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Inelastic Seismic Analysis on High-Rise Building

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Abstract:- **To know the inelastic seismic behavior, the pushover analysis to eccentric multistoried buildings a procedure is to be developed. The procedure conducts the elastic spectrum analysis of the building to obtain the target displacements and load distributions for pushover analysis. The two-dimensional inelastic static analysis is conducted on the lateral load resisting element. To investigate the efficiency of this model, three different types of eccentric buildings are studied. The first model is a ductile moment resisting frame building. The second model is a set-back building. These building are subjected to gradual increase of lateral load and ground motion excitations at the base are calculated. This means maximum responses of these buildings are computed using 3-D inelastic dynamic analysis and the proposed procedure. A Comparison of the set of results finds to determine the capabilities and advantages of the procedure adopted**

Keywords: **Base shear, maximum response, Pushover analysis, Target displacement.**

I. INTRODUCTION

Pushover analysis, is a practical way of calculation the displacements and damage pattern of a structure, is getting increasingly more attention. The procedure consists of two parts. First, need to find target displacement of building established. The target displacement is an estimation of the top displacement of the building when exposed to earthquake excitations. Then the pushover analysis is carried out on the building until the top displacement of the building equals to the target displacement. The present paper investigates the efficiency of the response-spectrum-based pushover method for three different types of eccentric buildings. They are ductile moment resisting frame, set-back building and wall frame structures.

II. PROCEDURE

The procedure consists of 2 parts. First, the target displacements are determined by performance an elastic spectrum analysis on the building. The top displacement of the resisting elements is a symmetrical building. Therefore, many target displacements need to be determined. The accuracy of a push-over analysis depends on distribution of lateral loads. Once the target displacements and the corresponding lateral load distributions are found, a series of pushover analysis can be carried out for specific elements. Only inelastic modeling of these elements is needed. Each element is loaded with a set of static loads with same distribution as the elastic force distribution on the element is loaded with a set of static loaded. The element is pushed until its top displacements yields its large target displacements.

III. EXAMPLE BUILDINGS

To explain the application and accurateness of the proposed procedure, the seismic responses of ten story buildings subjected to a collective of ten reproduction ground motion records as input are calculated. The plans of the buildings are similar (Figure 1.a). The first building is a reinforced concrete yielding moment resisting frame building. The building has a rectangular plan measuring 26m X 19m and storey height of 3m. The ground motions are expected to come from the Y-direction and the lateral loads resisting elements in that direction consists of three identical ductile moment resisting frames (Figure 1.b). Frame B is an internal frame and frames A and C are located at the edges of the buildings as shown.

The second building is similar in all aspects to the first building the only difference is that three regular frames (Figure 2.b) are replaced by three set-back frames (Figure 2.a)

For each building, the accuracy of the pushover results is established by comparing the results obtained using an inelastic by dynamic analysis on the building, treating it as a multi-degree of freedom (MDOF) system.

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Table.1 Description of Structure

Type of the Structure	Multi-story R.C Structures
Occupancy	Residential Building
Number of stories	G+9
Total height of building	30m
Dimension of building	26m X 19m
Columns size	0.30m X 0.60m
Beam size	0.23m X 0.45m
Thickness of slab	0.150m
Grade of concrete	25Mpa
Grade of steel	Fe 415 Mqpa
Density of concrete	25 KN/m3
Earthquake Factor (Z)	0.16(III)[IS 1893-2002]-P-II
Importance Factor (I)	1.0 Table 6
Response Reduction factor	3.0 (OMRF) Table 7
Soil	Type III (Soft soil)
Live Load	3.5 KN/m2
Fundamental Natural period	0.961(T)
Average Spectral Acc…	1.737 (Sa/g)

