Seismic Analysis of Irregular (L-Shaped) RCC Building

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Abstract

A performance-based Analysis is aimed at controlling the structural damage based on precise estimations of proper response parameters. Performance-based seismic design explicitly evaluates how a building is likely to perform; given the potential hazard it is likely to experience, considering uncertainties inherent in the quantification of potential hazard and uncertainties in assessment of the actual building response. It is an iterative process that begins with the selection of performance objectives, and finally redesign and reassessment, if required, until the desired performance level is achieved. In this present study three new R.C.C buildings unsymmetrical in plan (L-shape) (designed according to IS 456:2000) is taken for analysis: 4, 8 and 20 storey to cover the broader spectrum of low rise, medium rise & high rise building construction. Different modelling issues were incorporated through six model for each building were; bare frame (without infill), having infill as membrane, replacing infill as an equivalent strut in previous model. The pushover analysis has been carried out using ETABS, a product of Computers and Structures International. Buildings located in Zone-III have been analyzed Comparative study made for bare frame (without infill), having infill as membrane, replacing infill as an equivalent strut. The results of analysis are compared in terms of Base Shear, Storey Displacement and Drift Ratio.

Keywords: Pushover, Symmetry, Capacity Curve, Time Period, Torsion, Base Shear, Drift, Performance Based Seismic Engineering (PBSE)

I. INTRODUCTION

Amongst the natural hazards, earthquakes have the potential for causing the greatest damages since earthquake forces are random in nature & unpredictable, the engineering tools needs to be sharpened for analyzing structures under the action of these forces. Performance based design is gaining a new dimension in the seismic design philosophy wherein the near field ground motion (usually acceleration) is to be considered. Earthquake loads are to be carefully modelled so as to assess the real behaviour of structure with a clear understanding that damage is expected but it should be regulated. In this context pushover analysis which is an iterative procedure shall be looked upon as an alternative for the orthodox analysis procedures. This study focuses on pushover analysis of multistore RC framed buildings subjecting them to monotonically increasing lateral forces with an invariant height wise distribution until the preset performance level (target displacement) is reached. The promise of performance-based seismic engineering (PBSE) is to produce structures with predictable seismic performance.

II. LITERATURE REVIEW

Sadjadi et al. (2007) [1] presented an analytical approach for seismic assessment of RC frames using nonlinear time history analysis and push-over analysis. The results from analytical models were validated against available experimental results. He observed that ductile and less ductile frames behaved very well under the earthquake considered.

Adiyanto (2008) [3] analyzed a 3-storey hospital building using STAAD Pro. Seismic loads were applied to the building. The dead loads and live loads were taken from BS6399:1997 and seismic loads intensity is based on equivalent static force procedure in UBC1994. Result showed that the building can withstand any intensity of earthquake. It means that the buildings were suitable to be built in any area located near the epicenter of the earthquake.

Poonam et al. (2012) [4] concluded that any storey must not be softer than the storeys above or below. Irregularity in mass distribution contributed to the increased response of the buildings.
III. OBJECTIVES

1) To evaluate the effect of masonry wall for low, medium and high rise building in terms of Top Storey Displacement
2) To study the load carrying capacity of different frames (considered in this work) using masonry wall as infill and equivalent diagonal strut in terms of Base Shear at performance point

IV. METHODOLOGY

If the structure not properly designed and constructed with required quality they may cause large destruction of structures due to earthquakes. Response spectrum analysis is an useful technique for time history analysis of structure when the structure shows linear response.

ETABS is integrated software for analysis and design of structures. Using ETABS nonlinear time history analysis is performed on the proposed building. Models are prepared by using assumptions; input data is feed into the ETABS to analyse the structural parameters such as base shear, base moment, lateral displacement, storey drift, time period, bending moment and axial force. Advanced analytical techniques allow for step-by-step large deformation analysis, Eigen and Ritz analyses based on stiffness of nonlinear cases, Catenary cable analysis, material nonlinear analysis with fiber hinges, multi-layered nonlinear shell element, buckling analysis, progressive collapse analysis, energy methods for drift control, velocity-dependent dampers, base isolators, support plasticity and nonlinear segmental construction analysis. Nonlinear analyses can be static and/or time history, with options for FNA nonlinear time history dynamic analysis and direct integration.

ETABS is general-purpose civil-engineering software ideal for the analysis and design of any type of structural system. Basic and advanced systems, ranging from 2D to 3D, of simple geometry to complex, may be modelled, analysed, designed, and optimized using a practical and intuitive object-based modelling environment that simplifies and streamlines the engineering process. An additional suite of advanced analysis features are available to users engaging state-of-the-art practice with nonlinear and dynamic consideration.

Integrated modelling templates, code-based loading assignments, advanced analysis options, design-optimization procedures, and customizable output reports all coordinate across a powerful platform to make ETABS especially useful for practicing professionals.

