International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)

Impact Factor: 5.858 (SJIF-2019), e-ISSN: 2455-2585

Volume 6 , Issue 2 , February -2020

PERFORMANCE EVALUATION OF R.C. MOMENT RESISTING ASYMMETRIC FRAME UNDER SEISMIC LOADS USING NON-LINEAR DYNAMIC ANALYSIS

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***Abstract**—Engineering structures are often very complex and difficult to analyze for their dynamic, or vibrational, seismic behavior. Structures subjected to force such as earthquake must be structurally resisted as they are dynamic in nature.Hence, structure's response is also dynamic and that's what causes the unsafe and uncomfortable conditions. Modern performance-based design methods require ways ofidentifying the structure's realistic behavior of structures under such conditions. To determine structural response beyond the yield point, out of two types of nonlinearity i.e. material and geometrical, material nonlinearity is considered in present paper. Incremental dynamic analysis (IDA) as well as Static Pushover Analysis (SPA) includes performance- based structure analysis. But incremental dynamic analysis is pretty accurate, and this method can obtain actual response of the structure from the particular earthquake considered earthquake. It involves conducting a series of nonlinear dynamic analyzes in which the intensity of the ground motion selected for the collapse investigation is incrementally increments until the global collapse capacity of the structure is reached. In the present Paper, non-linear dynamic of reinforced concrete 8 storey building is carried out. The above frame is designed as per provisions of IS-456:2000, IS-1893(Part1):2016. Nonlinear Time History Analysis (NLTHA) & Incremental Dynamic Analysis (IDA) of above frames are performed using SeismoStruct Software. NLTHA and IDA will be performed for set of 6 artificial ground motions. Finally, Performance evaluation is done from the performance criteria mentioned in ATC-40 and FEMA-356 in terms of displacement profile and Interstorey Drift profile.*

***Keywords**— Plan Irregularity, Seismic Analysis, Non-Linear Dynamic Analysis, Seismic Risk Assessment, SeismoStruct*

INTRODUCTION

Building codes require that structures should be designed to withstand a certain intensity of ground acceleration, withthe intensity of the ground motion depending on the seismic hazard. Because of the high forces the earthquake imparts to the structure, the structures are usually designed to yield. The aim of the earthquake engineering is to reduce life loss due to the collapse of yielding system. However, the costs involved in replacing and rehabilitating structures damaged by the relatively moderate earthquakes have proven that the "life-safe" building design approaches are economically inefficient. As a result, the principle of "performance-based earthquake engineering" (PBEE) has been proposed which promotes the idea of designing structures with higher performance standards across multiple limits states. A new theoretical methodology, called incremental dynamic analysis (IDA), was developed in accordance with PBEE concepts to assist the engineer in assessing the efficiency of Structures.

The structural members capacity to undergo inelastic deformations governs the structural behavior and damageability of multi-storey buildings during earthquake ground moments. From this point of view, in addition to stresses caused by the amadous static forces as defined in serval seismic regulations and codes, evaluation and design of buildings should be focused on elastic deformations required by earthquakes. In general, researching the inelastic seismic responses of buildings is not only useful in improving the guidelines and code requirements to minimize potential damage to buildings, aut also critical in providing economic design by making use of the building's reserved strength as it experiences inelastic deformations.

NON-LINEAR DYNAMIC ANALYSIS

Nonlinear dynamic analysis is required by some building codes and guidelines for buildings of unusual configuration or of special importance. This method is the most rigorous and provides the most reliable on building response and performance. Displacement and acceleration demand at each story along with the force demand for each member is determined accurately. In order to perform dynamic response history analysis, it is necessary to define a complete hysteretic behavior of the materials and set of natural records.

A. Non-linear Time History Analysis (NLTHA)

Nonlinear time history analysis is the most accurate method used to predict seismic responses of structures that are subjected to ground motions. Computer software development causes this method to be widely used in design of new buildings over the past decade and it evaluating building performance. To perform nonlinear time history analysis, ground motions directly applied to the model, it needs a suitable ground motion. In non-linear time history analysis, the selection of ground motions should be accurate.

B. Incremental Dynamic Analysis (IDA)

This analysis method was adopted by the Federal Emergency Management Agency (FEMA 2000a) and is considered as the state of-the-art method to estimate the structural responses under seismic loadings. IDA is a parametric analysis that predicts full structural reactions and performances. In this analysis, a set of ground motion records are subjected to a properly defined structural model, and the intensity of those ground motions is gradually increased using scale factors. The intensity continues to rise when the entire structural responses ranges from elastic to the nonlinear followed by structural collapse.

