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Damage severity estimation of an elastoplastic single-degree-of-freedom oscillator from its ground and response accelerations

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ABSTRACT

Structural health monitoring requires procedures for estimating seismic damage. An energy-based method is proposed for the estimation of occurrence in time and severity of damage of a damped elastoplastic single-degree-of-freedom oscillator from its absolute and ground accelerations, using ductility as the adopted damage index. This estimation requires the calculation of the yielding history, relative velocity and dynamic parameters of the oscillator. Oscillators of several frequencies, subjected to two different bandwidth motions, are examined. Yielding history is identified by the discrete wavelet transform (DWT) highest scale coefficients of the absolute acceleration. This identification is not possible in responses with high-frequency content. A DWT filter is proposed for this situation to enable this identification. A least-square method that acknowledges the unloading known from the yielding history is proposed to fit the velocity obtained from the time integral of the relative acceleration. The results show that the precision in estimated ductility is sensitive to the accuracy of the yielding history, as this history influences the calculation of the other parameters and variables required for the estimation of ductility. Small deviations in the actual yielding history generate important variations in estimated ductility. However, the proposed method successfully identifies the occurrence in time and severity of damage produced in most yielding stages. Copyright © 2013 John Wiley & Sons, Ltd.

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1. INTRODUCTION

Structural health monitoring provides important information for maintaining structures within safe levels of operation; this is especially true for structures that are regularly subjected to earthquakes. Such monitoring consists of estimating damage severity and its occurrence in time and space during an earthquake. This information is relevant for estimation of the vulnerability of the structure to future earthquakes and also provides useful information for optimization of maintenance costs.

Several methods, which can be used to estimate the occurrence of damage in time, have been developed [1–3]. These estimations depend on the severity of damage, frequency sampling and fundamental frequency of the single-degree-of-freedom (SDOF) ratio, in addition to the frequency content of the response. Severity of damage has been estimated using several indexes such as the magnitude of the wavelet coefficients [4], variation in stiffness [5] and ductility [6].

Structural health monitoring requires the acquisition of registers related to the response of the structure of interest. The basic configuration of a monitored structure generally consists of two instruments that register the ground acceleration $\ddot{x}_g$ and the absolute acceleration of the structure $\ddot{x}_a$, defined as

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