Comparative Pushover Analysis of High Rise RCC Building Frame with and Without Vertical Irregularities

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Abstract - *The seismic behavior of multi-storied building frame during an earthquake motion depends upon the distribution of strength, mass and stiffness in both horizontal and vertical planes. The structural damage of the building frame is occurs due to the discontinuity in the stiffness mass and strength between the adjacent stories. The common type of discontinuity is vertical geometric irregularity which is due to the irregular building configuration in vertical plane. So there is need to study the seismic response of building frames under different structural irregularities .Pushover analysis is one of the analysis method which is adopted for the present study. This work shows that the comparison seismic performance and behavior of building frame with and without vertical irregularity in terms of parameter base shear, storey displacement, storey drift, , spectral acceleration and spectral displacement. Five types of geometry are taken for present study-one regular building frame and four building frames with variation in percentage of vertical irregularities. All building frames are analyzed by using design and analysis software ETABS and design as per IS 456:2000 and IS 1893:2002.*

Key Words: *pushover analysis, vertical geometric irregularity, story drift, base shear, lateral displacement, spectral acceleration, spectral displacement.*

1. INTRODUCTION

Pushover analysis is method by which the limit state and ultimate strength can be efficiently investigated after yielding which has been applied in practice for the seismic design of the structure. Hence the non linear static analysis is carried out in order to study the behavior of building under earthquake forces.

There are different types of vertical irregularities, the vertical geometric irregularity is considered for present study which is due to the irregular vertical building configuration. Vertical geometric irregularity exist, when the horizontal dimension of lateral force resisting system in any adjacent storey is more than 150% of that in an adjacent storey. For this study vertical geometry is obtained by reducing the number of bays in vertical downward direction. Five building frames are considered, one regular building frame, two building frame with 200% vertical irregularity and remaining two building frames with 300% vertical irregularity. The main objective of present work is to compare seismic behavior of multistory building frame with and without vertical irregularity (height of building) in terms of parameter storey displacement, storey drift and storey shear

The scope of the present work is to study the performance of building frame with vertical irregularity as a measure to reduce the seismic response of structure under seismic loading.

2. PROBLEM DISCRIPTION

For this present study five (one regular and four vertical geometric irregular) RC building frames are selected and it is proposed to analyze all the frame by using design and analysis software ETABS version 9.5.0.The structural design data and seismic data for all the building frame is same.

The RC building frame of G+ 7 floors is considered for obtaining performance point. It consists of 6 bays along both the directions. The typical storey height and ground storey height is same i.e. 3.0 m. The bay width is 4.5m along x-direction and 3m along Y-direction. The frame is situated in zone III.

2.1 Design data:

Type of structure	: RC Moment Resisting Frame
Seismic zone	: III
Zone factor	: 0.16
Number of storey	: G+7
Floor height	: 3m
Base Floor height	: 3m
Slab Thickness	: 150 mm thick
Wall	: 230mm
Live load	: 4.0 kN/m^2
Floor Finish	: 1.0 kN/m^2
Earthquake load	: As per IS-1893:2002
Type of soil	: Type II

2.2 Description of Building Frame:

No. of floors : G+7
Storey height : 3m
No. of Bays : 6 along both direction.
Spacing along X-axis : 4.5 m
Spacing along Y-axis : 3 m
Size of columns:
C_1=520X480mm for ground floor, 1st,2nd and 3rd floor
C_2=340x300mm for 4th ,5th,6th 7th floor
Size of Beams:
B_1=420X380mm for 1st , 2,3rdand 4th floor
B_2=340X320mm for 5th,6th,7th and 8th floor
Materials : Concrete M30, Steel Fe 415

2.3 Percentage of Vertical Irregularity for Different Models

M-I - Regular
M-II - Irregular-300%
M-III - Irregular-200%
M-IV - Irregular-200%
M-V - Irregular-300%

