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SEISMIC ANALYSIS OF DIFFERENT SHAPED SCHOOL BUILDING

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Abstract: **-** Around the world, the buildings are hit by the seismic forces which leaves impact on the structures, school structures are the structures which are used as shelter in case of natural calamities so these structures are expected to take these seismic forces better than other structures. The effect of seismic forces can be minimized by various ways, one of this is plan shape of the structure.

In this project, three different shaped plans of school structure have been analyzed for seismic loads in two different seismic zones, zone 3 and zone 4. The application Etabs 2020 is used to simulate and analyze structural data. Wind load is taken into account in accordance with IS 875 part 3 and seismic zone in accordance with IS 1893(Part 1): 2002. The Results of all three shaped building analysis are compared, and the results are shown in terms of story displacement, storey drift, base shear, and time period.

***Index Terms* – Plan Irregularity, Displacement, Storey drift, Base Shear, Time Period, ETABS software.**

I. INTRODUCTION

The development of modern architecture resulted in a surge of complicated and different building designs, dramatically altering the landscape of construction. However, these cutting-edge architectural wonders frequently pose difficulties for structural engineers, particularly with regard to the crucial elements of a structure's stability and safety. Due to its capacity to evenly distribute loads over a building's cross-section, the symmetrical form has traditionally been preferred in structural design. The effective transfer of these loads to the foundation depends on both vertical and horizontal geometry. A building's geometry has a significant impact on how it responds to outside pressures and how it behaves.

1.1 Plan Irregularity:

1.Torsional Irregularity: In the typical scenario, a well-proportioned building does not undergo torsional twisting around its vertical axis. This occurs when: a) The vertical elements responsible for withstanding lateral forces are designed with stiffness distributed in a way that aligns with the mass distribution at each story level within the building's layout. b) The floor slabs possess adequate stiffness within their own plane, typically occurring when their plan aspect ratio not greater than 3.

2.Re-entrant Corners: A building is considered to possess a re-entrant corner in a given plan direction when its structural arrangement in the plan includes a projection that exceeds 15 percent of the total plan dimension in that particular direction **Floor 3.Slabs with Excessive Cut-Outs or Openings**: Openings within floor slabs can induce flexible diaphragm behavior, leading to an uneven distribution of lateral shear forces among frames and vertical members. This effect becomes more prominent when the opening is positioned near the slab's perimeter. A building is deemed to possess an in-plane stiffness discontinuity when floor slabs have cut-outs or openings that surpass 50 percent of the total floor slab area.

4.Out-of-Plane Offsets in Vertical Elements: Vertical elements that deviate out of their designated plane to resist lateral loads can disrupt load distribution, posing a detrimental impact on a building's earthquake safety. A building is considered to exhibit out-of-plane offsets in vertical elements when structural walls or frames are shifted out of alignment on any floor level throughout the building's height.

5.Non-Parallel Lateral Force System Buildings can exhibit intricate seismic responses and the possibility of damage when their systems for resisting lateral forces are not aligned in two plan directions that are mutually perpendicular. A building is categorized as having a non-parallel system when vertically oriented structural systems designed to withstand lateral forces are not aligned with the two primary orthogonal axes in the building's layout.

II. LITERATURE REVIEW

1. **Dhananjay Shrivastava, Dr Sudhir Singh Bhaduria(2017)**

The impact of geometric regularity on the seismic performance of structures has been a subject of substantial interest and investigation within the field of structural engineering. A consensus has emerged from various analyses indicating that buildings characterized by regular geometries tend to exhibit superior behaviour during earthquake events in comparison to their irregular counterparts

In addition to the advantageous effects of geometric regularity, the importance of uniform load distribution around buildings has been underscored by research, it is reasonable to conclude that buildings designed with regular geometric configurations offer a more secure, serviceable, and economically viable option in earthquake-prone regions, as compared to structures with irregular geometries. The inherent ability of regular shapes to dissipate and evenly distribute seismic forces leads to heightened structural robustness and superior performance during seismic events.

