Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2018, 5(11): 867-878

Research Article ISSN: 2394 - 658X

Parametric Analysis using Incremental Dynamic Method

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ABSTRACT

The objective of this paper is to estimate the performance of the seismic load structure in more detail and to plot a maximum inter-story drift curve of the structure as a function of the intensity level (spectral acceleration), using incremental dynamic analysis which is a parametric analysis method that has emerged recently under different forms.

Key words: Parametric analysis, Incremental dynamic method, Inter-story drift, Intensity level

INTRODUCTION

Incremental dynamic analysis is a parametric analysis method requiring the application of a series of earthquakes already recorded to the structure, where each earthquake is amplified in a gradual manner (up to 5 times greater than its initial intensity).

The incremental dynamic method is divided into two steps the first one is the determination of the maximum inter-story drift value of the structure in order to reach this goal; we must calculate the inter-story drift of a structure, which is subject in its two directions to different earthquakes [1].

The inter-story drift is raise to square and then summed; then we put the result under the square root and in the end, all is divide by the height of the floor all this for the whole history of the response of the structure. Once you have repeated all this steps for all floors, then we take into account the maximum value.

The second part is based on the determination of the intensity level (spectral acceleration), in this case we must have the period of the structure in both directions, then for each applied earthquake we have to determine the two spectral accelerations [3] corresponding to each period in both directions; which will subsequently multiply between them (spectral accelerations). At the end, the obtained result is under square root.

STEPS OF INCREMENTAL DYNAMIC METHOD

We can summarize the steps of incremental dynamic analysis principle in figure form as follow:

The first part, which is based on the determination of the maximum inter-story drift max (ISD) for each earthquake and story.

$X_4 - X_3 = \Delta X$

$Y_4 - Y_3 = \Delta Y$

$ISD = \frac{\sqrt{(\Delta X)^2 + (\Delta Y)^2}}{H}$

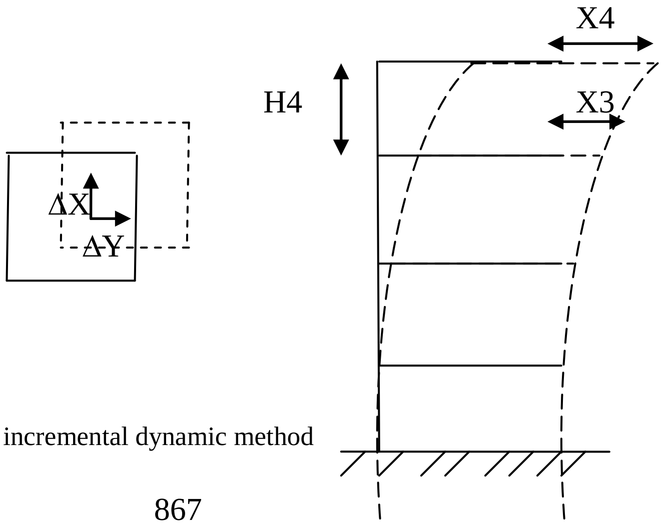

Fig. 1 Steps of incremental dynamic method

The second part, is based on the determination of the intensity level (spectral accelerations Sa)
Sa(Tx)=B
Sa(Ty)=C
$Sa = \sqrt{B.C}$
Once the two steps are completed, we are able to draw the maximum inter-story drift of the structure vs the intensity level (spectral acceleration) curve.

Fig. 2 Incremental Dynamic Curve

The point 1 represented in figure 1 is the result of all the steps mentioned before, in order to determinate another points to be able to draw the curve Sa vs Max (ISD) it is necessary to repeat all the steps for each applies earthquake.

MODELING AND APPLICATION OF THE INCREMENTAL DYNAMIC METHOD

The modeled structure in this research is 4-storey reinforced concrete structure shown using Etabs software [2], which is shown in Figure 3.

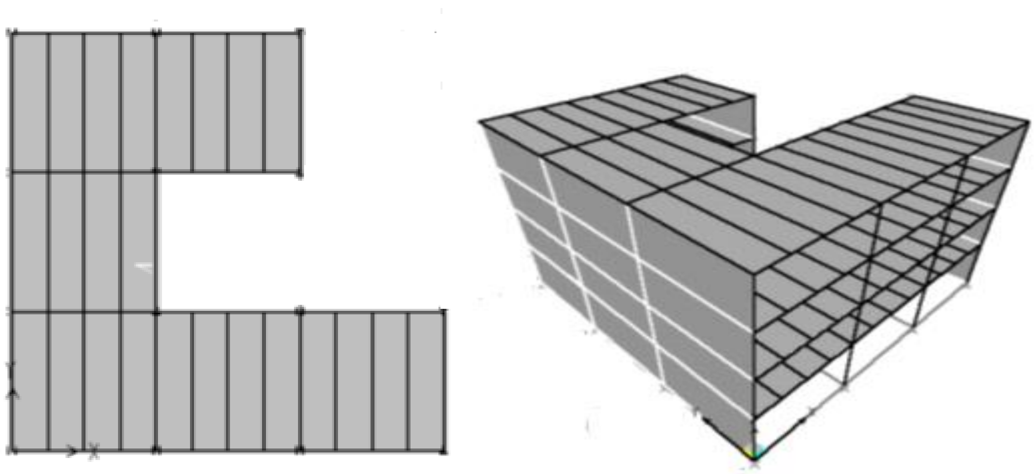

Fig. 3 Model of a 4-storey reinforced concrete structure

The dimensions of the structure and the periods in both directions are:
X=Y=22m, h=15.54m, T_x=0.83s et T_y=0.77s
The dimensions of the structural elements are:
Width main beam = 0.8m height main beam = 0.46m
Width secondary beam width = 0.5m height secondary beam = 0.54 m
Width column = 0.45 m height column = 0.45m
The mechanical properties are:
The modulus of elasticity E = 3 * 107 KN / m^2
Poisson coefficient υ = 0.2
Compressive strength of concrete Fc = 30000KN / m^2
Density ρ = 25 KN / m^3

EARTHQUAKES AND RESPONSE CURVE OF STRUCTURE (SPECTRAL ACCELERATION (Sa) vs MAXIMUM INTER-STORY DRIFT (ISD))

In our parametric study we use 9 earthquakes in both directions of structure (x, y) using an Earthquake engineering Software solutions [4]; for each earthquake applied we apply all the steps already mentioned before in order to be able to draw Spectral acceleration (Sa) vs Maximum inter-story drift (ISD) curve.

All applied earthquakes in two directions and structure response are represent as follows.

