IJSRD - International Journal for Scientific Research & Development| Vol. 8, Issue 7, 2020 | ISSN (online): 2321-0613

Analysis of Differently Shaped Footing for a Mid Rise Structure Considering Lateral Forces Using Safe Software

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Abstract— As foundations are considered as the most important part of any structure due to its role in distributing structure load to the soil beneath. Before designing of structure soil investigation is necessary to determine the suitable type of footing shape, but this shape and type is adopted on some basic facts and principles which does not state a proper specific description. 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 stacking. In this study we are analyzing G+5 structure for seismic zone V considering medium type soil. Here we are comparing three different type of footing i.e. isolated, combined and raft footing of same area using analysis tool SAFE.

Keywords: Soil, Footing, Structure Analysis, Seismic, Shape, Forces, Reactions

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 stacking. 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 stacking.

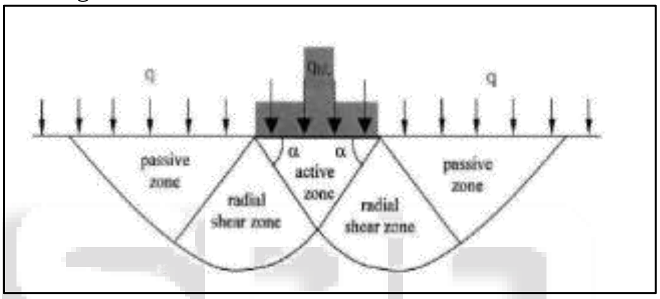

Fig. 1: Typical Failure Mechanism of Axially Loaded Footing

II. 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.

III. Literature Review

M Major et al (2019) The research paper introduced a correlation of solid footings with pyramid finished attachments to the normal attachment foundation developments unadulterated Axial loading moved from development, no material and item blemishes, absence of demonstrated support bars and attachment balance subsidence equivalent zero. The association with cut-off pyramid makes a chance to decrease the necessary stature of foundation in contrast with the regular arrangements and prompts diminished load just as expenses of the foundation casting. The similar examination secured three distinctive outer shapes for the two foundations (with ordinary and pyramid finished attachment) for example crystal, ventured and inclined. The subject of intrigue was if and how much the stature of foundations could be decreased in contrast with the typical attachment footing. The numerical investigation was performed with the use of SolidWorks Finite Element Method based programming.

Sushilkumar B. Magade and Ramakant K. Ingle (2019)The research paper introduced a straightforward methodology for computing the profundity to meet the inflexible condition under static loading. The proposed figuring strategy created a superior unbending nature than the current methodologies and it corresponded well to the limited component technique (FEM) for low subgrades. Steel was consistently implanted all through the length or width of regular foundation techniques, however, it was discovered improper because the bending moment was not uniform along the length or width of the footing. The examination proposed arrangements rethinking the position of steel in the focal zone of the balance. The compelling zone for support depended on the FEM results. This basic system was created for computing the most extreme moment utilizing the Diagonal Strip Method (DSM). DSM subbed for FEM, and it has been appeared to correspond well. The BM at the focal zone just as at the edges can be determined to characterize the dispersing of the fortifications.

The paper introduced a basic way to deal with ascertain the profundity of and the position of steel support for a detached square balance under concentric loading. Perceptions were restricted to square footings and sections with concentric loading. The working pressure strategy (WSM) and the breaking point state prerequisite. According to the proposed strategy, 40% of the reinforcement must be given at the focal zone, because the BM circulation was most elevated and the staying 60% ought to be put in the rest of the zones.

Anil Kumar Singh and Dr. G.R. Selokar (2016) the research paper presented the examination of piled raft foundation using finite element programming ANSYS. Parametric examinations were done in medium sand by fluctuating pile measurements and pile lengths in various mixes to introduce the conduct of piled raft foundation. The three sorts of communications, to be specific pile-soil-pile, pile-soil 1-raft and raft-soil-raft was represented utilizing the versatile hypothesis of Mindlin.

Results expressed that Pile distance across impacted a definitive limit of pile raft foundation though the heap length has not of much importance. It was inferred that an ideal blend of pile diameter of 0.5 m at the focal point of the raft with 0.4 m at the edges of the raft was giving an extreme pile of 4.45 MN with the settlement of 26.76 mm which was in acceptable limits.

IV. METHODOLOGY

Following steps are followed in a row to complete the study are as follows:
Designing the three different cases