3. MODELING ON ETABS

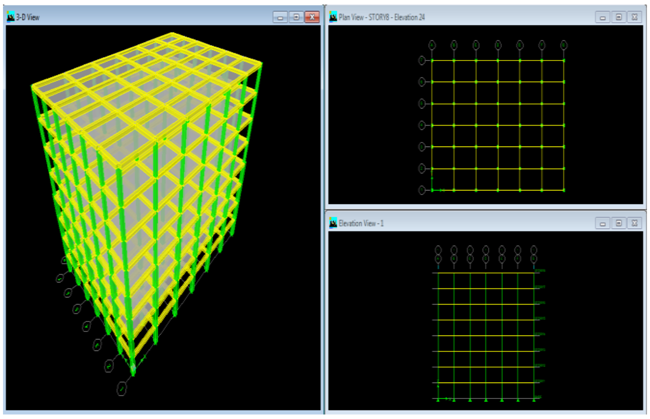

Fig.3.1 Plan elevation 3D view for base model M-I

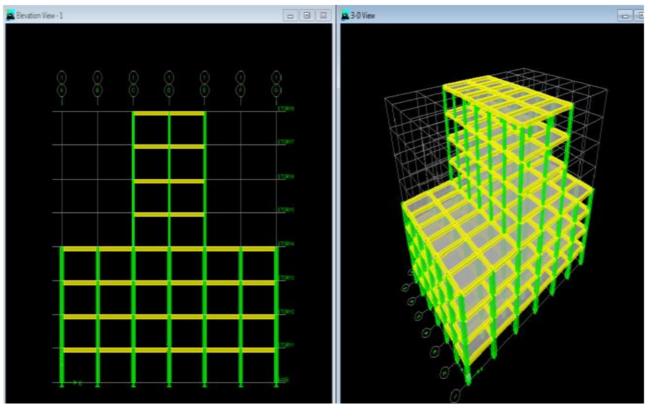

Fig.3.2 Elevation and 3D view of model M-II

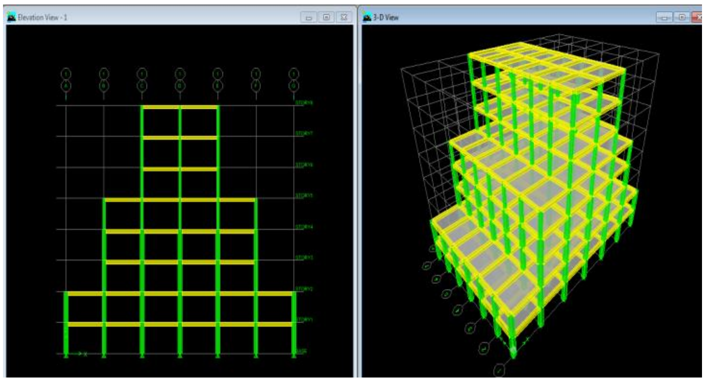

Fig.3.3 Elevation and 3D view of model M-III

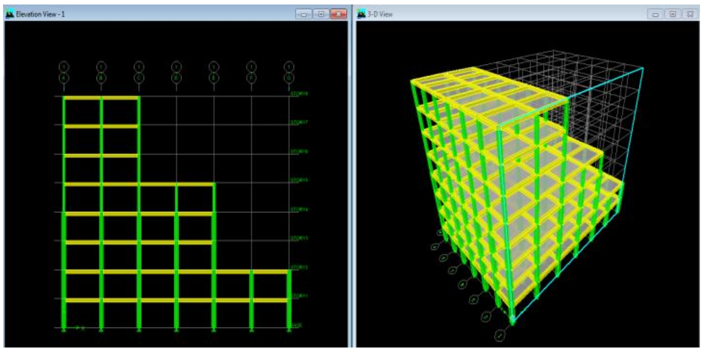

Fig.3.4 Elevation and 3D view of model M-IV

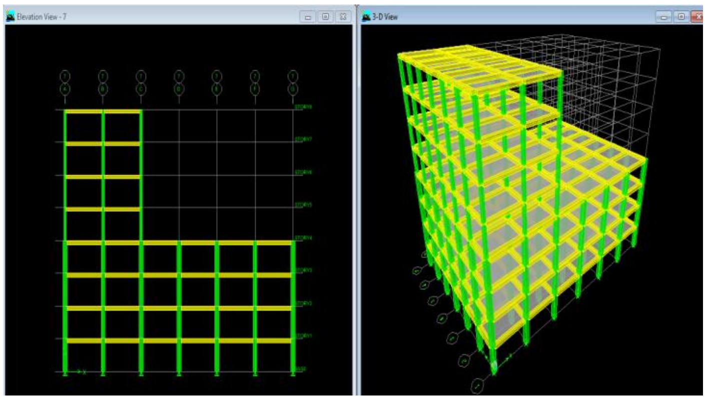

Fig.3.5 Elevation and 3D view of model M-V

4. PUSHOVER ANALYSIS

The pushover curve obtained by the analysis of building frame with and without vertical irregularity by using ETABS version 9.5.0 is as shown below,

