International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 08 August 2024
Page No: 2141- 2147
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0291

Different Types of Staircase Effected in A Structure Subjected to Seismic Force

Harshkumar L. Hirani[1], Arjun M. Butala[2], Nirmal S. Mehta[3], Ankitkumar S. Patel[4]
[1]PG Student, Department of Civil Engineering, Ganpat University Mehsana - Gujrat, India
[2,3,4]Assistant Professor, Department of Civil Engineering, Ganpat university, Mehsana-Gujrat, India
Emails: *harshhirani475@gmail.com[1], amb03@ganpatuniversity.ac.in[2], nsm01@ganpatuniversity.ac.in[3], asp03@ganpatuniversity.ac.in[4].*

Abstract
Generally, staircases are crucial part in buildings, serving an essential function within the secondary system of the structure. They ensure safe and efficient vertical movement, contributing significantly to the overall accessibility of the building. Staircase, when compared to the modern escalators, offer significant advantages, particularly in emergency situations like fires or natural disasters. They serve as reliable escape routes and contribute to the building's structural stiffness, enhancing overall safety and resilience. Due to the complex modelling, staircases are designed separately for non-seismic and seismic forces. It is clear that the staircases effect analysis and design of reinforced concrete frame buildings. Its structural contribution and impact on overall stability and safety cannot be ignored. The Linear Response Spectrum analysis of the models has been carried out as per IS: 1893 (Part 1) - 2002 and IS: 456 – 2000 with the help of Tabs 18 software.
Keywords: *Response spectrum analysis; Story displacement; Story drift.*

1. Introduction
An earthquake is a disaster event and behavior is very differently. The force generated a seismic behavior like an earthquake is different than other loads, such as wind and gravity load. It is the week point of all three-dimensional building. Its design and method of construction result, many difficulties in the structure, thus because it is damage to a life and property [1], [3]. Staircase is the secondary part of the structure system and it is one of the necessary parts of a building because it is important to the structure. Due to the complex model of staircase, it is design individual for seismic and non-seismic forces. By modelling the staircase, stiffness of the structure increases. Depending on the staircase's location, modeling the staircase results in a change in the displacement of stories [4], [2]. According to a geometrical perspective, a stair is made out of inclined element (beam and slabs) and by short section. These components increase stiffness of the structure [4]. 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 soil is medium taken for analysis.

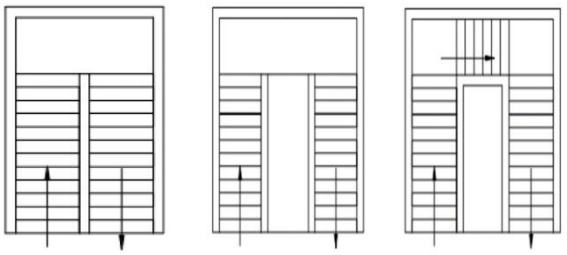

Figure 1 Types of Staircase

As Shown in Figure 1, here the first photo is half turn second is open well and third is open well with quarter turn show [5].

1.1. Aim of Study
Your research aim, "Effect of Different Types of Staircases in a Structure Subjected to Seismic Forces," is quite focused and addresses an important aspect of structural engineering, particularly in regions prone to earthquakes.

1.2. Objective of Study
1. To study different types of staircase effect and how to behaves in a structure.
2. To study the story displacement, story drift.

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 08 August 2024
Page No: 2141- 2147
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0291

3. To study the without stair and with stair comparison.
4. How different types of staircases respond to seismic forces. This includes their deformation patterns, and potential modes of failure.

2. Method

The ETABS software is used here to model building structure for same heights of building models and all structures are square 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 soil is medium taken for analysis [6], [7].

