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Advancements in Seismic Performance of Steel Beam-Column Joints: A Review on Shear Thickening Fluid Damper Applications

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ABSTRACT

Steel Structures possess notable resilience to deflections, distinguishing them from concrete structures. The inherent qualities of , rapid assembly or disassembly, and sustainability, enhance its capacity for constructing . Design modifications can be incorporated into the connections between beams and columns in steel structures to enhance their structural strength and improve their capacity to dissipate energy, especially in the context of seismic-resistant designs.

An effectively designed semi-rigid connection at joints can provide enhanced deformation capacity and reduce the risk of brittle failure. Due to numerous failures linked to fractures in welded lateral load-resisting systems. These systems have been implemented in steel frames to minimize structural damage and facilitate post-earthquake repairs. Other shear walls, dampers, and the concept of rocking structures have been utilized. Semi-rigid connections are structural joints where a certain level of rotational flexibility exists, permitting relative movement between connected members. These connections are designed to provide a balance between structural stiffness and rotational capacity. They allow for limited rotational deformation under applied loads, which can help improve the overall behavior of the structure under various loading conditions, including seismic events. The design of semi-rigid connections involves careful consideration of factors such as connection geometry, material properties, bolted or welded configurations, and the desired level of rotational flexibility.

1. INTRODUCTION

Fixed (rigid) joints provide full restraint against rotation and are typically used in moment-resisting frames to resist bending moments. Joint detailing, including the selection of bolts, welds, and connection configurations, is crucial to ensure efficient load transfer and minimize stress concentrations. Special attention is required towards connection design in seismic-resistant structures where that need to accommodate significant lateral forces and provide ductility to absorb seismic energy. Advances in technology and research have led to the development of innovative joint systems, such as pre-engineered connections, moment- resisting connections with boltless/weld-free connections, smart connections, prefabricated connections, 3D printed connections, damping connections and composite sections

Semi-rigid joints are connections between structural members in steel frames that exhibit a certain degree of flexibility or rotational behaviour. Semi-rigid joints are intermediate between fully rigid (fixed) and fully pinned (hinged) connections. They provide a balance between structural stiffness and

the ability to dissipate energy by allowing movement within the structure and for improved structural performance under various loading conditions. The behaviour of semi-rigid connections depends on factors such as joint geometry, bolt pre-tensioning, and the presence of additional elements such as end-plate connections. Semi-rigid joints can enhance the ductility and energy dissipation capacity of steel structures, contributing to improved seismic performance and resistance to cyclic loading.

In steel building construction, nearly all beam-to-column connections are of the semirigid type in reality. However, structural analysis and design based on this are rarely employed in reality due to the difficulties of determining the strength and deformational behaviour of such connections. The moment-rotation relationship for semi-rigid connections is nonlinear for almost all loading conditions.

To accurately predict the performance of steel frames, a comprehensive understanding of connection behaviour is required. By taking into account the plastic rotational capacity of the connections and other real-world joint behaviour, steel framework analysis may be made more precise.

2. LITERATURE REVIEW

Balaji et al. (2020) highlighted that vibration may be found at isolation devices can provide superior vibration isolation than linear devices over a wide frequency span. Bio-inspired gadgets have also been effective in reducing vibrations. Vibration reduction has become a hot topic of research in various engineering fields due to its presence at different levels. Nonlinear vibration isolation devices have been found to provide superior vibration isolation compared to linear devices across a wide frequency range

Lisa et al. (2022) stated that semi-rigid connections are cost-effective and prevent immediate frame breakage without compromising the overall structure. Steel frame construction was described in building codes for simple seismic buildings.

Jia et al. (2019) studied a low-energy composite wall construction using a prefabricated lightweight steel frame. Four full-scale pre-fabricated structure specimens were subjected to a low-reversed cyclic-loading test.specimens with the embedded composite wall were higher compared to those without it.

Qiang et al. (2019) worked on semi-rigid steel frames and concluded that they are considered an effective alternative to fully rigid steel frames due to their cost-effective nature and satisfactory seismic performance.

Ghassemieh et al. (2018) investigated . When the connection is subjected to this procedure, the corresponding plastic strain and dissipated energy are also reduced.

Ahmad et al. (2018) concluded that the seismic load on viscous dampers may surpass their capability during major earthquakes. A technique could limit device damage during strong earthquakes by modifying the damping coefficient. The unique strategy decreases the likelihood of damper damage as well as the maximum demands on the structure at various seismic hazard levels.

Junhua et al. (2018) reviewed on The three existing types of DRSRS systems can decrease post-loading damage. Energy dissipation devices and dampers can greatly improve the proposed structural system's energy dissipation capability.

Yu *et al.* (2018) have presented that smaller nanoparticles have a stronger shear-thickening impact than bigger microparticles. As the temperature rises, the greater Brownian motion causes the critical shear rate to rise. These fluids are particularly sensitive to the shear rates with fast viscosity change for a response.

Jianho *et al.* (2017) have concluded that a Shear-Thickening Fluid (STF) augmented with SiC nanowires had 30% higher viscosity than a pure STF. The influence of the mechanism was analyzed using hydrodynamic cluster theory and an analytical model of viscoelasticity.

Han *et al.* (2018) have described a preparation method for shear thickening fluid (STF) using a mixed aqueous solution of modified water- soluble cellulose ether, sodium dehydroacetate, and xanthan gum. The method involves preparing the mixed aqueous solution, stirring and mixing it with corn starch, and drying the mixture to obtain the shear thickening fluid

Tarig *et al.* (2010) have concluded that shear-thickening fluid has been synthesised using a sonochemical process. It is made up of hard silicon dioxide nanoparticles and a liquid polymer called polyethylene glycol. Utilizing a high-intensity ultrasonic irradiation, nine distinct forms of STF were produced.

Yeh *et al.* (2014) have explored Shear-Thickening Fluids (STF) as a good filling material for revolutionary damper devices. STF samples were made in the lab using three sizes of silica nanoparticles dispersed in three different solvents. The results indicate that the STF damper presented in this research has a lot of potential.

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