International Journal of Engineering Research and General Science Volume 5, Issue 1, January-February, 2017
ISSN 2091-2730

NON LINEAR STATIC ANALYSIS FOR RC FRAMED RESIDENTIAL BUILDING USING SAP2000

YECHURI SAI SANDEEP KUMAR[1] , B. BEERAIAH [2]

1 REASEARH SCHOLAR,VNR College Of Engineering.

2 ,ASSISTANT PROFESSOR ,REASEARH GUIDE, VNR College Of Engineering.

ABSTRACT:
This research presents the steps used in performing a pushover analysis of a simple three-dimensional building of existing five storied located in seismic zone-v. SAP2000, a state-of-the-art, general-purpose three-dimensional structural analysis program, is used as a tool for performing the Pushover Analysis. According to pushover analysis the vertical distribution of static monotonically increasing lateral loads is applied to a mathematical model of the structure. The loads are increased until the peak response of the structure is obtained on a base shear vs. roof displacement plot. From this plot, and other parameters representing the expected, or design, earthquake, the maximum deformations the structure is expected to *undergo during the design seismic event can be estimated*. After completion of pushover analysis the performance point and developing of plastic hinges for each storey can be identified.

INTRODUCTION:
The recent advance of performance based design has brought the nonlinear static pushover analysis procedure to the forefront. Pushover analysis is a static, nonlinear procedure in which the magnitude of the structural loading is incrementally increased in accordance with a certain predefined pattern. With the increase in the magnitude of the loading, weak links and failure modes of the structure are found. The loading is monotonic with the effects of the cyclic behaviour and load reversals being estimated by using a modified monotonic force-deformation criteria and with damping approximations. Static pushover analysis is an attempt by the structural engineering profession to evaluate the real strength of the structure and it promises to be a useful and effective tool for performance based design. In light of these facts, it is imperative to seismically evaluate the existing building with the present day knowledge to avoid the major destruction in the future earthquakes.

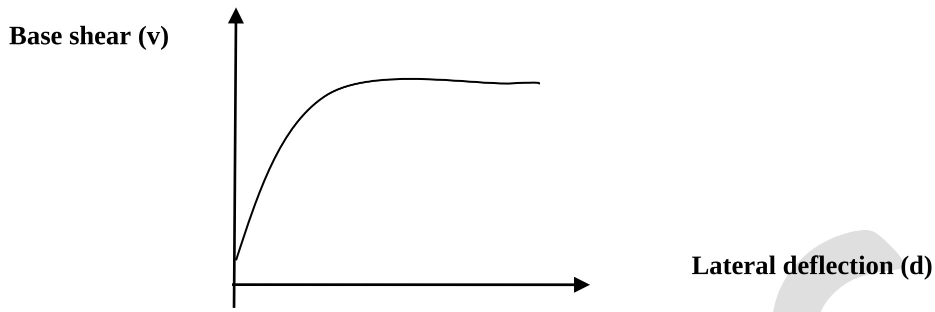
Research Approach:
The general finite element package SAP 2000 has been used for the analyses. A three dimensional model of each structure has been created to undertake the non linear analysis. Beams and columns are modelled as nonlinear frame elements with lumped plasticity at the start and the end of each element. SAP 2000 provides default-hinge properties and recommends P-M-M hinges for columns and M3 hinges for beams as described in (**FEMA-356 ,2000)**.Based on the location of hinges and location of performance point the damage intensity of the building can be evaluated and suitable retrofitting methods and materials are suggested for seismic strengthening of building.

A pushover analysis is performed by subjecting a structure to a monotonically increasing pattern of lateral loads, representing the inertial forces which would be experienced by the structure when subjected to ground shaking. Under incrementally increasing loads various structural elements may yield sequentially. Consequently, at each event, the structure experiences a loss in stiffness. Using a pushover analysis, a characteristic non linear force displacement relationship can be determined. Based on the results obtained from pushover analysis various retrofitting techniques for each individual elements of building are adopted to strengthen the building under seismic action.

