ESC2016-181-3, 2016
35th General Assembly of the European Seismological Commission

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4–10 September 2016 Trieste

SPO2FRAG V1.0: software for derivation of seismic fragility functions via static pushover

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Studies for seismic risk assessment performed within the probabilistic framework of performance-based earthquake engineering, often rely on fragility (or vulnerability) functions to provide the probability of exceeding some predefined structural performance limit-state, given a certain level of seismic intensity. In the case of site- and structure-specific studies, the need arises for analytically derived fragility functions. Analytical estimation of seismic structural fragility can be achieved by various methods involving non-linear dynamic analysis – for example, incremental dynamic analysis (IDA). However, there can be significant computational burden associated with this approach and this constitutes its principal disadvantage. In order to circumvent such computationally demanding methods of seismic structural assessment, while still maintaining some of their advantages, engineers often turn to approximate methods, such as static non-linear procedures, which estimate seismic demand of the structure by making recourse to an equivalent single-degree-of-freedom (SDOF) oscillator. A simple and effective link between IDA and static non-linear analysis can be found in the SPO2IDA algorithm, which acts as a predictive equation of the fractile IDA curves of SDOF systems with multi-linear pushover curves. The SPO2FRAG (Static Pushover to Fragility) software is conceptually based on this SPO2IDA algorithm and comprises a series of computational tools that permit an effective transition from the SDOF structural representation to seismic fragility of the actual structure.

This novel software operates following a sequential structure: user-provided static pushover results are input along with the necessary dynamic characteristics of the structure. The pushover curve is passed on to an automatic multi-linearization algorithm and the equivalent SDOF parameters are input to the SPO2IDA algorithm. After the necessary conversions of the resulting fractile IDA curves from SDOF to MDOF {Intensity Measure, Engineering Demand Parameter} coordinates, the limit-states are defined along with their associated EDP thresholds. Finally, decisions pertaining to insertion of additional variability are made and the parameters of the fragility functions are estimated. The software revolves around a graphical user interface (GUI) that allows the user immediate visualization of all intermediate results produced by the various modules and sub-routines. The individual modules that comprise the operational part of the software are the input interfaces, automatic multi-linearization module, dynamic characteristics toolbox, SPO2IDA module, an interface for definition of limit-states, their corresponding thresholds and additional sources of uncertainty, the fragility function module and the output post-processing module.