BUILDING STRABLE AND FIXED BASE WITH SAP

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ABSTRACT:

Prior conventional building configuration chosen was regular or symmetrical building with fixed base. Practically speaking the building configuration need not be symmetrical always. In reality building rests on the soil. Usually flexible soil condition and nonlinearity of the building is neglected during analysis. In such case, the building is to be analyzed considering soil structure interaction and nonlinear conditions using appropriate software. The 3D model analysed using software should be a replica of realistic structure. In the present study a 10 storey, 3D irregular building is chosen and analysed using SAP 2000 V19.2.1 software. The irregularity chosen is in vertical direction with fixed base and with flexible soil base (continuum method). The irregular building is subjected to linear static analysis and non linear static pushover analysis. The results obtained for vertically irregular building are compared for fixed and flexible base for both linear and nonlinear analysis. The variation in displacement, base force and time period are observed. The building which displays better realistic results can be chosen for future reference.

Keywords: *Nonlinear analysis , Fixed base, Continuum method.*

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1. INTRODUCTION

Performance Based Design is promising field in seismic design of structure.

Though elastic analysis gives a good indication of elastic capacity of structures and shows where yielding might first occur, it does not consider redistribution of force. Non-linear static analysis can foretell these more precisely as it considers the inelastic behavior of the structure. It can aid in identifying critical members which are likely to reach critical state during earthquake.

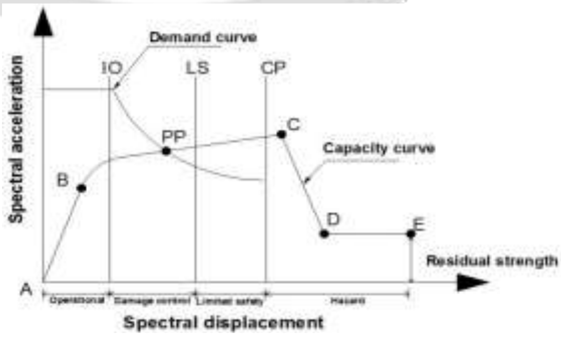

Fig.1.Pushover curve

In Fig.1. AB shows linear elastic range, followed by an inelastic but linear response of reduced (ductile) stiffness from B to C. CD shows a sudden reduction in load resistance, followed by a reduced resistance from D to E, and finally a total loss of resistance from E to end. The nonlinear state is represented by hinge formation here non-linear states are defined as ‘Immediate Occupancy’ (IO), ‘Life Safety’ (LS) and ‘Collapse Prevention’ (CP) within its ductile range.

Pushover analysis, is for examination how much load or displacement either X or Y direction can a building take under monotonically increasing load or displacement.
Considering soil structure interaction, in this study soil is idealised by continuum method. Continuum method is where a 3D-elastic half-space model is discretized using FE as solid elements. The flexibility of soil is modeled as continuum model where soil is considered as isotropic, homogenous elastic half space (3D) model. Soil parameters such as dynamic shear modulus and poisson’s ratio are considered as input. The finite element idealization of Continuum model is carried out using eight nodded solid elements having three degrees of freedom of translation in the relevant co-ordinate direction at each node. To fix the region of soil below and around the foundation which influence the soil behavior, it is necessary to consider pressure Isobars. Isobars are considered based on Boussinesq equation (Bowles 1988). During analysis, bottom boundary is fixed while lateral translation is arrested at vertical boundaries of the soil medium.

2. METHODOLOGY

In the present study, nonlinear analysis is performed on vertically irregular bare frame with fixed base and flexible soil base. Various parameters are considered for modeling bare frame along with soil parameters for modeling soil base. The building is modeled using software SAAP 2000 V19.2.1. The various parameters applied for model and continuum method is as given in Table 1.1 and Table 1.2

Table 1.1 Building details

Sl.No	Structural Element	Dimension	Unit
1	Building Dimension	25 x25	m
2	Building Height	3	m
3	Number of story	10	No.
4	Number of Bay in “both X and Y directions”	5	No.
5	Soil Dimension for CM	50 x 50	m
6	Depth of soil for CM	20	m
7	Importance factor as per “(IS 1893 Part1 2002)”	1.5	
8	Seismic Zone as per “(IS 1893 Part1 2002) “	V	
9	Zone Factor (Z)	0.36	
10	Response Reduction factor as per” (IS 1893 Part1 2002) “	5	
11	Seismic Intensity	Very severe	

Table1.2 Parameters for 3D soil model in case of Continuum method (CM)

Sl. No.	Type of Soil	“Effective Shear modulus ‘G’ kN/m^2”	“Elastic modulus ‘Es ‘ kN/m^2”	“Poisson’s ratio ‘μ’”
1	Soft soil (Soft Clay)	1182.000	3310.000	0.400

3. RESULT AND DISCUSSION

The results obtained on 3D model with fixed based pushed for monitored displacement of 4.0m is given in Table 1.3. Similarly results obtained for 3D continuum model with 3d soil base pushed for a monitored displacement of 4.0m is given in Table 1.4.

