PUSHOVER ANALYSIS OF SHEAR WALL RC FRAMED BUILDING

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ABSTRACT

Over the past several years, seismic design codes which have consequently been updated for the seismic rehabilitation of buildings have become more stringent for the implementation of Performance Based Design principles, especially for existing structures. Performance-Based Design requires rigorous nonlinear analysis. The structural safety for seismic loading is one of the most important factor along with building serviceability and potential for economic loss during major earthquakes. As multi-storeyed structures are coming up in large numbers, the designers are in a necessity to provide adequate lateral strength and stability against the earthquake and wind loads. Hence in order to provide the lateral strength and stability, shear walls are introduced into the high-rise buildings. This paper deals with the non-linear analysis of shear wall in a building frame. In this present study, the focus is to identify effective location of shear wall in multi-storey building.

Key words: *Seismic Areas, Structural Safety, Pushover Analysis, Shear Wall.*

INTRODUCTION

The demand of skyscrapers (tall buildings) is increasing in both residential and commercial areas. This increases the effect of lateral loads like wind loads and earthquake loads on the structure. The Concept of seismic design is to provide building structure with sufficient strength and deformation capacity to sustain seismic demands imposed by ground motion with adequate margin of safety. Even if the probability of occurrence of earthquake within the life span of structures is very less, strong ground motion would generally cause greater damage to the structure. For designing the structures for this combination having less probability and extreme loading, a criterion is adopted in such a way that a major earthquake, with a relatively low probability of occurrence is expected to cause significant damage which may not be repairable but not associated with loss of life Performance based seismic design is gaining popularity from last decades. Hence designers are provided with a responsibility to ensure adequate strength and stability against lateral loads. For this purpose, shear walls are introduced into the system, they can form an efficient lateral force resisting system. Structural behaviour under seismic loading requires an understanding of the behaviour under large inelastic deformations. Pushover Analysis (Non-linear Static Analysis) is a procedure that is used to evaluate the building loaded beyond elastic range.

OBJECTIVES

1) To develop a complete comprehensive model of the Symmetric and Asymmetric Building Structures
2) To design the buildings as per IS codal provisions
3) To compare the results of Pushover Analysis with the Nonlinear Dynamic Time History Analysis

4) To determine the most effective pushover methods for the building structures
5) To determine the response of the symmetrical and asymmetrical building structures by nonlinear (static)
pushover analysis for five different earthquake ground motions

Literature Review

J. B. Mander (2001) reviewed from an historical perspective past and current developments in earthquake engineered structures. Based on the present state-of-the-practice in New Zealand, and a world-view of the state-of-the-art, he argued that in order to make progress towards the building of seismic resilient communities, research and development activities should focus on performance-based design which gives the engineer the ability to inform clients/owners of the expected degree of damage to enable a better management of seismic risk. To achieve expected performance outcomes, it will be necessary to supplement, current force-based design standards with displacement-based design methodologies.

Anuj Chandiwala et al (2012) the researcher, had tried to get moment occur at a particular column including the seismic load, by taking different lateral load resisting structural systems, different number of floors, with various positions of shear wall for earthquake zone III in India has been selected. Demand of earthquake resisting building which can be fulfilled by providing the shear wall systems in the buildings.

Y.M.Fahan et al (2009) explained the proper modelling of the shear walls is very important for both linear and nonlinear analyses of building structures. In linear analyses of structures, Reinforced concrete (RC) shear walls are modelled utilizing different techniques either using shell elements or combination of frame elements.

R. K. Goel and A. K. Chopra presented an improved Direct Displacement-Based Design Procedure for Performance-Based seismic design of structures. Direct displacement-based design requires a simplified procedure to estimate the seismic deformation of an inelastic SDF system, representing the first (elastic) mode of vibration of the structure.

A. Whittaker, Y. N. Huang et al (2007) summarize the next (second) generation tools and procedures for performance-based earthquake engineering in the United States. The methodology, which is described in detail in the draft Guidelines for the Seismic Performance Assessment of Buildings, builds on the first-generation deterministic procedures, which were developed in the ATC-33 project in the mid-1990s and in ASCE Standard: ASCE/SEI 41-06 Seismic Rehabilitation of Existing Buildings.

Description of pushover analysis

INTRODUCTION

The pushover analysis of a structure is a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static lateral loads approximately represent earthquake induced forces. A plot of the total base shear versus top displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity. On a building frame, and plastic rotation is monitored, and lateral inelastic forces versus displacement response for the complete structure is analytically computed. This type of analysis enables weakness in the structure to be identified. The decision to retrofit can be taken in such studies.

ANALYSIS

The seismic design can be viewed as a two-step process.

1. The first, and usually most important one, is the conception of an effective structural system that needs to be configured with due regard to all important seismic performance objectives, ranging from serviceability considerations. This step comprises the art of seismic engineering. The rules of thumb for the strength and stiffness targets, based on fundamental knowledge of ground motion and elastic and inelastic dynamic response characteristics, should suffice to configure and rough-size an effective structural system. Elaborate mathematical/physical models can only be built once a structural system has been created. Such models are needed to evaluate seismic performance of an existing system and to modify component behaviour characteristics (strength, stiffness, deformation capacity) to better suit the specified performance criteria.

