**Review of:**

***Structural Analysis and Design to Prevent Disproportionate Collapse***

Author: Feng Fu

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Book Review

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**General**

In recent years there has been renewed interest in the progressive collapse of structures and also increased awareness of the need to understand the mechanisms involved, especially after the 9/11 attacks on the World Trade Center. From the historical perspective, the study of progressive structural collapse began in the 1940s, when J.F. Baker began to study the way in which buildings collapsed under bombing in London during the Second World War. Also in London, in 1968 the collapse of the Ronan Point apartment block induced the authorities to change building codes to make them consider the risk of progressive collapse in the design stage.

There have been many accidents as a result of the progressive collapse of structures; the best known cases include the collapse of the Ronan Point Building in 1968, the attack on the US Marines Barracks in Beirut in 1983, the partial collapse of the Alfred P. Murrah Federal Building in Oklahoma in 1995, and the attack on the World Trade Center in 2011. However, the problem is not confined to buildings; it can also appear in bridges (e.g. I-35W in Minneapolis in 2007, and Kutai Kartanegara in East Borneo in 2011) or in space structures (e.g. Charles de Gaulle Airport Terminal in Paris in 2004).

Progressive collapse may be due to diverse reasons: fire, gas explosions, terrorist attacks with explosives, vehicle impact, etc., although the biggest fear at present is the damage that could be caused by terrorists using explosives, a threat to which many countries all over the world are now subject.

In the last 15 years great advances have been made in this field, especially in building structures. These advances have led to the publication and updating of codes and design recommendations, as well as the diffusion of results in the form of scientific articles and papers read at congresses. However, in spite of these advances, there are still not enough books available that describe how to include specific measures to avoid structural progressive collapse in the design stage, unlike, for example, what has happened in the case of protecting structures from the effects of earthquakes.

In 2009, Prof. U. Starossek of the Hamburg University of Technology took the excellent initiative of giving us the benefit of his experience in this field in his book “*Progressive Collapse of Structures*”, published by Thomas Telford. Although this book was a success and became a reference of great interest, other authors have not published new books dealing with the subject.

As his professional background and research work bear witness, the author of the reviewed book, Dr. F. Fu, has wide experience in the field of the disproportionate collapse of structures. He has published a number of papers in high impact journals and is a committee member of the Disproportionate Collapse Mitigation of Building Structure Standards and Blast Protection of Building Structure Standards of the American Society of Civil Engineers, and so is ideally qualified to write such a book.

The book is divided into seven chapters and considers the disproportionate collapse of three types of structure (multi-storey buildings, space structures and bridges), and analyzes the effects of fire and blasts. The book is quite compact, only 184 pages, and gives an interesting introduction to the phenomenon of disproportionate collapse of structures and offers suggestions on how to mitigate its effects. Since the book is so short, it does not offer an in-depth analysis of the problem, but even so it can be considered a useful introduction to the subjects for students, architects and engineers.

All the chapters (except Chapters 1 and 7) are similarly organized; they start by introducing the problem, some case studies are described, aspects of design and methods of mitigating failures are commented on, and a numerical simulation of a case study is given.

The last parts of Chapters 2 to 6 are especially interesting, since they deal with the FEM (finite element modelling) simulation of actual structures, mostly by means of ABAQUS software. Even though more advanced tools are now available to simulate the progressive collapse of structures, the author does not refer to them in his book.

Some criticisms could be made as regards the numerical simulations; firstly, as the figures and captions do not indicate the units represented by colors, the reader is unable to interpret the results. Secondly, readers will not be able to reproduce the models as they are not provided with enough details about them. In this regard, the author could perhaps have made the model codes available on a web page to those readers interested in reproducing them. Thirdly, the analysis of the results of the numerical models does not go deep enough and so does not offer clear conclusions. However, considering the limited size of the book, it is understandable that these slight defects should appear.

