

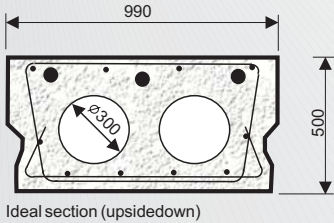
Non-Destructive Testing in Civil Engineering



IMPACT-ECHO TESTS ON CONCRETE BRIDGE

BEAM SPECIMEN

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Ideal section (upsidedown)

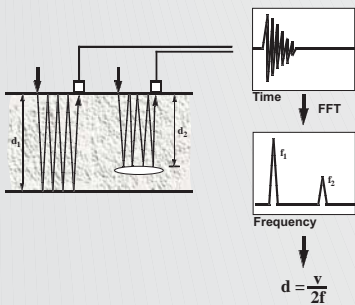


Real section

In the former DDR's **BRIDGE CONSTRUCTION** praxis, to spare material and to lessen the dead load, cardboard formworks were placed in the low-stressed area of prefab post-tensioned concrete beams to create cavities. During concrete casting, if these internal formworks would shift upwards, the height of the compressed section would be reduced and the load-bearing capacity of the beam would be lower. Laboratory IE tests were carried out to assess the position of the cavities in one such beam.



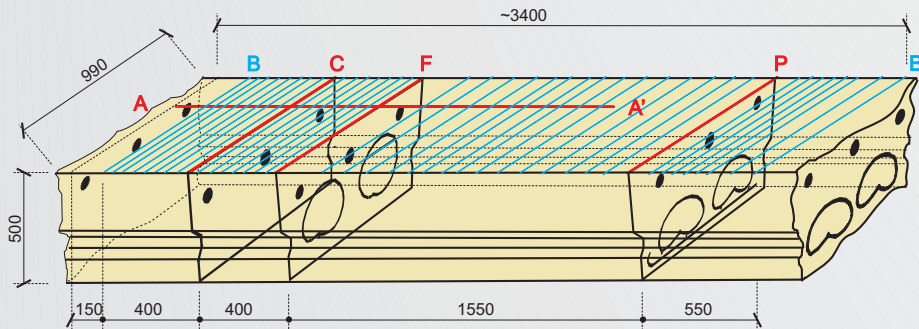
Automated data collection



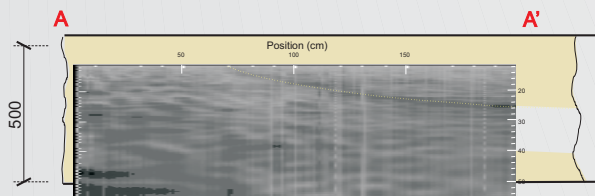
IMPACT-ECHO is based on multiple reflections of an acoustic wave between the surface (where it has been mechanically produced with a small hammer or ball bearing) and the element's backside face and/or internal target parallel to that surface. Via a transducer located beside the impactor, a time waveform is recorded and analysed in frequency domain. Inhomogeneities and defects are detected from the peaks present in the frequency (f) spectrum and their distribution. Their depth (d) is calculated if the sound velocity (v) through the material is known.



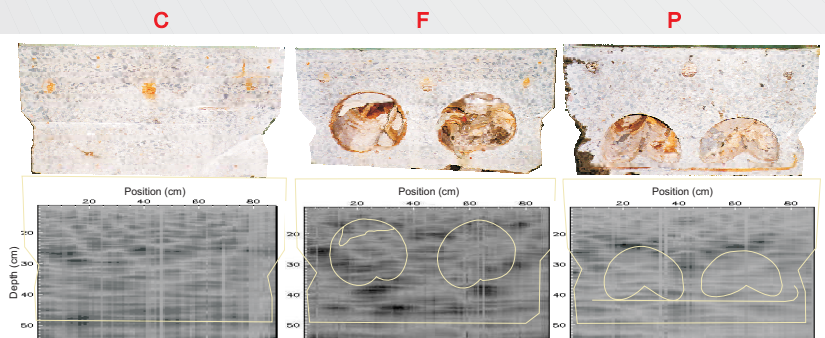
At BAM, **SCANNING IMPACT-ECHO** data are automatically collected along lines. Hammer and receiver are mounted on a frame and data displayed on the screen in real time (frequency up to 18 kHz).



TESTING: a 3.4-m long beam section was cut out from a demolished bridge and tested from the underside. Transversal measurement lines were made up of 88 points, 1-cm spaced. Longitudinal measurement lines run along the two cavities. Data are plotted as 2-D images of depth vs. position on the concrete. Dark grey tones represent stronger signal amplitude.



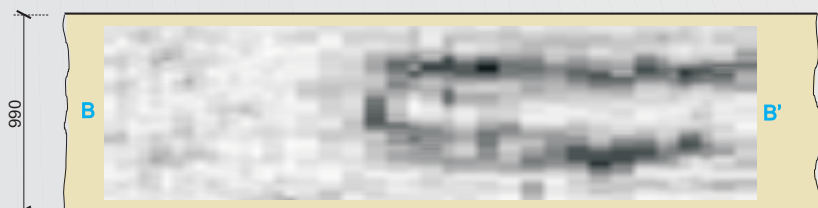
This 2-m long **scan along A-A'** shows the profile of one cavity as a curve instead of a horizontal straight line, as it should have been, indicating a shift of the cardboard formwork. The reflection from the underside of the beam is visible on the left of the image, where the cavities are not present.



The vertical transversal section at measurement **line C** shows the reflection from the beam's underside at 50-cm depth.

The IE transversal section along **line F** shows the top of the two cavities at 15 cm depth (for the left cavity) and 17 cm (right cavity). The wave velocity is 4000 m/s.

Along measurement **line P**, the top of the 2 cavities is visible at 24.5 cm and 25.4 cm depth. The reflection from the underside of the beam was here not detectable.



Horizontal section B-B' at 24-cm depth (+/- 2 cm): by interpolating the measurements collected in transversal parallel lines, data could be plotted in horizontal slices parallel to the surface, or depth-slices. This figure, averaging the data corresponding to a depth of 22-26 cm, shows the 2 cavities with their up-going course due to the erroneous shifting of the formwork during concrete casting.

CONCLUSIONS: to evaluate bridge safety and the carrying capacity of its post-tensioned concrete beams it is important to know if its inner cavities are in anomalous position. With Impact-Echo tests it was possible to locate the position of the cavities and to visualise their profile. Therefore an important construction defect was highlighted via NDT.