Pundit 250 Array
Application Booklet

Swiss Solutions since 1954

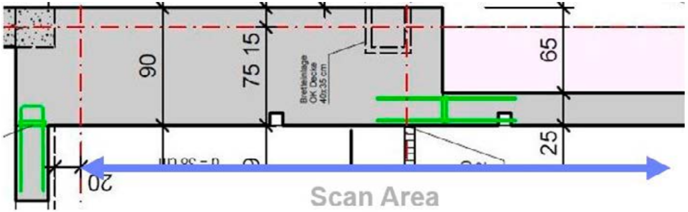
This booklet is intended to illustrate the applications of the Pundit 250 Array instrument. More than that it is intended to be a vehicle that will allow Pundit 250 Array users to share and build their knowledge. This booklet will be updated on a regular basis. If you as a user, have a successful application example that would be of interest to other users or you wish to test a new application, please contact Proceq.

Contents

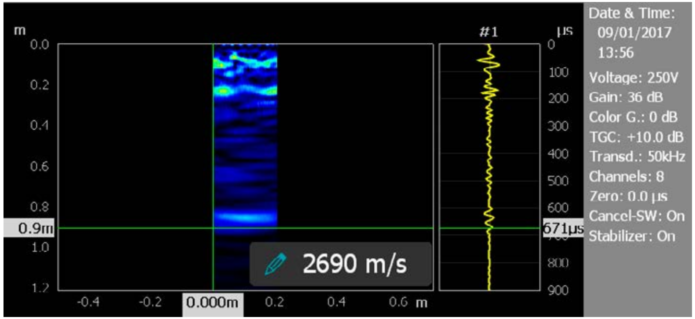
1. Thickness variations

Ultrasonic pulse echo technology is excellent for detection variations in the thickness of concrete structures. In particular the panorama B-scan function is ideally suited to this.

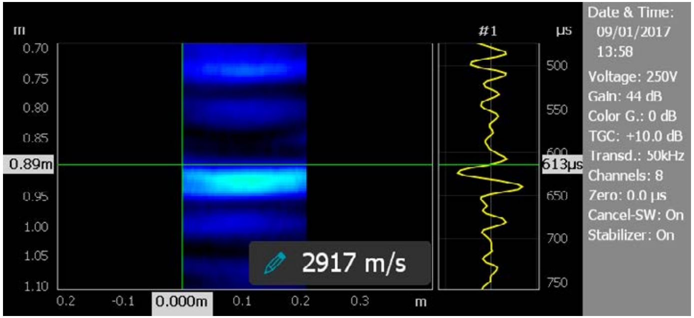
The following example shows how a typical structural assessment can be carried out. In this case, there is a relatively thick section of concrete. The transmission range of pulse echo instruments depends on the quality of the concrete and the amount of reinforcement steel. The current practical range of commercially available instruments is typically around 1m. It can be seen that the structure here is close to that limit.

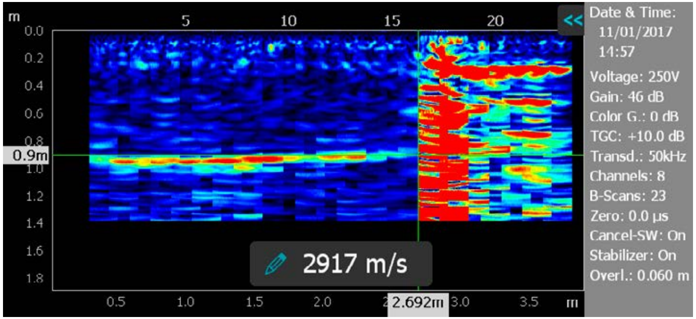


The first step is to do simple spot checks to establish whether or not it is even possible to see the back-wall echo in the thick section of the structure. The same procedure would be used if the task was to locate objects such as pipes, tendon ducts, delaminations or honeycombing within the structure. Begin with rapid spot checks to locate anomalies then carry out more detailed scans in the areas of interest.