Incorporating findings from these studies into engineering practices not only enhances the safety of structures but also underscores the significance of adhering to regular geometries when designing buildings in seismic zones. As ongoing research continues to advance our understanding of structural behavior, these insights provide valuable guidance for designing buildings that can effectively withstand the challenges posed by earthquakes.

2. **T. Prasanthi, P. M. Lavanya (2017)**

Comparison of Building Shapes: A comprehensive examination of various parameters has yielded insights indicating the favourable behavior of rectangular buildings over C-shaped structures. This comparison underscores the superiority of the rectangular geometry in terms of structural performance.

Higher Values of Base Shear and Top Storey Displacement: An overarching observation pertains to the consistently higher values recorded for base shear and top storey displacement when employing both analysis methods

Maximum Storey Drift: Within both rectangular and C-shaped buildings, the 15th storey has been identified as the point of maximum storey drift

Dynamic Analysis vs. Static Analysis (Base Shear): The dynamic analysis approach yields a base shear force value that surpasses that obtained from static analysis by a margin of 9% for both building configurations.

Dynamic Analysis vs. Static Analysis (Top Displacement): In contrast, the values of top displacement derived from dynamic analysis are approximately 12% lower than those deduced from static analysis for both types of buildings.

3. **Gaurav Patidar, Vaibhav Singh(2022)**

1. Vulnerability of T-Shaped Plan Irregular Buildings: Within the scope of plan irregularity, the susceptibility of T-shaped plan irregular buildings to roof displacement becomes a pivotal point of consideration. In stark contrast, when examining vertical irregularity, buildings of L and T shapes exhibit superior performance in comparison to their square counterparts. This dynamic is attributed to the presence of a greater number of shear walls in L and T shaped structures, effectively attenuating roof displacement during dynamic loading conditions.

2. Time Period Trends: An investigation into buildings' time periods offers a unique perspective on their oscillatory behavior. In this regard, L-shaped buildings tend to manifest greater time periods, indicative of prolonged oscillations. Interestingly, this trend undergoes a shift within the domain of vertical irregular buildings, where both square and L-shaped configurations display extended time periods.

3. Storey Drift and Plan Irregularity: The scrutiny of storey drift behavior among plan irregular buildings uncovers a significant pattern. Specifically, T-shaped structures emerge with the highest values of storey drift, underscoring their heightened susceptibility to lateral displacements during dynamic events.

III. OBJECTIVES

1. To analyse (G+4) storey irregular shaped school building structures using equivalent static method for seismic stresses.
2. To compare the seismic performance of school buildings that are U-shaped, H-shaped, and hollow shaped in various zones.
3. To identify the several plan geometries at which the building operates most effectively when seismic forces are applied to it.
4. To look into the base shear, displacement, story drift, and time period responses of the building.
5. To compare the results with the same parameter in another seismic zone and to examine the results for base shear, displacement, story drift, and time period.

IV. METHODOLOGY

1. In this work an attempt is undertaken to study the variations in parameters made by seismic forces on different plan configuration buildings.
2. For the study three plan configurations of school buildings are considered i.e., U-Shaped, H-Shaped and Hollow Shaped.
3. Each model is analysed and studied in two seismic zones, zone 3 and zone 4.
4. For this study the medium type soil i.e., type II is considered for all the models in both zones
5. ETABS 2020 is used for creating and analysing all the models.
6. Equivalent Static method of analysis is used to analyse this model.

V. DESCRIPTION OF MODELS

5.1 The descriptions of the models are as follows:

1. MODEL-1 (M1): U-Shaped G+4 School Building in Seismic zone III
2. MODEL-2 (M2): H-Shaped G+4 School Building in Seismic zone III
3. MODEL-3 (M3): HOLLOW-Shaped G+4 School Building in Seismic zone III
4. MODEL-4 (M4): U-Shaped G+4 School Building in Seismic zone IV
5. MODEL-5 (M5): H-Shaped G+4 School Building in Seismic zone IV
6. MODEL-6 (M6): Hollow-Shaped G+4 School Building in Seismic zone IV

