RC Structural Behavior of Hollow Core Slab and Reinforced Concrete Slab

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***Abstract*— The study and development of slabs continue to be an important topic in structural engineering. As there is an increasing need for cost-efficient and quick construction methods, Hollow Core Slabs (HCS) have become a better option than traditional reinforced cement concrete (RCC) slabs. These slabs help reduce the time needed for construction while maintaining the same quality, and they also allow for longer spans, better insulation against heat and noise, and overall cost savings. In one year, the cost of building the same floor area using HCS instead of RCC slabs can be quite different, making HCS a sensible choice in today's construction industry. This research examines a reinforced concrete (RC) framed building with 21 floors (G+21). The structure is analyzed separately using both HCS and RCC slabs in seismic zones II, III, IV, and V. The main goal is to compare the performance of these two structural systems—one using hollow core slabs and the other using RCC slabs. The study evaluates various structural factors such as shear force, bending moment, deflection, axial force, storey shear, and displacement. Separate models were created for each slab type in every seismic zone, and the results were analyzed for each zone. The research aims to show the cost benefits of HCS over RCC slabs by assessing the structural behavior of important components like columns, floors, and foundations.**

***Index Terms*— Hollow Core Slabs (HCS), Reinforced Cement Concrete (RCC), Voids, Pre-stressed, Shear, Moment, Deflection, Axial force, Storey shear and Displacement.**

I. INTRODUCTION

Background

The analysis and design of slab systems play a vital role in structural engineering, as slabs are a key element in most building projects. Since the early 1900s, reinforced concrete (RC) slabs have been commonly used because of their strength, durability, and adaptability. However, modern construction trends are pushing for more cost-effective solutions, faster project timelines, and better structural performance. To address these needs, Hollow Core Slabs (HCS) have become a viable and innovative option compared to traditional reinforced concrete slabs.

Hollow Core Slabs are precast, prestressed concrete elements that feature continuous longitudinal voids. These voids significantly decrease the weight of the slab, which in turn improves the structural performance and allows for smaller supporting elements like beams, columns, and foundations. These slabs are manufactured in controlled factory settings, ensuring consistent quality, high precision, and efficient installation at the construction site. Standard HCS units are typically available in widths ranging from 0.9 meters to 1.25 meters, thicknesses between 150 mm and 300 mm, and can span up to 18 meters. The voids, which are usually circular or elliptical, reduce the self-weight of the slab by over 30% compared to solid slabs, thus providing significant economic and functional benefits.

Problem Statement

While conventional RCC slabs are commonly used, they often require longer construction periods and larger supporting members, which contribute to higher project costs. Since construction time directly affects project expenditure, delays in casting and curing slabs can greatly impact budgets. Moreover, RCC slabs impose higher dead loads, which increase the demand on structural elements and foundations. This underscores the need to explore alternative slab systems that offer better structural efficiency while reducing time and cost.

Objectives

The main objectives in purview of this study are as follows:

1. To examine and compare the structural performance of Hollow Core Slabs and conventional RCC slabs in high-rise reinforced concrete framed structures.
2. To assess critical structural parameters such as bending moment, shear force, axial load, deflection, storey shear, and lateral displacement.
3. To evaluate the impact of different slab types on the performance of key components like columns, floors, and foundations.
4. To evaluate the economic benefits of HCS over RCC slabs in terms of material savings, construction time, and overall project cost.

II. LITERATURE REVIEW

L.J. Woods, D.K. Bull, and R.C. Fenwick (2008) Their study explored the performance under gravity loading conditions of HCS also highlighted the significance of negative bending moments in HCS and how these conditions affect slab behavior. The

paper also emphasized the necessity of accounting for flexural and shear demands in negative bending regions during design, in order to prevent structural failures.

Prateek Ghosh (2016)The study concluded while obsrving the HCS with steel and RCC structure that precast concrete construction is particularly advantageous in regions of low seismicity, owing to its cost-effectiveness, faster assembly, and reduced raw material requirements. Hollow core slabs, due to their lower self-weight, are widely utilized across India, Europe, the United States, and Canada.

Prasad Bhamare, Sagar Bhosale, Akshay Ghanwat, Shubham Gore, Sheetal Jadhav, and Sachin Patil (2017) concluded that precast members can be highly economical when designed with proper care. Their research noted that precast construction reduces both cost and time in comparison with traditional methods. Additionally, the study highlighted that better quality concrete and lighter structural units can be achieved through the precast approach.