1) Case I Single Footed isolated Type

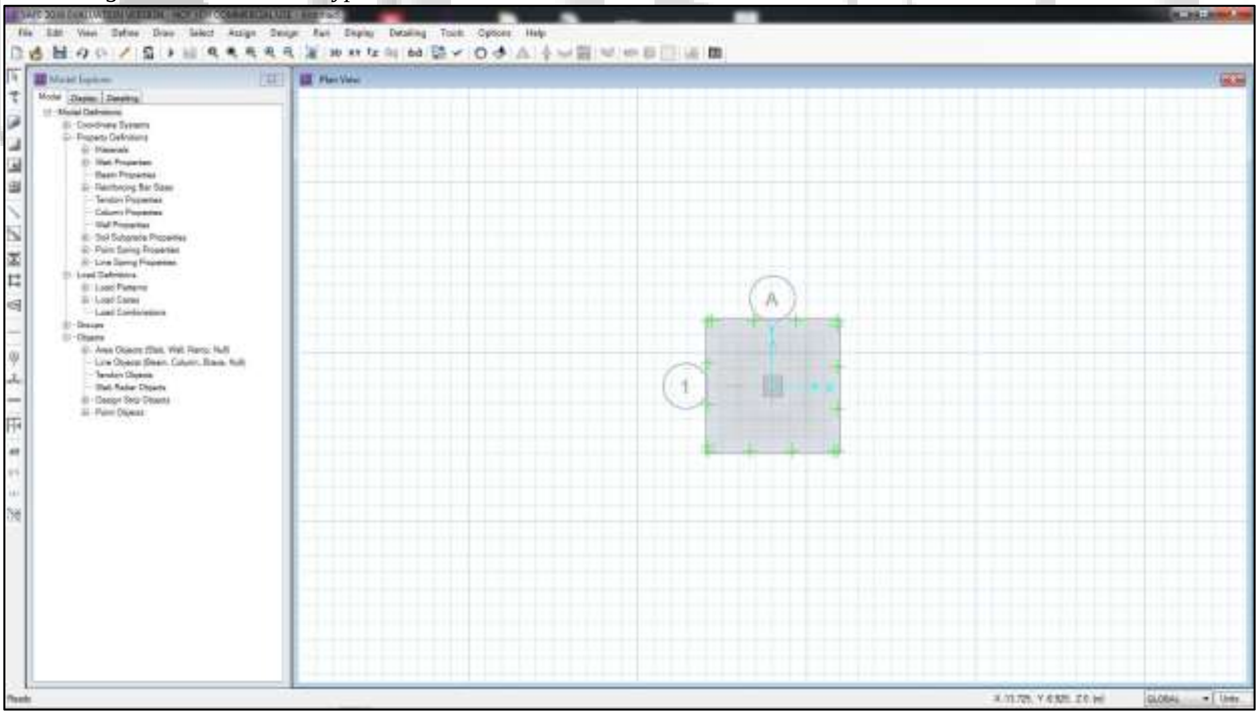

Fig. 2: Single Footed Isolated Type

2) Case II Combined Footing

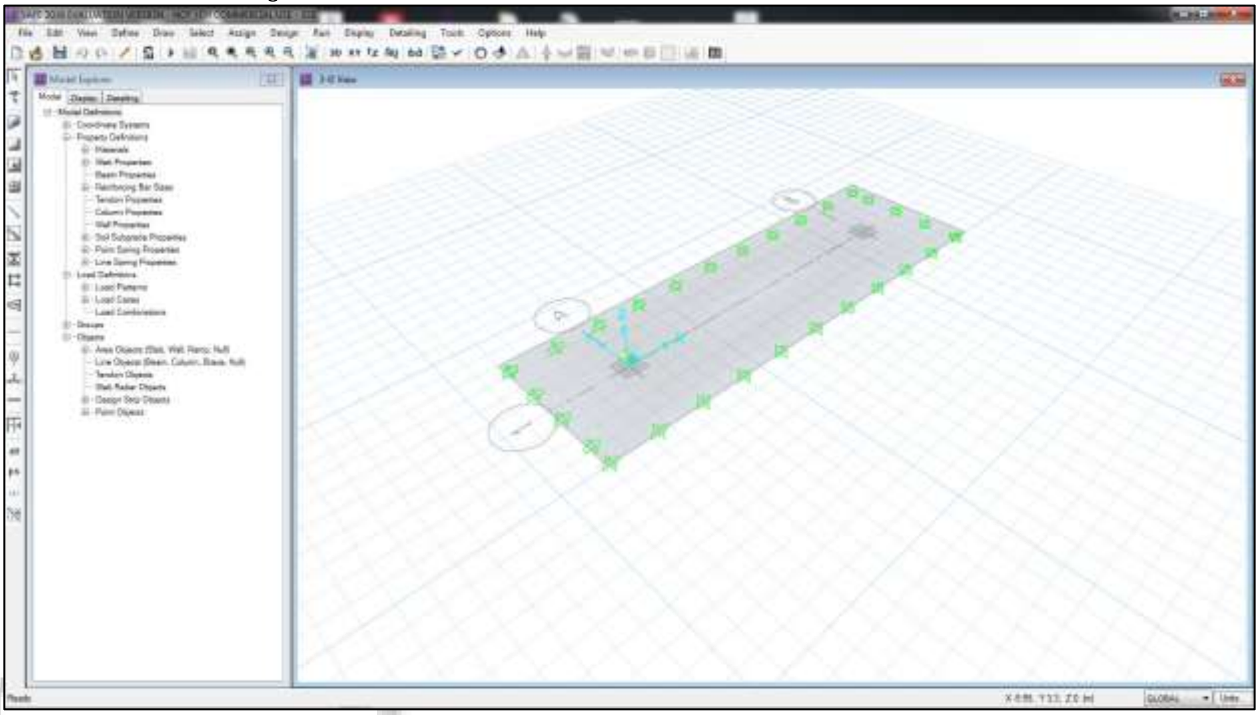

Fig. 3: Combined Footing

3) Case III MAT or Raft Footing

