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Impact of Earthquake loads on different foundation systems by using ETAB

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Abstract: Earthquakes pose a significant challenge to structural stability, making it essential to design buildings with foundation systems that can effectively withstand seismic forces. The foundation of a structure plays a critical role in dissipating seismic energy and ensuring the safety of the superstructure. Two Different types of foundation systems respond differently to earthquake loads, depending on soil conditions, structural weight, and dynamic forces. This study focuses on analyzing the impact of seismic loads on two different foundation systems raft foundation, and strap footing using ETABS software and Safe software as foundation design tool.
The objective of this research is to evaluate and compare the seismic performance of these foundation systems when subjected to earthquake loads. A single building structure will be modeled and analyzed using ETABS, with three variations in its foundation system. The comparative analysis will help determine which type of foundation between Raft and Isolated footing is most effective in minimizing structural displacement, base shear, and overall stresses during an earthquake. The study aims to provide valuable insights into the suitability of each foundation type in seismic-prone areas. Since foundation behavior depends on multiple site-specific factors such as soil properties, groundwater conditions, and seismic zoning, this study will use randomly assumed input data rather than being based on a specific site. This approach ensures that the analysis remains generalized and applicable to a wide range of seismic conditions. The results obtained will be evaluated based on key structural response parameters, such as lateral displacement, inter-story drift, and foundation settlements, to assess the efficiency of each foundation system.
The primary objective of this study is to analyse and compare the seismic performance of raft, and isolated foundations using ETABS software and safe as foundation design tool. A common building structure will be modelled, and the two foundation systems will be applied separately to evaluate their responses under earthquake loads. Key parameters such as base shear, lateral displacement, and settlement will be examined to determine the most effective foundation type for seismic resistance. The study will focus on the structural behavior of these foundation systems rather than site-specific characteristics; hence, the input data for the analysis will be assumed randomly instead of being derived from a specific location.
Key Words: Seismic forces, Earthquake loads, Displacement, settlement, Seismic zones, Raft, Isolated footing.

1. Introduction

Earthquakes are natural phenomena that impose significant challenges on structural stability, often leading to severe damage or even collapse of buildings. The ability of a structure to resist seismic forces largely depends on its foundation system, as the foundation serves as the primary interface between the structure and the ground. The selection of an appropriate foundation type is crucial for ensuring structural safety and minimizing damage during an earthquake. Various foundation systems, such as raft foundation, and Isolated footings, respond differently to seismic forces, depending on their load distribution mechanism and interaction with the soil. In seismic-prone regions, engineers face the challenge of designing foundation systems that can effectively absorb and transfer earthquake loads without causing excessive deformation or instability. Raft foundations, provide uniform load distribution and are suitable for structures where differential settlement needs to be minimized. Isolated footing, help in reducing differential settlement and improving load distribution. However, the suitability of each foundation system under earthquake loading varies, making it necessary to conduct a comparative analysis to determine the most effective option.

This study aims to analyze the impact of earthquake loads on two different foundation systems using ETABS software and safe as a foundation design tool. A single building structure will be modeled and tested with two foundation types raft foundation, and isolated footing to evaluate their seismic performance. The study will focus on key structural response parameters such as base shear, lateral displacement, and settlement to determine which foundation system performs best under seismic conditions.

1.1.1 General Approach to Analyze effects of earthquake on different types of Foundations

A systematic approach is adopted to analyze the effects of earthquake loads on two different shallow foundation types. The methodology includes modeling, analysis, and comparison based on key seismic response parameters. Since the study is not site-specific, assumed data will be used for consistency in comparison.

1. **Selection of Building Model**
   - A common building structure will be considered for analysis.
   - The structure will be modelled as a multi-story reinforced concrete (RC) building (with Diagrid) with identical loading conditions for both foundation types.
   - The superstructure parameters such as column and beam dimensions, floor height, and material properties will be kept constant across all models to ensure a fair comparison.
2. **Selection of Foundation System**

   Two commonly used foundation systems:

   Raft Foundation – A large continuous slab foundation that distributes loads evenly over a wide area, reducing differential settlement.

   Isolated Footing – A type of shallow foundation where two or more individual footings are connected with a rigid beam to improve load distribution.

   Each foundation type will be modelled separately by using Safe tool for the same building structure to analyse its seismic response.
3. **Assumed Data for Analysis**

   Since the study is not based on a specific site, the following parameters will be assumed:

   Soil properties: Different assumed values of soil stiffness and bearing capacity.

   Seismic parameters: Randomly selected seismic zone, ground motion data, and peak ground acceleration (PGA).

   Material properties: Standard concrete and reinforcement grades as per IS codes.

   Loading conditions: Dead loads, live loads, and earthquake loads as per relevant building codes (e.g., IS 1893:2016 for seismic analysis).
4. **Earthquake Load Application**

   Seismic forces will be applied to the building model as per standard seismic design codes. Equivalent Static Analysis (ESA) will be used to assess earthquake effects on the structure.

   Base shear, lateral displacements, and foundation settlement will be recorded for each foundation type.
5. **Comparative Analysis**

   The seismic performance of the two foundation types will be compared based on:

   Base shear: The total horizontal force induced by the earthquake. Lateral displacement: Maximum horizontal movement of the structure.

   Foundation settlement**:** The extent of soil displacement due to earthquake loads.

   The results will be analysed to determine which shallow foundation type between these two performs better in resisting earthquake loads.

2. Objectives

1. To study the seismic behavior of isolated footings and raft foundations, using ETABS and SAFE as a foundation design tool.
2. To compare and analyze critical performance parameters, such as base shear, lateral displacement, axial and shear stresses.

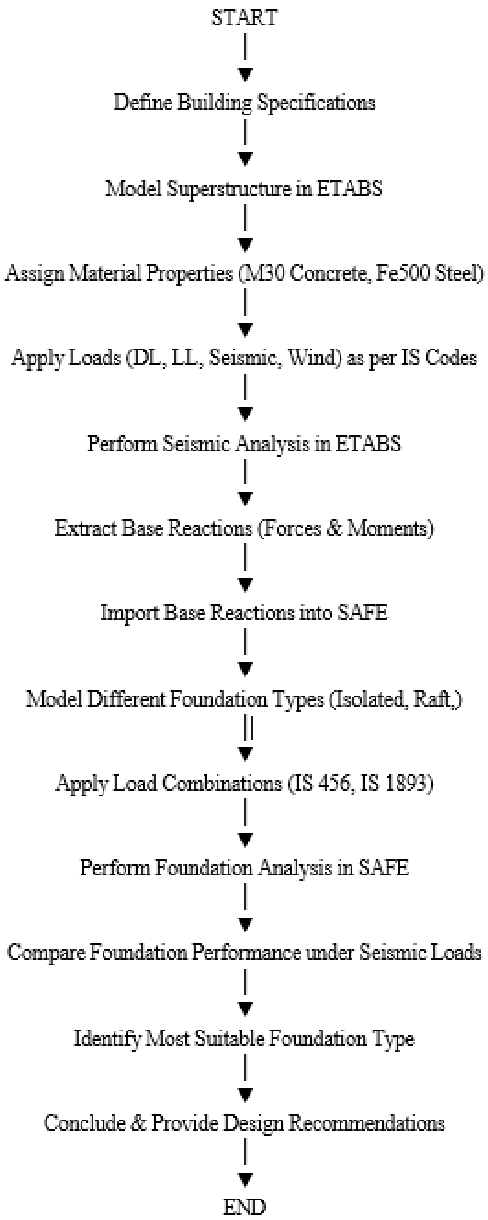
3. To determine the most suitable shallow foundation between isolated and raft type for high-seismic zones

3. Methodology

The main contributions of this thesis of Impact of Earthquake loads on different foundation systems by using ETAB can be summarized as follows:

The methodology involves analyzing a G+6 RCC building (With Diagrid) located in Seismic Zone V with an assumed SBC of 200 kN/m². The superstructure is modeled in ETABS using M30 concrete and Fe500 steel. Loads are applied as per IS 875 (Part 1, 2, 3) and IS 1893:2016, and seismic analysis is conducted to obtain base reactions. These reactions are exported to SAFE, where two foundation types—Isolated Footing, and Raft foundation, are modeled. Load combinations are applied according to IS 456:2000 and IS 1893, and each foundation system is analyzed for structural safety, soil pressure, and displacement. The performance of two foundation types is compared under seismic conditions, and the most suitable foundation is identified based on results.

