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Damage behavior of steel beam-to-column connections under inelastic cyclic loading

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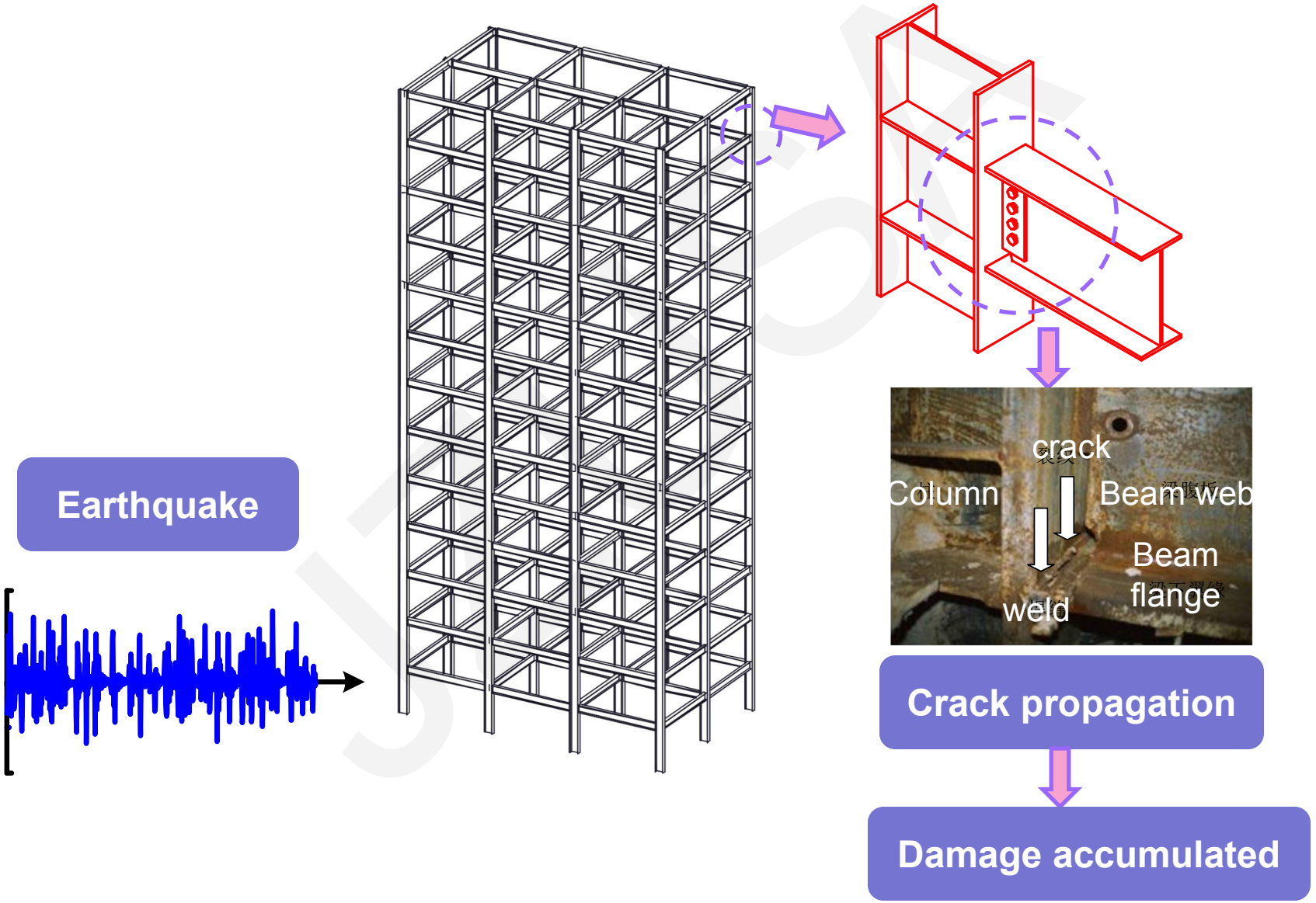
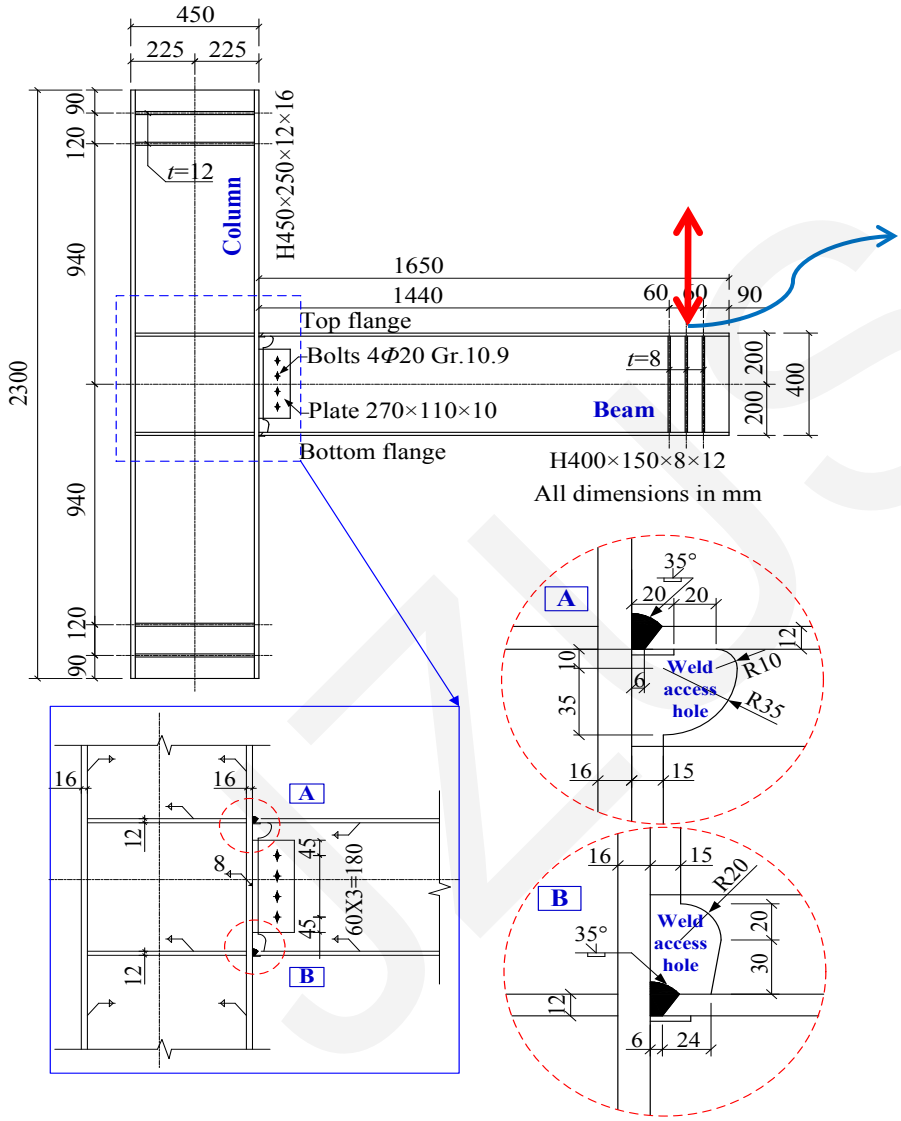
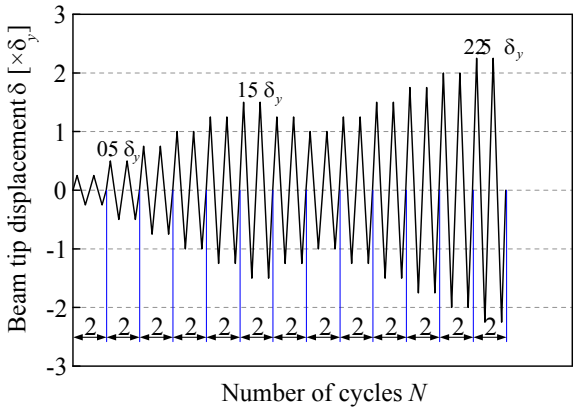
Connection damage