Use of Push over curve or Capacity curve:

a) We can construct Capacity Spectrum
b) Estimation of Equivalent Damping
c) Determination of Demand Spectrum
d) Determination of Performance Point
e) And Verify Acceptance

International Journal of Engineering Research and General Science Volume 5, Issue 1, January-February, 2017
ISSN 2091-2730



Earthquake Lateral Loads:
The design lateral loads at different floor levels are calculated corresponding to fundamental time period and are applied to the model. The method of application of this lateral load varies for rigid and flexible floor diaphragms. In rigid floor idealization the lateral load at different floor levels are applied at center of rigidity of that corresponding floor in the direction of push in order to neglect the effect of torsion. The steps as follows,

1. Modal analysis is performed to obtain modal periods/frequencies.
2. Calculate the Seismic weight of each floor: Which is its full dead load plus appropriate amount of imposed load. While computing the seismic weight of each floor, the weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey.
3. Calculate the total Base shear: Design seismic base shear (V_b) is calculated according to clause 6.2.4 of IS: 1893-2002.The response spectrum ordinates used are for Type –I (Medium soil) for 5% damping and for seismic Zone-V. The design seismic base shear (V_b) can also be calculated from SAP 2000 Nonlinear using Response Spectrum Analysis as per IS: 1893-2002. The total base shear is given by,

$$\mathbf{V_b = A_h\, W} \qquad \ldots\ldots\ldots\ldots\ldots \qquad \mathbf{(a)}$$

$$\mathbf{A_h = \frac{Z\, I\, (Sa/g)}{2R}} \qquad \ldots\ldots\ldots\ldots\ldots \qquad \mathbf{(b)}$$

Where,
Z = Zone factor given in table 2 of IS: 1893 -2002
I = Importance factor given in table 6 of IS: 1893-2002
R = Response reduction factor given in table 7 of IS: 1893-2002

Sa/g = Average response acceleration coefficient.

W = Total Seismic Weight of the Structure.
A_h = is the design horizontal seismic coefficient.

4. Calculation of Lateral Loads: The design Base Shear distributed along the building height as per IS code and ATC-40 for parabolic and triangular, uniform lateral load distributions. IS parabolic lateral load (PLL) at floor 1 is given by,

$$\mathbf{Q_{pi} = \frac{V_b.\, W_i\, .h_i^2}{\sum W_j\, h_j^2}} \qquad \ldots\ldots\ldots\ldots\ldots \qquad \mathbf{(c)}$$

$$\mathbf{Q_{pi} = \frac{V_b\, .W_i\, .h_i^2}{\sum W_j h_j}} \qquad \ldots\ldots\ldots\ldots\ldots \qquad \mathbf{(d)}$$

$$\mathbf{Q_{pi} = \frac{V_b.\, W_i\, .h_i^2}{\sum W_j}} \qquad \ldots\ldots\ldots\ldots\ldots \qquad \mathbf{(e)}$$

Where,
Q_{pi} = Lateral loads as per IS: 1893-2002 and ATC-40 at each floor level
W = Total seismic weight the structure
W_i = Seismic weight of floor i
h_i = Height of floor measured from base
n = Number of levels at which the masses are lumped.

RESULTS AND DISCUSSIONS:

Seismic Analysis of a Five storey Building

A five storey building for residential building has plan dimensions as shown in Figure 54. The building is located in seismic Zone-V on a site with medium soil. Designing the building for seismic loads as per IS 1893 (Part 1): 2002.

1. The building will be used for residential purpose, only external walls 230 mm thick with 12 mm plaster on both sides are considered. For simplicity in analysis, no balconies are used in the building.
2. At ground floor, slabs are not provided and the floor will directly rest on ground. Therefore, only ground beams passing through columns are provided as tie beams. The floor beams are thus absent in the ground floor.
3. Secondary floor beams are so arranged that they act as simply supported beams and that maximum number of main beams get flanged beam effect.
4. The main beams rest centrally on columns to avoid local eccentricity.
5. For all structural elements, M20 grade concrete will be used.
6. The Sizes of all columns in upper floors are kept the same, however for columns up to plinth, sizes are increased.
7. The floor diaphragms are assumed to be rigid.
8. Centre-line dimensions are followed for analysis and design. In practice, it is advisable to consider finite size joint width.
9. Preliminary sizes of structural components are assumed by experience.
10. For analysis purpose, the beams are assumed to be rectangular so as to distribute slightly larger moment in columns. In practice a beam that fulfils requirement of flanged section in design, behaves in between a rectangular and a flanged section for moment distribution.
11. However, it is mandatory in seismic Zone-V.
12. Seismic loads will be considered acting in the horizontal direction (along either of the two principal directions) and not along the vertical direction, since it is not considered to be significant.
13. All dimensions are in mm, unless specified otherwise.
14. Selection of building plan and its dimensions were given below.

Building plan and Dimensions Details:

The following are the specifications of existing G+4 building and location is in zone V.