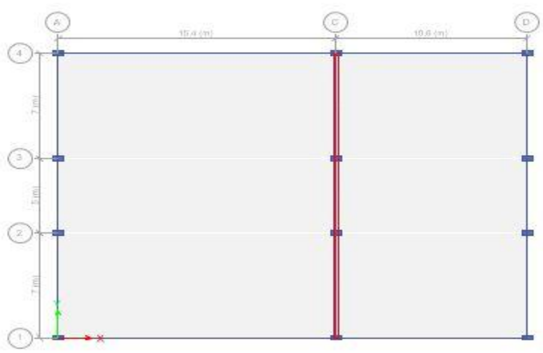

Fig. 1(a) Original Frame

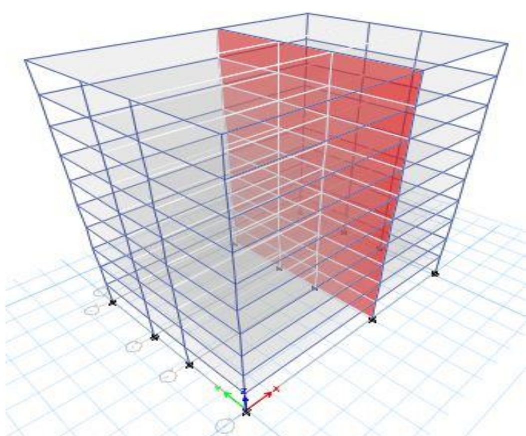

Fig. 1(b) Original 3-D Frame

Fig. 2(a) Plan Set-Back Frame

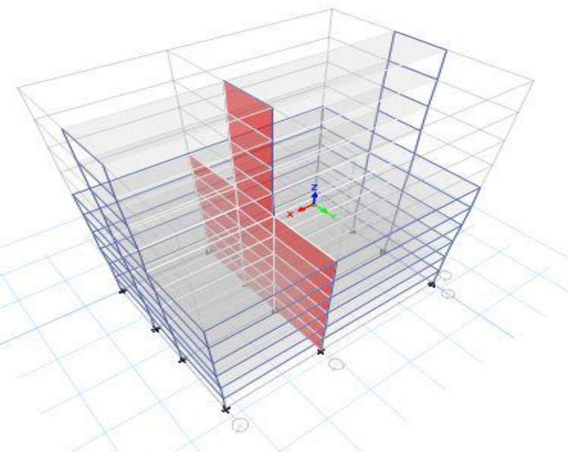

Fig. 2(b) 3-D set -back Frame

Calculations Of Equivalent Static Analysis

Area = A= (26 X 19) = **494 m2**

Columns (C1) = **12 No's**

Beams (B1) = **13 No's**

Dead load of slab = (0.15 X 25)

= **3.75 KN/m2**

Total Dead load of slab = (3.75 X 494)

=**1825.5KN**

DL of beam on Transverse direction

= (0.23X0.45X15.4X2X25)

=**79.695KN**

DL of beam on Transverse direction

= (0.23X0.45X10.6X2X25)

= **54.855KN**

DL of beam on longitudinal direction

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=0.23X0.45X7X6X25
= **108.675KN**

DL of beam on longitudinal direction
= (0.23X0.45X3X5X25)
= **38.812KN**

DL of wall (interior wall) =19X3X0.25X20=285KN

DL of Columns = (0.3X0.6X3X13X25)
= **175.5KN**

Total DL = (DL of slab+ DL of beam+ Wall+ Column)
= (1852.5+282.037+285+175.5)
= **2595.037KN**

Total DL on Roof = DL of slab + DL of Beam + $\left[\frac{\text{DL of wall}}{2} + \frac{\text{DL of Column}}{2}\right]$

= (1852.5+282.037) + $\left[\frac{285}{2} + \frac{175.5}{2}\right]$

= **2367.787KN**

Live Load = **3.0 KN/m2**

Total LL = (3X494)
= **1482KN**

Seismic weight on each floor = (Total DL) + (0.25XLL)
= (2595.037) + (0.25X1482)
= **2965.537KN**

Total Seismic weight (**W**) = (2965.537X9+2367.787)
W = 29057.62KN

Base shear (Vb) = (Ah x W)

Ah = [(Z/2x I/R x Sa/g) X Damping factor]

We know

Z=0.16, Soil Type = soft (III) type, Importance Factor (I) = 1, Response factor(R) = 3

Fundamental Natural Period with wall is given by

TN = [0.075 $h^{0.75}$]
= [0.075$(30)^{0.75}$]

TN = 0.961

Spectral Acceleration Sa/g = 1.67/T
= 1.67/0.961
= 1.737

Ah= $\left[\frac{0.16}{2}\right]$ x $\left[\frac{1}{3}\right]$ x (1.737)

Ah = 0.046

Base Shear (Vb) =1336.65KN

IV. RESULTS AND DISCUSSIONS

Table.2 (a) Maximum Story Displacement Original Frame

Story	Elevation	Location	X-Dir
	m		mm
Story10	30	Top	626
Story9	27	Top	589.8
Story8	24	Top	542.3
Story7	21	Top	482.7
Story6	18	Top	412.5
Story5	15	Top	334.2
Story4	12	Top	251.3
Story3	9	Top	167.8
Story2	6	Top	90
Story1	3	Top	27.8
Base	0	Top	0

Table.2 (b) Maximum Story Displacement Set-back Frame

Story	Elevation	Location	X-Dir
	m		mm
Story10	30	Top	604.3
Story9	27	Top	546.4
Story8	24	Top	482.4
Story7	21	Top	414.9
Story6	18	Top	349.8
Story5	15	Top	290.3
Story4	12	Top	227.9
Story3	9	Top	162.8
Story2	6	Top	98.6
Story1	3	Top	41.6
Base	0	Top	0