2.1. Response Spectrum Analysis of Structure in ETABS

The analysis was carried out by considering different types of staircases for structure. Multi-storied buildings are taken of G+ 10, G+ 15 storeys. The analysis is carried out on total numbers of 6 models using response spectrum analysis in ETABS 2018. Codal provisions are considered for the analysis [8]. The plan dimensions considered for analysis are rectangle shape building has 17mX 31.50m.
Model taken for analysis are as follow:

Table 1 List of Model

Model Number	Number Of Storey's	Type of Staircase
1	G+10	Without Stair
2	G+10	Half Turn
3	G+10	Open Well
4	G+10	Open Well With Quarter Turn Landing
5	G+15	Without Stair
6	G+15	Half Turn
7	G+15	Open Well
8	G+15	Open Well With Quarter Turn Landing

Considering the data of Model - 1, 2, 3, 4 shown in table-2:

Table 2 Details of G+ 10 Model

Number of Storey	G+10
Distance (X – dir.)	17.00 m
Distance (Y – dir.)	31.50 m
Concrete grade	M 30
Steel grade	Fe 415
Seismic zone	III
Height of floor	3 m
Column size	350 x 450mm
Beam size	230 x 450 mm
Depth of slab	125 mm
Thickness of wall	125 mm
Parapet wall height	1.5 m
Density of concrete	24 kN/m^3
Floor Finish	1.5 kN/m^2
Live load	3 kN/m^2
Importance factor	1.2
Response reduction factor	5
Type of soil	Medium
Type of support	Fix

Table 1 shows List of model. Table 2 shows the details of G+10 model. Figure 2 shows the model-1, Figure 3 shows the model-2, Figure 4 shows the model-3, Figure 5 shows the model-4.

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 08 August 2024
Page No: 2141- 2147
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0291

