COMPARATIVE STUDY OF SEISMIC PERFORMANCE OF RC FRAME BY STATIC PUSHOVER ANALYSIS AND INCREMENTAL DYNAMIC ANALYSIS

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Abstract- Structures are designed to resist environmental forces such as lateral forces like wind and earthquake, along with vertical gravity loads such as dead and live loads. These forces are random and dynamic in nature. Response of the structures is dynamic which produces dangerous and difficult situations.

Therefore, performance-based design and analysis of the structures is required which is attained by Incremental dynamic analysis (IDA) and static pushover analysis (SPA). Incremental dynamic analysis is reasonably precise and real responses of the structures from the specific considered seismic records are obtained by these methods. IDA includes implementation of numbers of non-linear dynamic analyses in which the intensities of seismic records selected for collapse study are incrementally amplified until the global collapse capacity of the building is achieved.

In current study, incremental dynamic analysis of 8 story RC building used for commercial purpose is performed. IDA curve is developed with respect to peak ground acceleration (PGA). Performance levels of building. Yield and collapse should be described with respect of the PGA of the respected seismic records from IDA curves. Serviceability measure for interstorey drift ratio (IDR) specified by various seismic codes are checked by IDA. Structure susceptibility is found out that whether the structure can withstand the considered earthquakes or not are obtained by using incremental dynamic analysis.

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Variation of deformation responses like displacement and story drift with the intensity of the considered earthquake are also studied with the increment in the intensity of that particular seismic record up to collapse of the building.

Static push over analysis of 8 story RC building is also performed, from the static pushover analysis, plot of base shear versus roof displacement is plotted. From the plot, base-shear capacity of the building is obtained. Base shear capacity of that building is also attained by using IDA and capacity curves of base shear versus roof displacement from SPA is compared with that of IDA

KEY WORDS: IDA , SPA , Interstorey drift ratio , peak ground acceleration

I. INTRODUCTION

Incremental dynamic analysis (IDA) is a tool used to investigate the performance of structures. The reaction of the structure varies from the elastic curve to the plastic curve, resulting in dynamic instability. We tried to find the structure's behaviour for various life safety measures such as life safety (LS), immediate occupancy (IO), and collapse prevention (CP). A multitude of nonlinear dynamic analyses are done in incremental dynamic analysis, in which the intensity of the seismic data is steadily increased until the building collapses. The IDA curve is a plot of intensity measurements (IM) such peak ground acceleration versus response or damage measures like peak inter-storey drift ratio (peak IDR). The IDA curve evolves from linear to nonlinear, eventually leading to

dynamic instability. When the curve becomes practically flat or the slope reaches less than 20% of the starting slope of the structure, the structure has achieved its global failure capacity.

It is also known as dynamic pushover analysis because, in static pushover analysis, loads are applied and increased statically until the required collapse capacity of the building is reached, whereas in dynamic pushover analysis, a real-time history with dynamic loading is applied and intensity is increased until the global collapse capacity is reached. To get trustworthy findings and statistical averages, the analysis is repeated for many sets of seismic motion. It serves as the foundation for evaluating earthquake engineering performance based on performance. To accomplish it, seismic recordings must be chosen, either from the zone in which the structure is located or from other areas of the world with strong seismic zones and matched with the target spectrum of that location. To modify the intensity of the recordings, the records must be scaled. Displacement, base-shear, and interstorey drift are all measured. IDA curves are drawn between IM (PGA) and DM (inter storey drift ratio), with PGA on the y-axis and IDR on the x-axis. A non-linear static (pushover) analysis is performed to determine the structure's capacity curve and base shear capacity

1. We can set the dimensions of the building's elements to achieve the required strength, which will be able to withstand a stronger earthquake with a high intensity and a longer duration time of shaking.

2. The response of the building must be in the elastic limit during maximum ground shaking is important for the design of seismic proof building, and IDA effectively performs performance-based evaluation of structure.

3. From IDA curve, limit states such as IO, LS and CP can be defined for different performance stages like yield and collapse.

II. OVERVIEW OF WORK

The salient objectives of the present study have been identified as follows:

- To check the building susceptibility and serviceability to the considered earthquakes,
- Well understanding of the variations in the behavior of structural response as intensity of seismic motion increases,
- Thorough understanding the limit states of the structure (i.e. IO, CP),
- To obtain a great interpretation of the response vs the potential level of seismic motion records,
- To find the yield and collapse base shear capacity,
- To develop the IDA curve and to estimate dynamic capacity of the structure.

