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Experimental study of the pinned double rectangular tube assembled buckling-restrained brace

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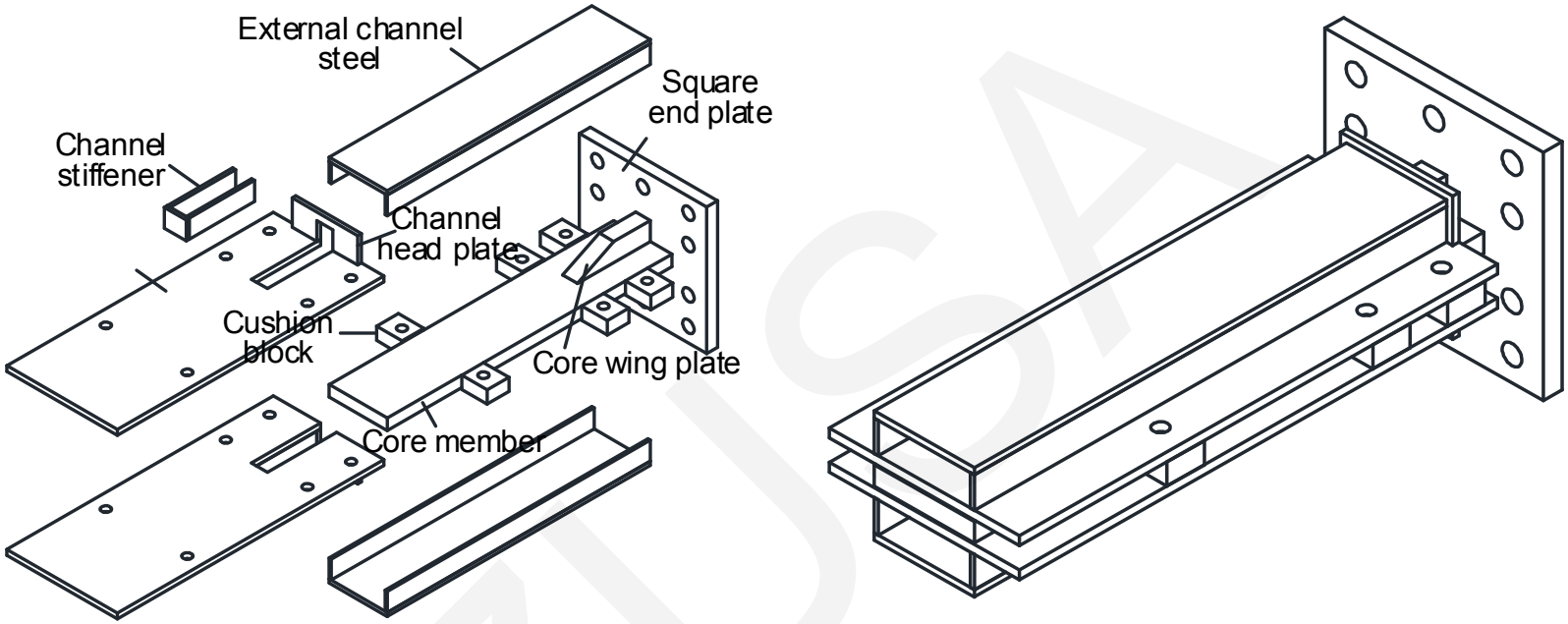
Highlights

