Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation)

(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: JBPE223

Project Title: Strength of mortise and tenon structure

Project Type: Investigation

***To our best knowledge, there ~~are~~ / are no * similar works in the field*; (if there are,) related research links are as below:**

The enhancement our project made / the difference with related research are:

***Please delete if not applicable. The competition values the originality of works. Students must do enough literature research to ensure that their works are unique and list relevant reference materials before starting research or invention.**

I. Background

Mortise and tenon joint structures have multiple advantages over the use of nails. First, it can be much easier to build, as assembling it is much easier than using nails to hammer them in together. It can also be convenient to dispose of it especially when we need to separate different materials for recycling. If nails are used instead, it would be time-consuming to remove the nails and separate the materials for recycling or reusing. Moreover, potentially harmful substance like adhesives are not required. This reduces environmental pollution. Considering the above advantages of using mortise and tenon joint structure, we would like to investigate if its strength is comparable to or even better than that of using nails.

From the literature, we find that mortise and tenon can effectively limit twisting in all directions. Another advantage is that they increase the contact surface area between blocks, thus increasing the friction and the stability of the structure. Not using iron nails in the structure can also prevent the weakening of the structure by rusting of nails or the splitting of the wooden material when the nail is wedged in. Nonetheless, using only one material can make sure that the degree of thermal expansion and contraction is the same between different parts of the structure and no gap will be created due to the different expansion rate between different materials.

II. Objectives

We want to test if the strength of structures made of mortise and tenon joints is comparable to or even better than that of using nails.

III. Hypothesis

Hypothesis: Structures assembled using tenon and mortise is stronger than those using using nails.
Testing: 3D-printed miniature tables are designed using nails and tenon and mortise, assembled and put in loading tests.

IV. Methodology

Preparing the miniature table models

Background research on the common tenon and mortise structures will be first conducted. Then, miniature tables using tenon and mortise structures of different styles and nails are made using 3D-printed printers. Three miniature tables using tenon and mortise designs are 3D-printed and assembled for the loading test. One miniature table assembled using iron nails is also 3D-printed and assembled for comparison.

Loading test on the table models

Each of the miniature tables was placed on a graph paper for measuring deformation. During the loading test, dumbbells of 10, 15, 20, 25, 30, 45 and 60 lb were rested on the miniature tables. Deformation and damages were checked in each loading. After the test using dumbbells, a student weighing 115 lb and a teacher weighing 220 lb were invited to slowly step on the miniature tables. Then, they were asked to raise another feet and with the feet standing on the miniature table supporting all their weights. The miniature tables are checked then checked for damages.

V. Results

All four miniature table models (3 using tenon and mortise design and 1 using soil nails) survived all the loading tests up to 220 lb.

Potential of tenon and mortise structures

From our results, it is observed that miniature tables assembled using tenon and mortise structures can support loading as strong as those assembled using iron nails. Considering the advantages of tenon and mortise structures, they have great potential to be used in furnitures or even buildings. Moreover, we can install backup parts immediately in case we broke it accidentally, like when we did when carrying out our experiment.

Further improvements of the experiment

In our test, the heaviest load we can put on the miniature tables for testing is our body weight. Unfortunately, none of the tables is damaged nor deformed. We are unstable to really find out which design is stronger. We can only conclude that all 4 designs are able to survive rather heavy loading.

VI. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. *(Word limit: 300 words)*

Our project shows that structures assembled using tenon and mortise design are as strong as those using iron nails. Using tenon and mortise design in furniture or buildings increase the ease of repairing, reusing and recycling, and also reduce pollution by the use of potentially harmful chemical like adhesives. By promoting the use of tenon and mortise design, it is expected we can reduce pollution, reduce the demand on raw materials and eventually lead to a more sustainable society.

VII. If your team will compete the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award. *(Word limit: 300 words)*

VIII. Conclusion

From our results, we find that structures using tenon and mortise structures have comparable strength as those assembled with iron nails.

☐ **Our project is developed based on previous project and the enhancement is below:**