K.M. Monisha and G. Srinivasan (2017) carried out a comparative analysis of HCS and conventional RC slabs. Their findings showed that prestressed hollow core slabs are significantly more cost-efficient, with load-carrying capacity approximately 20% higher than that of RCC slabs.

K. Soundhirarajan, M. Raghupathi, R. Ragupathi, K. Sathishkumar, and V. Sureshkumar (2018) examined the structural performance of hollow core slabs and concluded that HCS provide an economical and efficient solution for flooring and roofing applications. The authors stressed their advantages in terms of load-carrying capacity, long-span capability, and deflection control. They further suggested that the top surface of HCS can be enhanced using non-structural fill concretes of 15–50 mm thickness, or by applying a composite structural topping, depending on functional requirements.

Ihsan A. Al-Shaarbaf, Adel A. Al-Azzawi, and Radhwan Abdulsattar (2018) reviewed existing studies on hollow core slabs (HCS) and highlighted their feasibility as one-way roofing systems in buildings. Their work emphasized that Near-Surface Mounted Carbon Fiber Reinforced Polymer (NSM-CFRP) strengthening techniques significantly enhance both the flexural and shear capacity of prestressed HCS. They also reported that reducing the shear span-to-depth ratio in solid slabs increases flexural strength by approximately 29.06% and ultimate deflection by about 17.79%. A reduction of approximately 29–35% in the cross-sectional area of block slabs was noted, which in turn resulted in a significant decrease in the overall weight of Hollow Core Slabs when compared with traditional reinforced concrete (RCC) slabs.

III. METHODOLOGY

The present work was conducted through the following systematic steps: Review of seismic analysis methods: An in-depth study of available seismic analysis techniques was carried out to establish the basis for structural evaluation.

Code-based framework: Relevant clauses pertaining to the design and analysis of reinforced concrete (RC) structures were reviewed from the following Indian Standards:

IS 456:2000 – Code for Plain and RCC
IS 1893:2016 –Code for Earthquake Resistant Design of Structures
IS 13920:2016 – Code for Ductile Detailing of RCC in seismic load
IS 875 (Parts 1, 2, and 3) – Code for Practice for Design Loads.

Model selection: A high-rise RCC building with a ground floor and 21 upper floors (G+21) was chosen for analysis.

Structural analysis: The building components including columns, beams, slabs, and foundations were modeled and analyzed using ETABS software.

Comparative study: The performance of the RC structural system was evaluated based on key response parameters:

Columns: Axial force, shear force, and bending moment.

Floors: Storey displacement and storey shear.

Foundation: Base shear.

Structural Modeling: The study examines a high-rise reinforced concrete (RC) building with a configuration of one ground floor and 21 storeys (G+21). Two analytical models were created for comparison: one using conventional reinforced cement concrete (RCC) slabs and the other using Hollow Core Slabs (HCS). Both models were designed with the same geometric dimensions, material grades, and loading conditions to ensure that any differences in performance could be attributed solely to the type of slab used.

Table 1 *Building Specifications*

Case I	Case II
• Slab type: RCC slab • Storey: G+21 • Plan Dimension: 60m x 48m • Height of each storey: 3.5m • Slab Thickness: 300mm • Column Size: 750mm x 750mm (M40) • Beam Size: 300mm x 700mm (M40) • 4 model each for Zone II, III, IV and V. • Building is fairly symmetric in plan and elevation.	• Slab type: Hollow core slab • Storey: G+21 • Plan Dimension: 60m x 48m • Height of each storey: 3.5m • Slab Thickness: 300mm • Column Size: 750mm x 750mm (M40) • Beam Size: 300mm x 700mm (M40) • 4 model each for Zone II, III, IV and V. • Building is fairly symmetric in plan and elevation.

ETAB Model

Fig - 1 ETAB Model

IV. Results and Discussion

Axial Force

The maximum axial forces in the three main columns, measured in both longitudinal and transverse directions, were evaluated for seismic Zones II, III, IV, and V for two scenarios: Case I (conventional RCC slabs) and Case II (Hollow Core Slabs). In all storeys, the axial forces in Case II were consistently lower than those in Case I for both directions. Percentage reduction in axial forces for each column is summarized as follows:
Column 1: Axial force reduction ranged from 14% to 18.5% across all four seismic zones.
Column 2: Reduction varied between 17% and 22% for all zones.
Column 3: For Zones II, III, and IV, reductions ranged from 14% to 20%, while in Zone V the reduction was between 12% and 20%. A representative graph illustrating axial force reduction for Column 1 in Zone II is provided.