METHODOLOGY

A. Description of Structure

8-storey asymmetric (U-Shape) RC moments resisting frame with typical storey heights of 3.50m and ground storey height of 4.5m is considered for the study. It was located in Zone-V and assumed to be constructed on firm soil condition. Response Reduction factor of 5 was used for design of special RC moment-frame. The loading considered was self- weight of beams, columns and slabs, floor finish and live load on slabs. The frame was then designed for load combination as per IS Code. The design acceleration spectrums were used, which corresponds to IS 1893 (Part 1): 2016 for firm soil for 5% damping. As per following table shows size of beam and column.

Floor No.	Beam Size	Column Size
1st	300 X 550	550 X 550
2nd	300 X 550	550 X 550
3rd	300 X 550	500 X 500
4th	300 X 500	500 X 500
5th	300 X 500	450 X 450
6th	300 X 400	400 X 400
7th	300 X 400	400 X 400
8th	300 X 400	400 X 400

Table -1 Beam and Column Size 8-storey

B. Methodology of Non-linear Time History Analysis

The most accurate method used to predict seismic responses of structures subjected to ground motions is the nonlinear time history analysis. Computer software development causes this method to be widely used in the design of new buildings and in the assessment of building performance over the past decade. There are two methods of achieving a structural model’s dynamic responses, which are direct time integration and modal superposition. Ground motions applied directly to the model to perform nonlinear time history analysis and it requires an effective ground motion. The nonlinear analyzes of time history presented herein belong to the method of direct integration which is a differential equation of second order. The equations of motion represented by MDOF model for a structural system are shown in the following equation below. At each time step this equation is solved and displacements are calculated:

$$M\ddot{U} + C\dot{U} + KU = -MI\ddot{u}_g$$

where:

M = the mass matrix
C = the damping matrix
K= the stiffness matrix
$\ddot{u}_g$=earthquake ground acceleration
U=displacement calculated

C. Formation of IDA Curve

Step1: Create an appropriate model.

Step2: Select pairs of ground motion records to perform dynamic response history analysis.

Step3: Select a ground motion Intensity Measure (IM) and a Damage Measure (DM).

Step4: Incrementally increase the IM level and run a nonlinear time history analysis each time, Stop incrementing when numerical non-convergence is first encountered.