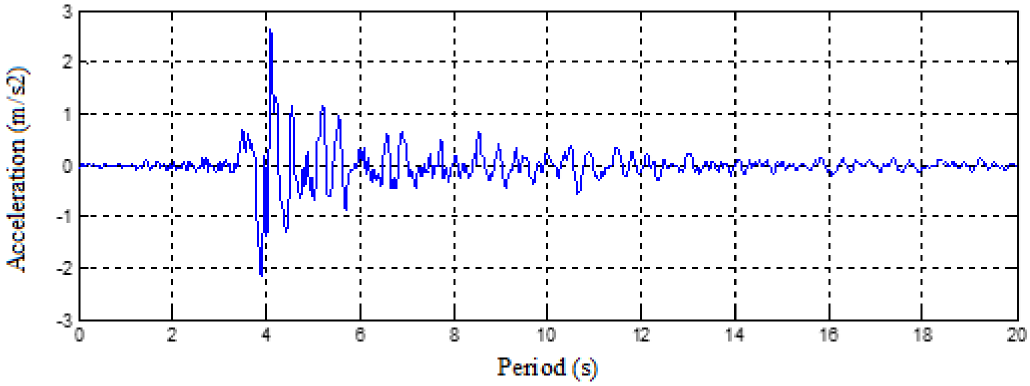

Fig. 4 Earthquake 1x applied in x direction

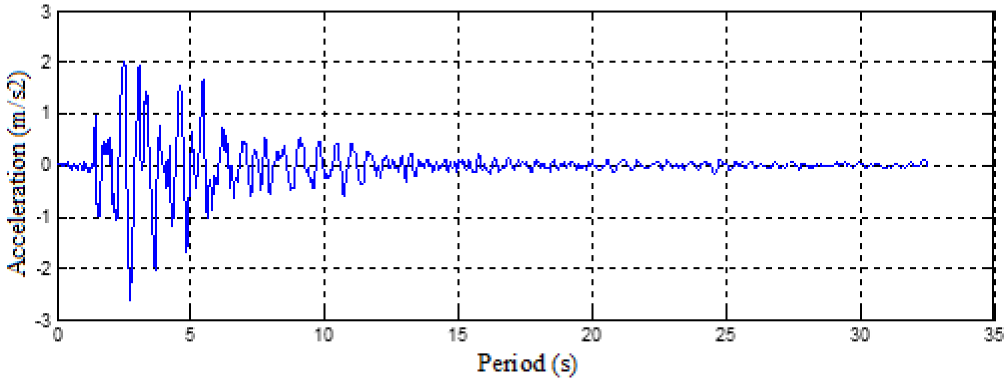

Fig. 5 Earthquake 1y applied in y direction

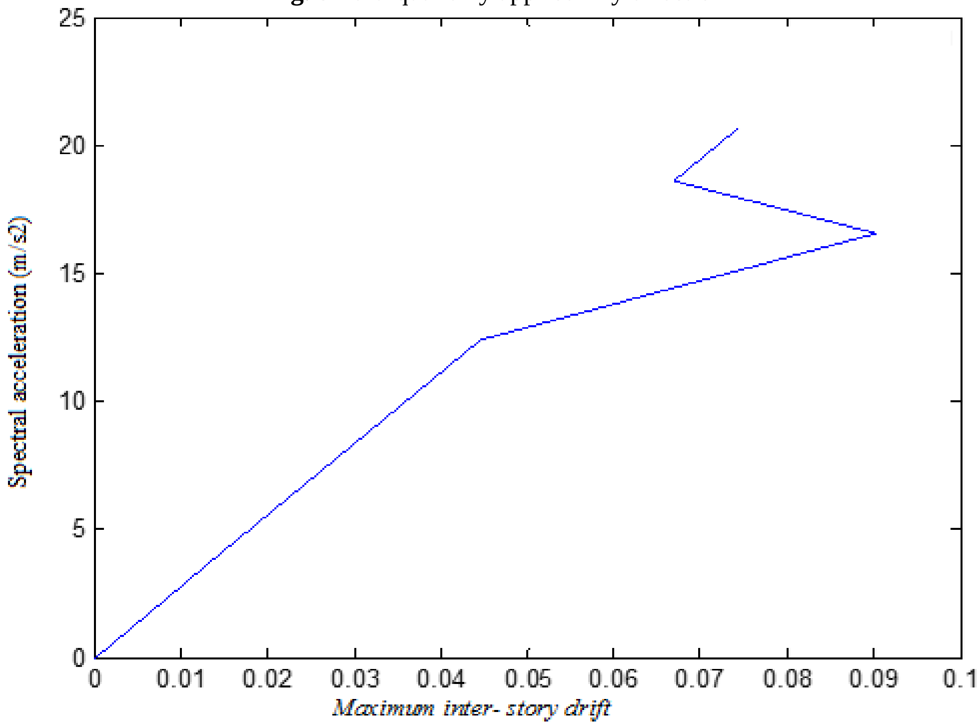

Fig. 6 Structure response due to the application of earthquake1x and 1y respectively