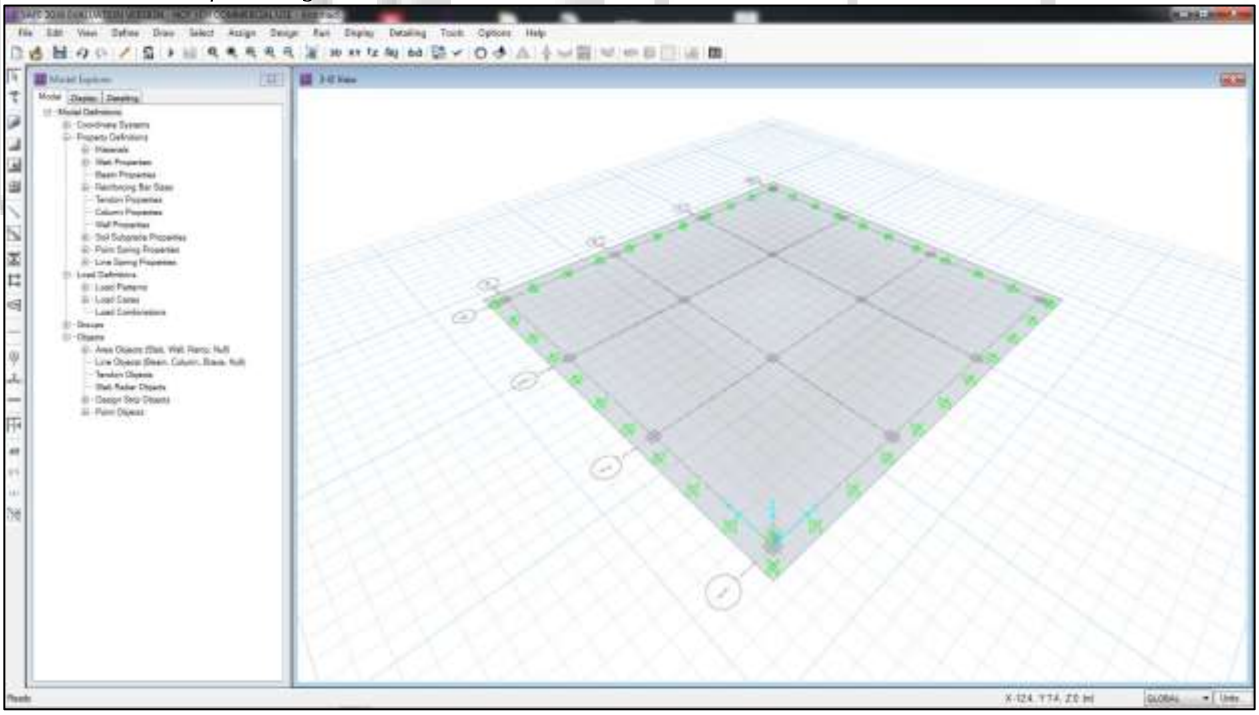

Fig. 4: MAT or Rat Footing

1) Step-1 First step is to review the literature related to our work done in past to justify the scope of work.
2) 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.