V. SEISMIC ANALYSIS

For the determination of seismic responses there is necessary to carry out seismic analysis of structure. The analysis can be performed on the basis of external action, the behaviour of structure or structural materials, and the type of structural model selected. Based on the type of external action and behaviour of structure, the analysis can be further classified as:

A. Linear Static Analysis

Linear static analysis or equivalent static method can be used for regular structure with limited height. Linear dynamic analysis can be performed by response spectrum method. The significant difference between linear static and linear dynamic analysis is the level of the forces and their distribution along the height of structure. Nonlinear static analysis is an improvement over linear static or dynamic analysis in the sense that it allows inelastic behaviour of structure. A nonlinear dynamic analysis is the only method to describe the

B. Non-Linear Static Analysis

Non-linear static analysis is the method of seismic analysis in which behaviour of the structure is characterized by capacity curve that represents the relation between the base shear force and the displacement of the roof. It is also known as Pushover Analysis.

C. Linear Dynamic Analysis

Linear Dynamic Analysis Response spectrum method is the linear dynamic analysis method. In that method the peak response of structure during an earthquake is obtained directly from the earthquake response, but this is quite accurate for structural design applications.

D. Nonlinear Dynamic Analysis

Nonlinear Dynamic Analysis It is known as Time history analysis. It is an important technique for structural seismic analysis especially when the evaluated structural response is nonlinear.

VI. NON-LINEAR DYNAMIC ANALYSIS – TIME HISTORY ANALYSIS

Nonlinear dynamic analysis is most accurate method to determine the seismic responses of structures. In this method the structure is subjected to actual ground motion which is the representation of the ground acceleration versus time. The ground acceleration is determined at small time step to give the ground motion record. Then the structural response is calculated at every time instant to know its time history and the peak value of this time history is chosen to be design demand. Hence “A
mathematical model directly incorporating the nonlinear characteristic of individual component and element of the building shall be subjected to earthquake shaking represented by ground motion time history to obtain forces and the displacement. Since numerical model directly accounts for the effect of material nonlinearity, inelastic responses and calculated internal forces will be reasonably approximate to those expected during the design earthquake. There are two methods by which the time history analysis is carried out: a) Nonlinear Modal Time History Analysis b) Nonlinear Direct Integration Time History Analysis.

A. Non-Linear Modal Time History Analysis

As mentioned earlier, from the fundamental of structural dynamics it is clear that the response of the MDOF system can be estimated from its modal responses. In this analysis, also called as Response history Analyses, the modal load vectors are determined for the predefined no of modes. For the selected mode, the static analysis of the structure is carried out to estimate its modal static responses, the structure being subjected to corresponding modal load vector. Then the dynamic analysis of the corresponding ESDOF system is carried out to get its spectral ordinates at every time step. This spectral ordinate at each time step is multiplied with the corresponding modal static response to get the actual Time history of that response for that modal quantity. The same procedure is carried out to other modes and corresponding modal response history is determined. These modal responses are then added at each time step to get the time history of the selected response for the design ground motion record.

B. Nonlinear Direct Integration Time History Analysis

The fundamental equation governing the response of MDOF system subjected to ground acceleration is given by

$$m\ddot{u} + c\dot{u} + fs(u)\sin(\dot{u}) = -m\ddot{g}(t)$$

The only unknown quantity in the above expression is the displacement vector u. In this method, the above equation is formulated for the entire structure at every time step at which the ground acceleration is determined. This equation is then solved by any of the well-known methods to get directly the displacement at each time step. The other response quantity time history is then calculated from known displacement time history.

GEOMETRY OF THE STRUCTURE

![Figure 4.7 (h) Hinge pattern infill as masonry wall frame 20 Storey building](image)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Roof Displacement</th>
<th>A-B</th>
<th>B-IO</th>
<th>10-LS</th>
<th>LS-CP</th>
<th>CP-C</th>
<th>C-D</th>
<th>D-E</th>
<th>&gt;E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>366 mm</td>
<td>3265</td>
<td>655</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3920</td>
</tr>
</tbody>
</table>

The drift ratio of the building is 0.366/64 = 0.00571 = 0.571% < 1%

VII. CONCLUSION

1) Due to presence of the infill wall (as membrane) displacement at top storey decreases to 33%, 19% and 7% for four, eight, twenty stores (respectively) with respect to bare frame. From the above observation it can be seen that due to enhance height of the building influence of stiffness of the infill wall will be less, thus it should be used more lateral load resistant system to increase the stiffness of the multi-storey building. And results show that stiffness of the infill walls (as membrane) is efficient for building with low and medium height.

2) Due to presence of the infill as equivalent strut, displacement at top storey decreases to 25%, 16%, and 5% for four, eight, twenty stores (respectively) with respect to bare frame.

3) The seismic analysis of RC frames should be done by considering the infill walls in the analysis. For modeling the infill wall the equivalent diagonal strut method can be effectively used.

REFERENCES