Structural Design of Steel Joints for Industrial Mixer Plant using AISC Guidelines

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Abstract—

The study focuses on the structural design and detailing of steel joints for an industrial mixer plant in accordance with guidelines provided by the American Institute of Steel Construction, incorporating provisions from AISC 360 and relevant design guides to ensure safe and efficient performance under demanding industrial conditions. Industrial mixer plants are subjected to complex loading scenarios that include not only conventional dead and live loads but also significant dynamic forces arising from rotating equipment, vibration effects, and cyclic stresses that may lead to fatigue over time. This work addresses these challenges by presenting a comprehensive approach to the design of various types of steel connections, including bolted, welded, shear, moment-resisting, and base plate connections, ensuring that each connection type satisfies strength and stability requirements while also meeting serviceability criteria such as deflection control and vibration resistance. Special emphasis is placed on the behavior of joints under repeated loading conditions, highlighting the need for fatigue-resistant design and the selection of appropriate connection configurations such as slip-critical bolting where necessary. In addition, the study underscores the importance of proper detailing practices, including adequate spacing, edge distances, weld quality, and constructability considerations, to facilitate ease of fabrication and erection. Overall, the design methodology aims to achieve structural safety, durability, and long-term operational reliability, ensuring that steel joints perform effectively throughout the service life of the industrial mixer plant under both static and dynamic conditions.

Keywords—American Institute of Steel Construction (AISC),AISC 360, Steel Joints, Industrial Mixer Plant,Fatigue and Vibration, Bolted and Welded Connections

I. INTRODUCTION

Steel structures are widely used in industrial mixer plants due to their strength, durability, and suitability for heavy equipment support. Steel connections are critical components that govern load transfer, stability, and overall structural performance. Industrial mixer plants experience static, dynamic, vibration, and fatigue loads, making connection design especially important. Improper connection design or detailing can lead to excessive deformation, vibration issues, or structural failure. AISC Specifications and Design Guides provide standardized and reliable procedures for the design and detailing of steel connections in industrial structures.

II. LITERATURE REVIEW

1. Iman Faridmehr et al. (2018)Mohd Hanim Osman, and Abbas Razavykia studied the behavior of steel beam-to-column connections in steel structures. Their research focused on connection stiffness, strength, and rotational capacity under different loading conditions. The study highlighted that the structural performance of steel frames depends largely on the proper design an classification of joints. The authors emphasized that accurate connection design improves thestability and load-carrying capacity of steel structures.

2. Ioannis Papargyriou et al. (2022) Jurgen Becque, and Kypros Pilakoutas investigated bolted beam-to-column connections used in cold- formed steel structures. Their research analyzed the influence of bolt arrangement, plate thickness, and connection stiffness on the strength and ductility of steel frames. The study concluded that properly designed bolted connections enhance the structural performance and reliability of steel structures subjected to dynamic loads.

3. Yun-Long Zhong et al. (2023)Yang Xiang, and Yan-Bo Wang conducted research on innovative beam-column connections incorporating energy-dissipating steel rods. Experimental and numerical analyses were performed to evaluate cyclic performance and seismic resistance. The results indicated that the proposed connection system improved strength, ductility, and energy dissipation capacity compared to conventional steel joints.

III. METHODOLOGY

The structural design of steel joints for an industrial mixer plant following American Institute of Steel Construction guidelines involves defining the design basis using AISC 360 (and AISC 341 if seismic effects are considered), identifying the types of connections in the structure, determining all relevant loads including dead, live, dynamic, wind, and seismic loads, idealizing the joint behavior (pinned, rigid, or semi-rigid), selecting appropriate connection types such as bolted, welded, or hybrid systems, designing the connection components by checking bolts, welds, and plates against governing limit states like shear, tension, bearing, and block shear, evaluating fatigue performance due to vibration from the mixer equipment, designing base plates and anchor bolts for stability and load transfer, verifying serviceability requirements such as deflection and vibration limits, detailing the connections according to code requirements for spacing and constructability, and finally preparing and reviewing design documentation to ensure safety, durability, and compliance.

IV. RESULTS AND DISCUSSION

The results of the structural design of steel joints for the industrial mixer plant, carried out in accordance with the provisions of the American Institute of Steel Construction using AISC 360, indicate that all designed connections, including bolted, welded, shear, moment-resisting, and base plate joints, satisfy the required strength and stability criteria under governing load combinations involving dead, live, wind, and significant dynamic loads induced by mixer operation.The analysis shows that slip-critical bolted connections perform effectively in minimizing relative movement under vibration, while properly designed welds provide adequate rigidity and load transfer in moment connections.

Fatigue assessment under cyclic loading conditions confirms that stress ranges remain within allowable limits, ensuring acceptable performance over the expected service life of the structure. Base plate and anchor bolt designs demonstrate sufficient capacity to resist combined axial loads, shear forces, and overturning moments without excessive deformation or uplift. The discussion highlights that dynamic effects and vibration play a critical role in governing connection design, often controlling over static strength requirements, thereby necessitating careful

selection of connection types and detailing practices. Furthermore, it is observed that adherence to proper detailing, including adequate bolt spacing, edge distances, and weld continuity, significantly enhances constructability and reduces the likelihood of stress concentrations and premature failures. Overall, the study confirms that the application of AISC guidelines leads to safe, reliable, and efficient joint design capable of withstanding the demanding operational conditions of an industrial mixer plant while ensuring durability and long-term performance.

V. CONCLUSION

Proper design and detailing of steel connections ensures safety, stability, and reliability of the industrial mixer plant structure. Adhering to AISC Guides provides standardized, efficient, and code-compliant connection designs.Integration of analysis and modeling software (SDS and Tekla) improves accuracy, coordination, and constructability. Optimized connections result in economical use of steel while meeting strength and serviceability requirements. Detailed and precise connection drawings minimize fabrication and erection errors, ensuring smooth on-site implementation and long-term performance.

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