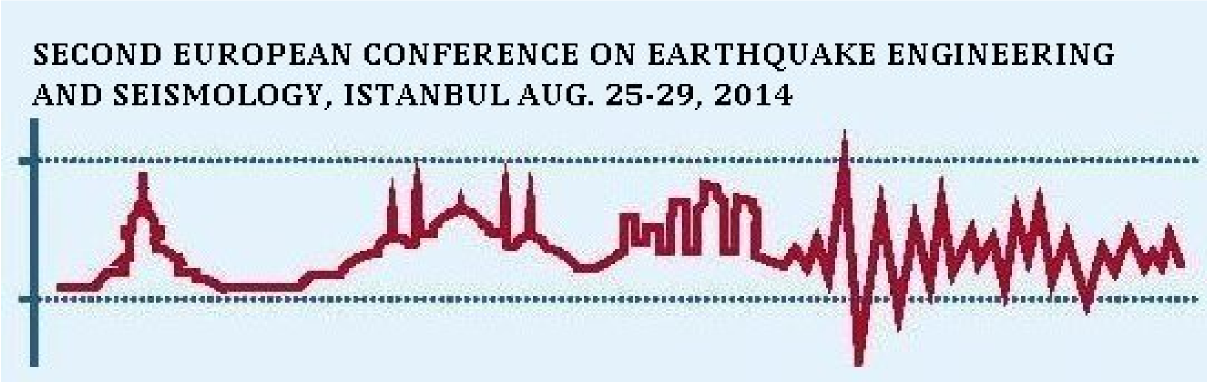

DUCTILITY SPECTRUM METHOD FOR DESIGN AND VERIFICATION OF STRUCTURES: SINGLE-DEGREE-OF-FREEDOM BILINEAR SYSTEMS

Benazouz CHIKH[1], Moussa LEBLOUBA[2] , Youcef MEHANI[3], Abderrahman KIBBOUA[4] and Ali ZERZOUR[5]

This study presents a new method, applicable to evaluation and design of structures has been developed and illustrated by comparison with the Capacity Spectrum Method (CSM), adopted by the Applied Technology Council (ATC-40., 1996). This method uses inelastic spectra and gives peak responses consistent with those obtained when using the nonlinear time history analysis (NL-THA). Hereafter, the seismic demands assessment method is called in this paper Ductility Spectrum Method (DSM). It is used to estimate the seismic deformation of Single-Degree-of-Freedom (SDOF) bilinear systems based on inelastic response spectrum.

This proposed procedure is a relatively simple method for determining the seismic demands of structures. It combines the Nonlinear Static Analysis (Pushover analysis) of SDOF bilinear model shown in figure (1), with a demand spectrum. This seismic demand formulated in the ductility demand – period format are applied, it is determined by using the Ductility Demand Response Spectrum (DDRS Spectrum) that was developed by the author in his last work (Chikh et al., 2012).

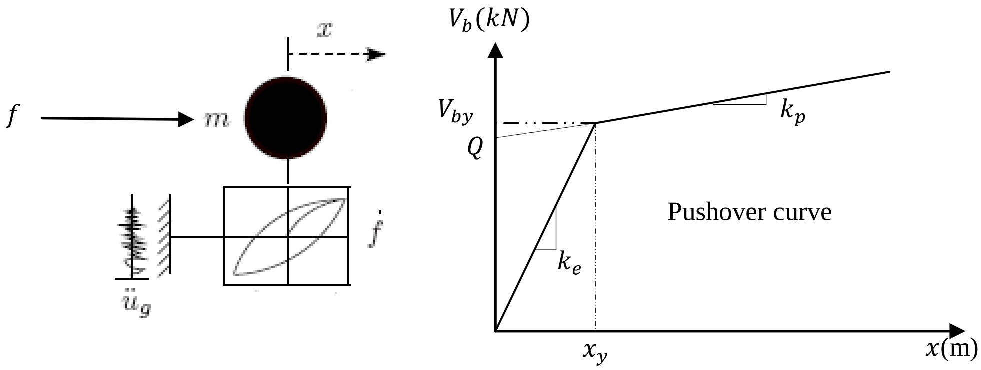

Figure 1. SDOF System and (b) Capacity curve

This feature represents the major difference with respect to the DSM Method. Moreover, seismic demand can be obtained without iteration. The differences between the proposed method and the CSM Method are discussed, and some examples are processed to check these differences.

The procedure to construct the ductility response spectrum for inelastic systems is based on normalized yield strength η of structures. This parameter can be obtained using Pushover curve after idealization in Acceleration-Displacement format (Figure 2).

[1] Senior Researcher, Earthquake Engineering Research Center, Algiers, cheikhpbsd@gmail.com
[2] Associate Professor, High National School of Public Works, ENSTP, Algiers, mlablouba@gmail.com
[3] Senior Researcher, Earthquake Engineering Research Center, Algiers, mehani_youcef@yahoo.com
[4] Senior Researcher, Earthquake Engineering Research Center, Algiers, a-kibboua@hotmail.com
[5] Professor, High National School of Public Works, ENSTP, Algiers, a.zerzour@enstp.edu.dz

$$\eta = \frac{qg}{PGA} \tag{1}$$

Where

PGA stands for the Peak Ground Acceleration

q Yield strength coefficient.