III. NEED FOR THE PROPOSED WORK

The purpose of study is to access the structure performance by approximating strength and deformation capacities by using nonlinear dynamic analysis. Objective of study stands to check structure susceptibility and serviceability for the particular earthquakes, for well understanding of the changes in structural behaviour as intensity (IM) of earthquake motion intensifies, thorough understanding limit states of the structure (i.e. IO, CP) and to find the collapse and yield base shear capacity.

Various dynamic and static analysis method are proposed for seismic analysis. It is not likely to forecast future earthquakes and time of event. Therefore, previous seismic data are still generally used to analyse for future earthquakes. In addition to uncertainties in earthquake loads, uncertainties related with building material, structure geometry, design procedure, and construction will lead to the usage of probability to forecast structural responses. It’s required to evaluate the weakness of standing structures. For this, numerous approaches have been projected, one of the tools utilised to estimate execution of building to oppose earthquake activities is incremental dynamic analysis.

IV. LITERATURE REVIEW

Many researchers has studied about IDA till date and it is the newly developed method to study behaviour of structure. All the literature have been studied and summarized in this chapter for those useful to the present investigation. Finally, an acceptable conclusion is produced, and the current study work's objectives are completed by identifying the gaps.

Rojit Shahi, Nelson T K Lam, Emad F Gad, Ismail Saifullah, John L Wilson and Ken Watso (2014) guided about how to select the intensity measures like PGA, Spectral acceleration, PSA, Sa (Tn, 5% damp) etc. Their study shows results from the examination it is intended to determine which seismic motion considerations are best appropriate for usage as the IM while letting the occurrence signified of the seismic records to diverge in the IDA. Their study shows the results of study where non-linear dynamic time history evaluation including usage of both records and synthetic accelerogram remained accepted on model representative of the structure made of cold formed steel. Structures with normal period and thus the peak-acceleration demand PAD are obtained to be required selections of IM consideration as max as given that the related IDA curve are usually insensible to selection of accelerograms collectively uses. Structures having larger time period of shaking, others seismic motion parameter are obtained to additional popular varieties.

Constantinos C. Repapis (2016) compared non-linear static technique and IDA, found that average IDA curves are accord with the pushover-curves. In their study earthquake execution is examined for two structures, first one is standard structure of the 1960s and second one is standard of the 1980s. IDA forecasts are associated with outcomes of the pushover-analysis and therefore the earthquake demand should we matched with capacity spectrum technique and N2-Method. Outcomes from the IDA curve shows great distribution on responses of the structure, existing ductility capability, and performance aspect and collapse deformation, reliant on intense seismic record. CSM-N2 forecasts are enclosed by non-linear dynamic forecasts, but then important variations from average uses. Both type of study shows that completely infilled frame displays an enhanced performance related to reveal frame.

M M Maniyar and R K Khare (2011) gives guidelines about how to select the seismic records for execution of incremental IDA of standing RC structures in India on basis of magnitude and nearest distance from fault plane. There work deals with selection of a set of seismic records based upon its effect on seismic demand evaluation of elastic or inelastic structures. They selected records as follows 'larger magnitude near to the fault, larger magnitude short distance, larger magnitude long distance, lesser magnitude short distance and lesser magnitude long distance based on this they selected 20 records

Mwafy A., Elnashai A., (2001) in their study, compared the outcome of non-linear static assessment to non-linear dynamic assessment of 12 reinforced concrete buildings of different characteristics. IDA is used to prepare dynamic-pushover sets and relate this with static-pushover outcomes. They used actual and simulated seismic histories executed on diverse reinforced concrete structure of changed features. This includes consecutive scaling and applied on every accelerogram obeyed by evaluation of greatest record, till the collapse of building.

S W Han and Anil K Chopra (2006) performed approximate IDA using modal pushover-analysis. MPA based estimated technique used towards determining IDA curve, MPA techniques are used for estimation of seismic demand because of every seismic motion at every intensity-level as alternative of nonlinear-RHA. MPA built estimated method to find IDA curve, MPA technique are used for estimation of earthquake demands because of every seismic motion at every intensity-level in its place nonlinear-RHA. IO is gone against when elastic slope (constant slope) becomes inelastic and collapse-level are reached when slope of IDA-curve becomes 20 percent of slope of IDA-curve in elastic-limit or max drift ratio=10 percent, any one arises first, at lesser intensity-level. Dynamic instability is found by feature flattening of every IDA. Also guided about how to minimalize number of nonlinear-RHA essential to produce IDA for every seismic movement.

