

Ultrasonic examination of concrete with one side access in practice

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Abstract. This paper presents analysis of Ultrasonic tomography as a non-acoustic method for testing concrete. It includes description of theory, measuring equipment, advantages and difficulties which can occur during investigation. The whole content of study part is preceded by a deep survey of the literature. The experimental part consists of description of a study, photos, results and conclusions.

1. Ultrasonic tomography

Ultrasonic Tomography is constructed on shear wave pulse-echo technique which is based on exciting an elastic wave in the tested specimen [1, 2]. The excitation source is usually a multi-head antenna (usually a few tens of integrated ultrasonic heads), which is also used for receiving and processing ultrasonic signals as shown in the figure 1.

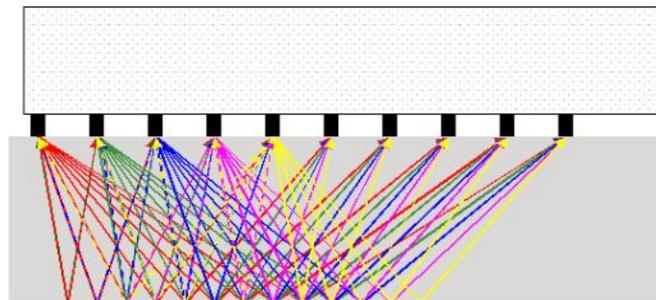


Figure 1. Collecting the data by tomograph A1040 MIRA, [<http://www.acsys.ru/eng/production/detail/a1040-mira/>]

The Ultrasonic Tomographic Imaging becomes more and more demanding due to its feasibility to more precise and effective detection of different flaw types, higher resolution of testing and applicability for deeper thicknesses of testing object at one-side access testing. By using ultrasonic tomography we can assess the condition of reinforcement in reinforced structures.



2. Measuring equipment

Measuring equipment was invented by Acoustic Control Systems in 2008 and it is called MIRA A1040. It uses automated acquisition of a number of parallel line scans, which allows to build a three-dimensional volume that can be viewed in two-dimensional cross-sections and depth sections with combinational sounding. The device is an autonomous measuring block, which contains a matrix antenna of 48 (12 blocks with 4 elements) low-frequency broadband transverse wave transducers with DPC and ceramic wear-resistant tips.



Figure 2. A1040 MIRA Ultrasonic Tomograph: on the left side view, on the right bottom view, [<http://www.acsys.ru/eng/production/detail/a1040-mira/>]

3. Advantages and limitations

The main advantage of application is simplicity in use and rapidly obtained results. Another feature is ability to test a specimen having access only from one side.

In order to avoid coming to the wrong conclusions, the resulting images need to be interpreted by experience and qualified staff [3-5], utilizing additional information if possible. Due to the fact that this is new method, it is still expensive equipment.

4. Experimental part

In experimental part there were tested two probes seen on a figure below. Probe no. 34 and 10 with dimension 1000 x 1000 x 1000 mm are presented in the Fig. 3.

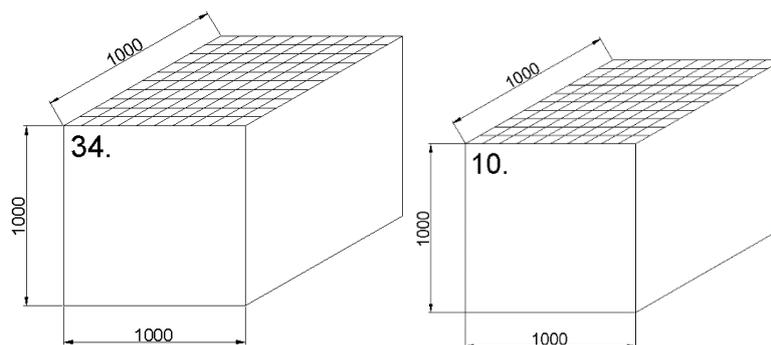


Figure 3. Scheme of probe no. 34 and no. 10 with its dimensions

Probes were tested as in the scheme below. Tomograph with every single scan moved with a distance of a one cell - 100 mm. Starting with top surface of a specimen.