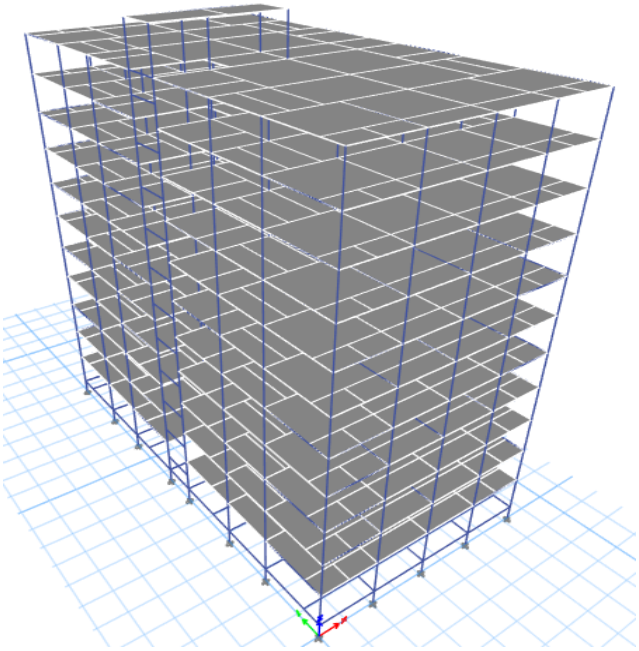

Figure 2 Model – 1

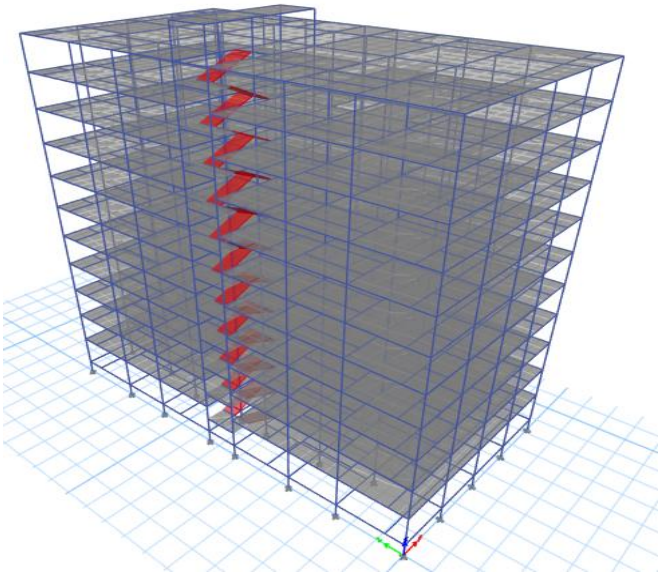

Figure 4 Model – 3

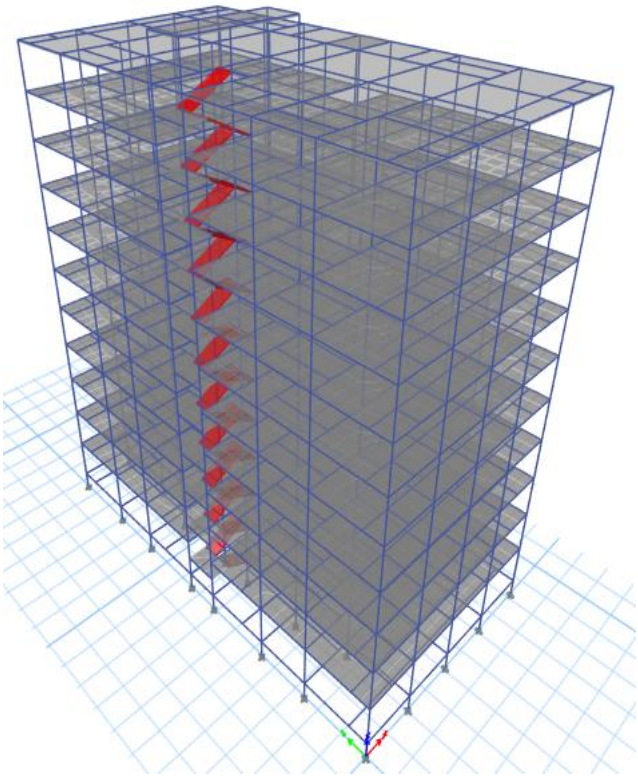

Figure 3 Model - 2

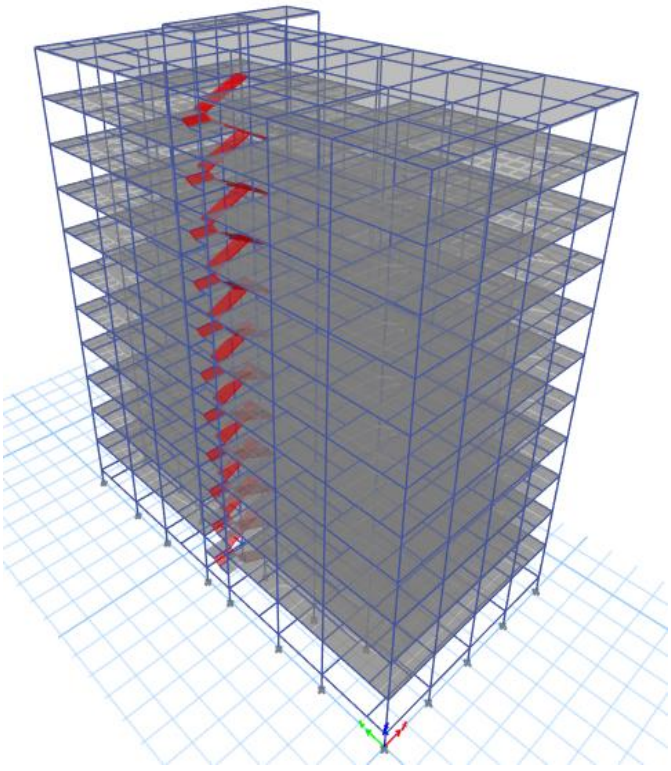

Figure 5 Model – 4

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 08 August 2024
Page No: 2141- 2147
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0291

Considering the data of Model - 5, 6, 7, 8 shown in table-3:

Table 3 Details of G+15 Model

Number of Storey	G+15
Distance (X – dir.)	17 m
Distance (Y – dir.)	31.5 m
Concrete grade	M 30
Steel grade	Fe-415
Seismic zone	III
Height of floor	3 m
Columns size	450 × 500mm
Beams size	230 x 450 mm
Depth of slab	125 mm
Thickness of wall	125 mm
Parapet wall height	1.5 m
Density of concrete	24 kN/m^3
Floor Finish	1.5 kN/m^2
Live load	3 kN/m^2
Importance factor	1.2
Response reduction factor	5
Type of soil	Medium
Type of support	Fix

Table 3 shows the details of G+15 model. Figure 6 shows the model-5, Figure 7 shows the model-6, Figure 8 shows the model-7, Figure 9 shows the model-8.