5.2Geometrical and Structural data

Sl. No	Description	Values
02	Carpet Area	610.5m^2
03	Total number of story	4
04	Each story height	3.0m
05	Footing end condition	Fixed support
06	Size of RCC Column	300x600mm
07	Size of RCC Beam	300x450mm
08	Slab thickness 1) One way slab 2) Two-way slab	 150mm 150mm
09	Concrete grade used	M30
10	Rebar Grade Used 1) Grade of main steel 2) Grade of confinement steel	 Fe550 Fe415

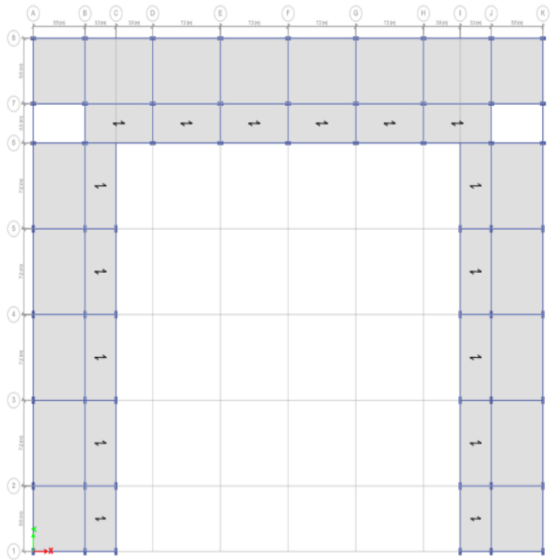
5.3 Details of Load Applied

Dead Load = Self Weight of Structure
Live Load on Floor = 3.0 KN/m^{2}From (IS 875 PART-2)
Floor Finish on Roof and Floors = 1.5 KN/m^2
Wall Load = 12kN/m (for 230mm wall).

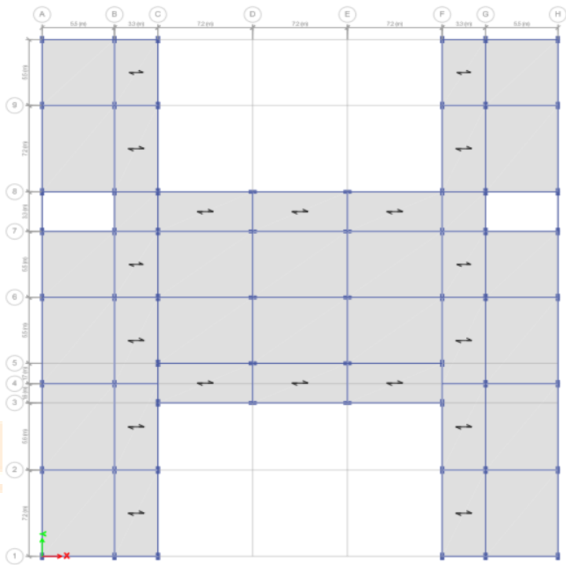
5.4 Seismic Load Detail

Seismic Data: - From (IS 1893 PART-1 2016)
Type of Structure = Institutional building
Zone Factor = 0.16(M1,M2,M3), 0.24(M4,M5,M6)
Type of soil = Medium
Response Reduction Factor = 3
Importance Factor = 1.5

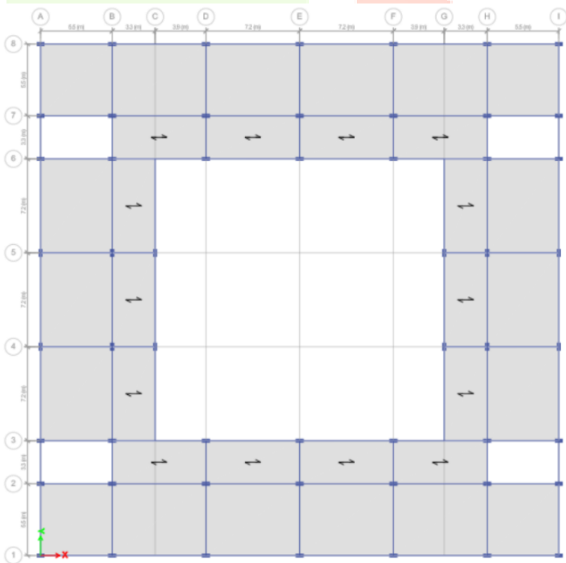
VI. MODELLING



Plan of C Shaped(M1 and M4)



