Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 199 (2017) 558–563

Procedia Engineering

www.elsevier.com/locate/procedia

X International Conference on Structural Dynamics, EURODYN 2017

Inelastic deformation ratio for seismic demands assessment of structures

Benazouz Chikh[a,*], Ahmed Mebarki[b], Nacer Laouami[a] and Youcef Mehani[a]

[a]National Earthquake Engineering Research Center, CGS, Rue Kaddour Rahim, BP 252 Hussein-Dey, Algiers, Algeria
[b]University Paris-Est, Laboratoire Modelisation et Simulation Multi Echelle (MSME), UMR 8208 CNRS, 5 Bd Descartes, 77454 Marne-La-Vallee, France

Abstract

Modern seismic codes rely on performance-based seismic design methodology which requires from the structures to withstand inelastic deformation. Many studies have focused on the inelastic deformation ratio evaluation for various inelastic spectra. The purpose is to investigate the ratio between the inelastic and elastic maximum lateral displacement demands. Three options are considered in the present work to express the inelastic response spectra in terms of the ductility demand, yield strength reduction factor and inelastic deformation ratio. This later, a new non dimensional parameter called inelastic deformation ratio (C_η), depends on the natural period (T), the post-to-preyield stiffness ratio (α), the normalized yield strength coefficient (η) and the peak ground acceleration (PGA). The inelastic deformation ratio (C_η), is not evaluated for a fixed ductility ratio or for a fixed strength reduction factor. Though the ductility demand and yield strength reduction factor differ greatly for given ranges of T and η, they take close values for systems for any T value when $\eta > 1$. It confirms also previous studies stating that they take unity value for periods $T \geq 1sec$.

Peer-review under responsibility of the organizing committee of EURODYN 2017.

Keywords: Inelastic, deformation, seismic demand, ductility, yield strength, static, dynamic

1. Introduction

For nonlinear dynamic analysis of structures, several simplified methods have been proposed. They estimate the seismic response by considering the structural capacity as well as the seismic intensity. Due to nonlinear materials

* Corresponding author. Tel.: +213-23-775-815; fax: +213-23-772-323.
E-mail address: cheikhpbsd@gmail.com

1877-7058 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the organizing committee of EURODYN 2017.
10.1016/j.proeng.2017.09.168

behavior, the dynamic structural characteristics change with time during important earthquakes. Therefore, ductility plays an important role in structural response and earthquake engineering design. To study the nonlinear response, one may use real time history analysis, by analytical or numeric procedure considering elastic and inelastic response, or simplified approach such as pushover analysis. Thus, it has been extensively investigated and discussed for seismic performance evaluation.

Among such methods, the most widely used are the Capacity Spectrum Method (CSM) (ATC-40 1996) that was developed for the first time by Freeman [10], the N2 method developed by Fajfar [5, 6] and the Displacement Coefficient Method (DCM) of the Federal Emergency Management Agency FEMA-273 and FEMA-356 [7, 8]. More recently, the FEMA-440 (FEMA 2005) was developed as improvement of nonlinear static seismic analysis procedures of FEMA-356 and the Applied Technology Council ATC-40 [1] for seismic rehabilitation of buildings.

For instance, in FEMA-273 and FEMA-356, the DCM method is adopted. They derive the maximum structural inelastic deformation from the maximum linear elastic deformation by using a modifying factor. In fact, the DCM method requires various correction factors in order to adjust the linear displacement for adequate representation by an equivalent nonlinear displacement. The most influent correction factor is represented by the modifying factor C_1which concerns the inelastic deformation ratio.

The Inelastic Displacement Ratio (Inelastic Deformation Ratio), known as C_1 in DCM method, is considered as the most influent reduction factor [9]. The role of inelastic deformation ratio on performance evaluation for existing structures and the seismic design assessment for new structures has been widely investigated [4, 11, 13, 14, 15, 16, 17, 19, 20].

To evaluate the inelastic deformation ratio, the present work presents an investigation about a new theoretical expression for SDOF bilinear systems derived from the bilinear capacity curve (Pushover curve).

2. Theoretical backgrounds

An adequate design aims required yield and peak (maximal) displacements according to the ductility demand during an earthquake. This has been initially introduced through the response spectrum for elastic-perfectly plastic systems [18]. This ductility demand (or ductility factor) for the bilinear system is expressed as [4], (see Fig. 1):

$$\mu = \frac{x_m}{x_y} \tag{1}$$

The Strength Reduction Factor is defined as the ratio of the elastic strength demand, f_0, to the inelastic strength demand, f_y, or the ratio of the elastic displacement to yield displacement x_y [4], (see Fig. 1):

$$R_y = \frac{f_0}{f_y} = \frac{x_0}{x_y} \tag{2}$$

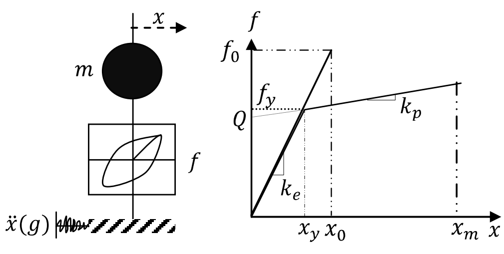

Fig. 1. Elastic behavior of an (SDOF) and its corresponding bilinear system

The inelastic deformation ratio (C_η) defined as the deformations ratio of inelastic vs. linear SDOF system is expressed as a function of the mechanical characteristics of the SDOF system, i.e. the mass (m), the elastic stiffness (k_e), the yield strength(Q) and the post-to-pre-yield stiffness ratio (α). (Chopra and Chintanapakdee 2004), (see Fig. 1):