In the B-scan above the back wall echo can be seen at a depth somewhere between 0.8 m and 0.9 m. For ultrasonic pulse echo measurements, depth information is determined by the pulse velocity. For this scan the pulse velocity (2690 m/s) was estimated by measuring surface velocity (Estimate by SW). This is typically the starting point for any investigation and must often be used when access is only available from one side and there is no accurate documentation available on the structure. However, it is well known that the pulse velocity at the surface of a concrete structure can differ significantly from the pulse velocity when measured directly through the structure. According to the literature this difference can be as much as 20 %. Better results can be obtained if the pulse velocity is calibrated at a point on the structure where the actual thickness is known.

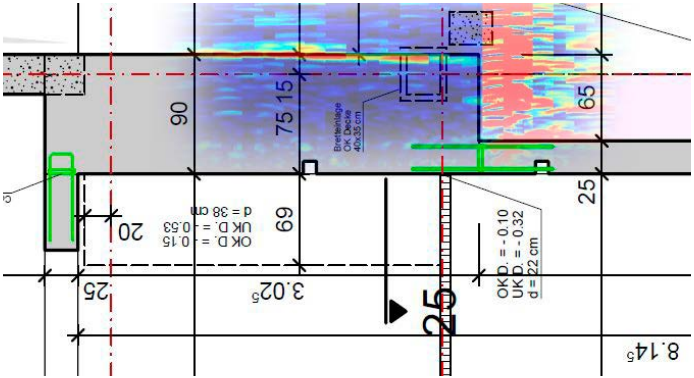




The can above shows a B-scan at the same location after the pulse velocity has been calibrated by measuring at an area of the structure where the thickness is known (Estimate by Echo). The A-scan to the left of the B-scan is used to align the cursor to the beginning of the echo. The difference in pulse velocity from the surface velocity measurement is 227 m/s which resulted in a measured thickness error of about 7 cm or 8 % in this case. This illustrates the importance of pulse velocity calibration if accurate depth information is required. The gain has also been optimized to give a clear back wall signal. These settings can then be used to generate a wide area scan using the panorama B-scan.

This is a scan of around 3.5 m. It consists of 23 separate B-scans stitched together. The overlap is set to 6 cm which is equivalent to two channels. It took less than 2 minutes to generate this scan. After 2.7 m from the beginning of the scan there is a step change in the wall thickness. From here on there are multiple back wall reflections due to the short path length.

The image below shows how this scan relates to the construction drawings. The wall thickness variations are mapped very accurately.



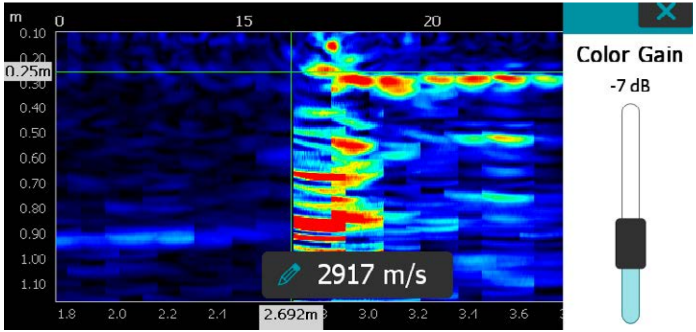
Gain settings

There are three gain adjustments available to the user. Two of them, gain and time gain compensation (TGC) can be controlled directly by the buttons on the measurement probe. Both of these affect the raw signal that is saved as part of the measurement and cannot be adjusted afterwards. The colour gain on the other hand is a digital gain which can be used as part of the post processing to obtain the best image.

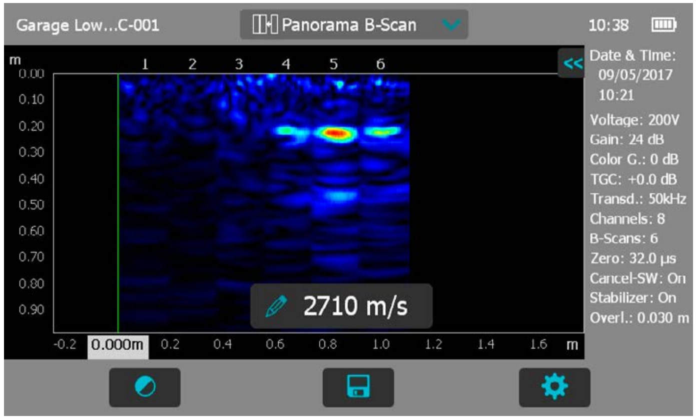
The scans above had a relatively high gain and high TGC. This was necessary in order to achieve a strong back wall echo at a depth of 90 cm.