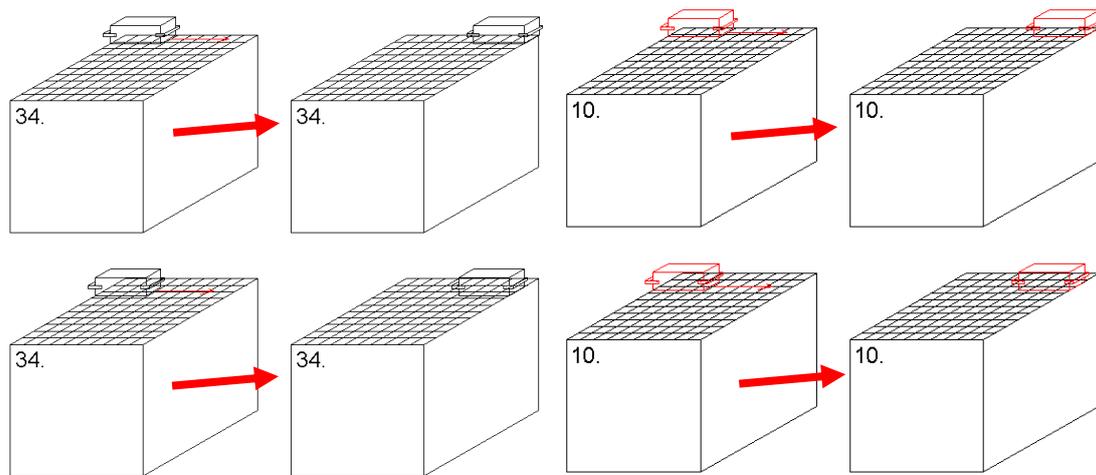


Figure 4. Scheme of testing procedure. Starting with top left image

4.1. Probe no. 34

4.1.1. General information.

Probe number 34 seen on a figure below in generally has not any deforms or cracks, but on front side of a specimen there is a little longitudinal crack almost in the middle of a height. It may be the signal off inserted supplement into the concrete, however there were no additional information about elements inside the specimen.



Figure 5. Picture of probe no. 34 and a zoom to longitudinal crack on it

4.1.2. Results

From scanning only top side of a specimen we obtain 10 rows – 7 images in one column (1.1; 1.2...1.7 etc.). In all we obtain 70 scanning images. In this example, rows are marked with Y, and columns with X.

In the figure 6. On the image 1-7 which is located in the 1st row at the beginning of tested element we can already noticed reflected wave at the depth of around 420 mm – almost in the middle of specimen's height exactly in the place of a longitudinal crack. The same situation is noticeable in every image for example in the image 3-4; 5-3; 7-2.

At the depth of 5 to 120 mm and 100 to 900 mm there are light spots which might be some kind of air voids, It also can be the effect of badly compacted concrete mix. In exemplary images we can also

noticed air voids marked with a light spots and a reflection at the depth 1000 mm which is the height of a tested probe.

