Analysis of the Differences between Chinese and American Standards and their Impacts in the Structural Design of the BAI Alumina Project in Indonesia

Xin Zhang
Senior Engineer
Shenyang Aluminium and Magnesium Engineering & Research Institute (SAMI), Shenyang, China
Corresponding author: zhangxin830608@outlook.com
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Abstract

With the increasing number of international engineering projects undertaken by Chinese engineering firms, the impact of differing national and regional standards in the field of industrial structural design on engineering and construction has become increasingly evident. This paper takes the Borneo Alumina Indonesia (BAI) Project as a case study to explore the practical application of American standards (ASCE, AISC, ACI, etc.) in the structural design of the project, focusing on specific aspects such as the standard system, load determination, analytical methods, seismic design, and component and joint design. Through a comparative analysis with Chinese structural design standards, this paper summarizes the significant differences between U.S. and Chinese codes in terms of design philosophy, design parameters, and detailing requirements. This study analyses the impact of U.S.-China code differences on industrial structural design.

Keywords: American standards, Structural design, U.S.-China code comparison.

1. Introduction

Under the global trend of economic integration, international engineering projects have emerged rapidly. In the field of industrial structural design, significant differences exist among the standards of various countries and regions, which have a considerable impact on key aspects such as project design concepts, construction processes, and cost control. With its well-established system and widespread recognition, the American standards are extensively adopted in international engineering projects. Taking the BAI Project as a starting point, this paper conducts an in-depth analysis of the specific application of American standards in structural design, and comprehensively compares and analyses the impact of U.S.-China code differences on industrial structural design, aiming to provide valuable references for professionals in related fields.

2. Overview of the Indonesia BAI Alumina Project

The BAI Project aims to construct a modern alumina refinery located in Mempawah, West Kalimantan, Indonesia, with a designed production capacity of one million tonnes. The project is invested in by Indonesia's BAI and designed and constructed by China Aluminium International Engineering Corporation Limited under an EPC general contracting model. The project encompasses a variety of industrial and civil buildings and structures, including single- and multi-story steel structure factory buildings, single- and multi-story civil buildings, concrete silos, large equipment foundations, concrete pools, underground concrete corridors, above-ground steel conveyor corridors, and pipe supports. According to the project contract, all structural designs must comply with American standards and technical requirements. All technical documents, drawings, and calculation reports related to structural design must be reviewed and approved by the Project Management Consultant (PMC) appointed by the owner before construction can proceed.

3. Application of American Standards in the Structural Design of the BAI Alumina Project

3.1 Main American Structural Design Standards Adopted

The structural design of this project is primarily based on the International Building Code [4] (IBC) issued by the International Code Council (ICC). The IBC itself does not provide additional detailed structural design provisions but instead integrates and references relevant codes and standards issued by the American Concrete Institute (ACI), the American Institute of Steel Construction (AISC), and the American Society of Civil Engineers (ASCE) as the basis for structural design compliance. Table 1 lists the ACI, AISC, and ASCE standards adopted in the BAI Alumina Project, along with their corresponding Chinese standards.

Table 1. Major U.S. structural design codes and standards adopted in the BAI alumina project.

U.S. Code		**Corresponding Chinese Code**	
No	**Title**	**No**	**Title**
American Concrete Institute (ACI)			
ACI 318	Building Code Requirements for Structural Concrete	GB 50010	Code for Design of Concrete Structures
ACI 313	Specification for Concrete Bin Design for Storing Bulk Materials	GB 50077	Code for Design of Reinforced Concrete Silos
ACI 530	Building Code Requirements for Masonry Structures	GB 50003	Code for Design of Masonry Structures
American Institute of Steel Construction (AISC)			
AISC 360	Specification for Structural Steel Buildings	GB 50017	Standard for Design of Steel Structures
AISC 341	Seismic Provisions for Structural Steel Buildings	GB 50011	Code for Seismic Design of Buildings
American Society of Civil Engineers (ASCE)			
ASCE 7	Minimum Design Loads and Associated Criteria for Buildings and Other Structures	GB 50019 GB 50011	Load Code for the Design of Building Structures Code for Seismic Design of Buildings

3.2 Design Load Values

ASCE 7 [1] specifies the minimum design loads to be applied in the structural design of various types of buildings and structures, including gravity loads such as dead loads, live loads, and snow loads, as well as lateral loads such as seismic and wind loads. Among them, the minimum values of live loads differ significantly from those required in China's GB 500095. Table 2 lists the minimum uniformly distributed live loads for floors and roofs as specified by U.S. and Chinese codes. It is evident that the minimum values of floor and roof live loads in civil and industrial buildings specified by ASCE 7 are generally higher than those specified in GB 50009, which may lead to increased internal forces in structural components.

Both ASCE 7 and GB 50009 allow for reductions in uniformly distributed live loads on floors and roofs based on the use of the building and the tributary area of the components. However, the methods of calculating the reduction factors differ greatly. Chinese structural engineers must pay close attention when determining these live loads according to ASCE 7.

4.5 Differences in Member Connections

There is little difference between Chinese and American standards regarding the connection types and fundamental design principles for steel structural members. However, in actual engineering practice, steel structure installation in China primarily relies on field bolted connections, though a significant portion of connections are also executed via welding. For overseas projects designed to U.S. standards, considerations such as worker skill levels, labour costs, and installation schedules typically dictate a preference for field bolted connections whenever possible. Therefore, for foreign steel structure projects, structural engineers must take bolted connections as a basic design assumption during the initial design stage.

5. Conclusion

This paper has discussed the application of American standards in the structural design of the BAI Alumina Project from five perspectives: code systems, design load values, direct analysis method, seismic design, and member and connection design. It also analysed the differences and impacts between Chinese and American standards in these areas, and the conclusions are as follows:

(1) Chinese standards are primarily based on mandatory national codes, offering low flexibility but strict enforcement; U.S. standards are based on industry association specifications and offer greater flexibility and innovation.

(2) The minimum live load values and partial load factors for live loads specified in U.S. standards are higher than those in Chinese standards, which can lead to increased member forces and material quantities.

(3) Fundamental differences exist between Chinese and American standards in steel structure analysis methods. U.S. standards require the use of the direct analysis method for steel structure analysis and design, with stricter demands for second-order and nonlinear analysis. For overseas projects designed to U.S. standards, steel structure design using Chinese codes generally fails to meet U.S. requirements.

(4) There are significant differences in seismic design philosophy between the two standards. U.S. standards emphasize ductility-based seismic design, while Chinese standards focus on elastic design. For projects designed to U.S. standards, seismic design according to Chinese codes does not meet U.S. requirements.

(5) Unlike in China, where both bolted and welded field connections are commonly used, overseas steel structure projects are predominantly bolted. Therefore, for such projects, structural engineers must establish the structural scheme with bolted connections as a primary condition from the outset.

6. References

1. SEI/ASCE 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures.
2. ANSI/AISC 360-05 Specification for Structural Steel Building
3. ANSI/AISC 360-16 Specification for Structural Steel Building
4. 2018 International Building Code
5. Load Code for the Design of Building Structures (GB 50009-2012). Beijing: China Architecture & Building Press (in Chinese).
6. Code for Seismic Design of Buildings (GB 50011-2010). Beijing: China Architecture & Building Press (in Chinese).
7. Unified Standard for Reliability Design of Building Structures (GB 50068-2018). Beijing: China Architecture & Building Press (in Chinese).