Book Review

Structural Design of Tall Steel Buildings, Vol. SB (Lynn S. Beedle, Editor)

REVIEWED BY GEERHARD HAAIJER

A remarkable feat of international cooperation of the past decade has been the work of the Council on Tall Buildings and Urban Habitat. As part of this effort, authors from around the world have produced a five-volume monograph constituting a compendium of knowledge about virtually all aspects of the planning, design, construction and use of tall buildings. Volume SB deals with the structural design of tall steel buildings. Separate committees were responsible for the preparation of the individual chapters. Credits are given to 188 people for their contributions to one or more chapters. Clearly, an effort involving so many people cannot lead to a unified text or handbook. As stated in the preface, the volume can best be viewed as a comprehensive record, compiled in the late 1970's, of how a number of the world's leading structural engineers understand the behavior of tall buildings, their views on how to design them, and their impressions of what is to come.

Chapter SB-1, Commentary on Structural Design, provides an important perspective that guides the reader in interrelating elastic analysis and design (Chapter SB-2), plastic analysis and design (Chapter SB-3), and load and resistance factor design, also referred to as limit-states design (Chapter SB-8). The treatment of these design methods as separate entities reflects the fragmented approach to analysis and design that is the current practice. The commentary makes it clear that the full response of a building from the onset of loading to failure must be considered.

The emergence of the limit-states design philosophy promises a significant advance towards a more integrated approach. In a clouded crystal ball a few things appear rather clear to the Council: an increase in the innovative use of steel in tall buildings; an increase of mixed steel-and-concrete construction; the use of more complex and precise analytical methods; the inclusion of all building elements that have any strength and stiffness in the assessment of structural response; the design of integral segments of a structure rather than beam-by-beam and column-by-column design; further consideration of human response to building motion; improved design methods for earthquake loading; and increased recognition of the probabilistic nature of structure phenomena and loading.

Chapter SB-2, Elastic Analysis and Design, includes a guide to the principles for optimizing a structural system. First, it provides an enumeration and discussion of the many factors, such as height-to-width ratio and floor framing alternatives, which have been found empirically to influence efficient and economic use of materials. Second, it introduces the mathematical theory of optimization as an indication of things to come. Approximate methods of analysis are presented to provide a basis for preliminary sizing of members, for relative evaluation of different designs that may be under consideration, and to serve as a check on the reasonableness of computer analyses. In the discussion of computer-aided analyses of final designs, special attention is given to modifications to the member stiffness that are required for an accurate analysis of tall buildings, including the effects of shear deformation, axial load, and connection flexibility and size. Methods to establish elastic response to dynamic loads including wind and earthquake are also present in some detail.

Chapter SB-3 presents the basic theory of simple plastic analysis and the more complex aspects of tall-building frames that often require consideration of elastic criteria such as overall stability and sway deflection. Because plastic-design recommendations for columns differ between methods used in the United States and Great Britain, both approaches are presented.

Stability of both two- and three-dimensional frames is treated in Chapter SB-4. It clarifies definitions and terms and puts them in the context of stability problems in tall buildings. The basic design alternatives for treating stability are given: bifurcation load determination, second-order analysis, and approximate methods for assessing P-Δ effects. Special methods are given for special building types such as tube buildings and staggered-truss systems.

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In designing tall structures that might be subject to either earthquakes or high winds, the structural engineer is also faced with the problem of providing adequate rigidity. Although there are no firmly established drift criteria in current building codes, the information presented in Chapter SB-5 will be of value to engineers in selecting appropriate criteria for specific situations.

Fatigue and fracture, which may occur as another consequence of dynamic loads, are treated extensively in Chapter SB-6. As presented in Chapter SB-7, the design principle of connections is greatly influenced by whether gravity or horizontal loads are dominant. For areas of the world where gravity load dominates, economical structures may be designed with semirigid or simple connections. In areas where the intensity of ground acceleration due to earthquake is large, structures may be allowed to undergo substantial plastic deformation. The reader should be aware, however, that the draft of the chapter was completed in 1976, with the result that no reference is made to the more recently published work by Popov and Roeder on eccentric seismic bracing.

Load and resistance factor design (limit-states design) is presented towards the end of the volume in Chapter SB-8. The briefness of the chapter is probably inversely proportional to its significance as an indication of things to come. Because of the many disagreements and variances of ideas, both in the United States and Europe, the chapter defines the subject and clarifies the nomenclature. A gap is noted between theoretical development and reliability analysis and the actual formulation of design due to limited statistical information on loads. Again, some of these gaps are being closed by research conducted after completion of the draft.

The Council sees a movement to the utilization of both steel and concrete in mixed construction. Chapter SB-9 discusses not only the behavior and design of composite members and their connections, but also mixed steel-concrete systems, such as concrete core-braced systems, systems involving composite claddings, panel-braced systems, and mixed systems with precast concrete elements. Examples demonstrate that mixed steel-concrete construction has been effectively used in many recent buildings and offers opportunities for creative solutions that take advantage of the best properties of both materials.

The utility of the entire volume is enhanced by the careful attention that was given to the preparation of the nomenclature, including glossary, symbols and abbreviations. A 98-page bibliography includes all articles referred to in the text. Complete building, name, and subject indices round out the volume.

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