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Comparative Analysis of Raft Foundation, Raft with Top Cap & Pile Raft Foundation

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Abstract - *This study provides a detailed comparative analysis of three different foundation systems: Raft Foundation, Raft with Drop, and Pile Raft Foundation. Utilizing advanced structural analysis and design software, the research explores the structural and geotechnical behaviors of these foundations. The performance is evaluated under various loading conditions and soil profiles, focusing on critical factors such as soil pressure, punching shear, settlement, and overall structural integrity. CSI SAFE software's finite element analysis capabilities are employed to model bearing capacity, settlement characteristics, and the interaction between the foundation and soil. This approach offers a comprehensive understanding of the geotechnical aspects involved.*

Key Words: **Foundation Design, Raft Foundation, Pile Raft foundation, Raft with Top Cap, Structural Design, Seismic Load, CSI SAFE, Etabs.**

1. INTRODUCTION

Choosing the appropriate foundation system for high-rise buildings is crucial for their stability and resilience in structural engineering. As urban landscapes continue to develop vertically, a deeper understanding of foundation design becomes increasingly important. This study utilizes ETABS and CSI SAFE software to perform a comprehensive comparative analysis of Raft Foundation, Raft with Top Cap, and Pile Raft Foundation, with the main objective being to evaluate and compare their geotechnical responses and structural performance in high-rise buildings.

By focusing on the complex interactions between these foundation systems under different seismic zones and soil types, this research aims to provide valuable insights for practitioners and stakeholders. These insights will facilitate informed decision-making in selecting foundation systems that effectively address the challenges of various seismic conditions and soil profiles. The ultimate aim is to contribute to the ongoing enhancement of foundation design techniques, ensuring the structural integrity and long-term resilience of high-rise buildings in dynamic urban environments.

The application of ETABS for structural analysis reflects a commitment to utilizing advanced computational tools to improve the structural components of tall buildings. This includes assessing structural responses to diverse loads, ensuring compliance with safety regulations, and optimizing overall performance. Simultaneously, detailed foundation modelling with CSI SAFE software highlights the essential role of foundations in maintaining the structural integrity of high-rise buildings.

2. OBJECTIVE

- To compare Raft Foundation, Raft with Top Cap, and Pile Raft Foundation using structural analysis and design software.
- To support ongoing advancements in high-rise building foundation design methodologies, ensuring long-term resilience and structural integrity in dynamic urban environments.
- To provide a comprehensive understanding of different foundation types, their advantages and disadvantages, suitable applications, and design and construction considerations.
- To research and evaluate various foundation types used in the construction industry, exploring their designs and the use of alternative materials to enhance firmness, durability, and environmental sustainability.
- To develop robust, cost-effective, and environmentally friendly foundation bases for both bungalows and tall buildings.
- To examine factors such as soil bearing capacity, settlement, and seismic behaviour in relation to Raft, Raft with Top Cap, and Pile Raft foundations.

3. METHODOLOGY

The multistory building with a different seismic zone and soil condition analyzed and designed from Etabs software after that export base reactions file for CSI SAFE software then import this file to safe software. In safe there are majorly five steps for designed and analysis of foundation: Import ETABS Data File Define, Draw, Assign, Analysis, Design. For analysis of RCC structures there must be require good amount of knowledge of IS codes and Fundamental of structures. Total 27 models are made for the exact data validation and for comparison

4. Input Data

Table-1: Data Input in Etabs Model

Density of block masonry	7.5 kN/m^3
Density of Plaster	20 kN/m^3
Density of Concrete	25 kN/m^3
Live Load	2 kN/m^2
Floor Finishing	1.25 kN/m^2
Sunk load	1.6 kN/m^2
Importance Factor	1.5
Grade of Concrete in Beam & slab	M25
Grade of Concrete in Column	M30
Grade of Rebar	Fe500
Time period	1.406 sec
Depth of Foundation	12.7 m

