Comparative Pushover Analysis of G+10 RC Frame in Seismic Zones of India

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Abstract: ***Non-linear analysis is necessary to evaluate the seismic demand of the proposed or existing structure, as linear analysis is inadequate in assessing the seismic demand under severe earthquakes. In this article non-linear static analysis (pushover analysis) has been done to understand the behaviour of G+10 multi-storeyed residential building located in different seismic zones (II, III, IV, V) of India having similar geometrical properties using SAP2000. The behaviour of multi-storeyed building has been investigated in terms of force-displacement relationships, inelastic behaviour of structure and sequential hinge formations etc. Plastic hinge formation gives real behaviour of the structure. From the analysis results, it was observed that, when the zone varies from II to V, base shear, displacement and time period has been increased gradually, indicating the severity of seismic activity. In this analysis, firstly hinges were formed in beams and then in columns at ground floor of structure. The hinge formation propagates from ground floor to middle floor columns and then finally to the upper floor columns. The propagation of hinges from lower stories to upper stories leads to collapse of structure. Results indicate that, the damage in a building is limited and columns at the lower stories can be retrofitted based on the importance of the structure.***

Keywords: Performance Point ,Hinge Formations, Structural Displacements, Base Shear

1. Introduction

Since there are a number of earth quakes were faced in the society, there is a very much need of this subject to emerge. Many government and some private building owners today require that new buildings be designed to resist the effects of Earthquakes and other incidents that could cause tremendous local damage.

In this discussion it may be possible to design buildings to resist such attacks without severe damage, the loading effects associated with these hazards and so intense that design measures necessary to provide such performance would result in both unacceptably high costs as well as impose unacceptable limitations on architectural design of such buildings.

Fortunately, the probability that any single building will actually be subjected to such hazards is quite low. As a result, a performance based approach to design has evolved. The most regular performance goals are to permit severe and even tremendous damage effect a structure, but avoid huge loss of life often, design to resist earthquakes, impact and other unusual loads must be thought of in the content of life safety, not in terms of serviceability or lifecycle performance. The serviceability and reuse may be required for test facilities, but most commercial office and industrial facilities will not have to perform to these levels.

Structures designed to resist the effects of earthquakes are permitted to contribute all of their resistance, both material linear (elastic) and material non-linear (inelastic), to absorb damage locally, so as not to compromise the integrity of entire structure. It is likely that local failure can and may be designed to occur, due to uncertainty associated with such Seismic-loads.

2. Plan and Configurations

A G+10 reinforced concrete building is modelled, analysed and studied. The examine is completed in all of the seismic zones of India and conclusions are drawn. The input statistics required for the layout of G+10 building are supplied within the tables below. Table 1 show the building details which includes plan length, overall top of the constructing, ground peak and place details which include region, soil type and so on. The elements together with significance element, reaction discount aspect values are taken from IS 1893 (element 1): 2002. Table 2 indicates the material properties and segment houses. Table 3 suggests the loading information at the building for designing.

Table 1: General building and Location details

Plan size	20m × 20m
Building height	34m
Type of structure	Multi storey RC frame (G+10)
Zone	All Seismic Zones of India (i.e., Zone II,III,IV,V)
Soil type	Type II (medium soil)
Damping	5%
Storey height	Ground floor 4m, remaining floors 3m.
Bays in x and y directions	4m

Table 2: Details of materials and Section properties

Beam	300mm×600mm
Column	600mm×600mm
Slab	125mm
Concrete	f_{ck}= 25 MPa, Density = 25 kN/m^3
Steel	f_y= 500 MPa
Brick	Density = 20 kN/m^3

Table 3: Loading details for the design

Imposed load	2.0 kN/m^2
Floor finishes load	1.5kN/m^2
Wall load on beams	14.0 kN/m
Equivalent lateral loads	According to IS 1893 (Part I):2002

3. Methodology

Create a 3D model by defining and assigning the material properties and frame sections such as beams, columns, and slab. Fig. 4.1 shows building modal details such as (a) plan, (b) elevation and (c) isometric view of the reinforced concrete structure.