4. Process Flow



5. Codes References

- S 1893:2016 – Earthquake Analysis
- IS 456:2000 – Concrete Design
- IS 6403:1981 – Bearing Capacity of Soil
- IS 875:2015 (Part 1, 2, 3) – Loads on Buildings

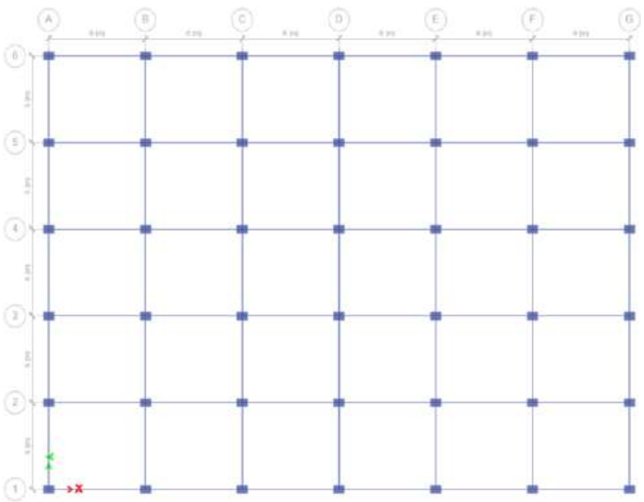
6.Scope Of Project

This study offers significant future potential in structural and foundation engineering, especially in seismic-prone areas. Future research can focus on integrating AI and machine learning with ETABS and SAFE to enhance predictive analysis and real-time seismic assessment. Incorporating dynamic soil-structure interaction, nonlinear time-history analysis, and regional seismic data will provide more accurate and site-specific designs. Sustainable foundation strategies, including the use of eco-friendly materials and hybrid systems like piled rafts, can improve both performance and environmental impact. Integration with BIM for smart, adaptive foundation systems, along with advancements in retrofitting techniques and full-scale experimental validation, will further refine earthquake- resistant designs. The insights gained could also contribute to the evolution of seismic design codes like IS 1893, Eurocode 8, and ASCE 7.

7. Foundation Design and Modeling

1. Superstructure Modelling and seismic analysis using Etab software

Fig 7.1 2D *View of G+6 Building*



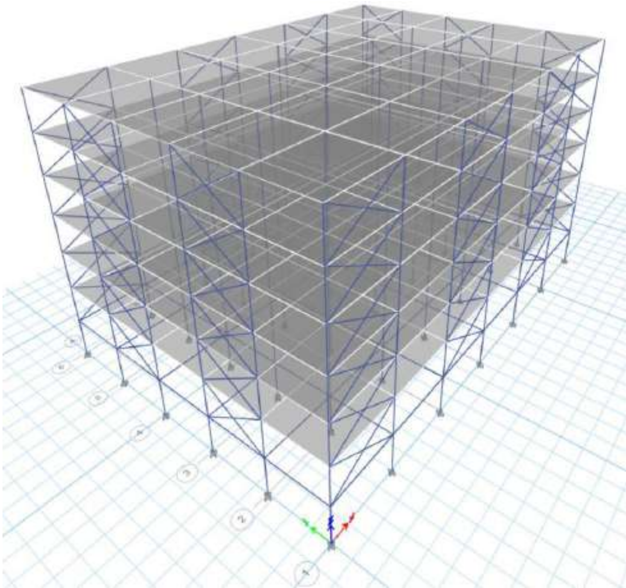


Fig 7.2 *3D View of G+6 Building*

2. Foundation Design using SAFE software

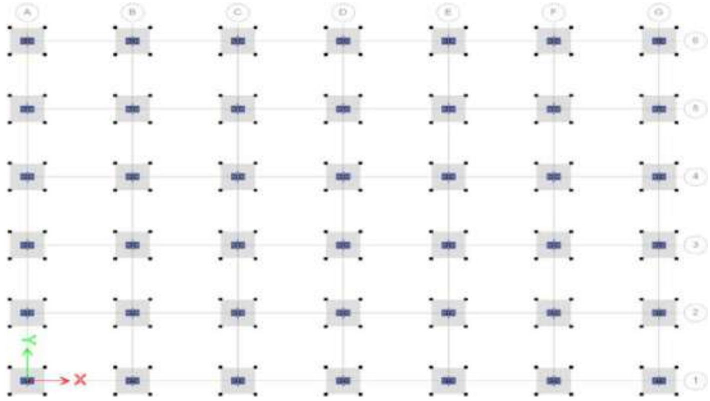


Fig 7.3 Base plan of Isolated Footing

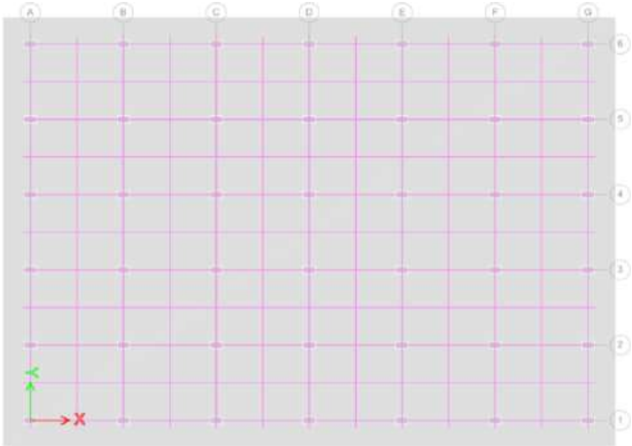


Fig 7.4 Base plan of Raft Foundation

8. Results

The results shown below are the results for Superstructure (Etab Software)

Lateral Displacement Results

The lateral displacement of the structure was analyzed using ETABS under seismic loading conditions as per **IS 1893:2016 (Part 1)**. The permissible lateral displacement limit, as per the code, is given by: $\Delta_{max} \leq H/500$ Where: H = Total height of the building = 21 m

Therefore, we got max Allowable displacement = 42 mm

After performing seismic analysis in ETABS, the maximum lateral displacement (EQX) obtained at the topmost story is 22.5 mm and (EQY) is 29.36mm, which is significantly lower than the permissible limit.

Thus, the structure satisfies the lateral displacement criteria, ensuring adequate stiffness and stability against seismic forces.