Plan of H Shaped(M2 and M5)



Plan of Hollow Shaped(M3 and M6)

VII. RESULTS

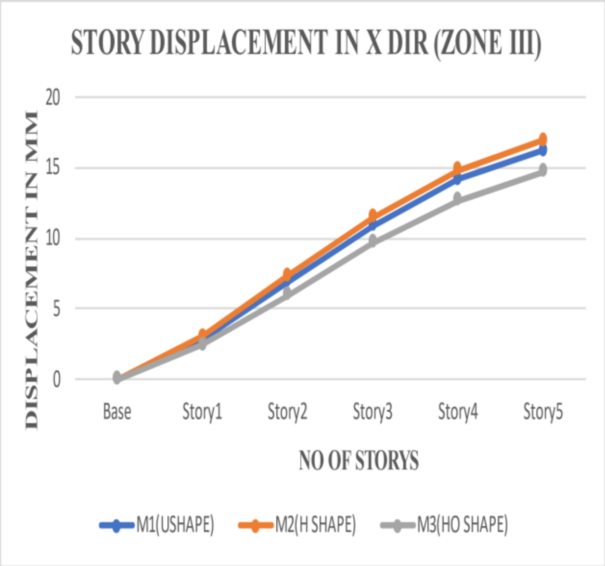
For study all 6 models are subjected to seismic and wind loads. All the models are created using ETABS software 2020. The resulting effects of parameters like displacement, story drift, base shear and time period are tabulated and graphed below and the mentioned are studied and compared.

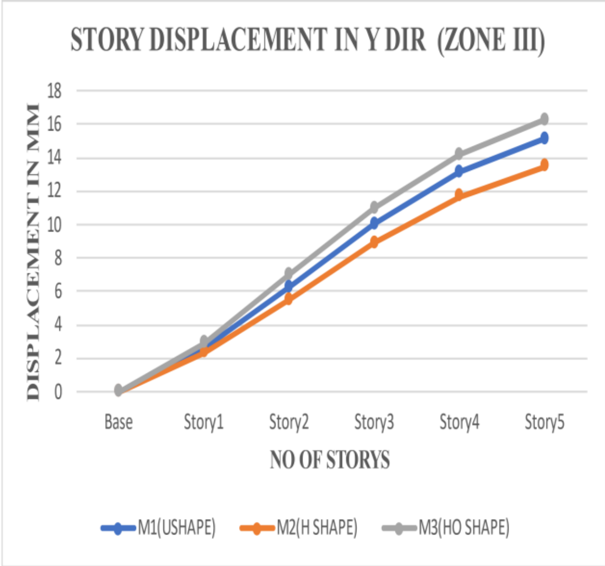
A total of 6 models are created among which 2 models M1 and M4 are U-Shaped, 2 models M2 and M5 are H-Shaped and 2 models M3 and M6 are Hollow Shaped. Models M1, M2, M3 are analyzed in seismic zone 3 and Models M4, M5, M6 are analyzed in seismic zone 4.

The models are analyzed and the results of displacement, story drift, base shear, time period due to seismic loads are withdrawn, the results of various shaped schools building are compared as well as results in both seismic zones are compared.