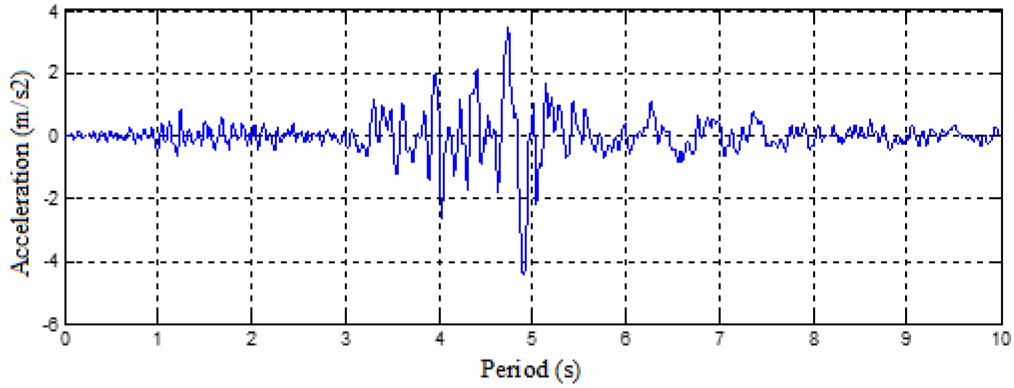

Fig. 7 Earthquake 2x applied in x direction

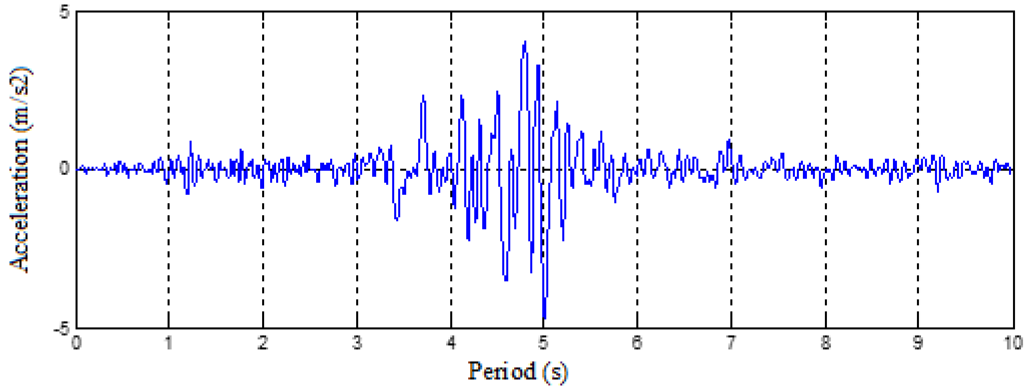

Fig. 8 Earthquake 2y applied in y direction

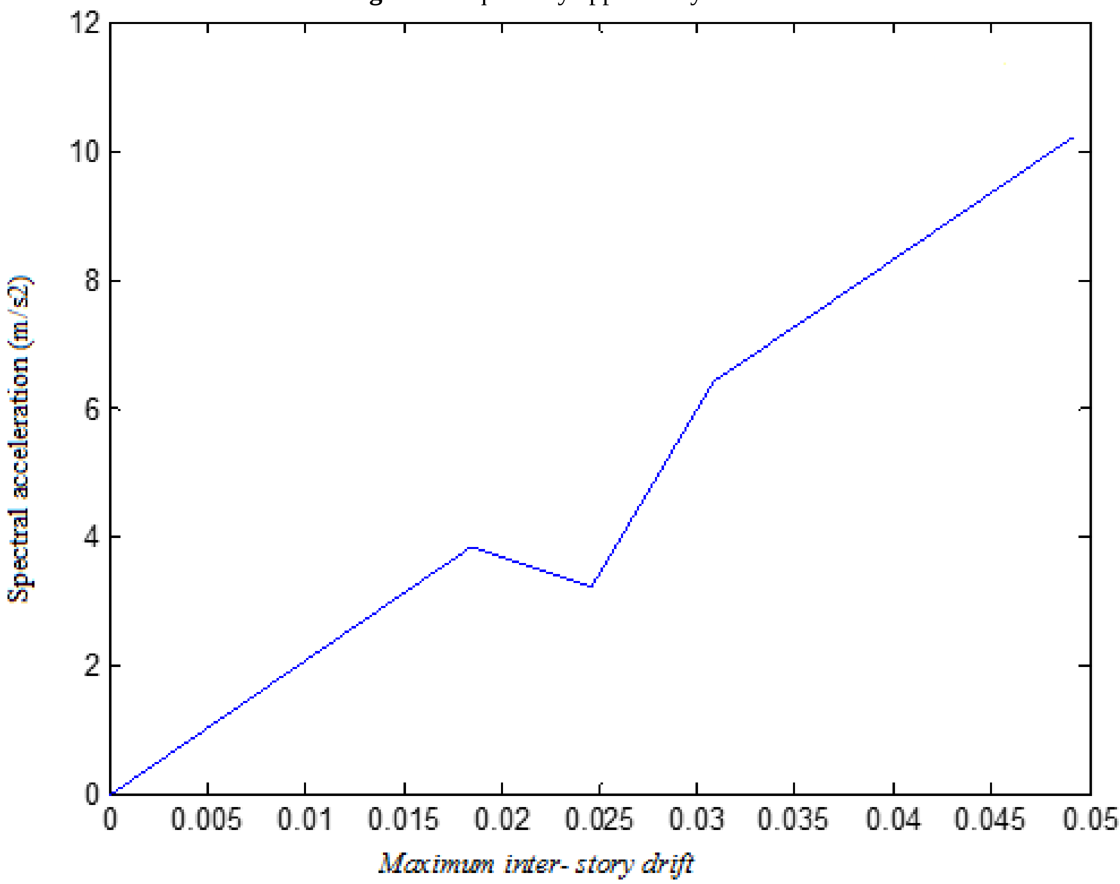

Fig. 9 Structure response due to the application of earthquake 2x and 2y respectively

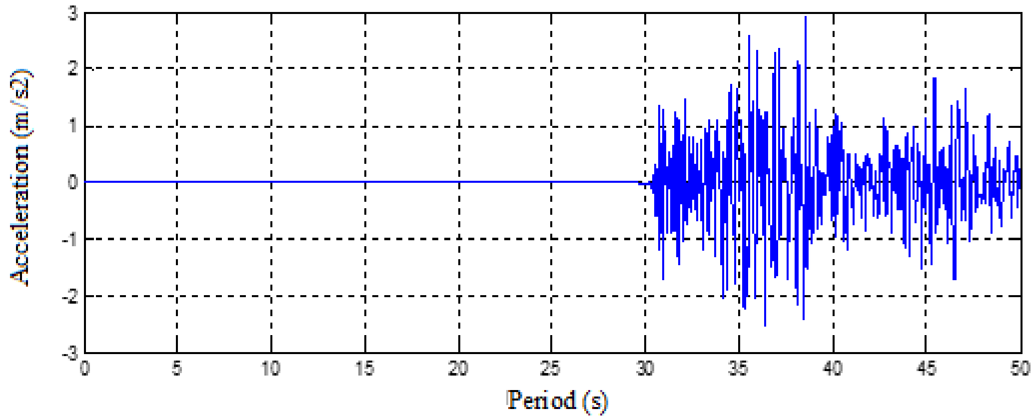

Fig. 10 Earthquake 3x applied in x direction

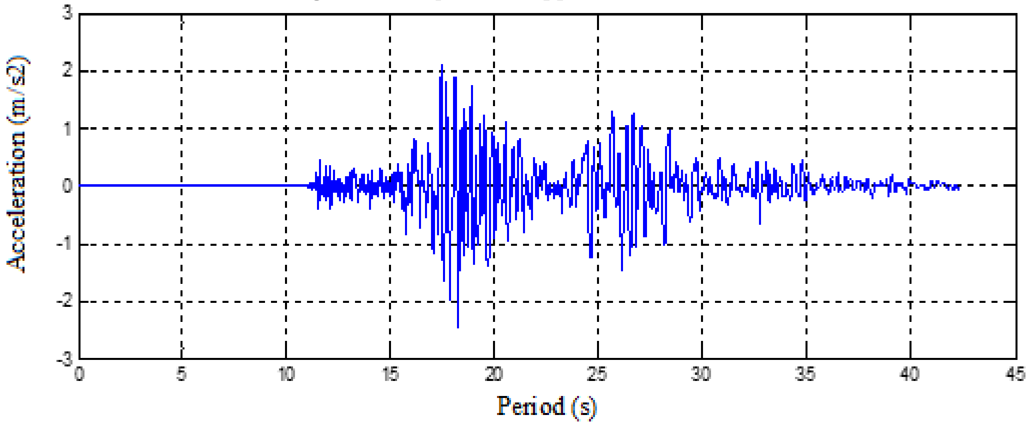

Fig. 11 Earthquake 3y applied in y direction

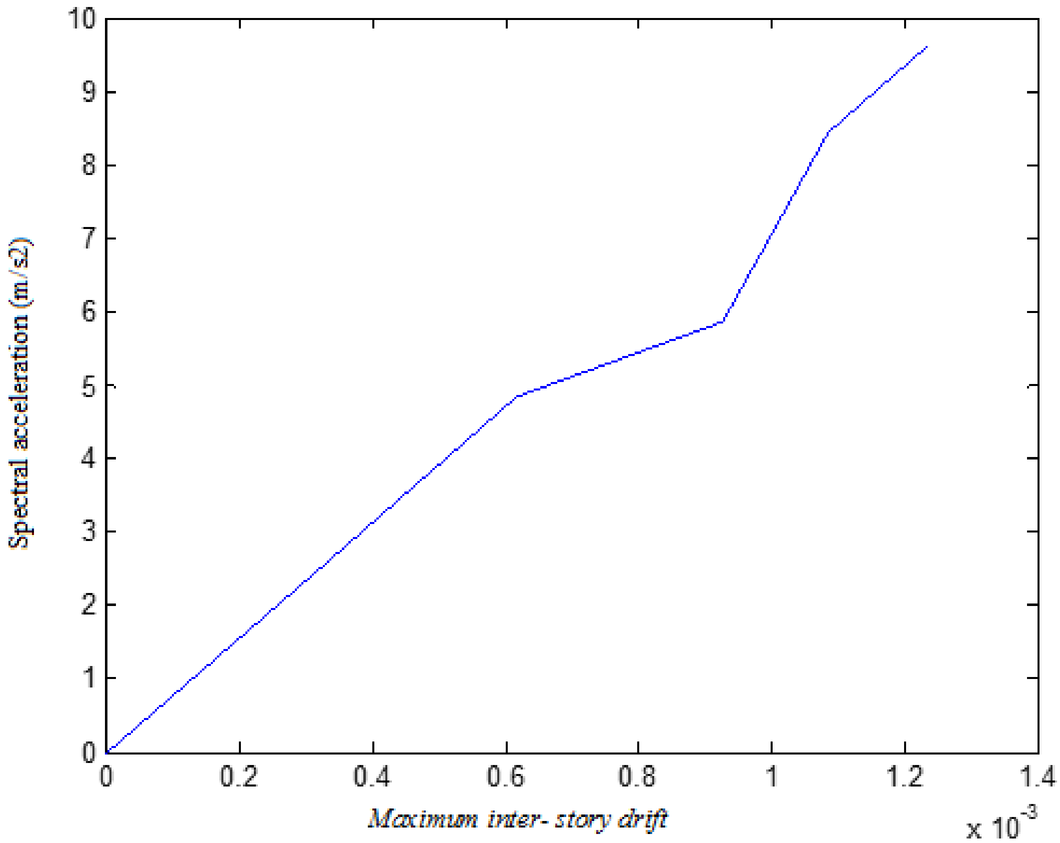

Fig. 12 Structure response due to the application of earthquake 3x and 3y respectively

