PERFORMANCE BASED SEISMIC ANALYSIS OF RC BUILDING USING SOFT STOREY CONSIDERATION

ANIL KUMAR M S [1], KRISHNA MURTHY G R [2], SYED AHAMED [3]

[1] Post Graduate Student, Civil Engg Dept, Sambhram Institute of Technology, Bengaluru, Karnataka, India.
[2] Professor, Civil Engg Dept, Sambhram Institute of Technology, Bengaluru, Karnataka, India.
[3]Assistant Professor, Civil Engg Dept, Ghousia college of Engineering, Ramanagara, Karnataka, India.

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Abstract – *Soft storey is the one of which the rigidity is lower than any further storeys due to the fact that it has not got the wall with the identical properties the other ones have. If vertical load bearing structural elements and the partitioning wall prolong in all the storeys, there is no soft storey in the construction. Soft storey in a building causes stiffness irregularity in a structure. Due to this the structures undergoes unequal storey drift, formation of plastic hinges and finally collapse. In this regard, this paper talks about the provided strength and stiffness to the building frame by modified soft storey provision in two ways, (i) By providing bracing as lateral load resisting system & (ii) By considering building model inclined to horizontal plane. Also study has been carried out to compare storey shear, storey drift and obtaining pushover curve for considered building models by using linear and nonlinear analysis.*

Key Words: *Softstorey, storey shear, storey drift, bracing, nonlinear analysis.*

1. INTRODUCTION

The term earthquake can be used to designate any kind of seismic event which may be either natural or introduced by humans, which generates seismic waves. Earthquakes are caused commonly by rupture of geological faults; but they can also be generated by other events like volcanic activity, mine blasts, landslides and nuclear tests. The sudden release of energy in the Earth's crust which produces seismic waves results in what is called an earthquake, which is also known as a tremor, a quake or a temblor. The frequency, type and amount of earthquakes practiced over a period of time defines the seismicity (seismic activity) of that area. The remarks from a seismometer are used to measure earthquake.

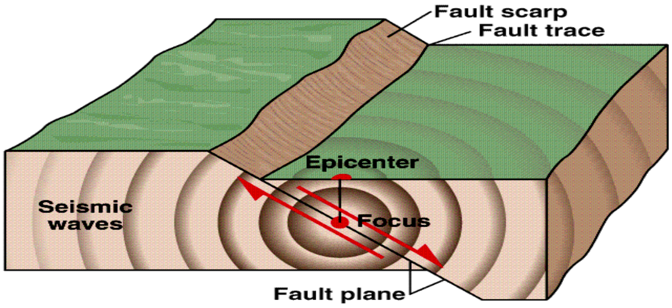

Fig.1: Influx of seismic waves

Due to increasing population since the past few years car parking space for residential apartments in populated cities is a matter of major concern. Hence the trend has been to utilize the ground storey of the building itself for parking. These types of buildings having no infill masonry walls in ground storey, but infilled in all upper storeys, are called Open Ground Storey buildings. They are also known as 'open first storey building' or 'stilted buildings'. There is significant advantage of these category of buildings functionally but from a seismic performance point of view such buildings are considered to have increased vulnerability.

From the past earthquakes it was evident that the major type of failure that occurred in Open Ground Storey (OGS) buildings included snapping of lateral ties, crushing of core concrete, buckling of longitudinal reinforcement bars etc. Due to the presence of infill walls in the entire upper storey except for the ground storey makes the upper storeys much stiffer than the open ground storey. Thus, the upper storeys move almost together as a single block and most of the horizontal displacement of the building occurs in the soft ground storey itself.

Major indemnities caused by earthquake on RC buildings are

- Poor class of construction materials and corrosion of reinforcement
- Plan and mass irregularity
- Disaster of Soft storey
- Pounding of buildings
- Uneven seismic performance of buildings

Fig.2: Example of Soft storey

2. OBJECTIVES

The dissertation work is focused on the following objectives

i. To examine the seismic performance of building using linear static and nonlinear static analysis using ETABS-13
ii. To examine the influence of soft storey for the considered building models
iii. To get base shear verses displacement curve / pushover curve using nonlinear static analysis using ETABS-13
iv. To locate the overall capacity of building models considered using nonlinear pushover analysis by ETABS-13
v. To accomplish various linear and nonlinear static results such as base shear, storey drift for the building models considered using ETABS-13
vi. To compare the various accomplished results obtained from both linear and nonlinear static analysis using ETABS-13

