International Journal of Scientific Research in Civil Engineering
© 2021 | IJSRCE | Volume 5 | Issue 3 | ISSN : 2456-6667

Analysis of Differently Shaped Footing for A Midrise Structure Considering Lateral Forces Using SAFE Software

Vijay Singh Dassondi[1], Rahul Sathbhaiya[2]
[1]P.G. Scholar, Department of Civil Engineering, Infinity Institute of Management and Technology, Sagar, Madhya Pradesh India
[2]Assistant Processor, Department of Civil Engineering, Infinity Institute of Management and Technology, Sagar, Madhya Pradesh India

Article Info
Volume 5, Issue 3
Page Number: 83-91

Publication Issue :
May-June-2021

Article History
Accepted : 25 May 2021
Published : 30 May 2021

ABSTRACT

In this study, comparative analysis was done on three different footing namely Single Footing, Combined Footing and MAT or Raft Footing with similar loading conditions. This included comparative study of their structural behaviour considering for building frame G+5. A comparison in analysis results was done on certain important parameters such as deflection, support reaction, axial force, torsion and Shear force. The cost analysis was conducted in this experimental investigation as per S.O.R, The investigation was fragmented towards introducing the different types of foundations along with their related advantages and disadvantages. The objectives included the comparative analysis on the defined three footings on the parameters as discussed before and results were scripted on Microsoft excel generated from the analytical program SAFE which was used for the structure analysis.

The results in the analysis stated Isolated footing distributes maximum Axial force comparatively to other conditions whereas Raft Foundation shows minimum. It was clearly visible that best support reaction was generated in isolated footing comparatively to other footings. As support reaction showcased its intensity to distribute load to the soil hence for this distribution isolated footing was considered best and suitable. Bending moment was observed minimum in Isolated foundation which results in minimum reinforcement requirement. As quantity estimation was done and rate was analysed as per S.O.R it was concluded that Isolated footing results in economical type of footing for same conditions whereas Combined Footing is costlier in comparison.

Keywords : Soil, footing, structure analysis, seismic analysis, shape of foundations, forces, SAFE.

I. INTRODUCTION

The lowest part of a structure which transfers its load to the soil beneath is known as foundation. The stability of a structure mostly depends on the performance of foundation. Its design should be done properly, considering its importance. Depending on the depth of embedment, foundations can be classified as shallow or deep. The ultimate load which can be sustained by the soil is identified as bearing capacity. Bearing capacity and settlement are two parameter requirement for the design of shallow foundation. It is essential for engineers to estimate the foundation's bearing capacity subjected to vertical loads. More often than not, such a significant number of concentrates for estimation of bearing limit includes foundation exposed to vertical loading. Notwithstanding, for certain structures, for example, projection, holding divider, entrance surrounded structure and water front structure, which are frequently exposed to unusual loads because of even push and bending moment. Settlement of foundation under loads because of the development of soil molecule on a level plane and vertically beneath the balance. Tilt of the footing caused by eccentric loading which results to non-uniform stress distribution and unequal settlement below the footing. When centric vertical load subjected to the foundation, uniform stress distribution under the footing and equal settlement at both edges occurred. The tilt of footing directly proportional to the (e/B) ratio, i.e. it increases with the increasing (e/B) ratio. At the point when flightiness proportion is more prominent than 1/6, the edge of the balance which is far from focus will lose its contact with the soil. Therefore, it will diminish the successful width (B') of balance and which will lessen a definitive bearing limit of foundation. Stress created in various layers of soil because of the forced loads by different structures at the foundation level will dependably be joined by some measure of strain, which causes settlement of the structures.

The research work presents the impacts of soil-foundation structure communication on the seismic reaction. Three sorts of foundations with recurrence based plan were dissected, including spread foundation, mono heap, heap bunch with top, and consolidated foundation. Soil is demonstrated both certainly (subgrade response modulus) and unequivocally. The limited component technique utilizing the CSi SAFE program was first approved utilizing test information. Proposals were given to streamline the soil foundation structure connection investigation of seismic loading.

