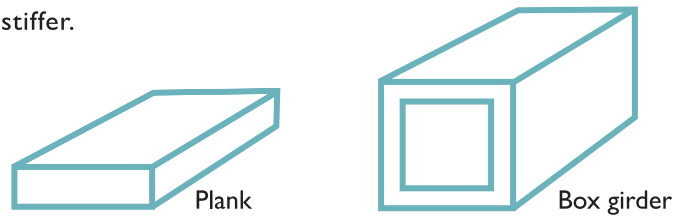
Welding with Chocolate
Teachers' Notes

Welding with Chocolate supports D&T and Science KS 1-4 learning. It is suitable for all ages and is an innovative and fun way of demonstrating welding and engineering principles in the classroom or at home!

Bridge Building

Bridges are made of all kinds of materials, wood, stone, steel, bamboo, concrete, and in this experiment - chocolate. A simple bridge can be made of one plank that spans the distance to be crossed.

A box girder bridge, however, is made from a long beam in a box shape instead of simply a plank. This box shape makes the beam much stiffer.



Welding a chocolate box girder bridge

We can demonstrate this by 'welding' chocolate bars into a box girder and comparing the weight a chocolate box girder can take in comparison to a chocolate plank.

- **how much more load can you add to a box girder bridge compared to the plank bridge?**
- **if and when the bridge breaks, how does it break?**
- **why is your chocolate box girder bridge stronger?**

You can use welding to make a chocolate box girder bridge from single bars. The heat source we use is hot water (from a kettle) in a straight-edged glass bottle.

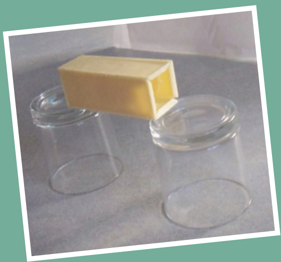
1. Hold the edges of your chocolate bars against the bottle of hot water until they melt slightly.
2. Press the melted edges together in a right angle, and leave to cool. This is half the box section. Make another half-section in the same way.
3. When the half sections have cooled, melt the remaining long edges and press them together to form the box section. Leave to cool for at least 20 minutes, or put it in the fridge.

Experiment 1 – Chocolate Plank Bridge

See how strong a plank bridge is. Unwrap one chocolate bar and place it between the two span points.

Now begin to load your bridge, carefully adding a little at a time. You can use weights if you have them, or load coins into a yoghurt pot. Just make sure that the bridge is loaded in the free span part of the bridge. How much load have you added when the bridge breaks? Does another chocolate bar break at the same load?

Experiment 2 – Chocolate Box Girder Bridge



Once your box girder has properly cooled and solidified along the edges then it's time to test it. First take some time to look at your box girder. Has it melted and joined perfectly all along each edge? Are there places that haven't stuck or holes along the joins? Is there some distortion so that the beam is not a perfect square in section? Do you think these factors might affect how strong the bridge is?

Place the box girder bridge between the span points the same as the plank bridge. The box girder is made from four bars so it ought to hold at least four times the load that the plank bridge broke at, right? Does it?

How much more load can you add to your box girder bridge compared to the plank bridge? If you manage to break the bridge, how does it break? Were the welds the weak points of the bridges that broke? Imagine how much stronger they would be if the welds and joints were perfect quality.

Question … Why is your chocolate box girder bridge stronger?

The box girder bridge can carry more load because the box beam is stiffer than a single plank, which means it deflects less under load. The deflection on the under side of the bridge is ultimately what causes it to break. Different shapes of beams have different stiffness. You can demonstrate this by flexing your ruler. It's pretty flexible and bends easily. Now turn it on its edge and try bending it again. It hardly moves! The same material in a tall thin beam is stiffer than a wide flat beam. The box girder exploits this by carrying most of the load on the two sides of the girder which are tall, thin beams with high stiffness.

The strength of the material is also important. If you use a caramel-chocolate bar to make your bridge, it slowly bends under load as it is not very strong. It finally fails in a 'ductile' manner after significant deformation. Using solid white or milk chocolate bars results in a sudden *bang* as the bridge breaks in a 'brittle' manner. There is little deflection to warn you that it is about to fail. Which type of failure mode is preferable in a bridge design?

Engineering is about understanding these properties of materials and structures in order to solve problems and build things in the best possible ways.

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