Nonlinear Static Analysis of Frames with various Bracing Arrangements

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Abstract— In last decades Steel structure has played an important role in construction Industry. It is necessary to design a structure to perform well under seismic loads. The seismic performance of a multi-story steel frame building is designed according to the provisions of the current Indian code (IS 800 -2007). The shear capacity of the structure can be increased by introducing Steel bracings in the structural system. Bracings can be used as retrofit as well. There are „n" numbers of possibilities to arrange Steel bracings such as D, K, and V type eccentric bracings. A typical six-story steel frame building is designed for various types of eccentric bracings as per the IS 800- 2007. D, K, and V are the different types of eccentric bracings considered for the present study. Performance of each frame is studied through nonlinear static analysis.

Key words: Pushover Analysis, Steel Frames, Bracings, Behavior Factor, Nonlinear

I. INTRODUCTION

In a decades ago Steel structure assumes an essential part in the development business. It is important to plan a structure to perform well under seismic burdens. Shear limit of the structure can be expanded by presenting Steel bracings in the basic framework. Bracings can be utilized as retrofit also. There are „n" quantities of potential outcomes are there to mastermind Steel bracings. For example, D, K, and V sort unpredictable bracings. Outline of such structure ought to have great flexibility property to perform well under seismic burdens. To appraise flexibility and different properties for every flighty supporting Push over examination is performed.

A basic PC based push-over investigation is a procedure for execution based outline of building structures subject to quake stacking. Push over examination accomplishes much significance in the previous decades because of its straightforwardness and the adequacy of the outcomes. The present investigation builds up a push-over examination for various offbeat steel outlines composed by IS-800 (2007) and pliability conduct of each edge.

A. Steel

Steel is by a wide margin most valuable material for building development on the planet. Today steel industry is the fundamental or key industry in any nation. It quality of around ten times that of solid, steel is the perfect material of current development. It"s for the most part focal points are quality, speed of erection, construction, and demount capacity. Auxiliary steel is utilized as a part of load-bearing casings in structures, and as individuals in trusses, scaffolds, and space outlines. Steel, be that as it may, requires fire and consumption security. In steel structures, claddings and separating dividers are comprised of stone work or different materials, and frequently a solid establishment is given. Steel is likewise utilized as a part of conjunction casing and shear divider development Due to its substantial quality to weight proportion, steel structures have a tendency to be more sparing than solid structures for tall structures and expansive traverse structures and extensions. Steel structures can be built quick and this empowers the structure to be utilized early in this way prompting general economy steel offers much preferred compressive and rigidity over cement and empowers lighter developments. To get the most advantage out of steel, steel structures ought to be composed and secured to oppose erosion and fire. They ought to be planned and point by point for simple creation and erection. Great quality control. The impacts of temperature should be considered in design. Steel structures are flexible and vigorous and can withstand serious loadings, for example, seismic tremors. Steel structures can be effortlessly repaired and retrofitted to convey higher burdens. Steel is one of the friendliest natural building materials – steel is 100% recyclable. To get the most advantage out of steel, steel structures ought to be outlined and ensured to oppose consumption and fire. They ought to be planned and definite for simple manufacture and erection. Great quality control is basic to guarantee legitimate fitting of the different basic components. The impacts of temperature ought to be considered in plan. To forestall improvement of breaks under weakness and tremor stacks the associations and specifically the welds ought to be composed and point by point appropriately. Unique steels and defensive measures for erosion and fire are accessible and the originator ought to be acquainted with the alternatives accessible. Since steel is created in the manufacturing plant under better quality control, steel structures have higher CHAPTER -2

II. LITERATURE REVIEW

A. General

To give a natty gritty survey of the writing identified with displaying of structures completely would be hard to address in this part. A short audit of past investigations on the use of the sucker examination of steel outlines is introduced is this area. This writing audit concentrates on late commitments identified with sucker examination of steel outlines and past endeavors most firmly identified with the necessities of the present work.

