Strength Testing of Biscuits

For my project, I investigated two aspects of stone behaviour under prestress: the effects of tendon location and bedding plane orientation on the failure load of the samples. I did this by threading a tendon through the sample and tensioning it until the point of failure. I wanted my outreach activity to be reflective of my project, so we did a different test to investigate the effect of tendon location for a different type of layered material. We tested pink wafer biscuits by threading a wire through a hole in each biscuit and suspending load from the wire until the biscuit broke. The holes were made in advance by pushing the tip of round nosed pliers gradually through the biscuit, and the distance of the hole from the edge of the biscuit was measured and written on the biscuit in marker pen (see figure 1). Pink wafer biscuits were chosen as the focus as they are made from layers of weak and strong material, similar to the structure of limestone. Time permitting, the effect of the orientation of these layers on failure load could be investigated.

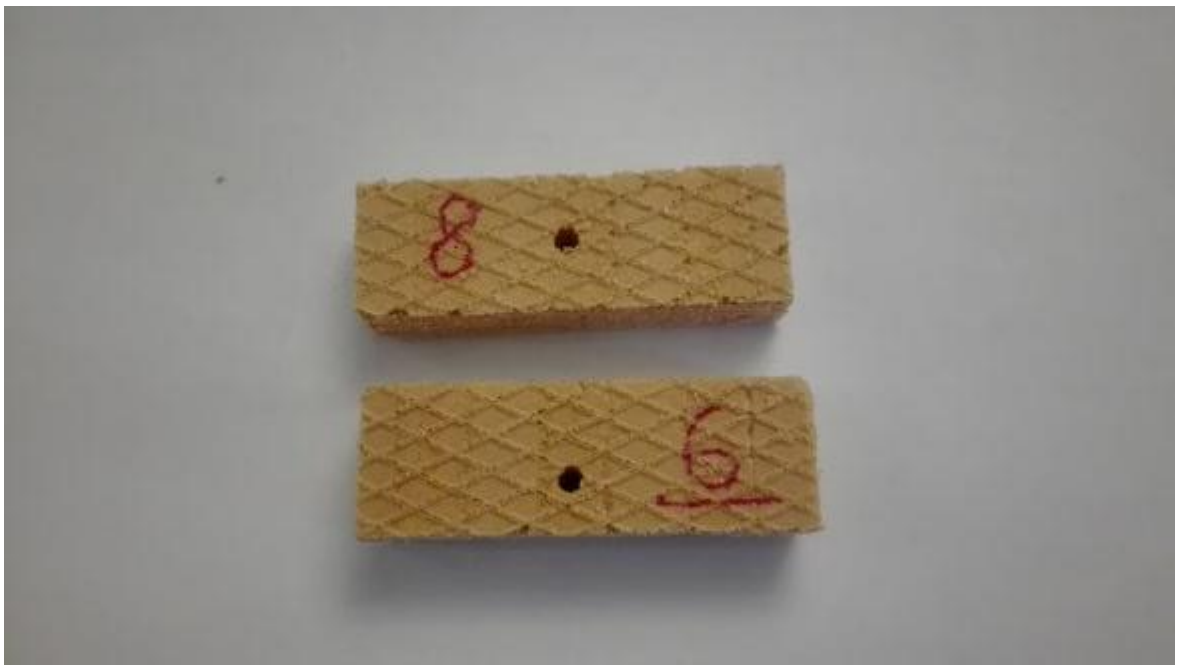

Figure 1: biscuits with pre-made holes

In order to carry out the testing, biscuits with pre-made holes were balanced on top of the vice jaws in the Dyson Centre with the outer edges of the jaws set equal to the width of the biscuit. It was not anticipated that the width of the jaws would affect the results, but it was fixed so as to avoid this possibility. A length of plastic-coated jewellery wire with loops was threaded through the hole in the biscuit (see figure 2); loops had been made at each end of the wire in advance by looping it back on itself and securing with crimp tubes. Penny washers were then suspended from the wire loops on a mass hanger.

Figure 2: On of the wires which was threaded through the biscuits for testing. The mass hanger was suspended from the loops at either end.

The students were divided into pairs to carry out the testing and the pairs tested one or two biscuits. Each pair was given one biscuit with a hole close to the edge (4-6 mm) and one nearer the centre (8-10 mm from the edge). Washers were added, five or six at a time initially, then fewer as the testing progressed. After the biscuit failed, the penny washers were weighed, and their total mass recorded. See the final page for the full instruction handout.

There were extension activities planned – testing a different type of biscuit, testing a biscuit with no hole by positioning the wire over the biscuit and testing a different orientation of wafer, again with the wire looped over the top of the biscuit – but there was not enough time for these.

Prior to starting the testing, I gave a short powerpoint presentation, highlighting some of the challenges that must be overcome when designing with natural stone. I also briefly explained the concept of pre-stressing, using a common child's toy as an example of prestressing as a means of giving strength to a structure (see figure 3).

Figure 3: Child's toy which makes use of pre-stressing

Evaluation

The students were engaged by the activity and seemed to enjoy it. A number of pairs became quite competitive, loading the biscuit very gradually and carefully in an attempt to have the strongest biscuit. Each pair managed to test at least one biscuit, with most testing two. Generally, biscuits with low edge distances failed at low loads and biscuits with larger edge distances failed at higher loads, however towards the end of the activity, some groups added lots of washers at once to make sure their biscuit failed before time ran out. This resulted in one sample failing under 1300g, compared to 800g for other biscuits with the same hole location.

Having more time would have improved the activity. Students could have carried out some of the extension activities to look at other biscuit types or other layer orientations, which would have given them a better understanding of the effect that the presence of layers has on strength. Overall, I think the activity was successful at demonstrating some considerations that must be addressed by structural engineers when selecting structural materials.

Testing Biscuits

You will need:

- Two biscuits
- One mass hanger
- One wire
- Washers – if you run out, you may need to share with a nearby group

DO NOT EAT THE BISCUITS

1. Set the vice so its jaws line up with the ends of the biscuit
2. Thread the wire through the hole – you may need to squeeze the sides of the loop
3. Balance the biscuit on top of the vice jaws to match the photo
4. Add 4 or 5 washers to the mass hanger
5. Hook the hanger onto both loops of the wire and lower the mass hanger slowly until it is fully supported by the wire loops. Keep you toes away from the hanging masses!
6. Count to three, then gently lift the mass hanger off and repeat steps 4-6 until the biscuit breaks
7. Pick up your mass hanger and any masses that may have fallen off. Weigh the masses and hanger using the scales next to the screen
8. Input your results on the screen – the type of biscuit, hole location (written on the biscuit) and the mass that caused failure
9. Repeat with a new biscuit

If there is time at the end, try one of the following:

- Test a shortbread finger – no layers. How does this affect failure load?
- Test a wafer with no hole – is the load different?
- Test a wafer in a different orientation – how does orientation affect failure load?