Pushover Analysis of Existing RC Frame Structure: A State of the Art Review

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Abstract - *The method of Pushover analysis is to observe the successive damage states of a building. this method is relatively simple to be implemented and provides information on strength and deformation and ductility of the structure and distribution of demands which help in identifying the critical member likely to reach limit states during the earthquake and hence proper attention can be given while design and detailing. Modeling for such analysis requires the nonlinear properties of each component in the structure of the determination, quantified by strength and deformation capacities, which depend on modeling assumption . In this building frame is designed as per Indian standard i.e. IS-456:2000 and IS-1893:2002 and IS-875:1987. The study of the main objective to check performance of building when designed as per Indian Standard. The structural engineering profession has been using the nonlinear static procedure or pushover analysis described in FEMA-356 and ATC-40, when pushover analysis is used carefully it provides useful information that cannot be obtained by linear static or dynamic analysis procedure. The reinforced concrete structure are analyzed by nonlinear static analysis (Pushover analysis) .Using structural analysis and design ETABS 2016 Software. the present study is to evaluate the behaviour of two typical new R.C.C building regular and irregular structure were taken for analysis G+8 and G+12 floors reinforced concrete frame structure subjected to earthquake forces in Zone II. The paper gives the study of different literature investigation taken on pushover analysis.*

Key Words: **Earthquake, standards and specifications, Base shear, storey shear, pushover analysis , response spectrum method , Capacity Gravity and Seismic load.**

1. INTRODUCTION

The static pushover analysis is becoming a popular tool for seismic performance evolution of existing and new structures . Earthquake is known to be one of the most destructive phenomenon experienced on earth . It is caused due to a sudden release of energy in the earth's crust which results in seismic waves. When the seismic waves reach the foundation level of the structure, it experiences horizontal and vertical motion at ground surface level. Due to this, earthquake is responsible for the damage to various man-made structures like buildings, bridges, roads, dams, etc. It also causes landslides, liquefaction, slope-instability and overall loss of life and property the expectation is that the pushover analysis will provide adequate information on seismic demands imposed by the design ground motion on the structural system and its components. the pushover analysis of a structure is static non-linear analysis under permanent vertical loads and gradually increasing lateral loads the equivalent static lateral loads approximately represent earthquake induced forces. the capacity of structure is represented by pushover curve. the most convenient way to plot he load deformation curve is by tracking the bas shear and the roof displacement. amongst the natural hazards, earthquakes have the potential for causing the greatest damages. since earthquake forces are random in nature & unpredictable , earthquake loads are to be carefully modeled so as to assess the real behavior 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 procedure the promise of performance based seismic engineering (PBSE) is to produce structure with predictable seismic performance. the identifying and assessing performance capability of a building is an integral part of the design process. there is a big space in the qualitative comprehension of the response history of the system as well as difficulties in verification of results. Pushover analysis uses lateral external static forces at floor levels in combination with inelastic response spectra.

2. Planning For RC Frame Structure

RCC Frames regular and irregular structure with G+8 and G+12 have been considered in the study. Fundamental period of vibration of the frame with fixed support .In this building frame is designed as per Indian standard i.e. IS-456:2000 and IS-1893:2002 and IS-875:1987 and model analysis has been evaluated. In order to understand the effect of pushover analysis of existing RC frame structure base model using ETABS 2016. Response spectrum method and Pushover analysis of the models are performed using ETABS 2016 .

Table -1: Design Content

No. of stories	G+8 and G+12
Floor to Floor Height	3000 mm
Beam size	450*300 mm
Column size:	450*450 mm

Thickness of slab	150 mm
Density of concrete	25kN/m³
Soil Type	Medium
Zone Factor(Z)	0.36
Important factor(I)	1
Response reduction factor(R)	5
Grade of Concrete	M25 and M30
Grade of Steel	Fe415

2.1. PERFORMANCE BASED DESIGN

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. These is a major shift from traditional structural design concepts and represents the future of earthquake engineering. This provides procedure a method for determining acceptable levels of earthquake damage. Also, it is based on the recognition that yielding does not constitute failure and that preplanned yielding of certain members of a structure during an earthquake can actually help to save the rest of the structure.

2.2. STATIC NON-LINEAR ANALYSIS

In performance based design response of structure is considered beyond elastic limit as opposed to code based approach. Static non-linear analysis is one of the analysis technique used for performance based design. Two types of pushover analysis are as:

Force controlled

Used when load is known and structure is desired to support this load. For gravity load on structure force controlled, push over analysis is used.

Displacement controlled

Used when load is unknown but displacement is known and structure is desired to lose their strength and become unstable. For lateral load on structure displacement controlled, pushover analysis is used.

Three main steps involved in this analysis procedure.

1. Evaluation of Capacity of building i.e. Representation of the structure's ability to resist a force.

2. Evaluation of Demand curve i.e. Representation of earthquake ground motion.

3. Determination of Performance point i.e. Intersection point of demand curve and capacity.

Capacity

The increasing lateral displacement as a function of the simplified non-linear procedure is followed for the generation of the capacity curve.

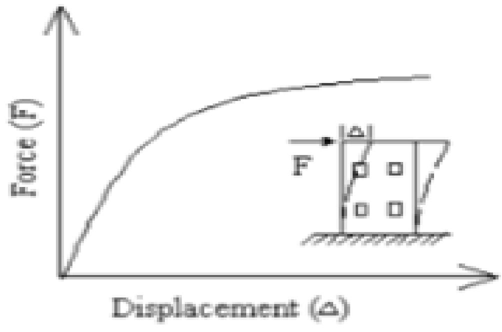

Fig 1. Force and Displacement Graph…

Demand

Spectral Acceleration (Sa) versus Time Period (T) curve is given in IS:1893(Part1)-2002 which is converted in to Spectral Acceleration (Sa) versus Spectral Displacement (SD) curve. The Capacity curve and Demand curve are generated in spectral coordinates to find out performance point.