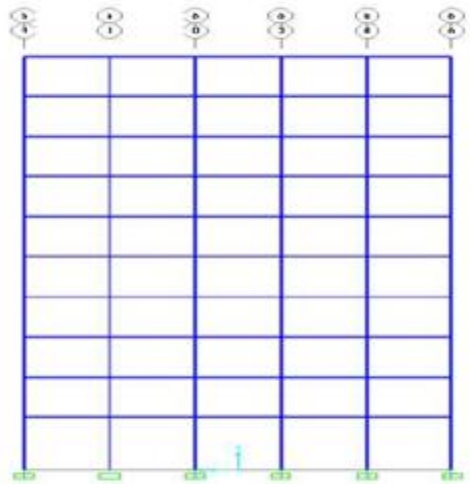


Figure 1: Elevation

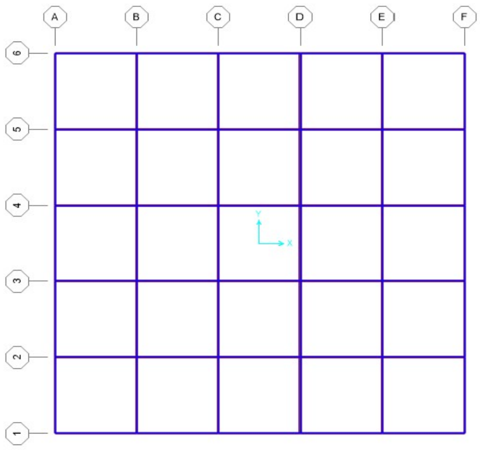


Figure 2: Plan

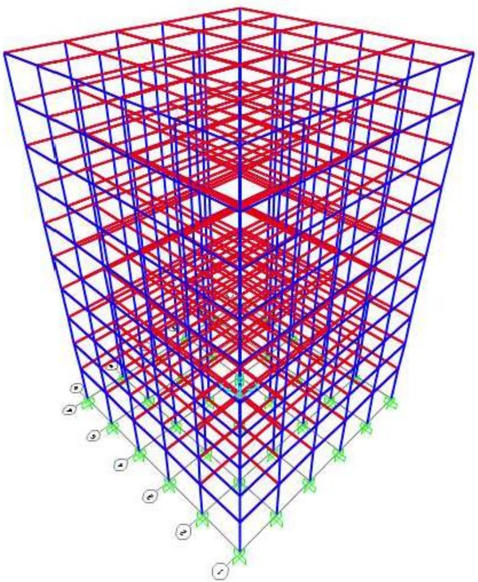


Figure 3: 3-D Isometric View

The comparison of performance factor in all of the zones (quarter II to V) for the taken into consideration constructing. Overall performance factor is explained within the shape of Spectral displacement vs. Spectral acceleration graphs. Overall performance factor offers the global behaviour of the building. The effects will gain within the form of capacity and call for curves. Formation of plastic hinges gives real behaviour of shape and their elements. Ability curve was proven in inexperienced colour in which as demand curve became proven in black shade. The intersecting point of each the curves offers performance factor. Hinges are normally shaped in beams and very few are fashioned in columns which observe the susceptible beam and strong column idea. The overall performance factor adjustments from LINEARITY to IO to as region considerations from quarter II to region V.

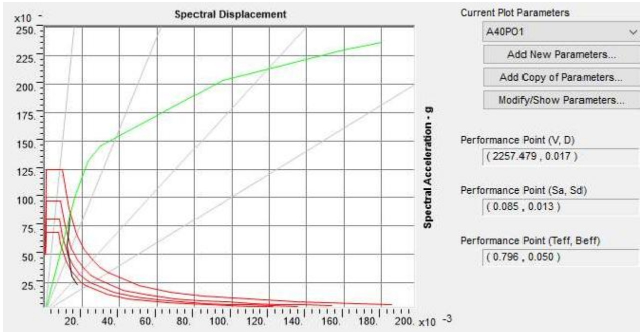


Figure 4: Spectral acceleration Vs Spectral Displacement (Zone-II)

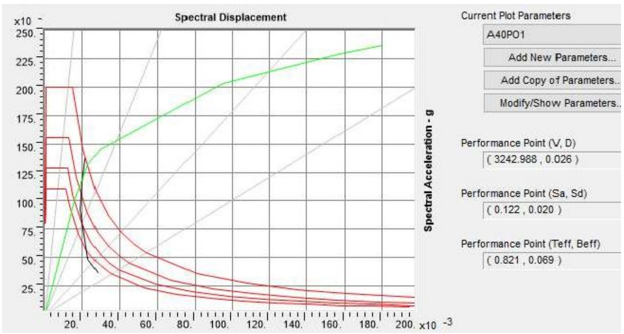


Figure 5: Spectral Acceleration Vs Spectral Displacement (Zone – V)