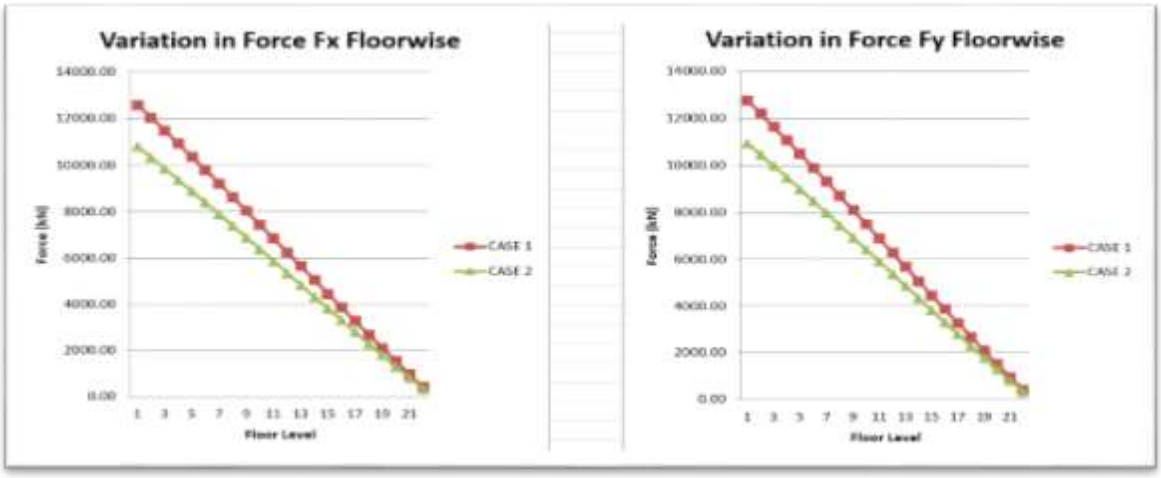

Fig - 2 Axial force graph of Column 1 (Zone II)

Shear Force

The maximum shear forces in the three columns, along both longitudinal (X) and transverse (Y) directions, were evaluated for seismic Zones II, III, IV, and V under Case I (RCC slabs) and Case II (Hollow Core Slabs).
Across all seismic zones, shear forces in both X and Y directions were consistently lower in Case II compared to Case I.
Since shear force demand directly influences the required area of shear reinforcement (Ast), the reduction in shear forces in

Case II implies a corresponding reduction in reinforcement, thereby improving the overall economy of the structure.
The percentage decrease in shear forces in Case II was observed to be in the range of 18%–22% relative to Case I.
A representative graph illustrating the shear force variation for Column 3 in Zone III is presented.