B. Literature review on pushover analysis

Anuja Dhatrak, Dr. R. S. Talikoti (2016),. In this studied non-linear analysis is carried out for high rise steel frame building with different bracing configuration. Steel braced frame is one of the structural systems used to resist lateral deflection of the structures. In this project a steel building model is taken, this model is compared in different aspects such as Natural frequencies, fundamental time period, inter story drift and base shear etc. using different bracing configuration in different locations. After the numbers of trial the results of seismic analysis of high rise steel building with different

pattern of bracing system which type of bracing at which location is more suitable would be selected for the structure.

C. N. Thombare (2016) et al Investigated of efficient configuration pallet racking system are modeled and analyzed on the general purpose FE platform under monotonic unidirectional lateral loads. The results of NSPA show that pallet racking system with horizontal and inclined bracing is more efficient as evidenced from good estimates of the overall displacement, base shear and yielding capacities.

C. Limitations of existing studies

Many experimental and analytical works has been done by many researchers in the area of the pushover analysis of the steel frames. The concept of pushover analysis is rapidly growing now a days. This research is concerned with the pushover analysis of the steel frames. The uses of pushover analysis of the steel frames have been studied extensively in previous studies. However, many researchers performed experimentally and analytically on the pushover analysis but limited work is done on the study of pushover analysis. Push over analysis is carried out using Seism structure (2012) software.

D. Closure

The literature review has suggested that use of a pushover analysis of the steel frame is feasible. So it has been decided to use Seism structure for the modeling and analysis. With the help of this software study of steel frame has been done.

III. PUSHOVER ANALYSIS – AN OVERVIEW

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 recognized for last two decades 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 (Euro code 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. The structural Pushover analysis assesses performance by estimating the force and deformation capacity and seismic demand using a nonlinear static analysis algorithm. The seismic demand parameters are storey drifts, global displacement (at roof or any other reference point), storey forces, and component deformation and component forces. The analysis accounts for material inelasticity, geometrical nonlinearity and the redistribution of internal forces. Response characteristics that can be obtained from the pushover analysis are summarized as follows:

- Estimates of force and displacement capacities of the structure. Sequence of the member yielding and the progress of the overall capacity curve
- Estimates of force (axial, shear and moment) demands on potentially brittle elements and deformation demands on ductile elements.
- Estimates of global displacement demand, corresponding inter-storey drifts and damages on structural and non-structural elements expected under the 20 earthquake ground motion considered.
- Sequences of the failure of elements and the consequent effect on the overall structural stability.
- Identification of the critical regions, when 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 (modeling nonlinearity and change in analysis algorithm) over the linear static analysis. Step by step procedure of pushover analysis is discussed next.

A. Introduction

The study in this thesis is based on nonlinear analysis of steel frames with eccentric bracings models. Different configurations of frames are selected such as D, K and V frames by keeping total weight of building is same. This chapter presents a summary of various parameters defining the computational models, the basic assumptions and the steel frame geometry considered for this study .Accurate modeling of the nonlinear properties of various structural elements is very important in nonlinear analysis. In the present study, beams and columns were modeled with inelastic flexural deformations using fiber based element using the software Seism structure.

B. Frame Geometry

The details of frames are obtained from literature (Adel Mere Özel, Ezra Mete Güneyisi, 2010).The buildings are assumed to be symmetric in plan, and hence a single plane frame may be considered to be representative of the building along one direction. Typical bay width and column height in this study are selected as 6m and 3m respectively. A configuration of 6 stories and 6 bays (G+5) is considered in this study. Different arrangements of steel frames such as K, D and V frames are considered as shown in fig. 1 on details of steel columns, beams and bracings

IV. RESULT ANALYSIS

The selected frame model is analyzed using pushover analysis. This chapter presents behavior factors for the different eccentric steel frames using pushover curves obtained from push over analysis. First natural time period Building and corresponding mode shape is calculated. Load for push over analysis is selected according to first mode shape. The results obtained from these analyses are compared in terms of behavior factors.