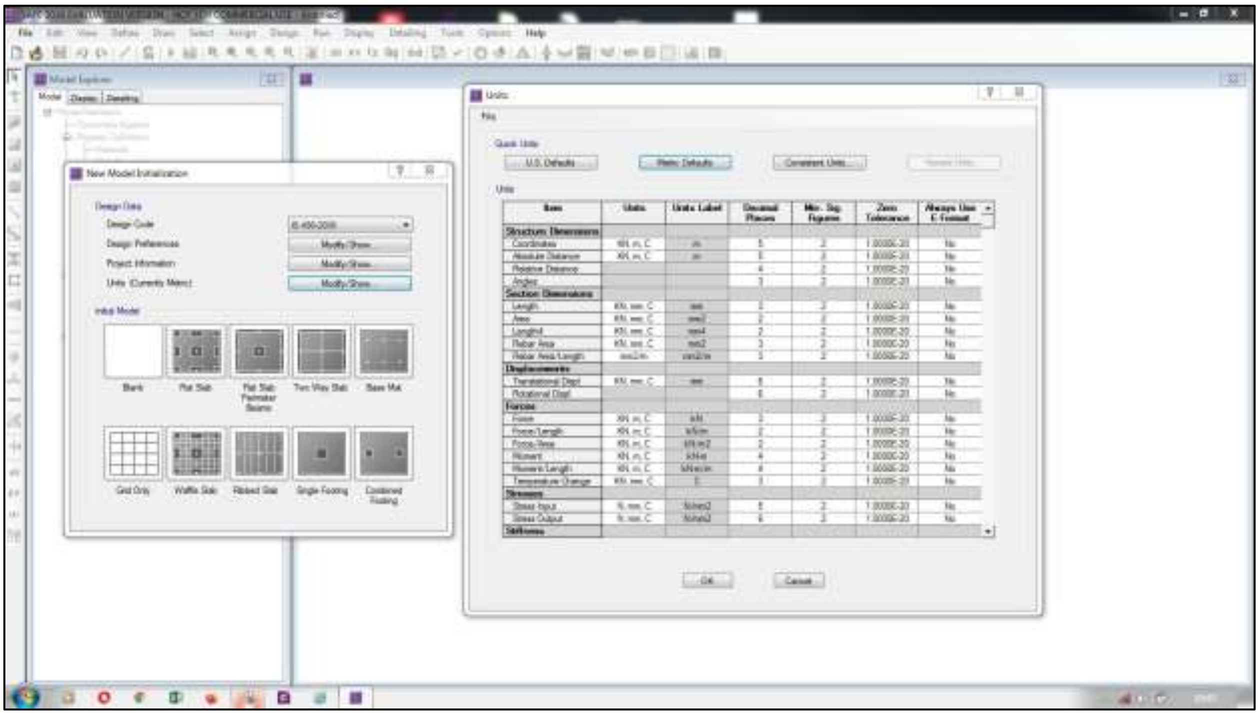

Fig. 5: Assigning Units

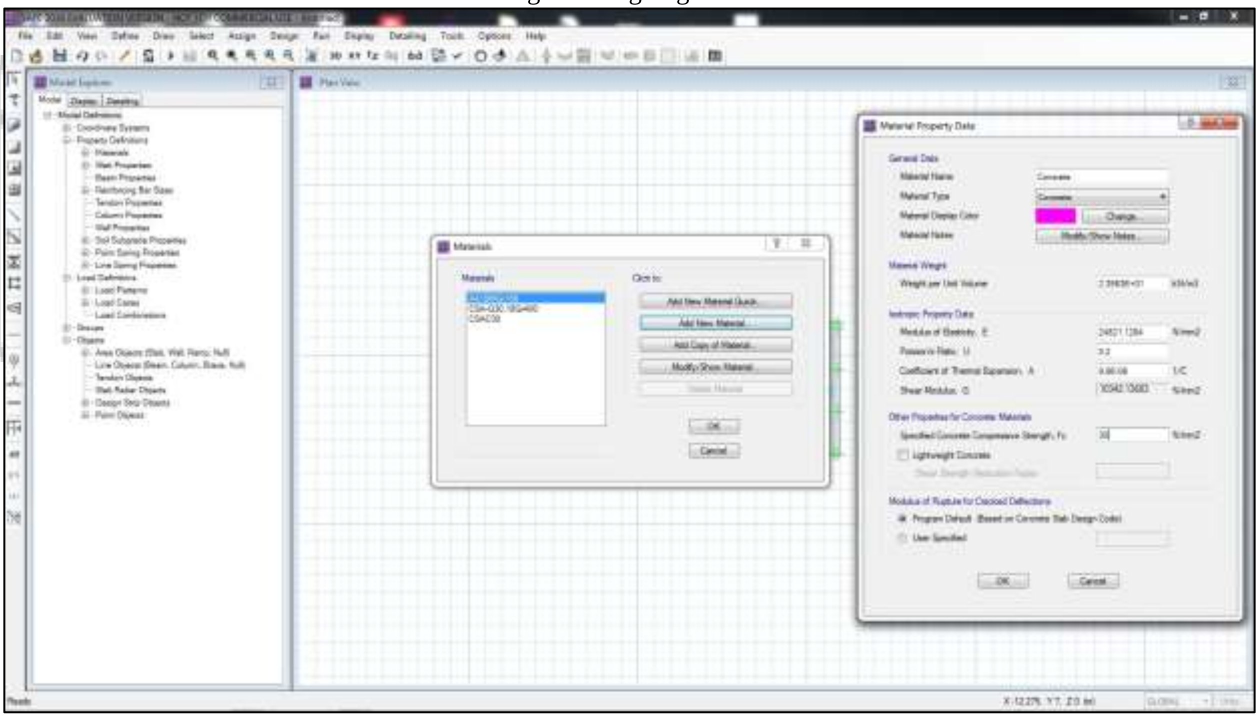

Fig. 6: Assigning Material Property Data

3) Step-3 third step is to model the reinforced bar size assigning Bar Id and Bar area 1017.9mm2 with diameter 36 mm.

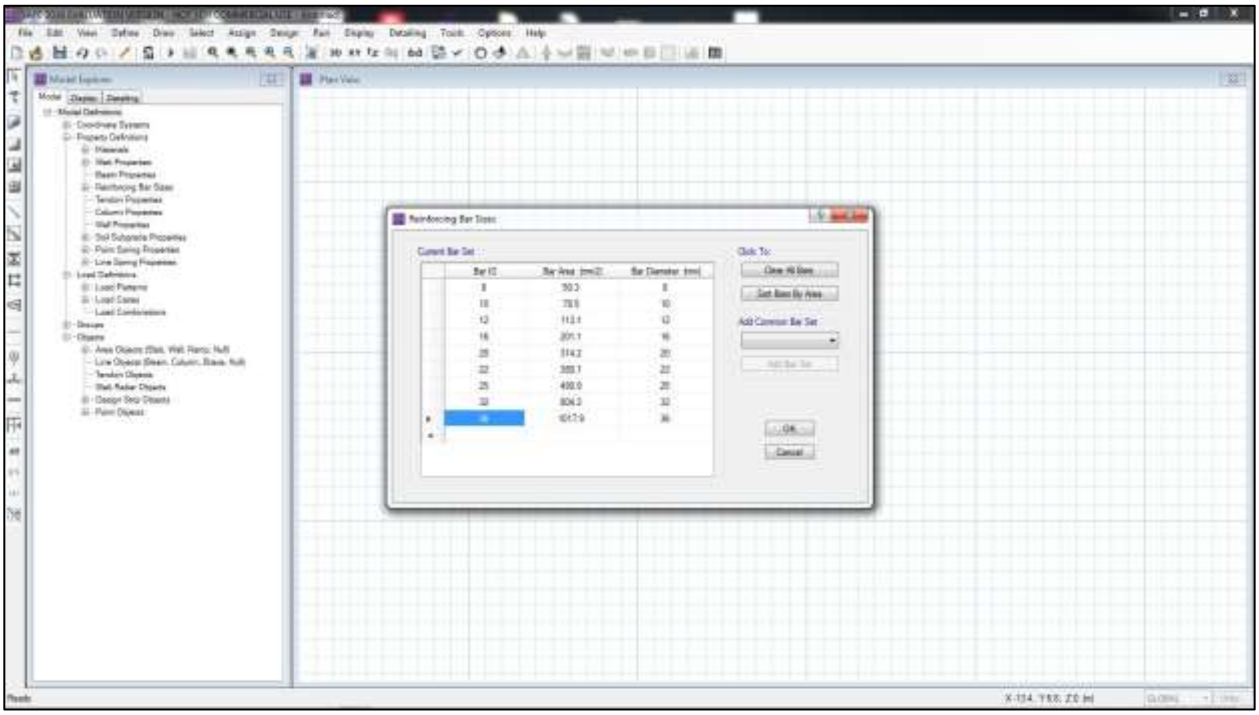

Fig. 7: Assigning reinforced Bar Size.