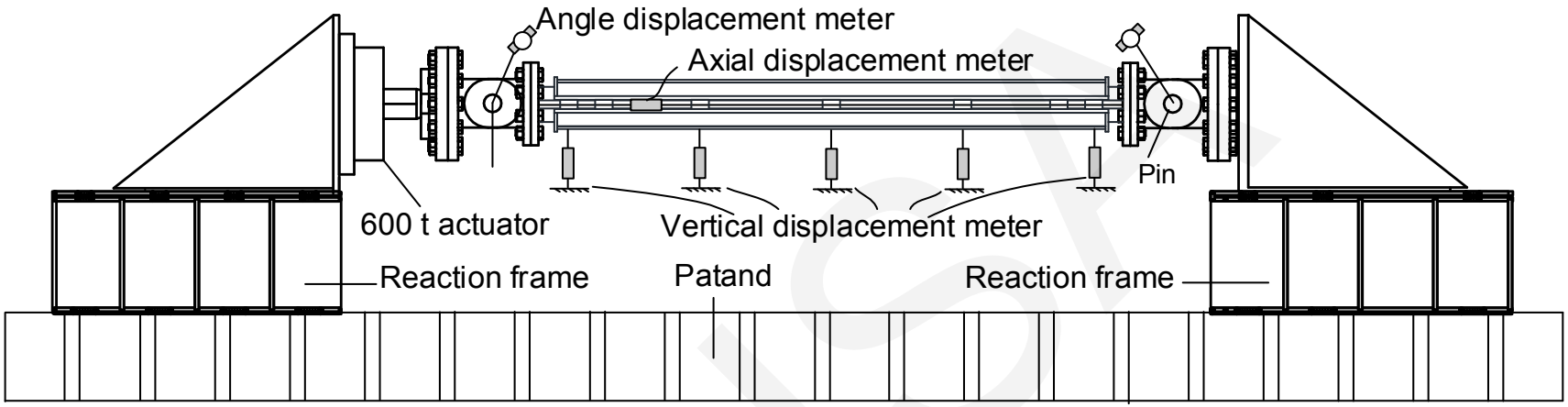
- Double rectangular tube assembled BRB composition and its end structure are given.
- Seven pinned DRT-ABRB specimens are characterised using the axial cycle test.
- The failure mode and energy consumption capacity of the DRT-ABRB are investigated.
- Four types of failure modes of the pinned DRT-ABRB are shown on.
- The DRT-ABRB with restricted end rotation, its hysteretic behaviour is improved.

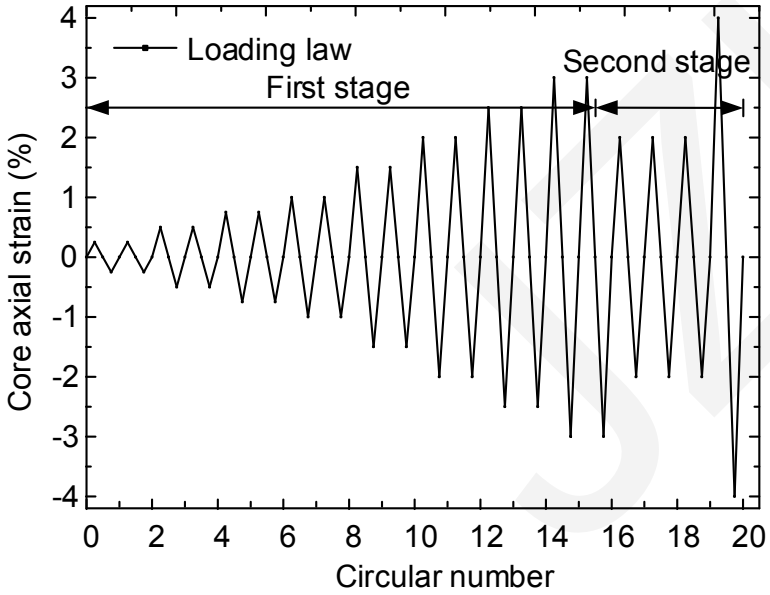
Layouts of the DRT-ABRB



Each DRT-ABRB is composed of an internal core member, external restraining members, and an un-bonded material between them. The external restraining members of the DRT-ABRB consist of an upper and a lower rectangular tube, each of which is fastened via high-strength bolts and cushion blocks. The external rectangular tube can be soldered by using a cover plate and channel steel or four flat plates. The external cover plate should be wider than the internal core member to enable the bolts to be fastened easily. The corresponding holes should be set in the extension place, in which the bolts are arranged along the longitudinal direction of the member, and a pair of strengthening bolts should be added to the external end to ensure a reliable connection between the upper and lower rectangular tubes.

