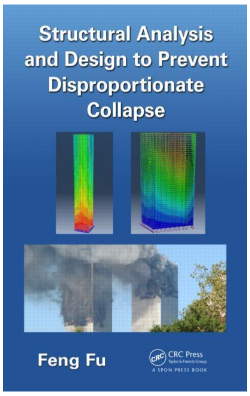

Structural Analysis and Design to Prevent Disproportionate Collapse

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Conclusion

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CHAPTER 7
Conclusion

7.1 Introduction

In this book, design methods for preventing disproportionate collapse for different types of structures, such as multistorey buildings, space structures, and bridges, were discussed. Different loading regimes that can trigger the collapse of structures, such as fire and blast, were introduced. The collapse mechanisms of different types of structures were also analyzed. In addition, progressive collapse analysis methods were introduced and demonstrated using commercial programs through modelling examples of the Twin Towers, World Trade Center 7, Murrah Federal Building, and Millau Viaduct.

In this chapter, the relevant design and analysis methods are summarized.

7.2 Summary of Design Guidances and Methods

In this book, we introduced several design guidances for preventing disproportionate collapse. They are mainly for building structures, such as the Building Regulations 2010 (HM Government, 2013) and BS 5950 (BSI, 2001) in the UK, Eurocode EN 1990 (BSI, 2010) in Europe, CSA-S850-12(CSA, 2012) in Canada, and the Department of Defense (DOD, 2009), General Services Administration (GSA, 2003), ASCE Standard 7 (ASCE, 2005), and NIST (2007) in the United States. There are no major design guidances available regarding the disproportionate collapse of space structures. For bridge structures, PTI (2007) and FIB (2005) are two guidances with special requirements to make sure progressive collapse is not triggered.

Several design methods have been proposed by design guidances such as DOD (2009), GSA (2003), and BS 5950 (BSI, 2001) for building structures. They are divided into two major categories, direct design method and indirect design method, which include the design of a key element, the tying force method, and the alternative load path method.

7.3 Summary of the Analysis Method

For building structures, there are four basic analysis methods proposed by GSA (2003): linear static, linear dynamic, nonlinear static, and nonlinear dynamic. There is no clear analysis method in design guidances for space structure and bridge structures; therefore, the aforementioned methods can be used to analyze space structures and bridge structures in the current design practice.

7.4 Summary of Collapse Mechanisms and Measures to Prevent Progressive Collapse

7.4.1 Multistorey Buildings

For building structures, catenary action can be utilised to resist the progressive collapse of a building. Providing sufficient ties in both steel and concrete buildings, increasing the ductility, and providing alternative load paths are the most effective methods in progressive collapse design.

In addition, increasing the redundancy of a structure system will definitely enhance its resistance to progressive collapse. Some researchers have also developed retrofit methods, such as enhancing beam-to-column connections, using steel cables, or providing a backup system. However, these methods increase the cost of projects. Engineers should make selections based on the category of the building and the requirements of the client.

7.4.2 Long-Span Space Structures

The loss of some critical members due to an excessive gravity load, such as snow, will cause the collapse of long-span structures such as double-layer grids. For single-layer space structures, such as domes, local snap-through of certain critical members can cause global buckling. Therefore, an extra margin of safety should be made for the structural members to prevent progressive collapse due to abnormal gravity loads.

In addition to the above considerations, the space frame roof structure requires consideration for support flexibility in the design.

7.4.3 Bridge Structures

Bridge structures or continuous beam bridges can be designed to be span independent; therefore, the failure of one span will not trigger the collapse of the whole structure. Pier failure is one of the major reasons for bridge collapse. A pier protection method, such as an artificial island, can be used. Hanger failure is a major reason for the collapse of suspension bridges. Therefore, in the design of hangers, a large margin of safety should be used. Cable-stayed bridges feature high redundancy; however, they should be able to accommodate cable failure. In their design, checks should be made by removing one or several cables to determine the robustness of the bridges.

7.5 Conclusion

The main purpose of this book was to provide some guidance and case studies for engineers to perform design and analysis to prevent disproportionate collapse. This book is based on the best knowledge of the author. I sincerely hope readers get some benefit from this book.

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