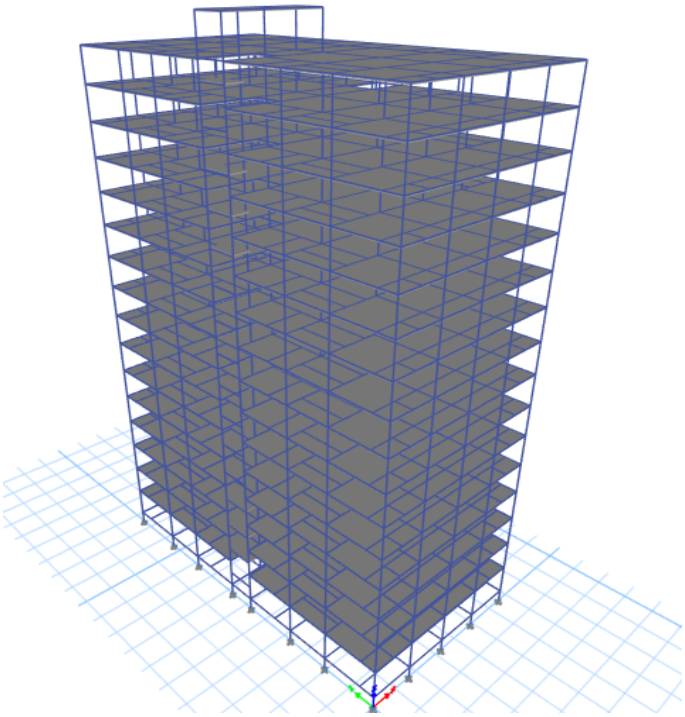

Figure 6 Model-5

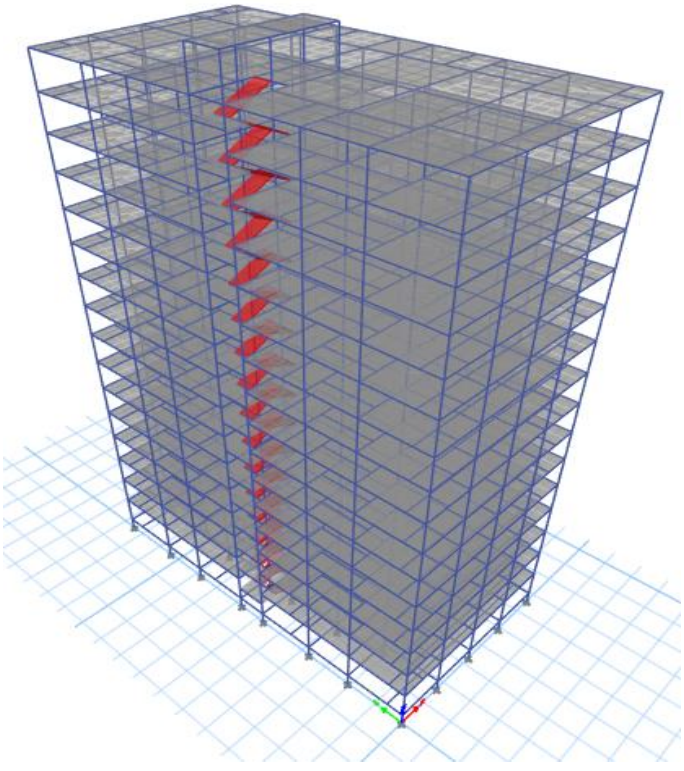

Figure 7 Model-6

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 08 August 2024
Page No: 2141- 2147
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0291