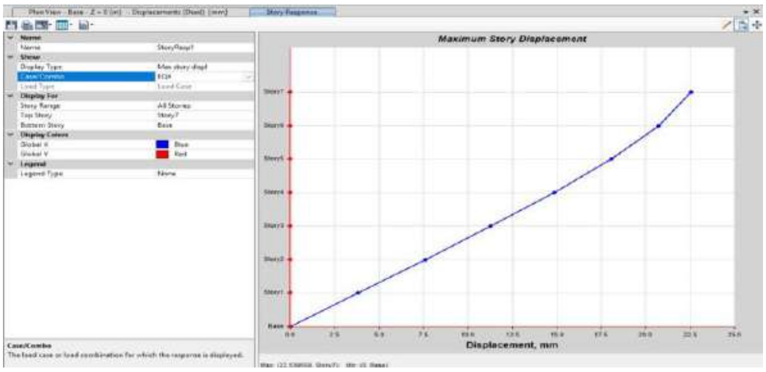


Fig 8.1: Result for Lateral Displacement (EQX)

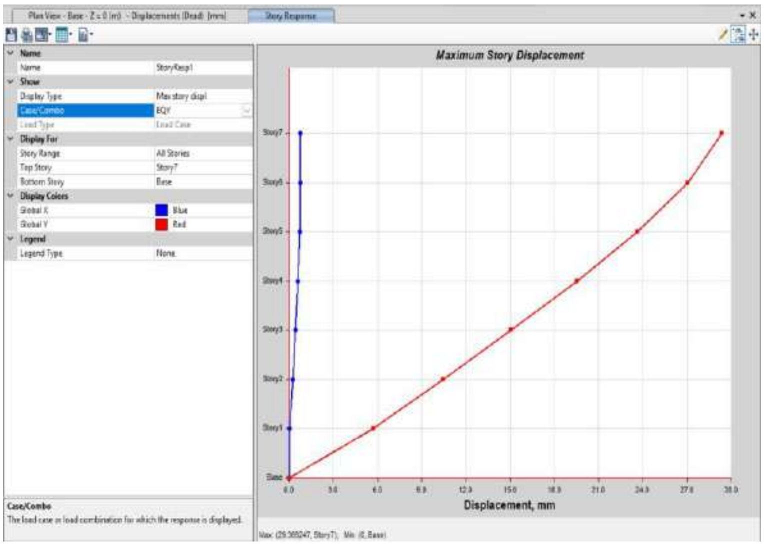


Fig 8.2: Result for Lateral Displacement (EQY)

Building Height	Max Allowable Displacement	Maximum Displacement (EQX)	Maximum Displacement (EQY)	Result
21mm	42mm	22.5mm	29.36mm	Safe

Table 8.1: Lateral Displacement Result for Superstructure

Check For Drift Ratio:

Drift Ratio = Displacement at floor level/Story

Height Drift Ratio ≤ 0.004 (For Seismic Zone)

In X and Y Direction the Drift is within limit (Max value is 0.001906 in EQY and 0.001272 for EQX which is less than 0.004) According to code **IS 1893:2016 (Part 1)**, Hence the model is safe.

Drift ratio									
Story	Output Case	Case Type	Direction	Drift	Drift/	Label	X m	Y m	Z m
Story7	EQX	LinStatic	X	0.000607	1/1648	42	36	25	21
Story7	EQY	LinStatic	Y	0.000774	1/1292	6	0	25	21
Story6	EQX	LinStatic	X	0.00089	1/1124	42	36	25	18
Story6	EQY	LinStatic	Y	0.001134	1/882	6	0	25	18
Story5	EQX	LinStatic	X	0.001078	1/927	42	36	25	15
Story5	EQY	LinStatic	Y	0.001369	1/730	6	0	25	15
Story4	EQX	LinStatic	X	0.001183	1/846	42	36	25	12
Story4	EQY	LinStatic	Y	0.001498	1/667	6	0	25	12
Story3	EQX	LinStatic	X	0.001215	1/823	42	36	25	9
Story3	EQY	LinStatic	Y	0.001532	1/653	6	0	25	9
Story2	EQX	LinStatic	X	0.001269	1/788	42	36	25	6
Story2	EQY	LinStatic	Y	0.001577	1/634	6	0	25	6
Story1	EQX	LinStatic	X	0.001272	1/786	42	36	25	3
Story1	EQY	LinStatic	Y	0.001906	1/525	6	0	25	3

Table 8.2: Result for Story drift ratio

Fig 8.3: Result for Story drift ratio (EQX)

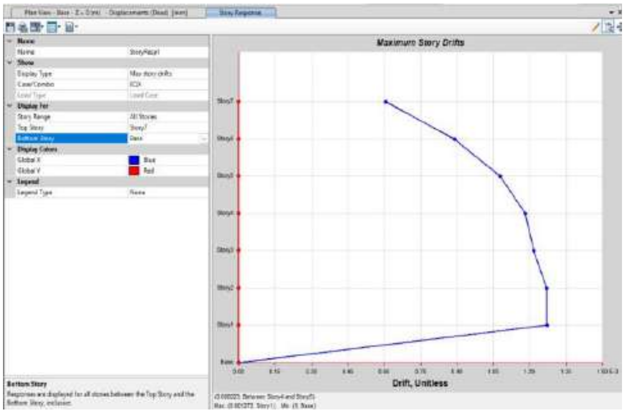
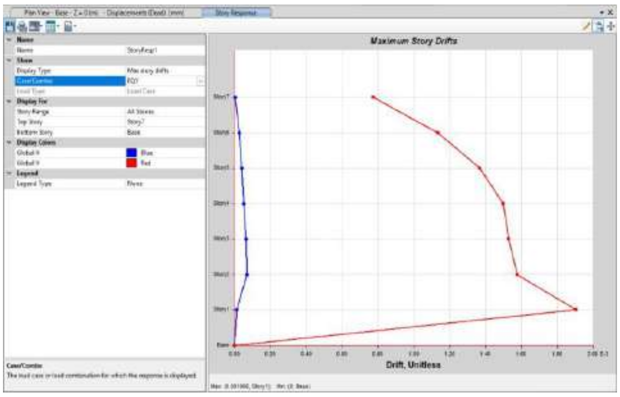


Fig 8.4: Result for Story drift ratio (EQY)



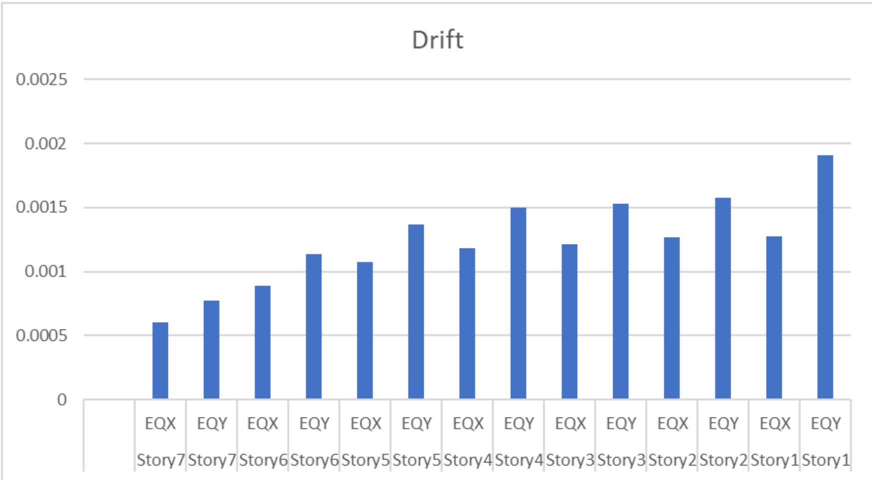


Fig 8.5: Result for Story drift ratio

Torsional Irregularity

Torsional Irregularity Ratio= Maximum Drift at a corner / Average Drift at all corner

According to IS 1893:2016 (Part 1) Clause 7.9.1, If Ratio value ≤ 1.2 → Building is **SAFE**, Here the obtained ratio is less than 1.2, hence safe.

