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An overview on the concepts and methodologies of incremental dynamic analysis IDA (with a single record and multiple records)

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Abstract:

Incremental dynamic analysis is a seismic analysis of structures based on the structural performance which states the behavior of the structures in a range of different intensities of earthquake. Due to the dynamic and non-linear nature of the earthquake, certainly the results of this method in comparison to the other types of analyses are closer to the reality of structural behavior. However, this method is a time consuming method and like other kind of time history methods, is too dependent on the records. Moreover, selection of intensity measures and engineering demand parameters are important issues that should be discussed. In this paper, a review on the history and concepts and how to perform incremental dynamic analysis (IDA) are discussed with a single record and multiple records

Keywords: Incremental dynamic analysis; Intensity measure; Engineering demand parameter; Seismic Vulnerability; levels of performance

1. Introduction

The increasing growth of computer processing power may enhance the accuracy of analysis results by using more complex methods. As a result, analyses are shifted from linear static to linear dynamic, nonlinear static and nonlinear dynamic. For the latter, nonlinear dynamic analysis, is usually designed to control structures, structural analysis with one or more records to obtain one or more single point. On the other hand, in the methods like the Push-over method (ATC, 1996) (SPO) or the capacity spectrum method (ATC. 1996), With scaling the representative of static load , a continuous picture of the behavior of structures in all domains of the elastic mode to the yielding mode and eventually collapse of the structure, are given to us.

As we pass through a single static analysis we reach to the Pushover analysis, similarly by the development of time-history analysis, we only reach a few history-time analysis by which the seismic loads are scaled. Firstly, the concept of this method is expressed by Bertero(1977) and is used by several researchers later.

This method has accepted by the guidlines of Federal Emergency Management

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Agency (FEMA) as The Incremental Dynamic Analysis (IDA) and can be used as a method in order to determine the potential collapse capacity of the entire structure. IDA is already a widely used and versatile method which only some of its objectives are:
1. Full understanding of the response or demand of the structure in a vast range of different levels of ground motion records.
2. Better understanding of the structural effects at different levels of the ground motion with less or more power.
3. Better understanding of changes of the nature of structure response with increase of the intensity of ground motion (e.g.: changes in maximum displacements in height, beginning of reducing the hardness, strength and their models).
4. Evaluation of the dynamic capacity of the entire structural system.
5. Finally, surveying IDA curves with multiple records and how to remain constant …

2. IDA concepts with a record:

As a first step, it is necessary to briefly explain the different terms of this method:

We suppose that we have an accelerogram which is chosen from the accelerogram database of earthquakes as the first step. (Seismologists may reform the baselines, filter and rotate them before).Unscaled accelorogram a1 is a vector with members: a_1 (t_i), $t_i = 0$, t_1... t_{n-1},. To determine the effect of stronger and weaker earthquake, a simple transfer with a unified scale is introduced that scales the amplitude of accelerograms by λ as a scale factor to high and low. It can also be done by scaling the linear acceleration spectrum with λ as a coefficient or scaling the amplitudes in all frequencies with λ in the frequency domain.

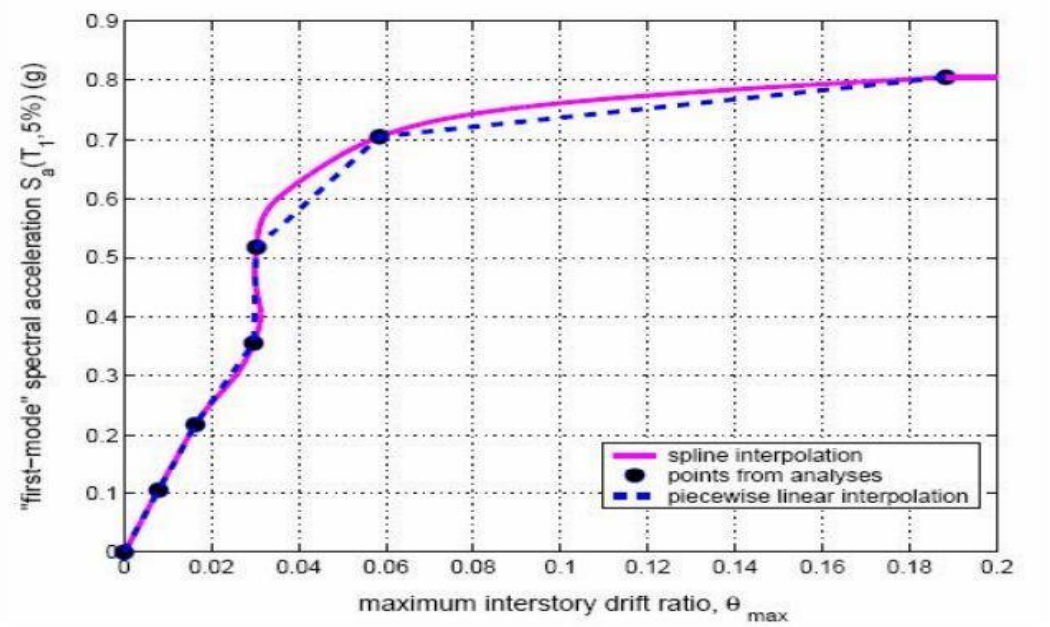

Figure.1 The IDA curve with six converged points in nine-story steel structure (the Vamatsikos et al. 2002) [1]

