Effects of joint member wood density on the performance of mortise and tenon joints

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1. Introduction

Mortise and tenon joint is one of the strongest joints in structural connection of wood for construction of furniture especially chairs and tables. However, there are many factors that affect the performance of this joint, and these factors are associated with the quality of the parts or members used in the construction of the joint. Every joint member has an individual extent at which it affects the performance of the joint. In this study, the performance of mortise and tenon joint as affected by joint member bearing strengths (LBS), a function of wood density {LBS = f (ρ)}, was investigated.

2. Materials and methods

Three wood species, *Tilia japonica* (L)、*Acer mono* (M) and *Acer saccharum* (H) of varying densities (ρ) were selected for study and their densities were denoted as; L, M, H representing low, medium and high densities of the species, respectively. A simple simulated chair seat mortise and tenon T-joint was adopted because it is a common failure point in chairs and is often constructed using the same wood species for both the rail and the post. Mortises of 40mm length, 12mm width and 40mm depth were cut In relation to the mortise dimensions, the tenon was constructed providing for a clearance of about 0.05mm. Specimen had 13 replicate types (HH, HL, HM, MH, MM, ML, LH, LM, LL, HHb, HLb, LHb, LLb; with the first latter representing mortise member and b, no shoulder specimens). For each specimen type, 6 samples were constructed giving a total of 78 specimens. To evaluate the impact of the shoulder, 4 replicates were constructed with out shoulders. The specimens were tested under cyclic loading to 400N initially for 10 cycles, then to 800N for more 10 cycles, and then loaded in tension to failure. The test was carried out to determine the maximum moment (M), initial stiffness (K_i), taken off deflection of 400N, and energy absorption (U) of the joints.

3. Results and discussion

Shift in tenon density, for members with shoulders, from L to H increases energy absorption by 49.8% with high density mortise. Tenon density also has effects on the initial stiffness of the joint. It increases by 36-41% as tenon density shifts from L to H compared to 23-29% in mortise shift. Joint member densities and bearing strength have a greater effect on the performance of the mortise and tenon joint because of embedment of the members onto each other as loading is exerted on the joint.

The mortise and tenon joints with shoulders on the tenon have better performance in relation to maximum bending strength and stiffness. With high mortise density members, energy absorption increases by less than 10% between joints with and those without shoulders, which actually reduces in regard to tenon density variation. Energy absorption increment is inverse with mortise density variation as well. Effect of tenon shoulder on the performance of the joints can be explained in terms of tenon shoulder embedment into the mortise cheeks as well as the embedment of the tenon sides into the mortise.