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Experimental Study of Concrete-filled Steel Plate Composite Coupling Beam

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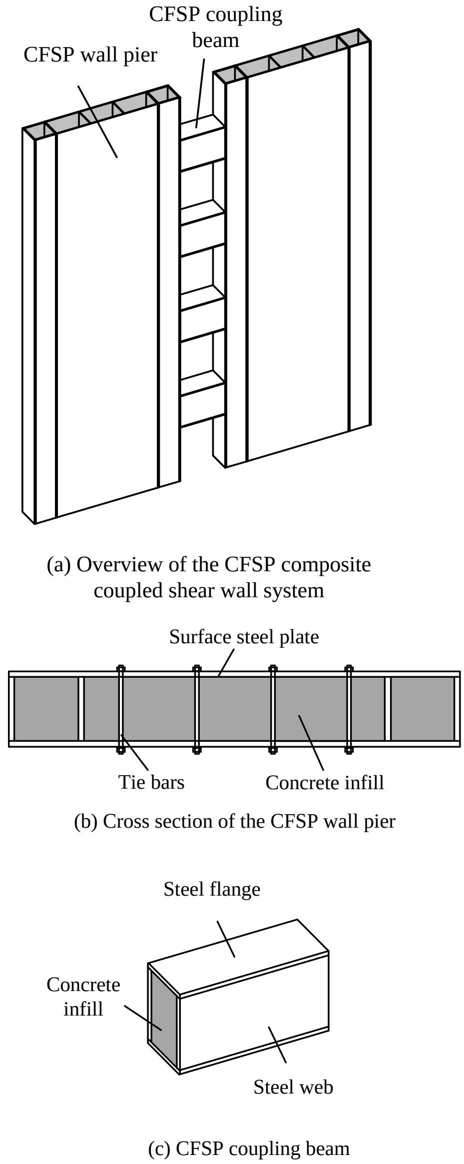
1. Introduction

Coupled shear wall systems that consist of two or more shear walls connected by coupling beams are efficient lateral force resisting systems, which have been widely used in mid-rise and high-rise buildings (El-Tawil et al, 2010). As the building height increases, the internal forces in the structural members increase significantly, which makes the conventional reinforced concrete (RC) coupled shear wall system uneconomic or even impossible to accomplish a design. To overcome this problem, a new coupled shear wall system referred to as concrete-filled steel plate (CFSP) composite coupled shear wall system was proposed by the authors, as shown in Fig. 1. In the proposed coupled shear wall system, CFSP composite wall piers (Nie et al, 2013; Hu et al, 2014) are coupled by CFSP composite coupling beams. Since the two structural members have similar configurations (both consist of surface steel plates and concrete infill), it is easy to proportion them with matched stiffness, load-carrying and deformation capacities. In this paper, six coupling beam specimens were tested under reversed cyclic loading to study the seismic behavior of CFSP composite coupling beam.

2. Experimental program

Six specimens were designed with coupling beams between two shear wall piers. The wall piers were each rigidly attached to end plates that allowed the specimen to be bolted to the test setup. The parameters that were varied between specimens included the coupling beam span and steel plate thickness used for the coupling beam. A schematic diagram of the test setup are shown in Fig. 2. The specimens were rotated 90° from their actual orientation in a building to be attached into the test setup. The shear force was applied by a 1000kN servo-hydraulic actuator through the L-shaped loading girder. The center of action of the actuator passed through the center of the beam span, so the point of inflection was located at the mid-span of the coupling beam and equal rotations at the two beam ends were maintained, which simulated typical boundary conditions expected in real buildings.