A. Pushover Curve

The pushover curves for all the steel frames with V type of bracing are shown in Fig 3. The type of curve is more close to an elastic plastic type. The initial slopes of the pushover curves are marginally same. The base shear capacity of steel

frame V1 is marginally more than that of other frames. It is observed that over strength is high for V1 frames and ductility is more for V4 frames among the V family type.

The pushover curves for all the steel frames with D type of bracings are shown in Fig 4. The initial slopes of the pushover curves are marginally different. The base shear capacity of steel frame D3 is marginally more than that of other frames. It is observed that over strength is high for D1 frames and ductility is more for D1 frame among the D family type.

The pushover curves for all the steel frames with K type of bracing are shown in Fig 5. The initial slopes of the pushover curves are marginally same. The base shear capacity of steel frame K3 is marginally more than that of other frames. It is observed that over strength is high for K1 frames and ductility is more for K4 frame among the K family type.

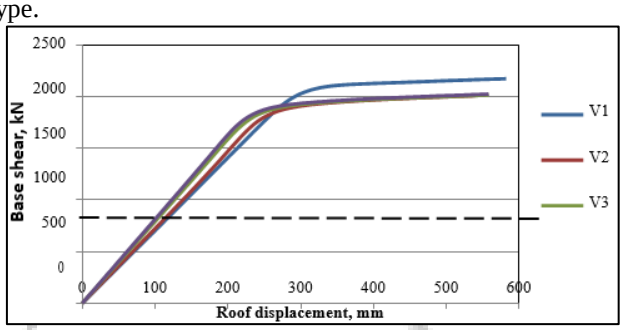

Fig. 1: Comparison of Push over analysis of V Type Frames

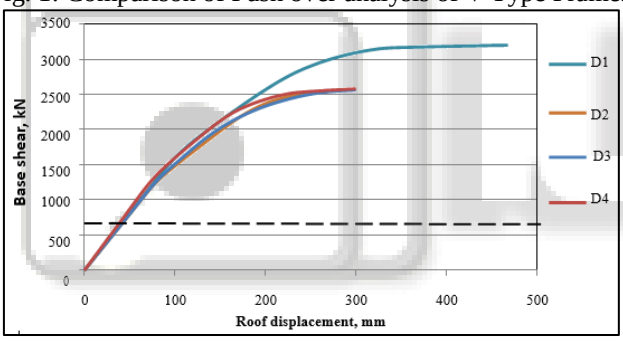

Fig. 2: Comparison of Push over analysis of D Type Frames

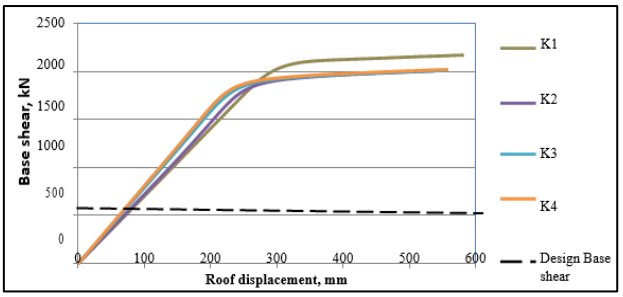

Fig. 3: Comparison of Push over analysis of K Frames

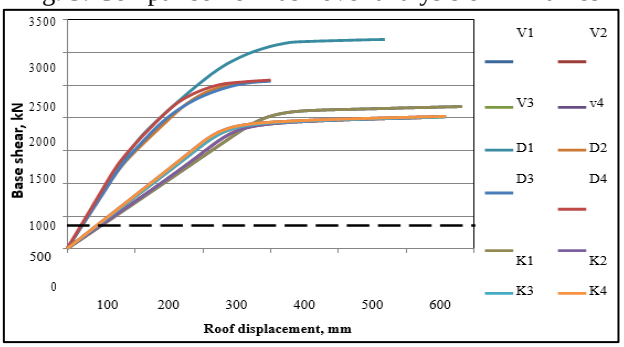

Fig. 4: Comparison of Push over analysis of all types of Frames selected

B. Performance Parameters

Table 1 illustrates various frames considered for the study, time periods and response reduction factors considered for the design. The parameters, displacement ductility (Reza Ambaries. al.(2013)), Rμ, Rs, and Y are calculated and depicted in the Table 1 for all the frames. From table 1. In order to find the effectiveness of each bracing arrangement, the frames with same weights are considered. It is seen that V4 and D4 have more ductility when compare with other frames. Ductility reduction factor is more for D1 type of frame marginally. V4 and D1 give more over-strength factor. K3 gives more allowable stress factor. It can be seen that with regard to the frames V1, V2, V3 and V4 the total weight is same, and the behavior factor, R are different. For the frame V4, the R factor is marginally more than that of others. Hence the bracing arrangement of the frame V4 can be treated as relatively efficient. But overall D1 frame shows more reduction factor as shown in table1. Similarly it is found that the bracing arrangement in D and K family, D1 & K4 respectively are found to be performing better compared to that of others.

Frame	Design R value	Ductility μ	Rμ	Rs	Y	Over strength	R	Total weight ton- force
V1	4	1.94	1.71	1.60	3.55	5.65	9.81	884