Title: Torsional Irregularity						
Floor Level	**X- Direction**		**RATIO Δ2/Δ1 (<1.5 AND NOT .2)**	**Y- Direction**		**RATIO Δ2/Δ1 (<1.5 AND NOT .2)**
	Δ1= DISPLACEMENT AT THE ONE END	**Δ2= DISPLACEMENT AT THE OTHER END**		**Δ1= DISPLACEMENT AT THE ONE END**	**Δ2= DISPLACEMENT AT THE OTHER END**	
	2.093	2.093	1	-0.0004379	-0.0004379	1
	1.879	1.879	1	-0.0002839	-0.0002839	1
	1.561	1.561	1	-0.0002035	-0.0002035	1
	1.177	1.177	1	-0.0001437	-0.0001437	1
	0.764	0.764	1	-0.0001077	-0.0001077	1
	0.344	0.344	1	-5.51E-05	-5.51E-05	1

Table 8.3: Result for Torsional Irregularity

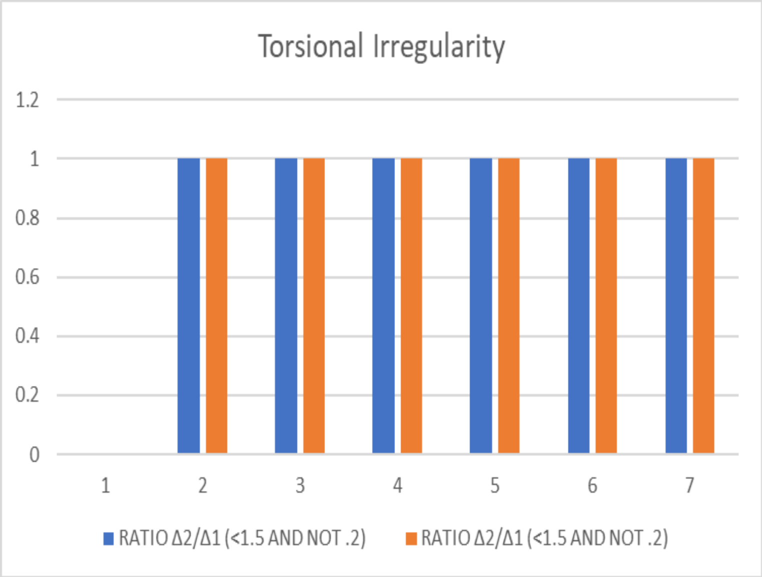


Fig 8.6: Result for Torsional Irregularity

Base Reaction

1. Codal Base Shear Calculation (IS 1893:2016)

The base shear for the building was calculated based on the seismic parameters provided by IS 1893:2016 using the following formula:

V_b= Z x I x S_a

x W/R

Where,

V_b= Base shear (in kN)

Z = Seismic Zone

Factor = 0.36 I =

Importance Factor

= 1.5

S_a = Response Acceleration

Coefficient = 1.36 R = Response

Reduction Factor = 5

W = Seismic Weight of the building (total

weight)=66000 kN V_b= Z x I x S_a x W/R= 9700

kN

2. Base Shear from ETABS Results:

In ETABS, the base shear in both directions (X and Y) was calculated using the static seismic analysis method. Initially, the base shear values in ETABS were:
EQX Load Case (X-direction):

Base shear (FX) =
4073.20 kN EQY
Load Case (Y-
direction):
Base shear (FY) = 3755.01 KN

These values were below the codal base shear requirement of 9700 kN.

3. Scaling of Seismic Loads:

In accordance with IS 1893:2016 Clause 7.8.2, a scaling factor was applied to ensure that the seismic loads complied with the codal base shear.
The initial base shear values were 4073.20 kN in the X-direction and 3755.01 kN in the Y-direction. A scaling factor of 2.42 was applied, calculated as:
Scale Factor = 9700/4073.20 = 2.42

4. Scaled Base Shear Results:

After applying the scale factor of 2.42, the new base shear values obtained were: EQX Load Case (X-direction):
Base shear (FX) = 9711.93 kN EQY Load Case (Y-direction):
Base shear (FY) = 9087.13 kN

These values are now close to the codal requirement of 9700 kN, ensuring that the building is compliant with the seismic design criteria.

Conclusion:

The scaled base shear values for the building are:

EQX: 9711.93 kN

EQY: 9087.13 kN

These values are close to the codal base shear of 9700 kN, confirming that the building's seismic design is in compliance with the provisions of IS 1893:2016. Hence Model is safe.

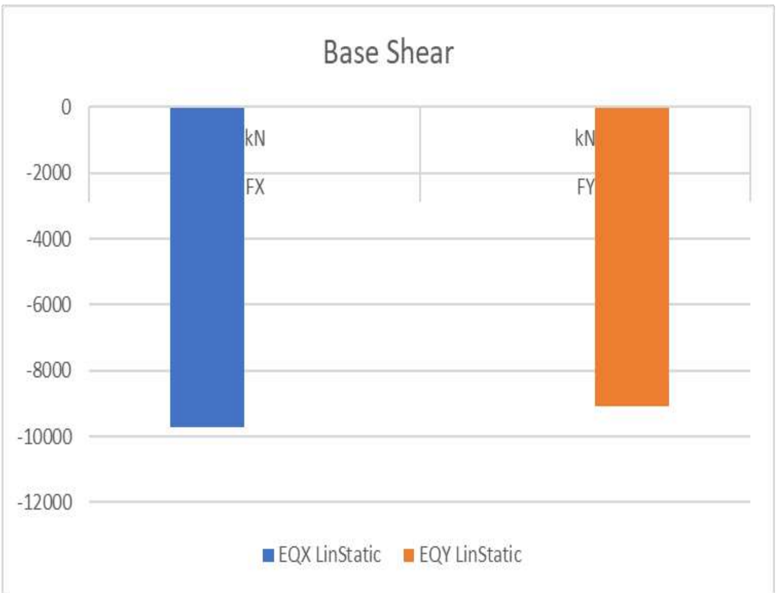


Fig 8.7: Result for the base Reaction

Output Case	**Case Type**	**FX**	**FY**
		kN	**kN**
EQX	LinStatic	- 9711.94	0
EQY	LinStatic	0	-9087.13

Table 8.4: Base Reaction

The results shown below are the results for Raft Foundation in safe software

1. **Soil Bearing Pressure**

Check Condition (IS 6403 & IS 1904)

Max Soil Pressure ≤ Safe Bearing Capacity (SBC)

Here in our case max SBC is 200 kn/m^2 and the maximum soil pressure for service load is approximately 25 (EQX) to 40 kn/m^2 (EQY) hence condition is safe.