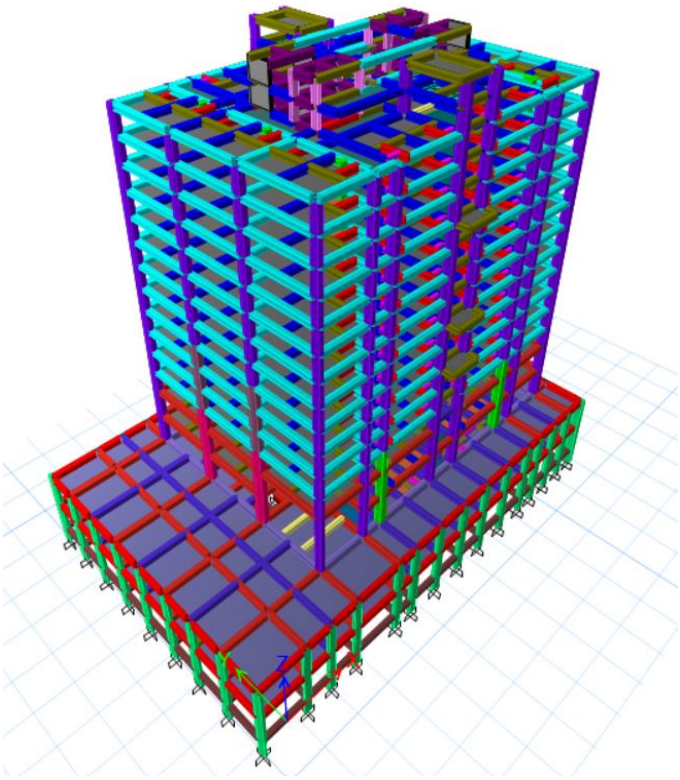

Fig -1: 3D VIEW OF ETABS MODEL

- Soil Subgrade Modulus will be Soil Bearing Capacity of soil for an allowable settlement, so if the soil is soft soil and allowable settlement is 125 mm for SBC 22 Ton then,
- Soil Subgrade Modulus =
  SBC/Allowable settlement= 220/0.125
  =1760 kN/m/m2
- Defined Pile as a Point Spring Property and value of this property will be,
  Point Spring value = Ec X Ap X H
  - Where,
  - Ec = 4700 X (Fc′)1/2
  - Fc′ = Specified 28-Day Compressive Strength of Concrete
  - Ap = Cross-Section Area of Pile
  - H = Depth of Pile
- Considered Pile Diameter 600 mm, 14 m Depth & M25 Grade of concrete.
- So value of Point Spring,
  Point Spring Value = (2.35 X 106) X (0.28) X (14)
  = 474604.89 KN/m

Table-2: Data Input in Safe Model

Soil Bearing Capacity	22 Ton
Area of Raft Foundation	59.51m X 39.27 m
Depth of Raft	1200 mm
Depth of Raft in Raft with Top Cap	1050 mm
Depth of top Cap	750 mm
Area of Raft Top Cap	2000mm X 2000 mm
Number of Raft Top Cap	30
Depth of Raft in Pile Raft	1200 mm
Diameter of Pile	600 mm
Depth of Pile	14 m
Compressive Capacity of Pile	825 kN
Number of Pile	368
Grade of Raft & Raft top Cap	M25
Grade of Pile	M25
Grade of Steel	FE500
Allowable Settlement in Soft Soil	125 mm
Allowable Settlement in Medium Soil	100 mm
Allowable Settlement in Hard Soil	75 mm
Soil Subgrade Modulus in Soft Soil	1760 kN/m^2/m
Soil Subgrade Modulus in Medium Soil	2200 kN/m^2/m
Soil Subgrade Modulus in Hard Soil	2933.34 kN/m^2/m
Point Spring for Pile	474604.89 KN/m

Using the above date, total 27 Safe models were prepared for all three type of foundation concurring seismic zone III, IV and V with different type of soil.