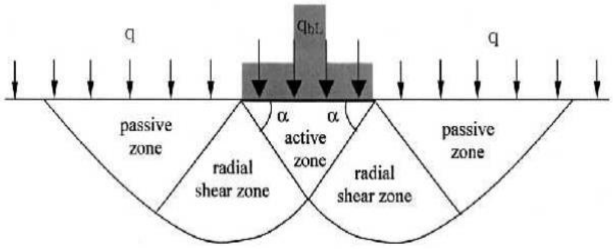


Fig: 1 Typical Failure Mechanism of Axially Loaded Footing

II. Literature Review

S.Balachandar and D.Narendra Prasad (2017) the research paper introduced the investigation of self-weight of footing concerning safe bearing limit, the examination of Depth Vs Reinforcement, and comparative analysis of footing geometry between the concentric Square footings, eccentric one-way square footing, eccentric both ways square footings. Self-load of the footing was considered as 10-15%, yet lay relies on the Safe Bearing Capacity of soil. So dependent on the site condition the level of self-weight was resolved. Furthermore, if the soil bearing limit has diminished the level of self-weight increments. The conclusion expressed that the profundity of footing relied upon the bearing limit of the soil. The bearing limit was equivalent to the profundity of footing and reinforcement was identified with its property. The depth of footing was expanded, the support diminished. Correlation of Concentric, Eccentric(one way), Eccentric (the two different ways) footings were structured by similar information however fortifications step by step increment dependent on the proportion of 1: 254: 4.08.

V. Thiruvengadam et al (2018) The research paper introduced the amount and cost demonstrating of building foundations of strengthened cement multi-storeyed structures in the scope of two to ten stories intended for seismic forces in the different seismic zones of the Indian subcontinent and measures the cost premium for giving seismic resistance. The foundations considered in the examination were disconnected footings, pontoon and heap foundations under various admissible bearing tension estimations of the supporting soils. The exploration paper gave the prerequisite of basic amounts and foundation costs per unit floor region of the structure in various seismic zones. The cost ramifications for consolidating the seismic protections in low to high seismic zones of the Indian subcontinent are evaluated.

The outcomes were very proficient for the structure experts and cost engineers during beginning times of structure improvement and cost arranging and featured the feasible economy in foundation costs through appropriate assessment of passable bearing weight of soils through satisfactory geotechnical examinations of the structure operating sites.

Seok Jung KIM et al (2019) The research paper stated load resistance factor design (LRFD) technique which could be utilized to assess the opposition of a structure considering vulnerability dependent on dependability examination. Here, 13 sets of drilled shaft load test information were acquired utilizing strain checks, and a heap move investigation was performed to decide the precise shaft and base obstruction esteems.

For bi-directional loads tests, the identical load's relocation bend was attracted to decide the complete obstruction. Adjustments of the versatile modulus of the penetrated shaft concrete and the proportionate load uprooting bend considering the hub loads and flexible settlement were directed to get progressively exact opposition esteems. After deciding exact opposition esteems, a dependability investigation was performed to decide the objective unwavering quality file and the obstruction factors utilizing the propelled first-request second-moment (AFOSM) unwavering quality strategy.

For the AASHTO-prescribed objective unwavering quality list of 3.0, the pole obstruction factors were seen as inside 0.13–0.32 of the AASHTO-based qualities, the base opposition factors were inside 0.19–0.29 of the AASHTO-based qualities and the absolute opposition factors were inside 0.28–0.42 of the AASHTO-based qualities for each bearing limit condition assessed. The opposition factors were as needs be resolved to be 30–60% of the AASHTO-prescribed qualities for the pole obstruction and 40–60% of the AASHTO-suggested values for the base opposition. These distinctions in obstruction factors were the aftereffect of errors in the state of the stones where the bored shafts were established. The opposition factors recommended by AASHTO were resolved to utilize sedimentary and unblemished stone conditions pervasive in the US, while the bedrock in Korea will, in general, be endured or delicate rock and gneiss. Results decided balanced opposition components to represent this distinction in rock type and condition, giving improved structure wellbeing and loads obstruction exactness when utilizing penetrated shafts in Korea.