Connection tests



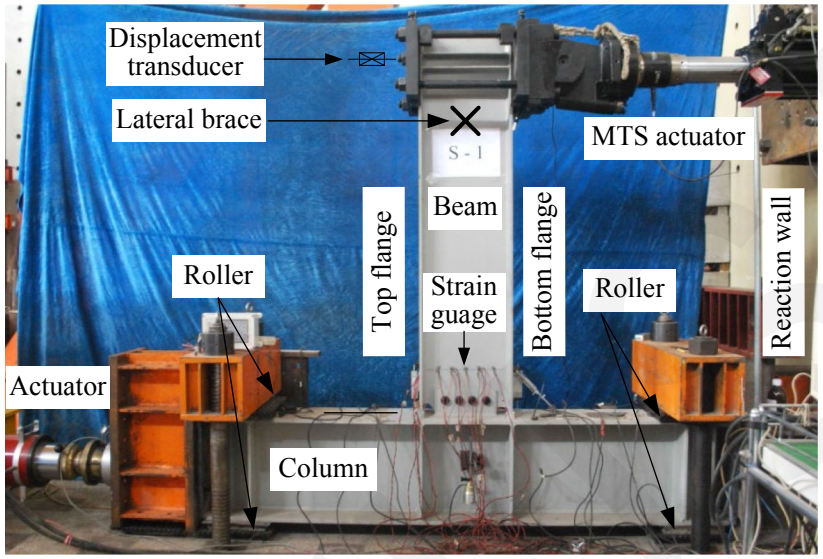
9 specimens tested under various cyclic loadings



loading history for SP-3

Fig. 1 Geometries and weld details of the beam-to-column connection specimen

Connection tests



5 constant amplitude cyclic loadings

4 variable amplitude cyclic loadings

Fig. 2 General view of test setup, measurement and specimen

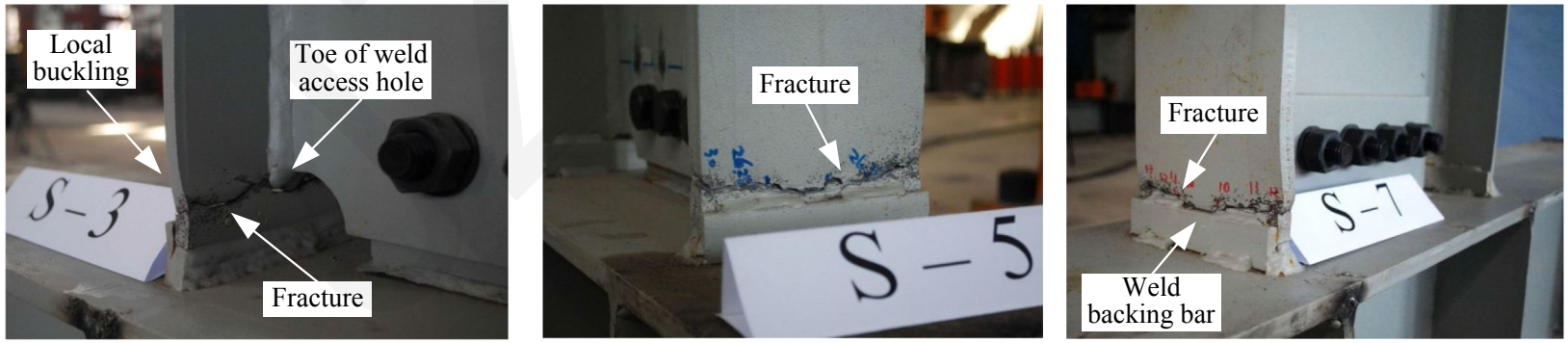
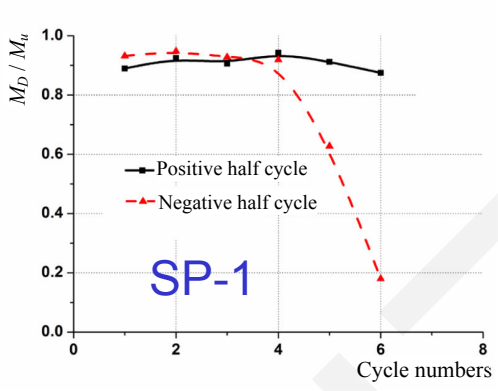