Test program





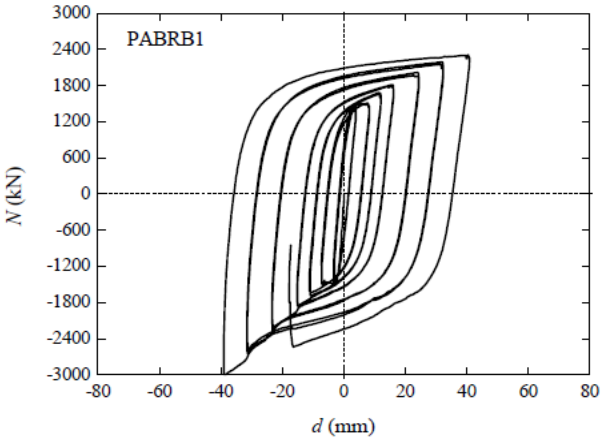
The hysteresis experiment was conducted using a 600t tension and compression actuator at the Structure Laboratory of Tsinghua University, China. Both ends of the specimens were connected to the actuator and reaction frames through a flange and pinned joints. The flange of the pinned joint was constructed with a 50-mm-thick Q345 steel plate, and a 10.9 M30 high strength bolt was used as the connecting bolt. The loading law adopted in this test may be di-vided into two stages.

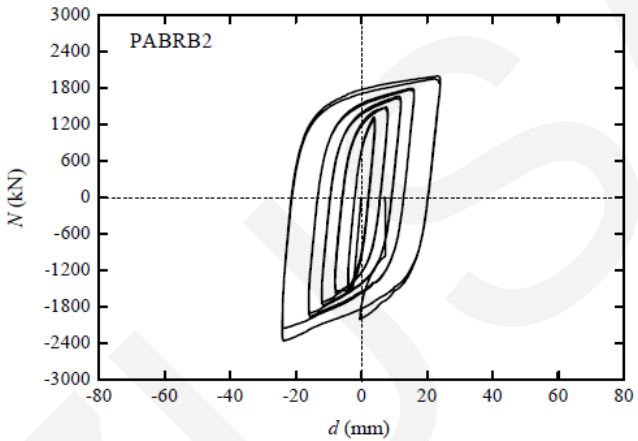
Failure mode and failure mechanism

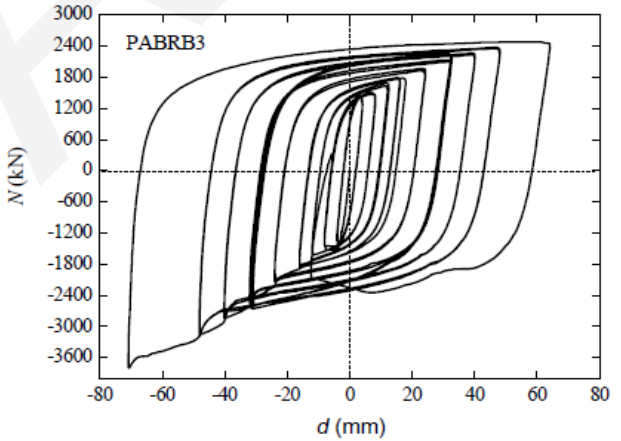
The DRT-ABRB specimens in this study showed four failure modes: (1) extended strengthened core bending failure, (2) external end local pressure- bearing failure, (3) multi-wave local buckling failure, and (4) overall buckling failure

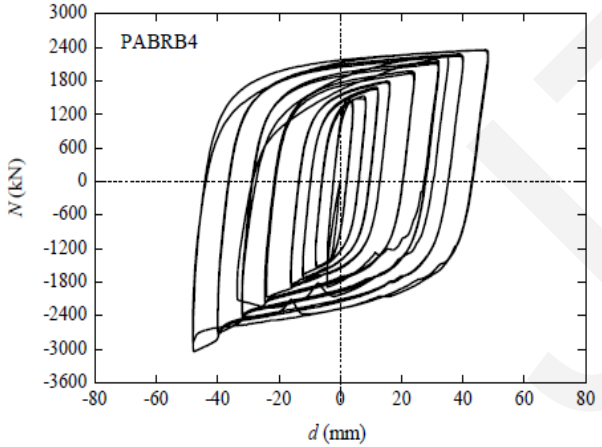
Hysteresis curve

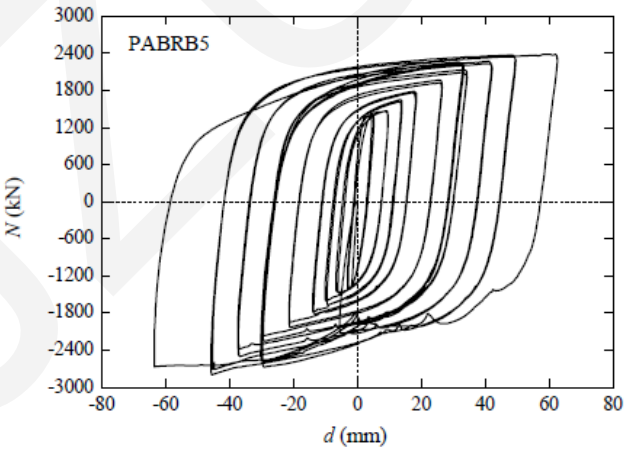
These hysteresis curves show that all the tested specimens had a relatively stable hysteretic behaviour, with a plump hysteresis curve and adequate energy dissipation capacity.