III. Objectives of the study

Objective of this research is to study the effect of different types of footing geometries for same high rise building with same loading conditions in considering dynamic analysis using response spectrum method as per 1893-I 2016, modelling of RCC frame building and different footing is analysed using SAFE

1. To determine the most suitable type of footing for cohesive medium soil
2. Analysis of different footing type and shape for same soil bearing capacity.
3. To determine the best suitable footing type and Shape for a considered soil property.

IV. METHODS AND MATERIAL

Following steps are followed in a row to complete the study are as follows:

Designing the three different cases

Case I Single Footed isolated Type

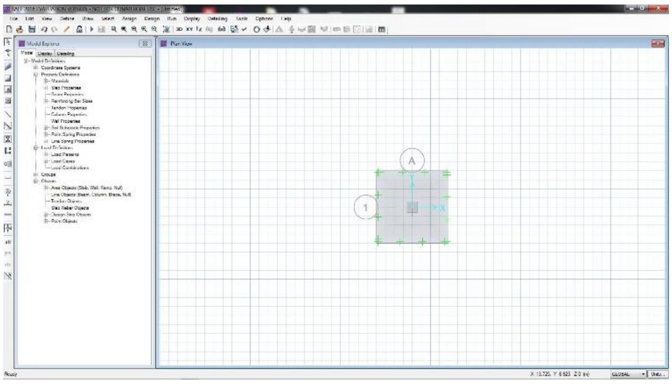


Fig 2. Single Footed Isolated Type

Case II Combined Footing

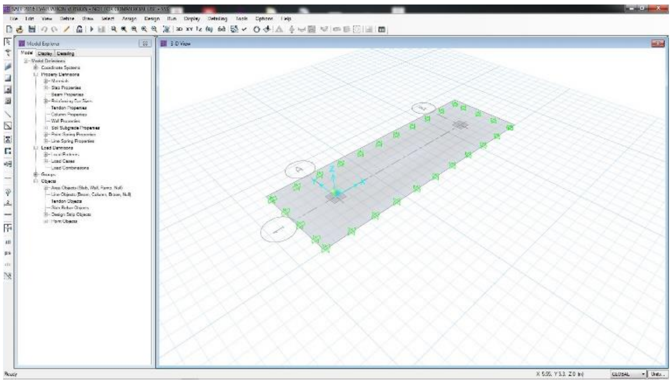


Fig 3. Combined Footing

Case III MAT or Raft Footing

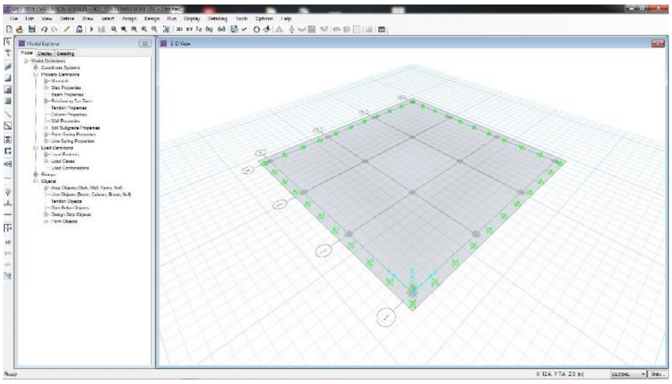


Fig 4. MAT or Rat Footing

Step-1 First step is to review the literature related to our work done in past to justify the scope of work.

Step-2 second step is to select the unit value and assigning data for material property with Specified concrete compressive strength as 30 N/mm^2.

