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Seismic Evaluation of Multi-Storey by Non Linear Static Analysis Using ETABS

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ABSTRACT:
Nonlinear static analysis is an iterative procedure so it is difficult to solve by hand calculation hence software is required to do nonlinear static analysis. ETABS 9.7 have features to perform nonlinear static analysis. This paper is an approach to do nonlinear static analysis in a simplified and effective manner. The structure has been evaluated using Pushover Analysis, a non-linear static procedure, which may be considered as a series of static analysis carried out to develop a pushover curve for the building. The structure is being analyzed by ETABS v 9.6.0 considering M20 concrete and Fe415 steel reinforcement. The pushover curve is generated by pushing the top node of structure to the limiting displacement and setting appropriate performance criteria. The target displacement for the structure is derived by bi-linearization of the obtained pushover curve and subsequent use of Displacement Coefficient Method.

Keywords:
ETABS 9.7, Non linear static analysis, Static analysis, Designing, Pushover curve.

INTRODUCTION:
The pushover analysis is a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. A plot of total base shear versus top displacement in a structure is obtained by this analysis that would indicate a premature failure or weakness. All the beams and columns which reach yield or have experienced crushing and even fracture are identified. A plot of total base shear versus inter-story drift is also obtained.

A pushover analysis is performed by subjecting a structure to a monotonically increasing pattern of lateral loads that shows the inertial forces which would be experienced by the structure when subjected to ground motion. Under incrementally increasing loads many structural elements may yield sequentially. Therefore, at each event, the structure experiences a decrease in stiffness. Using a non-linear static pushover analysis, a representative non-linear force displacement relationship can be obtained. Pushover analysis is an estimated analysis method where the structure is subjected to different monotonically increasing lateral forces, with a distribution which is height-wise invariant, until the target displacement is touched. Pushover analysis comprises of a series of successive elastic analysis, superimposed to estimate a force-displacement curve of overall structure.

First, a two or three dimensional model that includes bi-linear or tri-linear load-deformation figures of all the lateral force resisting elements is created and gravity loads are applied. Then, a predefined lateral load pattern that is distributed along the building height is applied. Until some members yield, the lateral forces are amplified. The structural model is modified in order to account for reduced stiffness of the yielded members and the lateral forces are increased again till additional members yield. This process is continued till a control displacement at top of the building reaches a particular level of deformation or else the structure becomes unsteady. The roof displacement is plotted with respect to the base shear so as to get the global capacity curve. Pushover analysis can be performed as force-controlled or displacement-controlled.

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In force-controlled pushover procedure, full load combination is applied as specified, i.e., force-controlled procedure should be used when the load is known (such as gravity loading). Also, in force-controlled pushover procedure some numerical problems that affect the accuracy of results occur since target displacement may be associated with a very small positive or even a negative lateral stiffness because of the development of mechanisms and P-delta effects. Pushover analysis has been the preferred method for seismic performance evaluation of structures by the major rehabilitation guidelines and codes because it is conceptually and computationally simple. Pushover analysis allows tracing the sequence of yielding and failure on member and structural level as well as the progress of overall capacity curve of the structure.

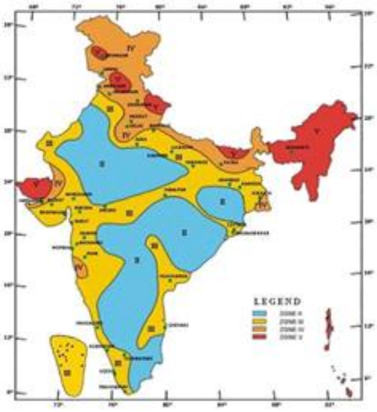

Fig.1. Seismic Zoning Map of India

According to the Seismic Zoning Map of IS: 1893-2002, India is divided into four zones on the basis of seismic activities. They are Zone II, Zone III, Zone IV and Zone V. The methodologies available so far for the evaluation of existing buildings can be divided into two categories-(i) Qualitative method (ii) Analytical method.

MODELING OF THE STRUCTURE:

R.C moment resisting frame structure having G+10 storey is analysed for garvity and latral load (earth quake and wind loads).

The effect of axial force, out of plane moments, lateral loads, shear force, storey drift, storey shear and tensile force are observed for different stories. The analysis is carried out using ETABS and data base is prepared for different storey levels as follows.

1.1. MODELLING OF R.C MOMENT RESISTING FRAME STRUCTURE:

In this present study G+10 conventional building is considered. The constriction Technology is R.C.C frame structure and slabs. The modeling is done in ETABS as follows.