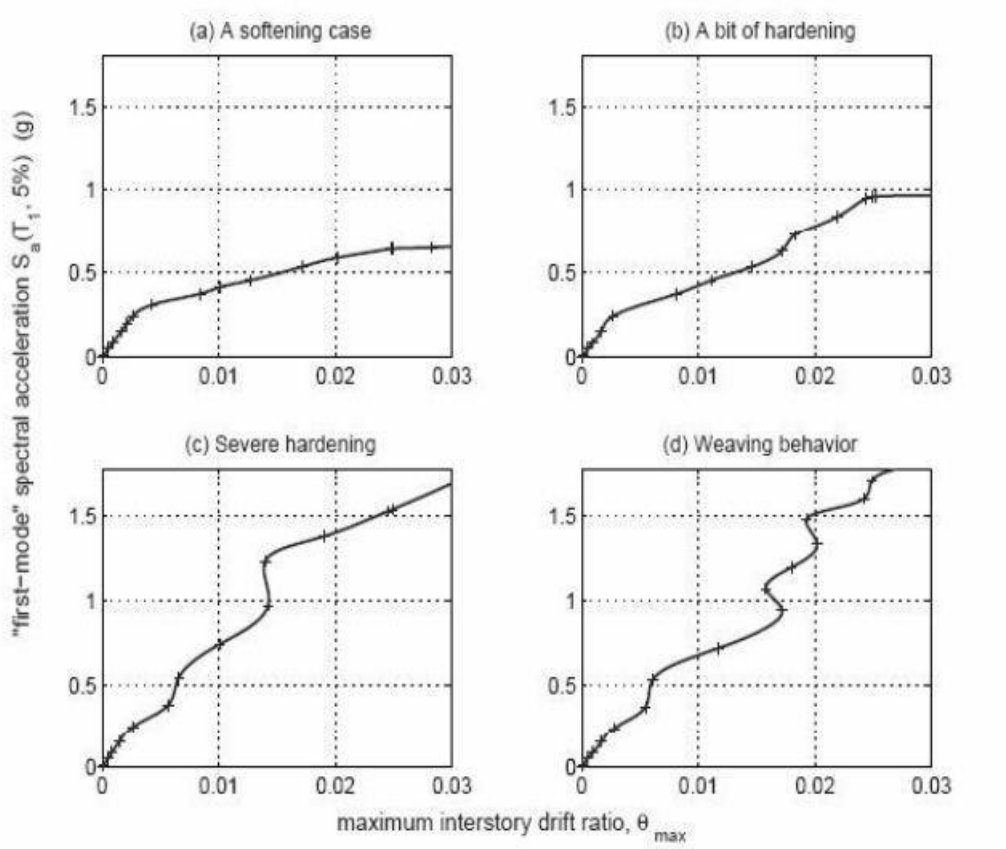

Figure.2 IDA curves for four different accelerograms in a braced five-story Steel structure [1]

Due to the other end of the curves in figure (2), it is observed that how the curves come to an end in different levels of IM. The curve (a) suddenly becomes straight after its first buckling and it indicates huge relative displacements and sudden collapses. On the other hands, the curves (c) and (d) are ragged around the elastic slope; similarly all these curves behave based on the equal displacement rule. It means in structures with the mean period proportionate to total nonlinear displacements, usually are about elastic model displacements. Rotating pattern which the curves (c) and (d) indicate, consist of progressive parts from softening in regions in which local slope or hardness with IM increases more. In technical words, it means sometimes the rate of accumulation of EDP accelerates in structures and sometimes this acceleration decreases which this decrease can be powerful enough to avoid accumulation of EDP instantaneously or even move it back. Thus IDA curve locally goes to relatively lower EDPs and give us a non-monotonous function of IMs (fig.2 (d)). Sometimes with assuming that the structure is allowed to have a little collapse mechanism and the used EDP can consider it, when EDP is accumulated with a higher rate in the structure, the final straightening region happens which indicates the beginning of dynamic instability. Similarly, this phenomenon is defined in the static instability, in which with a few increase in IM, the deformations change to infinity. Then the curve becomes straight at the maximum value of IM where IM goes to straight line and EDP to infinity (fig.2 (a, b)).