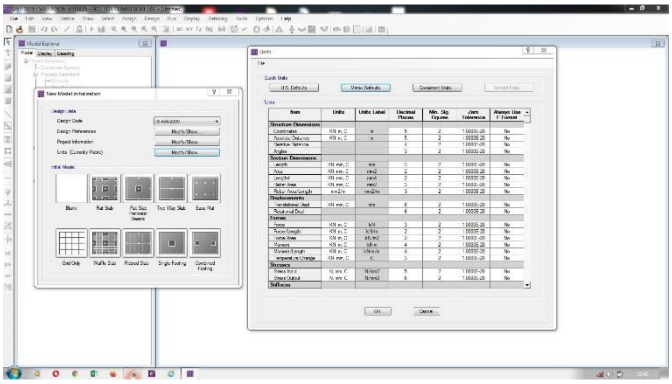


Fig 5. Assigning Units

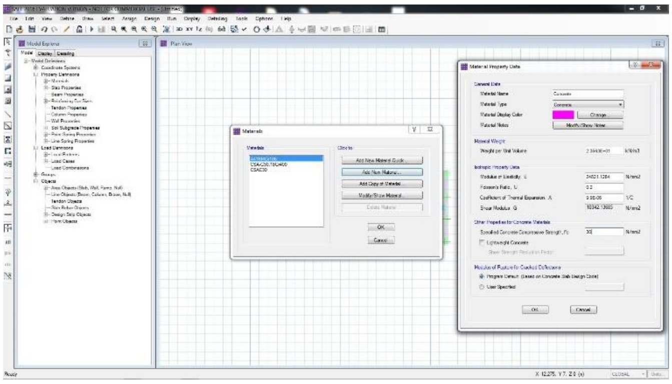
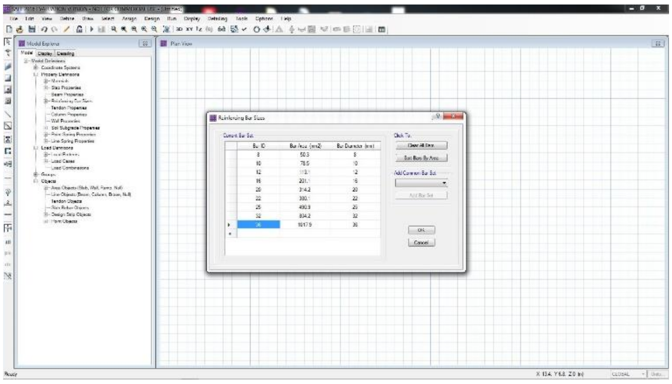


Fig 6. Assigning Material Property Data

Step-3 third step is to model the reinforced bar size assigning Bar Id and Bar area 1017.9mm^2 with diameter 36 mm.

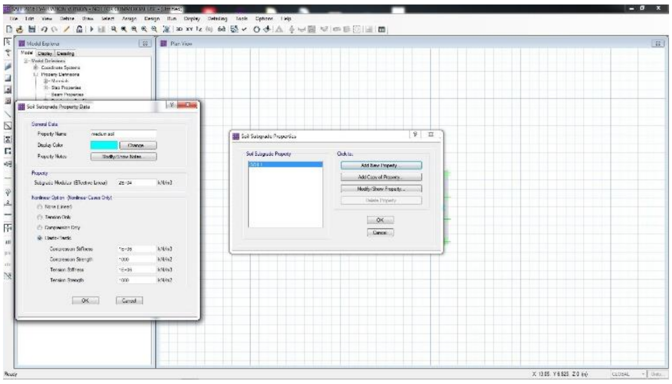

Reinforcing Bar Sizes

Current Bar Set

Bar ID	Bar Area (mm2)	Bar Diameter (mm)
8	50.3	8
10	78.5	10
12	113.1	12
16	201.1	16
20	314.2	20
22	380.1	22
25	490.9	25
32	804.2	32
36	1017.9	36

Fig 7. Assigning reinforced Bar Size.

