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Effect of Different Types of Staircase in a Structure Subjected To Seismic Forces

Vasudev J. Kerai[1], Arjun M Butala[2], Nirmal S. Mehta[3]
[1]PG Student,Department of Civil Engineering U.V.P.C.E.,Ganpat University at Kherva,India.
[2,3]Professor, Department of Civil Engineering U.V.P.C.E.,Ganpat University at Kherva, India.

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ABSTRACT: However, staircase is frequently ignored during design, which has the potential to impact the seismic response of structures. In this research, different type of staircase has been studied. I have three type of staircase studied. The impact of an earthquake on various types of staircases has been examined in this paper. The staircase is typically not considered a primary structural member in building design and is only considered a secondary structural member. One of the main components of the building is the staircase. Therefore, if not taken into account during analysis and design, the structure is vulnerable to damage. Here, we compare the staircase models for various types of staircases to see how seismic effects on buildings change as more staircases are added to an existing structure. Analysis by response spectrum method. ETABS software is utilised to conduct the analysis. Using the ETAB 18 software, the models linear response spectrum analysis was performed in accordance with IS: 1893 (Part-1) - 2016 and IS: 456 - 2000.

KEYWORDS: Story drift, Story displacement, Response spectrum analysis, time period.

I. INTRODUCTION

An earthquake behaves very differently because it is a spontaneous event. Different from other types of loads like gravity and wind loads is the force produced by an earthquake. The three-dimensional structure's weakest link is struck. The structure has many weaknesses as a result of poor design and construction, which can seriously harm people and their property. Because of its functional significance, the staircase is an integral component of secondary structural systems and one of a building's fundamental elements. The staircase has separate non-seismic and seismic designs because of the complicated modelling of the structure.

A stair is made up of an inclined element (beam and slabs) and a short column from a geometrical perspective. These components help the building become stiffness. This suggests that when analysing and designing RC frame buildings, the impact of a staircase cannot be neglected.

The response spectrum method, is a popular structural engineering technique for assessing the seismic response of buildings and other structures, provides an approximation of the structure's response to ground motion by taking the dynamic properties of the system into consideration.

The response spectrum shows a dynamic system's maximum response over a range of vibration frequencies. A target design spectrum, which is frequently based on building codes or particular design criteria, is then matched to the response spectrum of the ground motion. The expected response of the structure to ground motion with respect to various frequencies is described by the design spectrum. The structure's dynamic behaviour is modelled as a collection of idealised mass, stiffness, and damping elements. To ascertain the structure's natural frequencies, mode shapes, and modal masses, a modal analysis is carried out. Mode Superposition: Using the superposition principle, the responses to each mode are first calculated independently and then combined. Based on each mode's modal mass and participation factor, the overall response's contribution from each mode is weighted.

The response spectrum method is widely employed in seismic design and analysis as it provides a simplified yet effective approach to estimate the structural response to earthquakes. It allows engineers to assess the vulnerability of structures, optimize design parameters, and make informed decisions regarding seismic-resistant design strategies.

II. AIM, OBJECTIVE AND SCOPE OF WORK

2.1 Aim of study

The aim of my research work is "Effect of Different Types of Staircase in a Structure Subjected to Seismic Forces".

2.2 Objective of study

Objectives of the present study are as follows:

- To investigate how various staircase types affect a structure that is subject to seismic forces.
- To find out how loads are distributed and how that affects stairways.
- To investigate the structural members close to the staircase's seismic response to seismic loads.

2.3 Scope of work

- The main goal of this study is to understand how various types of staircases respond when they are subjected to seismic forces.
- This study also uses analytical and numerical methods to demonstrate the structural ideas.

III. ANALYSIS FOR EFFECT OF DIFFERENT TYPES OF STAIRCASE IN A STRUCTURE SUBJECTED TO SEISMIC FORCES

3.1 General:

The ETABS software is used here to model building structure for same heights of building models and all structures are same in geometry. The buildings are multi-storied and for analysis, response spectrum method is taken out. In all structures, seismic zone Ⅲ is taken and the type of is medium taken for analysis.