1. Plinth Area: 150 m^2
2. Height of Ground floor – 4.0 m
3. Remaining floors – 3.5 m each.
4. Slab thickness=130mm
5. Thickness of wall: 230mm
6. Beam sizes: 230mm×300mm (Remaining)
   230mm×350mm (outer beams)
7. Column sizes: 230mm×300mm (Remaining)
   230mm×350mm (corner columns)
8. Materials: Grade of steel –HYSD
9. Grade of concrete – M20
10. Density on concrete = 25 KN/m^3
11. LL on floors = 2 KN/m^2
12. Density of wall = 19KN/m^3

Calculation of Mass Distribution along floor height

Mass for various floor levels

Floor levels	Height in meters 'm'	Mass $KN\text{-}s^2/m$

1-1	4	73.26
2-2	7.5	72.66
3-3	11	72.66
4-4	14.5	72.66
5-5	18	68.76

Co-ordinates of Centre of Mass at various floor levels

Co-ordinates of Mass at various floor levels

Floor levels	Height in Meters (m)	Co-ordinate in X-direction	Co-ordinate in Y-direction
1-1	4	5	7.5
2-2	7.5	5	7.5
3-3	11	5	7.5
4-4	14.5	5	7.5
5-5	18	5	7.5

Calculation of Dead loads and Live loads

Earthquake Load Generation Method: Frame Stiffness Method (Direct Analysis Method) Wall Load Transfer Type: Half Wall Load is transferred on floor.

Total Weight calculation

Floor - Level	Dead Load KN	Live Load KN	Live Load Percentage	Effective Live Load KN
1-1	1444.08	450.00	25.00	112.50
2 -2	1995.36	450.00	25.00	112.50

3 -3	1995.36	450.00	25.00	112.50
4 -4	1995.36	450.00	25.00	112.50
5 -5	1954.11	450.00	0.00	0.00
Total	**9384.28**	**2250.00**	**- -**	**450.00**

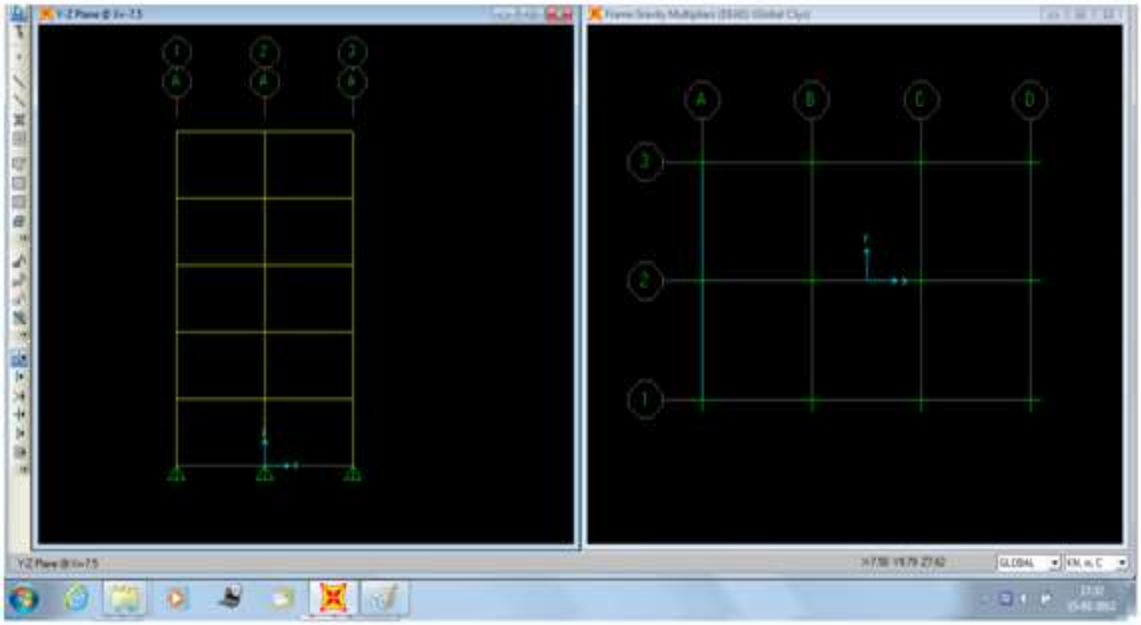
Calculation of Lateral forces at each storey

