Robustness based evaluation of a concrete frame considering the Eurocode design guidelines

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Abstract

Despite the development of structural codes such as the Eurocodes, one has to acknowledge that structural robustness is still an issue of controversy, being underlined by several structural failures in the past decades. One of the problems is the lack of a procedure to quantify the robustness of a structure in an objective way. In this contribution the robustness of a reference reinforced concrete frame is quantified applying a multi-level computational-efficient calculation scheme and using a risk-based robustness index to investigate the effectiveness of the Eurocode guidelines. Hereby the nonlinear behaviour of the reinforced concrete elements and the global behaviour of the structural frame are taken into account.

Keywords: Robustness, Probabilistic numerical analysis, Eurocodes, RC beams, Membrane action; Frame analysis

1 Introduction

Following multiple large structural failures such as the collapse at Ronan Point (1968), in most Western Countries there are structural guidelines, including the Eurocodes, which recommend several strategies to manage and decrease the risks of disproportional damage and progressive collapse in case of an unforeseeable event. Nevertheless, considering recent failures, current design codes are not completely satisfying. Moreover it is still unclear how effective these recommendations actually are in enhancing the structural robustness and certain aspects, such as the ductility and deformation limits of the RC elements, are not completely covered by the current regulations. Therefore, in this contribution it is intended to investigate the effectiveness of the current regulations regarding the robustness of a reference reinforced concrete frame, which is designed according to the Eurocodes. Specific attention is given to the horizontal ties according to EN 1991-1-7 [1] and an improved robust design is proposed. To obtain the system reliability of the considered RC frame and to evaluate the frame in an objective way in case of a notional column removal, a multi-level computational-efficient calculation scheme including the nonlinear behaviour of the RC elements is developed. Next the robustness is quantified using a risk-based robustness index for the specific damaged situation.

2 Reference case

2.1 Design without taking into account EN 1991-1-7 [1]

As a reference case a rectangular 6-storey office building designed according to EN 1992-1-1 (2004) [2] is considered which consists of a RC framework with four and six bays in the two orthogonal directions, respectively. Each bay has a span of 6 m and a total height of 21 m. The beams are placed in the 6-bay direction and the slabs which constitute the floors are one-way carrying precast

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