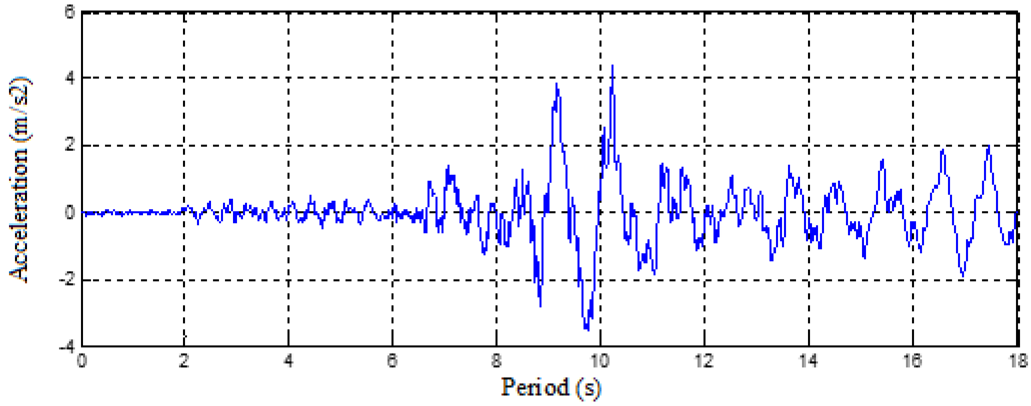

Fig. 13 Earthquake 4x applied in x direction

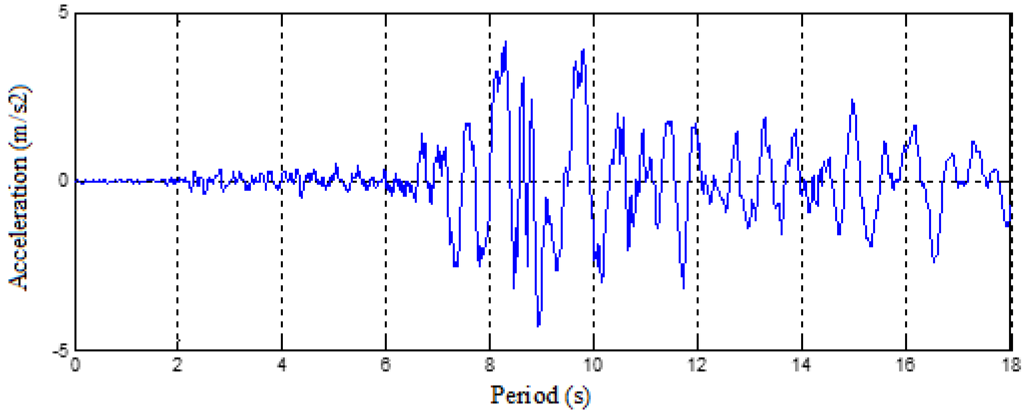

Fig. 14 Earthquake 4y applied in y direction

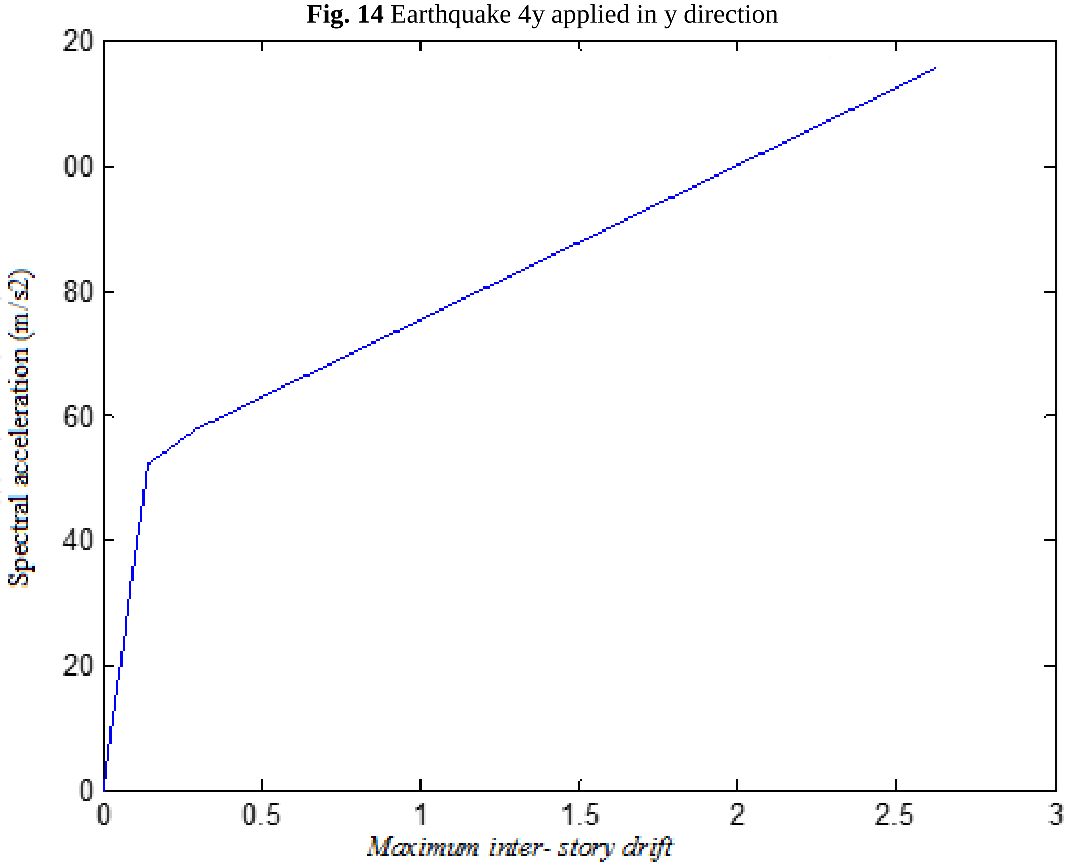

Fig. 15 Structure response due to the application of earthquake 4x and 4y respectively

