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NON-LINEAR STATIC ANALYSIS OF STRUCTURE FOR PLANER IRREGULARITY

KEYWORDS Non-Linear Static Analysis, seismic zone, pushover analysis, plan irregular building, Multi-story, performance

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ABSTRACT *The present work defines the structural performance of the building during the earthquake especially plan irregular building are considered for study. The paper throws light on the actual response of the building by analysis them with non-linear static/pushover analysis. In present study, Multi-story irregular buildings with 9 stories with floor are of 500 m^2 have been modeled using SAP 2000 for seismic zone V in India. The results proved the unsymmetrical planner building suffered the considerable loss than the symmetrical planner building. The Rectangular shape building shows the absolute performance in both the governing directions. Whereas the L shape & T shape buildings are shows poor performance than symmetric plan buildings.*

BACKGROUND

India also has suffered many earthquake strokes in history and the recent earthquake of Gujarat on 26 January 2001 has brought to over notice that the structure of 4 to 10 story has face the large destruction then the other structure. Earthquake field investigations repeatedly confirm that irregular structure suffers noticeable damage among columns and also emphasize the torsional effects than the regular structures.

Nowadays the need and demand of the latest generation of having innovative style of living and growing population has made architects and engineers inevitable towards planning of irregular configurations. Hence earthquake engineering is playing important role in understanding the actual behavior of building during earthquake.

The nonlinear dynamic response of a plan asymmetric masonry building is initially compared with the one of a symmetric building variant for several input ground motions; in order to evaluate the effects of the torsional response increase in wall displacement of about 20% has been measured at the flexible side that suffers larger damage by [3]. It is furthermore capable of accounting for the effect of torsional imbalance on structural damage. Starting from the concept of planar decomposition of a complex 3D frame, the procedure uses relative weighting of the contribution of the individual planar frame to the overall damage [5]. The capacity of the buildings may be significant but the seismic demand varies with respect to the configurations and can deform largely for less amount of forces [1]. Even though it is well established that plan-irregular structures suffer higher levels of earthquake damage than their regular counter-parts, a quantitative measure of the observed susceptibility to damage has been hitherto unavailable [4]. It is found that the mass and stiffness criteria of Uniform Building Code result in moderate increases in response quantities of irregular structures compared to regular structures. The strength criterion, however, results in large increases in response quantities and thus is not consistent with the mass and stiffness requirements [7].

Nonlinear static analysis has been developed over the past twenty years and has become the preferred analysis procedure for design and seismic performance evaluation purposes as the procedure is relatively simple and considers post elastic behavior. Non-linear static procedures were developed with the aim of overcoming the in sufficiency and limitations of linear methods, whilst at the same time maintaining a relatively simple application. Non-linear static methods differ in their application, simplicity, transparency and clarity of theoretical basis, but the basis of all methods is the same, i.e., the pushover method [2].

The procedure involves certain approximations and simplifications that some amount of variation is always expected to exist in seismic demand prediction of pushover analysis. Pushover analysis is the procedure with many assumptions which neglects the variation of loading patterns the influence of higher modes of vibration & the effect of resonance. In spite of this defect the method provides the reasonable estimation of the global deformation.

NONLINEAR STATIC PUSHOVER ANALYSIS

Pushover analysis is the approximate method used to evaluate the structure and is used popularly to evaluate as well as in performance based seismic design nonlinear static analysis is an improvement over the static or dynamic analysis in the sense that it allows inelastic behavior of the structure. The method is simple to implement and provides the information about strength, deformation and ductility of the structure as well as the demand. The pushover method applies the analysis under permanent vertical is loads and gradually increasing lateral load. The analysis consist of sequential elastic analysis in which the structure is subjected to monotonically increasing lateral force with an invariant height wise distribution until the target displacement is reached.

The simplified nonlinear techniques are used to estimate the seismic structural deformation which specifies the force displacement reaction. The results are recorded on the bases of yielding of the structural element by increasing the load gradually up to the structure is collapse or to reach certain level of lateral displacement. Pushover analysis can be performed as force controlled or displacement controlled.

CAPACITY CURVE

The overall capacity of a structure depends on the strength and deformation capacities of the individual components of the structure. This procedure uses sequential elastic analysis, superimposed to approximate force-displacement diagram of the overall structure. The mathematical model of the structure is modified to account for reduced resistance of yielding components and lateral force distribution is again applied until additional components yield.By corresponding this capacity curve to the seismic demand generated by the specific earthquake gives the performance point of the structure or target displacement and this point defines the maximum displacement of the building the earthquake will cause.

MODELING IN SAP 2000

The performance of buildings of different shape in plan suggested by the IS 1893 (2002) are compared with each other by keeping the self-weight, are in plan and height of structure are equal. The nine story structure models with floor area 500 sqm of different shape i.e. rectangular shape, T shape, L shape, I shape C shape accordingly as shown in Figure 3 are considered.

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Element Details –

Grade of Concrete	:	M30
Grade of Steel	:	Fe 500
Size of Column	:	550 × 550mm
Size of beam	:	350 × 500mm
Thickness of Slab	:	150mm

PUSHOVER ANALYSIS IN SAP 2000

The non-linear pushover analysis can be conveniently done in the SAP 2000 software. All the steps are same up to the restraining base as explained above and continue the pushover after the analysis and concrete design is done.

Choosing Select option select by line object type, at the first select column and specify frame non-linear hinges from frame/line in Assign option. For the column specify the non-linear hinges condition is Default-PMM. In this column conditions Default-PMM means Flexure and Bending. In this non-linear frame hinges, Similarly, follows first step and select beam and specify the frame non-linear hinges conditions. For the beam select non-linear hinges condition is Default-M3. In this beam conditions Default-M3 means bending. Similarly, follows two cases:

Then from Define option select the Static non-linear/pushover case and add new push1 case. In this case specify the push to disp. Magnitude is 0.3, load pattern etc. Then from Analyze option Run Static Nonlinear Analysis.

