Non Linear Static Analysis of Asymmetric building with and without Shear Wall

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Abstract - *In most of the RCC framed buildings irregularities are commonly observed. And the buildings with irregularities are most subjected to earthquake forces than buildings with regular configuration. The irregularities are of two types i.e, plan and vertical irregularity. For the assessment of the buildings behavior under earthquake forces Non-linear static analysis methods are adopted. In this case non linear static Pushover analysis method is used. The main objective of the paper is to study the performance level and behavior of structure in presence of shear wall for plan irregular building with re-entrant corners. The parameters considered in this paper are Base shear, Displacement and performance levels of the structure. The seismic codes for irregularities are as per the clauses defined in IS-1893:2002 and pushover analysis procedure is followed as per the prescriptions in ATC-40.The hinge properties are applied by default method as per codal provisions in FEMA 356. The model is analyzed using SAP2000 software.*

Key Words: Seismic, Pushover analysis, Irregularity, displacement and Base Shear.

1. INTRODUCTION

Earthquakes cause the buildings to collapse or damage by acting laterally on them. The north-east part of India is most affected by earthquake. And recently (April 2015) the earthquake hit Nepal thrice which also is in north-east part of India, and hence causing severe damage to the human life and buildings. Earthquake have been the most unexpected and disastrous thing. The structural engineers are responsible when the safety of the structure is taken into account. On assessment of the structures after earthquake, it is found that the structures with irregular configurations are more prone to damage and disaster. Therefore the non-linear static pushover analysis is most adopted in recent days for the seismic performance evaluation. This pushover analysis involves post elastic behavior of structure. By pushover method, the strength and deformation demand can be evaluated.

1.1 Irregularities in buildings

The paper involves the study of the behavior of structure with re-entrant corners under gravity and seismic loading. In reality almost all structures have irregularities. It can be either plan irregularity or vertical irregularity. The structures which are regular in plan and elevation and also there are no discontinuities are considered as symmetric structures, and the ones which are irregular in plan and elevation are called asymmetric structures. The regular structures perform well and are more resistant to seismic forces than irregular structures. The performance of the structure varies as there is variation in the irregularities. Building with the re-entrant corners is studied in this paper. Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 percent of its plan dimension in the given direction.

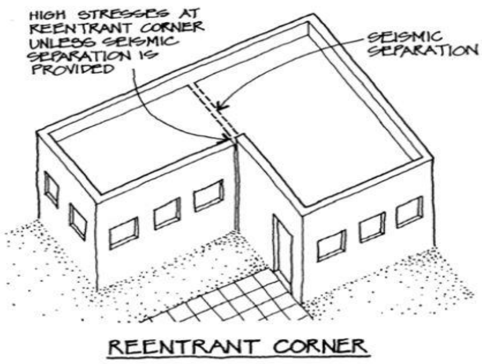

Fig-1: Building with re-entrant corner

1.2 Pushover analysis

Pushover analysis is a term used for the non-linear static analysis of frames. The practical method used for evaluating the displacement, time period etc is most done by pushover analysis. In this method first a distribution for the lateral loads on the frame is assumed and is increased monotonically. There are two steps involved in this method. Firstly the target displacement is found. This is an estimate of top displacement of the building up to the structure matches the target displacement [Tso & Moghadam 1998]. The amount of building damage at target displacement level is considered representative of the damage the building will experience when subjected to the design level ground shaking.

The base shear forces and roof displacements are converted to the spectral acceleration and spectral displacement of an equivalent single degree of freedom (SDOF) system respectively. These spectral values define the capacity spectrum. Inelastic demand spectra are determined from the elastic design spectra and are converted into acceleration displacement response spectra (ADRS) format.

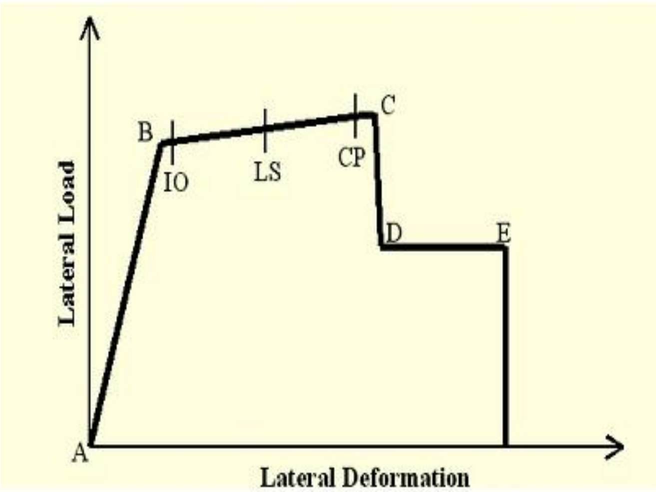

Fig-2: Lateral load Vs Deformation [1]