3.1.Pushover capacity values:

The Table 1.3 and Table 1.4 shows values of capacity curve incase of fixed and flexible base which indicates the number of hinge formation at various failure state with displacement and base force.

Table: 1.3 Pushover Capacity Curve – 4.0m fixed base

Step	Displace ‘m’	“Base .Force ‘kN’”	“A B”	“B IO”	“IO LS”	“LS CP”	“CP C”	“C D”	“D E”	“Bey E”	Total
0	0.000	0	1686	30	0	0	0	0	0	0	1716
31	0.187	9483	1196	398	122	0	0	0	0	0	1716
32	0.194	9650	1190	380	134	12	0	0	0	0	1716
33	0.200	9792	1188	344	166	14	0	4	0	0	1716
62	0.372	12764	1056	342	258	0	0	54	6	0	1716
78	0.417	12872	1024	336	246	4	0	76	30	0	1716

Table 1.4 Pushover Capacity curve –Continuum method

Step	Displace ‘m’	“Base .Force ‘kN’”	“A B”	“B IO”	“IO LS”	“LS CP”	“CP C”	“C D”	“D E”	“Bey E”	Total
0	0.001	0	1716	0	0	0	0	0	0	0	1716
3	0.012	1533	1713	3	0	0	0	0	0	0	1716

23	0.135	8032	1314	398	4	0	0	0	0	0	1716
53	0.322	14034	1100	356	258	2	0	0	0	0	1716
56	0.339	14536	1082	368	262	2	0	2	0	0	1716
65	0.399	16040	1018	375	247	0	0	76	0	0	1716

As observed in Table 1.3 and Table 1.4, continuum method shows lesser displacement of 0.135m with less number of hinge formation (4 numbers) in IO-LS state. This shows that continuum method shows better results compared to conventional fixed base. This may be due to flexible soil base provided in continuum method.

3.2. ATC40 - Demand Capacity spectrum

In case of fixed base Fig.1.1 shows Demand Capacity curve with Performance point. The Table 1.5 shows Demand Capacity values for a monitored displacement of 4.0m.

Table :1.5 Pushover Curve Demand Capacity - ATC40

Step	Teff ‘Sec’	β	Sd Capacity ‘m’	Sa Capacity	Sd Demand ‘m’	Sa Demand
0	1.227	0.050	0.000	0.000	0.019	0.050
1	1.227	0.050	0.004	0.010	0.019	0.050
2	1.227	0.050	0.007	0.020	0.019	0.050
3	1.233	0.052	0.011	0.030	0.019	0.050
4	1.264	0.059	0.015	0.038	0.019	0.047
5	1.311	0.068	0.020	0.046	0.019	0.044
6	1.347	0.072	0.024	0.054	0.019	0.042
75	2.814	0.154	0.328	0.167	0.031	0.016
77	2.847	0.157	0.334	0.166	0.031	0.016
78	2.863	0.160	0.336	0.165	0.031	0.015

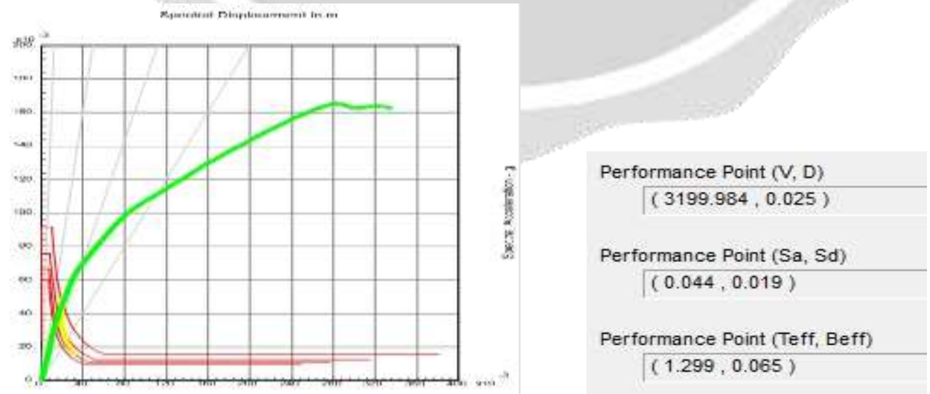

Fig. 1.1 Demand Capacity curve with Performance point incase of Fixed base

Table 1.6 Pushover Demand Capacity - ATC40 –Continuum method

"Step"	"Teff 'sec'"	"βeff"	"Sd Capacity 'm'"	"Sa Capacity"	"Sd Demand 'm'"	"Sa Demand"
0	1.3010	0.0500	0.0000	0.0000	0.0200	0.0470
3	1.3010	0.0500	0.0080	0.0200	0.0200	0.0470
4	1.3160	0.0530	0.0130	0.0300	0.0200	0.0460
5	1.3690	0.0650	0.0170	0.0360	0.0200	0.0420
6	1.4380	0.0780	0.0210	0.0410	0.0200	0.0380
16	1.9110	0.1050	0.0740	0.0810	0.0240	0.0260
17	1.9410	0.1040	0.0800	0.0850	0.0240	0.0260
19	1.9860	0.1030	0.0900	0.0920	0.0250	0.0250
57	2.3820	0.0920	0.2760	0.1960	0.0310	0.0220
65	2.4500	0.0950	0.3170	0.2130	0.0320	0.0210