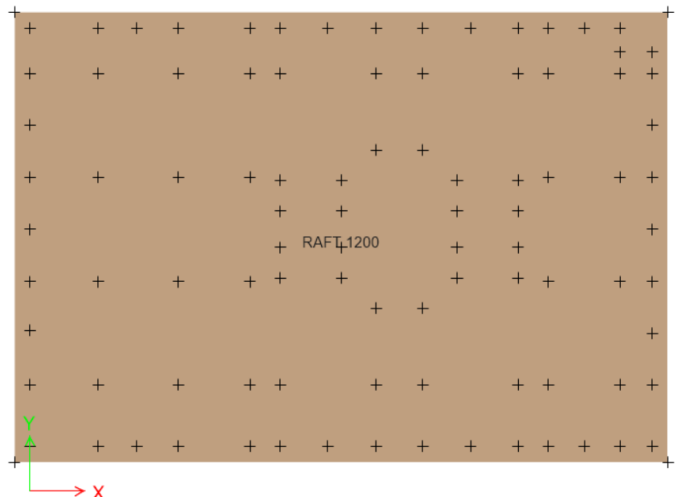

Fig -2: Raft foundation

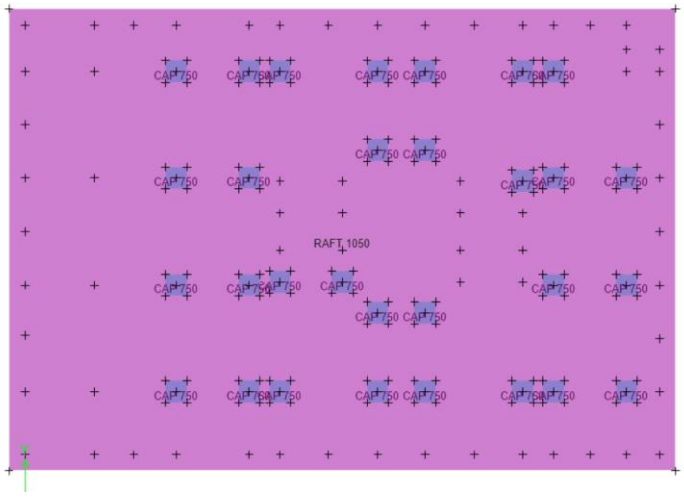

Fig -3: Raft foundation

Fig -3: Raft foundation

5. Observations

With use of Safe software different types of foundations such as raft foundation, Raft with top-cap foundation and pile raft foundation on different types of soil type and different types of Indian seismic zone were prepared so there was total 27 foundation model observed and mainly, soil pressure, Average punching shear and settlement was noted. Those observations are below in a chart form.

