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"Evaluating Seismic Performance of Flat Slab Systems in G+9 Structures with Different Shear Wall Positions"

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ABSTRACT :

Flat slab buildings have gained popularity in recent years due to their numerous advantages over traditional RC frame construction, including cost efficiency, optimal space utilization, ease of formwork, architectural versatility, and reduced construction time. However, their relatively poor performance under seismic loading limits their structural efficiency, emphasizing the need for detailed seismic analysis. This study focuses on evaluating the seismic behavior of G+9 flat slab buildings with shear walls positioned at various locations to enhance their resistance to seismic forces.

A multi-story building model with a 20 m x 20 m plan was analyzed using STAAD.PRO v8i software. Equivalent Static Analysis, in accordance with IS 1893:2016 (Part 1), was performed for seismic Zone V, and the findings were verified with dynamic Response Spectrum Analysis. Key seismic parameters examined include Fundamental Natural Time Period (Ta), Average Response Acceleration Coefficient (Sa/g), Base Shear (VB), Lateral Sway, Shear Force, Bending Moment, Axial Force, and Torsion.

The results indicate that the Ta values are consistent across both static and response spectrum methods. Similarly, the Sa/g values remain unchanged regardless of the analysis approach. Base shear (VB) exhibits significant fluctuations across various shear wall configurations, and lateral sway varies with shear wall placement. Shear force and bending moments also depend on the location of shear walls, while axial force shows a uniform increase due to the monolithic behavior of flat slab systems under seismic loads. Torsion values are minimal in structures with symmetrically placed shear walls, enhancing their seismic stability.

This study underscores the importance of strategic shear wall placement in optimizing the seismic performance of flat slab buildings, providing insights for improved design and structural resilience under earthquake loading.

Keyword: - Fundamental Natural Time Period, Sway (mm), Shear Force (kN), Moment (KN-M), Axial Force (KN), Torsion (kN-m).

Introduction :

GENERAL

One of the primary challenges we encounter in today's world, driven by the increasing population, revolves around the scarcity of available land. Due to this scarcity, we've witnessed the emergence of multi-story buildings as a solution, capitalizing on vertical development in response to the land shortage. These multi-story structures encompass a range of building types,including medium-rise, low-rise, tall, and skyscraper constructions (those exceeding 100 metersin height). Typically, these buildings employ frame structures that must contend with both vertical and horizontal loads.

The key concern during the construction of such buildings lies in their susceptibility to high lateral loads stemming from earthquakes (seismic activity) and wind forces rather than verticalloads. These two factors can exhibit an inverse relationship, meaning a structure designed to withstand vertical forces may not adequately resist lateral forces. Of these, lateral forces pose the greatest challenge, as they act in opposition to the expected vertical load distribution, whichgenerally increases linearly with height

OBJECTIVE OF THE STUDY :

- To compare the effectiveness of shear walls positioned at different locations within the structure.
- To study on shear walls and flat slabs.
- To examine the correlation between a flat slab and a shear wall.
- To compare the efficiency of structures with and without shear walls.
- To compare the seismic responses of comparable conventional and (G+ 9) storied with shear wall structures in high-intensity earthquakes, and to determine the best shear wall placement in a structure.

2 LITERATURE SURVEY :

Based on the past researchers following literature review can be done through Web sites, journals and books etc.

Bento et al. (2004) discuss performance-based engineering in seismic design. Their study models two multi- story houses in seismic zone V using SAP 2000 software, analyzing six different shear wall shapes to evaluate lateral force resistance. Time History Analysis is emphasized for its accuracy over Response Spectrum and Equivalent Static Analysis.

Sathawane and Deotale (2011) analyze flat slabs, finding that drop panels enhance shear strength and reduce punching failure. Flat slabs with drops require less steel and are more economical than grid slabs.

Arvind et al. (2012) explore U-Boot beton technology, a lightweight slab system using recycled polypropylene. This technology improves bearing capacity, reduces concrete usage, and increases construction efficiency.