3.2 Response Spectrum Analysis of Structures in ETABS :

The analysis was carried out by considering different types of staircase for structure. A multi-storied buildings are taken of G+7, G+10 storey. The analysis is carried out on total numbers of 6 models using response spectrum analysis in ETABS 2018. IS 1893:2016, IS 875:2015 codal provisions are considered for the analysis. The plan dimensions considered for analysis are rectangle shape building has 20.72mX 21.82m.

Models taken for analysis are as follow:

Table 1: Model List

Model Number	Number Of Storey's	Type of staircase
1	G+7	Half Turn
2	G+7	Open Well
3	G+7	Open Well With Quarter Turn Landing
4	G+10	Half Turn
5	G+10	Open Well
6	G+10	Open Well With Quarter Turn Landing

Considering the data for the **Model – 1, 2, 3** shown in table : 2

Table 2: Model Data – 1, 2, 3

Number of Storey	G+7
Distance in grid (X – dir.)	20.72 m
Distance in grid (Y – dir.)	21.82 m
Concrete grade	M 25

Steel grade	Fe-500
Seismic zone	III
Height of floor	3.1 m
Columns size	230 x 450mm, 350 x 600mm
Beams size	230 x 450mm, 300 x 600mm
Depth of slab	150 mm
External of wall	230 mm
Internal of wall	115 mm
Parapet wall height	1.5 m
Density of concrete	25 kN/m²
Density of masonry	22.5 kN/m²
Floor Finish	1.5 kN/m²
Live load	3 kN/m²
Importance factor	1.2
Response reduction factor	5
Damping	5%
Type of soil	Medium
Type of support	Fix

Considering the data for the **Model – 4, 5, 6** shown in table : 3

Table 3: Model Data – 4, 5, 6

Number of Storey	G+10
Distance in grid (X – dir.)	20.72 m
Distance in grid (Y – dir.)	21.82 m
Concrete grade	M 25
Steel grade	Fe-500

Seismic zone	III
Height of floor	3.1 m
Columns size	230 x 450mm, 350 x 600mm
Beams size	230 x 450mm, 300 x 600mm
Depth of slab	150 mm
External of wall	230 mm
Internal of wall	115 mm
Parapet wall height	1.5 m
Density of concrete	25 kN/m²
Density of masonry	22.5 kN/m²
Floor Finish	1.5 kN/m²
Live load	3 kN/m²
Importance factor	1.2
Response reduction factor	5
Damping	5%
Type of soil	Medium
Type of support	Fix