Lateral force and Base shear of each storey

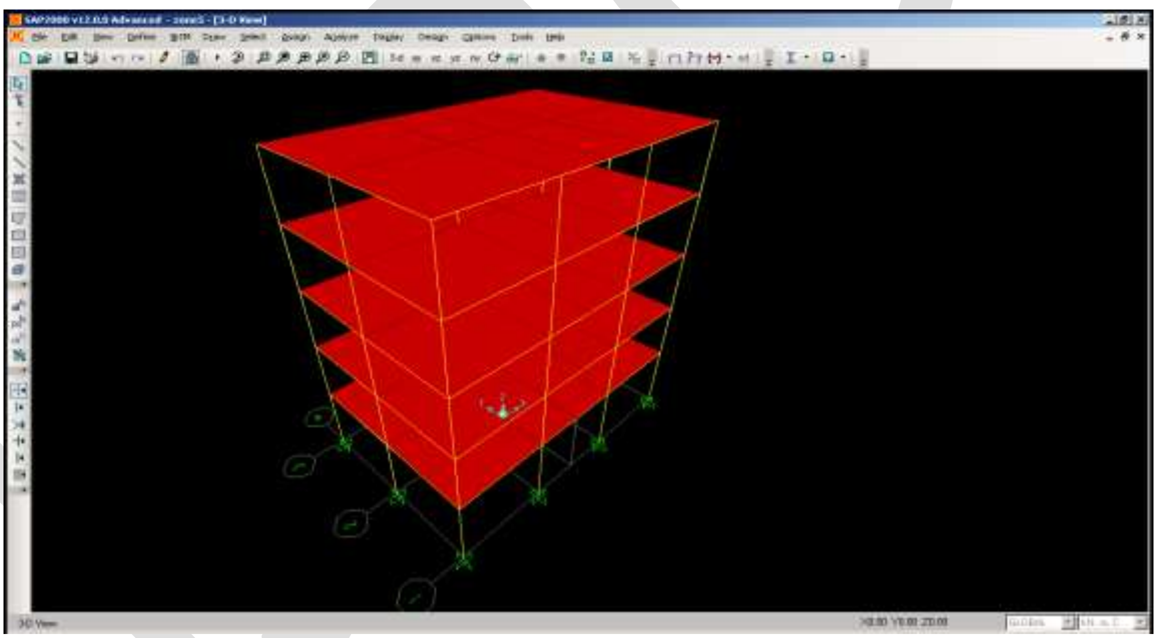
Floor Level	**W_i (KN)**	**h_i in 'm'**	**$W_i h_i^2 x10^{-3}$**	**$\frac{W_i hi^2}{\sum W_i hi^2}$**	**$Q_{i=} \frac{W_i hi^2 . V_b}{\sum W_i hi^2}$ (KN)**	**V_i (KN)**
1-1	2400	4	38400	0.024	25	25
2-2	2400	7.5	135000	0.087	89.26	114.26
3-3	2400	11	290400	0.187	191.86	306.12
4-4	2400	14.5	504600	0.326	334.4	640.52
5-5	1800	18	583200	0.375	384.75	1026
Total			**1551600**		**1026**	

Bending moment and Shear force results using SAP2000

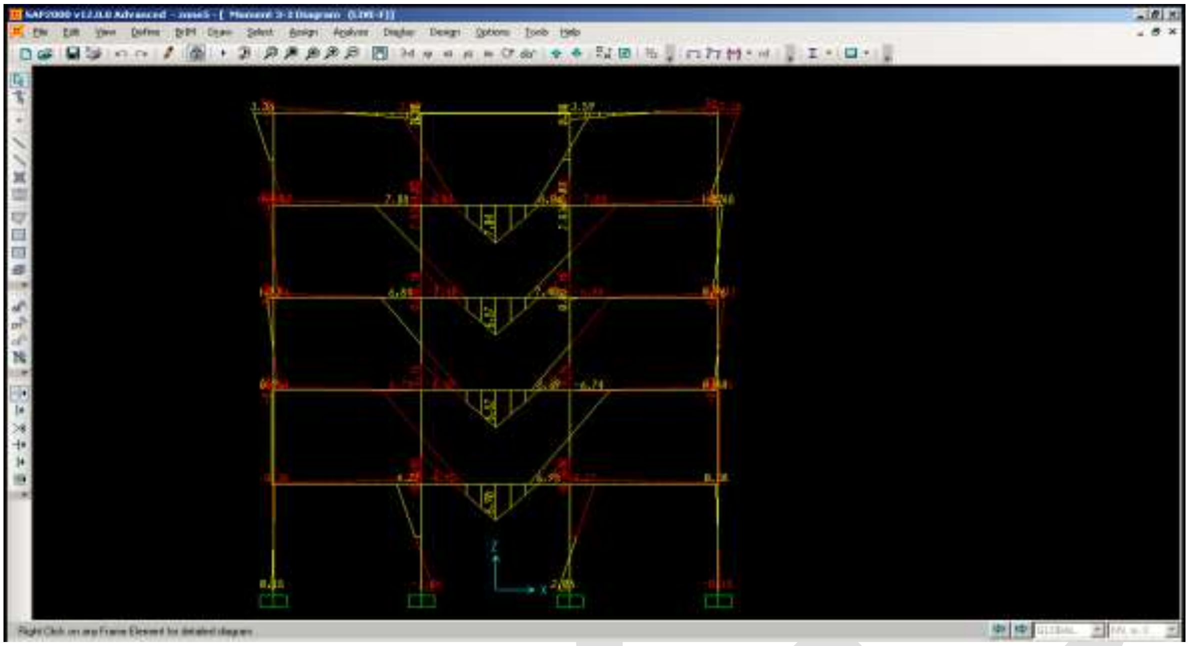
The Bending moment and Shear force diagrams along XZ, YZ directions of each bay for five storied building by using SAP2000 are presented below.