Bhina et al. (2013) compare flat slabs with drops, column heads, and conventional slabs for seismic performance in zone V. Their findings suggest that including shear walls improves structural stability under seismic conditions.

Sen and Singh (2015) highlight challenges in flat slab performance during earthquakes. Their study using ETABS software suggests that additional considerations are needed to enhance seismic resilience.

Tangri et al. (2016) compare the design capabilities of STAAD.Pro and ETABS for multi-story buildings. The study examines differences in shear forces, bending moments, and structural performance.

Kumar and Venkateswarlu (2017) analyze a multi-story building and find that static analysis is more conservative than dynamic analysis. They note increased stiffness reduces sway, and seismic loads significantly impact story drift and shear.

Patil et al. (2018) focus on shear walls in flat slab systems for seismic resistance. Their ETABS-based study of a 14-story building in zone IV shows shear walls improve seismic performance by reducing lateral displacement and drift.

Vijayan et al. (2019) confirm that traditional structures outperform flat slabs in earthquakes. They recommend adding drops, column heads, and lateral load-resisting elements like shear walls for improved seismic resilience.

Mawle et al. (2020)evaluate the performance of RCC buildings with flat slabs and shear walls under seismic forces, emphasizing the importance of shear wall placement for stability.

Borkar (2021)suggests that while flat slabs offer cost and construction benefits, they perform poorly under seismic loads. Their STAAD.Pro analysis recommends supplementary guidelines for seismic design.

Ibrahim et al. (2022) compare traditional slab structures with flat slabs reinforced by perimeter beams, analyzing seismic performance in different zones using ETABS. Perimeter beams improve structural rigidity and reduce displacement.

Omwanshi et al. (2023) study shear wall placement in a six-story RCC building in seismic zone II using STAAD.Pro. Different shear wall configurations are examined to optimize structural stability.

Pang et al. (2024) introduce a discretely connected precast concrete floor (DCPCF) system tested in a shaking table experiment. The results highlight seismic risks due to semi-rigid diaphragm behavior and propose design recommendations.

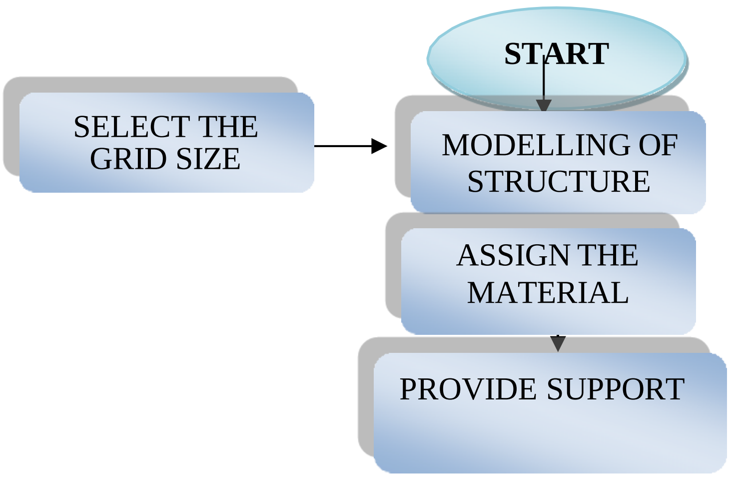
Haque et al. (2025) identify gaps in the Bangladesh National Building Code (BNBC 2020) for response reduction factors. Their ETABS-based study evaluates various RC structural configurations, proposing response reduction factors for inclusion in BNBC 2020.

METHODOLOGY :

This study aims to explore the dynamic interplay between flat slabs and shear walls when exposed to seismic forces, with a specific focus on multi-story structures. It delves into the structural behavior, scrutinizing the dynamics of the interaction between flat slabs and shear walls. To gain a comprehensive understanding of this interaction under seismic loads, the study conducts a systematic literature review and surveys the response and behavior of flat slab and shear wall interactions.