RESULTS AND DISCUSSION

The analysis nonlinear static pushover analysis is purposefully done to study the ultimate failure of the analytical model on the bases of yielding of the structural element by increasing the load gradually up to the structure is collapse. The five curves show similar features (Figure 1 & 2). They are initially linear but start to deviate from linearity as the beams and the columns undergo inelastic actions. The L and T shape (unsymmetrical) structures capable of accounting the effect of torsional imbalance on structural damage suffered the minimum displacement in first mode. The T shape building shows very small inelastic displacement than L shape building which causes brittle failure i.e. building undergoes severe damage (CL) for low base shear. Whereas symmetric plan buildings (i.e., Rectangular, I and C Shape) perform excellent and obtained a standard capacity curve as shown in figure 2 and 3. At a target drift of 0.30 m, base shear resistance of symmetric buildings almost equal i.e. 7500 kN. Whereas unsymmetrical building collapse before reaching target drifts.

PERFORMANCE POINT OF ALL BUILDINGS

The performance point of building defines the ultimate point after which the building undergoes sever damage or can say tends towards collapse. Here we see that the performance of symmetric building is comparatively good than the any other shape of building as shown in table 2 & 3 in both universal axis. The performance of L shape is very low which suffers more and fails at very low point i.e. base shear resistance is 2482.9 kN at 0.0045 m displacement. The demand of the spectrum is very high for the unsymmetrical buildings. The critical performance is observed in unsymmetrical buildings as not reaches the standard spectrum in Y direction.

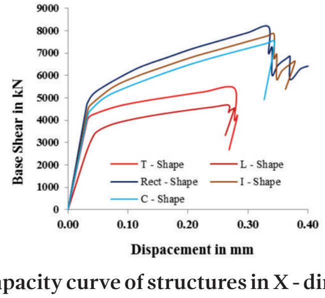


Figure 1: Capacity curve of structures in X - direction

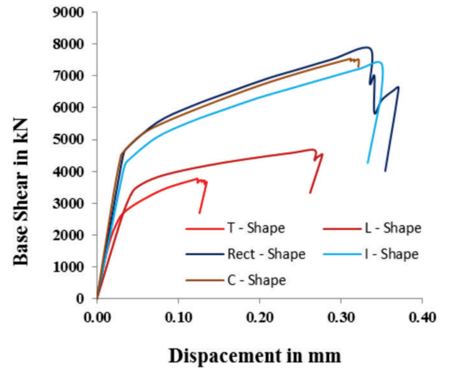


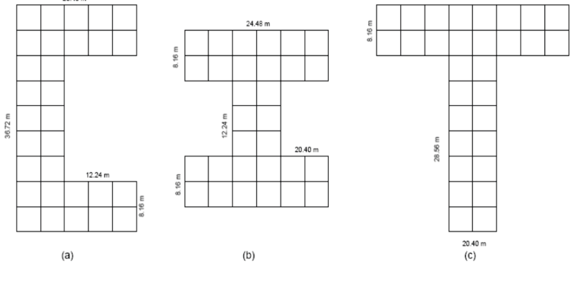
Figure 2: Capacity curve of structures in Y - direction

CONCLUSION

The results were seen for both the universal axis and were concluded in reference to the standard limit provided by the code. The ultimate failure pattern observed by the analysis is the standard ductile failure pattern. Unsymmetrical buildings (i.e. L and T shape) capable of accounting the effect of torsional imbalance on structural damage suffered the minimum displacement at very low base shear resistance in first fundamental mode. The symmetric building shows the absolute performance in both the governing directions i.e. high base shear resistance for desire target displacement and unsymmetrical buildings are seen poorly performing in both the direction for this analysis. The conclusion from the performance index of the building is the building are in the collapse level yet the ratio of symmetric building is showing good result while at the same time the symmetric buildings are collapsed with sever failure. The regular plan building shows the good performance than the building with plan irregularity is shown to be hold good for this analysis.

TABLE 1: PERFORMANCE POINT OF BUILDINGS

Model	C-Shape	I- Shape	L-Shape	Rect–Shape	T-Shape
Performance Point of Buildings in X- Direction					
Maximum Base Shear(kN)	7519.9	7844.4	4672.5	8178.6	5432.3
Maximum Displacement(m)	0.344	0.379	0.278	0.400	0.283
Performance Point (V,D)	6454.5	6469.7	2482.9	6984.5	5329.9
	0.201	0.168	0.0045	0.184	0.246
Performance Point of Buildings in Y- Direction					
Maximum Base Shear (kN)	7541.0	7398.5	4672.5	7869.0	3768.4
Maximum Displacement (m)	0.322	0.350	0.278	0.371	0.135
Performance Point (V,D)	6579.3	6139.4	--	6743.5	--
	0.186	0.178	--	0.191	--



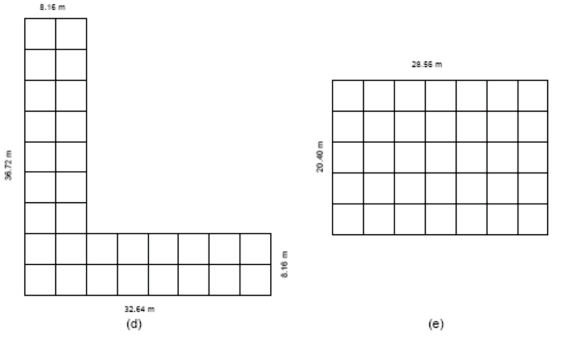


Figure 3: Plan of analytical models of different shape

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