Numerical Analysis and Theoretical Studies on Progressive Collapse of Suspend Dome Structures

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Abstract

Progressive collapse occurs when an initial local failure spreads progressively, resulting in collapse of an entire structure or a disproportionately large part of it. Suspend dome structures have the characteristics of large space volume, large open areas but low redundancy, thus in the event of unexpected loading suspend dome structures may develop catastrophic progressive collapse, causing a large number of casualties and substantial losses. This raises the demand for studies on anti-collapse capacity of suspend dome structures. This paper presents numerical and theoretical studies on progressive collapse behaviour of suspend dome structures. Numerical analysis was carried out via explicit dynamic nonlinear program LS-DYNA. A model of suspend dome was established for progressive collapse research. Based on the concept of alternative load path method, different dynamic responses were summarized when removing a cable segment in middle hoop cable or outer hoop cable from original structure. The results showed that the initial failure of hoop cable usually caused a significant reduction in both the stiffness and bearing capacity, leading to a total collapse. The collapse mechanism of suspend dome structures was summarized which based on the numerical analysis results. In addition, the sensitiveness judge method of the structural member is presented.

Keywords: suspend dome structures; progressive collapse; numerical analysis; collapse mechanism.

1 Introduction

Progressive collapse occurs when an initial local failure spreads progressively, resulting in collapse of an entire structure or a disproportionately large part of it, which has attracted more and more attention and research since the collapse of the World Trade Center towers in 2001. Nowadays, the research on progressive collapse behavior is mainly focused on frame structures including experimental study, numerical analysis and theoretical research. However, the research on progressive collapse behavior of long-span spatial structures such as suspend dome structures is still in its infancy[1]. Suspend dome structures have the characteristics of large space volume, large open areas but low redundancy, thus in the event of unexpected loading suspend dome structures may develop catastrophic progressive collapse, causing a large number of casualties and substantial losses. Moreover, the mechanical behavior, structural response and collapse mechanism are closely related to the configuration, member rigidity and prestress level, which is different from frame structures. Therefore, it is necessary to conduct an

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