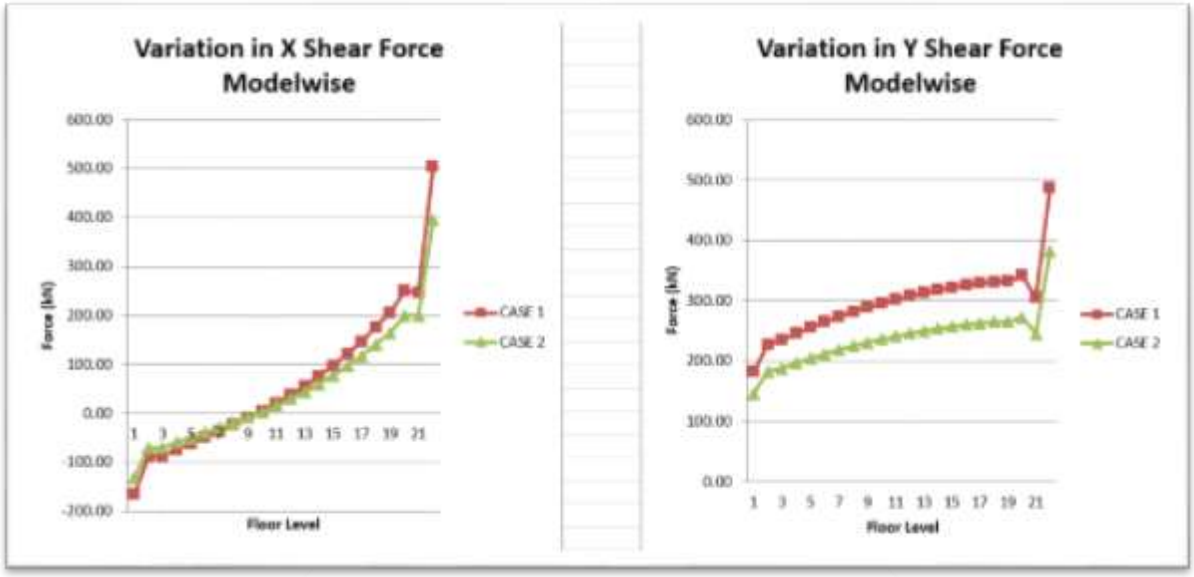

Fig - 3 Shear force graph of column 3 (Zone III)

Bending Moment

The maximum bending moments in the three columns, along both longitudinal (X) and transverse (Y) directions, were analyzed for seismic Zones II, III, IV, and V under Case I (RCC slabs) and Case II (Hollow Core Slabs). In all seismic zones, the bending moments in both directions were consistently lower in Case II than in Case I. Since bending moment demand directly governs the required area of longitudinal reinforcement (Ast), the reduction observed in Case II leads to decreased reinforcement requirements, thereby improving cost efficiency. The percentage reduction in bending moments for Case II ranged between 17% and 21% compared to Case I across the studied seismic zones. A representative graph showing the bending moment variation for Column 1 in Zone IV is provided.

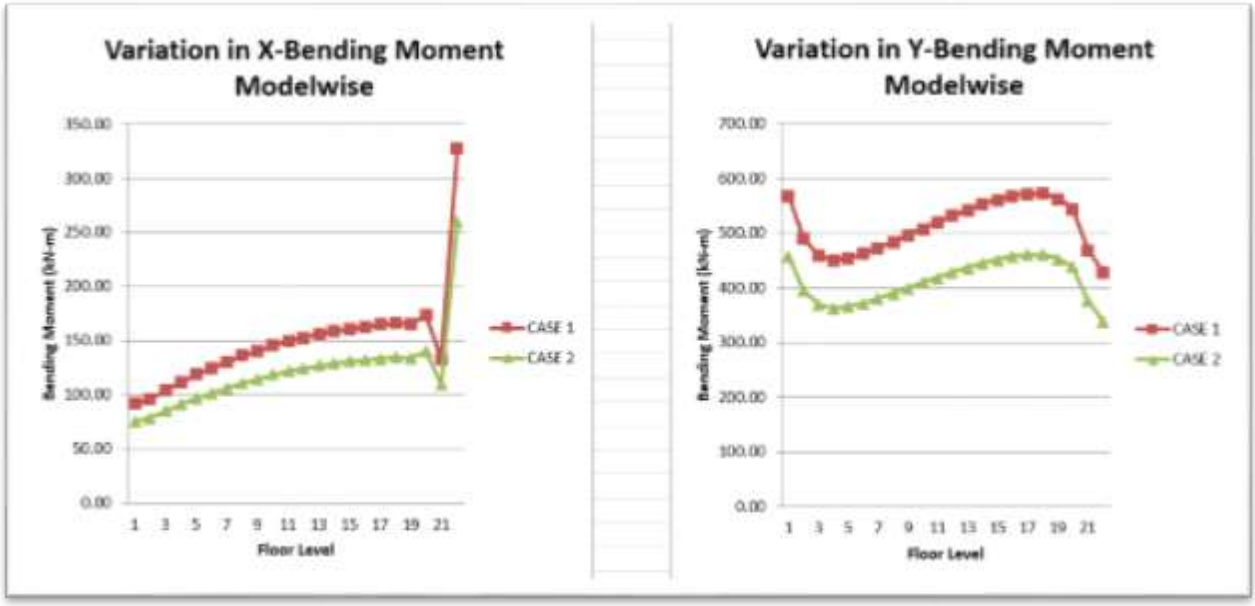

Fig - 4 Bending Moment graph of column 1 (Zone IV)

Displacement

Storey-level displacements in both longitudinal (X) and transverse (Y) directions were plotted against building height for Case I (RCC slabs) and Case II (Hollow Core Slabs), with both sets of results superimposed on the same graph. The graphs indicate that Case II consistently exhibited lower storey displacements in both directions when compared to Case I across all seismic zones. As the seismic intensity increased from Zone II to Zone V, displacement values increased for both cases; however, the HCS model (Case II) maintained smaller displacement values than the RCC model (Case I) in each zone. On average, Case II demonstrated approximately 20% lower storey displacement than Case I at every floor level in both longitudinal and transverse directions. A representative plot of storey-level displacements for Zone V is presented.