As Shown in figure-1

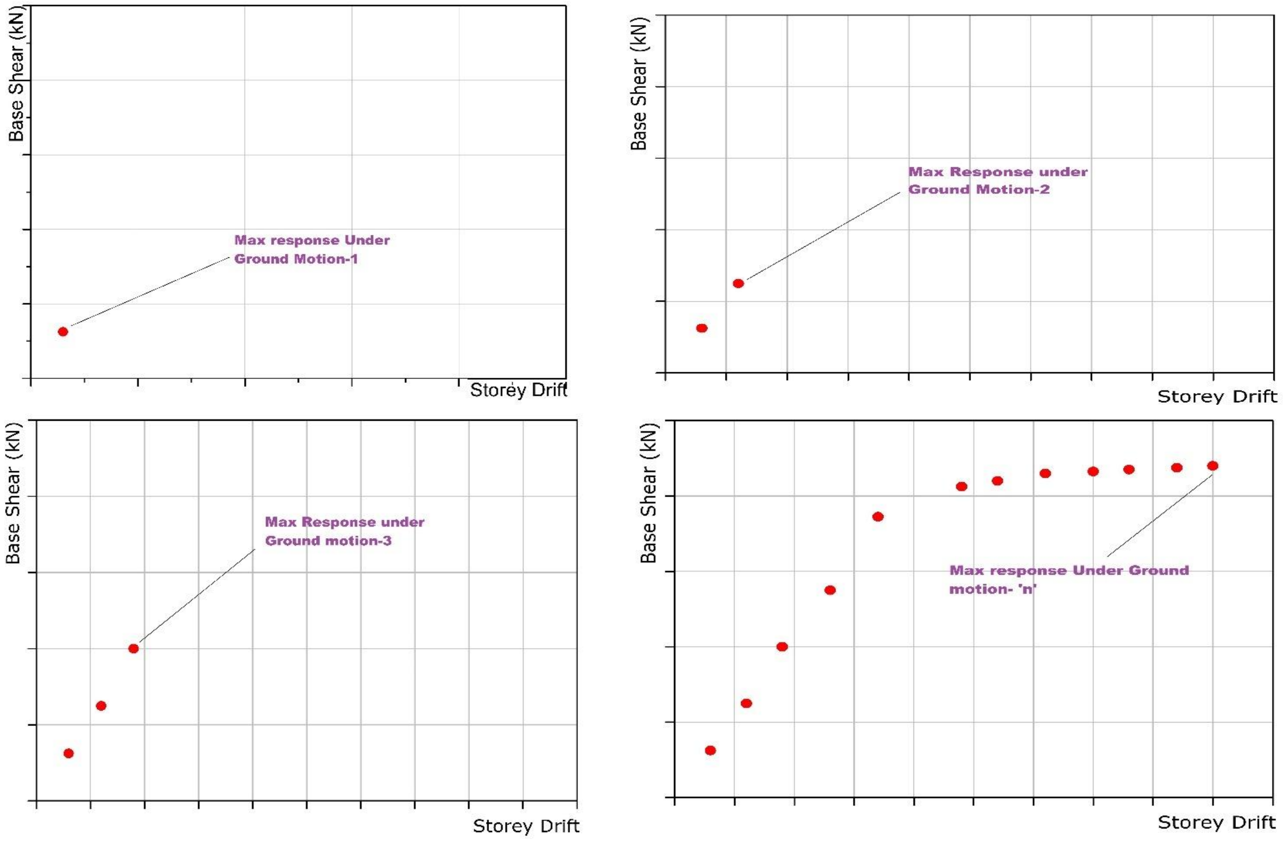


Figure-1 Formation of IDA curve

D. Selection of Ground Motions

The selection of ground motions is a major issue in the analysis of nonlinear time history. Factor affecting the selection of ground motions includes the severity of the earthquake, site condition and acceleration of ground. A set of 6 artificial ground motions. The Artificial ground motions were matched to IS response spectra as shown in Figure 2.

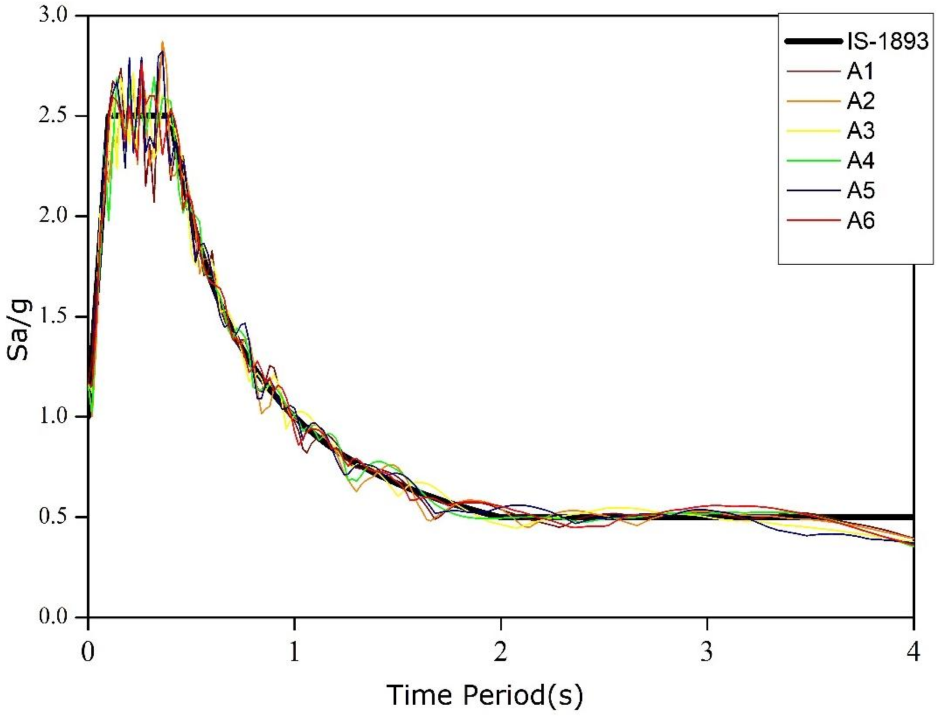
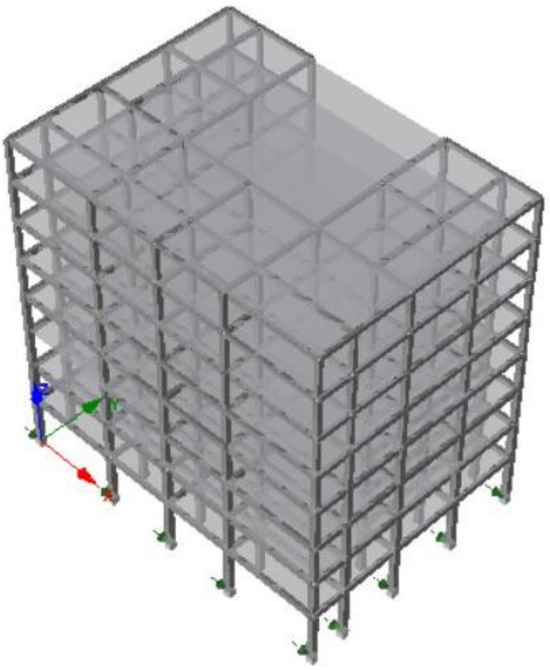
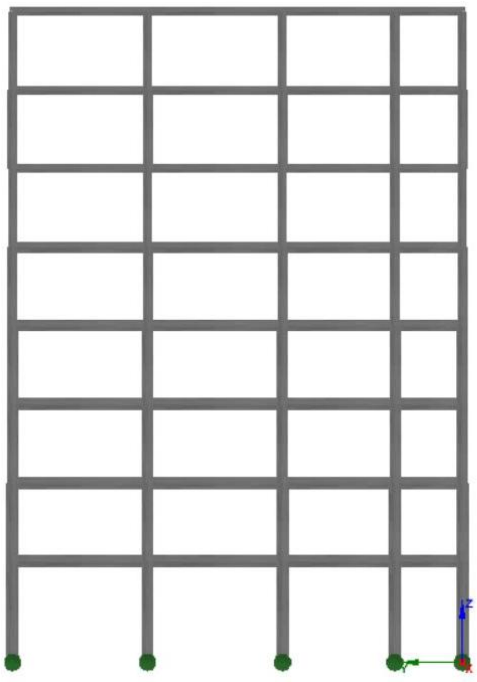