 All the chapters contain a good number of references that will allow readers to gather further information on any aspects that might interest them. However, it should be said that in spite of the apparently sufficient number of references, some important ones are missing; for example, one is surprised by the absence of any reference to Prof. Starossek’s book published in 2009.

**Brief description and review of each chapter**

Chapter 1 introduces the content of the book and outlines its aims and scope, defines terms such as *progressive* and *disproportionate collapse* and *robustness*, the main causes of progressive collapse and a summary of the current design guidance for preventing it. Section 1.5 is worth a special mention as it gives a very brief summary of the current design guidelines. Although the reader will not find a detailed explanation of the codes and design guidelines in this section, he will find an excellent survey with the corresponding references for further information, if required.

Chapter 2 deals with the progressive collapse of multi-storey buildings. A lot of attention has been paid to this topic in recent years by both research groups and the building codes, so that an in-depth approach to the subject would necessarily produce a book of considerable bulk. In this chapter the author manages to condense the most important aspects of the progressive collapse of buildings. In Section 2.3 the reader will find a very brief summary of the tools currently used to minimize the risk of this happening. In fact, this section is so condensed that the reader may be excused if he should fail to completely understand the explanations. This chapter ends with the numerical simulation of the collapse of the World Trade Center I.

Chapter 2, one of the shortest in the book, deals with the progressive collapse of space structures, a topic about which not a great deal is known and on which little has been published to date, so that the reader may find the author’s approach of special interest. The four case studies described in Section 3.3 are especially interesting. However, one of the references included in this chapter, whose author is none other than the author of the book, is still pending publication and should not therefore have been cited.

Chapter 4 is on the progressive collapse of bridges. Although Section 4.2 gives four very interesting case studies, the collapse of Bridge I-35W over the Mississippi River in Minneapolis, on which much has been written over the last few years, should have been included. On page 88 there is an error in the sentence *“The vertical deflection increased from 0.16 minute at 1 second to 0.28 minute after the cable removal.”* Here*,* “*minute*” should read “*meter*”, according to Fig.4.20. The numerical simulation of the Millau Viaduct given in Section 4.6 is noteworthy.

Chapters 5 and 6 describe the actions that most frequently cause the progressive collapse of structures: fire and blasts. Chapter 5 deals with fire in buildings. As the subject of fire on structures is a very wide field it would need a number of books in order to be adequately dealt with. However, the author has summed it up very well and has given the most important aspects of this phenomenon in very few pages.

Chapter 6 describes the effects of blast loading on buildings. As in Chapter 5, in a few pages the author is able to synthesize a complex subject on which a lot has been published in the last few years and cites interesting references to which the reader can accede for further information on blast loading. However, although his description of the collapse of the Alfred P. Murrah Federal Building is of undoubted interest, he fails to cite the leading papers published on this case study.

The book ends with Chapter 7, in which the author gives us the main conclusions he draws from his work.

**Conclusions**

For some years now there has been a demand for books to be published on the advances made in the field of the progressive collapse of structures. The codes have experienced radical changes and a great deal of research has been carried out on the subject, which could usefully be unified in book form.

In this book the reader will not find either a detailed description of the mechanisms that lead up to progressive collapse or suggestions on how to mitigate its effects. Neither will he be informed of the latest advances in this field of research, nor of the latest techniques in numerical simulation. Indeed, it is very likely that the author did not have these aims in mind when he wrote this book. What the reader will in fact find is an excellent introduction to the progressive collapse of structures that will allow him to understand the basic aspects of this phenomenon and help to improve structural designs. To sum up, this is a very compact and clearly written book which the reader will find easy to read.

Students of civil or structural engineering and architecture who wish to enter the field of progressive collapse will find this book very useful, although experienced engineers, architects and researchers in this field may not find it quite as helpful, as its scope does not permit a deeper analysis than the one carried out.

In spite of the need for more books to be published that offer a detailed analysis of the progressive collapse of structures, especially in buildings, we must commend and congratulate Dr. Fu for this initiative.