

Prestressed Ceramics

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What are prestressed ceramics?

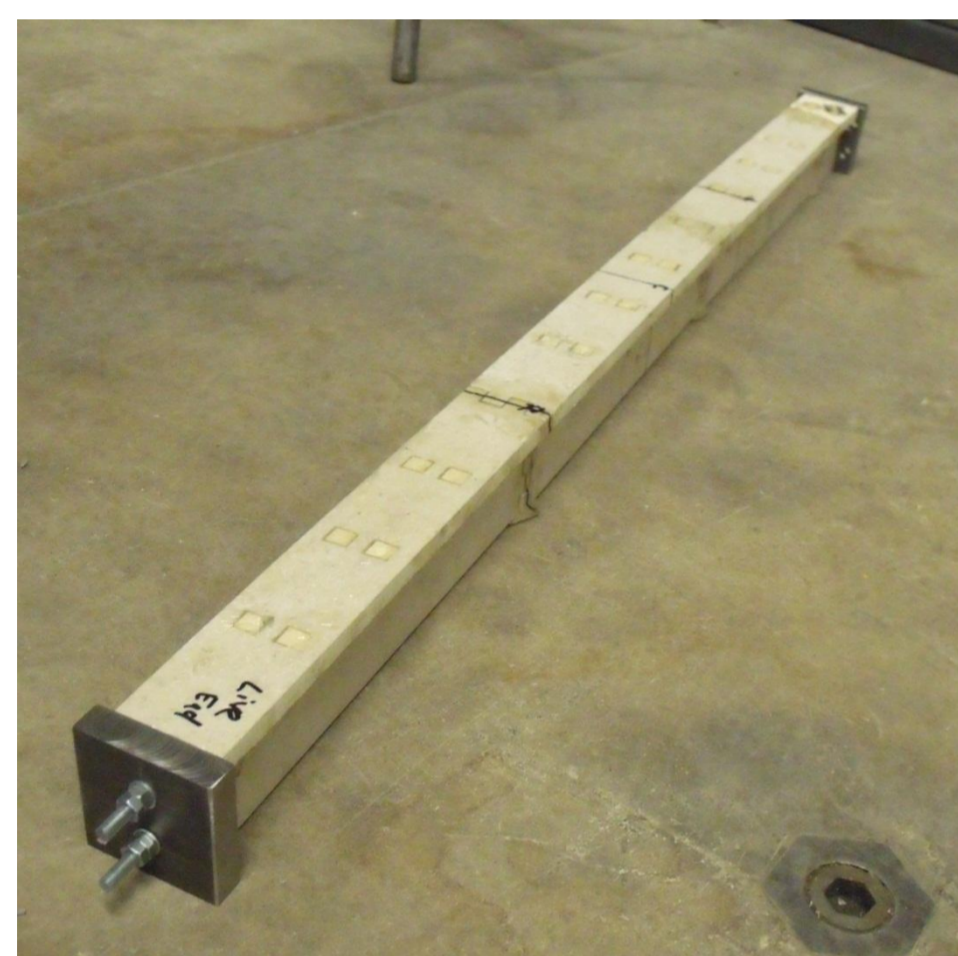
Prestressing refers to the method where loads are applied to a structure during the construction, in order to later assist the structure to carry loads applied during its lifetime. Prestressed ceramics can be designed and analysed by adapting the theory of prestressed concrete. Engineers first considered doing this in the mid-20th century.

Why prestress ceramics?

While the compressive strength of ceramics is usually high, the tensile strength is relatively low and leads to the poor performance of unreinforced ceramic beams in flexure. By applying a compressive stress to the ceramic during construction, greater tensile loads can later be carried by the structure. This allows for more efficient material use (ceramics usually fail in tension, leaving much of their compressive capacity unused).

One of the attractive properties of ceramic is its melting temperature, which is often between 2000-3000°C. This is greater than many metals and makes ceramics a very desirable material for high temperature environments.