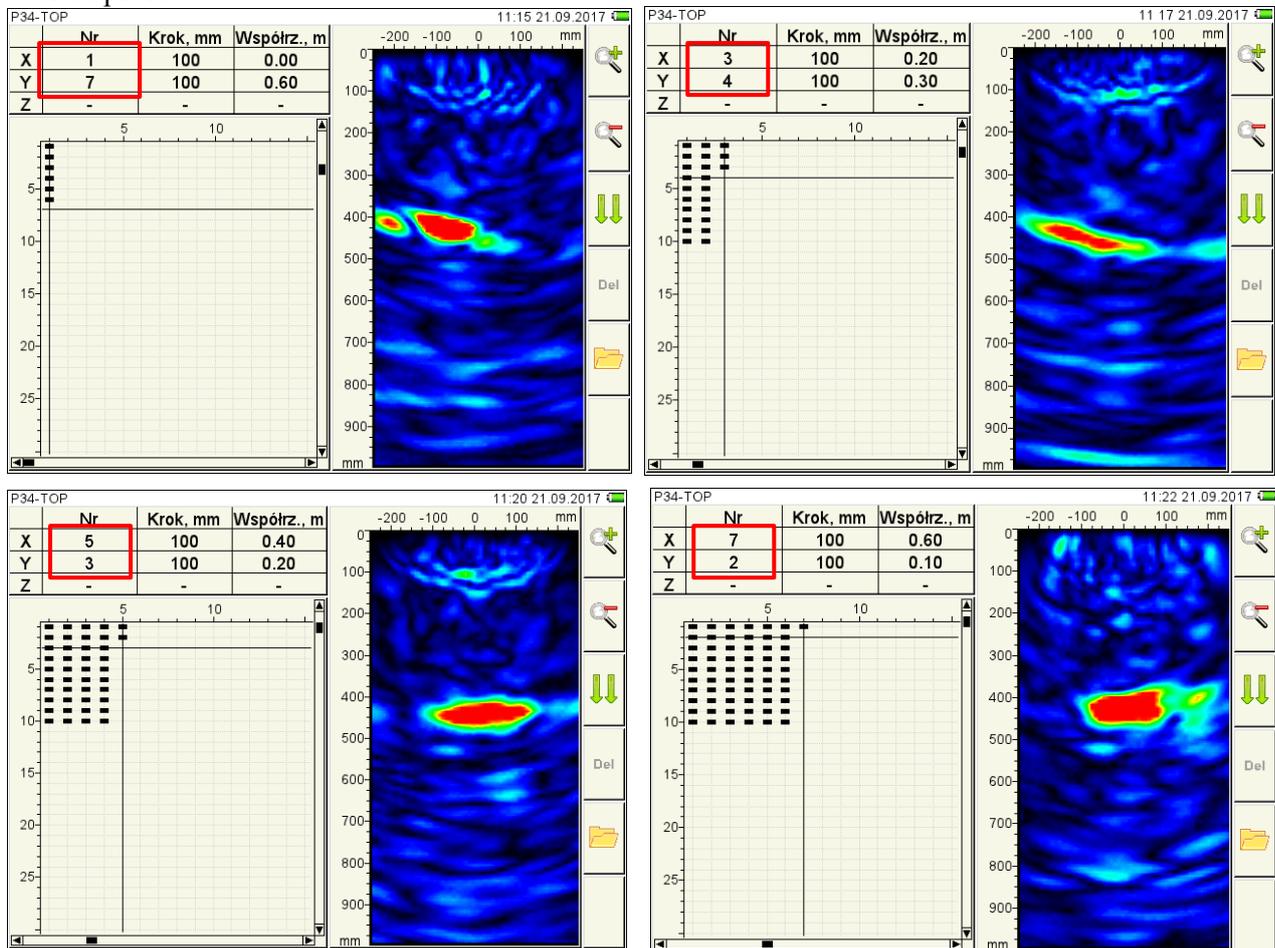


Figure 6. Scanning images obtained from testing top side of a specimen no. 34

4.1.3. Conclusions

Probe number 34 before testing had visible crack almost in the middle of specimen's height. After scanning top side of a probe there was the same reflection at the comparable depth in every image – from 1st to last row and column. It means that inserted barrier is located at full span and length of a sample. Slightly differences in depth of reflection might mean that inserted block is made with an elastic material, that bends because of a weight of a concrete mix. There are also visible spot lights in different depth of a probe that might be air voids or the cause of badly compacted concrete mix.

4.2. Probe no. 10

4.2.1. General information

The probe number 10 seen on the picture below, was tested in a different way. This time, before starting testing there were information about additional insertions in the specimen. Scanning probe no.10 was based on searching already known elements in the images of tomograph.

Picture below presents two pipes located on concrete mix. The length of the tubes reaches almost half of a probe's span. The material they are made of is probably PVC, there are no data if the pipe's

inside is filled with other material. The measuring tape indicates that the top part of a tube is located at depth of around 26 cm. There were no further information about extra supplements in other concrete mix layers.



Figure 7. Additional insertions in concrete mix

4.2.2. Results

Scanning top side gave the amount of 70 images, 10 rows and 7 images in one column (1.1; 1.2...1.7 etc.). In this example, rows are marked with Y, and columns with X.

In obtained images we ought to look at least for two reflections in the upper part of a specimen – around 26 cm from the top edge of concrete block.