FLOW CHART OF THE PRESENT STUDY

The process of analysis and design of structure performed on STAAD–Pro V8i is shown through Flow Chart in figure 3.33



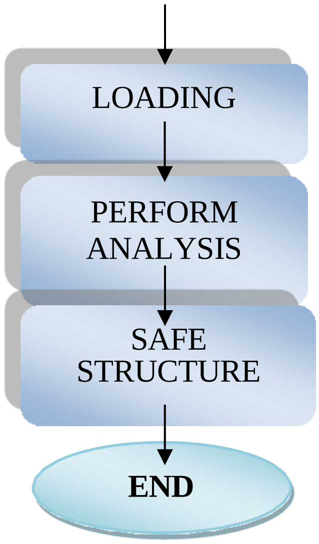
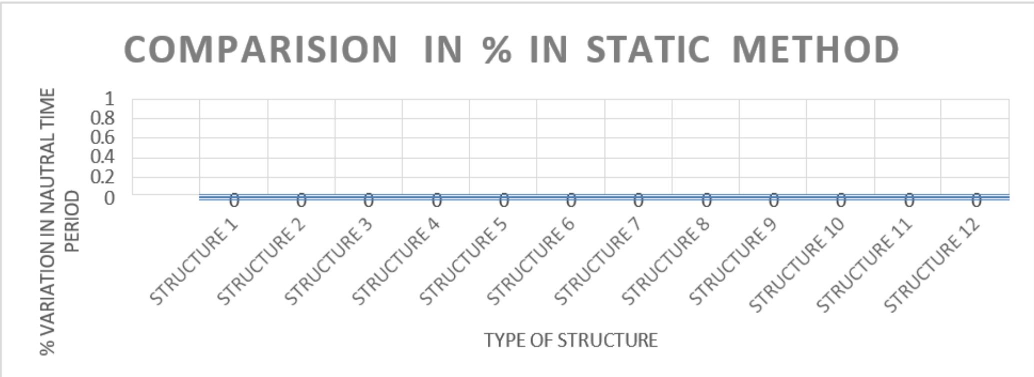
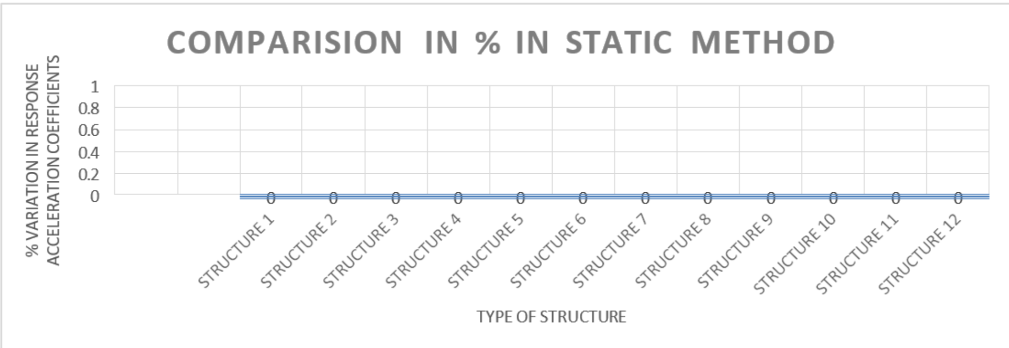


Figure 1: Flow Chart showing process of analysis and design of structure

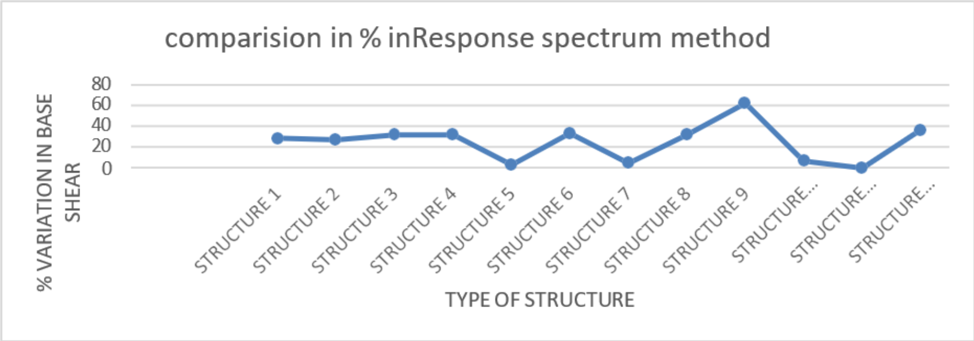
RESULTS & DISCUSSIONS :



