A Review On Pushover Analysis on RCC works

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Abstract

After 2001 Gujarat Earthquake and 2005 Kashmir Earthquake, there is a nation-wide attention to the seismic vulnerability assessment of existing buildings. There are many literatures available on the seismic evaluation procedures of multi-storeyed buildings using nonlinear static (pushover) analysis. There is no much effort available in literature for seismic evaluation of existing bridges although bridge is a very important structure in any country. There are presently no comprehensive guidelines to assist the practicing structural engineer to evaluate existing bridges and suggest design and retrofit schemes.

Keyword*- Earthquake, Construction , multi-storeyed buildings*

Introduction

India has had a number of the world's greatest earthquakes in the last century. In fact, more than fifty percent area in the country is considered prone to damaging earthquakes. The north-eastern region of the country as well as the entire Himalayan belt is susceptible to great earthquakes of magnitude more than 8.0. After 2001 Gujarat Earthquake and 2005 Kashmir Earthquake, there is a nation-wide attention to the seismic vulnerability assessment of existing buildings. Also, a lot of efforts were focused on the need for enforcing legislation and making structural engineers and builders accountable for the safety of the structures under seismic loading. The seismic building design code in India (IS 1893, Part-I) is also revised in 2002. The magnitudes of the design seismic forces have been considerably enhanced in general, and the seismic zonation of some regions has also been upgraded. There are many literature (*e.g.*, IITM-SERC Manual, 2005) available that presents step-by-step procedures to evaluate multi-storeyed buildings. This procedure follows nonlinear static (pushover) analysis as per FEMA 356.

Literature review

The use of the nonlinear static analysis (pushover analysis) came in to practice in 1970's but the potential of the pushover analysis has been recognised for last 10-15 years. This procedure is mainly used to estimate the strength and drift capacity of existing structure and the seismic demand for this structure subjected to selected earthquake. This procedure can be used for checking the adequacy of new structural design as well. The effectiveness of pushover analysis and its computational simplicity brought this procedure in to several seismic guidelines (ATC 40 and FEMA 356) and design codes (Eurocode 8 and PCM 3274) in last few years. Pushover analysis is defined as an analysis wherein a mathematical model directly incorporating the nonlinear load-deformation characteristics of individual components and elements of the building shall be subjected to monotonically increasing lateral loads representing inertia forces in an earthquake until a 'target displacement' is exceeded. Target displacement is the maximum displacement (elastic plus inelastic) of the building at roof expected under selected earthquake ground motion. Pushover analysis assesses the structural performance by estimating the force and deformation capacity and seismic demand using a nonlinear static analysis algorithm. The seismic demand parameters are global displacements (at roof or any other reference point), storey drifts, storey forces, component deformation and component forces. The analysis accounts for geometrical nonlinearity, material inelasticity and the redistribution of internal forces. Response characteristics that can be obtained from the pushover analysis are summarised as follows:

a) Estimates of force and displacement capacities of the structure. Sequence of the member yielding and the progress of the overall capacity curve.
b) Estimates of force (axial, shear and moment) demands on potentially brittle elements and deformation demands on ductile elements.

c) Estimates of global displacement demand, corresponding inter-storey drifts and damages on structural and non-structural elements expected under the earthquake ground motion considered.
d) Sequences of the failure of elements and the consequent effect on the overall structural stability.
e) Identification of the critical regions, where the inelastic deformations are expected to be high and identification of strength irregularities (in plan or in elevation) of the building.

Pushover analysis delivers all these benefits for an additional computational effort (modelling nonlinearity and change in analysis algorithm) over the linear static analysis. Step by step procedure of pushover analysis is discussed next.

Methodology

The selected bridge model is analysed using upper bound pushover analysis. This chapter presents elastic modal properties of the bridge, pushover analysis results and discussions. Pushover analysis was performed first in a load control manner to apply all gravity loads on to the structure (gravity push). Then a lateral pushover analysis in transverse direction was performed in a displacement control manner starting at the end of gravity push. The results obtained from these analyses are checked against the seismic demand corresponds to the Zone V (PGA = 0.36g) of India.

Modal Properties

Modal properties of the bridge model were obtained from the linear dynamic modal analysis. Table 4.1 shows the details of the important modes of the bridge in transverse direction (Y direction). The table shows that participating mass ratio in the first mode is only 56% cumulative mass participating ratio for first four modes is 65%. Therefore, unlike regular buildings the higher mode participation in the response of bridge is significant. Figs. 4.1 and 4.2 present the first four mode shapes in the transverse direction. One of the main assumptions for the standard pushover analysis (FEMA 356) is hundred percent fundamental mode contributions in the structural response which is not true for the bridges. Therefore, standard pushover analysis as per FEMA 356 is not suitable for the bridges.

Conclusion

i) Here the performance of the bridge, according to FEMA-356 and UBPA, is not acceptable. Therefore it requires retrofitting.
ii) The distributions of the hinges are different for the two pushover analyses carried out in this study. For FEMA-356 loading hinges are concentrated at the middle of the bridges.

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