# Rope-inforced Ice!

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**Concept:** Concrete beams are strong in compression but weak in tension. They require reinforcement to provide adequate strength to be used in a structure. Inserting steel at the bottom of the beam where tensile forces are greatest increases its strength as the steel is able to withstand the tensile forces that would usually crack the concrete and cause the beam to fail.

**Example:** I have demonstrated how this increase in strength using reinforcement can be achieved by comparing two beams made of ice. One will not contain any reinforcement and the second one will be reinforced with string. Their strengths will be compared by loading each of them to test how much load they can carry before failing.

**Matrix Material:** Ice

**Reinforcement Material:** Pieces of stapled string

*Figure 1: Stapled reinforcement string used in ice beam (2)*

**Method:** Two beams of equal dimensions are made. Beam (1) is not reinforced. Beam (2) has 60 small pieces of stapled string inserted in the water before it freezes to ice. The string is stapled to provide grip in the ice and to prevent all the reinforcement string from floating on the top of the water when forming the ice beam.

Gym weights were used to load the ice beams.

Figure 2 shows beam (1) prepared to be loaded. The stick in the centre of the beam is to ensure that the load applied is a point load at the centre of the ice beam.

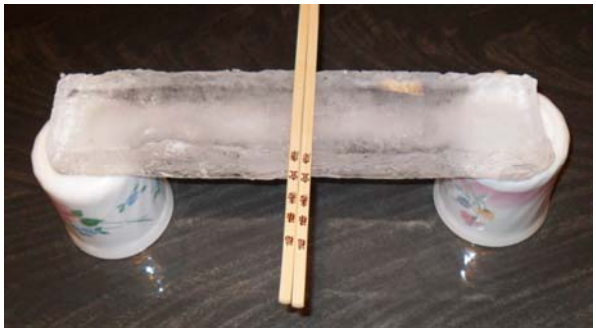

*Figure 2- unreinforced ice beam(1)*

*Figure 3 – Ice beam (1) failed under load of 1.25 kg*

*Figure 4: ice beam (2) – reinforced beam supporting a load of 11.25kg*

The unreinforced beam broke under a load of 1.25Kg. The reinforced ice beam (2) is able to carry a load of 11.25Kg without breaking.

**Theory:** When the beam is loaded it deforms by sagging as shown in figure 5.

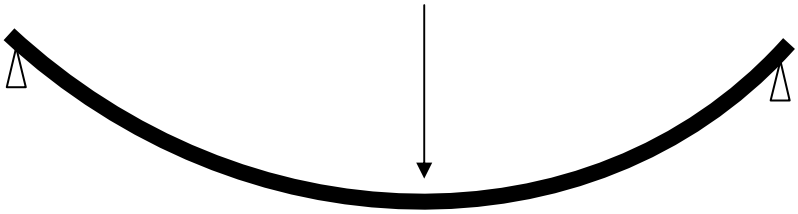

*Figure 5: Deflection of a simply supported beam with a central point load*

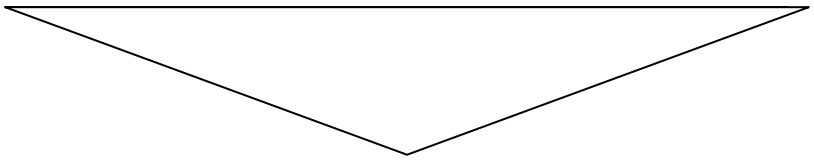

*Figure 6: Bending Moment Diagram - simply supported beam with point load in centre*

The bottom of the beam is in tension when the beam is loaded. The ice represents the concrete used in beams. This is a brittle material that is weak in tension. The string reinforcement is weak in compression but strong in tension. As the ice is stretched and is about to crack, the string takes the tensile load and prevents the beam from breaking and failing and so increases the strength of the beam.