Displacement

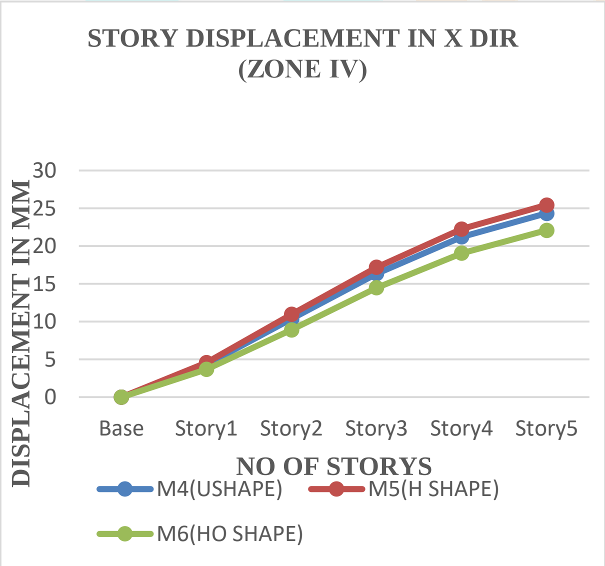
Displacement refers to the relative movement or shift of a point or structure from its original position as a result of ground motion during an earthquake or seismic event. This movement is a critical parameter in assessing the structural response and performance of buildings and other structures during seismic events

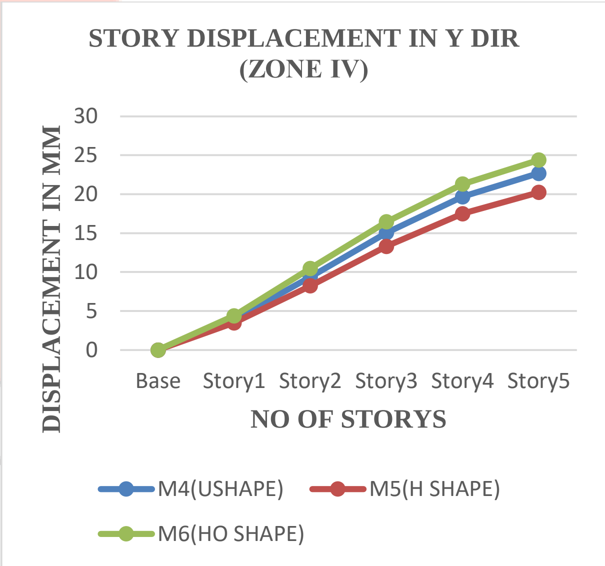




Graph 1:Displacement in X direction for M1 to M3

Graph 2:Displacement in Y direction for M1 to M3



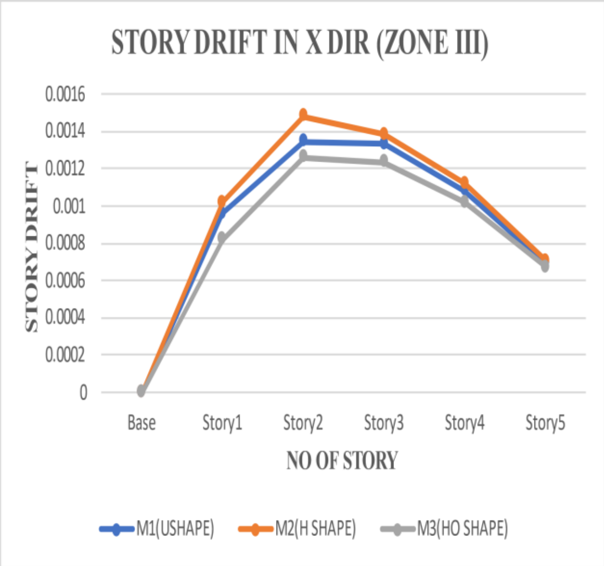


Graph 3:Displacement in X direction for M4 to M6

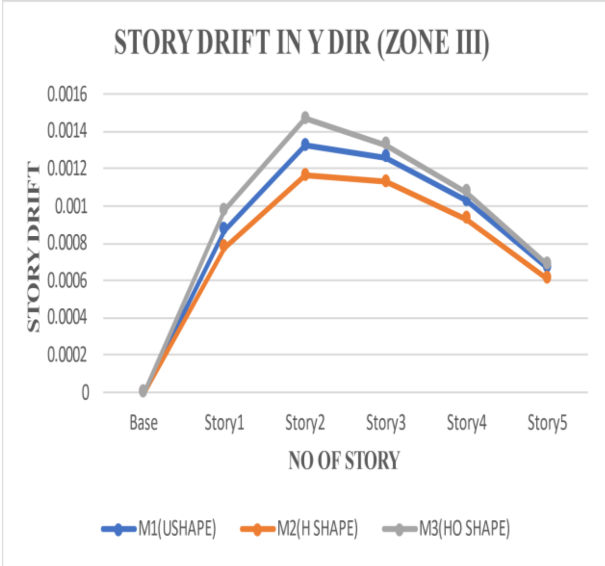
Graph 4:Displacement in Y direction for M4 to M6