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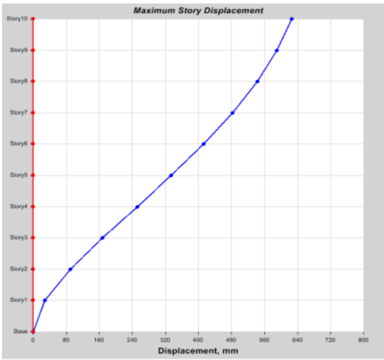

fig.3 (a) Maximum Story Displacement Original Frame

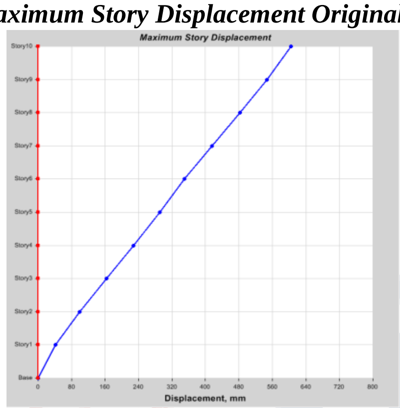

fig.3 (b) Maximum Story Displacement Set-back Frame

After the Equivalent static analysis for base shear Calculation, the pushover analysis is carried on the structure By equivalent lateral load at each floor uniformly. The Maximum story displacement for the normal plan and Set-back Structure is shown in table 2(a) and 2(b) and fig 3(a) Fig (b).

Table.3 (a) Base shear for Normal Structure

Story		VX (KN)
Story10	pushx Max	209.6807
Story9	pushx Max	390.7167
Story8	pushx Max	533.7576
Story7	pushx Max	643.2732
Story6	pushx Max	935.8365
Story5	pushx Max	1146.8688
Story4	pushx Max	1281.9294
Story3	pushx Max	1357.901
Story2	pushx Max	1391.6662
Story1	pushx Max	1400.0887

Table.3 (b) Base shear for Set-back frame

Story		VX (KN)
Story10	Pushx Max	303.4602
Story9	pushx Max	558.7264
Story8	pushx Max	760.4182
Story7	pushx Max	914.8385
Story6	pushx Max	1028.2901
Story5	pushx Max	1107.076
Story4	pushx Max	1157.4989
Story3	pushx Max	1185.8618
Story2	pushx Max	1198.4676
Story1	pushx Max	1201.619

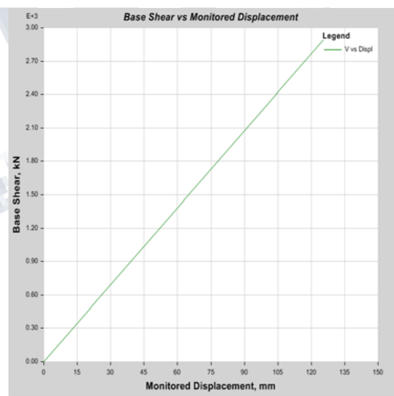

fig.4 (a) Base shear for Normal structure

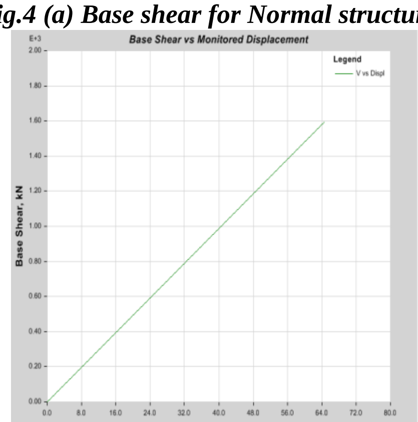

fig.4 (b) Base shear for Normal structure

The Base shear with its Monitored displacement are calculated for Normal structure and Set-back frame structure

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As shown in Table 3(a) and Table 3(b) and in fig 4(a) and 4(b). It is seen that the Base shear for Set-back structure is more as compared to Normal structure with pushover analysis.

V. CONCLUSION

The study conducted on Normal R.C structure considered with respect to Set-back frame, following observations were derived

- The lateral load resisting capacity of the structure on Normal structure is more compare to Set-back frame
- The Maximum Story Displacement is larger enough in Normal structure with compared to Set-back frame structure
- The Maximum Base shear induced in Set-back fame structure is more with compared to Normal Frame structure.
- The Fundamental Natural period reduces as the building stiffness increases, then there is also increase in Base shear
- The buildings we studied, found the plastic hinges are large enough in Set-back frame structure as compared to Normal frame structure.

The use of load distribution resulted from response spectrum analysis in Pushover analysis, improves the result for the frame building and deteriorates the results for the Set-back frame.

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