A plot is drawn between base shear and roof displacement. Performance point and location of hinges in various stages can be obtained from pushover curve as shown in figure. The range AB is elastic range, B to IO is the range of immediate occupancy IO to LS is the range of life safety and LS to CP is the range of collapse prevention. If all the hinges are within the CP limit then the structure is said to be safe. However, depending upon the importance of structure the hinges after IO range may also need to be retrofitted.

2. MODELLING AND ANALYSIS

T-shaped building is considered for the analysis.

Table-1: Presumed data:

Particulars	Details
No of floors	G+9
Zone factor	III
Building type	SMRF
Response reduction factor	(5)
Plan irregularity	Re-entrant corners
Soil type	Medium soil(II)
Concrete grade	M20
Steel grade	Fe415
Importance factor	1

Table-2: Dimensions:

Plan dimension	40m X29m
Beam size	230mmX500mm
Column size	230mmX600mm
Slab depth	150mm
Wall thickness	230mm
Foundation height	1.5m
Floor height	3.2m
Parapet height	1m of 230mm thickness

Table-3: Loads Considerations

Live load (in room)	2kN/m^2
Live load (passage and stairs)	3kN/m^2
Live load (Roof)	1.5 kN/m^2

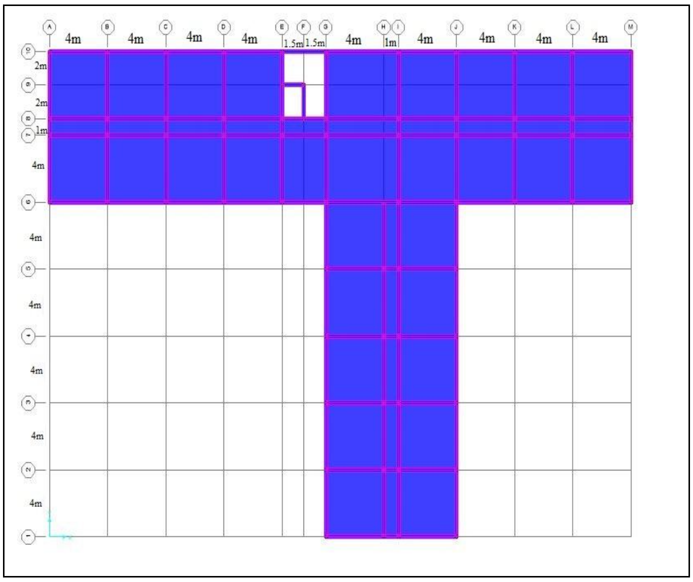

Fig-3: Plan of T-shaped building

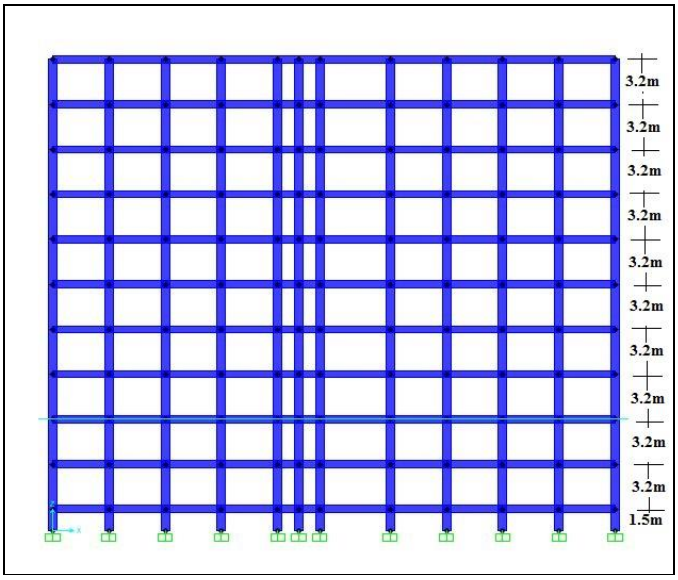

Fig-4: Plan of T-shaped building

3. RESULTS AND DISCUSSIONS

3.1 Base Shear

Table-4: Base shear in kN

Particulars	Base shear in X-Direction	Base shear in Y-Direction
Without shear wall	14688.21	9017.663
With shear wall	20476.72	14023.14