Step-4 Fourth step includes assigning of soil Subgrade properties in which we have considered medium soil in the analysis


Soil Subgrade Property Data

General Data
Property Name: medium soil

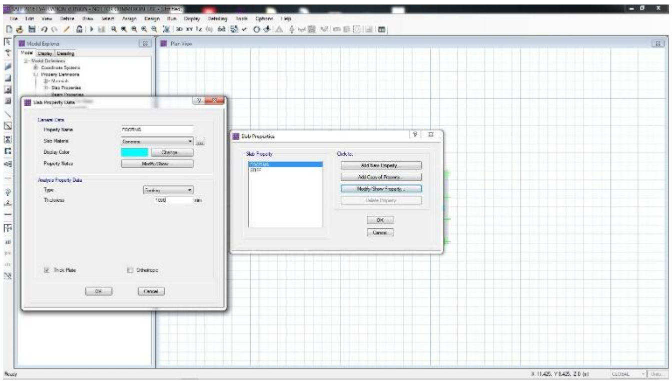
Property
Subgrade Modulus (Effective Linear): 2E+04 kN/m3

Nonlinear Option (Nonlinear Cases Only)
○ None (Linear)
○ Tension Only
○ Compression Only
● Elastic-Plastic
Compression Stiffness: 1E+06 kN/m3
Compression Strength: 1000 kN/m2
Tension Stiffness: 1E+04 kN/m3
Tension Strength: 1000 kN/m2

Soil Subgrade Properties
Soil Subgrade Property: SOIL1

Fig 8. Soil Sub Grade Property Data

Step-5 To analyze the footing depth along with Section and Materials.

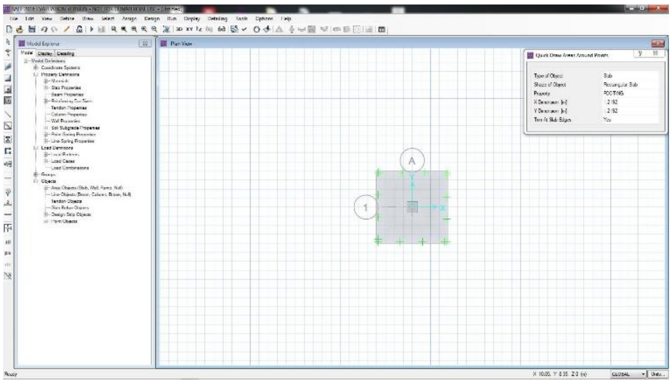

Slab Property Data

General Data
Property Name: FOOTING
Slab Material: Concrete

Analysis Property Data
Type: Footing
Thickness: 1000 mm
☑ Thick Plate
☐ Orthotropic

Slab Properties
Slab Property: FOOTING, SLAB

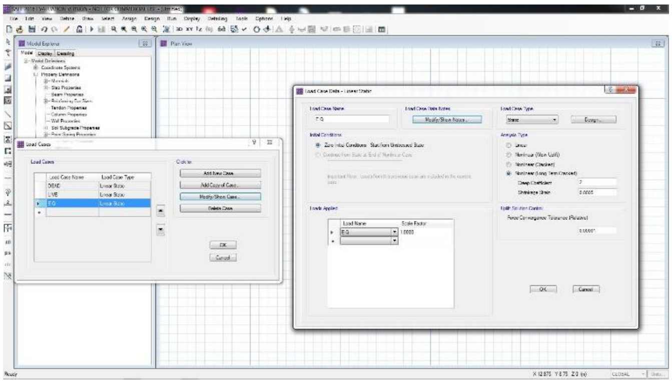
Fig 9. Assigning Footing Depth


Quick Draw Areas Around Points

Type of Object: Slab
Shape of Object: Rectangular Slab
Property: FOOTING
X Dimension (m): 2.192
Y Dimension (m): 2.192
Trim At Slab Edges: Yes

Fig 10. Assigning Section Properties

Step-6 Assigning Load patters on the basic front along with the seismic load as per IS 1893 I- 2016.


Load Cases

Load Case Name	Load Case Type
DEAD	Linear Static
LIVE	Linear Static
EQ	Linear Static

Load Case Data - Linear Static

Load Case Name: EQ
Load Case Type: Static

Initial Conditions
● Zero Initial Conditions - Start from Unstressed State
○ Continue from State at End of Nonlinear Case

Analysis Type
○ Linear
○ Nonlinear (Allow Uplift)
○ Nonlinear (Cracked)
● Nonlinear (Long Term Cracked)
Creep Coefficient: 2
Shrinkage Strain: 0.0005

