

Supplemental Material #1

Validation for nail joint model

We performed a simple experiment to validate the nail joint model (equation 4 in our paper). We created cantilever beam (Figure 1). The cantilever beam consists of 2 planks and 1 nail joint. We hang weights on the beam and measured displacement at the tip. We increased the weight gradually and, at each weight, we also unloaded the weight and measure the displacement. This displacement in unloaded state corresponds to the amount of slip between the nails undergo during the loading process.

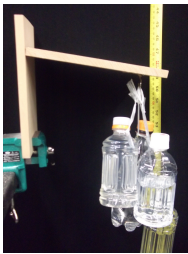
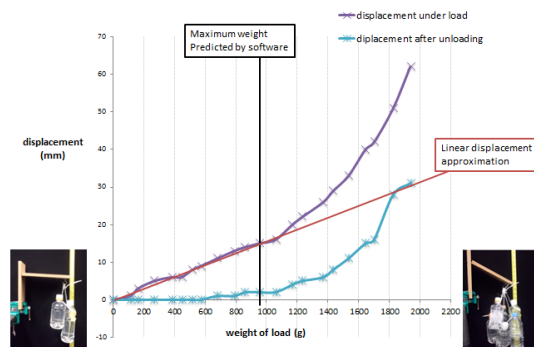


Figure 1 The cantilever beam

Three nails supported the cantilever beam. Each nails has 32mm length and can bear 35kN/m pulling force per length. The plank was 12mm thickness. Each nails goes into plank $32-12=20\text{mm}=0.02\text{m}$. From equation 4 in our paper, maximum bending moment the joint can support is $0.02*35000*0.006*3 = 1.86\text{Nm}$. The cantilever has arm length 0.19m. Hence in the model, the cantilever can bear $1.86/0.19 = 0.97\text{N}=1\text{kg}$.

The Graph 1 shows the result of actual experiment. When weights exceed the thresholds predicted by our software, the displacement under load increased rapidly out of linear curve, and also the displacement after unloading become obvious, showing the nails are slipping against plank and joint is collapsing.



Graph1 Weight and displacement