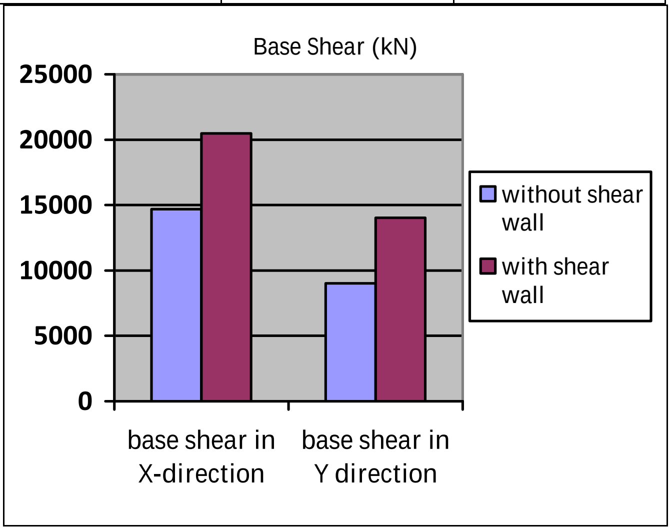

Chart-1: Base shear for T-shaped building

By comparing the building with shear wall and without shear wall, there is increase in base shear by 26% under presence of shear wall by pushover analysis.

3.2 Displacement

Table-5: Displacements in mm

Particulars	Displacement in X-Direction	Displacement in Y-Direction
Without shear wall	378	263
With shear wall	256	164

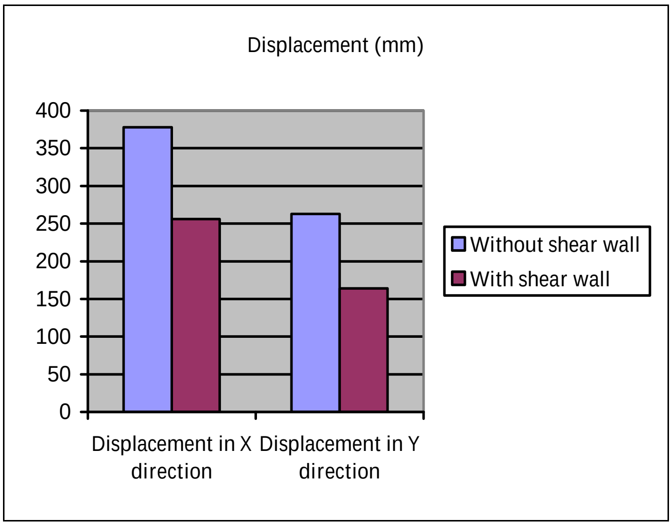

Chart -2: Displacement for T-shaped building

By comparing the building with shear wall and without shear wall, there is decrease in base shear by 23 % under presence of shear wall by pushover analysis.

3.3 Performance point and performance levels

Table-6: Base shear and displacement at performance point

Models	Displacement In mm		Base shear in kN		Performance level	
Direction	X	Y	X	Y	X	Y
Without shear wall	203	221	9201	3790	LS-CP	LS-CP
With shear wall	172	98	12362	5794	CP-C	LS-CP