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

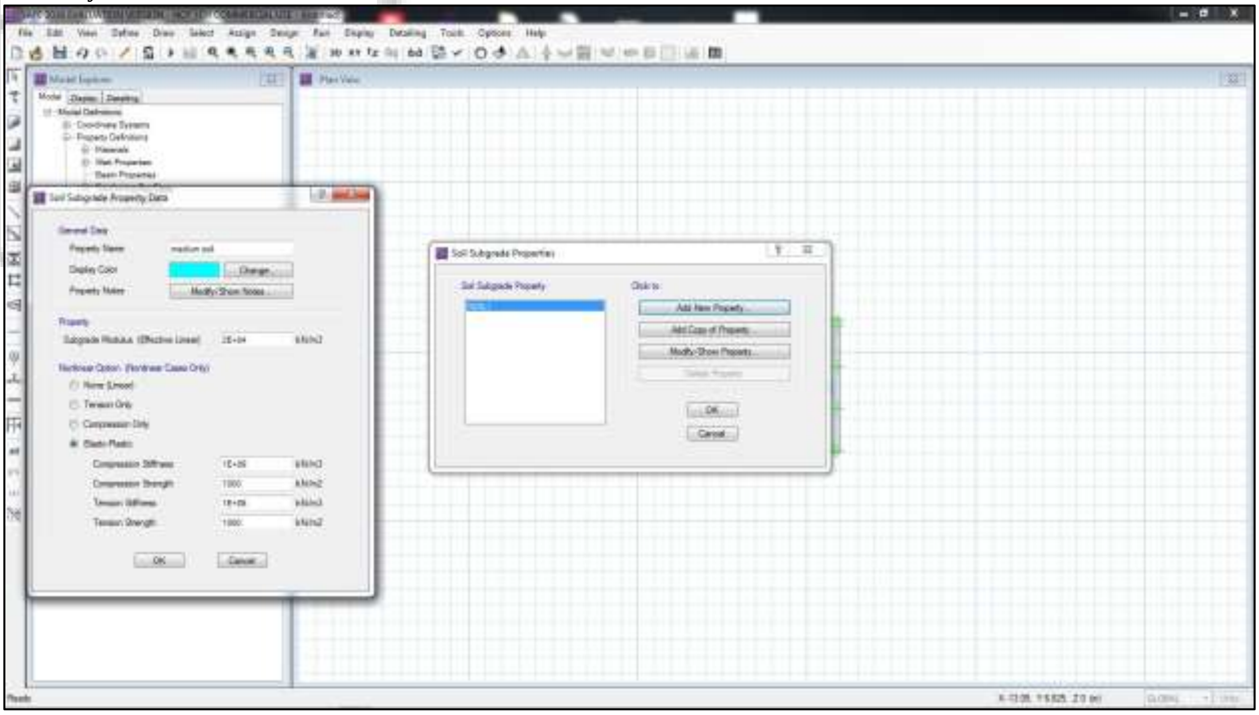

Fig. 8: Soil Sub Grade Property Data

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

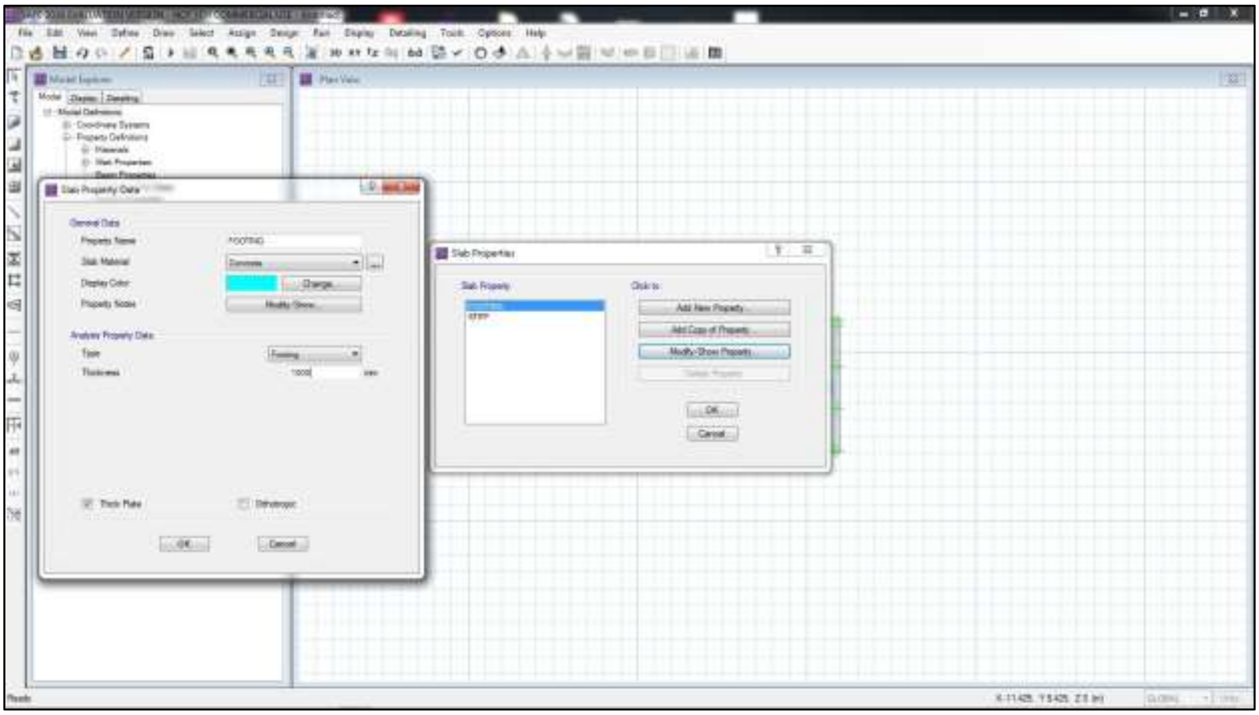

