The Welding Institute

Welding with Chocolate - Teachers Notes

Plank Bridge

Box Girder Bridge

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

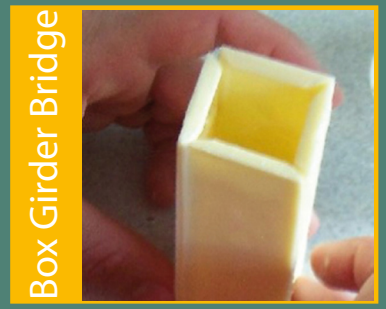
Bridges are made of all kinds of materials, wood, stone, steel, bamboo, concrete, and in this experiment - chocolate:

- 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.

Process: Welding your Box Girder Bridge

We can demonstrate this process by 'welding' chocolate bars into a box girder bridge. The strength of this chocolate box girder bridge can then be compared to a single bar chocolate plank bridge. You will be able to therefore answer the following:

- 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 the chocolate box girder bridge stronger?

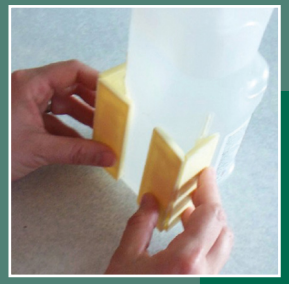


Step 1

Hold the edges of your chocolate bars against the bottle of hot water until they melt slightly.

Step 2

Press the melted edges together in a right angle, and leave to cool - this is half of the box section. Repeat this step again to produce both parts of the box girder bridge.



Step 3

Once both parts are cooled, melt the edges of both halves and join together to form your box girder bridge and leave to cool for 20 mins. HINT: it should look like the image above!

Experiments: Mechanical Testing of the Bridge

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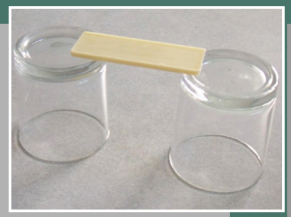
Single Chocolate Bar - Plank Bridge

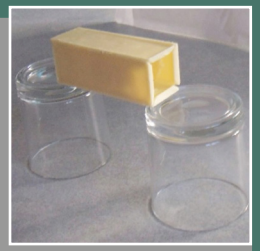


1. Place a single chocolate bar between the two span points (see image above).
2. Gradually begin adding weights to the centre of the bridge.

Observations:

- How much load have you added when the bridge breaks?
- Does another chocolate bar break at the same load?

Box Girder Bridge



Once your box girder has completely cooled and solidified along the edges it's time to test its strength.

1. Non-Destructive Visual Test

Weld defects: is your box girder melted and joined perfectly along each edge? Can you see any weld defects or distortions (HINT: distortion means the beam is not a perfect square in section)?

Will any of these visual findings affect the strength of the box girder bridge?

2. Destructive Testing

Repeat the first test using your constructed box girder bridge, gradually adding weights.
If the box girder bridge is made of 4 bars, will the bridge be 4 times stronger than the single bar bridge?
How much more load can you add to your box girder bridge compared to the plank bridge?
Did your bridge break? Were the welds the weak points of the bridges that broke?
How much stronger would your box girder bridge be if all the welds and joints were perfect quality?

Concluding Considerations for Students...

Why is your chocolate box girder bridge stronger than the single plank bridge?

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 and you can demonstrate this by flexing your ruler. It's pretty flexible and bends easily but when you 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 and 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 the properties of materials and structures in order to solve problems and build things in the best possible way.