EXPERIMENTAL STUDY ON LATERAL RESISTANCE OF TIMBER POST AND BEAM SYSTEMS

Haibei Xiong¹, Yingyang Liu²

ABSTRACT: In China, post and beam sawn timber buildings are widely used as small span residential houses with mortise-and-tenon connection. Nowadays, this traditional construction are challenged by the modern engineering timber post and beam systems which connected by bolts or rivets. In order to give some guidelines for the kind of new system in China, five lateral systems, pure post and beam frame system, frame with X-brace, frame with K-brace, frame with knee-brace and frame filled with light wood shear walls were selected and tested to compare their lateral resistances. Two monotonic tests and eight cyclic tests on full-scale one-storey, one-bay pure frame and strengthened frame with braces or walls were introduced and comprised in this paper. Based on analysis of failure modes and mechanical performances, some conclusions were obtained. Then, some suggestions were put into forward for the design specification of engineering timber buildings.

KEYWORDS: Timber post and beam structures, Cyclic test, Failure mode, Mechanical performance

1 INTRODUCTION

In China, post and beam sawn timber buildings are widely used as small span residential houses with mortise-and-tenon connection. Nowadays, this traditional construction are challenged by the modern engineering timber post and beam systems which connected by bolts or rivets.

The researches of modern post and beam structures mostly focused on the joint connections. The limited studies on the structures’ lateral resistance focused on load-carrying capacity and the energy dissipation capacity [1-3]. There are few studies on the comparison between different lateral resisting systems with same member sections and joint connections. This paper mainly focuses on the failure modes and mechanical performances of different lateral resisting systems.

2 TEST PROGRAM

2.1 SPECIMENS

There are ten specimens with span of 4110 mm, height of 2740 mm, and span-depth ratio of 1.5. Specimens have been divided into pure post and beam frame system and lateral strengthened structure system, as shown in Table 1.

<table>
<thead>
<tr>
<th>Specimen names</th>
<th>Lateral resisting systems</th>
<th>Sketch of the specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF1, CF1, CF2</td>
<td>Pure post and beam frame</td>
<td><img src="image1.png" alt="Sketch" /></td>
</tr>
<tr>
<td>MXB1, CXB1, CXB2</td>
<td>X-brace</td>
<td><img src="image2.png" alt="Sketch" /></td>
</tr>
<tr>
<td>CKB1, CKB2</td>
<td>K-brace</td>
<td><img src="image3.png" alt="Sketch" /></td>
</tr>
<tr>
<td>CHB1</td>
<td>Knee-brace</td>
<td><img src="image4.png" alt="Sketch" /></td>
</tr>
<tr>
<td>CFW1</td>
<td>Light frame wood shear walls</td>
<td><img src="image5.png" alt="Sketch" /></td>
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</tbody>
</table>


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2.2 TEST SETUP

Experimental study focused on the in-plane lateral resistance of the wooden frame, without considering the vertical load. The out-of-plane stability was ensured by the steel roller installed on the gantries. The test setup is shown in Figure 1.

Figure 1: Test setup

2.3 TEST PROCEDURE

The load was applied by displacement control method, referring to the Standard of American Society for Testing Materials, detailed by Clause E564 [4] and Clause E2126 [5].

3 TEST RESULTS

3.1 FAILURE MODES

Figure 2 shows the failure modes of frame with X-brace system and frame filled with light wood walls system. K-brace system and frame with Knee-brace system show the bolts cut of the brace joints when destructed.

All the specimens exhibit a failure mode of the "weak-joint and strong-member".

3.2 MECHANICAL PERFORMANCES

Figure 3 shows the envelope curves of the specimens. The peak load, the failure load, the ultimate displacement and the yield point can be determined from the envelope curves using EEEP (equivalent energy elastic-plastic) method.

Figure 3: Envelope curves

4 CONCLUSIONS

Based on comparison of failure modes and mechanical performances, some conclusions were obtained. First, pure post and beam frame system is not suggested to support lateral loads due to unreliable lateral stiffness and capacities. Second, frame with X-brace system and frame with K-brace system provide higher elastic stiffness but lower ductility compared to the frame with Knee-brace system. Meanwhile, the frame filled with light wood walls system performs desired elastic stiffness and ductility, but less flexible in space utilization.

REFERENCES