Figure-2 Response Spectrum of Artificial Ground Motions

E. Seismostruct Model





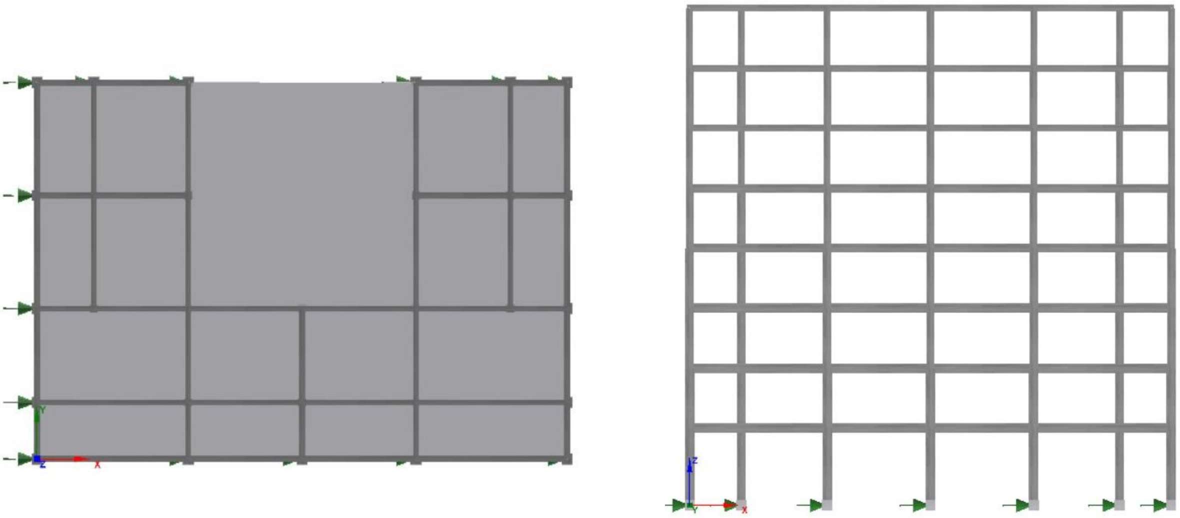


Figure-38-Storey (U-Shape) Seismostruct Model

RESULTS AND DISCUSSION

The nonlinear time history analysis was studied to examine the response of the 8-storey asymmetric RC frames subjected to varied earthquake excitations. In order to examine the structural response maximum storey drift is selected as damage measure. After analysis, the relative displacement at each storey are accurately determined. It should be noted that Interstorey drift ratio was computed as difference in a relative displacement of two intermediate floor levels divided by storey height. Displacement Profile of 8 storey for Artificial ground motions are shown in Figure 4, Inter Storey Drift Profile of 8 storey for Artificial ground motions are shown in Figure 5 and IDA for median with ATC-40 criteria shown in Figure 6.