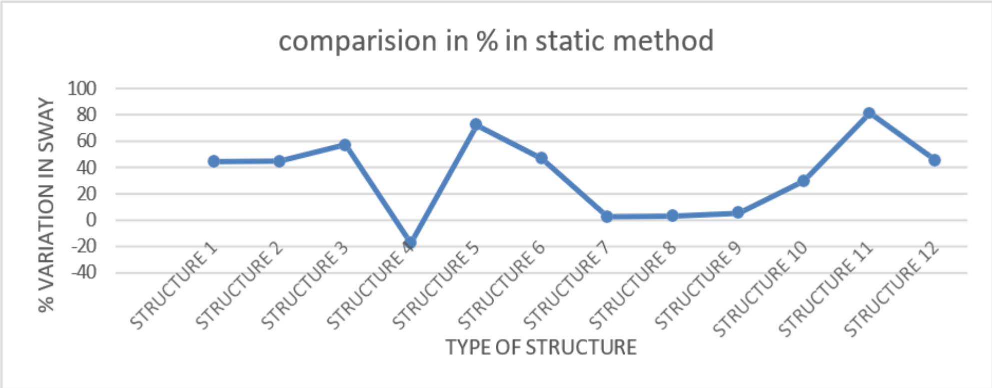
Graph 1 % Fundamental Natural Time Period in static method



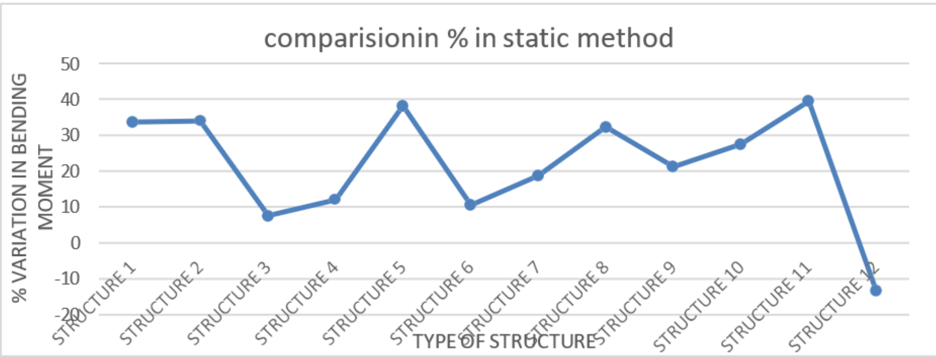
Graph 2 % Average Response Acceleration Coefficients



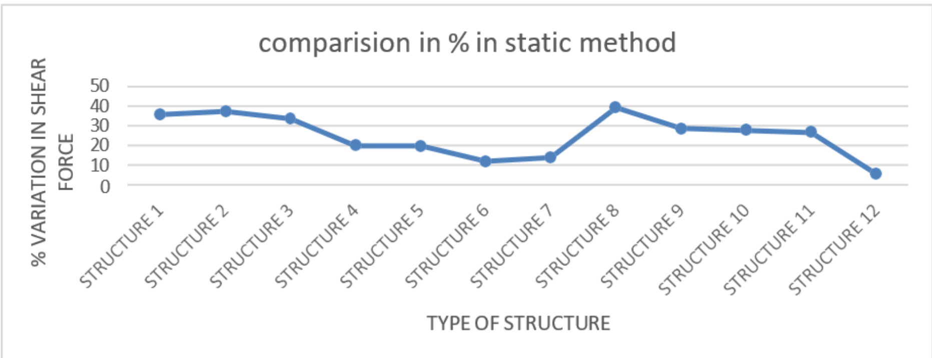
Graph 3 % Base Shear by Response spectrum method