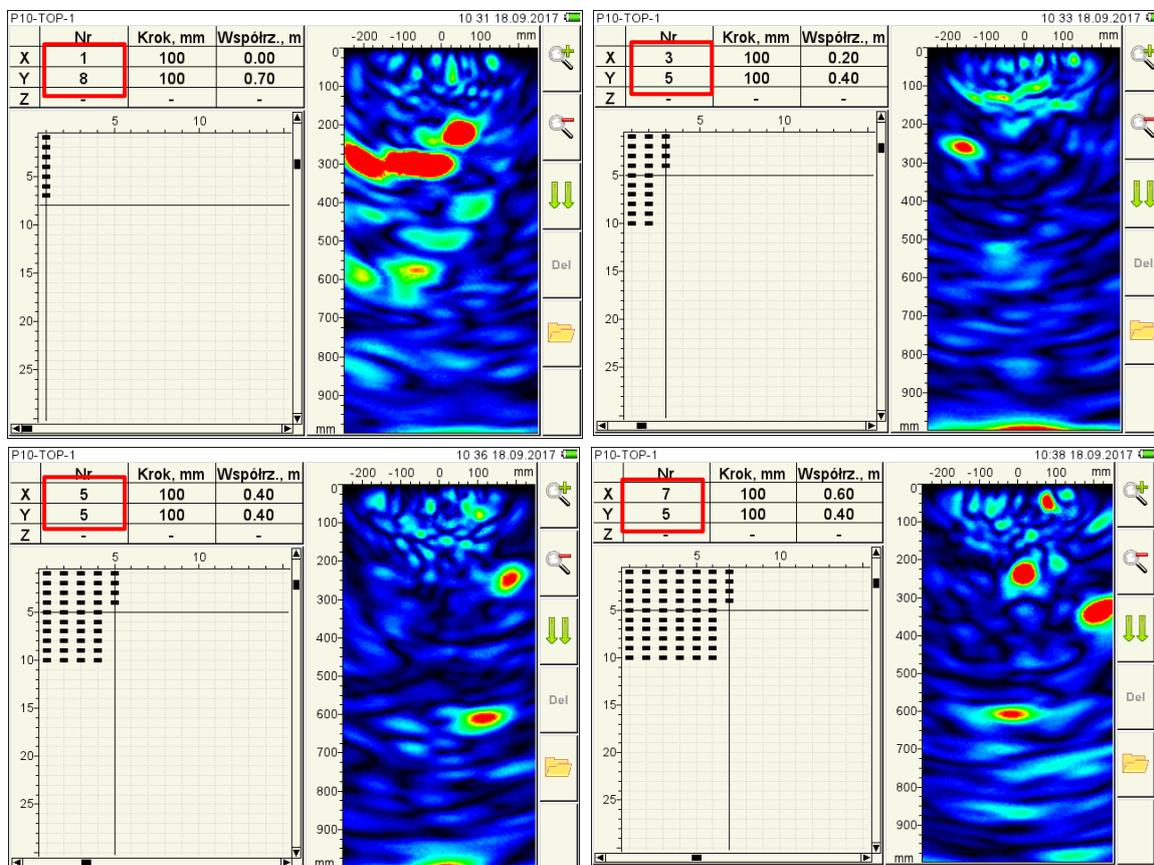


Figure 8. Scanning images obtained from testing top side of a specimen no. 10

In the image 1-8, we can notice many reflections in different places. Knowing the position of two pipes, we can assume that the right part of long and red spot is known inserted element, the left part at the edge of a probe and a red spot above identified pipe is an error reflection. This phenomena occurs when an propagated wave acts on edge of different density element or edge of a probe. Part of a wave reflects [5] on that edge and might be presented in scanning images as a defect, but in a reality it is not existing. This behaviour is called “edge effect”. Presented image 1-8 is located at the beginning of probe’s edge, in the 1st column. In the same image at the depth of around 600 mm there is a light reflection, also in this case the left reflection might be the cause of “edge effect”, but the right reflection at this depth could be the additional insertion. The area of 600 mm depth will be more precisely examine in next scanning images.

In the image 3-5, we can notice the strongest reflection at the depth of 260 mm, it is first inserted pipe, also the light spots at the top of an image might be the effect of a bad compacted concrete mix, some material defects or air voids. Red reflection at the depth of 1000 m indicates the bottom of tested probe.

In the image 5-5 we can see clear echo at the depth of 260 mm it is the second inserted pipe. In this image we can also observe strong reflection at the depth 600 mm, it is possible that there are inserted another two elements under know pipes but in the other layer.