Storey Drift

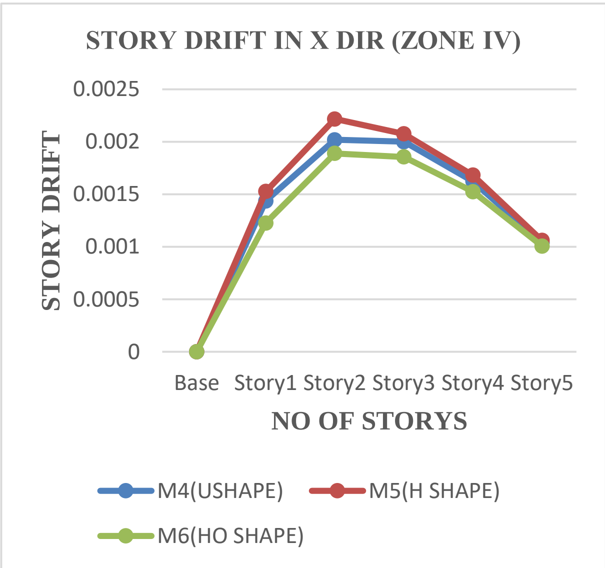
Storey drift is a term used to describe the horizontal displacement or movement of one floor in a building relative to the floor immediately below it. The storey drift ratio, on the other hand, is calculated by dividing the storey drift by the height of the storey in question. This ratio is a measure of the extent to which one floor has shifted laterally in relation to the height of that specific storey in the building.



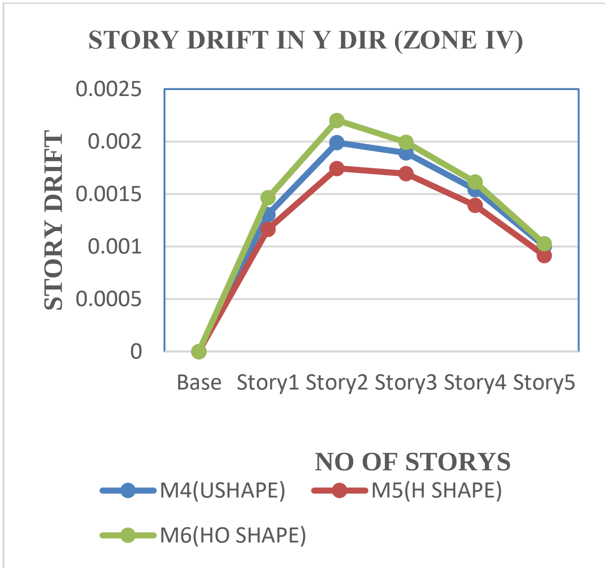
Graph 5:Story Drift in X direction for M1 to M3



Graph 6:Story Drift in Y direction for M1 to M3



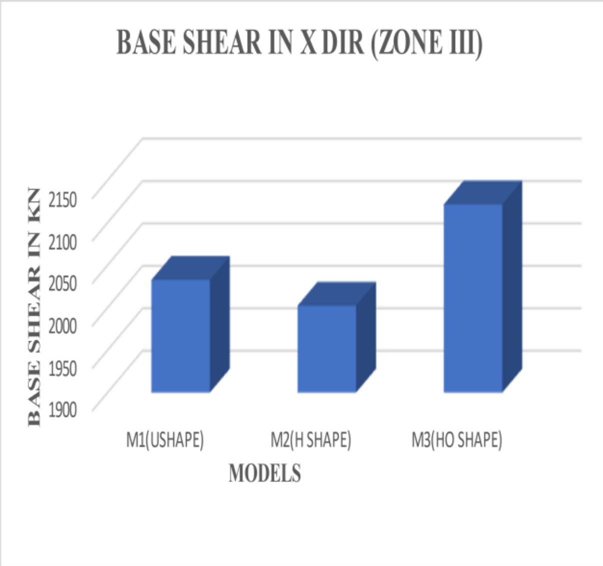
Graph 7:Story Drift in X direction for M4 to M6