2. The second step consists of the design process that involves demand/capacity evaluation at all important capacity parameters, as well as the prediction of demands imposed by ground motions. Suitable capacity parameters and their acceptable values, as well as suitable methods for demand prediction will depend on the performance level to be evaluated. The implementation of this solution requires the availability of as set of ground motion records (each with three components) that account for the uncertainties and differences in severity, frequency characteristics, and duration due rapture characteristics distances of the various faults that may cause motions at the site. It requires further the capability to model adequately the cyclic load-deformation characteristics of all important elements of the three-dimensional soil foundation structure system, and the availability of efficient tools to implement the solution process within the time and financial constraints on an engineering problem.

There are several types of sophistication that can be used over for pushover curve analysis.

Level-1: It is generally used for single storey building, where at a single concentrated horizontal force equal to base shear applied at the top of the structure and displacement is obtained.

Level-2: In this level, lateral force in proportion to storey mass is applied at different floor levels in accordance with IS:1893-2002 (Part-I) procedure, and story drift is obtained.

Level-3: In this method, lateral force is applied in proportion to the product of storey masses and first mode shape elastic model of the structure. The pushover curve is constructed to represent the first mode response of structure based on the assumption that the fundamental mode of vibration is the predominant response of the structure. This procedure is valid for tall buildings with fundamental period of vibration upto 1 sec.

Level-4: This procedure is applied to soft storey buildings, wherein lateral force in proportion to product of storey masses and first mode of shape of elastic model of the structure, until first yielding, the forces are adjusted with the changing the deflected shape.

Level-5: This procedure is similar to level 3 and level 4 but the effect of higher mode of vibration in determining yielding in individual structural element are included while plotting the pushover curve for the building in terms of the first mode lateral forces and displacements. The higher mode effects can be determined by doing higher mode pushover analysis. For the higher modes, structure is pushed and pulled concurrently to maintain the mode shape.

Case Study of Non-Linear Static Analysis using SAP 2000

The recent advent 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 criterion 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.

The ATC-40 and FEMA-273 documents have developed modelling procedures, acceptance criteria and analysis procedures for pushover analysis. These documents define force-deformation criteria for hinges used in pushover analysis. As shown in Figure 1, five points labelled A, B, C, D, and E are used to define the force deflection behaviour of the hinge and three points labelled IO, LS and CP are used to define the acceptance criteria for the hinge. (IO, LS and CP stand for Immediate Occupancy, Life Safety and Collapse Prevention respectively. The values assigned to each of these points vary depending on the type of member as well as many other parameters defined in the ATC-40 and FEMA-273 documents.

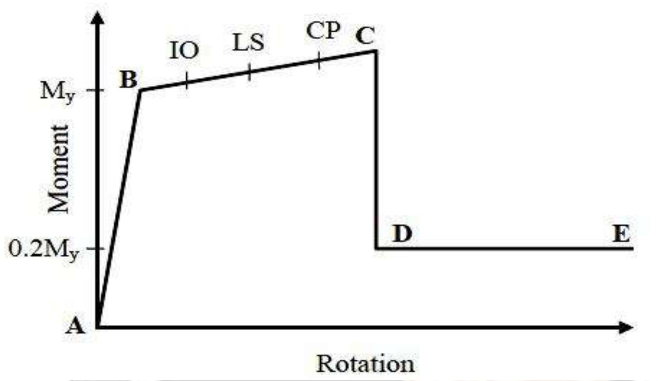

Figure 1: PERFORMANCE LEVEL OF PUSHOVER ANALYSIS

SAP2000, a state-of-the-art, general-purpose, three-dimensional structural analysis program, is used as a tool for performing the pushover. The SAP2000 static pushover analysis capabilities, which are fully integrated into the program, allow quick and easy implementation of the pushover procedures prescribed in the ATC-40 and FEMA-273 documents for both two and three-dimensional buildings.

MODEL GEOMETRY

Number of stories	4
Number X bays along X-direction	1
Number of bays along Z-direction	1
Storey Height	4 meter
Bay width along X-direction	5 meter
Bay width along Z-direction	5 meter
Grade of concrete	M-20
Grade of steel	Fe-415
Modulus of Elasticity of steel	21,0000 MPa
Modulus of Elasticity of concrete	22,360.68 MPa
Ultimate strain in bending	0.0035