3.3 Modelling of the Structure Using ETABS :

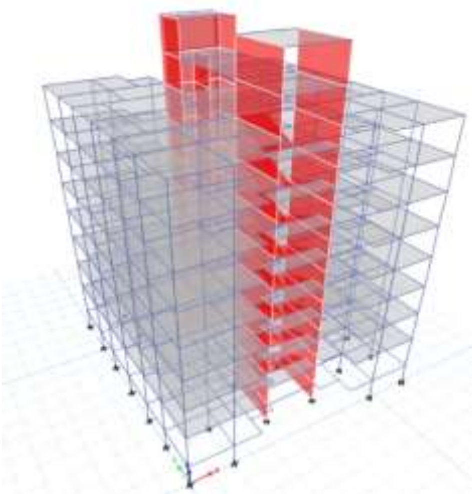

Fig 1 Model – 1

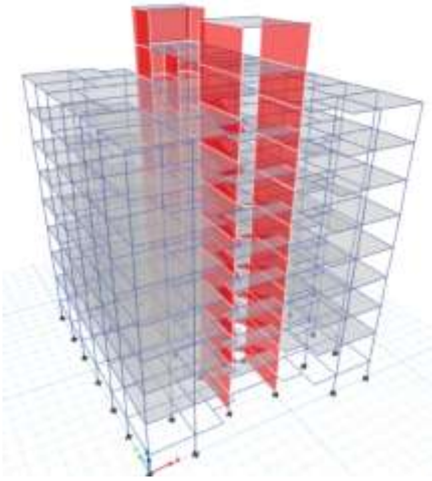

Fig 2 Model – 2

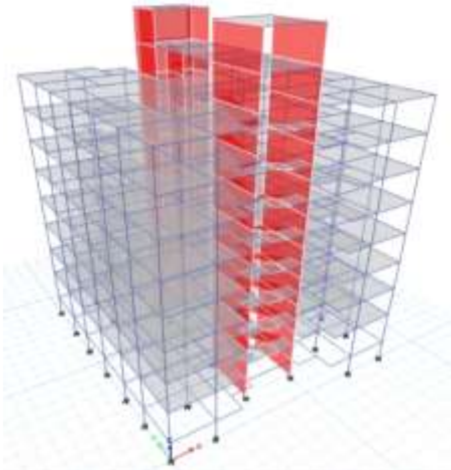

Fig 3 Model – 3

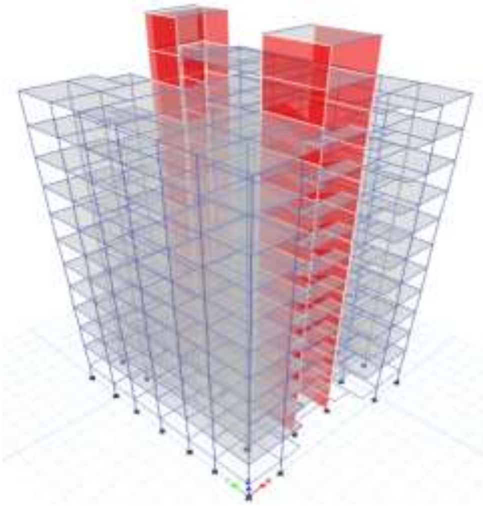

Fig 4 Model – 4

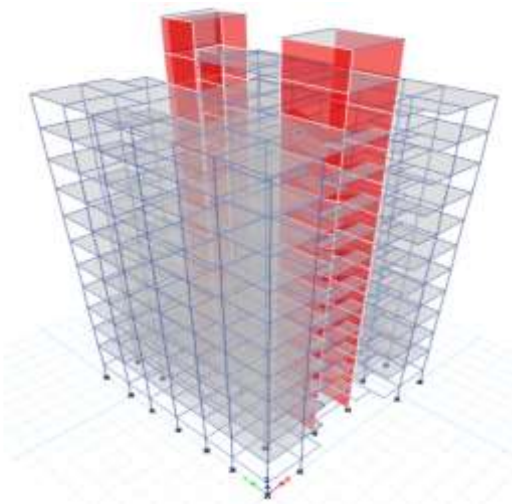

Fig 5 Model - 5

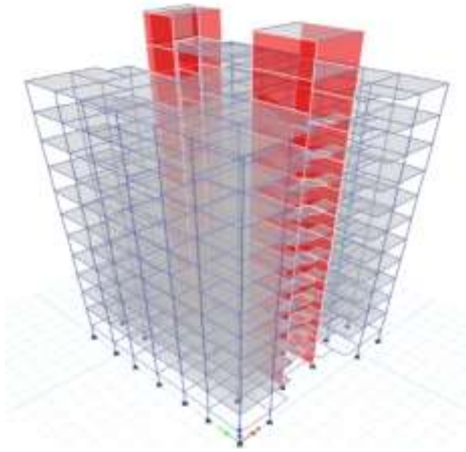

Fig 3 Model - 6