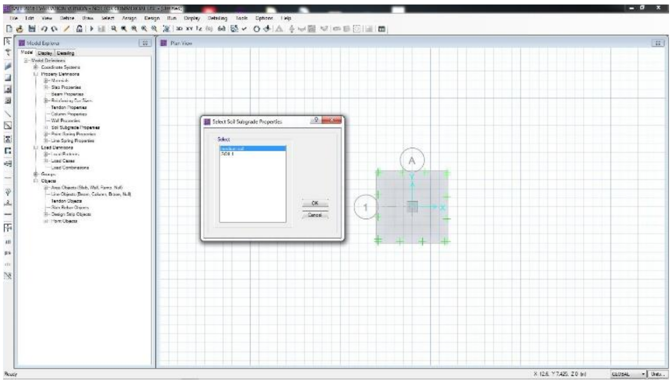
Loads Applied

Load Name	Scale Factor
EQ	1.0000

Uplift Solution Control
Force Convergence Tolerance (Relative): 0.0001

Fig 11. Defining Non- linear Seismic Load.

Step-8 Assigning Soil Condition


Select Soil Subgrade Properties

Select: medium soil, SOIL1

Fig 12. Selection of Soil Sub grade Properties

Step-9 Assigning Hinged Support at Bottom and Weak Spring at Soil Mass.

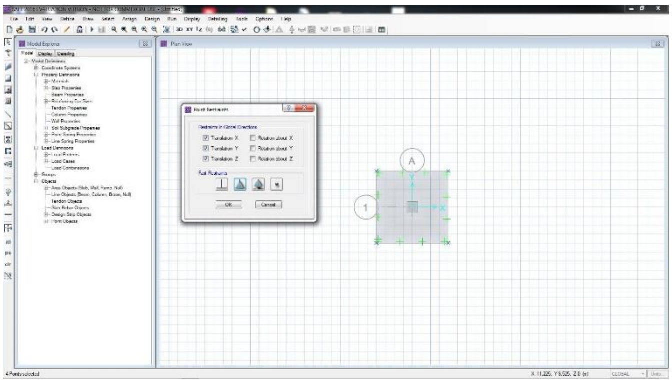


Fig 13. Assigning Hinged Support at Bottom and Weak Spring at Soil Mass

Step-10 Evaluate the output to determine the crack on affected nodes.

Step-11 To conclude our study in terms of results and cost analysis.

Table 1 Material Specification

S. No.	**Material Specification**	
1.	Grade of Concrete, M-25	f_{ck} = 25 N/mm^2
2.	Grade of Steel, Fe-415	f_y = 500 N/mm^2
3.	Density of Concrete	Υ'c = 25 KN/m^3
4.	Density of Brick wall considered	Υ'_{brick} = 18 KN/m^3
5.	Live Load	4KN/m^2
6.	Wall Load	12KN/m^2

Table 2 Building Description

Sno	**Building Description**	
1	Plane Area	15.8m X 13.8m
2	Storey Height	3.2 m
3	Number Of Storey	G+5
4	Beam Dimension	200 X 300 mm
5	Column Dimension	200 X 400 mm
6	Slab Thickness	0.15 m
7	Thickness Of Wall	0.1m
8	Bottom Support Condition	Fixed Support
9	Seismic Zone	V
10	Zone Factor	0.36
11	Soil Type	medium
12	Importance Factor	1.5
13	Response Reduction Factor	5

Analysis Result:

Table: 3 Max. Shear force (kN)

Shear Force KN		
Isolated Foundation	**Combined Footing**	**Raft Footing**
213.89	214.503	247.42