2.1 Analytical procedures

The analysis can be performed on the basis of external action, the behaviour of structure and the type of structural model selected. Based on the type of external action and behaviour of structure, the analysis can be further classified as:

a. Equivalent Static Analysis: On a building if series of forces are acting to represent the damage caused by the ground motion of earthquake, usually it is defined as seismic design response spectrum. It is assumed that there is response between building and the fundamental mode. From the response spectrum the response of the building can be known by the given natural frequency of the structure.

b. Response Spectrum Method: Linear Dynamic Analysis method is also termed as Response spectrum. During earthquake the building peak responses are achieved exactly from the earthquake design spectrum. The embodiment of the maximal responses of admirable SDOF has lesser amount of period & damping. The maximal response graph is plotted for various data of damping against natural period.

c. Time History Method: This type of approach is bit accurate when the earthquake is occurred, the building response will be determined for every second of the ground motion. To come across such an analysis a representative earthquake time history is required for a structure being evaluated. Seismic response of a structure under dynamic loading is required to representative earthquake.

d. Non-Linear Static (or) Pushover Analysis: The pushover analysis is a nonlinear static method which is used in a performance based analysis. The method is relatively simple to be implemented, and provides information on strength, deformation and ductility of the structure and distribution of demands which help in identifying the critical members likely to reach limit states during the earthquake and hence proper attention can be given while designing and detailing. This method assumes a set of incremental lateral load over the height of the structure. Local nonlinear effects are modelled and the structure is pushed until a collapse mechanism is developed. With the increase in the magnitude of loads, weak links and failure modes of the buildings are found.

2.2 Model description

Various models considered for the study are as follows and are shown in Fig.3 and Fig.4

i) MODEL I - Building model with open first storey with bracing as the lateral load resisting system.

ii) MODEL II - Building model with open first storey at 45 degrees inclination to horizontal plane.

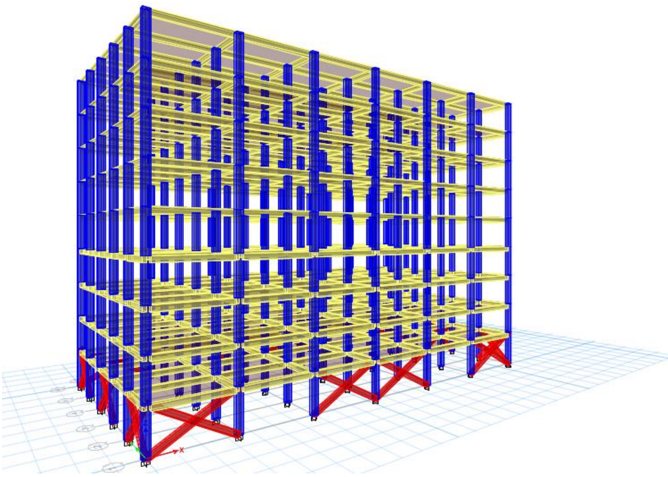

Fig.3: 3D view of building model with bracings as the lateral load resisting system.

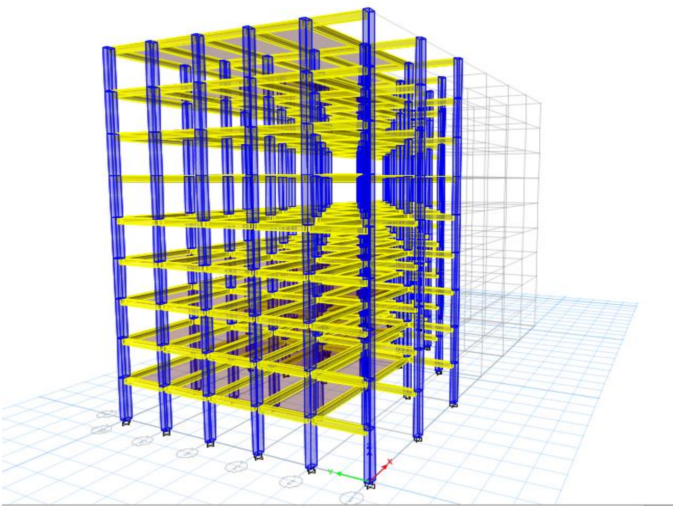

Fig.4: 3D view of building model with 45 degrees inclination to horizontal plane.

