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BUILDING A ROBUSTNESS INDEX

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ABSTRACT

"Structural robustness" is a term recently adopted by the literature in order to frame all the actions that a designer should take in addition to a mere (semi-probabilistic or probabilistic) safety analysis. The lifecycle scenarios may include rare, but possible extreme situations whose damaging consequences can be limited at no extra-cost by a suitable conception of the structural system.

The concept of structural robustness is clearly introduced by the Joint Committee on Structural Safety in its probabilistic model code (JCSS, 2001). The same concept is the object of a topic Eurocode activity (prEN1991-1-7, 2004). Furthermore, it is becoming a stringent constraint within the performance based design and those national codes which are based on it (US General Service Administration and Applied Research, 2003). However, the resulting set of design requirements still lacks an universally accepted definition able to quantify robustness. As a result, the related research must conceive procedures which pursue the comparison of the robustness of structural systems, or, in a simplified form, one must introduce robustness indexes [1].

To date, the proposed robustness indexes are mainly oriented to improve the structural reliability under assigned extreme scenarios. They can either take into account the local failures of the structural system or the occurrence of external hazards, which are likely to be present but not quantifiable in a statistical manner. With such an approach, one only considers the benefit aspect, thus forgetting the cost component of the optimization process.

Within this paper, a cost function is defined in the space of the design variables, and its value must either be constant or fall within an assigned range. Also a set of scenarios against which robustness should be assessed is introduced. The result will be a robustness index dependent on both the given range of design costs and the given aggression scenarios.

By adopting a Differential Evolution (DE) genetic algorithm [2-3], the zero-one (survival-failure) domains are identified in the space of the design variables. Each feasible solution, i.e., any structural design of given cost satisfying the safety requirement, will then be associated with a robustness index.

A numerical example is used to explain the computational details of the proposed method. In particular, with reference to Figure 1 [2], Table I provides the mean values of the limit moments in columns and beams when two different formulations of the robustness index, both aiming to promote the beam collapse mechanism with respect to the others, are alternatively considered in the objective function accounting for cost, reliability and, robustness.

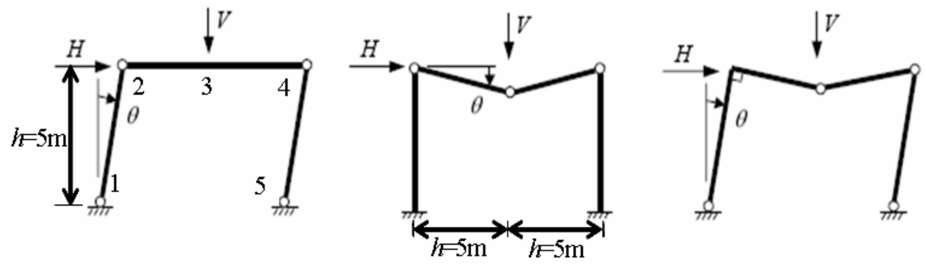

Figure 1: Numerical example: failure modes of a portal-frame.

Table I. Different requirements at the solution point

Case	μ_c	μ_b	I	I'	Cost	Iterations
Without robustness	166.50	154.57	0.63	0.015	808.66	4212
With Robustness Index, *I*	168.64	153.80	0.78	0.102	813.52	3098
With Robustness Index, *I'*	173.79	163.40	0.544	0.954	848.16	5236

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