For the section to the right it would be possible to use a much lower gain.

Once a panorama B-scan has been started, it is not possible to change the gain. This can lead to saturation when there are significant thickness changes as we have seen. If we zoom in to the right hand side of the scan where the wall thickness is 25 cm, we can reduce the colour gain to optimize the image in this section during analysis.

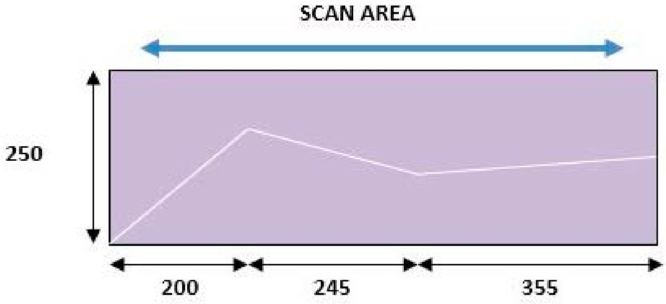


The image below is of the same section of the scan, but with the gain optimized for the 25 cm section. In this case TGC is set to zero. However, with this setting the back-wall reflection at 90 cm is not visible.

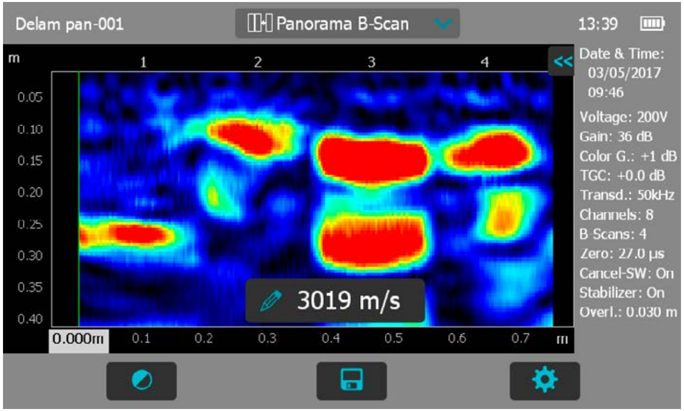


2. Delaminations

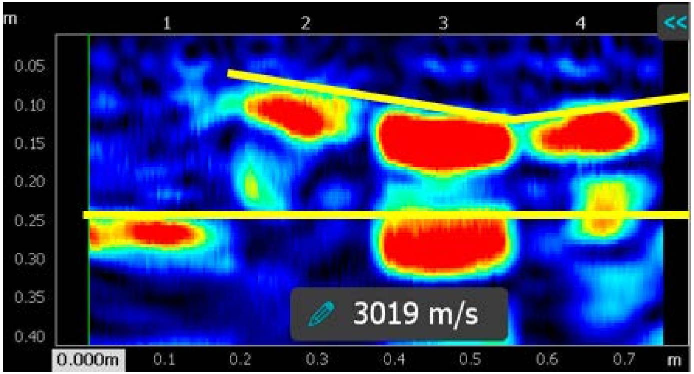
Pulse echo technology is ideally suited to detect delaminations running more or less parallel to the upper surface of the concrete. This example shows a test block 25 cm thick with a zig-zag delamination running through it.



The panorama B-scan of this block is shown below.



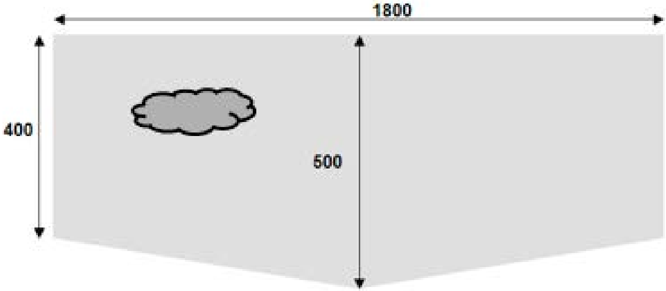
The image below shows how this scan would be interpreted.