Fig. 9: Assigning Footing Depth

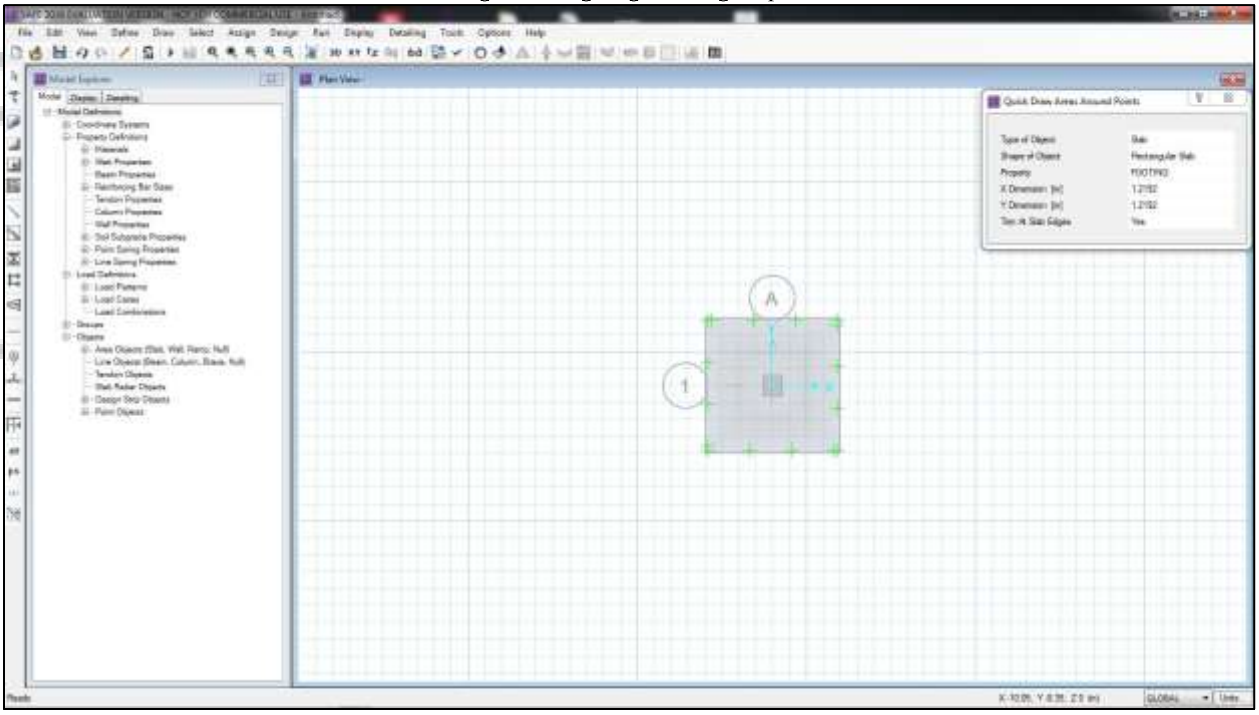

Fig. 10: Assigning Section Properties

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

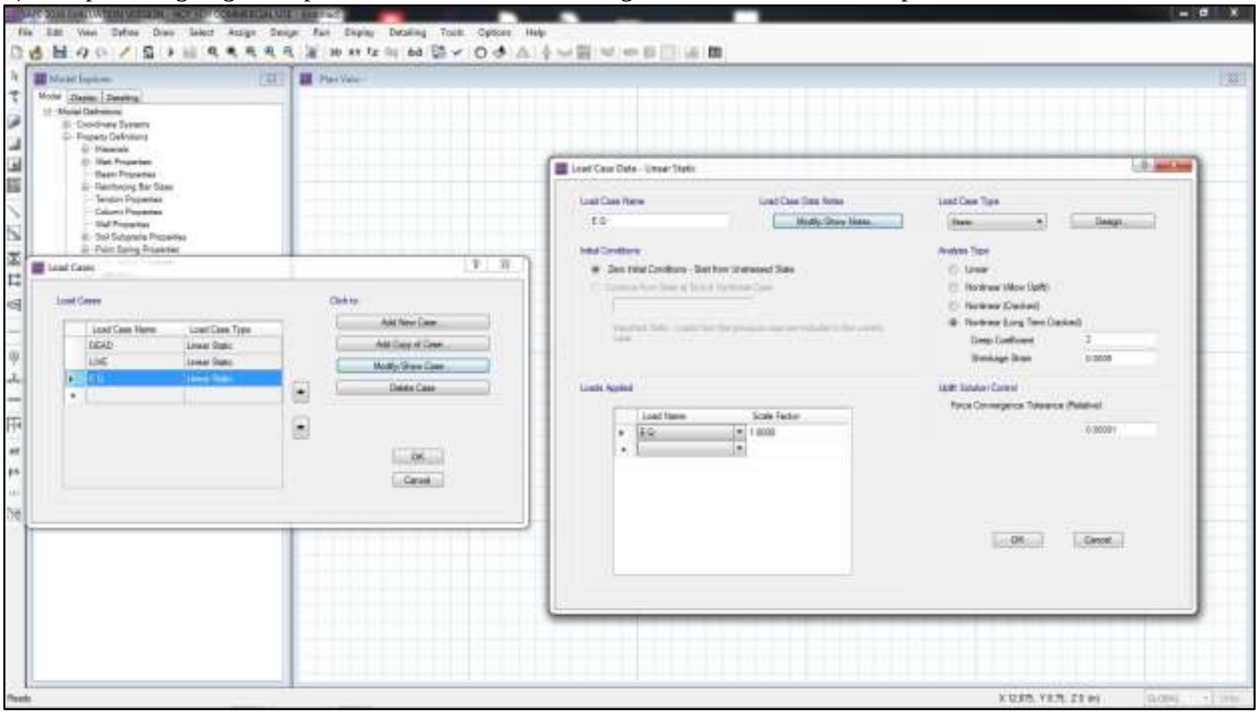

Fig. 11: Defining Non- linear Seismic Load.

