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Moment resistance statistical distribution of beam-to-column composite joints

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ABSTRACT

In seismic design of steel–concrete composite moment resisting frames, the randomness of beam-to-column joint rotational response can affect the location of dissipative zones. In fact, in case of full-strength joints, the dissipation of the earthquake input energy occurs at the beam ends; conversely, in case of partial-strength joints, the connection components of beam-to-column joints are involved. Within this framework, random material variability of joint components plays an important role, because it affects the joint flexural strength and, as a consequence, also the plastic rotation supply. Therefore, within the framework of a research program aimed at the evaluation of the seismic reliability of steel–concrete composite frames including random material variability, this paper focuses the attention on the analysis of the influence of random material variability on the rotational response of beam-to-column joints. In particular, the aim of the work is the evaluation, by means of Monte Carlo simulations, of the statistical distribution laws of the parameters describing, from the overall point of view, the rotational behaviour of beam-to-column joints. Such distribution laws represent important input data for a complete probabilistic seismic demand analysis of steel–concrete composite moment-resisting frames where the joint modelling is performed by using rotational spring elements whose parameters are selected as random values satisfying the distribution laws previously derived.
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1. Introduction

The accurate evaluation of the seismic response of structures is very complex, because of a large number of sources of uncertainty. This difficulty is due not only to the "natural variability", but also to the degree of accuracy resulting from the modelling of the physical behaviour [1].

The natural variability is the source of the so-called randomness or aleatory uncertainty. In fact, the seismic performance of structures during seismic events depends on many sources of randomness such as the intensity and the dynamic characteristics of the earthquake ground motion, the material mechanical properties, the quality of workmanship, the hysteretic behaviour of dissipative elements and joints, the dynamic characteristics, the response of non-structural elements employed and the degree of maintenance [2].

The degree of accuracy resulting from the structural modelling represents the so-called epistemic uncertainty. In fact, analysis methods may not accurately capture the actual behaviour due to necessary simplifications and approximations in analysis procedures and modelling of structures. In fact, our knowledge of the behaviour of structures during earthquakes is not complete. Finally, this uncertainty is also due to the degree of accuracy of the statistical models describing the distribution of the structural model parameters.

Therefore, the complete knowledge of seismic performances of structures requires stochastic response analyses with sophisticated nonlinear models for evaluating the structural damage for different earthquake design levels [3–5].

However, although electronics took a step forward in the last years, the burdensome calculation remains the most overhanging limit for the application, in everyday design practice, of a probabilistic procedure. Therefore, such procedures are mainly adopted for advanced seismic performance assessments of structures [6–12] and as decision analysis tools [13], rather than as design tools.

With reference to the seismic design of steel–concrete composite moment resisting frames, the randomness of beam-to-column joint rotational response can be of primary importance, because it affects the location of dissipative zones. In fact, under severe ground motions, the dissipation of the earthquake input energy at the beam ends is expected. In case of partial-strength beam-to-column joints, this is obtained through the yielding of some joint components, properly selected, and a ductile behaviour can be obtained provided that the fastening elements, such as the welds and/or the bolts remain in elastic range. To this scope such brittle joint components have to be designed with adequate overstrength with respect to the yielding component. In other words, hierarchy criteria at the joint component level have to be applied to design ductile partial-strength beam-to-column joints. Conversely, the use of full-strength beam-to-column joints having a sufficient overstrength with respect to the connected beam allows the complete

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