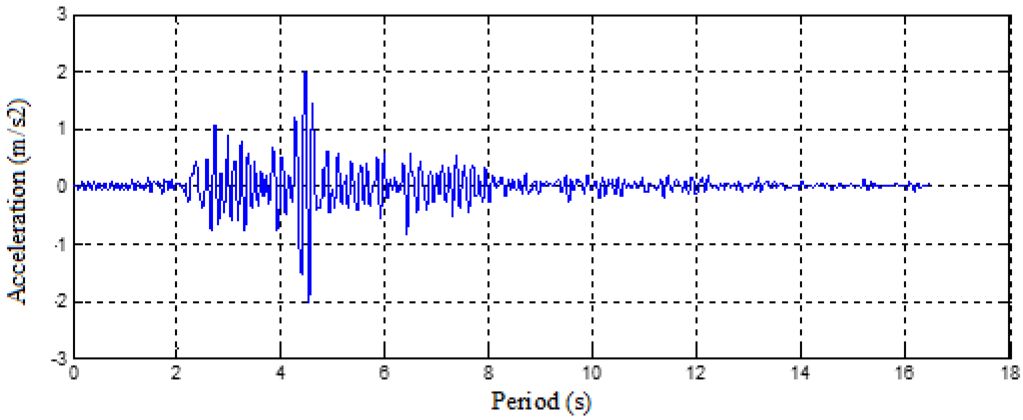

Fig. 16 Earthquake 5x applied in x direction

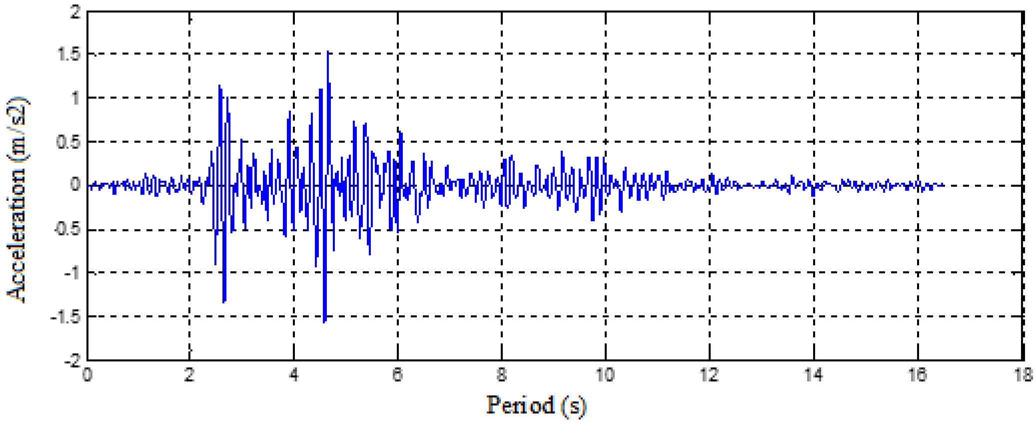

Fig. 17 Earthquake 5y applied in y direction

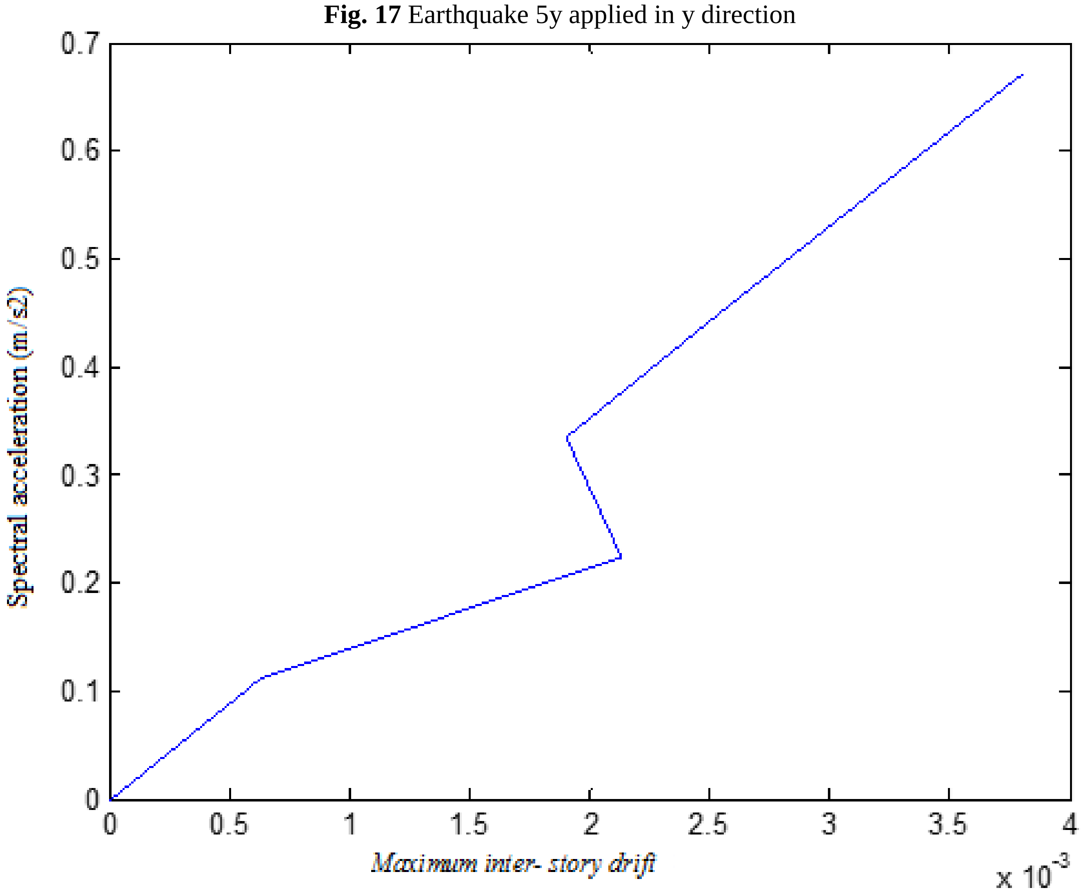

Fig. 18 Structure response due to the application of earthquake 5x and 5y respectively