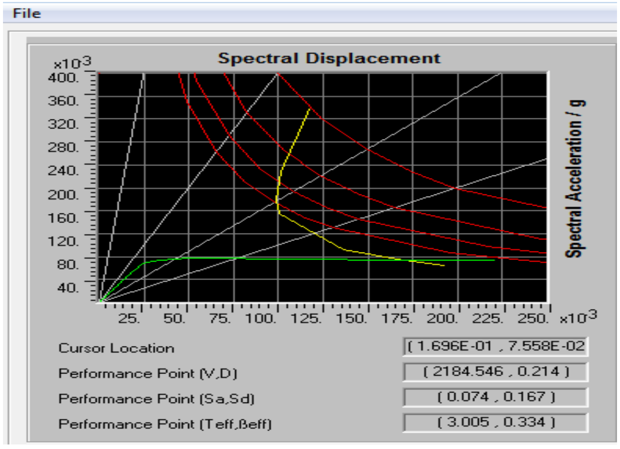

Fig.4.1 Capacity and demand curves of model M-I

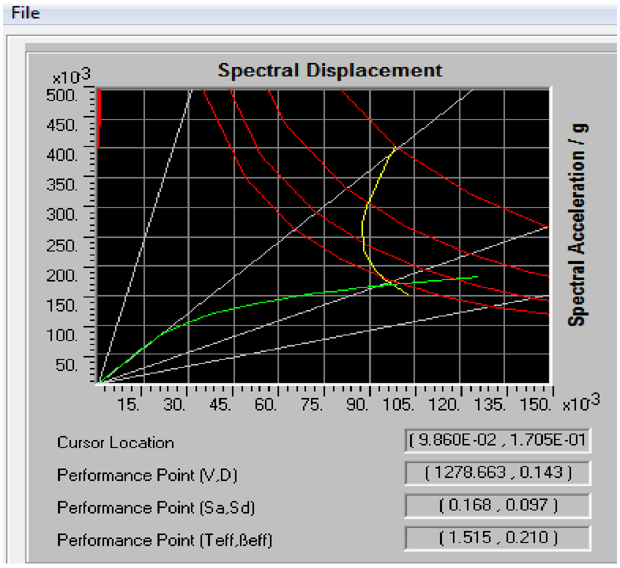

Fig.4.2 Capacity and demand curves of model M-II

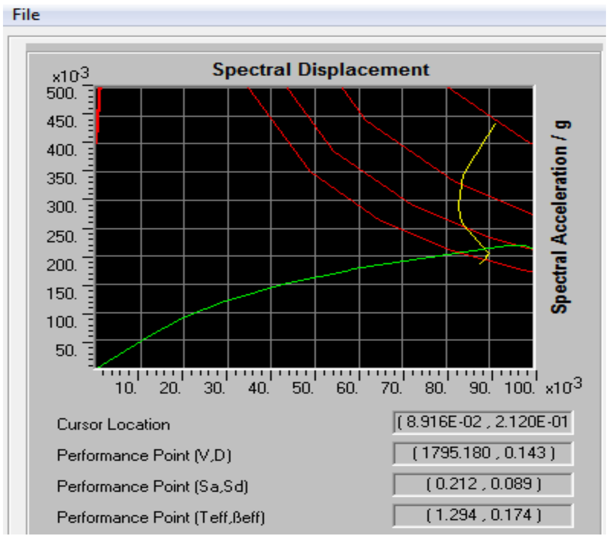

Fig.4.3 Capacity and demand curves of model M-III

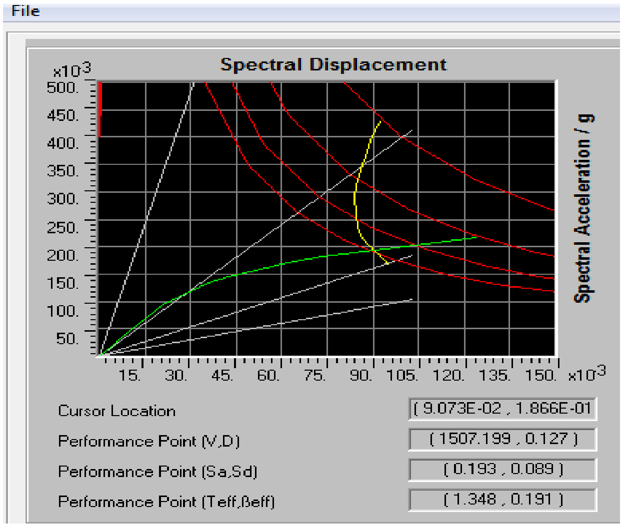

Fig.4.4 Capacity and demand curves of model M-IV

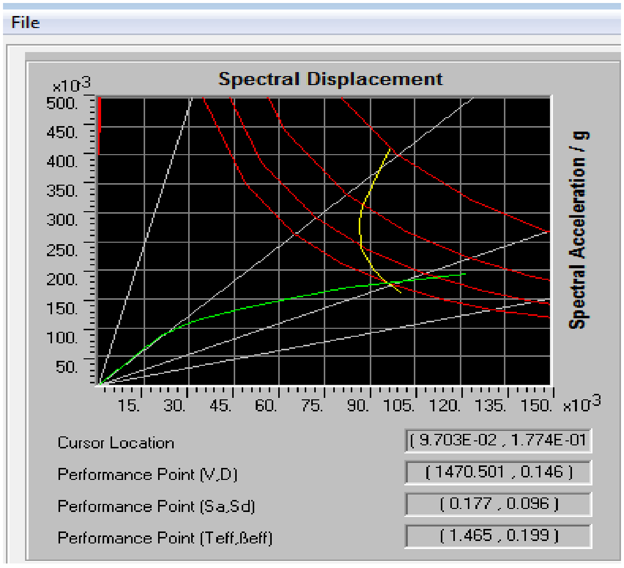

Fig.4.5 Capacity and demand curves of model M-V

5. COMPARISON OF SEISMIC PERFORMANCE IN TERMS OF PARAMETER STOREY DISPLACEMENT, STOREY DRIFT AND STOREY SHEAR