Method

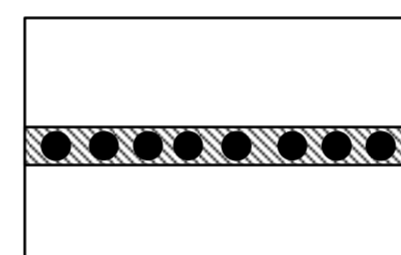


Prestressed ceramic beams were made from:

- Ceramic bathroom tiles
- Steel tendons (rods/wires)
- Araldite adhesive

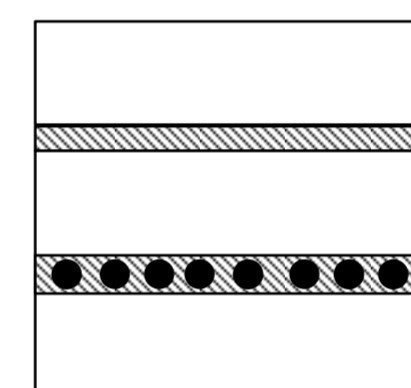


Altogether four different types of prestressed ceramic beams were designed and tested, with cross-sections as shown below.



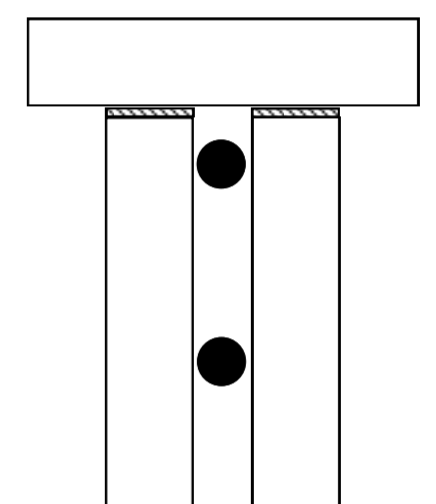
Beam 1

- Pre-tensioned
- Steel wires
- 7.2kN prestress at centroid



Beam 2

- Pre-tensioned
- Steel wires
- 10kN prestress eccentric to centroid



Beams 3 & 4

- Post-tensioned
- Steel rods
- 10kN prestress at centroid for beam 3, eccentric for beam 4