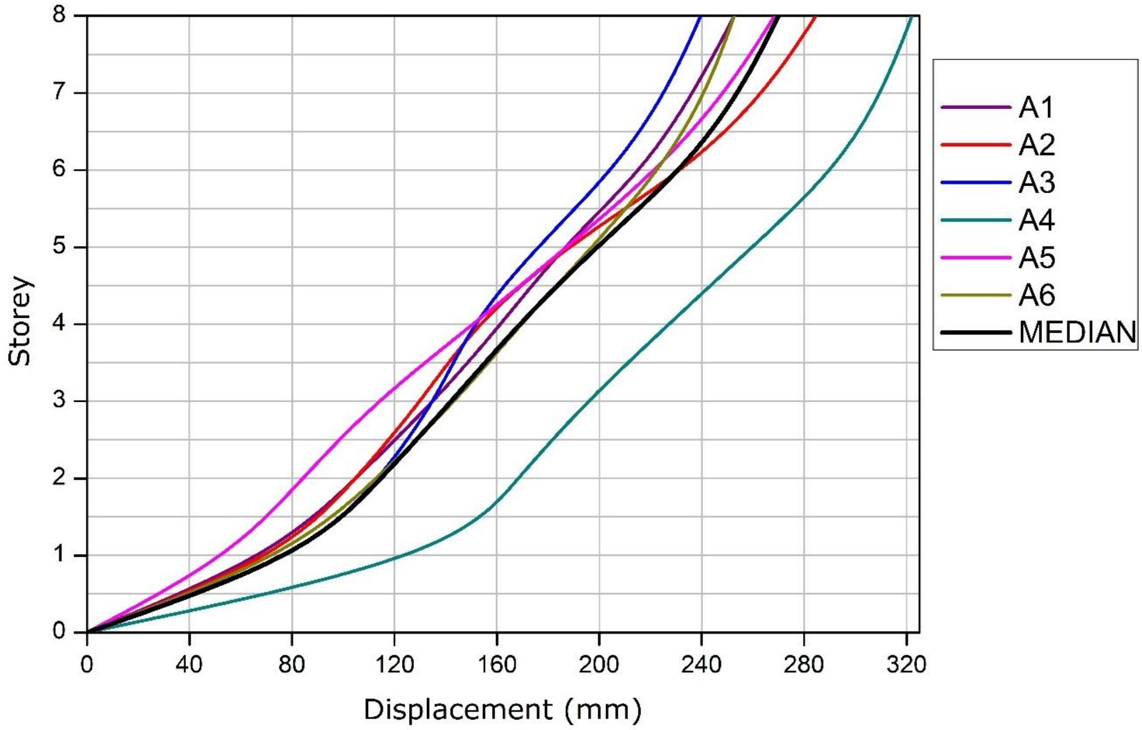


Figure-4 Displacement Profile