5.1 Soil Pressure

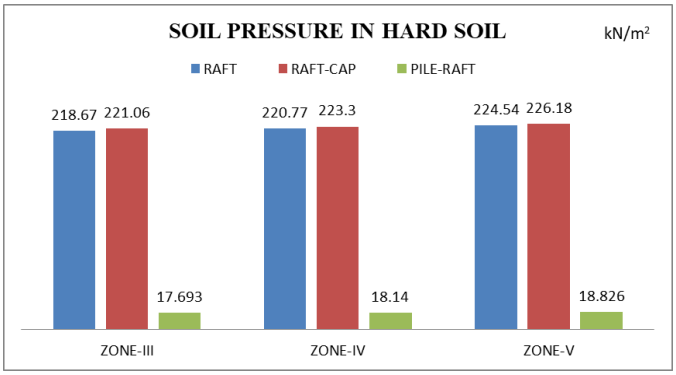

Fig -4: Soil Pressure in Hard Soil

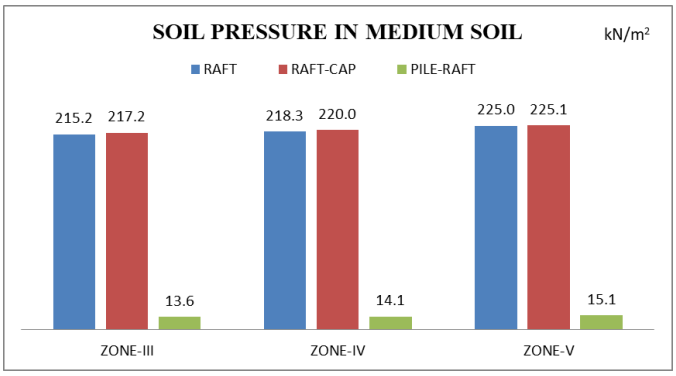

Fig -5: Soil Pressure in Medium Soil

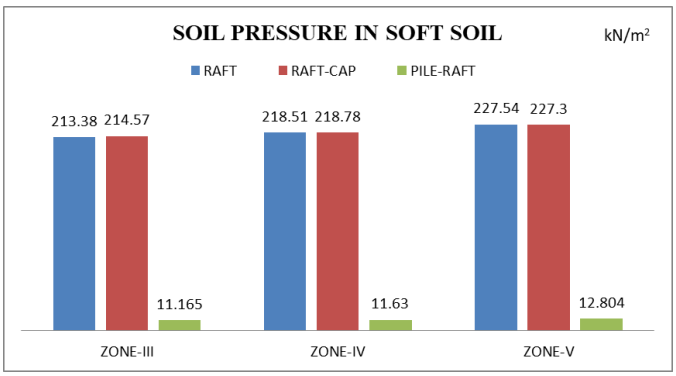

Fig -6: Soil Pressure in Soft Soil

5.2 Settlement

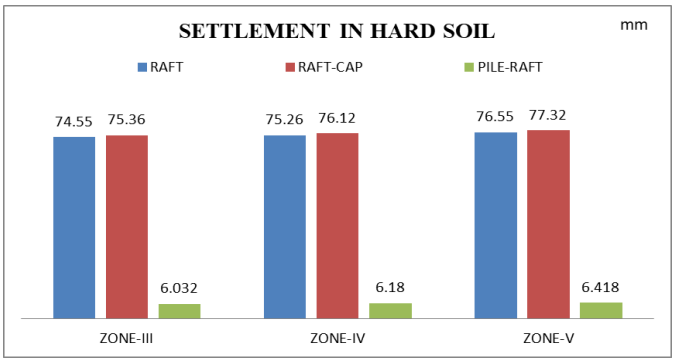

Fig -7: Soil Settlement in Hard Soil

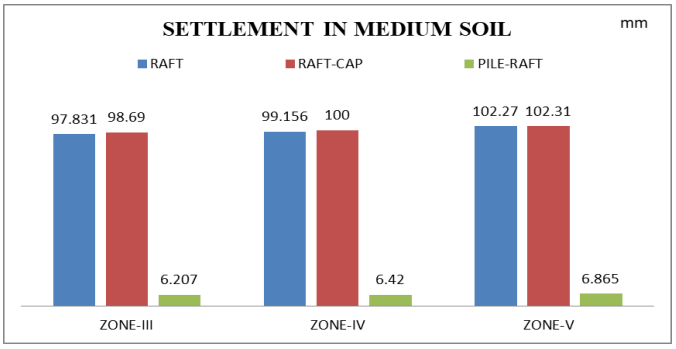

Fig -8: Soil Settlement in Medium Soil

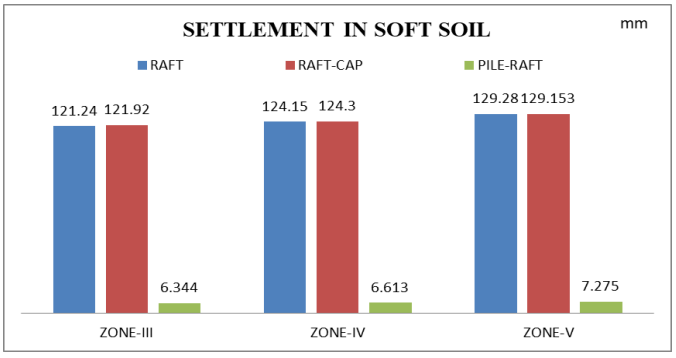

Fig -9: Soil Settlement in Soft Soil

5.3 Average Punching Shear

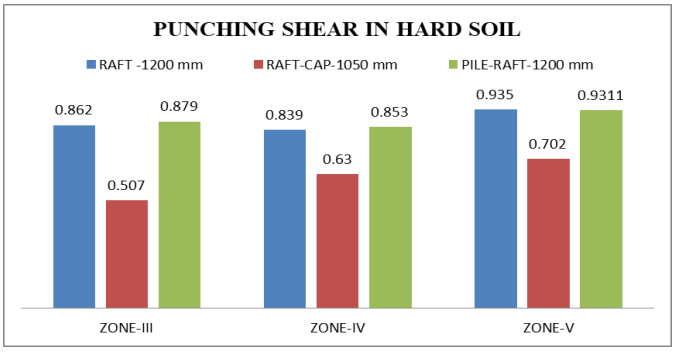

Fig -10: Punching Shear in Hard Soil

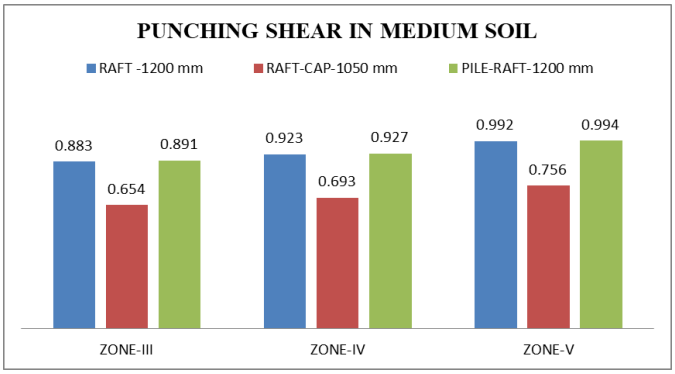

Fig -11: Punching Shear in Medium Soil

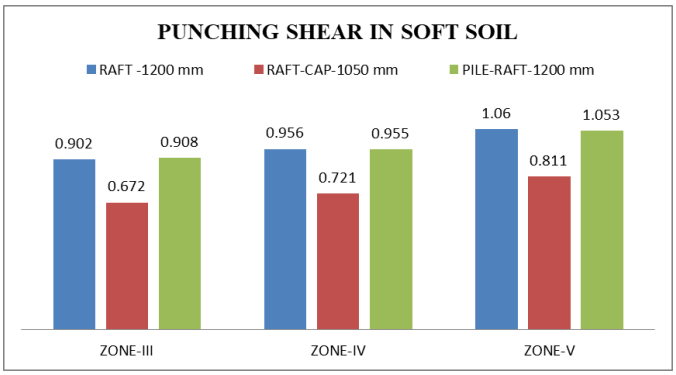

Fig -12: Punching Shear in Hard Soil

6. Conclusions

- Soil pressure increase with increase in seismic zone III to V in all three type of foundation.
- Soil Pressure is observed little high in raft with top cap foundation compare to raft foundation in all seismic zones.
- Soil pressure in pile raft foundation observed very less compare to raft foundation and raft with top cap foundation.
- Settlement increase with increase in seismic zone III to V in all three type of foundation.
- Settlement increases as all three types of foundations move from hard to soft soil.
- Settlement is observed little high in raft with top cap foundation compare to raft foundation in all seismic zones.
- Settlement in pile raft foundation observed very less compare to raft foundation and raft with top cap foundation.
- Punching shear increase with increase in seismic zone III to V in all three type of foundation.
- Punching shear increases as all three types of foundations move from hard to soft soil.
- Punching shear is observed very high in raft and pile raft foundation.

- Punching is observed very less in raft with top cap foundation compare to raft foundation and pile raft foundation in all seismic zones and soil type.
- Pile raft foundation performed better in soil pressure and settlement compare to raft foundation and raft with top cap foundation but when comes to punching shear in pile raft observed high.
- Pile with top cap with less thickness (1050mm) compare to raft foundation (1200 mm) and pile raft foundation (1200 mm).

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