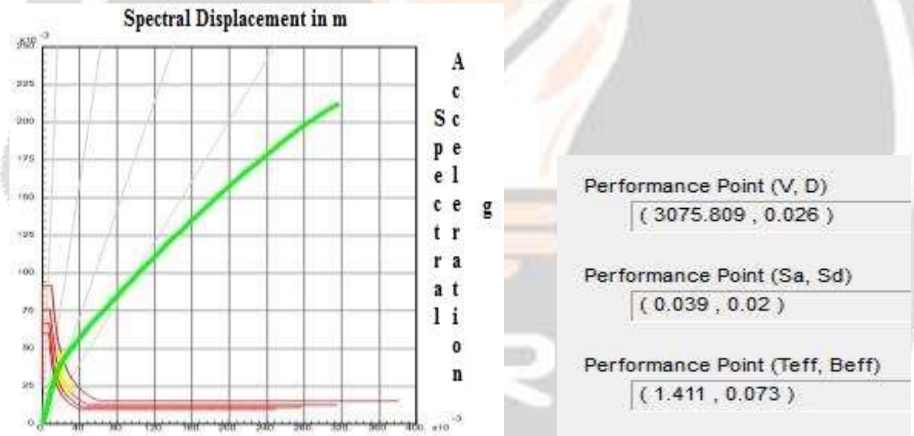

Fig. 1.2 Demand Capacity curve with Performance point in case of Continuum method The graph shown in Fig.1.1 and Table 1.5 indicates performance point for the values of Spectral Acceleration demand (Sa-0.044), Spectral Displacement demand (Sd-0.019), Effective Time Period (Teff –1.299sec) and Effective Damping(Beff-0.065) for fixed base. Similarly, Table1.6 and Fig 1.2 shows values in case of flexible base continuum method with Spectral Acceleration demand (Sa-0.039), Spectral Displacement demand (Sd-0.02), Effective Time Period (Teff –1.411sec) and Effective Damping(Beff-0.073). It is observed that the Effective Time period (Teff) and Effective Damping (Beff) increases in continuum method because of flexible soil base whereas, the spectral acceleration demand is less in continuum method.

3.3 Deformed shape of building:

Fig.1.3 and Fig.1.4 shows deformed shape of the building at IO-LS state in case of Fixed base and flexible continuum model. The hinges are formed at base incase of fixed base indicated by yellow colour whereas in case of continuum model the hinges are seen in beam. The results shows that less number of hinges are formed in continuum method at IO-LS state compared to fixed base at IO-LS state.

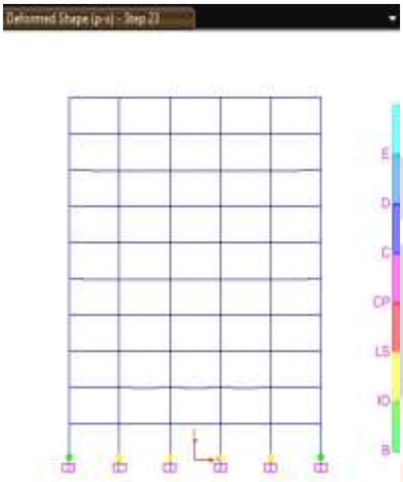

Fig. 1.3 Step 23 (IO-LS) Fixed base

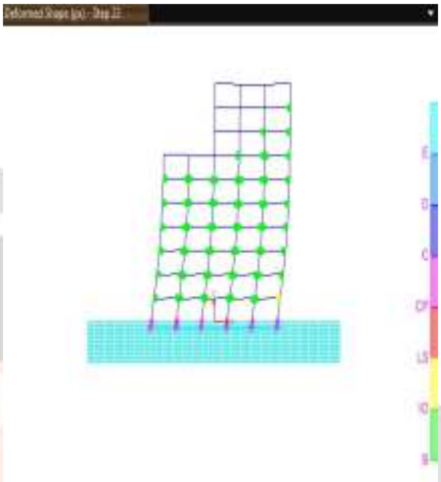

Fig.1.4 Step 23 (IO-LS) Continuum

4. CONCLUSION

1. The results indicate lesser displacement with less number of hinges formed in continuum method compared to conventional fixed base.
2. Lesser displacement with greater time period occurs in case of continuum method. This may be due to flexible soil base with soil properties incorporated.
3. Observing the deformed shape of the building, at IO-LS state the hinges are formed in beams in case of continuum method whereas in case of fixed base hinges are formed at support. This indicates continuum method reaches failure state slowly with less hinge formation compared to fixed base.
4. The study indicates the importance of performing pushover analysis with flexible soil base(continuum model).

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