Showing elevation along 123 direction and Plan of five storied building

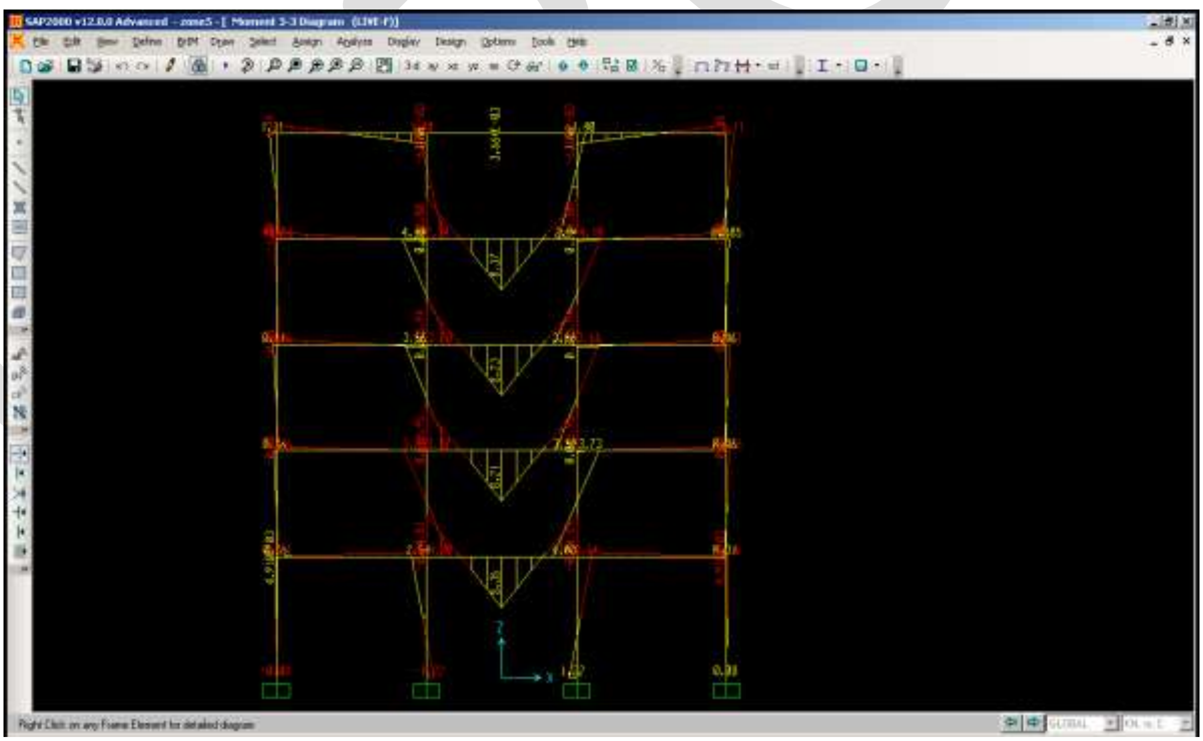


showing 3D View of five storied building



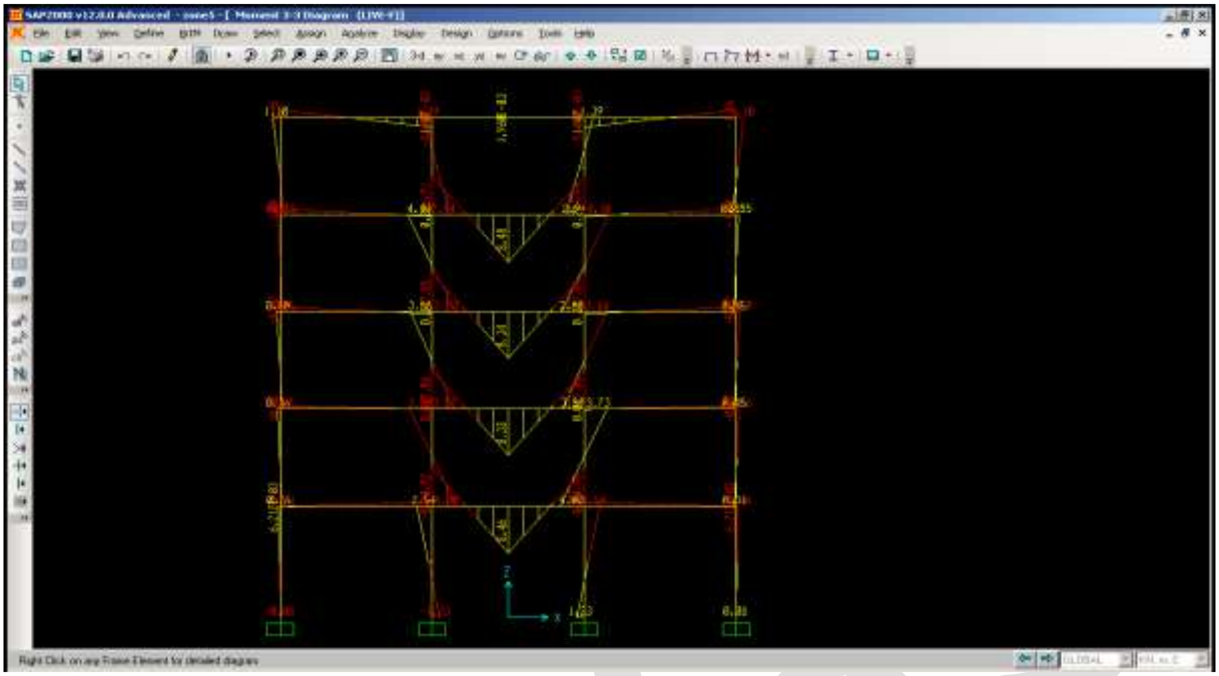
Showing Bending moment due to live load in XZ plane @Y=0

- The maximum bending moment due to live load in XZ plane @Y=0 is 7.88 KN-m



Showing Bending moment due to live load in XZ plane @Y=5m

- The maximum bending moment due to live load in XZ plane @Y=5m is 8.38KN-m



Showing Bending moment due to live load in XZ plane @Y=-5m

- The maximum bending moment due to live load in XZ plane @Y= -5m is 8.48 KN-m

CONCLUSION:

1. The pushover analysis is a useful tool for accessing inelastic strength and deformation demands and for exposing design weakness. The pushover analysis is a relatively simple way to explore the non linear behavior of buildings. The behavior of reinforced concrete framed building is adequate by indicating in terms of demand and capacity curves, and hinges are developed in beams**.**

2. After completion of pushover analysis the pushover curve is obtained. In this study both capacity and demand curves are intersected in between immediate occupancy and life safety zone. Such that building experiences moderate damage when subjected to pushover loads in seismic Zone-V.

3. For peak lateral load of 384.75 KN plastic hinges formation starts with beam ends and base columns of lower stories then propagates to upper stories and continue with yielding of interior intermediate columns in the upper stories.

REFERNCES:

[1] Applied Technology Council, (ATC-40), "Seismic Evaluation and Retrofit of Concrete buildings", Volume 1-2, Redwood City, California, 1996.

[2] Agarwal,P., "Experimental study of seismic strengthening and retrofitting measures in masonry buildings" Ph.D Thesis, Department of Earthquake Engineering, IIT Roorkee,1999.

[3] Alaee, F. J., Benson, S. D. P. and Karihaloo B. L. "Strengthening of RC beams with high-performance cementitious composites", Proc., Int. Conf. Civil Engineering, Technical committee ICCE-2001, Interline Publishing, Bangalore, India, 2001.
[4] www.google.com
[5] www.wikipidea.com
[6] Structural Analysis by Ramanamurtham