IV. ANALYSIS AND RESULTS

4.1 Results of Model – 1,2,3 :

Fig 7 Graph of Maximum Story Displacement in X-Direction of Model-1,2,3

Fig 8 Graph of Maximum Story Displacement in Y-Direction of Model-1,2,3

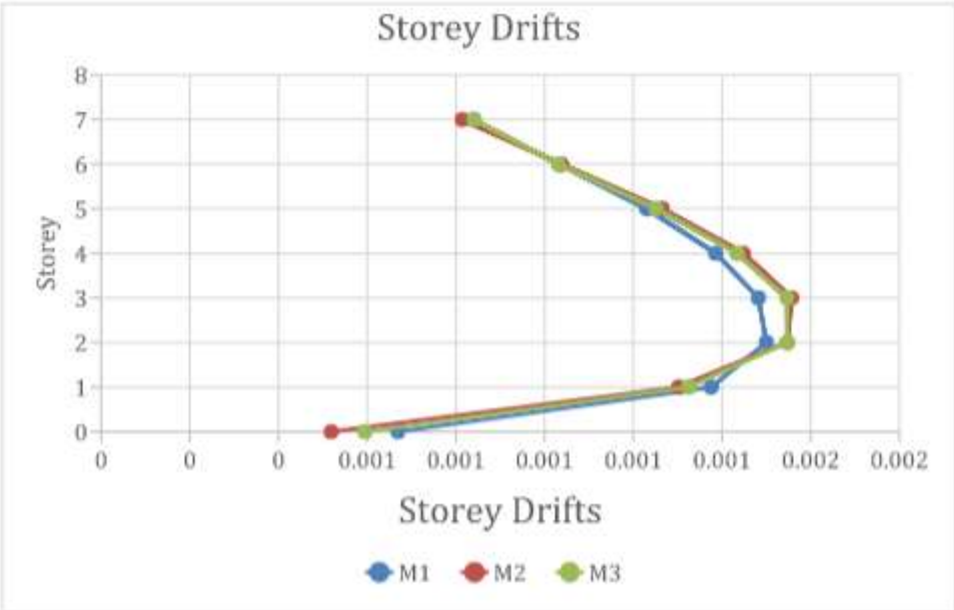

Fig 9 Graph of Maximum Story Drifts in X-Direction of Model-1,2,3

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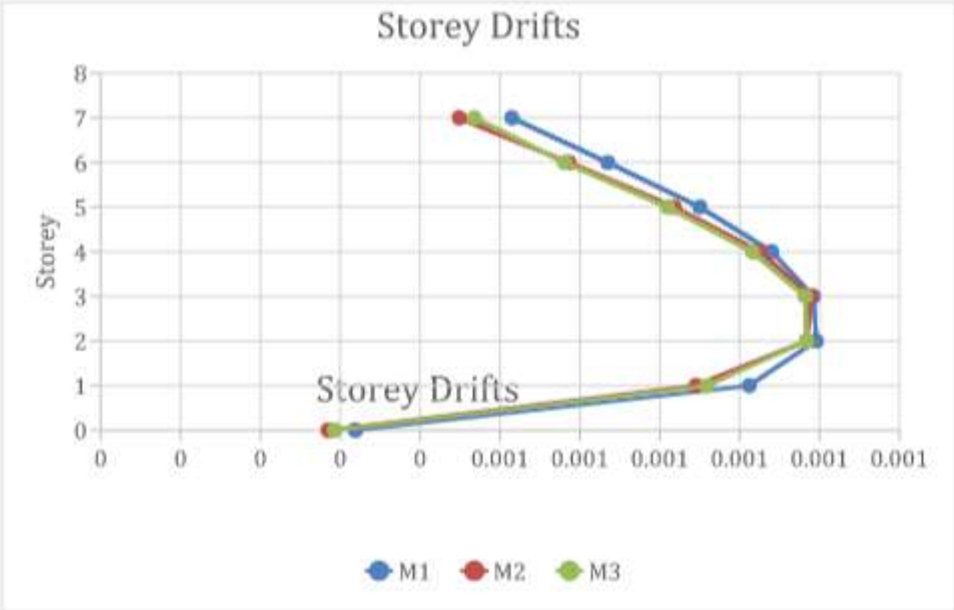

