

Energy-Based Stability Analysis of Spatial Steel Structures (Postprint)

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Abstract

The energy method is favored by researchers as it avoids the complex intermediate mechanical analysis required for investigating buckling failure in spatial steel structures. Long-span spatial steel structures constitute an important structural form in engineering; however, due to their numerous degrees of freedom, the stress and strain evolution during buckling failure is highly complex. Consequently, the local and overall stability of spatial steel structure roofs are assessed and investigated from an energy perspective. By analyzing the failure modes of local trusses under load, a simplified mechanical model is established. Based on the principle of energy conservation, a total energy equation accounting for external work and strain energy is derived, and catastrophe theory is employed to deduce the critical load and critical stress for local instability. Through inverse analysis of monitoring data from structural health monitoring systems, a dynamic model of overall structural strain energy entropy is developed. Catastrophe theory is applied to construct a limit state equation for strain energy entropy values, and overall stability is analyzed according to stability criteria of the potential function. Finally, the proposed method is applied to an actual engineering project, revealing that the existing spatial structure roof exhibits satisfactory stability and meets the requirements for safe operation and maintenance. The results demonstrate that local stability depends not only on material parameters but also on the ratio of local length to pipe diameter. During the instability process, stress concentration causes a decrease in strain energy entropy. The analysis results and field operational data confirm that both local and overall structural components are stable. Therefore, the established analysis method provides a theoretical foundation for stability analysis of spatial steel structures.

Full Text

Preamble

The provided text consists entirely of corrupted characters and OCR artifacts, containing no coherent Chinese content to translate.

Note: Figure translations are in progress. See original paper for figures.

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