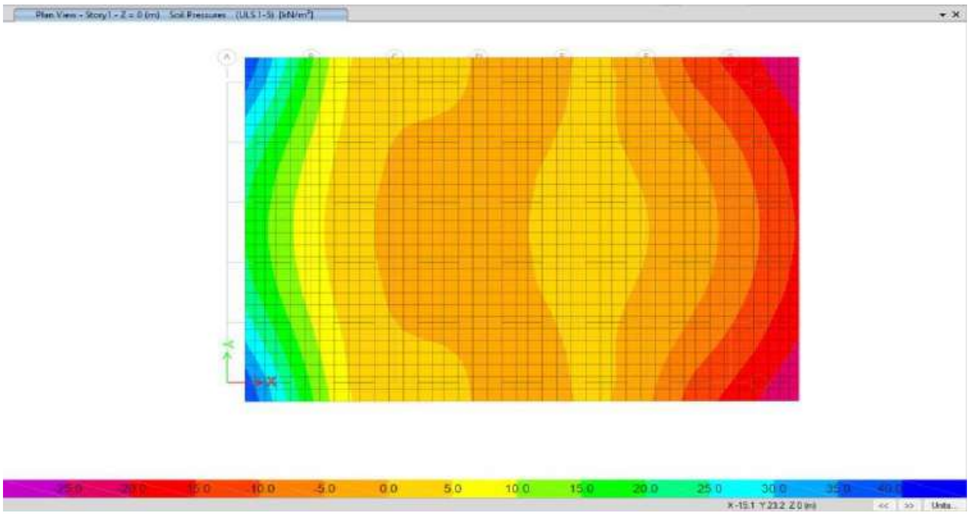


Fig 8.7: Result for Soil Bearing Pressure (EQX)

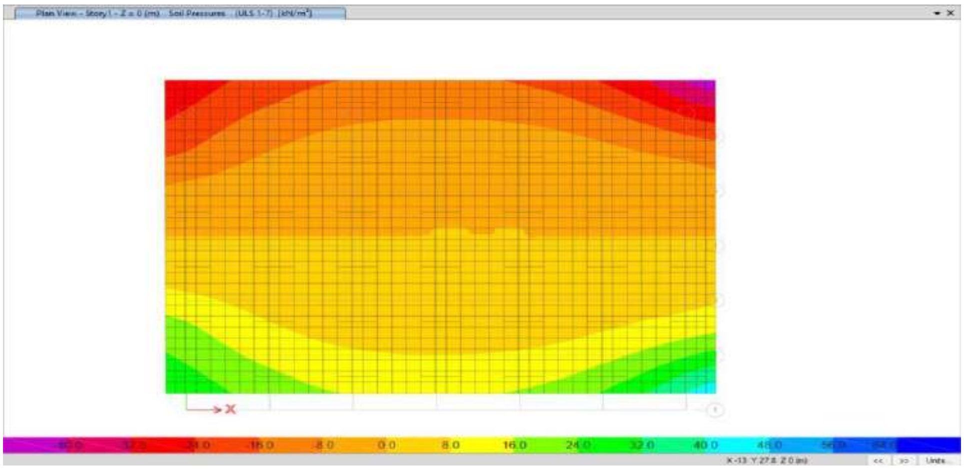


Fig 8.8: Result for Soil Bearing Pressure (EQY)

I have focused on the 1.5 (DL + EQX/Y) combinations because, according to IS 456:2000 and IS 1893:2016, these represent the critical design condition for strength, combining the full dead load with the full seismic force. This ensures that the raft foundation is safe under the most severe realistic scenario.
Here ULS 1-5 = 1.5 DL +1.5 EQX and ULS 1-7 = 1.5 DL +1.5 EQY

References:
IS 456:2000 – Clause 36.4.2
IS 1893:2016 – Clause 6.4.2 & 7.2.1

2. **Check For Deflection:**

As per IS 456:2000, Clause 23.2, the permissible deflection is span/250 for slabs and beams, and similar limits are applied to raft foundations to control cracking and serviceability.
For Raft Foundation, Deflection≤250mm (for normal soil) For Isolated Footing,

Deflection≤25mm (for normal soil)

Here we got the value for deflection is 20mm which is far less than the permissible value, hence foundation is safe.

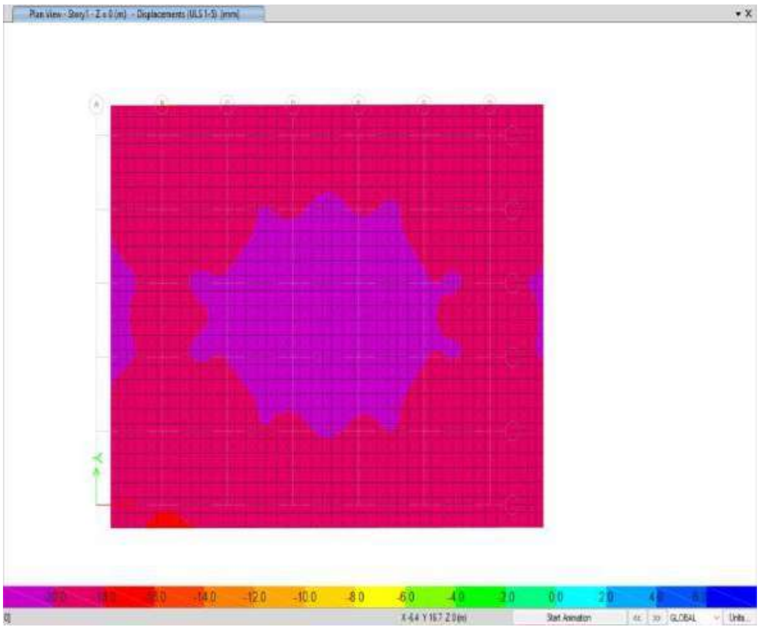


Fig 8.9: Displacement (EQX)

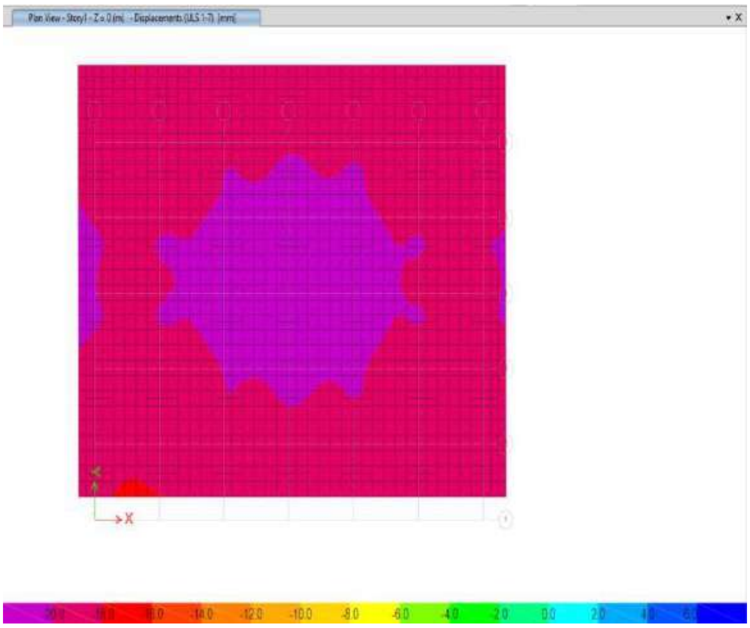


Fig 8.10: *Displacement* (EQY)

3.Check Punching Shear at Column Locations Check Condition (IS 456:2000 – Clause 31.6) Vpunching Vc≤1.0 (SAFE)

Where:

- Vpunching = Shear force at column
- Vc = Shear capacity of concrete

If Ratio > 1.0, increase raft thickness or provide shear reinforcement (shear studs/stirrups).

Here, punching shear at all points is in between 0.3 to 0.5 which is less than 1.0, Hence the Foundation is safe.