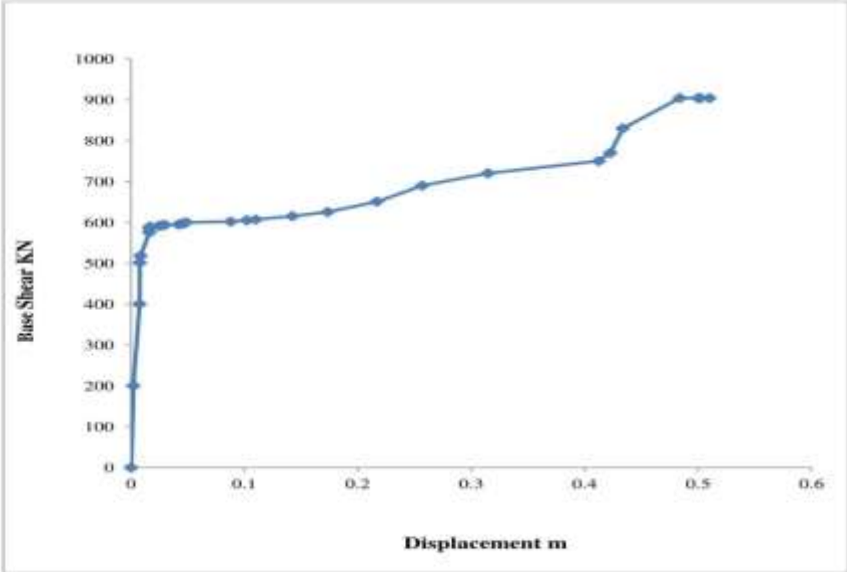

Figure 2. Pushover Curve of a Building

CONCLUSIONS

The frame behaved linearly elastic up to a base shear value of around 235 KN. At the value of base-shear 670KN, it depicted non-linearity in its behaviour. Increase in deflection has been observed to be more with load increments at base-shear of 670 KN showing the elasto-plastic behaviour. The joints of the structure have displayed rapid degradation and the inter storey deflections have increased rapidly in non- linear zone. Severe damages have occurred at joints at lower floors whereas moderate damages have been observed in the first and second floors. Minor damage has been observed at roof level.

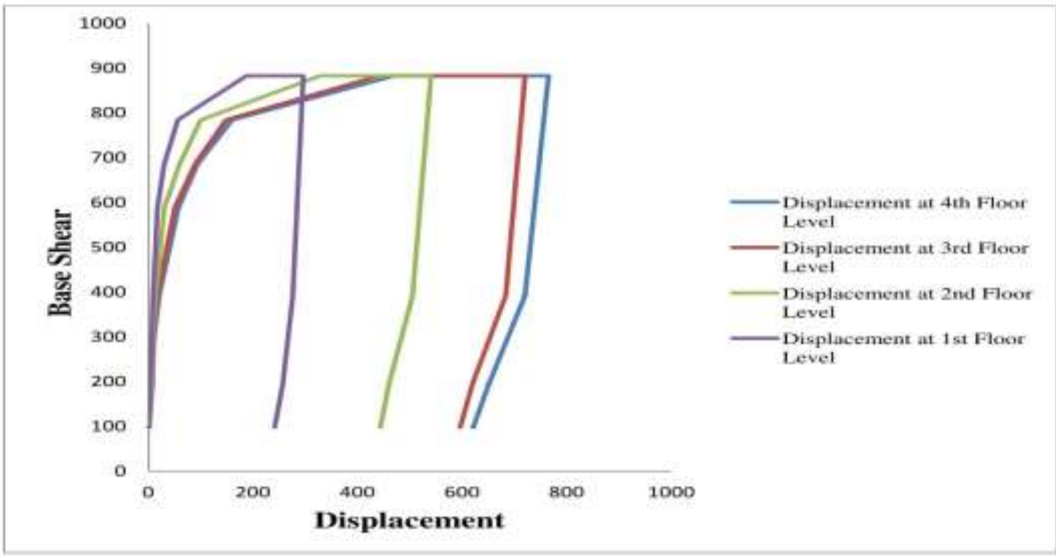

Figure 3. Combined Pushover Curve from Experimental Data (Reddy. et., al,2010)

The frame has shown variety of failures like beam-column joint failure, flexural failures and shear failures. Prominent failures are joint failures. Flexural failures have been seen in beams due to X-directional loading. It has been observed that the top storey experienced major damages in this case opposite to the case of frame.

REFERENCES

[1] Engineering structures journal, Vol. 20,1998 :- Pros and cons of a pushover analysis of seismic performance evaluation by Helmut Krawinkler and G.D.P.K. Seneviratna.
[2] CSI Reference Manual on SAP 2000 software.
[3] N.M.Nikam and L.G.Kalurkar, "Pushover Analysis of Building with Shear Wall" ILESC Vol.6 Issue No. 8.
[4] Made Sukrawa, "Earthquake response of RC infill frame with wall openings in lo w-rise hotel buildings" Science Direct, Procedia Engineering 125 (2015) 933 – 939.
[5] Rohit Bansal." PUSHOVER ANALYSIS OF REINFORCED CONCRETE FRAME". Thesis report in thapar university,2011.
[6] Nitin Choudhary and Prof. Mahendra Wadia," Pushover Analysis of R.C. Frame Building with Shear Wall", *IOSR-JMCE Volume 11, Issue 2 Ver. V (Mar- Apr. 2014), PP 09-13.*
[7] Mr.K.LovaRaju and Dr.K.V.G.D.Balaji," Effective location of shear wall on performance of building frame subjected to earthquake load" IASJSET *Vol. 2, Issue 1, January 2015*.