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Foreword to the Special Issue for the RINTC (The Implicit Seismic Risk of Code-Conforming Structures) Project

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The need for a code in which the design objectives are expressed in terms of probability of failure of the structure has been around for about 50 years [e.g., Cornell, 1969]. Such a need has been accepted by the community, but the way these concepts have been implemented in modern codes is a compromise between a probabilistic approach and a deterministic format compatible with the technical background of practitioners; that is, the so-called *load-resistance-factor-design* or LRFD [Ellingwood, 2000]. In the LRFD approach, *conservative* percentiles of load and resistance distributions of structural elements are employed in verifications. The assumption is that, in such a way, a level of structural reliability is indirectly warranted.

In seismic design, the design action results from probabilistic evaluations consistent with the *probabilistic seismic hazard analysis* [e.g., Cornell, 1968; McGuire, 2004]. The design ground motion (usually in the form of elastic response-spectrum ordinates) has a (rare) return period of exceedance at the construction site, which corresponds to some structural performance threshold that, if surpassed, determines failure; that is, the attainment of a *limit-state* [OES, 1995].

It is well known that this approach, although has represented a giant leap in earthquake-resistant design when introduced, does not allow to explicitly control the reliability of the designed structure, that is ultimately unknown. In fact, if design is such that the structure does not fail for intensities lower than the design intensity and fails with certainty for larger intensities, then the failure probability in any time interval coincides with the exceedance probability of the design intensity in the same time interval. However, because ground motion intensity has limited explanatory power with respect to structural response, there is always a non-negligible probability that the structure fails for intensities below that used in design. Moreover, the design procedures are such that, typically, there is a level of structural resistance surplus even at intensities larger than design. This renders the relationship between the exceedance return period of the design ground motion and the structural reliability less direct.

Recently, some approaches have been proposed to improve design towards more controlled failure probabilities. These ongoing attempts are collectively known as *risk-targeted ground motion* [i.e., Luco *et al*., 2007]. The latter approaches are promising (although requiring some careful calibration) and possibly will find their way into the next generation of design codes. However, given the present situation, insights about the seismic structural reliability implied by design according to current standards are the starting point to plan improvements, especially with respect to what should be the targeted reliability for code-conforming structures. This was

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indeed the goal of a large national research program: the *RINTC – Rischio Implicito delle Strutture Progettate Secondo le NTC* project, which ran from 2015 to 2017 [RINTC Workgroup, 2018]. This special issue of the Journal of Earthquake Engineering presents papers from the latter national research project. It addressed the seismic structural reliability implicit by design according to the Italian code, referred to as *Norme Tecniche per le Costruzioni* [CS.LL.PP., 2008, 2018], which has significant similarities with Eurocode 8 [C.E.N., 2004].

The RINTC project was commissioned and funded by the *Dipartimento della Protezione Civile* (i.e., the Italian civil defence) and for its purposes, a series of Italian sites was considered so as to span a wide range of seismic hazard levels within the country. A large group of researchers, experienced in specific structural typologies, designed a large number of buildings at these sites. The considered structural configurations were: *unreinforced masonry, cast-in-place reinforced concrete, precast reinforced concrete, steel*, and *base-isolated reinforced concrete*. The same designed buildings were also modelled in three-dimensions for the purposes of nonlinear dynamic analysis, which served for seismic structural fragility assessment via state-of-the-art methodologies. The fragility of these code-conforming structures was coupled with the probabilistic seismic hazard for the hypothetical construction sites, which in turn enabled the calculation of seismic structural reliability, expressed in terms of annual failure rates, according to the paradigm of *performance-based earthquake engineering* [Cornell and Krawinkler, 2000]. A significant effort, especially related to the selection of input ground motion, modelling assumptions and postprocessing of the results for reliability assessment, was required for consistency and comparability of the analyses carried out for the different structural typologies.

The objective of this special issue is to illustrate and discuss the main results of the RINTC project, which could be of interest to the international scientific community in the field of earthquake engineering. To this aim, the issue features eight papers: the first one reports and discusses the reliability assessment quantitative results [Iervolino *et al*., 2018]; the second one deals with the characterization and representation of uncertainties in structural modelling and within-building material properties [Franchin *et al*., 2018]. The others deal with the design and modelling of typology-specific structures [Cattari *et al*., 2018; Magliulo *et al*., 2018; Manzini *et al*., 2018; Ragni *et al*., 2018; Ricci *et al*., 2018; Scozzese *et al*., 2018].

The editors and the reviewers believe that the published papers help in highlighting the outcomes of the RINTC project that are relevant to the community, for example:

(1) the seismic structural reliability implied by code-conforming design generally decreases as the seismic hazard of the construction site increases, despite the design ground motion has the same exceedance return period everywhere;
(2) at the lowest hazard sites, the reliability implied by the code is so high that only upper bounds to the failure rates could be computed; conversely, for some structural typologies at the most hazardous sites, the failure rates are comparable to the exceedance rate of the design ground motion.

These conclusions notwithstanding, it is important to note that the modelling and design choices inevitably include some degree of conventionality, due to the available structural modelling capabilities, including the identification of the thresholds corresponding to the attainment the performance levels of interest. Moreover, the choices made by the researchers involved in the RINTC project may have influenced the quantitative conclusions listed above. Therefore, the precise values reported in this special issue should be always considered with due caution and having in mind the issues, assumptions and choices discussed in the papers of this special issue.

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