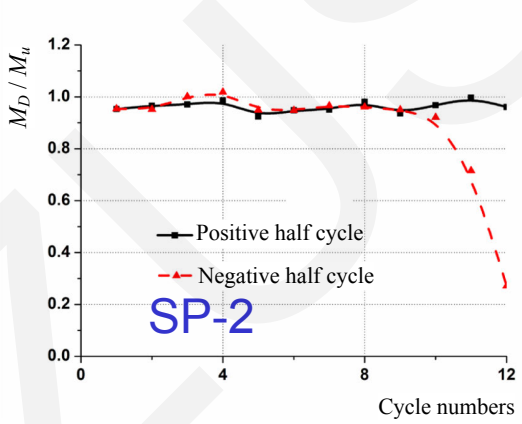
Fig. 3 Typical failure modes of the test specimens (SP-3, SP-5 and SP-7)

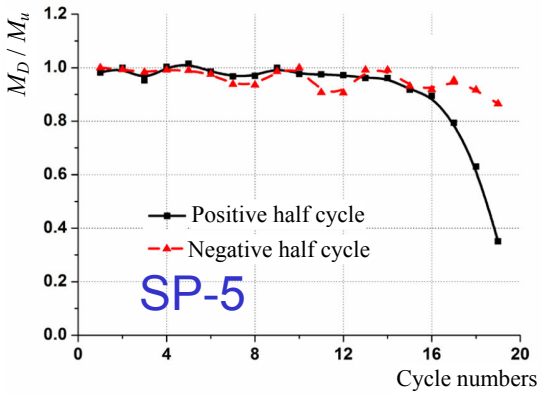
Damage analysis of connection

The effects of loading amplitude, loading history and peak load on the connection damage were analyzed

- **Connection damage process** $M_{\mathrm{D}} = M_{\mathrm{u}}\left(1-D\right).$







- **Connection damage evolution equation validation**

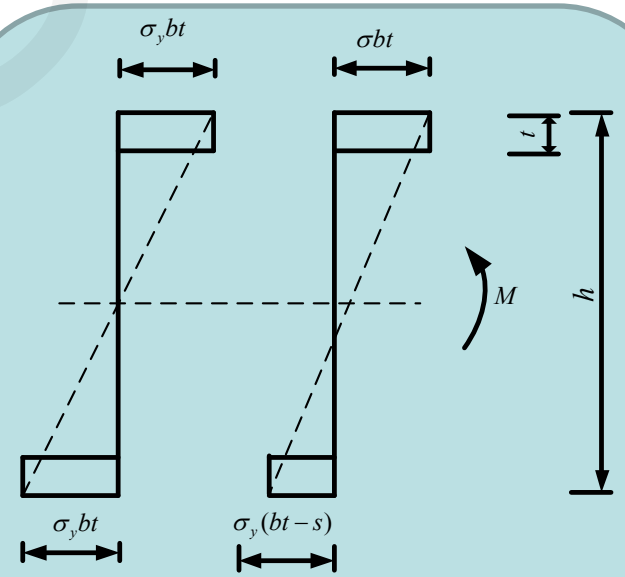
Damage analysis of connection

➢Connection damage evolution equation validation

- Linear cumulative damage evolution equation
- Power function damage evolution equation
- Modified Park-Ang combination model

➢Damage mechanism and ductile fracture based damage evolution equation

- Metal fatigue theory
- Metal ductile fracture theory
- Ductile fracture based damage evolution equation for connection



Schematic of calculation for connection bearing capacity after flange crack

Conclusions

- cracks initiated from the toes of the weld access holes in the beam flanges and then propagated through the thickness of the beam flanges just beneath the weld access holes.
- when the weld quality is guaranteed, load amplitude range has less impact on the connection damage behavior. The influence of loading history is closely related to the peak load cycle numbers, the bursting strong peak load is very detrimental to the connection.
- three commonly used damage evolution models were calibrated and validated. Power function based model and the Park-Ang combination model are suitable for simulating a connection under variable amplitude cyclic loading.

Conclusions

- The effective plastic strain was developed to quantify the damage process with reference to the nature of the damage caused to connections under cyclic reverse loading. It was defined by subtracting the compressed strain, which leads to the crack enclosure, from the tensile plastic strain, and variations in the microstructures of the material during the cyclic loading process were taken into consideration. Finally, based on the damage mechanism and ductile fatigue fracture mechanics, a damage evolution equation which adopts the index of effective plastic strain was proposed.