DURATION EFFECT ON SEISMIC RESPONSE OF STRUCTURES

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Motivation

Trifunac and Brady (1975) define the strong motion duration as the time interval between 5 and 95 percent of the root mean square acceleration (RMSA):

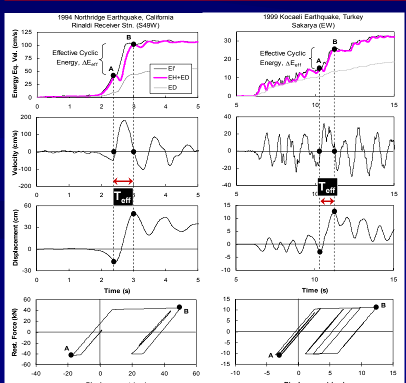
$$RMSA = \left[\frac{1}{t_E} \int_0^{t_E} a^2(t)\, dt \right]$$

This definition is one of the most widely used strong motion duration definitions and was proven to be correlated with the response of the structures under cyclic ground motions.

Impulsive records, however differ from the cyclic records in the sense that the maximum structural response is the result of a single impulsive cycle rather than the cumulative cyclic response observed in the latter records. Therefore in this study, an alternative duration definition so called "Effective Cyclic Duration" is proposed. This parameter is evaluated for 30 near-fault recordings. Its correlation is compared and contrasted with strong motion duration parameter by Trifunac and Brady against the elastic response of SDOF systems and also inelastic response of MDOF systems.

Effective Cyclic Duration

EFFECTIVE CYCLIC DURATION: Time interval between two consecutive zero-crossings of effective cyclic velocity. This definition is only applicable for impulsive near-fault recordings.



Unlike "STRONG MOTION DURATION" definition based on arias intensity, "EFFECTIVE CYCLIC DURATION" is depends on system response therefore varies at each spectral period. It is also a function of damping and hysteretic rule.

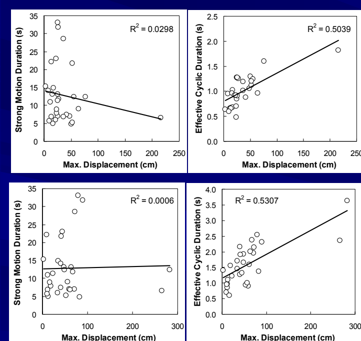
In this study, "EFFECTIVE CYCLIC DURATION" is computed for elastic system, yet it is also possible to compute this duration parameter for systems having constant ductility.

Ground Motion Data Set Utilized

A total of 30 forward directivity (23) and fling (7) accelerograms having impulsive characteristics were appositely compiled from world-wide earthquakes. These records contain distinct acceleration pulses.

SDOF Response versus Duration Parameters

Maximum elastic displacement demand of SDOF oscillators are compared with "Strong Motion Duration" and "Effective Cyclic Duration"



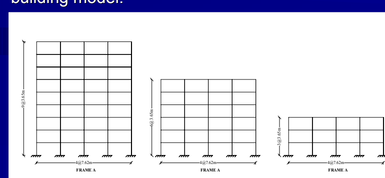
T=2.0 s

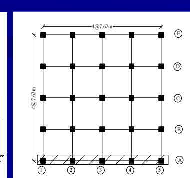
"Effective Cyclic Duration" yields better correlation with the peak displacement parameter

T=4.0 s

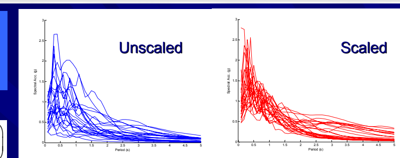
Moment Frame Structures Used for Evaluation

Three reinforced concrete (RC) frames with 3, 6, and 9 stories were designed according to IBC-2000 and used in the nonlinear time history analyses. Stable elasto-perfectly plastic material model was utilized for each building model.





Prior to NTH analyses, each ground motion was scaled individually so as to minimize the spectral difference with respect to NEHRP design spectrum within a period range of 0.3 to 3.0 seconds. In this way, we were able to consistently examine the effects of duration on demand.

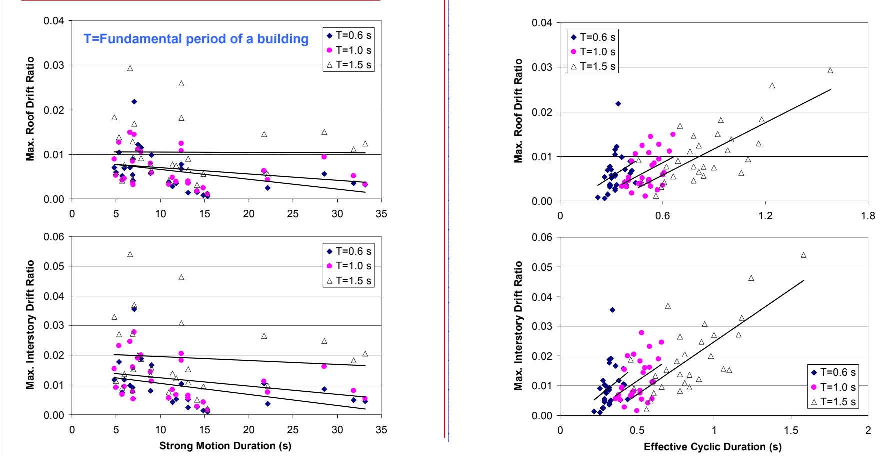


In order to minimize the error (δ), we calculated the k (scaling factor) simply by :

$$\delta = \sum_{i=1}^{n} (x_i - (k\, y_i))^2 \qquad k = \left(\sum_{i=1}^{n} (x_i\, y_i)\right) \Big/ \left(\sum_{i=1}^{n} (x_i\, x_i)\right)$$

MDOF Response and Its Correlation to Duration Parameters

Maximum roof drift ratio demand and maximum interstory drift ratio demand were selected as the main structural response parameter against which to compare two different duration parameters.



Concluding Remarks: The "Strong Motion Duration" parameter defined by Trifunac and Brady (1975) does not well correlated with the SDOF and MDOF systems' peak response parameters for near-fault impulsive records. Proposed "Effective Cyclic Duration", however is shown to be directly correlated with the time period of effective cycle during the response. This effective cycle is directly responsible in producing the ultimate displacement for near-fault pulse type records. Therefore "Effective Cyclic Duration" may be considered as a new duration parameter to measure the intensity of earthquake ground motions recorded in the vicinity of causative faults.