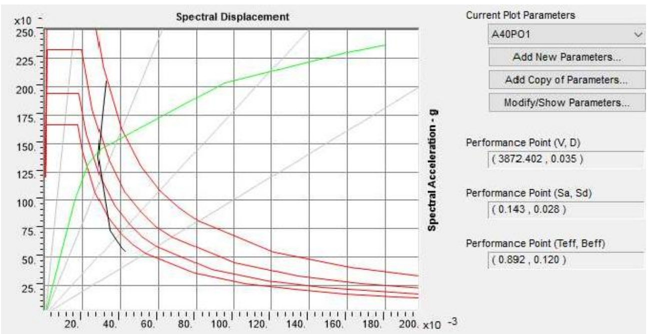


Figure 6: Spectral Acceleration Vs Spectral Displacement (Zone – III)

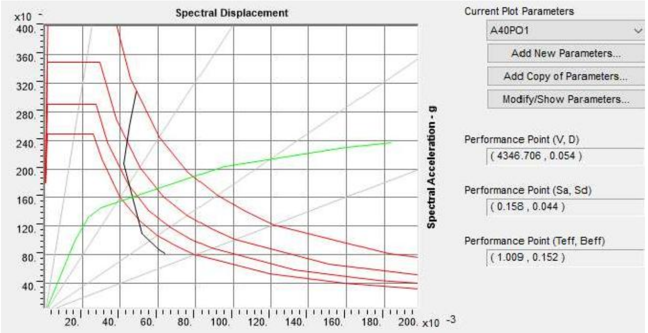


Figure 7: Spectral Acceleration Vs Spectral Displacement (Zone – IV)

Performance of the structure with respect to the performance points is compared in terms of Maximum base shear and total lateral displacement. Fig. 5.8 shows the comparison of Maximum base shear and total lateral displacements. Remaining parameters like time periods, damping ratios, spectral acceleration and spectral displacement are also compared.

A graph showing the comparative results for base shear in all the seismic zones of India. From Fig. 5.5 we can say that as the seismic zone increases from II to V, base shear also increases. The variation of maximum lateral displacements with the variation of seismic zones was shown in Fig. 5.5 and the maximum time periods for all the considered seismic zones were shown in Fig. 5.6.

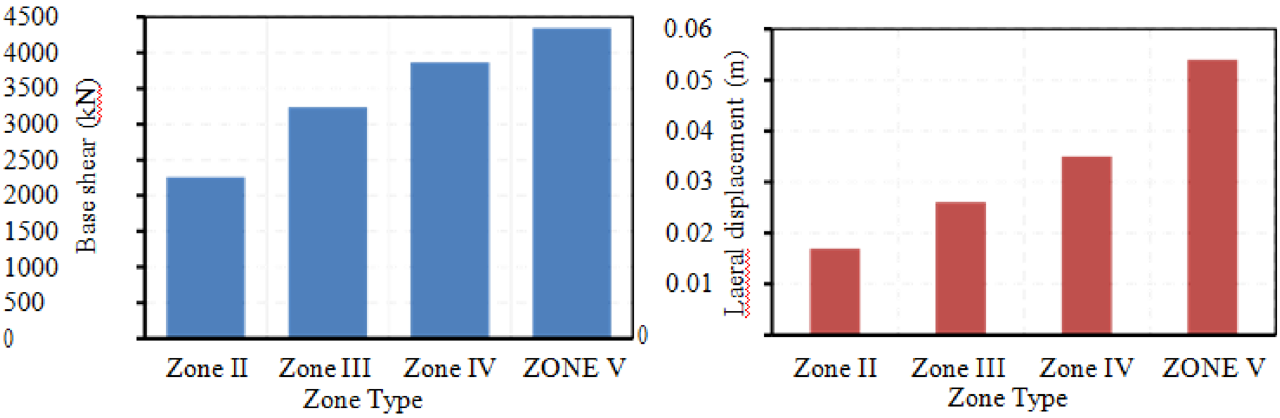


Figure 8: Comparison of maximum base shear & Lateral Displacements of different zones

