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A procedure for damage detection and localization of framed buildings based on curvature variation

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Structural Health Monitoring and Damage Detection are topics of current interest in civil, mechanical and aerospace engineering. Damage Detection approach based on dynamic monitoring of structural properties over time has received a considerable attention in recent scientific literature of the last years. The basic idea arises from the observation that spectral properties, described in terms of the so-called modal parameters (eigenfrequencies, mode shapes, and modal damping), are functions of the physical properties of the structure (mass, energy dissipation mechanisms and stiffness). Structural damage exhibits its main effects in terms of stiffness and damping variation. As a consequence, a permanent dynamic monitoring system makes it possible to detect and, if suitably concentrated on the structure, to localize structural and non-structural damage occurred on the structure during a strong earthquake. In the last years many researchers are working to set-up new methodologies for Non-destructive Damage Evaluation (NDE) based on the variation of the dynamic behaviour of structures under seismic loads. Pandey et al. (1991) highlighted on the possibility to use the structural mode shapes to extract useful information for structural damage localization.

In this paper a new procedure for damage detection on framed structures based on changes in modal curvature is proposed. The proposed approach is based on the use of Stockwell Transform, a special kind of integral transformation that become a powerful tool for nonlinear signal analysis and then to analyse the nonlinear behaviour of a general structure. Using this kind of approach, it is possible to use a band-variable filter (Ditommaso et al., 2012) to extract from a signal recorded on a structure (excited by an earthquake) the response related to a single mode of vibration for which the related frequency changes over time (if the structure is being damaged). İn general, by acting simultaneously in both frequency and time domain, it is possible to use the band-variable filter to extract the dynamic characteristics of a system that evolves over time.

Aim of this paper is to show, through practical examples, how it is possible to identify and to localize damage on a structure comparing mode shapes and the related curvature variations over time. It is possible to demonstrate that mode curvature variation is strongly related with the damage occurred on a structure. This paper resumes the main outcomes retrieved from many numerical non linear dynamic models of reinforced concrete framed structures characterized by different geometric configurations and designed for gravity loads only. The numerical campaign was conducted using both natural and artificial accelerograms compatible with the Italian code. The main results of experimental shaking table tests carried out on a steel framed model are also showed to confirm the effectiveness of the proposed procedure.

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