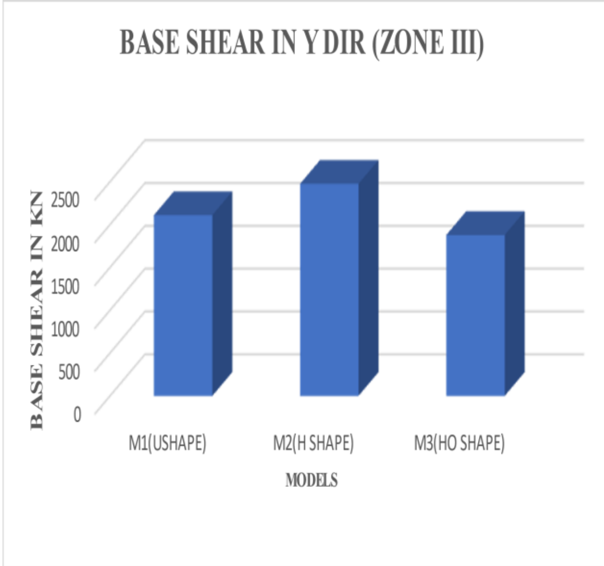
Graph 8:Story Drift in Y direction for M4 to M6

Base Shear

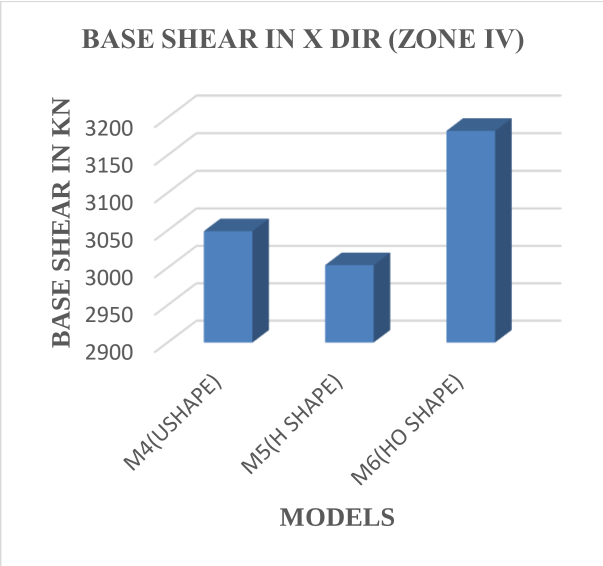
Base shear is a fundamental engineering term that refers to the total lateral (horizontal) force exerted at the base or foundation of a structure during an event that induces lateral movement, such as an earthquake or strong wind. It represents the shear force acting on the building's base due to the dynamic forces applied to the structure. Base shear is a critical parameter in structural design and analysis, as it helps engineers find out the strength and stability requirements for the building's foundation and structural elements to ensure it can withstand lateral forces and remain structurally sound during these events



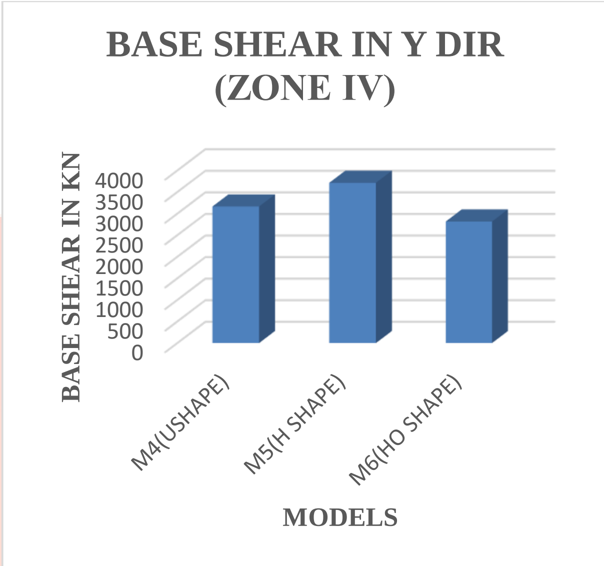
Graph 9:Base Shear in X direction for M1 to M3