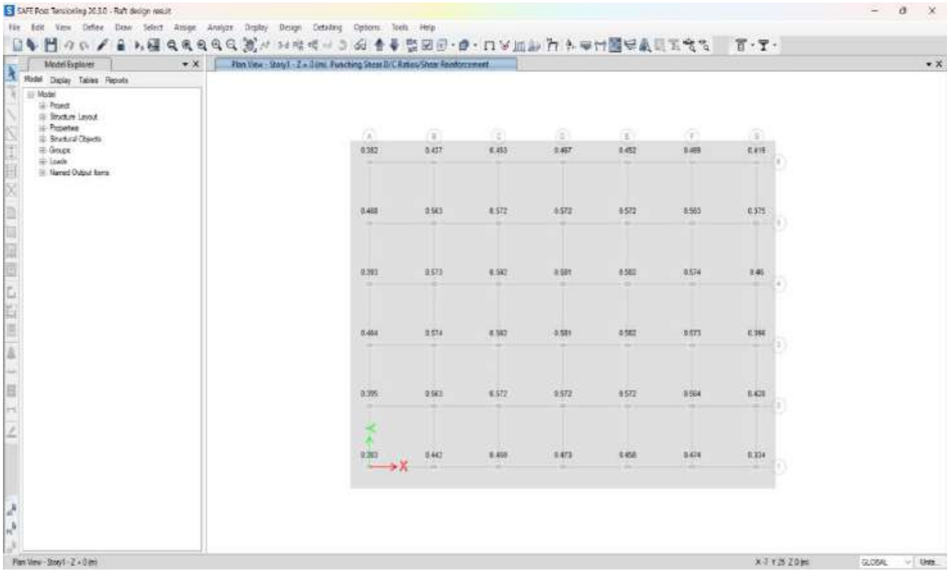


Fig 8.11: Punching Shear

2. **Check For Settlement:**

For settlement, IS 1904:1986 specifies that total settlement should not exceed 50 mm, and differential settlement should be within 20 mm to prevent structural distress.
Here, we got the value for Deflection is 20mm which is in the limit 20mm and 50mm, hence the foundation is safe.

Fig 8.12: Settlement Check (EQX)

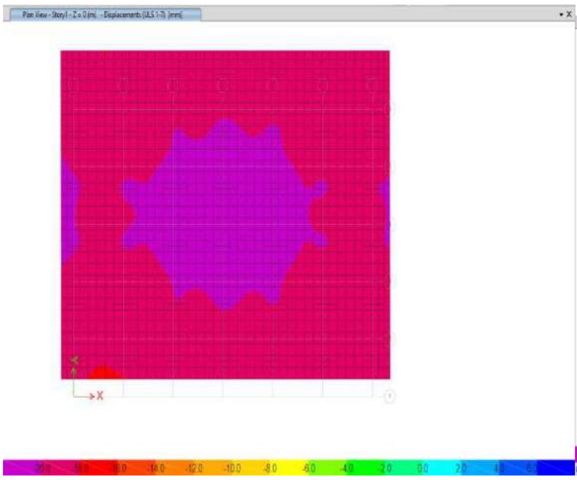
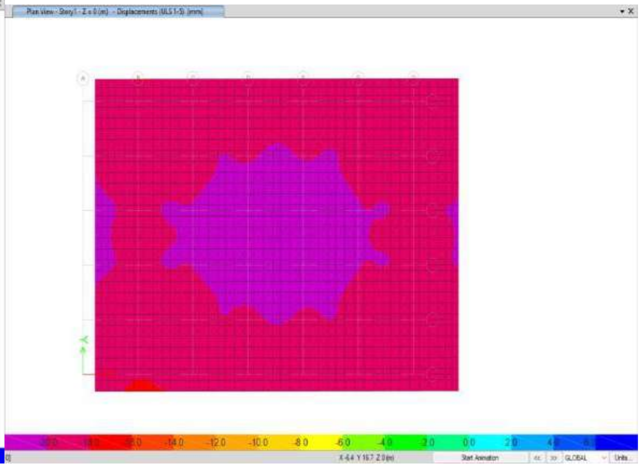


Fig 8.13: Settlement Check (EQX)



The results shown below are the results for Isolated Footing in safe software

1. **Check Soil Bearing Pressure (SBP)**

Check Condition (IS 6403 & IS 1904)

Max Soil Pressure ≤ Safe Bearing Capacity (SBC)

Here in our case max SBC is 200 kn/m^2 and the maximum soil pressure for service load is approximately 168 kn/m^2 hence condition is safe.

Fig 8.14: Soil bearing pressure (EQX)

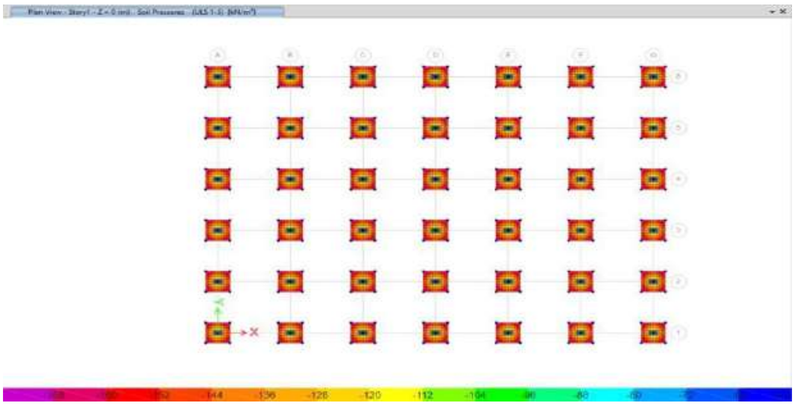
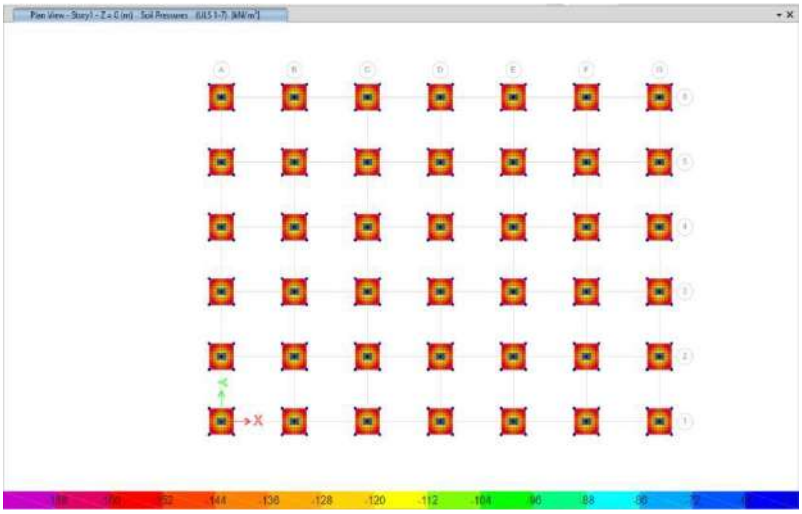


Fig 8.15: Soil bearing pressure (EQY)



2. Check For Deflection:

As per IS 456:2000, Clause 23.2, the permissible deflection is span/250 for slabs and beams, and similar limits are applied to raft foundations to control cracking and serviceability.
For Isolated Footing, Deflection≤25mm (for normal soil)

Here, we got the value for Deflection is 35mm which is not less than or equal to 25mm, hence the condition is not safe.