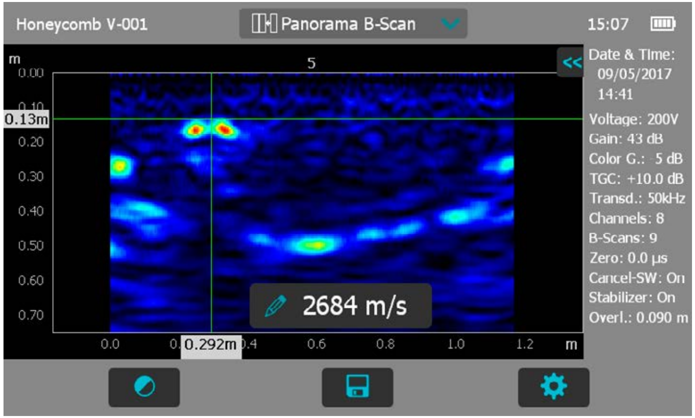
The back-wall depth has been marked with a yellow line at a depth of 25 cm. The delamination has also been marked. Below the delamination we see multiple echoes. At the very left, the delamination is too steep to be detected. At a certain angle the echoes are reflected away from the receiver. This is important to understand. Delaminations and cracks can only be detected if they are more or less parallel to the scanning surface.

3. Honeycombing

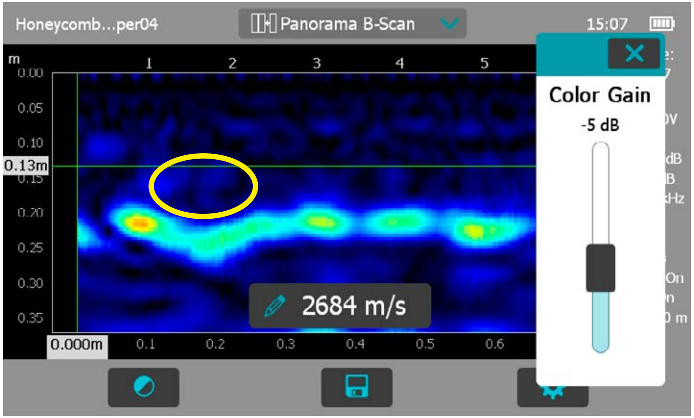
Honeycombing can be detected using pulse echo technology. The ease with which it can be detected and the strength of the echoes received depends on how loose the honeycombing is. Honeycombing with more air content will be easier to detect with stronger echoes. Dense honeycombing on the other hand is more difficult to detect, but can also be considered less of an issue structurally. The image below is a test block with a V-shaped back wall and a honeycomb in the upper left side.



The scan of this test block can be seen here. The thickness variation of the back wall can be traced easily. The honeycombing is loose in this case and can clearly be seen at a depth of 13 cm as indicated by the cross hairs.



In comparison the scan below is of a test block that is 20 cm thick. It has an area of densely packed honeycombing in the location indicated by the yellow ellipse.

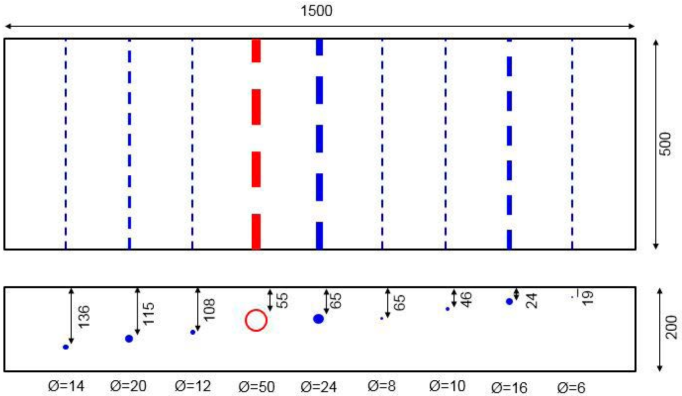


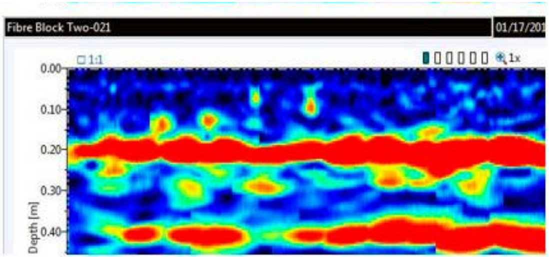
The only indication that there is a defect of some kind here is the deformation of the back-wall echo. This kind of bulge is caused because the object that is present causes the ultrasonic signal to travel a longer path. The object itself though cannot be seen.