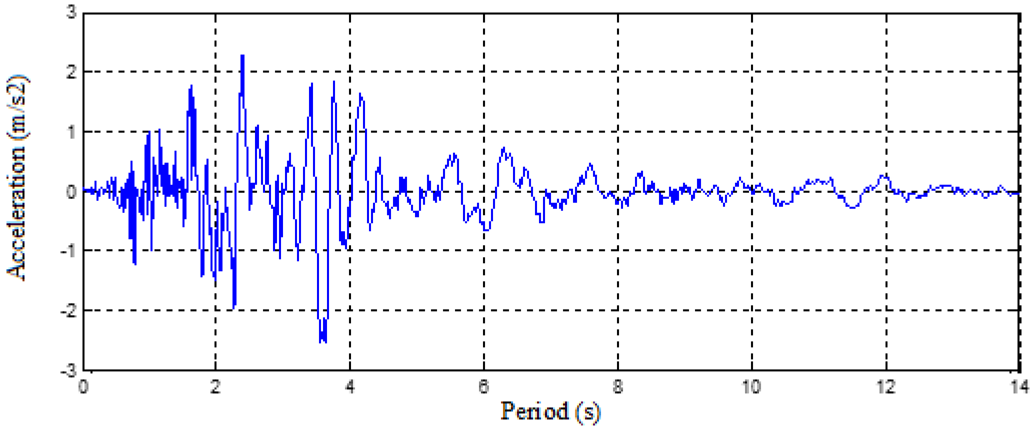

Fig. 19 Earthquake 6x applied in x direction

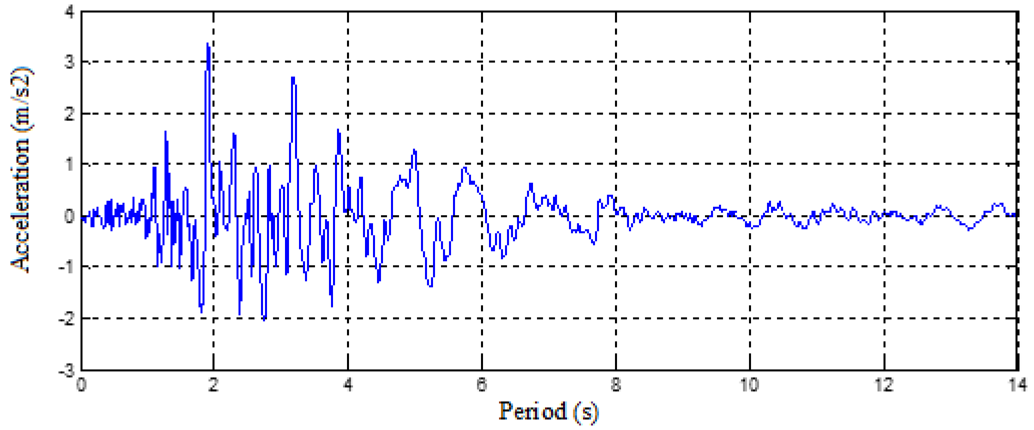

Fig. 20 Earthquake 6y applied in y direction

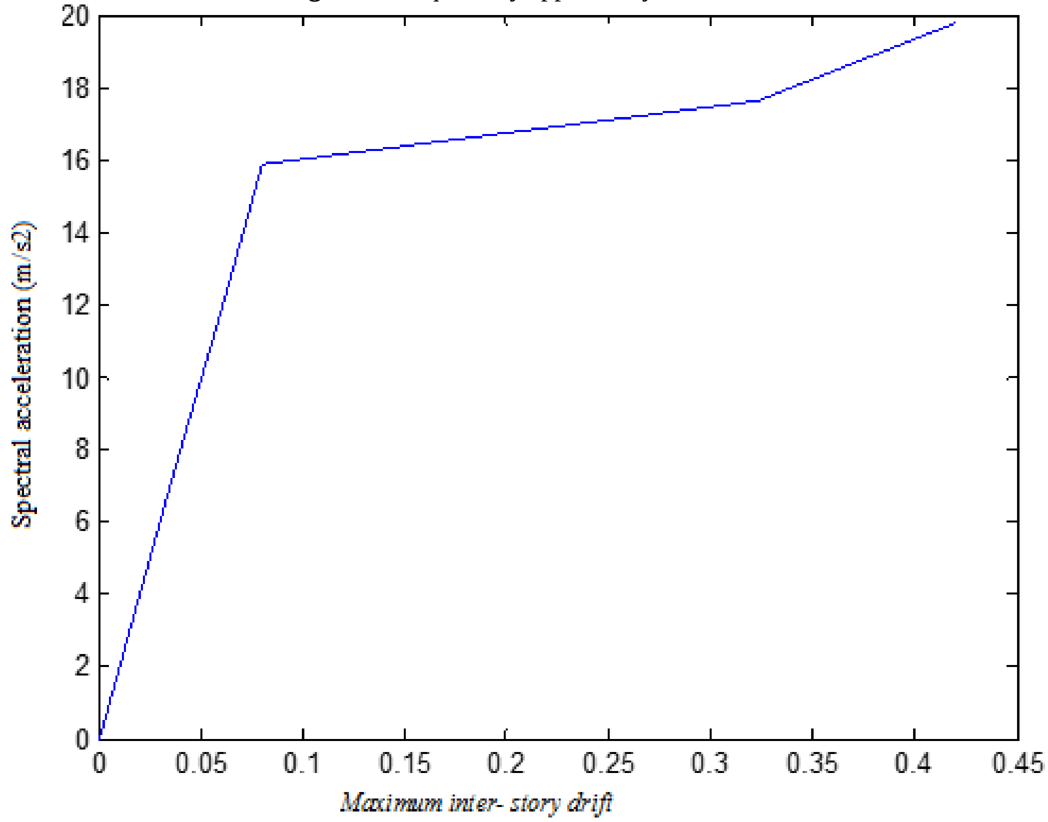

Fig. 21 Structure response due to the application of earthquake 6x and 6y respectively