Graph 10:Base Shear in Y direction for M1 to M3



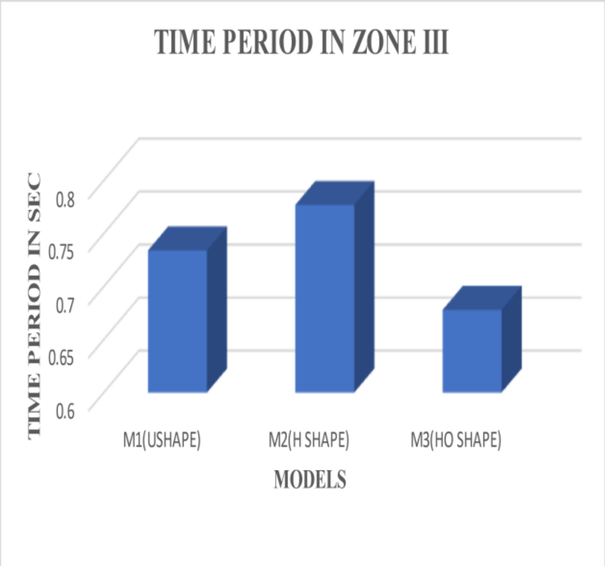
Graph 11:Base Shear in X direction for M4 to M6



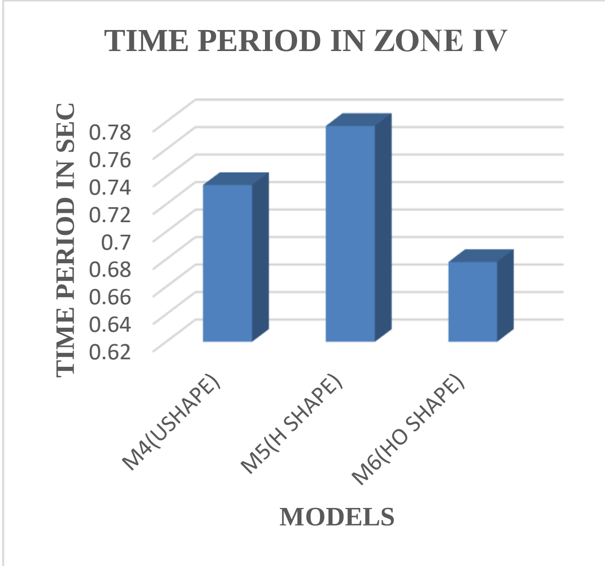
Graph 12:Base Shear in Y direction for M4 to M6

Time Period

Time period, in the context of structural engineering and dynamics, refers to the duration of one complete cycle of oscillation or vibration of a structure subjected to a dynamic force, such as an earthquake or wind. It is typically measured in seconds. The time period is a crucial parameter in understanding the behaviour of structures under dynamic loads because it influences the frequency and amplitude of the structural response. In the context of earthquakes, for example, the time period of a building can helps engineers assess its vulnerability to specific ground motions, and it plays a significant role in seismic design and analysis.



Graph 13:Time Period in Zone III



Graph 14:Time Period in Zone IV

VIII. CONCLUSION

1. Each of the six models used in the analysis displayed story displacement, storey drift values within the permitted limits.
2. The displacement values are higher in top stories of each model, since all the models are asymmetric the values in X-direction and Y-direction varies.
3. The story drift values are higher in 2nd stories of each model, since all the models are asymmetric the values in X-direction and Y-direction varies.
4. The highest values of base shear are observed in hollow shaped building s the lowest is obtained in H-Shaped building.
5. The time period values are maximum in H-Shaped and lowest in hallow shaped.
6. The values of Displacement, Story Drift, Base Shear have increased by 33% in zone IV.

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