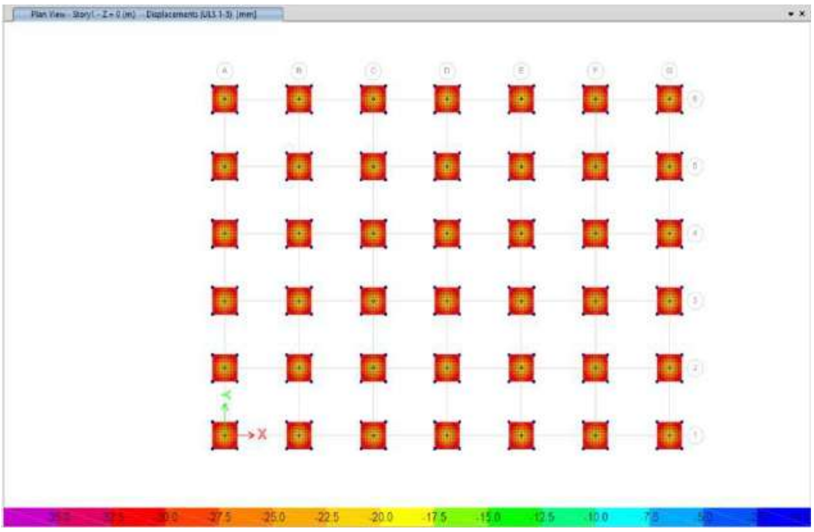


Fig 8.16: Displacement (EQX)

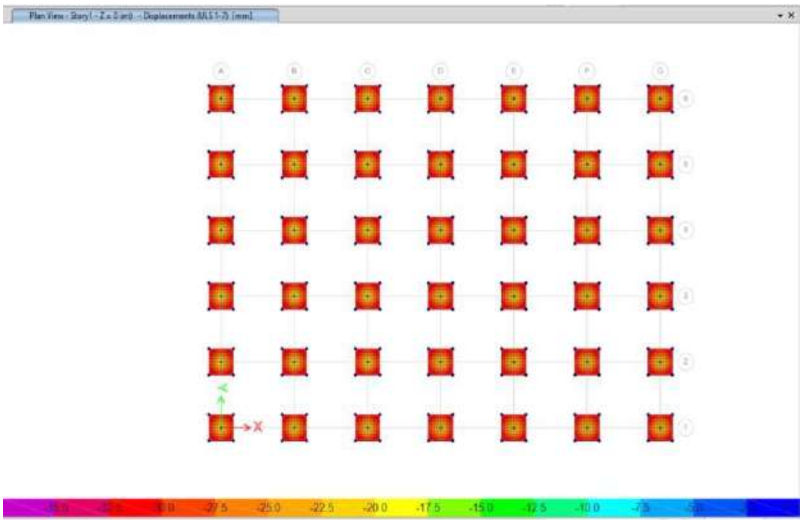


Fig 8.17: Displacement (EQY)

1. Check Punching Shear at Column Locations Check Condition (IS 456:2000 – Clause 31.6) Vpunching Vc≤1.0 (SAFE)
Where:

- Vpunching = Shear force at column
- Vc = Shear capacity of concrete

If Ratio > 1.0, increase raft thickness or provide shear reinforcement (shear studs/stirrups).

Here, punching shear at all points is in the range of 0.01 which is less than 1.0, Hence the Foundation is safe.

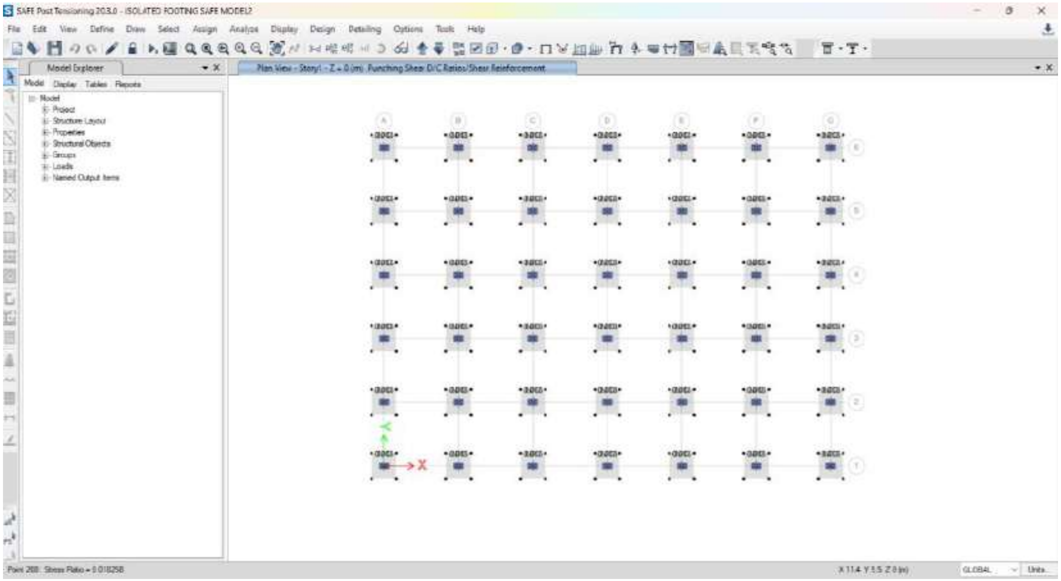


Fig 8.18: Punching Shear

2. Check For Settlement:

For settlement, IS 1904:1986 specifies that total settlement should not exceed 50 mm, and differential settlement should be within 20 mm to prevent structural distress.
Here, we got the value for Deflection is 35mm which is exceed the max limit of 20mm and 50mm, hence the foundation is unsafe.

Fig 8.19: Settlement (EQX)

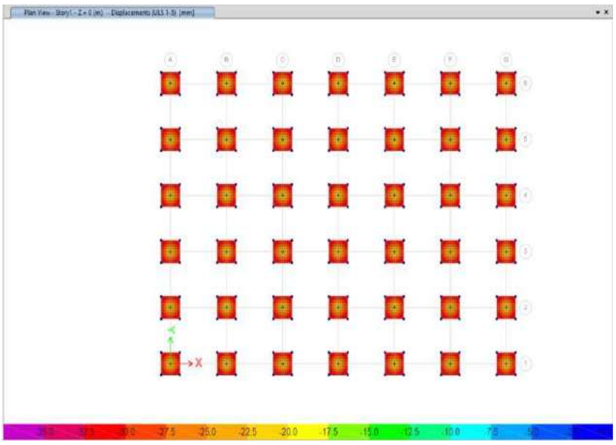
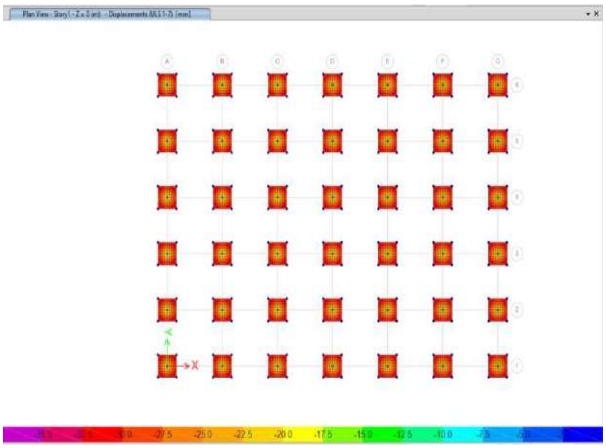


Fig 8.20: Settlement (EQY)



Comparative values of Raft and Isolated Footing:

Parameter	Raft Foundation	Isolated footing
Soil Bearing Pressure	40 KN/sqm	168 KN/sqm
Deflection	20 mm	35 mm
Punching shear	< 1 (Safe)	< 1 (Safe)
Settlement	20 mm	35 mm
Factor of safety (SBC)	5	1.19
Load Distribution	Uniform	Concentrated
Suitability for Seismic zone	Very good	Moderate
Construction Cost	High	Moderate
Structural Safety	High	Moderate
Best suited for	High rise, Heavy Structure	Low rise, Lighter Structure

Table 8.5: Comparative Analysis of Raft and Isolated footing

The comparative analysis of raft foundation and isolated footing under seismic loading conditions in Zone V has revealed significant insights into their respective performances. Raft foundations demonstrated superior behavior with lower soil bearing pressure (40 kN/m^2), minimal deflection and settlement (20 mm), higher factor of safety (5), and uniform load distribution making them highly suitable for high-rise and heavy structures in seismically active regions. In contrast, isolated footings showed higher soil pressure (168 kN/m^2), increased deflection and settlement (35 mm), and moderate safety and suitability, rendering them more appropriate for low-rise, lighter constructions. Although raft foundations incur higher construction costs, they offer greater structural safety and seismic resilience. Hence, Raft Foundation is more stable with lower pressure, lower deflection, and Lower settlement. Isolated Footing is economical, but for high seismic and high-rise, raft is better.

9.Summary

The study involves modeling a G+5 RCC building in Seismic Zone V using ETABS, applying all relevant loads per IS codes. Base reactions from seismic analysis are extracted and imported into SAFE for designing isolated and raft foundations. Each foundation type is analyzed under seismic load combinations to evaluate structural behavior and stability. A comparative assessment identifies the most suitable foundation system.

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11.Conclusion

The study compares raft foundation and isolated footing for a G+6 RC building under static earthquake loading using ETABS and SAFE. Results show that raft foundation offers better load distribution and stability, making it ideal for weak soils, while isolated footings work well on strong soil but may face higher settlement. The findings emphasize that foundation selection depends on site conditions and highlight the need for further research using dynamic analysis for improved accuracy.

References: -

1. *S. Das and P. K. Basudhar, "Seismic response of raft and pile foundations using finite element analysis," International Journal of Geomechanics, vol. 19, no. 4, pp. 04019011, 2019.*
2. *M. Ghaffarzadeh and A. Mahsuli, "Comparison of seismic performance of shallow and deep foundations," Soil Dynamics and Earthquake Engineering, vol. 105, pp. 282-295, 2018.*
3. *M. R. Javidan and M. H. Gandomi, "Seismic analysis of high-rise structures with different foundation systems using ETABS and SAFE," Structures, vol. 36, pp. 15-26, 2020.*
4. *H. K. Aggarwal and R. Jain, "Effect of soil-structure interaction on seismic response of reinforced concrete buildings," Earthquake Engineering & Structural Dynamics, vol. 47, no. 11, pp. 2309-2325, 2018.*
5. *B. K. Jena and P. K. Deb, "Raft foundation vs. isolated footings: A comparative study on seismic performance," Geotechnical and Geological Engineering, vol. 37, no. 3, pp. 1793-1809, 2019.*
6. *K. T. Gohil, R. P. Patel, and A. K. Solanki, "Analysis and design of raft foundation using SAFE software," International Journal of Civil Engineering and Technology (IJCIET), vol. 9, no. 7, pp. 1127-1135, 2018.*
7. *V. S. Kale and N. N. Handa, "Seismic behavior of buildings with different foundation types under static loading," Engineering Structures, vol. 201, pp. 110582, 2019.*
8. *Y. R. Choudhary and P. R. Gupta, "Performance analysis of raft and isolated footing under earthquake loads," Journal of Structural Engineering, vol. 46, no. 2, pp. 84-97, 2021.*
9. *S. K. Roy and M. S. Hussain, "Impact of earthquake forces on different foundation systems: A numerical study," Geotechnical Earthquake Engineering Review, vol. 12, pp. 45-62, 2020.*
10. *[10] D. Pradhan and V. P. Jagtap, "ETABS-based seismic analysis of G+6 structure with raft and isolated foundations," International Journal of Structural Engineering and Mechanics, vol. 28, no. 5, pp. 1123-1140, 2019.*
11. *[11] Shakib and F. Fallah, "Comparison of soil-structure interaction effects on shallow and deep foundations," Soil Mechanics and Foundations Journal, vol. 62, pp. 135-149, 2021.*
12. *[12] M. K. Shrestha, "Finite element analysis of multi-story buildings on different foundation types using ETABS,"*
13. *International Journal of Advances in Structural Engineering, vol. 11, no. 3, pp. 67-81, 2020.*
14. *[13] T. A. Sheikh and S. K. Sharma, "Effect of raft and isolated footings on seismic base shear of multi-story buildings," Structural Engineering and Mechanics, vol. 34, no. 4, pp. 411-425, 2021.*
15. *[14] L. P. Tiwari, K. R. Desai, and J. N. Patel, "Seismic performance evaluation of raft and isolated footings using ETABS," Earthquake and Structural Dynamics Journal, vol. 14, pp. 112-129, 2022.*
16. *[15] S. K. Gupta and V. N. Verma, "Numerical analysis of multi-story buildings under static earthquake loads with different foundations," Computers and Geotechnics, vol. 52, pp. 187-204, 2018.*
17. *Elshafey, A. M., El-Sayed, M. A., & El-Shihy, M. A. (2014). Soil–raft foundation–structure interaction effects on seismic performance of multi-story MRF buildings. International Journal of Advanced Structural Engineering, 6(4), 121–135.*
18. *Solanki, S. M., & Mundhada, A. R. (2022). Analysis and effect of piles on raft foundation for high-rise framed structures under seismic loading. Materials Today: Proceedings, 56, 1343–1352.*
19. *Roopa, M., Naikar, H. G., & Prakash, D. S. (2015). Soil structure interaction analysis on a RC building with raft foundation under clayey soil condition. International Journal of Engineering Research & Technology (IJERT), 4(12), 1045–1049.*
20. *Bhattacharya, S., Dey, S., & Dutta, A. (2020). Seismic analysis of piled raft foundation: Pseudostatic approach. International Journal of Geomechanics, 20(10), 06020028.*
21. *Elshafey, A. M., El-Sayed, M. A., & El-Shihy, M. A. (2014). Evaluation of soil–foundation–structure interaction effects on seismic performance of multi-story MRF buildings. International Journal of Advanced Structural Engineering, 6(4), 121–135.*
22. *Chaudhary, R. R., & Kadam, K. N. (2019). Behavior of piles with raft foundation using SAFE software. International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8(11), 3048–3052.*
23. *Patel, A., & Phadatare, N. P. (2021). Comparative study of seismic analysis of fixed base and base-isolated multi- storey structures. International Research Journal of Engineering and Technology (IRJET), 8(6), 2732–2738.*
24. *Majage, S., & Phadatare, N. P. (2019). Seismic behavior of tall building using piled raft foundation. International Research Journal of Engineering and Technology (IRJET), 6(11), 2255–2260.*
25. *Choudhury, D., & Kumar, A. (2020). Pseudostatic approach to analyze combined pile–raft foundation. International Journal of Geomechanics, 20(10), 06020028.*
26. *Halder, P., & Manna, B. (2019). Seismic analysis of piled raft foundation: Pseudostatic approach. In Proceedings of the 7th International Conference on Case Histories in Geotechnical Engineering.*