- The structure is divided into beam and column elements.
- The nodes are created as plan architect plan and node are connected through beam command, columns also connected.
- Boundary conditions are assigned to the nodes wherever it is required. Boundary conditions are assigned at the bottom of the structure i.e., at ground level where restraints should be against all movements to imitate the behavior of structure.
- The material properties are defined such as mass, weight, modulus of elasticity, Poisson’s ratio, strength characteristics etc. The material properties used in the models.
- The geometric properties of the elements are dimensions for the section.
- Elements are assigned to structure.
- Loads are assigned to the joints as they will be applied in the real structure.

  The model should be ready to be analyzed forces, stresses and displacements.

STAGES OF PLASTIC HINGES:

In order to obtain performance points as well as the location of hinges in different stages, we can use the pushover curve. In this curve, the range AB being the elastic range, B to IO being the range of instant occupancy, IO to LS being the range of life safety and LS to CP being the range of collapse prevention.

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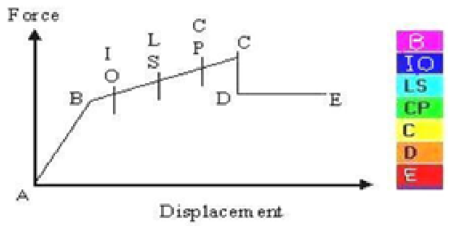
When a hinge touches point C on its force-displacement curve then that hinge must start to drop load. The manner in which the load is released from a hinge that has reached point C is that the pushover force or the base shear is reduced till the force in that hinge is steady with the force at point D. As the force is released, all of the elements unload as well as the displacement is decreased. After the yielded hinge touches the point D force level, the magnitude of pushover force is again amplified and the displacement starts to increase again. If all of the hinges are within the given CP limit then that structure is supposed to be safe. Though, the hinge after IO range may also be required to be retrofitted depending on the significance of structure.



Different stages of Plastic Hinge

The basic seismic response parameters taken into consideration are (i) Stiffness (ii) Strength (iii) Ductility. Now, if we consider any Reinforced Concrete frame building, we can summarize the sources of weakness as:

(i). Discontinuous load path/interrupted load path/irregular load path.

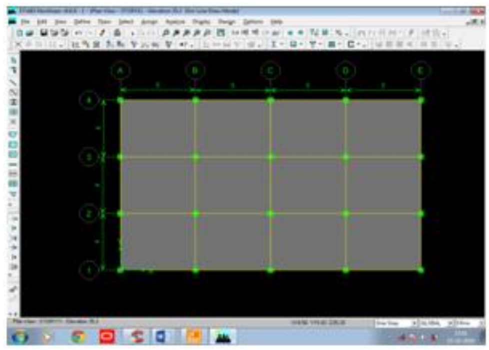
(ii). Lack of deformation capability of structural members.

(iii). Quality of workmanship and materials.

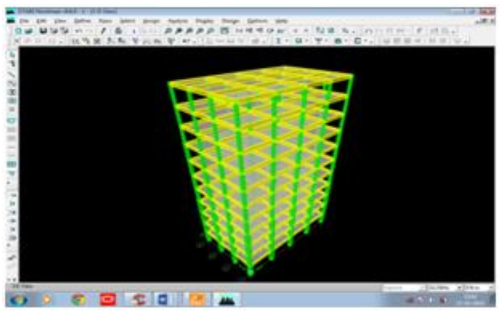
RESULTS AND DISCUSSION:

DATA REQUIRED FOR THE ANALYSIS OF THE FRAME..

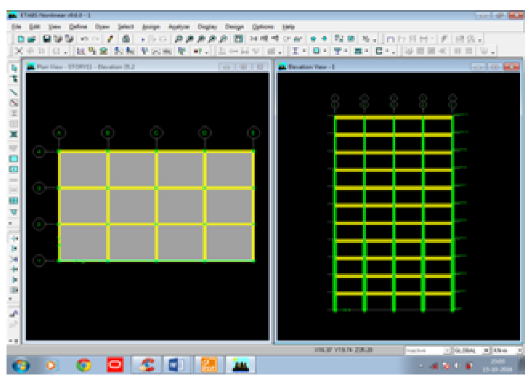
- Type of structure --> multi-storey fixed jointed plane frame.
- Number of stories
- Floor height 3.2m .
- Imposed load 2 kn/m2 on each floor and 2kn/m2 on roof.
- Materials Concrete (M 25) and Reinforcement (Fe415).
- Size of column 0.6m×0.6m
- Size of beam 0.23m×0.6m
- Depth of slab 150 mm thick
- Specific weight of RCC 25kn/m3.
- Specific weight of infill 19 kn/m3
- Type of soil Medium soil.



