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Robustness: a practitioner's perspective

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Abstract

In spite of their importance for structural performance, robustness considerations are not substantiated in detail in current codes and standards. Going out from this unsatisfactory situation, a practical approach for a risk-based design of robust structures is suggested in the present contribution. The proposal, which may also be adapted for the assessment of existing structures, generally envisages continuous, ductile structural systems due to their inherent advantages for persistent and identified accidental design situations, such as moment redistribution capacity and energy dissipation. In order to avoid progressive collapse given the occurrence of local failure due to unidentified accidental actions, either alternative load paths or predefined collapse mechanisms should be built into such systems. A procedure is proposed to achieve coincidence between assumed and real mechanisms in case of key member failure. For the design or assessment of such key members, risk-based target reliability indices are provided considering both, persistent and accidental situations.

Keywords: Load-bearing system; Structural safety; Target reliability; System reliability; Local failure; Progressive collapse; Robustness; Key element; Alternative load paths; Segmentation.

1. Introduction

The partial factor method, in conjunction with the limit state design which is currently being used in practice for the verification of the requirements regarding the resistance and stability of structures, has been established for separate calculations of action effects and structural response, respectively, and for the verification of structural safety at a cross-section or member level. In reality, structural collapse occurs if a full mechanism develops, depending on the system considered and its behaviour [1], among other parameters. Since the current design approach focuses on local failure, the results obtained in terms of structural reliability at a global or system level cannot be uniform. If the change in the static system due to the failure of one structural component and the subsequent redistribution of internal forces and moments leads to a successive collapse of other components, current procedures may produce unsafe designs, even if the required level of safety is provided to the individual elements constituting a structure [2].

Structural damage may result from a variety of circumstances such as accidents, overloading, deterioration or malevolence. Therefore, a good design should result in structures which are able to sustain such damage to a certain degree, e.g. in order to save lives by evacuating a building or infrastructure in due time, or avoid interruption of lifeline functions [3]. For this purpose, most modern structural design codes require that the consequence of damage to structures should not be disproportionate to the original cause [3]. Such requirements are usually not developed further,

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