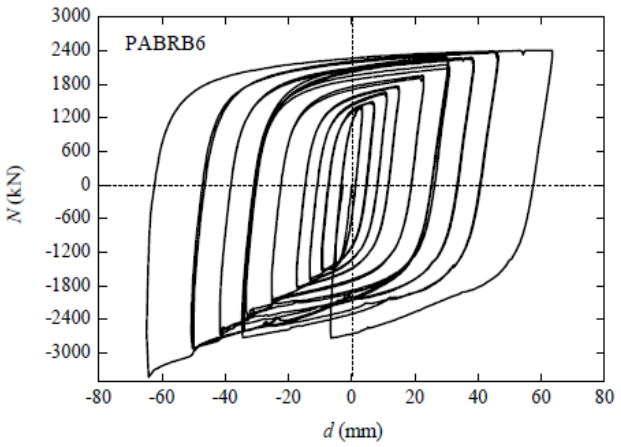












Mechanical properties of BRB

Table 4 Compression bearing capacity increase coefficient of the specimens

Specimen	Compression bearing capacity increase coefficient under each core axial strain						
	0.25%	0.50%	0.75%	1.00%	1.50%	2.00%	3.00%
PABRB1	0.987	1.014	1.026	1.049	1.163	1.225	–
PABRB2	1.066	1.012	1.039	1.039	1.059	–	–
PABRB3	1.009	1.040	1.039	1.054	1.107	1.217	1.325
PABRB4	1.001	1.047	1.046	1.086	1.104	1.169	1.299
PABRB5	1.013	1.013	1.034	1.030	1.061	1.078	1.155
PABRB6	1.005	1.057	1.060	1.065	1.109	1.123	1.241
PABRB7-Ru	1.027	1.045	1.082	1.067	1.107	1.138	–

Table 5 Energy dissipation indices of the specimens

Specimen	Equivalent damping ratio of the specimens under each core axial strain						Cumulative dissipated energy (kN·m)	Cumulative plastic deformation capability
	0.25%	0.50%	0.75%	1.00%	1.50%	2.00%		
PABRB1	0.254	0.409	0.410	0.430	0.444	0.446	1351	437
PABRB2	0.261	0.403	0.419	0.437	0.472	–	629	229
PABRB3	0.288	0.403	0.423	0.440	0.466	0.457	3737	1078
PABRB4	0.301	0.417	0.422	0.442	0.462	0.466	2784	845
PABRB5	0.270	0.456	0.447	0.463	0.473	0.491	3451	1022
PABRB6	0.296	0.417	0.418	0.437	0.454	0.473	3615	1042
PABRB7-Ru	0.254	0.409	0.417	0.446	0.472	0.481	1376	439

Conclusions

- In this study, cyclic loading tests of seven DRT-ABRB specimens were conducted to consider the influence of different design parameters on the hysteretic behaviour and energy dissipation characteristics of DRT-ABRBs and to investigate the failure mechanisms that may arise. Based on the experimental results, the following conclusions can be drawn:
- 1. When the external cover plate is thinner, the external member end of a DRT-ABRB will easily undergo local pressure-bearing failure. This failure mode can be avoided by implementing reasonable construction measures.
- 2. When the extended strengthened core region had a smaller stiffness, a larger end rotation of the BRB was observed, which was shown to be disadvantageous to its overall performance.
- 3. The observed hysteretic behaviour of the DRT-ABRB with restricted end rotation was superior to that of a pure pinned DRT-ABRB. However, the additional bending moment of the BRB's connecting joints tended to increase.
- 4. All DRT-ABRB specimens showed an excellent energy dissipation performance and verified the rationality of the BRB specimens' construction details, thereby providing a sufficient and reliable basis for engineering applications.