

Welding with Chocolate: Bridge Building

Bridges are made of all kinds of materials; wood; stone; steel; bamboo; or concrete. Often the best material is the one that is cheaply available, and which will perform its required function.



(A)



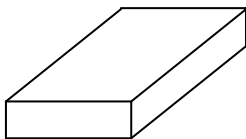
(B)



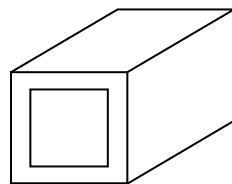
(C)

A bridge needs to support the weight of the traffic or people passing over it. The material that you are going to use to build your bridge from is chocolate in the form of milky bars. You will then test your bridge by loading it with weight in the middle of it.

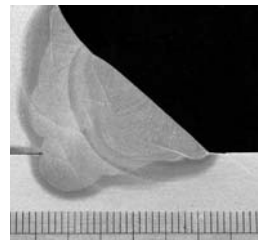
The simplest bridge is a plank that spans the distance to be crossed, like bridge B. As well as a plank bridge, you can also make a box girder bridge like bridge C, and test the strength of each bridge. A box girder is a long beam in a box shape instead of simply a plank, and the box shape makes the beam much stiffer.



Plank



Box girder



Fillet weld

Welding your box girder bridge

Welding is used to make more complicated structures out of simple components (such as planks or bars). When you weld two pieces of steel together you melt the edges of the two plates together, so that when the metal solidifies again, the metal is fused together as one piece. You can use welding to make your chocolate box girder bridge too. The heat source is hot water (from a kettle) in a bottle.

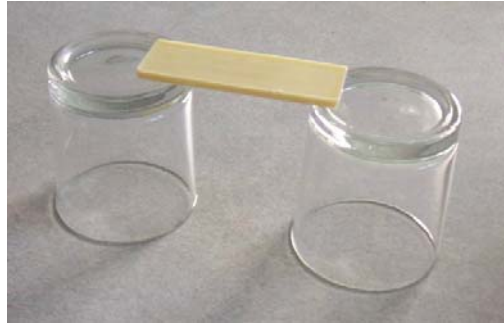
1. Hold the edges of your milky bars against the bottle of hot water until they melt slightly.
2. Press the melted edges together in a right angle, and leave to cool. This is half the box section. Make another half-section in the same way.
3. When the half sections have cooled, melt the remaining long 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 – Plank Bridge

See how strong a plank bridge is. Unwrap one milky bar and place it between 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 milky bar break at the same load?

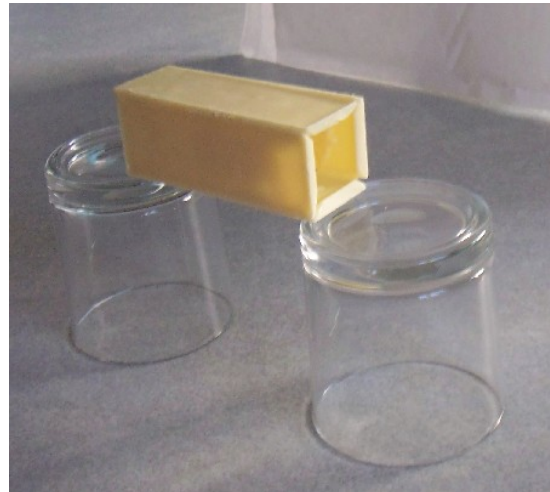


Experiment 2 – Box Girder Bridge

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.



Why is a box girder bridge stronger?

The box girder bridge can carry more load because the box beam is stiffer, which means it deflects less under load. The deflection on the under side of the bridge is 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. Engineering is about understanding these properties of materials and structures in order to solve problems in the best ways.

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