Fig 10 Graph of Maximum Story Drifts in Y-Direction of Model-1,2,3

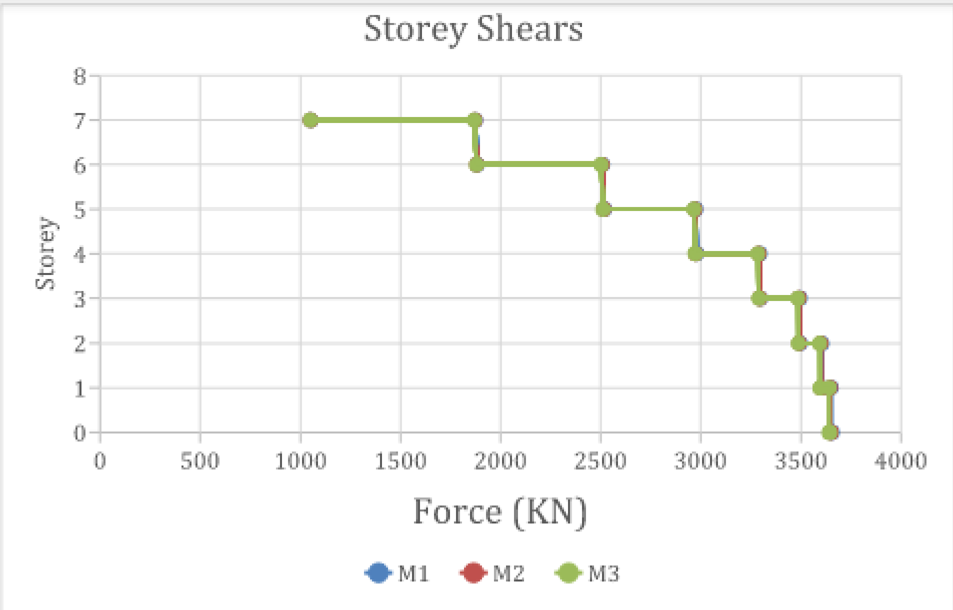

Fig 11 Graph of Maximum Story Shear in X-Direction of Model-1,2,3

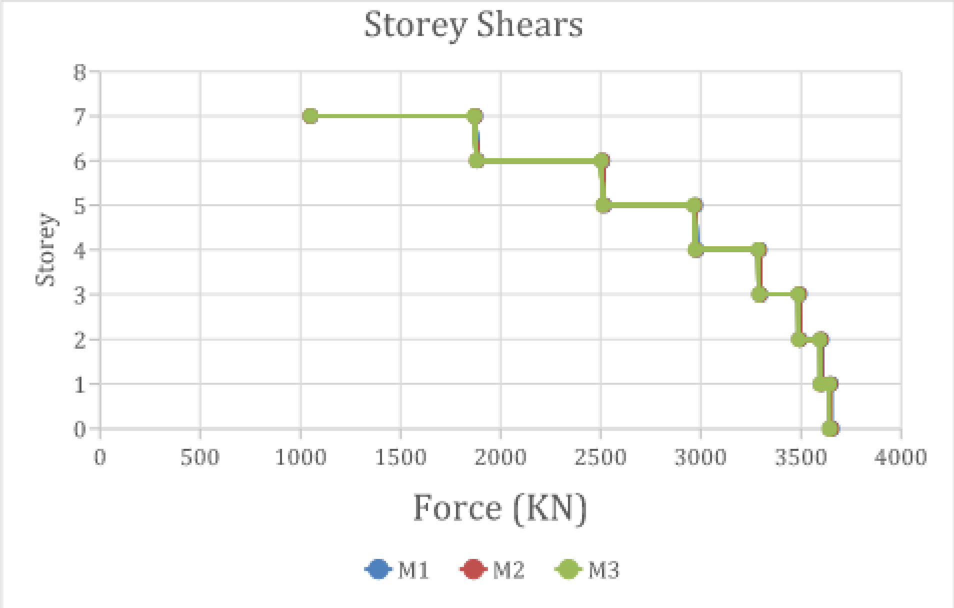