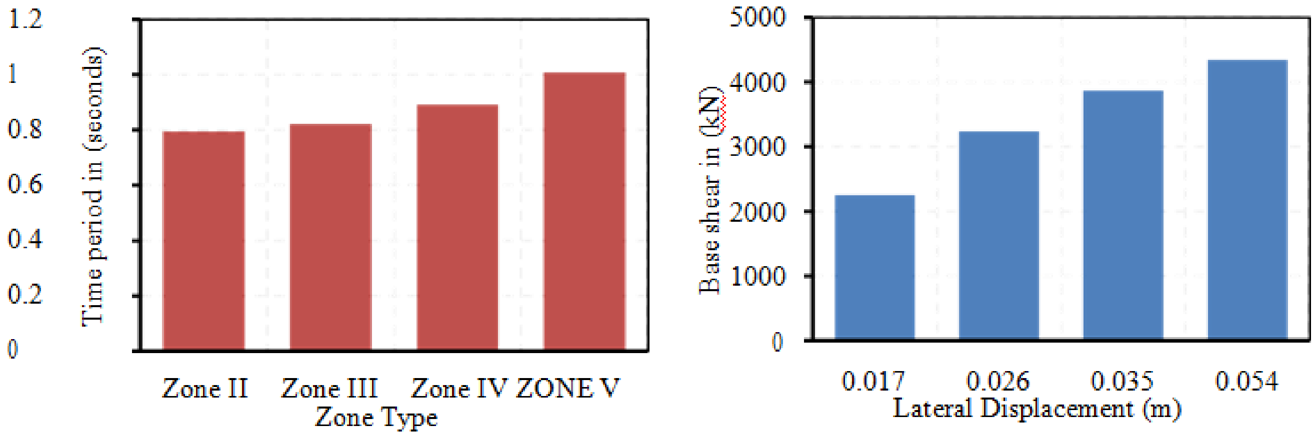
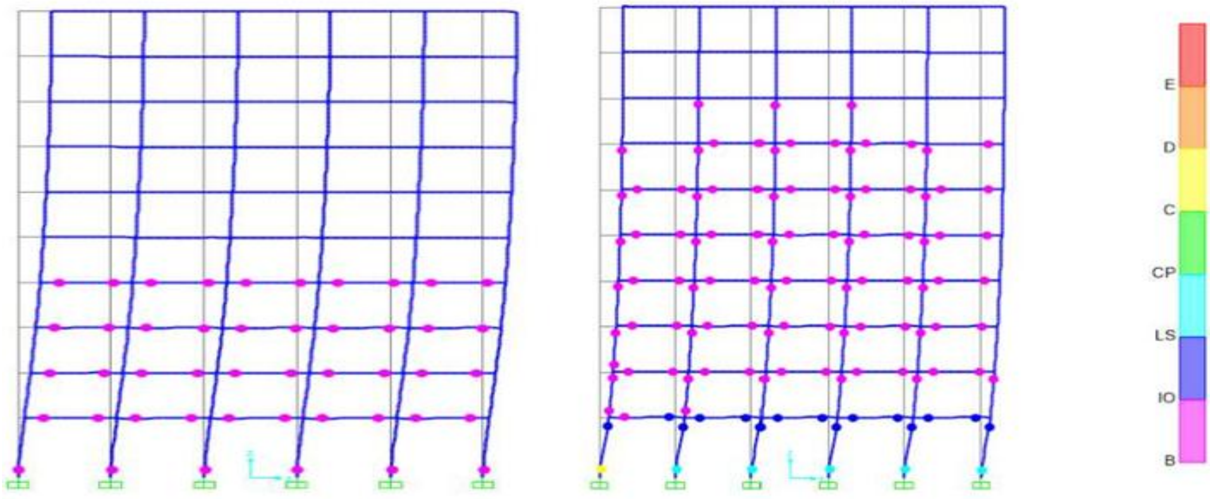


