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Structural robustness at the conceptual stage

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Abstract

The aim of this paper is to develop a complementary method to the numerical approaches proposed in the literature on the subject, which will help in assessing the constitutive dimensions of structural robustness at the conceptual stage. Based on geometrical thinking, this method defines robustness as the ability of a structure to maximise the rearrangement of its internal forces. This can be expressed graphically by admissible geometrical domains. The purpose and extent of this new approach are summarised and illustrated by the detailed robustness analysis of two case studies. The areas obtained for the admissible geometrical domains are then compared with values of the minimal load path and with structural stiffness, in order to decide on the right modelling strategy.

Keywords: robustness; structural design; strut-and-tie modelling; force redistributions; geometrical approach

1 Introduction

Structural robustness is a concept that started to be used after the 1968 incident at Ronan Point tower block, near London, where a gas explosion led to the entire collapse of a corner of the building.

Requirements linked to structural robustness are detailed in several different ways in literature on the subject. The definition made by Knoll and Vogel, for example, assesses robustness as "*the property of systems that enables them to survive unforeseen or unusual circumstances*" [1]. Such a definition proposes a good conceptual approach to the required performance, as long as it remains qualitative. However, when it comes to characterise a structure in particular, the lack of quantitative approaches can make the distinction between what is robust and what is not difficult. This can be problematic as robustness is a property required by design laws [2] [3], which should then be absolute – objective, universal and based on independent indices.

In practice, we can note that numerous structures nowadays are still prone to collapse through a deficit of robustness, even if they have been extensively verified by structural engineers [4]. Indeed, these verifications (reviewed in section 2), based on numerical approaches, can only assess robustness for chosen failure scenarios in structures that have already been designed. This, of course, does not allow coverage of the total range of possible unexpected damage that may occur during the life of a structure.

The aim of this paper is to develop a new complementary approach to structural robustness, based on geometrical thinking. This will allow taking robustness into account at the conceptual stage, and so at the very first step of the design process. In this perspective, robustness is defined as the property of structures that allows for maximisation of the rearrangement of their internal forces.

Section 2 will first review the existing numerical approaches to structural robustness and their limitations for the problem under consideration.

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