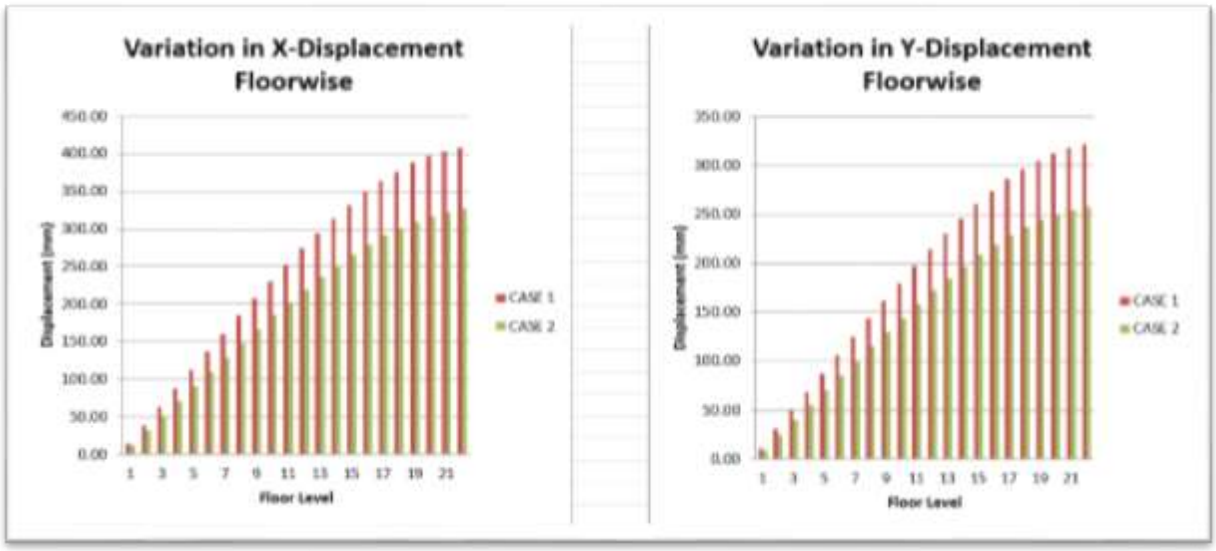

Fig - 5 Storey level displacement graph for Zone V

Storey Shear

Storey shear values in both longitudinal (X) and transverse (Y) directions were plotted against building height for Case I (RCC slabs) and Case II (Hollow Core Slabs), with results superimposed on the same graph for comparison. Across all seismic zones, the storey shear in Case II was consistently lower than in Case I.The reduction became more pronounced with increasing building height, indicating that the lighter HCS system significantly reduced shear demand in the upper storeys.The percentage reduction in storey shear for Case II ranged from approximately 19% at the ground level to 23% at the roof level compared with Case I.This trend of reduction remained uniform across all seismic zones. A representative graph illustrating storey shear variation for Zone II is provided.