Figure 9: Comparison of maximum Time period & Base shear of different zones

Table 4: Comparison of Performance Parameters

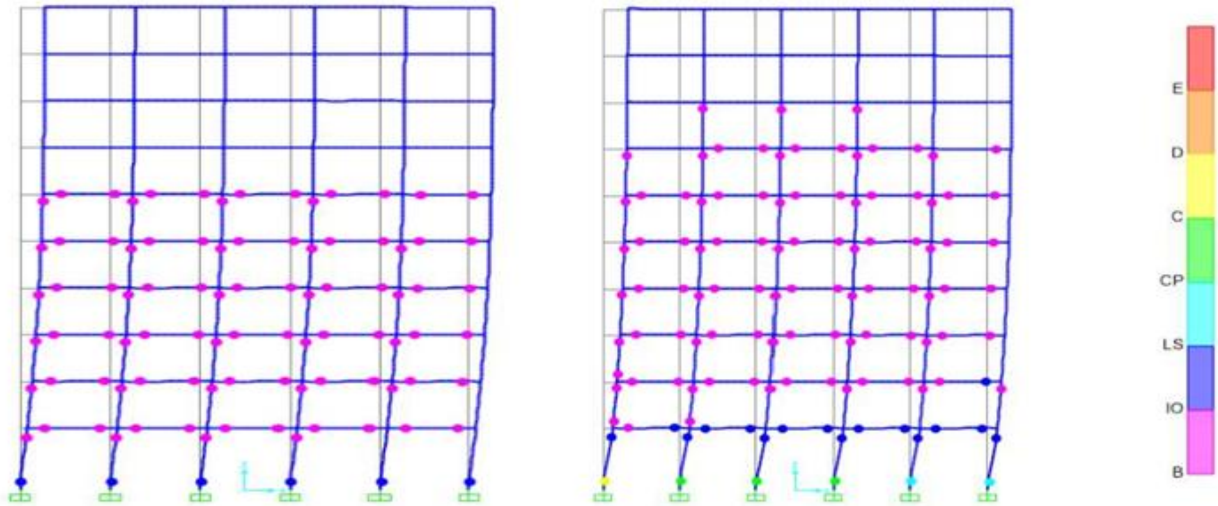
Indian Seismic Zone	II	III	IV	V
Spectral acceleration (m/sec^2)	0.083	0.120	0.138	0.149
Spectral displacement (m)	0.011	0.021	0.029	0.042
Damping ratio	0.051	0.070	0.130	0.162
Base shear (kN)	2257.479	3242.988	3872.402	4346.706
Time period (sec)	0.79	0.827	0.888	1.001
Displacement (m)	0.018	0.03	0.042	0.06

Structural behaviour was explained based on the sequence of formation of hinges. Hinge formation in a building of different zones has been obtained and observed. Figs. 5.7, 5.8, and 5.9 reveal the hinge formation patterns. From the Figs. 5.9 through 5.9, it is observed that the hinge formation patterns are similar in all zones. At first plastic hinges were formed at beam ends and at base level of lower storey columns, then hinge formation propagates to middle and upper stories. The yielding in the upper storey columns continues. Most of the hinges are formed at B, IO, and LS levels. For each zone hinge patterns at two stages were considered. One is at DBE (Design Based Earthquake) and other is at MCE (Maximum Considered Earthquake). Fig. 5.7 shows that for Zones III & IV the hinge formations at DBE, MCE are similar. From the results we can conclude that, the structure is very limitedly exposed to damage and the columns at the lower storey needed to be retrofit based on the importance of the building.



DBE MCE

Figure 10: Hinge patterns in the building at Zone III & IV



DBE MCE

Figure 11: Hinge patterns in the building at Zone – V

4. Summary and Results

Results and discussions encompass the contrast of performance point in all of the seismic zones of India. overall performance point gives the global behavior of the building. The results will achieve inside the form of capability and demand curves. Formation of plastic hinges gives real behavior of structure and their elements. capability curve turned into shown in green shade where as call for curve turned into proven in black coloration. The intersecting factor of both the curves offers overall performance factor. Hinges are commonly formed in beams and only a few are formed in columns which comply with the weak beam and robust column concept. Figures through 5.1 to 5.4 display the graphs

Among spectral displacements versus spectral acceleration. consequences consist of base shear, most pinnacle displacement, spectral acceleration, spectral displacement and powerful term. these types of values for distinct seismic zones are plotted in desk 4 and the graphs are attracted to each parameter with seismic zones and effects are compared through parent five to eight. However, structural behavior become defined based on the collection of formation of hinges. Hinge formation in a building of various zones has been obtained and located.

Figs. 5.7, 5.8 and 5.9 display the hinge formation styles. For every region hinge patterns at two tiers had been taken into consideration. One is at DBE (layout primarily based Earthquake) and different is at MCE (most considered Earthquake). Fig. 5.10 indicates that for Zones III & IV the hinge formations at DBE, MCE are similar**.**

5. Conclusions

The following conclusions are drawn from the non-linear static analysis:

1) As it go from zone II to V seismic demand increases.
2) Global behavior of the structure is significant to defy the lateral loads but there are local failures in columns which are not advisable.
3) The performance point changes from LINEARITY to IO, to LS level as zone considered from ZONE II to ZONE V.

4) As the Seismic Zone changes from II to V total storey drift, maximum base shear and time periods are increased constantly.
5) The performance point for different zones are as follow:
   Zone II, it is in linear state that is in between A to B.
   Zone III, it is at point B.
   Zone IV, it is beyond point B which is in nonlinear state.
   Zone V, it is in nonlinear state which is near to IO level.
6) Observations from the analysis results indicated that all hinges formed in the structure are within collapse prevention (CP) level for the design based earthquake (DBE).
7) Finally results show that, the damage in building is restricted and columns at the lower storey need to be retrofitted based on the significance of the structure.

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