V. DESCRIPTION OF STRUCTURAL MODEL

Geometric and Material Data

Number of storeys	8
Plinth height from foundation	3.5m
Floor to floor height	3.5m
Plan area of building	1184 m2
Total Height of Building	28 m
Unit weight of concrete	25 kN/m3
Grade of the concrete	M30
Grade of the steel	HYSD 500
Thickness of slab	150 mm
Floor Live load	3.5 KN/m2
Floor Finish load	1.5 KN/m2

Table 5.1 Details of Beams and Columns

Element	Beam/Column Size (mm)	Bar diameter (mm)	No. of bars
Column	600 × 600	20	8
Beam	300 × 500	20	8 (3 at top, 5 at bottom)

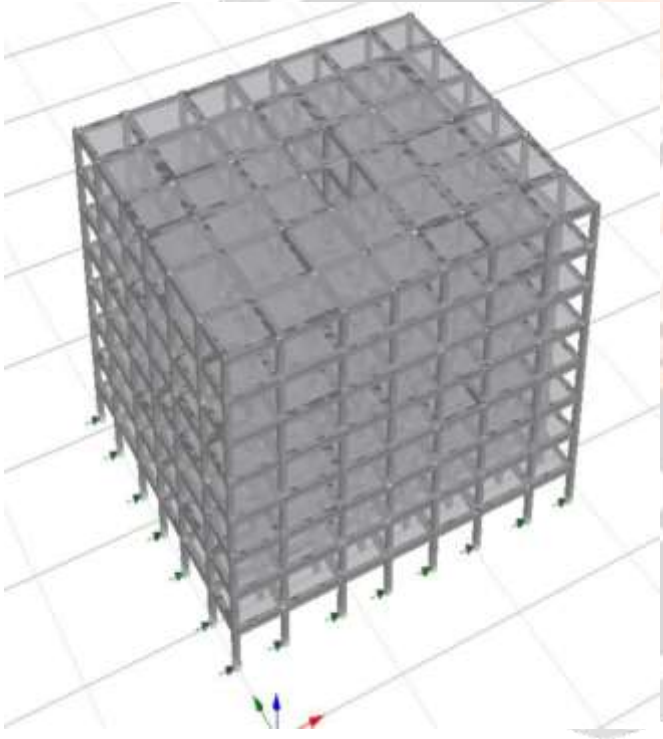

Fig5.1 : Elevation view of building

VI RESULT

The current study deal with various limit states of structure such as IO and CP. Also got the base shear capacity of structure by incremental dynamic analysis (dynamic pushover analysis) and nonlinear-static analysis (static-pushover analysis). All observations are shown here with proper comparison.

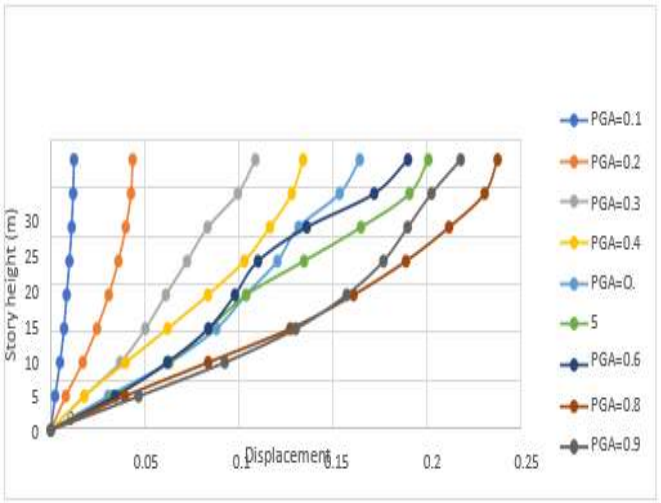

Fig 6.1: Storey displacement distribution along storey height in x direction

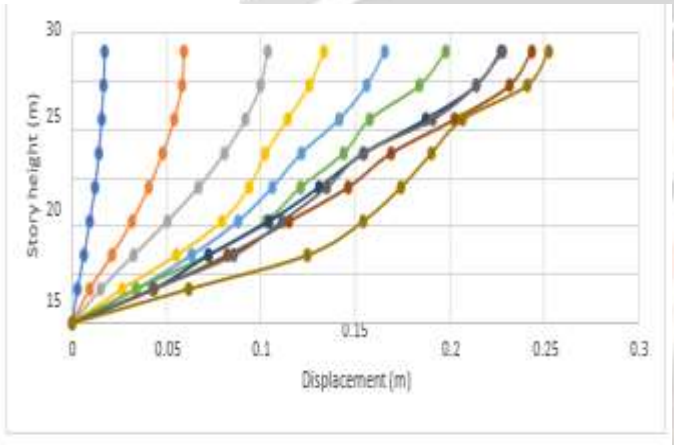

Fig 6.2: Storey displacement distribution along storey height in Y-direction .