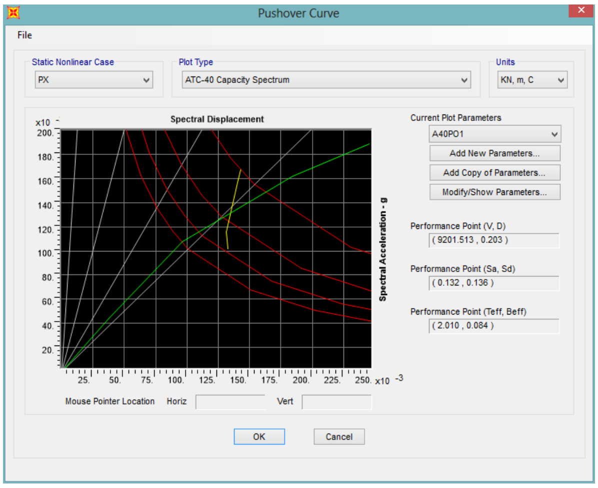

Chart -3: Performance point in X-direction for building without shear wall

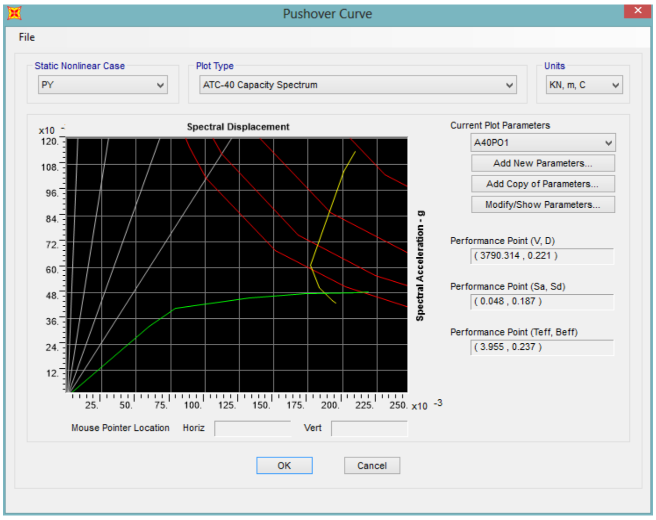

Chart -4: Performance point in Y-direction for building without shear wall

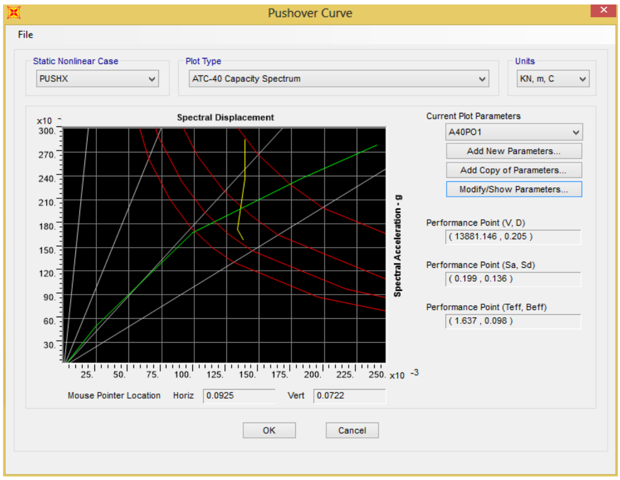

Chart -5: Performance point in X-direction for building with shear wall

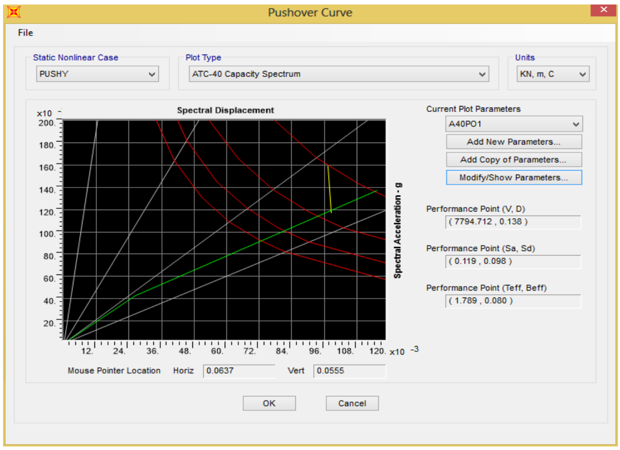

Chart -6: Performance point in Y-direction for building with shear wall

From table 6 and charts 3 and 4 it can be observed that the base shear at performance point are lower for models without shear wall. From table 6 and charts 5 and 6 it can be observed that the base shear at performance point are higher for model with shear wall.

4. CONCLUSIONS

1. The base shear of the building increase with the addition of the shear wall as the load resisting capacity increases.

2. The addition of shear wall significantly reduces the displacement in the structures when compared with the structures without shear wall.

3. The performance point of the models without shear wall will have base shear less compared to model with shear wall as the shear wall resists the earthquake forces to greater extent.

4. From results, it is observed that the buildings with re-entrant corners are more prone to earthquake damage causing Torsional effect.

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BIOGRAPHIES

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