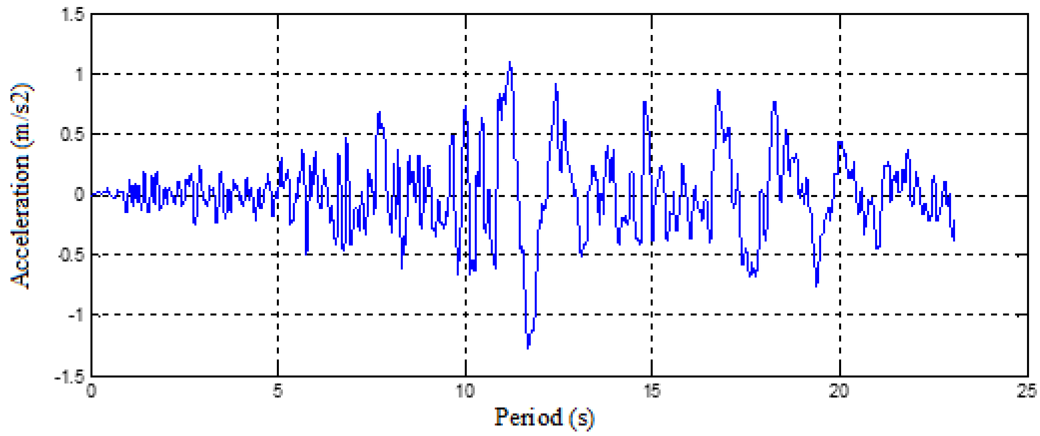

Fig. 22 Earthquake 7x applied in x direction

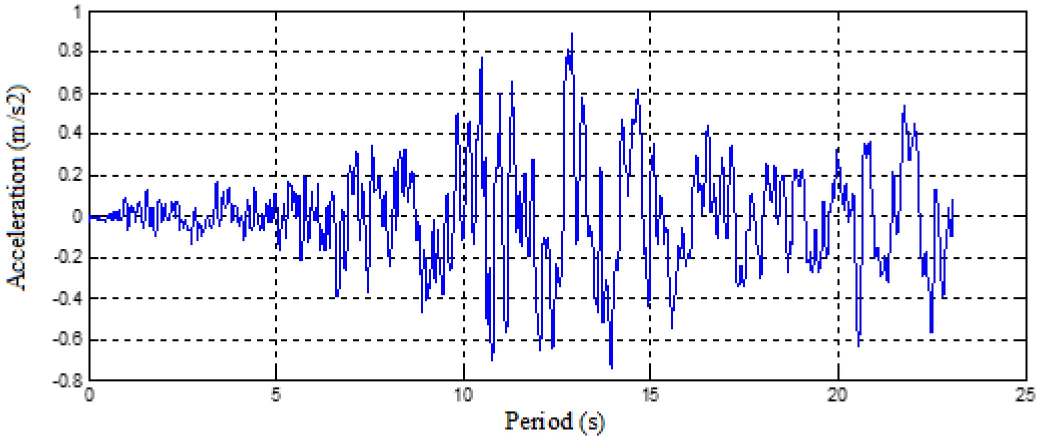

Fig. 23 Earthquake 7y applied in y direction

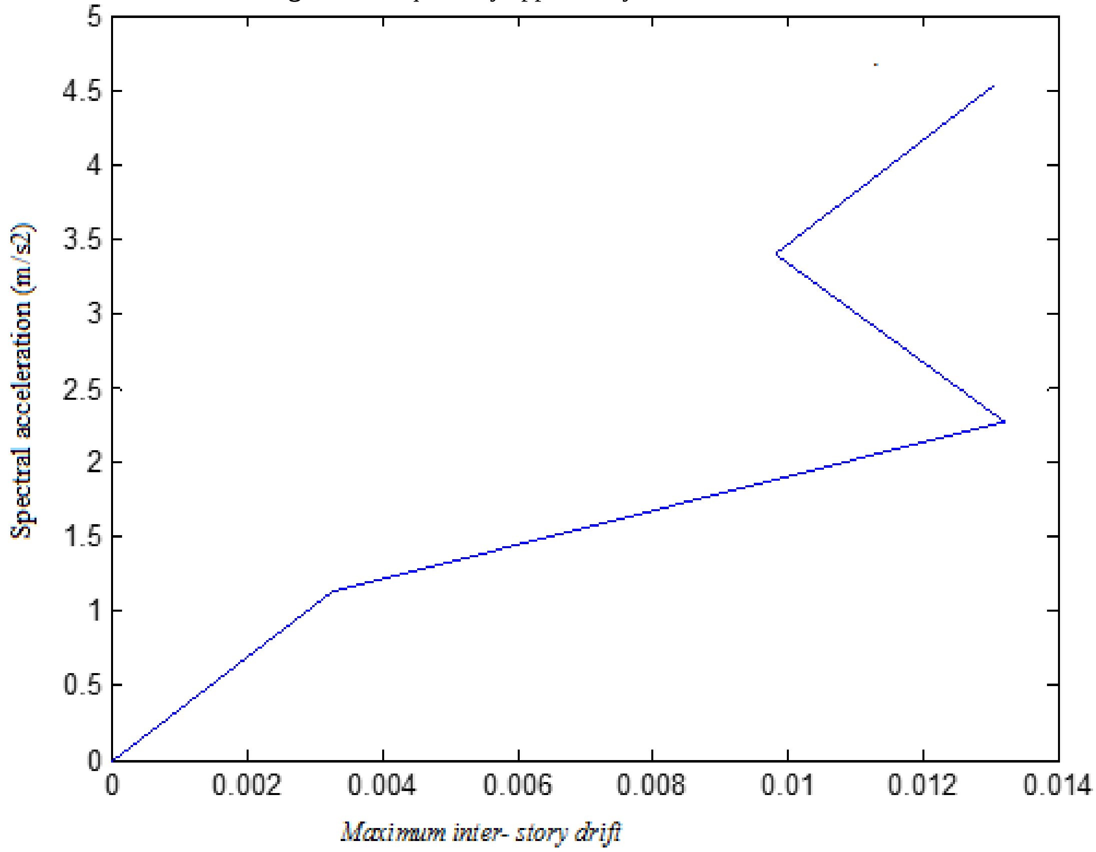

Fig. 24 Structure response due to the application of earthquake 7x and 7y respectively