V2	4	2.20	1.82	2.56	2.02	5.33	9.54	884
V3	4	2.33	1.83	1.60	3.33	5.41	10.27	884
V4	4	2.43	1.92	2.67	2.01	5.43	10.47	884
D1	4	2.42	2.01	2.87	2.82	8.07	16.43	884
D2	4	1.90	1.67	2.33	2.65	6.25	10.45	884
D3	4	1.92	1.74	1.62	4.00	6.41	11.32	884
D4	4	2	1.76	2.05	3.05	6.40	11.45	884
K1	4	2.03	1.71	1.35	4.37	5.84	10.12	884
K2	4	2.11	1.80	1.43	3.65	5.13	9.34	884
K3	4	2.42	1.94	1.11	4.63	5.28	10.23	884
K4	4	2.43	1.93	1.31	3.94	5.29	10.34	884

Table 1: R factors parameters of the frames.

V. SUMMARY AND CONCLUSIONS

A. Summary

The selected frame models are analyzed using pushover analysis. The seismic performance of a multi-story steel frame building is designed according to the provisions of the current Indian code (IS 800 -2007). Shear capacity of the structure can be increased by introducing Steel bracings in the structural system. Bracings can be used as retrofit as well. There are „n" numbers of possibilities to arrange Steel bracings such as D, K, and V type eccentric bracings. A typical six-story steel frame building is designed for various types of eccentric bracings as per the IS 800- 2007. D, K, and V are the different types of eccentric bracings considered for the present study. Performance of each frame is studied through nonlinear static analysis. Fundamental period of the Building frames and corresponding mode shapes are calculated. Pushover curves and behavior factors for the different eccentric steel frames are compared to find the relative performances of various frames considered.

B. Conclusions

Following are the major conclusions obtained from the present study.

- Modal analysis of a 2D steel frame models reveals that, there is huge difference between Computational Time periods and IS code Time period.
- Ductility of a moment-resisting steel frame is to some extent affected by its height. When bracing systems are included, the height dependency of ductility is greatly magnified. Shorter
- Steel-braced dual systems exhibit higher ductility and therefore higher R factors.
- Considering the range of ductility capacities shown by different systems discussed, it is found that the bracing arrangement in D and K family, D1 & K4 respectively are found to be performing better compared to that of others.

VI. FUTURE SCOPE

- Future work can be carried out for across earth quick response of the tall building with respect to structural system. The different type of system may be introduce for resisting the lateral force.
- Lateral system along with the different type of combination may be used for resisting the lateral force.
- Analysis using the better technique, a details dynamic analysis can be carried out collecting the response of the tall building at every mode.
- A study can be done to these lateral system for marking more effective in earth quick as well as wind resisting design.

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