The Importance of Dynamic Effects in Progressive Collapse

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Summary

This paper presents a methodology to assess the extent of damage to a multi-storey structure following localised collapse. This is accomplished through the design of an algorithm to track progressive collapse in a structure and its implementation as a computer program. The algorithm is based on the alternative path method of analysis. Individual elements are systematically removed from the structure, and these altered structures are analysed to determine the extent of the resulting collapse. By considering the effects of damage to all members in a structure the algorithm can identify whether a structure is unduly sensitive to the effects of localised damage. In order to accurately model the progression of collapse through a structure, it is necessary to consider dynamic effects. The algorithm is extended to include dynamic effects and calculate the corresponding increased bending moments and shear forces.

Keywords: robustness; progressive collapse; accidental actions; elasto-plastic analysis; dynamic analysis; alternative load path; structural reliability; vulnerability analysis.

1. Introduction

Progressive collapse is defined by ASCE 7-05 [1] as ***"the spread of an initial local failure from element to element resulting, eventually, in the collapse of an entire structure or a disproportionately large part of it"***. More generally, progressive collapse is characterised by the loss of load-carrying capacity of a relatively small portion of a structure. This initial damage triggers a cascade of failures, affecting a major proportion of the structure. A collapse of this nature can be triggered by many causes; including design and construction errors, as well as loading conditions with a low probability of occurrence (e.g. gas explosions, vehicular collisions). However, the unforeseen nature of these events presents the designer with a significant challenge when trying to improve structural safety.

Due to recent developments in computerised design, and high-performance materials, modern structures are more optimised than their predecessors. This optimisation has led to a reduction in the inherent margin of safety. The result of this is that modern structures have little excess capacity to resist unforeseen loading conditions. Therefore, modern structures are more vulnerable to unforeseen loading conditions. Gross and McGuire [2] suggest that this increased vulnerability can also be attributed to new construction methods which aim to reduce costs, but lack the strength and continuity of traditional forms of construction. Additionally, the increased threat of terrorism worldwide has highlighted the need to consider hazards that may not have been viewed as

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