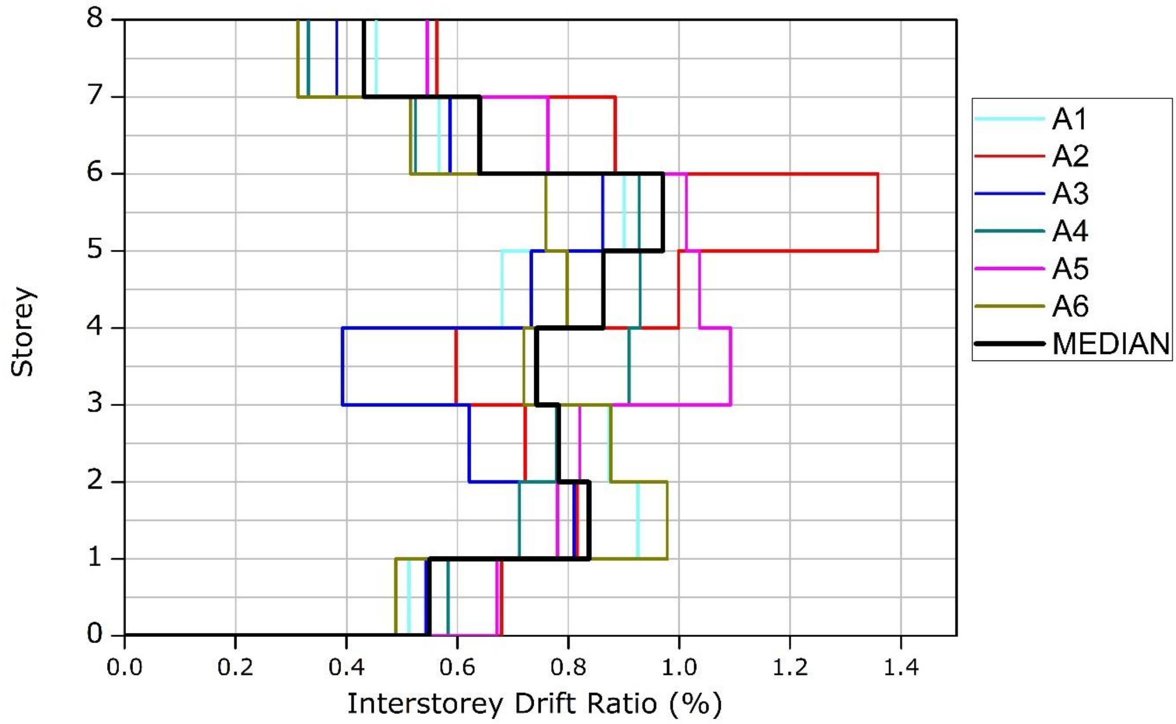
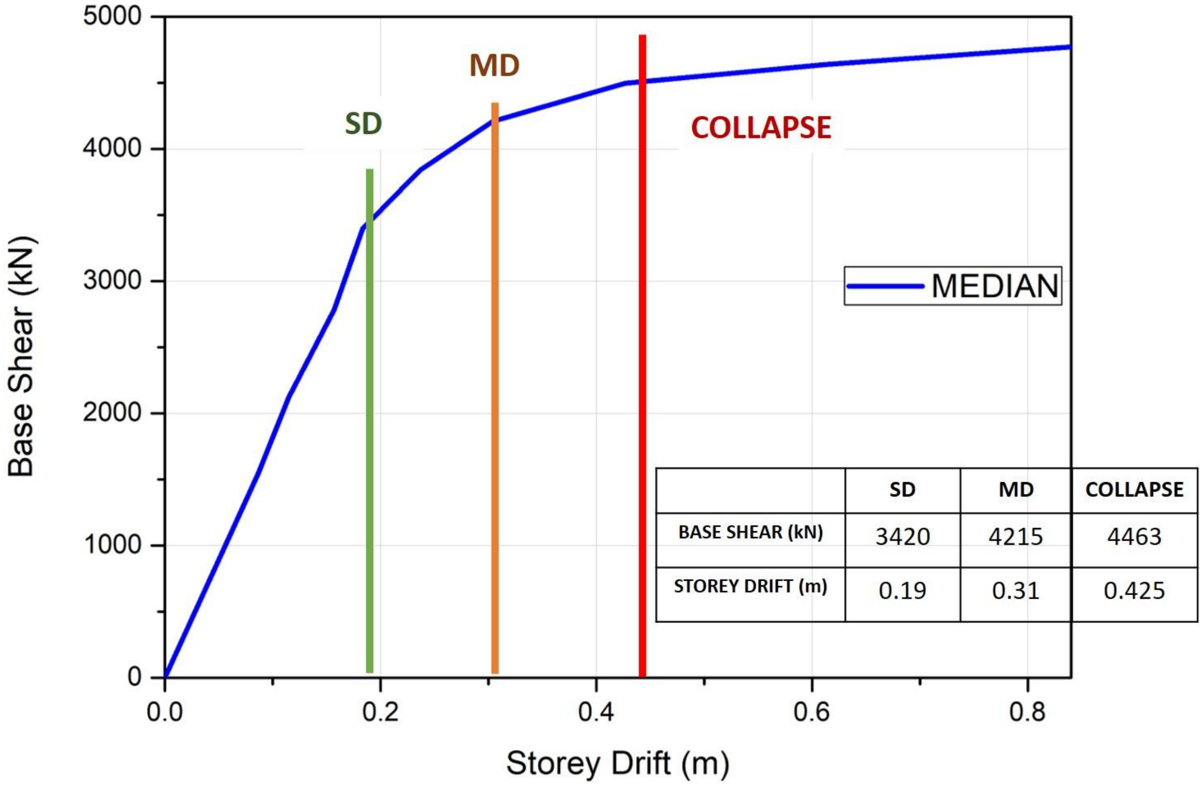