3D VIEW OF THE STRUCTURE



ELEVATION OF THE STRUCTURE



SUPPORTS

The supports given here are of fixed one, as shown in the above figure.

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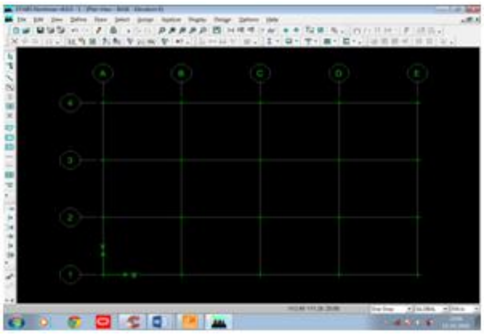


LOADS INPUT

Dead load is calculated as per IS 875 part1

Dead load : Assuming that slab is of 150mm thickness as per span/depth calculations of IS456.

Then total dead load is calculated as

0.15x24 = 3.6KN/m^2 + 1.5KN/m^2 (Floor finishing) = 5.1KN/m^2

The value of 5.1KN/m^2 has been assigned to the structure as shown in the figure and its distributing pattern also shown.

WALL LOADS

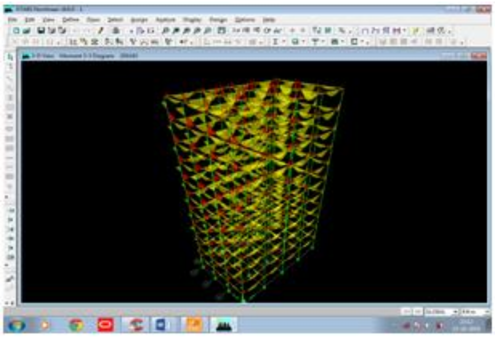
Here two types of walls are considered, i.e. 9” thickness wall (230mm) and $4\frac{1}{2}$” thickness wall (115mm).230mm is given to external walls (perimeter) and 115mm is assigned to all internal walls.

LIVE LOAD

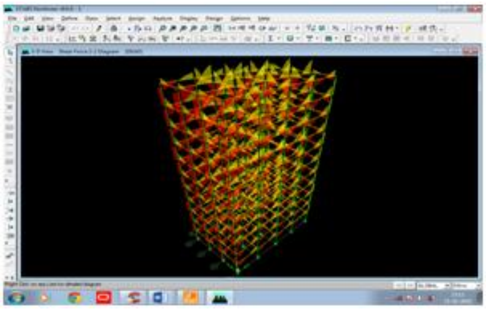
As per IS 875 part 2, the live load on the residential buildings should be taken as 2KN/m^2.So,here 2KN/m^2 has been assigned to entire structure.

For all the secondary beams, moment has been released, i.e. torsion effect has been removed and is treated as simply supported beams.

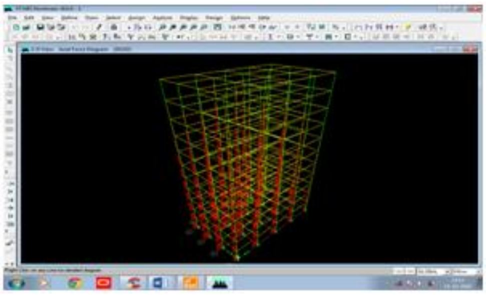
BENDING MOMENT OF THE STRUCTURE



SHEAR FORCE OF THE STRUCTURE



AXIALFORCES



CONCLUSION:

- As the number of storey were increased, there was a constant increase in the Base shear and Displacement values.
- Pushover analysis is non-linear static analysis in which there are good reasons for advocating the use for demand prediction since in many cases it will provide much more relevant information that an elastic static or even dynamic analysis, but it would be counterproductive to advocate this method as a general solution technique for all cases.
- Pushover analysis is a useful tool for assessing inelastic strength and deformation demands and for exposing design weaknesses.
- The results of the nonlinear static pushover analysis quantitatively establish that the seismic performance of masonry infill ,R/C adversely and significantly affected with varying thickness.
- Upon loading the structure to the calculated base shear and limiting the displacement of control node, the pushover analysis reveals the structure is safe and hence the building does not need to be retrofitted.

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