3.RESULTS AND DISCUSSIONS

Table.1: Building model data	
General details of building	
Number of storeys	9 Storeys
Ground storey height	3.85m
Storey height	3.5m
Seismic properties as per IS 1893-2002 (part-1)	
Building frame system	SMRF
Seismic zone	Zone-III
Zone Factor (Z)	Z = 0.24
Response reduction factor (R)	R = 5
Importance factor (I)	I = 1
Soil type	Type-II (Medium soil)
Material properties	
Grade of concrete	M25
Grade of steel	Fe500
Density of concrete	25kN/m^2
Density of brick masonry	20kN/m^3
Structural member Details	
Size of columns	400mmx600mm
Size of beams	300mmx500mm
Thickness of slab	150mm
Imposed load	3.2kN/m^2 on floors
	2.85kN/m^2 on roof

3.1 Storey shear:

Storey Shear in kN for G+8 storey model for both Linear and Non-linear analysis in longitudinal X Direction as shown in Table2 and Fig.5, where in Fig.5 shows the graph of storey shear.

Table.2: Storey Shear in kN for G+8 storey model for both Linear and Non-linear analysis in longitudinal X Direction

NO.OF STOREYS	MODEL I		MODEL II	
	EQ X	PUSH X	EQ X	PUSH X
STOREY9	634.48	918.30	296.75	530.92
STOREY8	1185.44	1715.73	561.13	1003.91
STOREY7	1608.76	2328.41	764.26	1367.32
STOREY6	1921.23	2780.66	914.20	1635.58
STOREY5	2139.65	3096.79	1019.01	1823.09
STOREY4	2280.81	3301.10	1086.75	1944.27
STOREY3	2361.51	3417.90	1125.47	2013.56
STOREY2	2398.54	3471.5	1143.24	2045.35
STOREY1	2409.32	3487.10	1148.16	2054.15

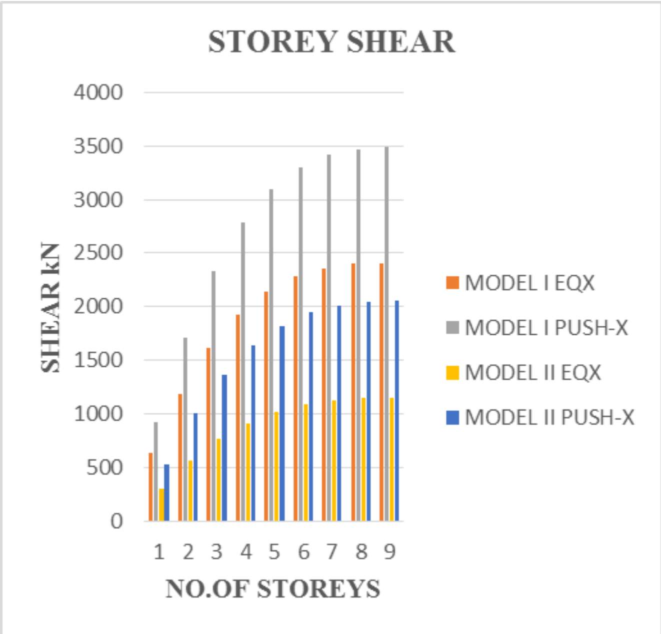

Fig.5: Storey shear for both linear and non-linear analysis

3.2 Storey drift: Storey Drift for G+8 storey model for both Linear and Non-linear analysis in longitudinal X Direction as shown in Table3 and Fig.6, where in Fig.6 shows the graph of storey drift.

Table.3: Storey Drift for G+8 storey model for both Linear and Non-linear analysis in longitudinal X Direction

NO.OF STOREYS	MODEL I		MODEL II	
	EQX	PUSHX	EQX	PUSHX
STOREY9	0.5389	0.7837	0.6789	1.2240
STOREY8	0.8836	1.2948	0.8308	1.5123
STOREY7	1.1891	1.7926	1.0411	1.9339
STOREY6	1.4227	2.3613	1.2453	2.3847
STOREY5	1.5844	2.9447	1.4088	2.7868
STOREY4	1.6718	3.2578	1.5067	3.0427
STOREY3	1.6399	3.0652	1.4899	3.0100
STOREY2	1.2423	2.1016	1.2803	2.5316
STOREY1	0.1508	0.2266	0.7744	1.444

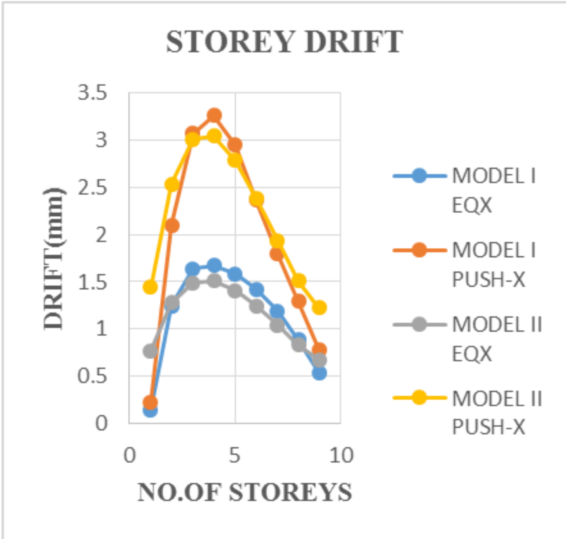

Fig.6: Storey drift for both linear and non-linear analysis

3.3 Non-linear Base shear verses Displacement curve (PO-Curves): Table4, Fig7 and Table5, Fig8 shows the PO-Curve results and curves for Model1and Model2.