Figure-5 Interstorey Drift Profile



	SD	MD	COLLAPSE
BASE SHEAR (kN)	3420	4215	4463
STOREY DRIFT (m)	0.19	0.31	0.425

Figure-6 IDA curve with ATC-40 Criteria

CONCLUSIONS

The main aim of the paper was evaluating the performance of asymmetric RC moment resisting frames designed as per IS code provisions. Illustrative frameof 8-storey U-Shapewas designed as per IS code guidelines. The buildings considered in the present work are designed for lateral forces of Zone V. As seen from nonlinear time history analysis, the capacity of building meets the demands imposed on it. To evaluate the performance, the nonlinear time history analyses and Incremental Dynamic Analysis of these frames were carried out using Seismostruct software. The results of time history analysis are plotted in terms of inter-storey drift profile and displacement profile for 6 artificial ground motions. The results of incremental dynamic analysis are plotted in terms of IDA curve with ATC-40 Performance criteria for6 artificial ground motions. The linear drift limit as per IS: 1893 (Part 1): 2016 is 0.4% and frames were designed with response reduction factor of 5. Therefore, the acceptable drift limit for frame is 2%. It is observed from the plots that target inter-storey drift limit of 2% is not crossed in any of the frames. Hence it can say that frames show satisfactory performance under dynamic loading.

REFERENCES

Ali RuziOzuygur, “Performance based seismic design of an irregular tall building”, (doi: 10.1016/j.istruc.2015.10.00)

D. Vamvatsikos, C.Cornell, “The incremental dynamic analysis and Its application to performance-based Earthquake engineering.” 12th European Conference on Earthquake Engineering (Pg-479)

Goncalo Carvalho, Rita Bento, Carlos Bhatt, “Non-linear static and dynamic analysis of R.C. buildings-comparisons of different modelling approach “, Earthquake and structures Vol. 4 ,No.5 (451-470)

Palak Trivedi, RutvikSheth, Devesh Soni (2016), “Performance Evaluation of R.C. Moment resisting Symmetric Frame using Non-linear Dynamic Analysis.” Global Research and Development Journals (e-ISSN : 2455-5703)

Rahul Rakshe, UttamKhalwane, “Incremental dynamic analysis and static pushover analysis of exiting RC framed buildings using SeismoStruct software”. International Journal of Advance Research, Ideas and Innovations in Technology.

Applied Technology Council, ATC 40, “Seismic Evaluation and Retrofit of Concrete building” Vol. 1, Red wood city, California.

IS 1893 (Part1):2002 Indian Standard, “Criteria for earthquake resistant design of structure General provision and buildings”, Bureau of Indian Standard, New Delhi.

IS-456:2000, “Plain and reinforced concrete-code of practice” by Bureau of Indian Standard, New Delhi.

SeismoStruct (2018) A computer program for static and dynamic nonlinear analysis. Available from URL: http://www.seismosoft.com: Seismostruct _2018_Release_3.

Anil K. Chopra, “Dynamics of Structures” by Pearson.

Chandrasekaran Srinivasan, “Seismic design aids for nonlinear analysis of reinforced concrete structures” by CRC press, Taylor & Francis Group.

Minoli Shah, “Performance evaluation of RC moment resisting Irregular frames under seismic loads using Nonlinear static and dynamic analysis” by DDIT thesis.

Palak Trivedi, “Performance evaluation of RC moment resisting symmetric frames using Nonlinear dynamic analysis” by DDIT thesis.

FEMA-356, (2000), Pre-standard and Commentary for the Seismic Rehabilitation of Buildings, Building Seismic Safety Council, Federal Emergency Management Agency, Washington, D.C., USA.