It is one of the utmost important measures of non-structural and structural damage of the structure under different levels of seismic motion. It is the difference between storey displacement of two successive floors. the variation of storey drift distribution along building height in X direction respectively. And figure 6.4.1 to 6.4.8 shows the variation of storey drift distribution along building height in Y direction respectively for the considered seismic records. Legend notations are same for all the plots

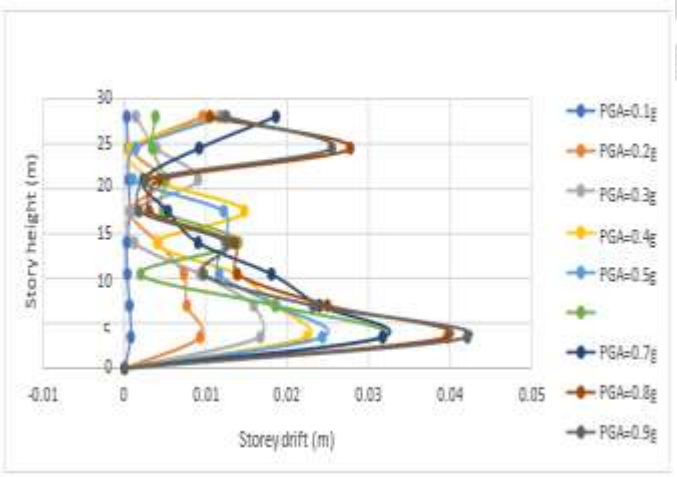

Fig 6.3: Storey drift distribution along storey height in x-direction (Saitsama)

It's described as the ratio of deformations of two successive floor to height of that floor, lateral displacements of some level relative to the others level above or below.
It is the most used damage measures for the evaluation of earthquake resistant design for different limit states of the structure.

VIII. CONCLUSION

Building serviceability and susceptibly are studied in this thesis. Our aim to check earthquakes resistance of standing structures so if they are found deficient then retrofitting of these building is required to increase the strength to bear the seismic loads. For applying the seismic loads, multiple seismic records matched with the target spectrum of the site is required.
All the records scaled to various intensity levels are applied and displacement response are recorded and from that damage parameters such as storey drift, max interstorey drift and roof drift ratio are studied with the variation of engineering demand parameters such as PGA.
Limit states of the structure (IO, CP) are checked with respect to damage measures (maximum IDR) and susceptibility of the building are checked that the building is failing in the yield or collapse or not for the individual earthquake. And from multiple records mean susceptibility are also checked.
Base shear capacity of structure is also calculated by nonlinear-static analysis and related with base-shear capacity just before collapse by incremental dynamic analysis. And found that IDA is more accurate than nonlinear-static analysis because response of structure is plotted by applying actual seismic records. So, response of the structure from IDA is real response generated by the considered earthquake. IDA is very much time consuming, if the

Building is of very much importance and high accuracy is needed, then only the incremental dynamic analysis is preferred. Nonlinear-static (pushover) analysis gives higher values of base-shear i.e. more than incremental dynamic analysis
If Structure is failing to the considered ground motion or failing to satisfy the measures of serviceability of the structure, stiffness of the building needs to be increased by increasing column dimensions and improving ductile behaviour of the building. If the acceleration at the yield and collapse of the structure is more than that of the un-scaled acceleration of the considered earthquake, then we can conclude that the structure will sustain the considered ground motion and if not, then the column size needs to be increase.

IX. SCOPE FOR FUTURE WORK

In the current study, different seismic loads are applied to structure, response of building is plotted for each scaled earthquake and IDA curve are plotted.

A comparative study can be done between different RC frames with individual seismic design such as base isolation, shear wall, bracing with the normal reinforced concrete frame to check how effectively these seismic designs are working in the seismic environment. Responses of the all the structures can be compared in future study.

Present work can be extended by evaluating probability of yield and collapse would be computed and fragility curve would be developed by using IDA curve. Mean and variance value have to be calculated from data of multiple incremental dynamic analysis.

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