# Comparative study of Seismic Performance Of RC frame by Static pushover analysis and Incremental dynamic analysis - A REVIEW

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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.*

*Serviceability measure for interstorey drift ratio (IDR) specified by various seismic codes are checked by IDA.*

*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*

***Keywords—*** *SPA , IDA , interstorey drift ratio , RC building ,PGA .*

## 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.

Earthquakes are one of the most dangerous natural occurrences, causing the majority of the destruction. However, the main reason that causes damage to human life is improper design without taking into account the provisions of earthquake resistant design and seismic codes, whether they are constructed prior to the adoption of recent seismic codes or for social or economic reasons. Furthermore, current Indian seismic codes do not address the assessment of earthquake resistance of existing buildings that are not seismically designed. Existing buildings that were not designed in accordance with current earthquake codes must be evaluated for their seismic performance in the event of an upcoming earthquake. Strengthening measures for deficient buildings must be ensured through retrofitting. As a result, existing RC buildings that lack safety measures must be evaluated and strengthened properly for the residents' safety using retrofitting techniques.

Several RC frame buildings collapsed during the 2001 Bhuj earthquake. Reinforced concrete buildings with brick walls carrying gravity loads performed extremely poorly, and thousands of buildings collapsed, demonstrating the seismic vulnerability of these structures. Existing RC buildings built before the 1980s are seismically deficient due to a lack of structural ductility and a lack of earthquake resistant design provisions

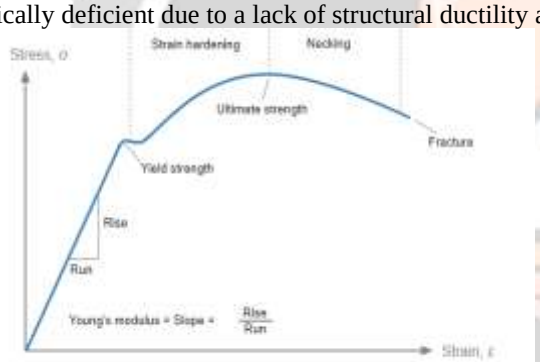


Fig. 1.1 Stress-strain curve from elastic limit up to fracture of structure

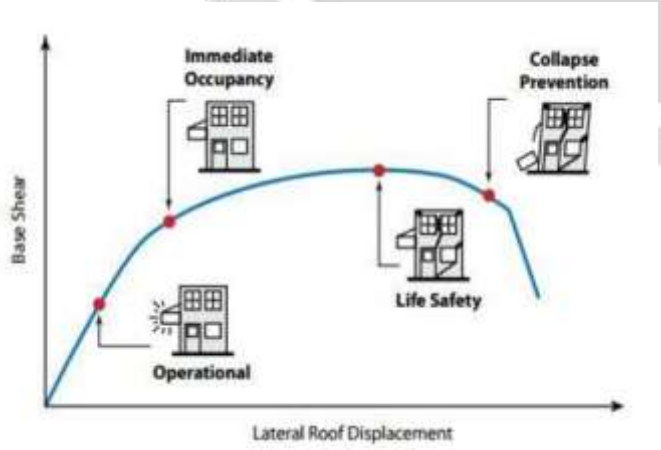


Fig. 1.2 Collapse stages of Building (IO, LS, CP)

## II. OVERVIEW OF WORK

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

## III. 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.

**Seismic-performance assessment of building (FEMA P 58 1, Vol. 1 – Methodology, 2012) -** This code describes the resulting methodology as well as the development of basic structure information, response measures such as fragilities, and important data used as inputs to the methodology.

**Dimitrios Vamvatsikos and C.Allin Cornell (2004)** in their work gives guideline about how to take steps and step size- Minimum number of run to draw single IDA curve are 6 to 8, Fill the gap between these runs by hunt and fill method, Draw the curve by interpolation, Collapse point located at point somewhere the slope is 20 percent of elastic slope as per ad-hoc rule, Global dynamic instability occurs where flatline is reached, Application of IDA to an RC-Structure, Immediate occupancy is at 1% interstorey drift ratio, Collapse prevention is at point where slope is equal to 20% of elastic slope. Eextreme hardening that causes the appearance of multiple possible CP points, the highest of which (in IM-terms) is the accepted one.

**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., (2010)** 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.

## IV. NEED FOR THE PROPOSED WORK

This effort covers evaluating the performance of RC buildings using incremental dynamic analysis. The sensitivity of a building to the particular considered earthquake is discovered. The building's resistance to the earthquake is also being investigated. The curve of base shear to roof displacement is displayed using the Incremental Dynamic Analysis. Seismostruct programme is used to detect building behaviour while utilising the IDA.

## V. OBJECTIVE OF THE WORK

The key objectives of the current work are as follows:

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

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