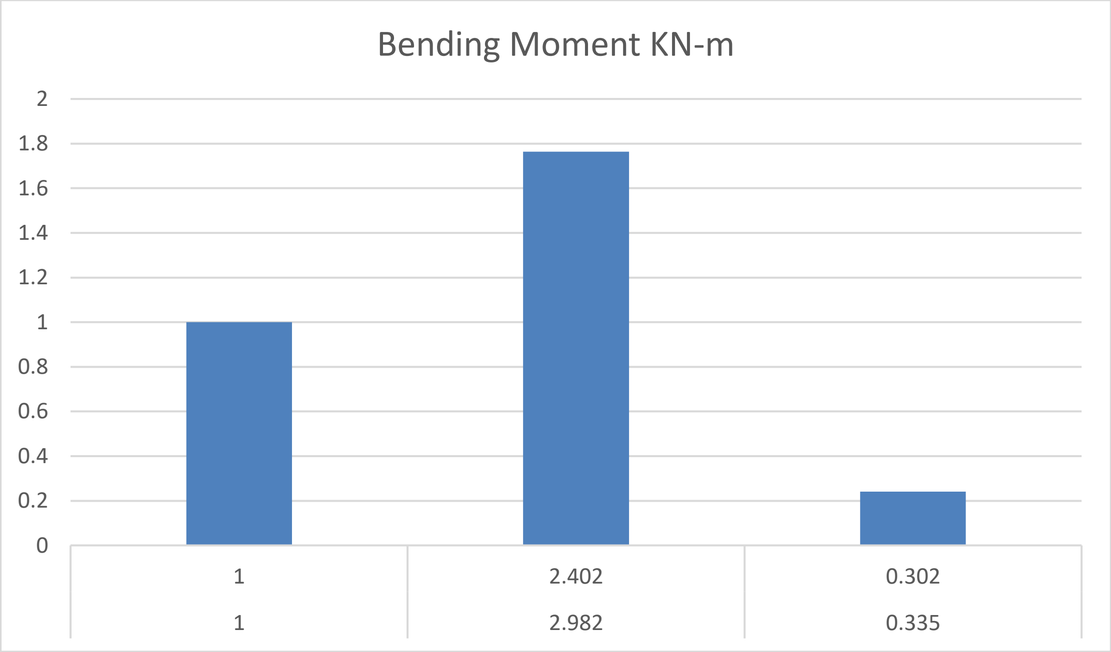
Inferences:

As observed in table 3. It can be said that unbalance forces are maximum in Raft or MAT Footing whereas minimum in Isolated. It can be said that Isolated footing serves the best in comparison to Combined footing and Raft Footing.

Max. Bending Moment kN-m

Table: 4 Max. Bending moment (kN-m)

Bending Moment KN-m		
Isolated Foundation	Combined Footing	Raft Footing
10.46	21.35	15.87



Graph 1 : bending moment KN-m

Inferences:

As shown in graph 1: Isolated Foundation footing is most economical and stable type whereas Combined footing was observed as most expensive type of footing as bending moment is directly proportional to Area of steel.

Cost analysis as per S.O.R.

Table 5. Cost analysis

S.No	Type of footing	Qty. of concrete	Qty. of reinforcement	Concrete rate/cu. M	Reinforcement rate/kg	Cost of concrete	Cost of reinforcement
1	**Isolated Foundation**	0.672	99.87	4500	48	3,024	4793.76
2	**Combined Footing**	0.672	109.76	4500	48	3,024	5268.48
3	**Raft Footing**	0.672	107.54	4500	48	3,024	5161.92

Inferences:

As quantity estimation is done and rate is analysed as per S.O.R it is concluded that Isolated footing results in economical type of footing for same conditions whereas Combined Footing is costlier in comparison.

V. CONCLUSION

The dynamic analysis of RCC building shows that dynamic analysis not only gives better understanding of the structural behavior but also following conclusion remarks can be made.

Isolated footing shows 52% less unbalanced forces comparing to combined footing case which makes rectangular footing.

1. It is clearly mentioned in the above chapter that Isolated footing distributes maximum Axial force comparatively to other conditions whereas Raft Foundation shows minimum.
2. It can be clearly visible that best support reaction is generated in isolated footing comparatively to others. As support reaction shows its intensity to distribute load to the soil hence for this distribution isolated footing is considered best and suitable.
3. Bending moment is observed minimum in Isolated foundation which results in minimum reinforcement requirement.
4. As quantity estimation is done and rate is analyzed as per S.O.R it is concluded that Isolated footing results in economical type of footing for same conditions whereas combined footing is costlier and in comparison to others.
5.