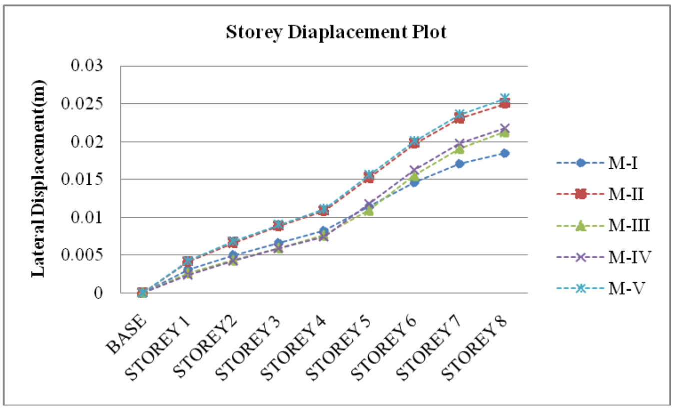

Fig.5.1 Building Performances-Variation in Displacement

In case of building frame without vertical irregularity the maximum storey displacement is 0.0214m and in case of building frame with vertical irregularity the max story displacements are 0.029m, 0.026m, 0.026m, 0.029m for models M-II,M-III,M-IV,M-V respectively. So, it is observed that the provision of vertical irregularity increases storey displacement about 27%, 17%, 17%, 27% for models M-II, M-III, M-IV, M-V respectively.