7) Step-8 Assigning Soil Condition

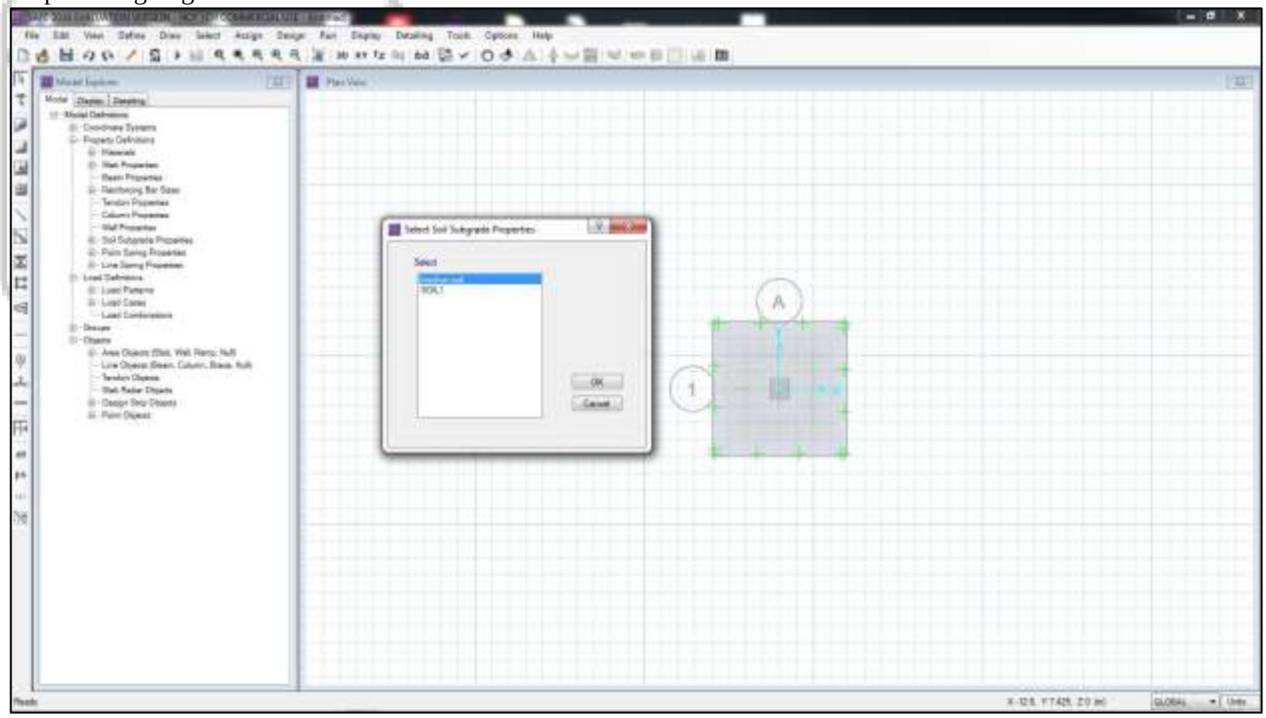

Fig. 12: Selection of Soil Sub grade Properties

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

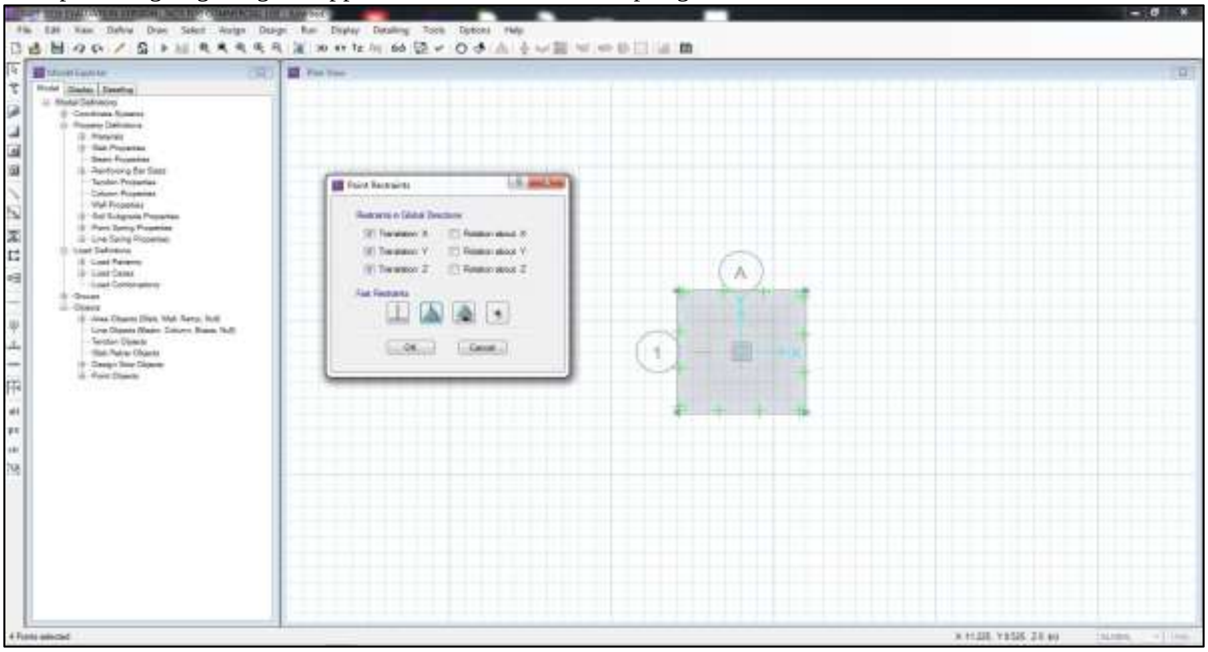

Fig. 13: Assigning Hinged Support at Bottom and Weak Spring at Soil Mass

9) Step-10 Evaluate the output to determine the crack on affected nodes.
10) Step-11 to conclude our study in terms of results and cost analysis.

