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DYNAMICS AND ANALYSIS OF LARGE SPATIAL STRUCTURES ASSISTED BY STAY-CABLE

Abstract

With the advancement of aerospace technology and the growing demands of human exploration, modern space structures are progressively evolving toward large-scale configurations and lightweight architectures—as exemplified by space telescopes, deployable antenna systems, and space solar-power stations—to support missions requiring high-precision observation and reconnaissance, high-capacity communication, and space-based energy utilization. However, the pursuit of structural enlargement and mass reduction introduces critical challenges, including insufficient structural rigidity, vibration-induced instabilities, and gravitationally induced deformations. These deviations from ideal operational states under vibration and gravity conditions may compromise system precision and operational stability. this study proposes a stay-cable-assisted large spatial truss structure. Previous studies have predominantly focus on vibration characteristics and vibration suppression of large spatial structures, while limited attention has been directed toward gravitationally induced structural deformations. This may contribute to compromised assembly precision and operational inaccuracies in such systems. This study proposes a stay-cable-assisted large spatial truss structure designed to counteract gravitational perturbations while enhancing torque transmission efficiency, thereby optimizing control performance. The principal contributions of this work are summarized as follows: 1. A novel stay-cable-assisted large spatial truss structure is introduced, accompanied by a dynamic model. The orbital platform is treated as a rigid body within a multibody dynamic system, while the truss structure is modelled using geometrically exact beam theory. The stay-cables are represented via a spring-damper model, with topology optimization implemented for mission-specific cable placement. 2. Systematic investigation of vibrational modes, stiffness evolution, and torque transmission characteristics is conducted through numerical simulations and nonlinear analytical methodologies. The obtained results reveal the fundamental dynamic behaviours of stay-cable-assisted large spatial truss structures and provide generalized design principles that can be applied to stay-cable-assisted large spatial systems. This work provides a theoretical foundation for large spatial truss structure design and advances practical strategies to enhance the operational feasibility of large spatial truss structure in orbital environments.

Keywords: Large spatial structures; Stay-cable; geometrically exact beam theory