Fig 12 Graph of Maximum Story Shear in Y-Direction of Model-1,2,3

4.2 Results of Model – 4,5,6 :

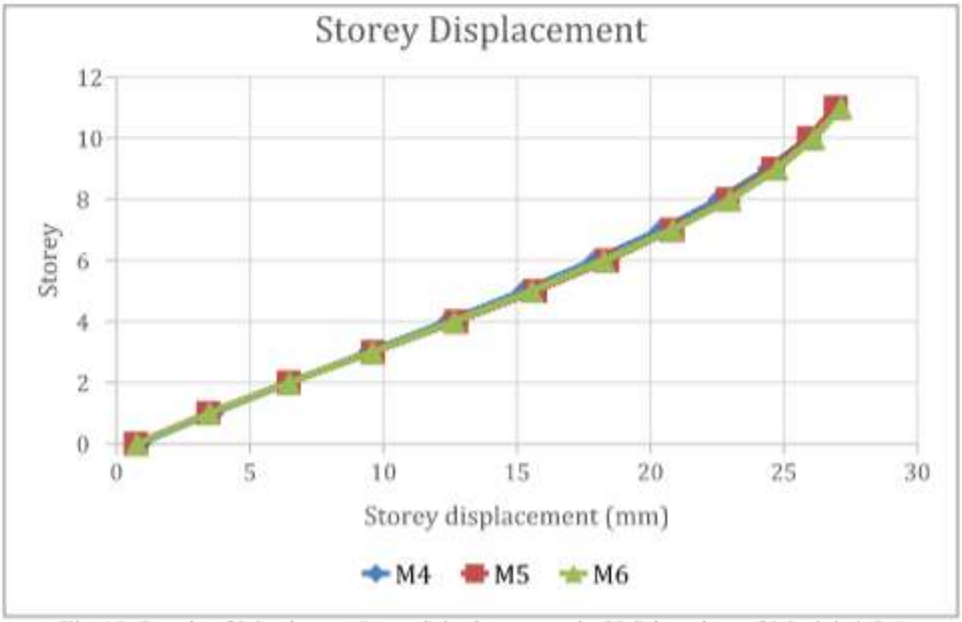

Fig 13 Graph of Maximum Story Displacement in X-Direction of Model-4,5,6

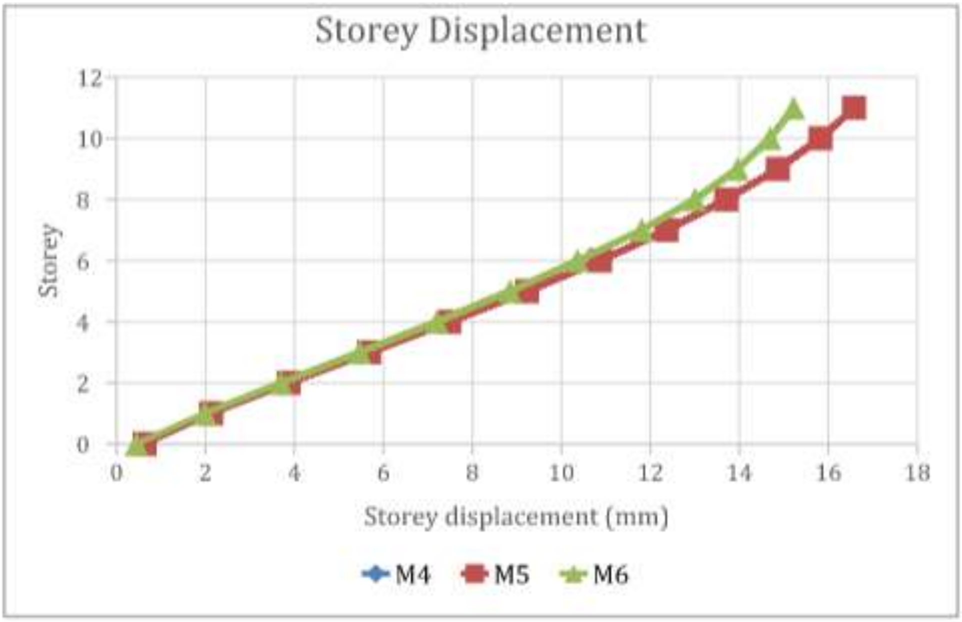