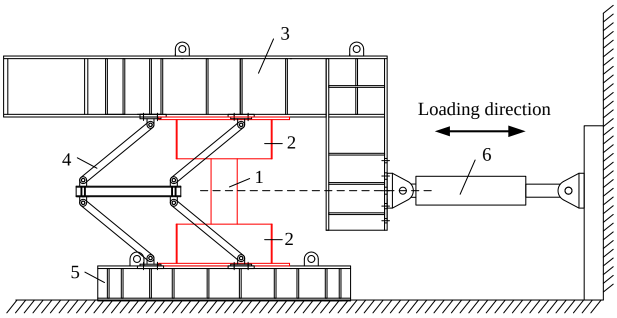


(a) Overview of the CFSP composite coupled shear wall system

(b) Cross section of the CFSP wall pier

(c) CFSP coupling beam

Fig. 1 Details of the CFSP composite coupled shear wall system



1- Coupling beam; 2- Wall pier; 3- L-shape loading girder;
4- Four-bar mechanism; 5- Foundation girder; 6- Actuator.

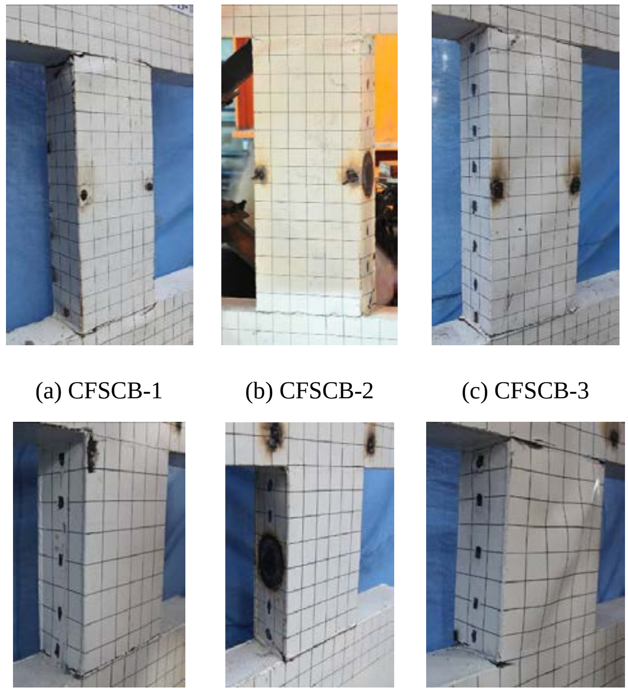
Fig. 2 Schematic diagram of the test setup for CFSP composite coupling beam testing

3. Test results

All the specimen experienced a progression of limit states from crack initiation, shear buckling of the steel webs, and fracture propagation which ultimately caused a significant loss of load carrying capacity. The final failure modes of all the specimens are shown in Fig. 3. The fracture limit state was identified as critical for the composite coupling beam configurations tested in this study as the fracture propagation through the web and flange plates was associated with significant loss of shear capacity in all specimens. The fractures initiated at the corners of the coupling beam, and propagated through the steel webs and flanges at the interface of the coupling beam to the wall pier. Two local buckling phenomena were observed including compression local buckling at the beam ends and shear buckling of the steel webs. The occurrence and form of local buckling was affected by the steel plate thickness, span-to-height ratio, and fracture of steel plates. Concrete compression failure was not observed in the infill concrete for any of the specimens. The concrete crack patterns were consistent with the deformation of steel plates. For the longer span specimens, the infill concrete cracked at the beam ends, while for the shorter span specimens, the infill concrete cracked along the diagonal of coupling beam.

4. Conclusions

Since the specimen of improved detailing achieved large ultimate chord rotation, and the hysteretic loops were plump for all the specimens, it can be concluded that the concrete filled steel plate composite coupling beam has large deformation and energy dissipation capacities if fractures are delayed. The concrete filled steel plate composite coupling beam is therefore a viable option to use in the high rise buildings with concrete filled steel plate composite walls.



(a) CFSCB-1 (b) CFSCB-2 (c) CFSCB-3

(d) CFSCB-4 (e) CFSCB-5 (f) CFSCB-6

Fig. 3 Final failure modes

References

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