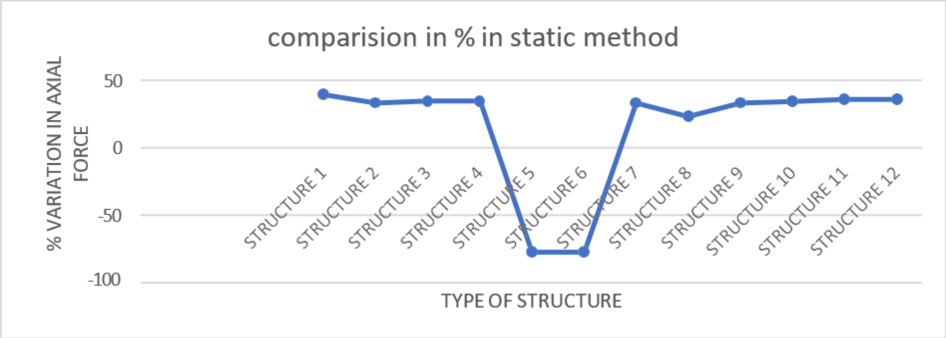
Graph 4 % sway by static method



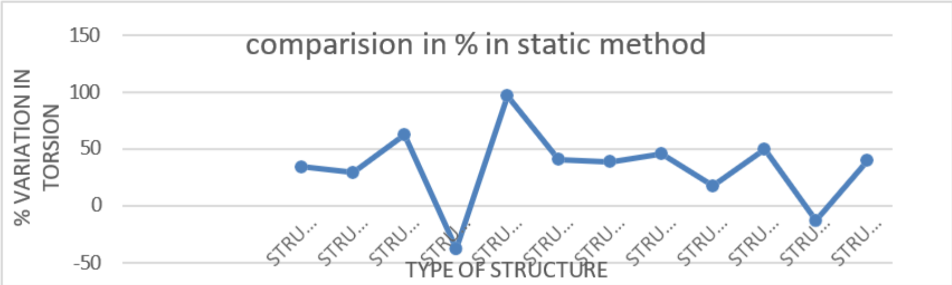
Graph 5 % shear force by static method



Graph 6 % Shear Force by static method



Graph 7 % Bending Moment by Static Method



Graph 8 % Torsion By Static Method

CONCLUSIONS :

Conclusions are drawn based on the results as follows:

- Fundamental Natural Time Period (sec.) By static method and Fundamental Natural Time Period (sec.) Response spectrum method for structure 1 to 12 are same and structure 1having both method by1.032.
- 2 Average Response Acceleration Coefficient By Static method and Average Response Acceleration Coefficient By Response spectrum method for structure 1 to 12 are same and structure 1having both method by1.317.
- 3 Base Shear (kN) by Static method and Base Shear (kN) by Response spectrum method for structure 9 having value 62.85%
- SWAY (mm) by Static Method and SWAY (mm) by Response spectrum Method for structure 11 having value 81.78%
- MAXIMUM SHEAR FORCE (kN) By static method and MAXIMUM SHEAR FORCE (kN) By Response spectrum method for structure 8 having value 39.56%
- MAXIMUM BENDING MOMENT(KN.M) by static method and MAXIMUM BENDING MOMENT (KN.M) by response spectrum method for structure 11 having value 39.58%
- Axial Force and Axial Force(KN) by response spectrum method for structure 1 having value 39.42%
- Maximum Torsion(KN.M) by static method and Maximum Torsion(KN.M) by response spectrum method for structure 5 having value 96.69%Torsion, represented by the applied torque, is another essential parameter in the analysis. The results reveal
- that as you ascend the floors, the torsion value increases. Frames 11 and 12 exhibit the highest values, while Frame 10 demonstrates the lowest.

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