VI. FUTURE SCOPE

In this study we are comparing three generally utilized shape of footing whereas in future other shapes can be consider.

In this study we are considering seismic forces whereas in future one can select winf=d load for analysis.

In this study we are considering one type of soil whereas in future we can consider two or more type of soil conditions.

VII. REFERENCES

[1]. Liam WOTHERSPOON, Michael PENDER and Jason INGHAM, [COMBINED MODELLING OF STRUCTURAL AND FOUNDATION SYSTEMS], 13th World Conference on

Earthquake Engineering Vancouver, B.C., Canada, August 1-6, 2004, Paper No. 411.

[2]. Dinesh S.Patil and Anil S.Chander, [Cost Effectiveness of Several Types of Foundation], International Journal of Advanced Research in Science Management and Technology, Volume 2, Issue 1, January 2016.

[3]. S.Balachandar and D.Narendra Prasad, [Analysis and Design of Various Types of Isolated Footings], International Journal of Innovative Research and Science, Engineering and Technology, Vol. 6, Issue 3, March 2017.

[4]. V. Thiruvengadam, J. C. Wason and K. I. Praseeda, [COST MODELING OF FOUNDATIONS OF REINFORCED CONCRETE BUILDINGS DESIGNED FOR SEISMIC EFFECTS], 13th World Conference on Earthquake Engineering, Vancour, B. C., Canada, Paper No: 1956. Year 2018.

[5]. Sang-Sup Lee, Jiho Moon, Keum-Sung Park, and Kyu-Woong Bae, [Strength of Footing with Punching Shear Preventers], The Scientific World Journal, Volume 2014, Article ID 474728, 15 pages.

[6]. Sami W. Tabsh and Abdul Raouf Al-Shawa, [Effect of Spread Footing Flexibility on Structural Response], PRACTICE PERIODICAL ON STRUCTURAL DESIGN AND CONSTRUCTION, 2005, 10(2): 109-114.

[7]. Hisham T. Eid, Omar A. Alansari, Abdelfattah M. Odeh, Mohannad N. Nasr, and Husam A. Sadek, [Comparative study on the behavior of square foundations resting on confined sand], Canadian Geotechnical Journal · April 2009.

[8]. D. Brown, T. Wulleman & M. Bottiau, [A comparison of design practice of bored piles/ drilled shafts between Europe and North America], DFI Journal - The Journal of the Deep Foundations Institute, 2016.

[9]. Seok Jung KIM, Sun Yong KWON, Jin Tae HAN and Mintaek YOO, [Development of Rock Embedded Drilled Shaft Resistance Factors in Korea based on Field Tests], Applied Science. 2019, 9, 2201.

[10]. Grigory Garmanov and Nadezda Urazaeva, [Design and Calculation of Cost Effectiveness of Various Types of Foundations in Central Russia], International Scientific Conference Urban Civil Engineering and Municipal Facilities, SPbUCEMF-2015.

[11]. Prabir K. Basudhar, Arindam Dey and A. S. Mondal, [Optimal Cost-Analysis and Design of Circular Footings], International Journal of Engineering and Technology Innovation, vol. 2, no. 4, 2012, pp. 243-264.

[12]. Xirong Niu, Yangping Yao, Yanfang Sun, Yuhao He and Haiqing Zhang, [3D Numerical Analysis of Synergetic Interaction between High-Rise Building Basement and CFG Piles Foundation], Applied Science 2018.

[13]. Nunzia Letizia, Chiara Iodice, and Alessandro Mandolini, [A Local Design Method for Pile Foundations], Advances in Civil Engineering, Volume 2018, Article ID 9486945, 14 pages.

Cite this article as :

Vijay Singh Dassondi, Rahul Sathbhaiya, "Analysis of Differently Shaped Footing for A Midrise Structure Considering Lateral Forces Using SAFE Software", International Journal of Scientific Research in Civil Engineering (IJSRCE), ISSN : 2456-6667, Volume 5 Issue 3, pp. 83-91, May-June 2021. URL : https://ijsrce.com/IJSRCE215312