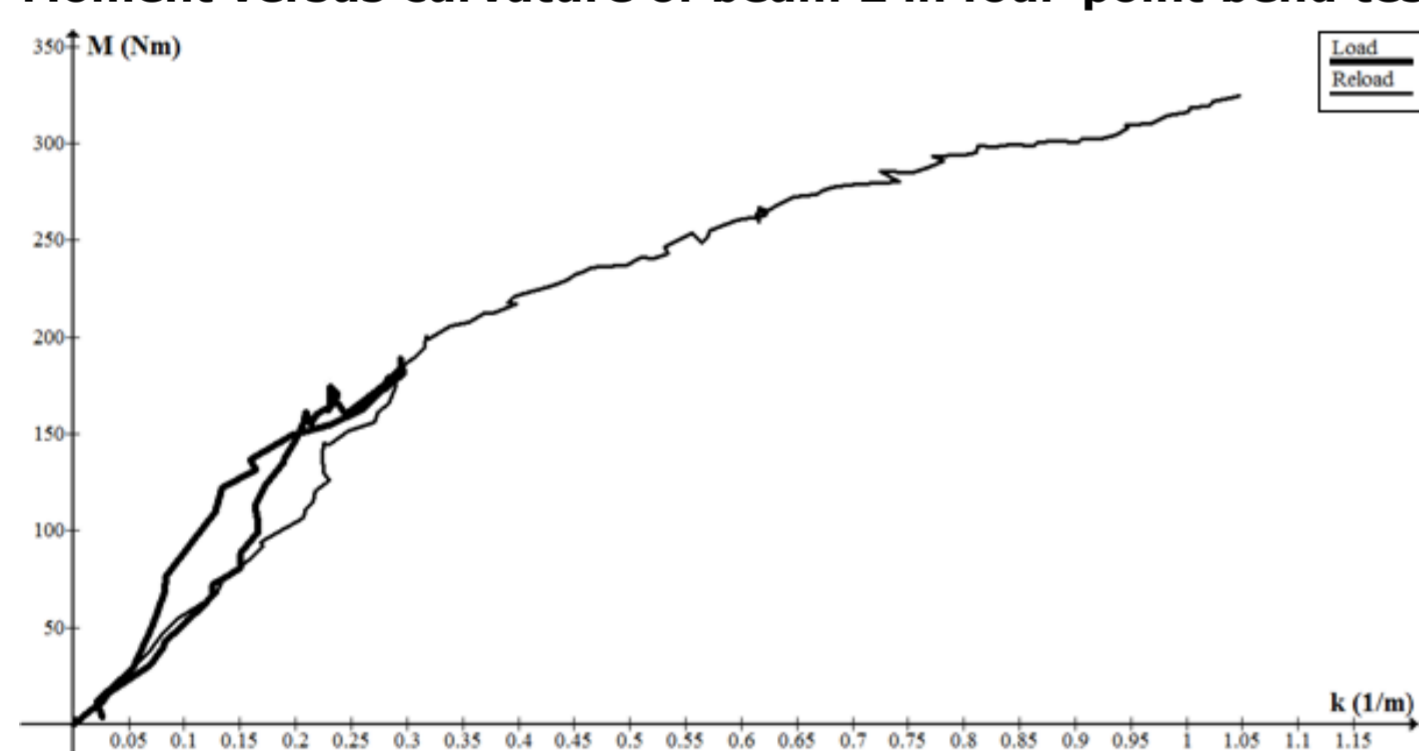
Key for diagrams

- Ceramic ▨ Araldite® ■ Steel

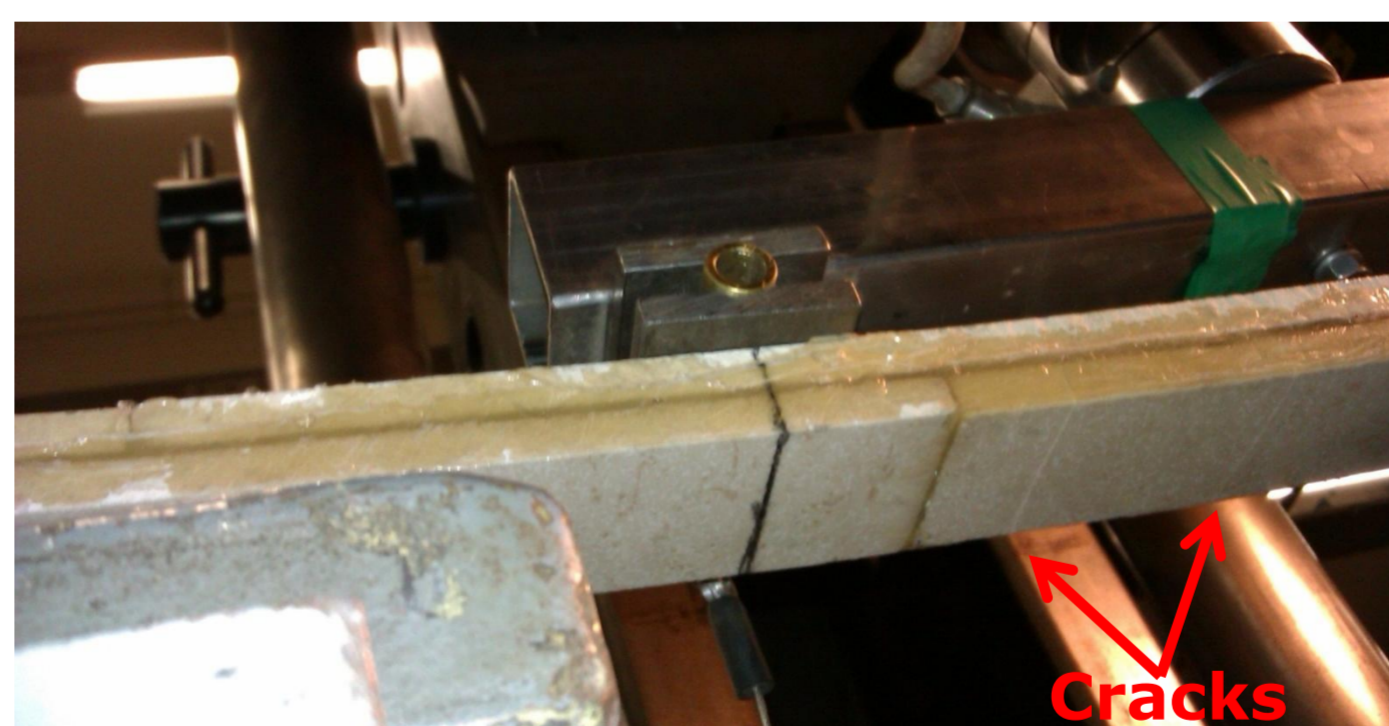
Photographs of two prestressed ceramic beams

Results

Moment versus curvature of beam 2 in four-point bend test.



Prestressed ceramic is not a brittle material.



Prestressed ceramic continues to carry loads after cracking has occurred.



Cracks were observed to propagate the ceramic gradually.



Prestressed ceramic can sustain large curvatures.



By prestressing the ceramic compressive failure can be observed.

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