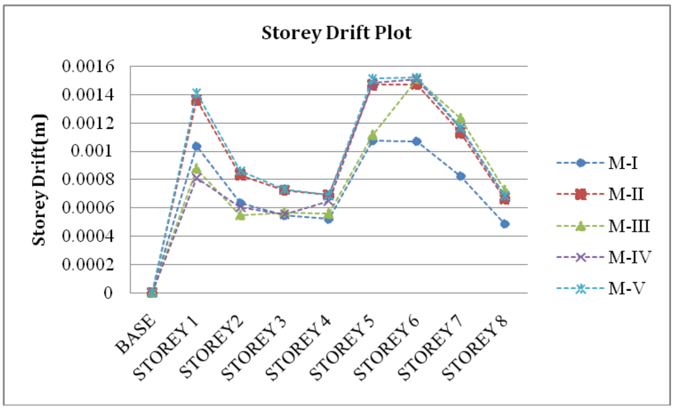

Fig.5.2 Building Performances-Variation in Storey Drift

Due to the discontinuity in stiffness, strength and mass, there is increase in storey drift for irregular structure.

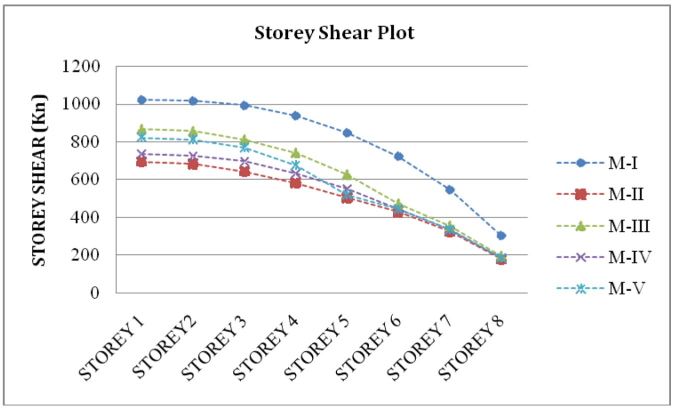

Fig.5.3 Building Performances-Variation in Storey Shear

After comparing the building performance, it is seen that there is decrease in storey shear for irregular structure as compared to the regular structure.

6. PUSHOVER RESULTS

Table.6.1 Comparison of overall seismic performances for building frame with and without vertical irregularity

MODEL / PARAMETER	M-I	M-II	M-III	M-IV	M-V
Base shear at performance point (kN)	2184.5	1278.6	1795.1	1507.	1470.5
Displacement at performance point (m)	0.214	0.143	0.143	0.127	0.146
Story displacement (m)	0.0214	0.029	0.026	0.0257	0.0294
Story Drift (m)	0.0010	0.0014	0.0015	0.001	0.0015
spectral acceleration (m/s2)	0.074	0.168	0.212	0.193	0.177
Spectral Displacement (m)	0.167	0.097	0.089	0.089	0.096

7.CONCLUSIONS

The main observations and conclusions drawn are summarized below.

1. The base shear at performance point in case of building frame with vertical irregularity is reduces as compared to the building frame without vertical irregularity. Hence it is optimum for model M-II and M-V having 300% vertical irregularity.(table 6.1)
2. The displacement at performance point reduces as the percentage of vertical irregularity increases.(table 6.1)
3. The building frame with vertical irregularity undergoes maximum storey displacement as compared to the building frame without vertical irregularity. The maximum storey displacement is occurred for building frame having 300% vertical irregularity that is for model M-II and M-V. (fig 5.1 and table 6.1)
4. Due to provision of vertical irregularity there is increase in storey drift and it is optimum for model M-V (fig 5.2 and table 6.1)

5. The spectral acceleration value for building frame with vertical irregularity is more as compared to building frame without vertical irregularity. (table 6.1)
6. The building frame with vertical irregularity shows the less value for spectral displacement as compared to the building frame without vertical irregularity.(table 6.1)
7. It is seen that, when the percentage of vertical irregularity increases, seismic performance of the building decreases.
8. From the above observations, it is concluded that the building frame without vertical irregularity has more lateral load carrying capacity as compared to the building frame with vertical irregularity.

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