Engineering Structures 33 (2011) 3422–3431

Contents lists available at SciVerse ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

Evaluation of maximum seismic displacements of SDOF systems from their residual deformation

George D. Hatzigeorgiou[a,*], George A. Papagiannopoulos[b], Dimitri E. Beskos[b,c]

[a] Department of Environmental Engineering, Democritus University of Thrace, 67100 Xanthi, Greece
[b] Department of Civil Engineering, University of Patras, Patras, Greece
[c] Office of Theoretical and Applied Mechanics, Academy of Athens, Athens, Greece

ARTICLE INFO

Article history:
Received 29 July 2010
Received in revised form
10 May 2011
Accepted 1 July 2011
Available online 6 August 2011

Keywords:
Seismic structural response
Residual displacements
Maximum displacements
Far-field earthquakes
Near-field earthquakes

ABSTRACT

The post-earthquake performance level of structures provides a very important source of information both for probable rehabilitation procedures and determination of structural response to probable incoming aftershocks. This performance is described by the maximum deformation which is directly related to structural damage. On the basis of extensive parametric studies on single degree of freedom structures, empirical equations are constructed for a simple and effective determination of the maximum seismic deformation from residual displacements, which can be measured in-situ after strong seismic events. The proposed method is applied both to far-field and near-field ground motions. It is found that the measure of residual deformation can be effectively used to evaluate the post-earthquake performance level of structures.

1. Introduction

Evaluation of post-earthquake structural performance has recently received considerable attention in terms of safety assessment, maintenance and repair. Thus, the post-earthquake performance level of structures provides a very important source of information both for rehabilitation procedures and determination of structural response to probable incoming aftershocks. In this respect, the dynamic characteristics of structures or their seismic response can be used to obtain one of the most important factors of structural performance, i.e., the damage index of the entire structure [1–3].

This paper proposes a simple and effective method to evaluate the post-earthquake performance level of structures from their residual deformation. It should be recognized that residual deformations play an important role for the assessment of the seismic performance level of structures, as shown in Refs. [4–10], which focus in quantifying and reducing residual displacements, mainly in a direct displacement-based design framework. After a strong ground motion, residual deformations can be measured in-situ using various methods of structural deformation measures such as the digital image correlation technique [11], the global positioning system (GPS) [12], or the usage of robotic theodolites (RTS) [13]. In general, the current status of seismic monitoring is mature and provides a variety of methods and measurement techniques [14].

Toussi and Yao [15] and Stephens and Yao [16] introduced a qualitative classification of damage, which is based on the residual interstorey drift ratio (IDR) of structures. However, the damage level is directly defined by the ultimate state and available ductility levels of the structure. Thus, in the cases of a non-ductile and a ductile frame with the same residual IDR values, the corresponding damage levels are quite different. Therefore, it seems more appropriate to determine other than IDR important structural performance properties, such as the maximum displacements, which are directly related to damage and lead to the total IDR levels and the ductility demands [17].

The proposed method provides simple empirical equations for evaluation of the maximum structural displacements both for far-field and near-field ground motions as functions of residual deformations which can be obtained experimentally. These equations are constructed on the basis of extensive parametric studies concerning the determination of the seismic response of single degree of freedom (SDOF) structures. Characteristic numerical examples are presented to illustrate the method and demonstrate its efficiency and usefulness.

* Corresponding author. Tel.: +30 25410 79373; fax: +30 25410 79373.
E-mail address: gchatzig@env.duth.gr (G.D. Hatzigeorgiou).

0141-0296/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.engstruct.2011.07.006