Fig 14 Graph of Maximum Story Displacement in Y-Direction of Model-4,5,6

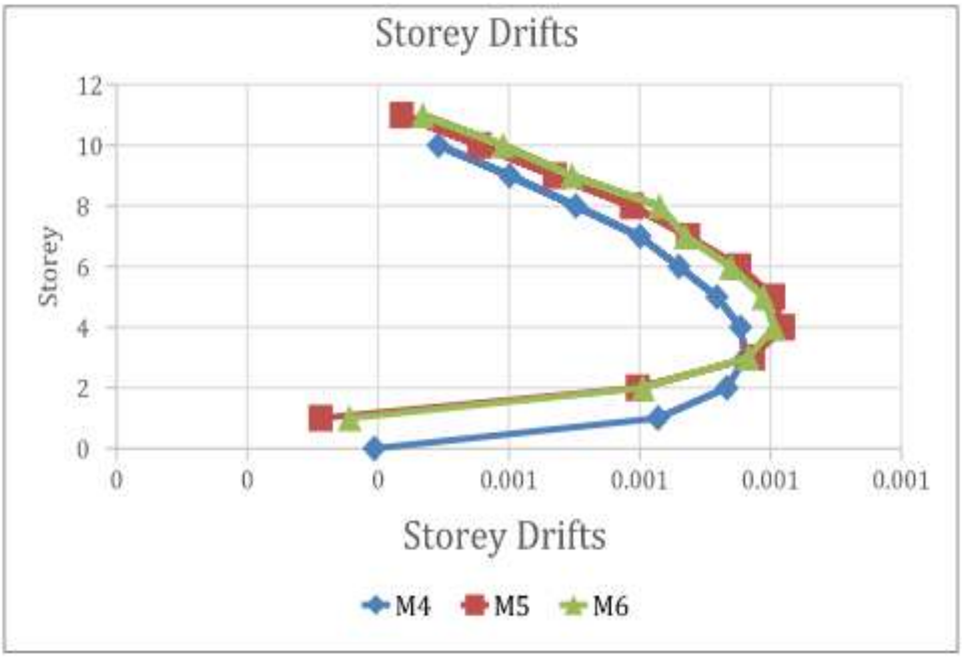

Fig 15 Graph of Maximum Story Drifts in X-Direction of Model-4,5,6

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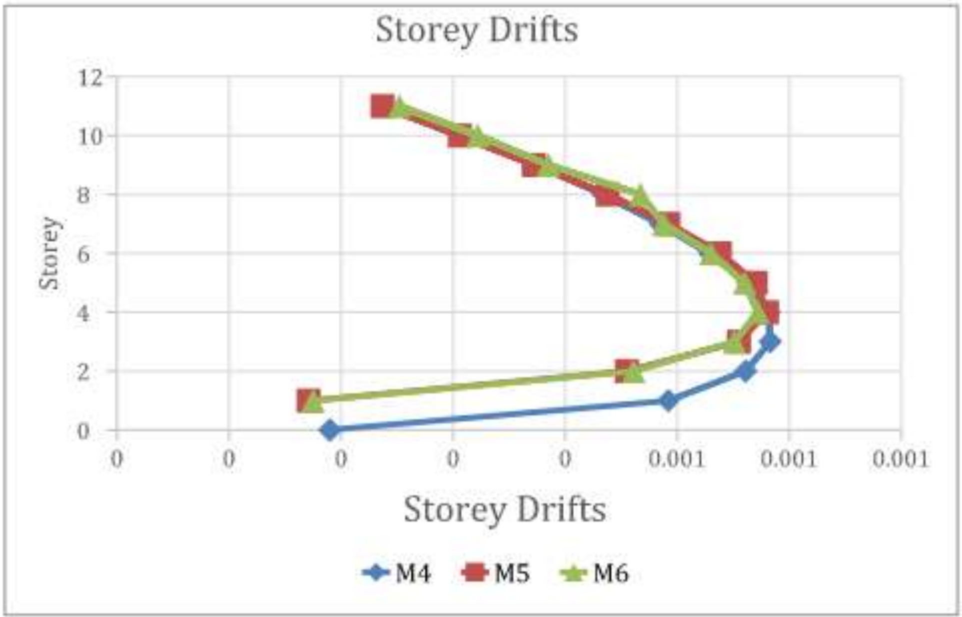