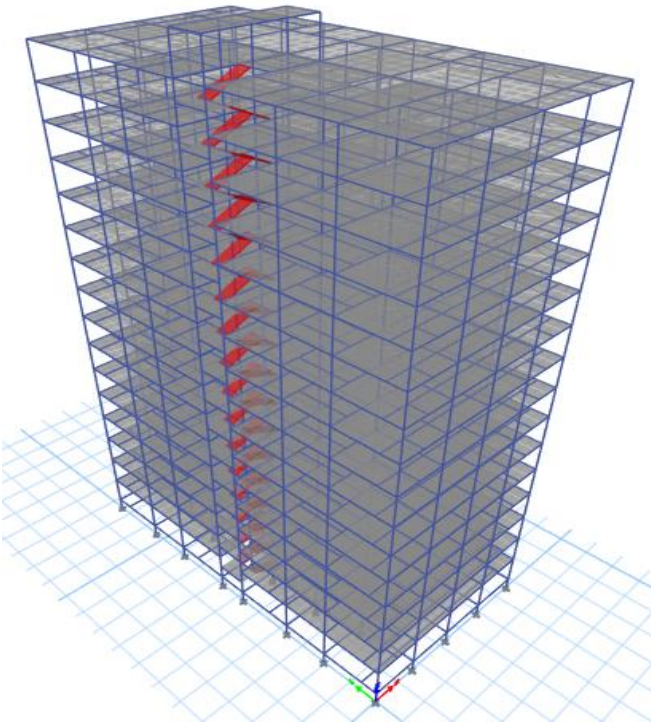

Figure 8 Model – 7

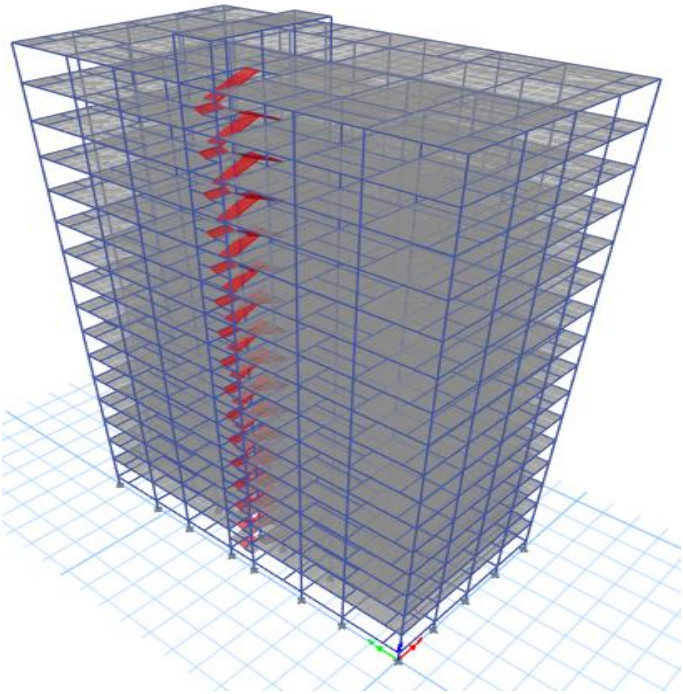

Figure 9 Model – 8

3. Results and Discussion

3.1. Results of Model-1, 2, 3, 4

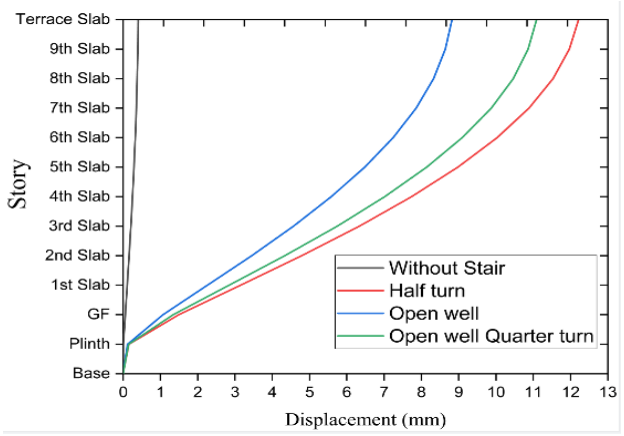

Figure 10 Maximum Story Displacement in X-Direction

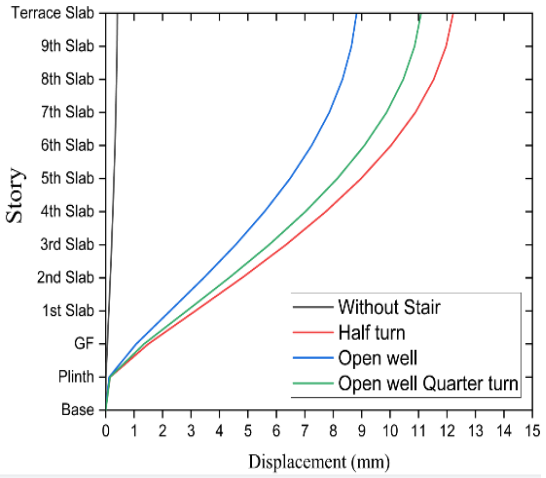

Figure 11 Maximum Story Displacement in Y-Direction

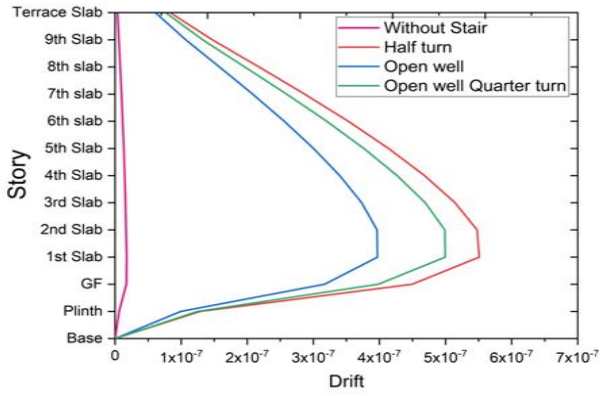

Figure 12 Maximum Story Drift in X-Direction

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 08 August 2024
Page No: 2141- 2147
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0291