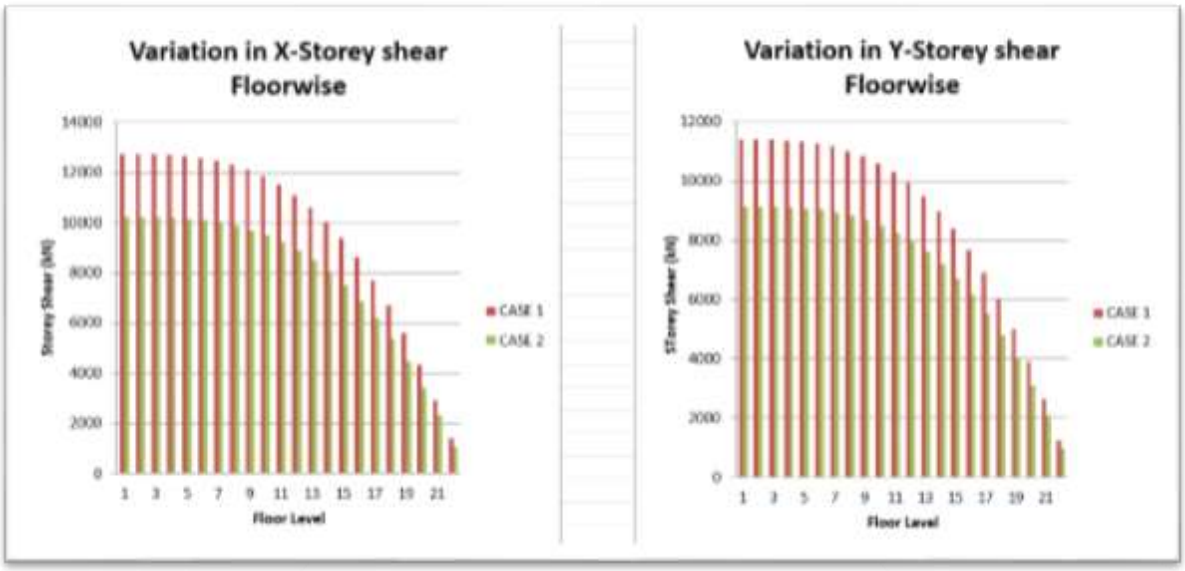

Fig - 6 Storey Shear Graph for Zone II

Base Shear

Base shear values in both longitudinal (X) and transverse (Y) directions were evaluated for the three columns under seismic Zones II, III, IV, and V, for Case I (RCC slabs) and Case II (Hollow Core Slabs). Owing to the reduction in structural weight of the HCS system (approximately one-third lighter than RCC slabs), the base shear in Case II was consistently lower than in Case I across all seismic zones. Although the magnitude of base shear increased with higher seismic intensity from Zone II to Zone V, the values for Case II remained smaller in comparison to Case I for each zone. Since base shear directly influences the reinforcement demand in foundations, the reduced values in Case II lead to a corresponding decrease in footing reinforcement, contributing to overall economy.

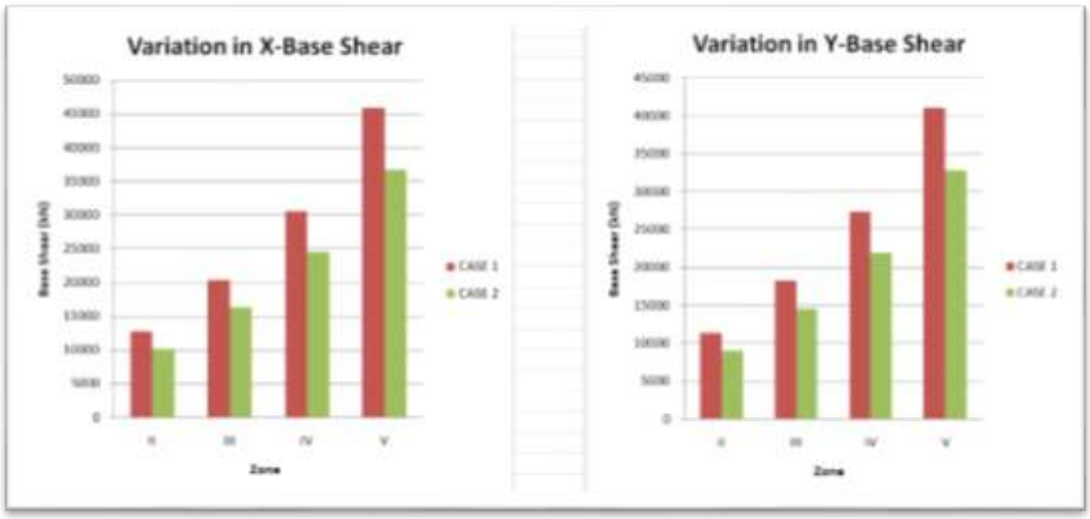

Fig - 7 Base shear graph

V. Conclusion

This study compared the structural performance of RCC and Hollow Core Slab systems in a high-rise building under seismic loading. The key findings are:

Axial forces reduced by 12–22% in HCS models compared to RCC.

Shear forces and bending moments decreased by 18–22% and 17–21%, respectively.

Storey displacements were about 20% lower with HCS across all seismic zones.

Storey shear reductions ranged from 19% at the base to 23% at the top storey.

Base shear values were consistently lower for HCS, leading to reduced foundation reinforcement.

Overall, Hollow Core Slabs proved to be a lighter, more efficient, and cost-effective alternative to RCC slabs, particularly beneficial for high-rise structures in seismic zones.

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