V. PROBLEM FORMULATION

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

Table 1: Geometrical description

VI. FINITE ELEMENT ANALYSIS OUTPUT:

A. Raft or Mat footing

1) Support reaction:

Node	L/C	Force-X kN	Force-Y kN	Force-Z kN
75	1	-0.007	10.512	1.989
544	1	-0.007	10.411	-1.988
64	1	0.691	10.117	1.896
86	1	-0.702	10.102	1.892
545	1	0.679	10.034	-1.895
543	1	-0.69	10.019	-1.891
53	1	1.342	8.861	1.587
97	1	-1.346	8.838	1.581
546	1	1.329	8.819	-1.586
542	1	-1.333	8.796	-1.58
42	1	1.764	6.888	1.044

Table: 2 Support Reaction

2) Forces:

Axial Force kN	Shear-Y kN	Shear-Z kN	Torsion kNm	Moment-Y kNm	Moment-Z kNm
-46.082	-214.986	0.076	-0.022	-0.063	15.797
-46.082	210.087	0.076	-0.022	-0.086	15.032
-47.191	-218.055	-0.074	0.045	-0.064	13.26
-50.167	212.907	0.219	0.059	-0.063	12.358
-50.167	-212.153	0.219	0.059	-0.007	12.262
-47.191	207.007	-0.074	0.045	-0.044	11.801
-49.81	-215.181	-0.634	-0.046	0.002	11.126
-49.81	209.874	-0.634	-0.046	0.151	10.502
-46.082	-214.98	0.076	-0.022	-0.065	10.207
-46.082	210.081	0.076	-0.022	-0.084	9.57
-47.191	-218.05	-0.074	0.045	-0.062	8.461
-50.167	212.902	0.219	0.059	-0.058	7.846
-50.167	-212.148	0.219	0.059	-0.012	7.766
-47.191	207.002	-0.074	0.045	-0.046	7.246

Table 3: Forces

B. Combined footing

1) Support reaction:

Node	L/C	Force-X kN	Force-Y kN	Force-Z kN
5	1	1.507	9.054	-1.131
1	1	1.492	9.016	1.132
6	1	-1.506	9.008	-1.117
2	1	-1.49	8.959	1.117
241	1	-0.006	5.197	-0.858
30	1	-0.006	5.153	0.851
240	1	0.358	5.073	-0.814
242	1	-0.368	5.066	-0.812
28	1	0.354	5.031	0.807
32	1	-0.364	5.023	0.805
239	1	0.691	4.7	-0.674

Table 4: Support reaction

2) Forces:

Axial Force kN	Shear-Y kN	Shear-Z kN	Torsion kNm	Moment-Y kNm	Moment-Z kNm
607.3	38.225	-25.069	0.026	13.361	21.351
-216.253	-50.549	-52.797	-0.959	-21.427	21.237
-216.249	-50.549	-52.797	-0.959	-21.251	21.068
-216.246	-50.549	-52.797	-0.959	-21.075	20.9
-216.243	-50.549	-52.797	-0.959	-20.899	20.731
-216.24	-50.549	-52.797	-0.959	-20.723	20.563
-216.237	-50.549	-52.797	-0.959	-20.547	20.394
-216.234	-50.549	-52.797	-0.959	-20.371	20.226
-216.231	-50.549	-52.797	-0.959	-20.195	20.057
-216.227	-50.549	-52.797	-0.959	-20.019	19.889
-216.224	-50.549	-52.797	-0.959	-19.843	19.72
-216.221	-50.549	-52.797	-0.959	-19.667	19.552
-222.19	-51.558	-52.763	-1.035	-19.721	19.397
-216.218	-50.549	-52.797	-0.959	-19.491	19.383
-222.187	-51.558	-52.763	-1.035	-19.545	19.225
-216.215	-50.549	-52.797	-0.959	-19.315	19.215

Table 5: Forces

C. Isolated footing:

1) Support reaction

Node	L/C	Force-X kN	Force-Y kN	Force-Z kN
14	1	-0.277	1.718	-0.898
18	1	-0.767	1.688	-0.526
1	1	0.919	1.672	0.004
22	1	-0.913	1.654	0.052
38	1	0.713	1.63	0.552
34	1	0.239	1.588	0.849
10	1	0.302	1.561	-0.824
6	1	0.702	1.544	-0.514
26	1	-0.65	1.473	0.528
30	1	-0.268	1.447	0.778

Table 6: Support reaction

2) Forces:

Axial Force kN	Shear-Y kN	Shear-Z kN	Torsion kNm	Moment-Y kNm	Moment-Z kNm
7.401	-212.558	-0.009	0	0.001	10.946
7.401	212.492	-0.009	0	0.003	10.939
6.659	-212.63	0.066	0.001	0.006	10.103
6.651	-212.556	-0.045	-0.001	-0.004	10.086
6.659	212.416	0.066	0.001	-0.007	10.082
6.651	212.49	-0.045	-0.001	0.005	10.08
5.948	212.561	-0.012	0	0.005	9.7
5.948	-212.483	-0.012	0	0.003	9.693
7.401	-212.553	-0.009	0	0.001	7.192
7.401	212.488	-0.009	0	0.003	7.186
6.659	-212.627	0.066	0.001	0.005	6.631
6.651	-212.552	-0.045	-0.001	-0.003	6.619
6.659	212.412	0.066	0.001	-0.006	6.614
6.651	212.486	-0.045	-0.001	0.004	6.614
5.948	212.557	-0.012	0	0.005	6.362

Table 7: Forces

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

Table 8: Cost Analysis

VII. 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.

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