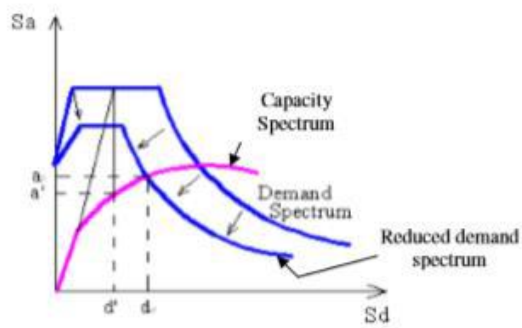

Fig 2. Sa and Sd Graph.

Performance

The intersection of the pushover capacity and demand spectrum curves defines as the "performance point" as shown in fig.

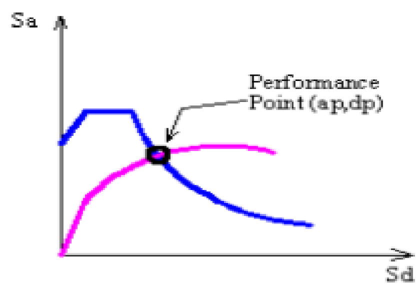

Fig 3. Performance Point

2.3. Calculation of Design Seismic Force

The Seismic load values were calculated as per IS1893-2016.ETABS has a seismic load generator is mentioned accordance with the IS code.The design Base Shear is computed by ETABS in accordance with the IS:1893(Part1)-2016

$$V=A_h*W$$

Where A_h=Design Horizontal acceleration spectrum which is calculated as follows

$$Ah = \frac{ZISa}{2Rg} \quad \text{. Equation (1)}$$

The natural period of vibration in seconds of a moment resisting frame with brick infill panels to be estimated by empirical expression as per IS:1893(Part1)-2016

$$T = \frac{0.09h}{\sqrt{d}} \quad \text{. Equation (2)}$$

Where d=base dimension of building at plinth level distribution of design force .

The design of base shear V_b shall be distributed along the height of the building as per in the following

$$Qi = Vb\frac{Wih i^2}{\sum_{i=1}^{n} Wih i^2} \quad \text{. Equation (3)}$$

Where,

Q_i=Design lateral force at floor i

W_i=Seismic Weight of floor i

H_i =Height of floor measured from base

N=No of stories in building

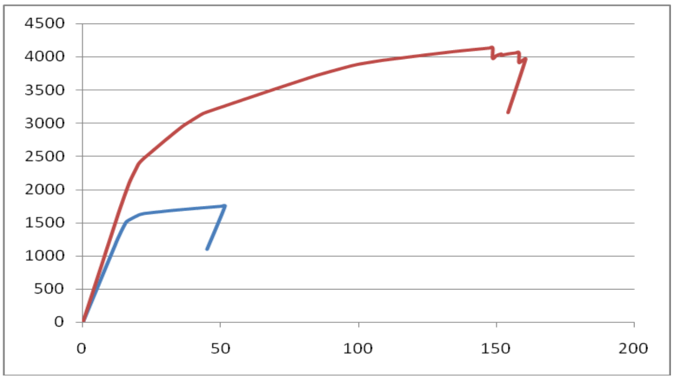

Fig 4. Capacity and demand curves for irregular structure PUSH X and PUSH Y S load case.

Chart -1: **Pushover Curve Result**

The study is based on frames which are plane and orthogonal with storey heights and bay widths. Different building geometries were taken for the study. These building geometries represent varying degree of irregularity or amount of existing . Three different width categories, ranging from 6 to 6 bays (in the direction of earthquake) with a uniform bay width of 4m were considered for this study. It should be noted that bay width of 4m – 4m is the usual case, especially in Indian and European practice. Similarly, four different height categories were considered for the study, ranging from 5 to 12 storey's.

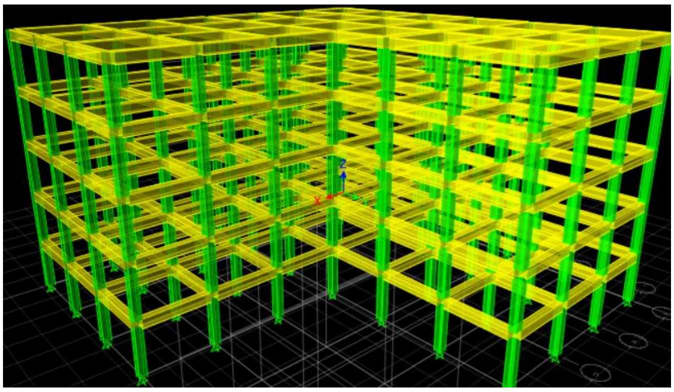

Fig -1: Irregular Structure

3. CONCLUSIONS

Based on the work presented in this thesis following point-wise conclusions can be drawn:

A detailed literature review on existing buildings conclude that the displacement demand is dependent on the geometrical configuration of frame and concentrated in the neighborhood of the existing for existing structures. The higher modes significantly contribute to the response quantities of existing structure. Also conventional pushover analysis seems to be underestimating the response quantities in the upper floors of the irregular frames.

As the shape of the triangular load pattern and first mode shape are similar for mid-rise regular buildings and close for high-rise and existing buildings, the resulting pushover curves are found to be similar for almost all the building studied here.

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