Table.4: Pushover Curve results for Model I

STEP	BASE FORCE	DISPLACEMENT
0	0	0
1	415.9204	6248
2	831.8408	12496
3	1247.761	18744
4	1663.682	24992
5	2079.602	31240
6	2495.523	37488
7	2636.41	39604.4
8	3042.713	46075.4
9	3328.763	55537.4
10	3487.103	62480

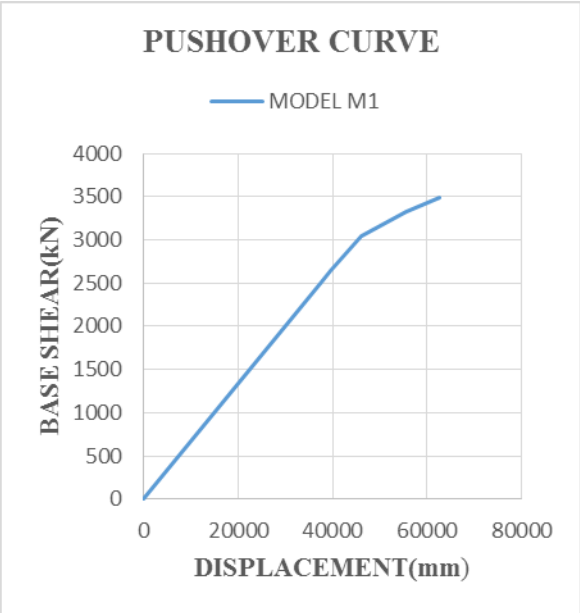

Fig.7: PO Curve for Model I

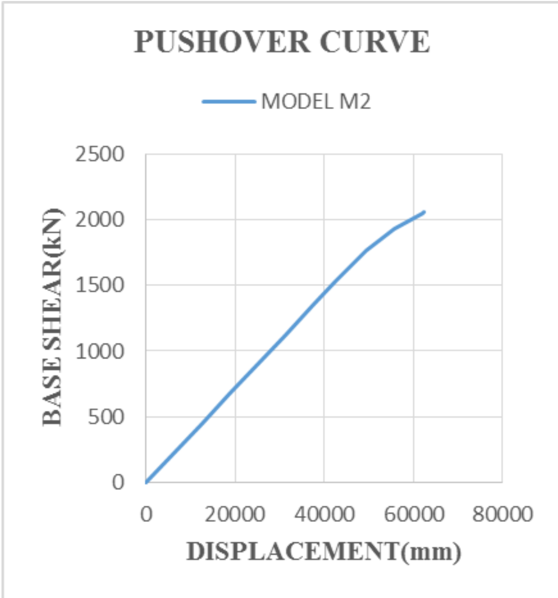

Fig.8: PO Curve for Model II

Table.5: Pushover Curve results for Model II

STEP	BASE FORCE	DISPLACEMENT
0	0	0
1	224.3721	6248
2	448.7442	12496
3	673.1163	18744
4	897.4883	24992
5	1121.86	31240
6	1346.233	37488
7	1529.007	42577.7
8	1765.932	49298.1
9	1934.634	55701.8
10	2046.968	62024.9
11	2054.155	62480

4.CONCLUSION

- The Storey shear obtained from non-linear analysis seems to be about 30.7%greater than storey shear obtained by linear equivalent static analysis. Also storey shear depends on the mass of the building model considered.
- Storey shear and storey drift values are also extracted, tabulated and graphed for both linear and nonlinear static analysis for the models load combinations considered.
- Amongst all the models considered, Model M2 i.e. Model with inclination w.r.t.horizontal plane is seemed to be vulnerable and Model M1 i.e. Model with soft storey having lateral load resisting system is less vulnerable.
- The storey shear obtained are calculated in table2 in longitudinal X direction and graph is obtained by plotting number of storeys in X-axis and shear in Y-axis. Which shows that as storey increases, storey shear decreases.
- Pushover curve is obtained by plotting displacement along X-axis and base shear along Y- axis which gives the nonlinear behaviour of the models considered.

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