論文の要旨

題目　Study on Seesaw-twisting System with Cylindrical Steel Slit Damper for Vibration Control of Steel Buildings

（建築鋼構造振動制御のための鋼製円筒スリットダンパーを用いたシーソー捻回システムに関する研究）

氏　名　　Shuai Feng

This thesis proposes an innovative application of a seesaw-twisting system (STS) that incorporates a newly proposed cylindrical steel slit damper (CSSD) to dissipate seismic energy and enhance the seismic performance of structures. In the text, two core research aspects were studied: the cyclic performance of the STS with CSSD; the damping performance of the STS using a prototype three-story steel moment frame. This dissertation has been structured in the following chapters:

Chapter 1 initiates with a mechanism of the STS, which operates with a newly proposed CSSD and gives brief explanations of the yield mechanisms of the CSSD under the reciprocating structural vibration. In addition, this section encompasses the presentation of research innovation, objectives, and the dissertation's scope.

In Chapter 2, the design of the proposed STS with CSSD is presented. Within this chapter, an in-depth examination of the system performance is conducted, focusing on the torsional stiffness and strength of CSSD, alongside the lateral stiffness and strength of STS.

In Chapter 3, the procedure of the displacement-controlled cyclic loading tests is outlined aimed at validating the system's performance. A comprehensive exploration of structural performance metrics, encompassing hysteretic behavior, energy dissipation capacity, strip strain distributions, cumulative plastic deformation capacity, and failure patterns, forms the core focus of this chapter.

In Chapter 4, a numerical study was conducted to investigate the detailed stress distribution within the proposed CSSD. The FEA results showcased a hysteretic behavior that closely resembled the experimental data, and the FEA curves provided a parallel forecast for the trend of the test skeleton curve, predicting yield at an almost identical damper rotation angle.

In Chapter 5, the damping performance of the STS was investigated using a three-story steel moment frame as a prototype building. Seismic response analyses, initially focusing on a typical STS configuration, involved examining peak inter-story drift angles under varying beam section, system stiffness and strength, and system specification. Subsequently, additional frames featuring four distinct STS configurations were analyzed to evaluate the peak story drift angles and plastic hinge formation. The results revealed the efficient reduction of peak story drifts achieved by the STS with the CSSD.

In Chapter 6, the findings of both the experimental and numerical investigations on STS with CSSD and the seismic performance of steel structures employing STS with CSSD are consolidated. Additionally, the chapter underscores potential avenues for future research and expansion in these two research directions.

As a result of this study, the following conclusions can be drawn.

The experimental and numerical investigation revealed robust hysteretic characteristics and a notable capacity for energy dissipation of the STS with CSSD. Significantly, all dampers exhibited plastic deformation at a low story drift angle, indicating the potential for early activation during earthquakes to efficiently dissipate energy. The experimental specimens displayed impressive resilience, enduring numerous loading cycles without failure and demonstrating exceptional plastic deformation capacity. The force-deformation relationship of the proposed system is effectively captured by a concise bi-linear model, accurately representing both the hysteretic curve and dissipated energy. The system's initial lateral stiffness and yield strength align well with theoretical predictions and finite element analysis. The system's performance is easily manipulable by adjusting strip thickness, length, and width, enabling independent design of lateral stiffness and yield strength, offering a broad spectrum of variations. Consequently, the proposed system holds the potential to cater to the specific requirements of seismic design practices.

The seismic response analysis explored the damping performance of the proposed STS with CSSD. In a standard damper configuration, damping devices are positioned at the midspan of each story (MA), resulting in a commendable damping effect. Generally, as the system's stiffness and strength increase, there is a corresponding decrease in the inter-story drift angle. The seismic performance of the MA is contingent upon its amplification factor, system stiffness, and system strength. By applying tension to the rods, it becomes feasible to use lengthy steel rods as bracing elements spanning multiple stories, allowing a three-story frame to be outfitted with a single damping system. The effectiveness of connecting the bracing to the outermost beam–column nodes (MB, MC) is superior, while connecting it to the intermediate nodes (MD, ME) results in diminished damping effectiveness. In comparison to connecting the bracing to the top floor (MB, MD), linking it to the third floor (MC, ME) reduces the damping effect of the STS on the top floor. All distinct models incorporate properly functioning CSSDs, effectively reducing the structural dynamic response and minimizing plastic hinge formation.