B03

Smart Retrofitting of Steel Irregular Connections in Traditional-style Buildings

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1. Introduction

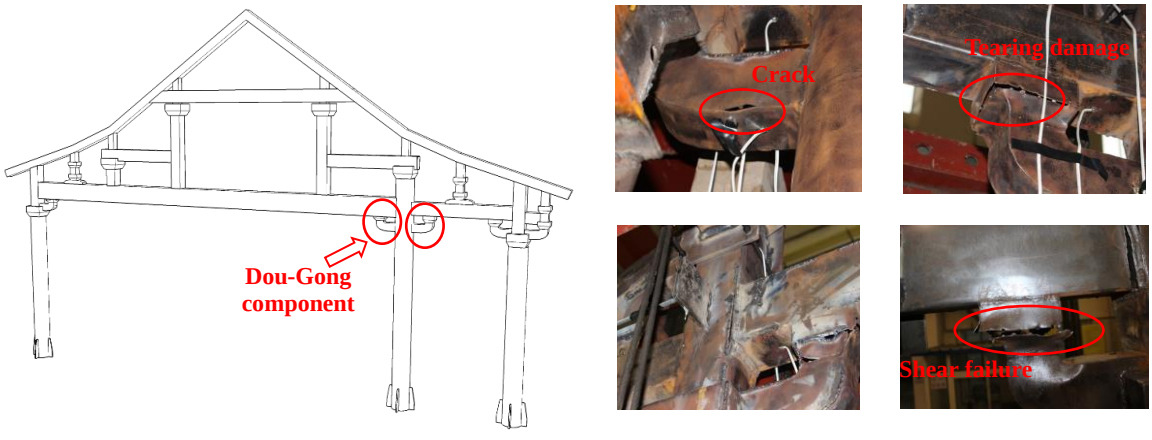
Traditional-style buildings are constructed using modern fabrication techniques and building materials, they imitate the shape of ancient timber structures. Steel is widely employed in traditional-style buildings to replace wood for its high bearing capacity and good seismic performance [1]. The preliminary tests showed that when traditional-style steel frame (Fig. 1(a)) were subjected to the low cyclic reversed loading, the Dou-Gong component connecting the beam and column end was firstly damaged and dissipated seismic energy (Fig. 1(b)), it played a critical role as the first seismic fortification line [2]. Thus, increasing the bearing capacity of the Dou-Gong component in traditional-style buildings can prevent premature failure of the connections under seismic load, and this will indirectly increase the bearing capacity of the integral beam-column joints [3].

2. Experimental program

The specimens were fabricated based on the engineering instance of a traditional-style building, and the size changed according to the relevant regulations of Building Standards of Song Dynasty. The lower column part is the seamless steel pipe, at the same time, the upper square steel column and the box beam are welded by four steel plates.

The viscous dampers were installed at the aforementioned location of Dou-Gong component to retrofit this kind of steel irregular connections, two newly designed 1/2.66 scale joint specimens with viscous dampers (SBJ-2 and SBJ-3) were fabricated and tested under periodic dynamic loads (Fig. 2), the other one without dampers (SBJ-1) were tested as well for comparison. The damping exponent kept the same during the test. The only different between the two damped specimens is the viscous coefficient, 60 kN $(s/m)^{0.38}$ for SBJ-2 while 88 kN $(s/m)^{0.38}$ for SBJ-3.

The beam end was connected to the ground beam using a tie rod, and the column bottom was restrained by a fixed hinge support. The axial load of 600 kN was applied in the vertical direction at the column top end, then the cyclic load was applied horizontally.



(a) Traditional-style steel frame (b) Damage behavior of Dou-Gong component

Fig. 1 Traditional-style steel frame test

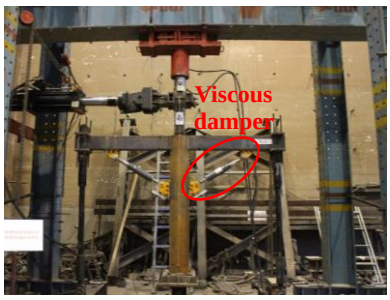


Fig. 2 Test setup

Given that the seismic wave can be seen as a collection of sine waves of different frequencies, so the sine acceleration waveform was adopted. Fig. 3 shows the loading protocol.

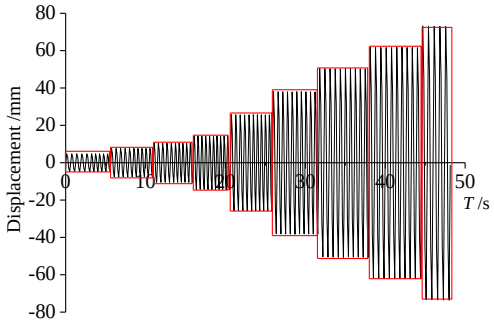


Fig. 3 Loading protocol

3. Results and discussion

The influence of viscous damper on the seismic performance of traditional-style irregular steel beam-column joints was assessed by looking at hysteretic performance, characteristic loads, ductility, energy dissipation capacity, and stiffness degradation. Fig. 4 shows the comparison of backbone curves.

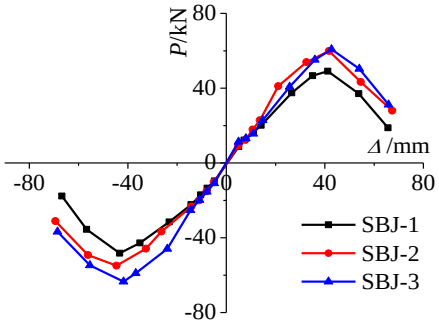


Fig. 4 Backbone curves

It can be seen that the new steel damping joint improved the mechanical performance of the traditional-style steel irregular joints, the maximum bearing capacity was increased by 17.9%-34.4% compared with the undamped joint, and the increase amplitude was more obvious with the larger damping coefficient.

Besides, the hysteresis curve of the new damping joint was more full and the energy-dissipating capacity was better, the damping devices delayed the development of the plastic hinge at the beam end and avoided the fracture of reinforcing fillet weld at the beam-column joint.

The secant stiffness of the damped joint was significantly higher than that without dampers, and it degraded slower before the specimen reached the peak load.

4. Conclusions

The following conclusion can be addressed.

1. The viscous damper increases the maximum strength of the beam-column joint and postpones development of the plastic hinge at the beam end, avoiding premature cracks at the connection region.

2. Viscous damping device is an alternative retrofitting method to strengthens steel irregular connections in traditional-style buildings.

3. The variation of viscous factor for dampers herein is limited, further study is needed to determine the reasonable range for retrofitting dampers

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References

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