Fig 16 Graph of Maximum Story Drifts in Y-Direction of Model-4,5,6

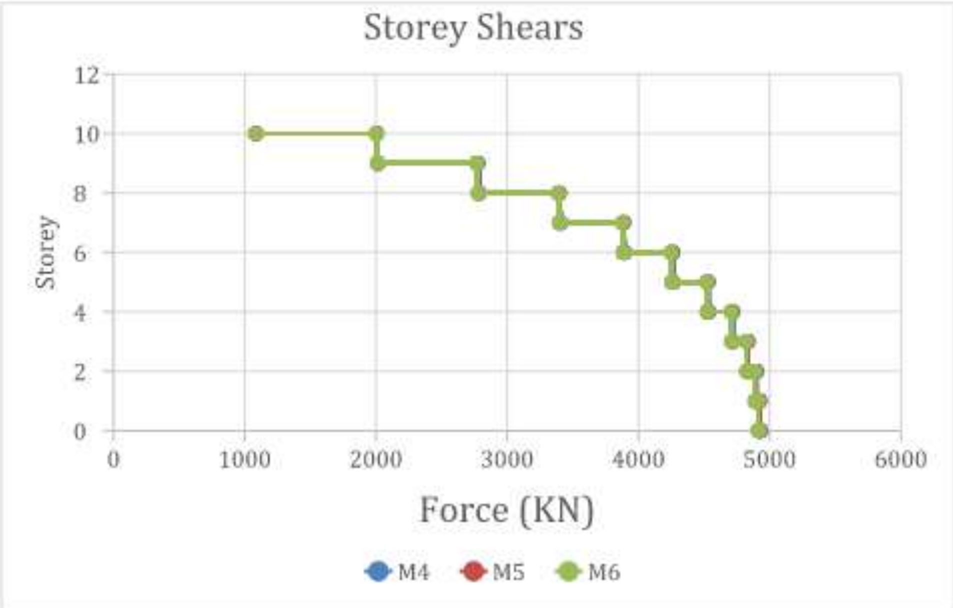

Fig 17 Graph of Maximum Story Shear in X-Direction of Model-4,5,6

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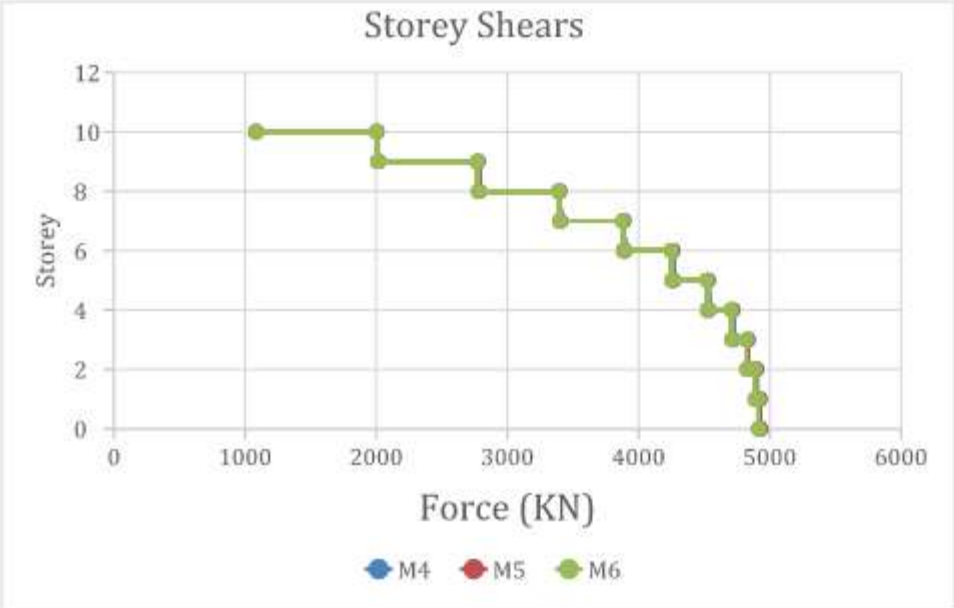

Fig 18 Graph of Maximum Story Shear in Y-Direction of Model-4,5,6

V. CONCLUSION

- According to the study, the percentage of rebar reinforcement varies depending on the type of staircase.
- Results shows that the Model-M1 has a lower maximum Story displacement value than Model-M2 and Model-M3, Model -M3 value is greater than Model-M1 and Model-M2 values, while Model -M2 value is less than Model-M3 value in storey displacement.
- The study determined that Model-M1 displayed the highest maximum Story drifts value compared to Model-M2 and Model-M3, where as Model-M3 carried the lowest maximum Story displacement value and Model-M2 displayed the highest maximum Storey drifts value.
- The findings indicate that Model-M1 has a greater maximum Story shear value than Models M2 and M3, where as Models M3 and M2 possess lower maximum Story displacement values and higher maximum Storey shear values, respectively.
- The study found that Model-M4 has a lower maximum story displacement value than Model-M5 and Model-M6, Model-M6 value is bigger than Model-M4 and Model-M5 values, and Model-M5 value has a lower maximum storey displacement value than Model-M6 value.
- The study concluded that Model-M4 has a higher maximum Story drifts value than Model-M5 and Model-M6, Model-M6 possesses a lower maximum Story displacement value than Model-M5, and Model-M5 gets a higher maximum Storey drifts value than Model-M6.
- The investigation found that Model-M4 had a higher maximum story shear value than Model-M5 and Model-M6, whereas Model-M6 had a lower.

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