Structural reliability of RC frames under sudden column removal scenarios considering static and dynamic methods

Luchuan DING[1], Ruben VAN COILE[2], Wouter BOTTE[3], Robby CASPEELE[2]

1. PhD student, Department of Structural Engineering and Building Materials, Ghent University, Ghent, Belgium

2. Professor, Department of Structural Engineering and Building Materials, Ghent University, Ghent, Belgium

3. Postdoc, Department of Structural Engineering and Building Materials, Ghent University, Ghent, Belgium

Contact: Luchuan.Ding@UGent.be; Ruben.VanCoile@UGent.be; Wouter.Botte@UGent.be; Robby.Caspeele@UGent.be.

Abstract

The alternative load path (ALP) method is widely used to investigate the performance of reinforced concrete (RC) buildings in case of progressive collapse (or disproportional collapse) scenarios. This kind of analysis can be carried out either in a static way or in a dynamic way. In this contribution, these methods are compared by means of nonlinear static and nonlinear dynamic analysis methods. A 5-storey RC frame subjected to two different sudden column removal scenarios is adopted as a case study. The probabilistic analysis considers 12 random variables. On the basis of the stochastic results, a dynamic amplification factor (DAF) is calculated. The mean values of the DAF are 1.114 and 1.102 for the external column removal scenario (Case A) and the internal column removal scenario (Case B), respectively. Compared to the failure probabilities obtained through a static analysis, the failure probabilities for the incremental dynamic analysis results are 184.0% and 180.7% higher for Case A and Case B, respectively.

Keywords: Structural reliability; dynamic analysis; pushdown analysis; incremental dynamic analysis; sudden column removal scenario; RC frame; dynamic amplification factor.

1 Introduction

It is crucial to design a structure to be robust enough in order to reduce the probability of progressive collapse (or disproportional collapse) triggered by accidental events, e.g. column loss [1-5]. The progressive collapse resistance of a building structure is often investigated by verifying the structural resistance in case of notional removal of one or more load-carrying elements from the structural system, i.e. the alternative load path (ALP) method. The analysis of such notional removal scenarios may require to account for dynamic effects [1, 4, 6].

Full nonlinear dynamic analyses are however computationally expensive. To avoid cumbersome nonlinear dynamic analyses, a nonlinear quasi-static pushdown analysis is widely used instead. However, it is important to recognize that structures which are statically safe can be dynamically unsafe [7]. As the quasi-static pushdown analysis neglects the inertial effect and dynamic effects such as the damping effect, a dynamic amplification factor (DAF) is adopted in some studies and standards to account for these dynamic effects. This DAF is often obtained through a regression analysis of the experimental or numerical results of different types of building

https://doi.org/10.2749/ghent.2021.1789
Distributed by structurae