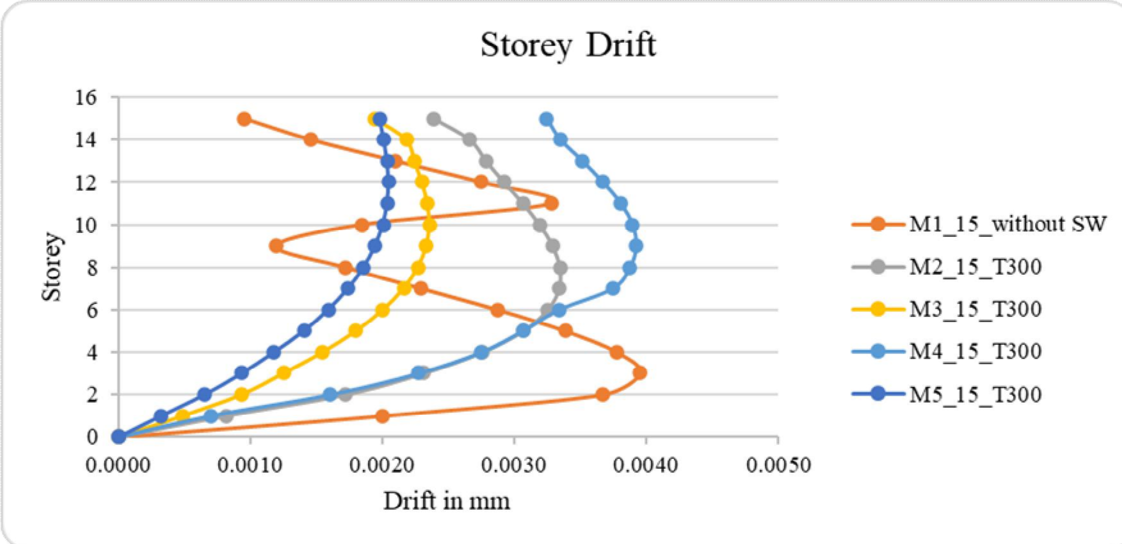
Graph 4 Storey Displacement in Y-direction for Shear wall thickness of 300 mm for G+15 Storey Building



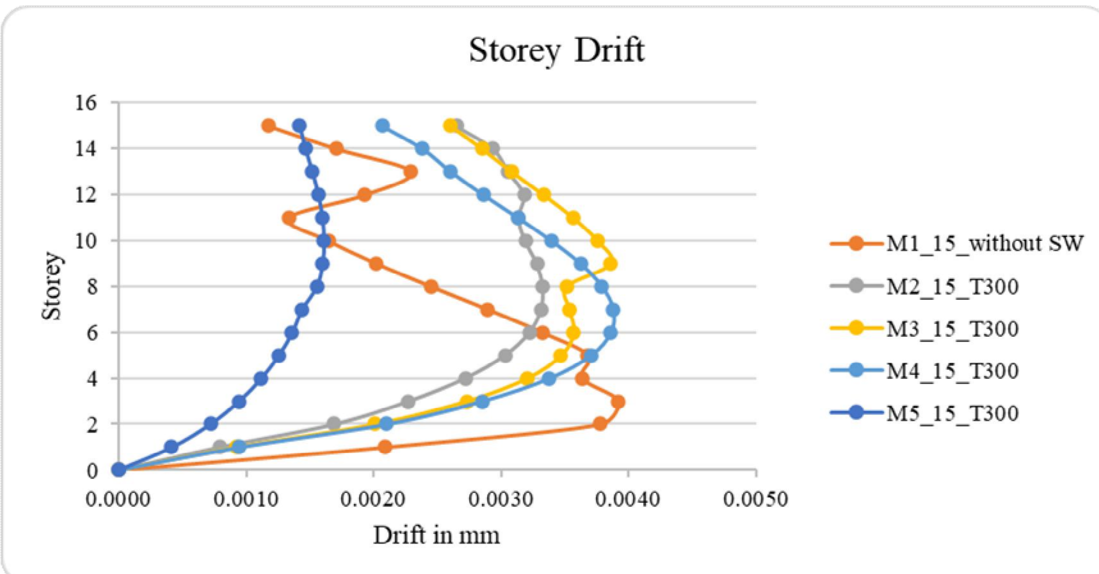
Graph 5 Storey Drift in X-direction for Shear wall thickness of 150 mm for G+15 Storey Building



Graph 6 Storey Drift in Y-direction for Shear wall thickness of 150 mm for G+15 Storey Building



Graph 7 Storey Drift in X-direction for Shear wall thickness of 300 mm for G+15 Storey Building



Graph 8 Storey Drift in Y-direction for Shear wall thickness of 300 mm for G+15 Storey Building

V. CONCLUSION

The aim of this study was to evaluate the effect of different shear wall ratios on the behavior of buildings to be utilized in the preliminary assessment and design stages of reinforced concrete buildings with shear walls. The wall ratios changed between 0.49 and 3.92 per cent in the model buildings.

1) Following conclusions were derived because of the study performed throughout work: As per the discussion of results, we conclude that there is a marginal reduction in Displacement, by introducing shear wall. But the Displacement is reduced by introducing shear wall at the corner along with both directions.
2) Changing the position of the shear wall will affect the attraction of forces, so that wall must be in the proper position.
3) If the dimensions of the shear wall are large, then a major number of horizontal forces are taken by the shear wall.
4) Providing shear walls at adequate locations substantially reduces the displacements due to earthquake.

In summary, the findings underscore the importance of shear wall ratios, their positioning, and dimensions in influencing the seismic behavior of buildings. The study provides valuable insights for enhancing the earthquake resistance of reinforced concrete structures during the initial stages of design and assessment.

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