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Seismic response of structures: from non-stationary to non-linear effects

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The need for an effective seismic protection of buildings, and all the problems related to their management and maintenance over time, have led to a growing interest associated to develop of new integrated techniques for structural health monitoring and for damage detection and location during both ambient vibration and seismic events. It is well known that the occurrence of damage on any kind of structure is able to modify its dynamic characteristics. Indeed, the main parameters affected by the changes in stiffness characteristics are: periods of vibration, mode shapes and all the related equivalent viscous damping factors.
With the aim to evaluate structural dynamic characteristics, their variation over time and after earthquakes, several Non Destructive Evaluation (NDE) methods have been proposed in the last years. Most of these are based on simplified relationship that provide the maximum inter-story drift evaluated combining structural variations in terms of: peak ground acceleration and/or structural eigenfrequencies and/or equivalent viscous damping factors related the main modes of the monitored structure. The NDE methods can be classified into four different levels. The progress of the level increases the quality and the number of the information.
The most popular are certainly Level I methods being simple in implementation and economic in management. These kinds of methods are mainly based on the fast variation (less than 1 minute) of the structural fundamental frequency and the related variation of the equivalent viscous damping factor. Generally, it is possible to distinguish two types of variations: the long term variations, which may also be linked to external factors (temperature change, water content in the foundation soils, etc.) and short period variations (for example, due to seismic events), where apparent frequencies variations could occurred due to non-stationary phenomena (particular combination of input and structural response). In these cases it is possible to confuse apparent frequencies variations with real ones (related to nonlinear phenomena) which could lead to an incorrect assessment of the structural safety.
In this paper a new theoretical approach is proposed to discriminate non-stationary from non-linear effects, it was tested on both numerical and experimental accelerometric recordings respectively retrieved from one degree of freedom oscillator and one timber framed structure monitored during the 2011 Canterbury Seismic Sequence.