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Finding Critical Element in the Progressive Collapse of RC Structures Using Sensitivity Analysis

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Abstract

Failure of some elements in the structure can play triggering role for beginning of collapse progression. The critical element is the structural element that when it fails, leads to progressive collapse. To find the critical element of the structure, sensitivity analysis should be done. But there are not specific structural criteria for using in sensitivity analysis. In this paper following GSA, UFC 4-023-03 and ASCE guidelines, sensitivity analysis has been modified and applied to find the critical element of a major number of reinforced concrete structures. 1080 3D nonlinear pushdown analyses were done and the results showed that the place of the critical elements differs in different stories and different plan shapes of high rise structures. In the structures with high aspect ratio in height, the critical element of the whole structure is located in the story of 2/3 height of the structure. When the aspect ratio of the structure in plan increases, sensitivity of the columns in the long dimension of the structure become closer to each other.

Keywords: Progressive Collapse; Modified Sensitivity Analysis; Critical Element; Reinforced Concrete Structures; High Rise Buildings.

1. Introduction

Local failure is mostly defined as loss of the load carrying capacity of one or more structural elements which are parts of a whole structural load carrying system [1]. After some structural elements failure, the structure should be able to provide an alternative load carrying path that can redistribute the loads of the structure. After redistribution of loads on remaining structural elements, each element will support different new loads. If this new load exceeds the load carrying capacity of any member, it will cause another local failure. Such sequential failures can propagate through a structure. If a structure loses too many members, it may suffer partial or total collapse. Progressive collapse is a failure sequence that relates local damage to large scale collapse in a structure and is defined 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" [2]. It is estimated that at least 15 to 20% of the total number of building failures are due to progressive collapse [3]. A popular example of such a failure is the Ronan Point building collapse in England [4].

Some researchers studied the progressive collapse with a specific event or reason [5-6]. Kheiroddin and Mehrabi [7] studied the implementation of UFC 4-023-23 to protect structures against progressive failure and analyzed, designed, and investigated two steel buildings, 12 and 20 stories, using the AP method. Considering sudden column loss as a design scenario, Izzuddin et al. [8-9] proposed a framework for progressive collapse assessment of multi-story buildings.

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