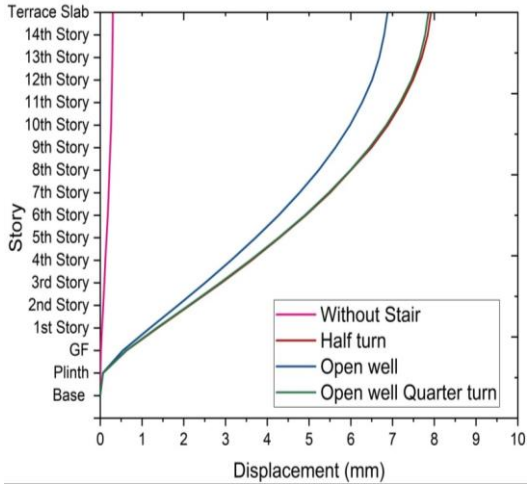

Figure 13 Maximum Story Displacement in X-Direction

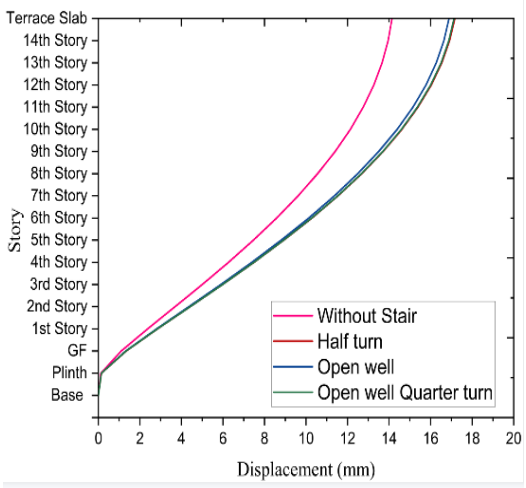

Figure14 Maximum Story Displacement in Y-Direction

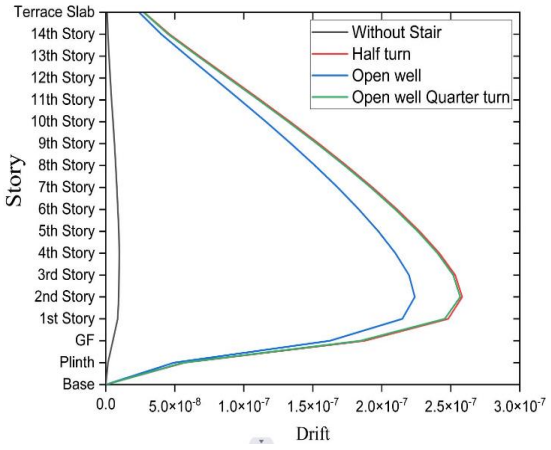

Figure 15 Maximum Story Drift in X-Direction

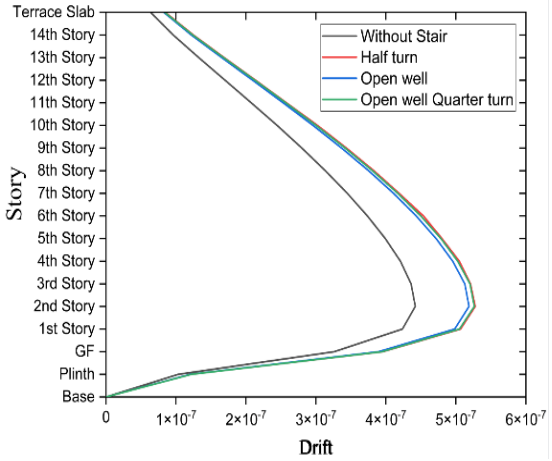

Figure 16 Maximum Story Drift in Y-Direction

Figure 10 shows the maximum story displacement in X-Direction, Figure 11 shows the maximum displacement in Y-Direction, Figure 12 shows the maximum story drift in X-Direction, Figure 13 shows the maximum story displacement in X-Direction, Figure 14 shows the story displacement in Y-Direction, Figure 15 shows the maximum story drift in X-Direction, Figure 16 shows the maximum story drift in Y-Direction. [8]

Conclusion

According to the study without staircase and model 5 is minimum story displacement and story drift. He studies show the model 2 was maximum displacement value than model 3 and model 4. Model 3 is minimum story displacement compare to the model 2 and model 4. From the study, it is observed that the maximum displacement value of model 6 is greater than model 7 and model 8, model 8 values are greater than model 7. Model 5 is without stair its value is minimum for all model 6, 7 and 8. The study determined that model 2 displayed the highest maximum story drift value to the model 3 model 4 and model 1. Where model 1(without staircase) carried lowest story drift value. The study show the maximum story drift is model 6 greater than the model 7 model 8 and model 5. Model 7 is lowest maximum value compared to the model 8 and model 6. Also the model 5 is without stair so that is very low value of story drift-direction and Y-direction both direction the model 2 and model 6 is maximum value of story drift and story displacement compared to the

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 08 August 2024
Page No: 2141- 2147
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0291

model 3, model 4 and model 7, model 8. According to study without staircase story displacement and story drift are minimum value compare to the with staircase model.

Reference

[1]. Zaid M., M. Danish, M. Shariq, A. Masood & A. Baqi. Effect of Staircase On Rc Frame Structures Under Seismic Load. International Conference on Trends and Challenges in Concrete Structures Ghaziabad.

[2]. Ankit R. Shelotkar, Mayur A. Banarase. Effect of Staircase on Seismic Performance of Multi-storeyed Frame Structure. International Journal of Innovative and Emerging Research in Engineering.

[3]. Dr. A.R. Gupta, Miss. Priya R. Mundada. Effect of Staircase on a Structure Subjected to Seismic Forces. International Journal for Research in Applied Science & Engineering Technology (IJRASET).

[4]. Mohammad Aghajani D., Mahsa Pahlavikhah V., Khosro Bargi. (August 16, 2017). Effects of staircase on the seismic performance of reinforced concrete frame buildings considering the position of the staircase. International Conference on Contemporary Iran on Civil Engineering Architecture and Urban Development Iran Tehran.

[5]. Chintan Raghwani & Rajeshkumar Suthar. (2019). Effect of Staircase on a Structure Subjected to Seismic Forces. International Journal for Research in Applied Science and Engineering Technology.

[6]. Indian Standard(IS): 1893 (Part-I) 2016, “Criteria for Earthquake Resistant Design of Structures”.

[7]. Indian Standard(IS): 456 -2000, “Indian Standard Plain and Reinforced Concrete – Code of Practice”.

[8]. Indian Standard(IS): 875:2015, IS Code of Practice for Design Loads (Other than earthquake) for buildings and Structures.