4. Fibre reinforced concrete

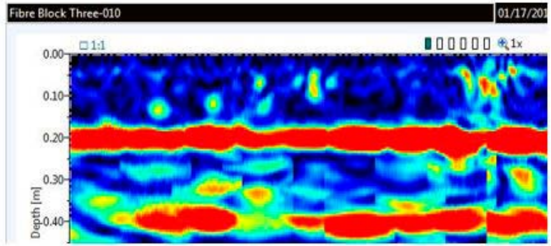
Traditional measurement techniques used for estimating cover depth use electromagnetic waves. The very nature of these technologies means that they cannot be used on concrete with steel fibre content. Ultrasonic pulse echo testing on the other hand has been shown to be an effective technique on this material. Rebars and pipes can be clearly detected and their relative cover can be determined.

The test blocks shown below are identical except for varying steel fibre content. Test block 1 was constructed with standard concrete with no fibre content. Test block 2 had a fibre content of 30 kg/m3 and test block 3 had a content of 60 kg/m3. Dramix steel fibres 1 x 50 mm were used. The concrete used had a concrete compressive strength class of C25/30 with a maximum aggregate size of 32 mm.



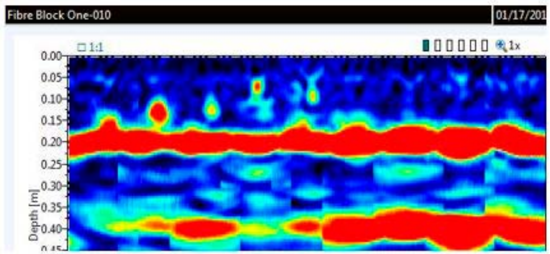


Block 2



Block 3

The following panorama B-scans show that the test results are largely unaffected by the amount of fibre content.



Block 1

The back wall echo can be seen at a depth of 20 cm. The estimate by echo technique was used to calibrate the pulse velocity in this case as the thickness of the object was known. The hollow pipe and the rebars to the left hand side of the block can be clearly identified.

5. Tendon ducts

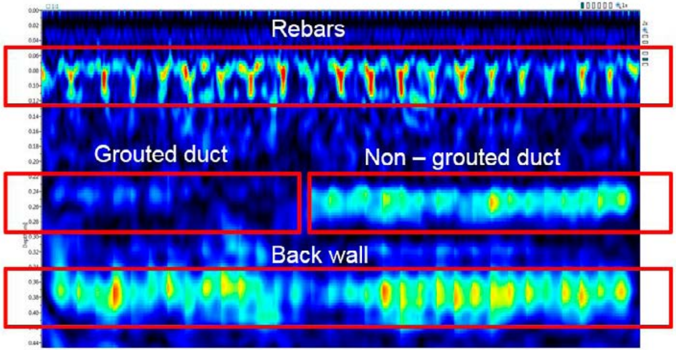
Ultrasonic pulse echo technology can be used to locate tendon ducts and to a certain extent it can be used to investigate the condition of the grouting. Experiments have shown that it is possible to differentiate between the grouted and ungrouted condition by the change in amplitude of the received echoes. The test blocks shown below were created to investigate this.

Rebar spacing:	150 mm
Specimenthickness:	355 mm
Rebar size:	D13
Concrete strength:	40N/mm^2

Here we can see the internal structure of the test block. The example is a scan of the middle tendon duct. The details of this PT System:

Stranded wire:	(12S12.4 mm)
Sheath diameter:	70 mm
Concrete coverage thickness:	220 mm

The left hand side of this duct is grouted and the right hand side is not grouted. The scan below shows a span of +/- 1-5 m from the centre.



The back wall echo can be clearly seen at around 35 cm. The rebar grid can be seen at about 7-8 cm.

The PT duct is at a depth of about 25 cm. There are very strong echoes from the PT duct without grout. Where it is fully grouted the echoes are much weaker.

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