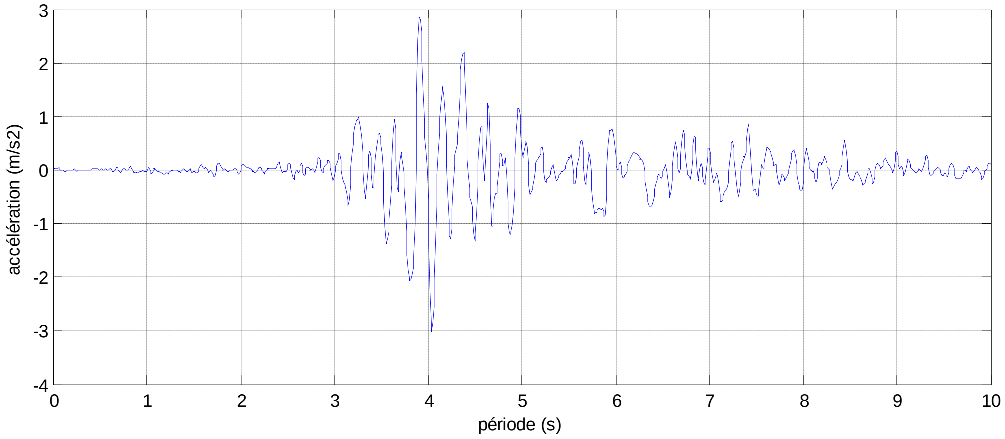

Fig. 25 Earthquake 8x applied in x direction

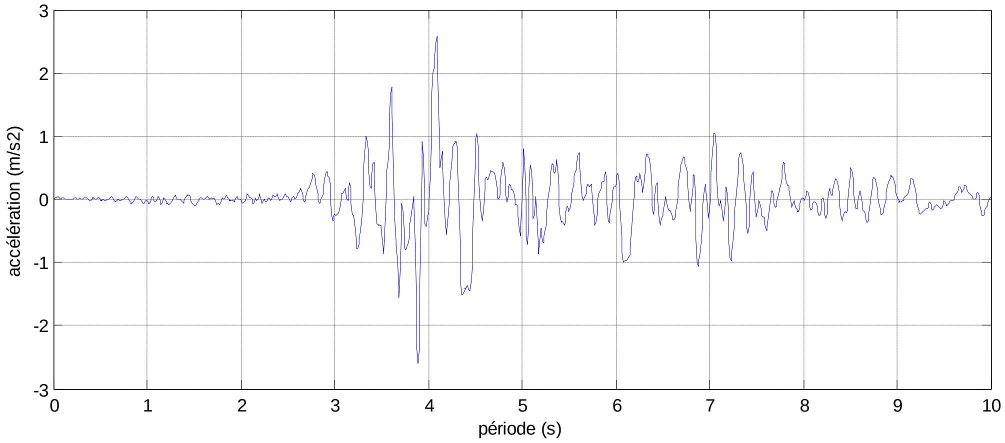

Fig. 26 Earthquake 8y applied in y direction

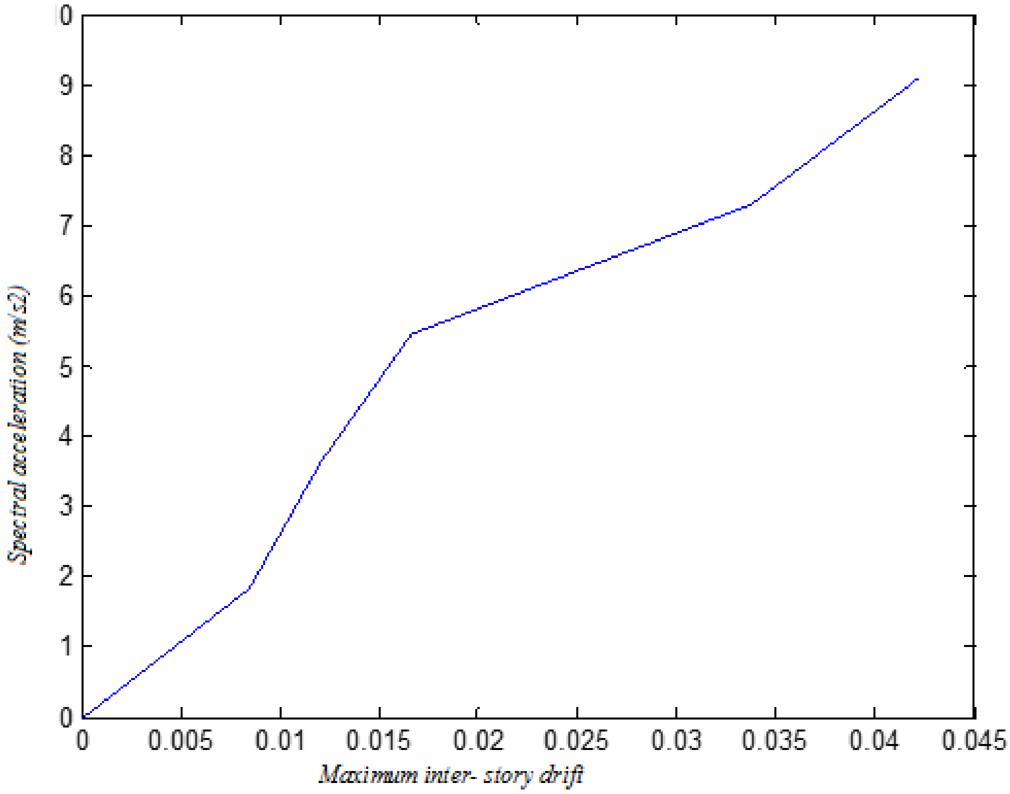

Fig. 27 Structure response due to the application of earthquake 8x and 8y respectively

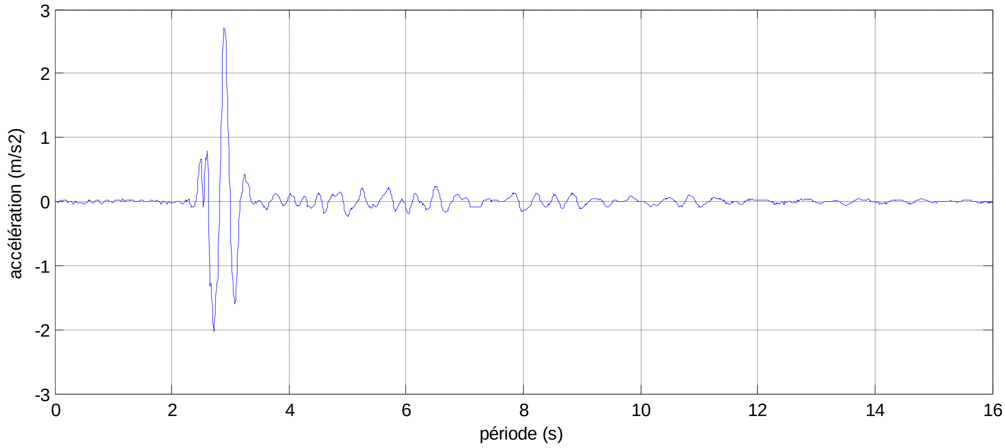

Fig. 28 Earthquake 9x applied in x direction

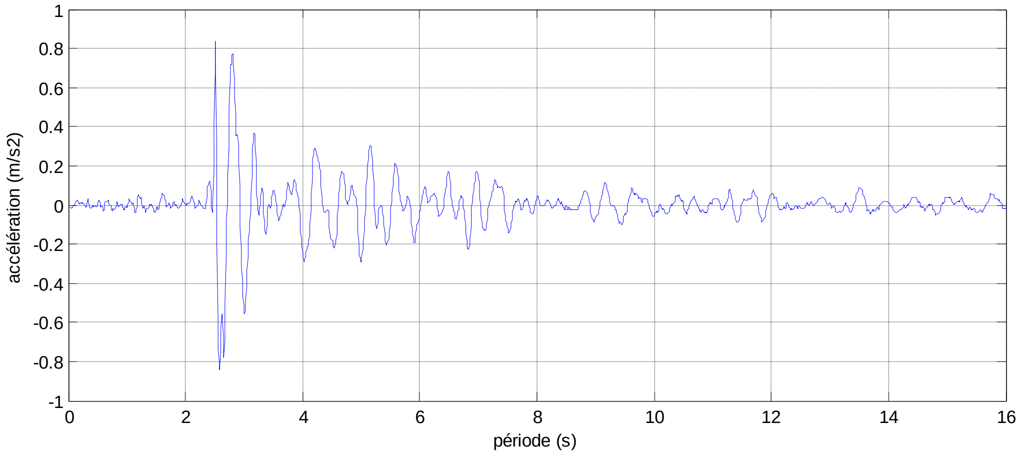

Fig. 29 Earthquake 9y applied in y direction

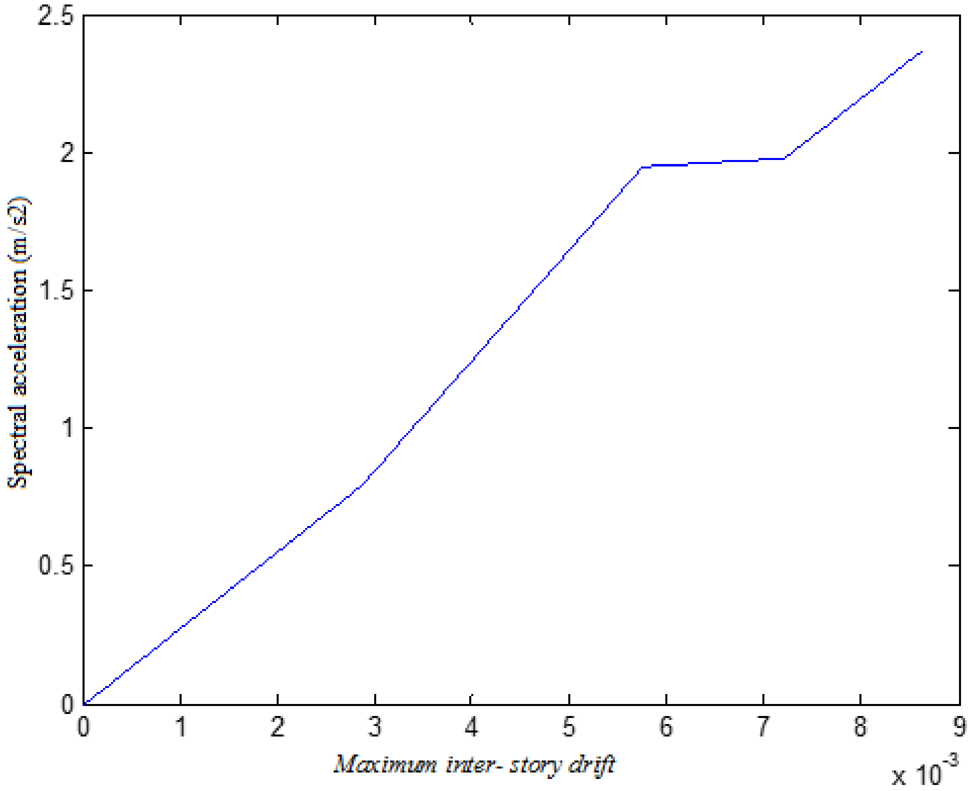

Fig. 30 Structure response due to the application of earthquake 9x and 9y respectively

CONCLUSION

On the basis of this first part of the work we can only observe that the structure does indeed show a strange behavior, after the application of an earthquake, which is gradually increased until it reaches 5 times its initial intensity.

This strange behavior is reflected by the appearance of a stiffness (an energy, a possibility of resistance), in another way a decrease in deformation after yielding [3]. It can be conclude that after yielding a structure still has a hidden strength that needs to be explore.

There is more work to do in this context, which will be the subject of the second part of the research to fully understand this behavior of the structure and to be able to compare between the incremental dynamic method and the pure and hard dynamic method. .

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