Use of the processing of capacity curve in Acceleration – Displacement format, the coefficient q is determined by the following formula:

$$A_s(g) = \frac{V_b}{mg} \Rightarrow q = \frac{Q}{mg} \tag{2}$$

A_s Spectral acceleration

Q Yield strength

m Masse of the system

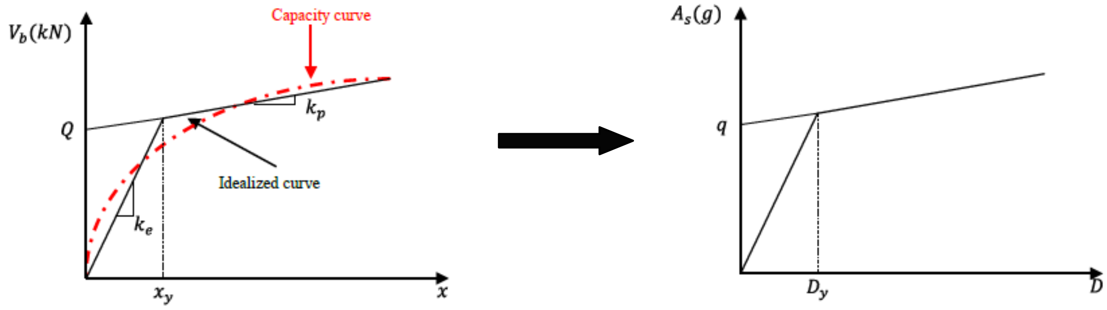

Figure 2. (a) Capacity curve and (b) capacity diagram

The value of the ductility factor is read from the DDRS spectrum and multiplied by x_y to obtain the peak deformation, x_m.The DDRS is constructed also for El Centro 1940 ground motion (N/S) component (PGA=0.32g, PGV=36.14 cm/sec, and PGD=21.34cm) and is shown in figure 3.

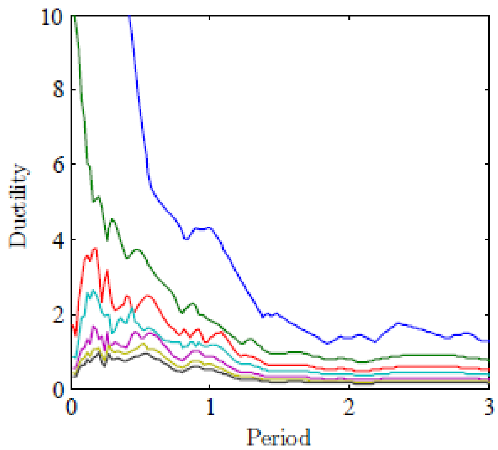

Figure 3. DDRS for inelastic system computed for El Centro 1940 (N/S) component (η = 0.25, 0.5, 0.75, 1, 1.5, 2, 2.5from top line to bottom line)

An application based mainly on the comparison of CSM method to the proposed method developed in this paper that gives the same results to those of the Nonlinear Time History Analysis (NL-THA). Ductility and inelastic displacement demand determined by the DSM and the CSM method of ATC -40 associated with the El Centro 1940 earthquake are compared in Figure 4 (a and b).

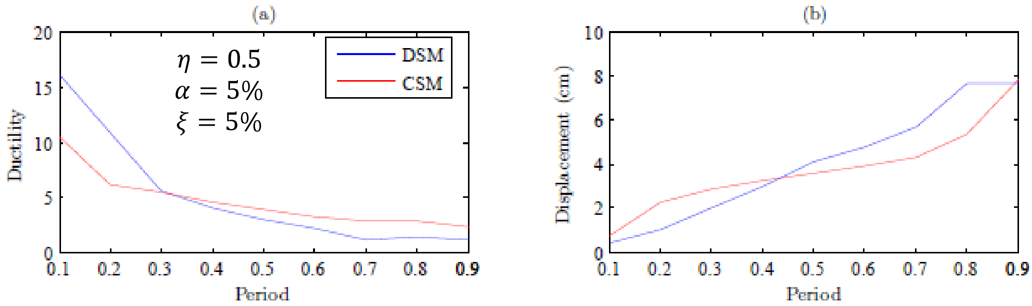

Figure .4 Comparisons of two approaches CSM and DSM (a) Ductility and (b) Displacement

The efficiency of the DSM is evident; the designer needs only to have the DSM for the design earthquake (s) to determine peak response of any structure, namely, base displacement and base shear.

The DSM method is applicable to a variety of uses such as a rapid evaluation technique for a large inventory of buildings, a design verification procedure for new construction, an evaluation procedure for an existing structure to identify damage states.

The ductility demand is given by the direct estimation where the ductility calculated from the DDRS diagram matches the value associated with the period of the system. This method gives the deformation value consistent with the selected DDRS inelastic response spectrum, while retaining the attraction of graphical implementation of the ATC-40 methods.

REFERENCES

ATC-40 (1996), “Seismic evaluation and retrofit of concrete buildings”, *Applied Technology Council (1996).*

Chikh B, Moussa L and Zerzour A (2012), “Ductility and Inelastic Deformation Demands of Structures”, *Structural Engineering and Mechanics Journal, 42(5):305-600*

Chopra A K and Goel R K (1999), “Capacity-demand-diagrams based on inelastic design spectrum“, *Earthquake Spectra, 15(4):637-656*

Fajfar P (1999), “Capacity spectrum method based on inelastic demand spectra", *Earthquake Engineering and Structural Dynamic, 28(9):979-993*