# Assuring Robustness of Non-Prescriptive Building Structures in China

**Mark Sarkisian P.E., S.E.**
Director
Skidmore, Owings & Merrill, LLP
San Francisco, CA, USA
*mark.sarkisian@som.com*

Mark Sarkisian received his Bachelors degree in Civil Engineering from the University of Connecticut and his Masters degree in Structural Engineering from Lehigh University. He joined SOM in 1985.

**Neville Mathias P.E., S.E.**
Associate Director
Skidmore, Owings & Merrill, LLP
San Francisco, CA, USA
*neville.mathias@som.com*

Neville Mathias received his Bachelors degree in Civil Engineering from Madras University, India, and Masters degrees in Structural Engineering and Architecture from the University of California, Berkeley. He joined SOM in 1985.

**Joanna Zhang P.E.**
Associate
Skidmore, Owings & Merrill, LLP
San Francisco, CA, USA
*joanna.zhang@som.com*

Joanna Zhang received her Bachelors and Masters degrees in Civil and Structural Engineering respectively from the University of California, Berkeley. She joined SOM in 2008.

## Summary

China arguably has one of the best regulatory processes in the world today for validating the designs of tall and complex non-prescriptive building structure designs, thereby assuring their robustness. This paper presents the basic and special requirements of this code / regulation mandated process. While the process often necessitates strenuous analytical and design efforts, it also opens the doors to exciting and robust first principle structural designs.

Future trends in approaches to robust structural design are briefly discussed.

**Keywords:** Robustness, Resilience, Seismic Design, Key Elements, Performance Based Design, EPR

## 1. Introduction

The past few decades have seen a rapid multiplication of the total stock of tall buildings in the major cities of China. This growth has now spread to the so called “second-tier” cities. What is very striking, when looking at these buildings, is the sheer scale and complexity of many of their structures. The building codes of most nations, and China is no exception, set limits on the applicability of their prescriptive design regulations. If these limits are exceeded in a manner or to an extent defined in the codes that renders the prescriptive procedures inapplicable, the structure is deemed non-prescriptive, and special design measures are needed to assure at least the same level of robustness as intended for prescriptive buildings by the codes. Over the years, through several cycles of code and regulation development, China has evolved a very rigorous method for assuring this robustness.

It is appropriate to begin by defining robustness in the context of building structures as the definition changes from field to field. With building structures, robustness can be defined as the ability of the system to mantain its function within defined limits over a preset range of imposed conditions and, when the conditions are exceeded, to ensure that functionality persists and is only lost gradually and not catastrophically to eventual failure. This type of robustness implies assured overstrength of function critical or key components and resilience (ductility, for example,) of typical system components. The requirement for this type of overstrength and resilience is intrinsically embedded in code design requirements to achieve robust structures. But there is a trend towards an evolved definition of resilience as a component of robustness, particularly in areas of high seismicity: where resilience has come to be seen as a measure of a system’s ability to return as closely as possible to its original functionality after experiencing conditions that severely exceed the

https://doi.org/10.2749/222137813807018935