In the figure below in the image 7-5, so at the other edge of a specimen we can notice a red spot at the depth of around 210 mm it is seen on an image 5-5 second inserted pipe. The difference in the depth of tube’s localization can be the cause of a diagonal pipe insertion or a tube movement during compacting concrete mix. The red signal on the right might be the effect of “edge effect”, but the echo at the depth of 600 mm indicates another insertion mentioned in a description of an image 5-5.

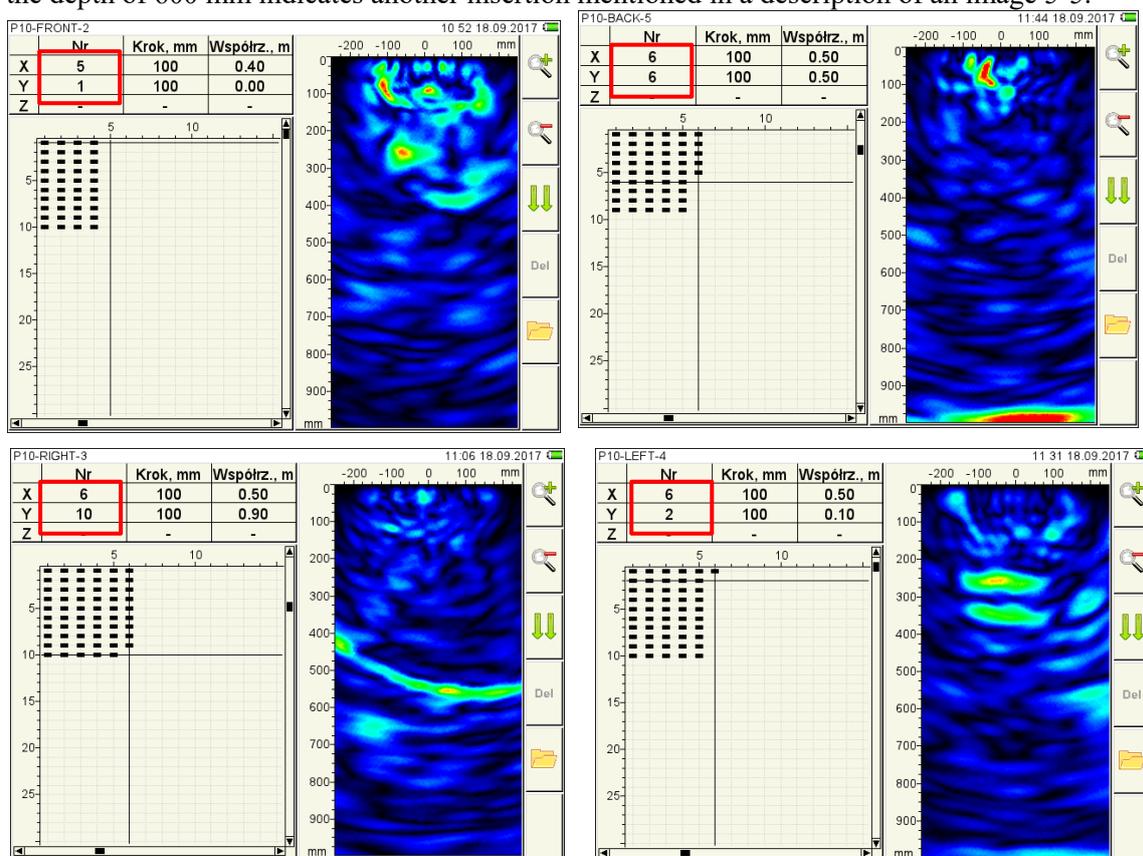


Figure 9. Scanning images obtained from testing a specimen no. 10

To conduct more precise testing, probe was scanned in more four directions, which is a front, back, left and right side of a specimen. On each side Tomograph moved exactly in the same way as in the top side. Every side of a specimen was divided into cells, creating a mesh. Tomograph with every single scan was moved with a distance of a one cell - 100 mm. Obtained results are presented in the Fig. 9. Starting with a front side of a specimen, obtained images did not show any interesting reflections, as in the image 5-1, the only light spots occurs in the top part of a concrete block, which might be the effect of a wrongly compacted concrete mix or air voids.

Obtained images from scanning back side of a specimen also did not bring any satisfying results. Noticeable reflections in the image 6-6 shows only the depth of a probe and a problems at the top of a concrete block mentioned before.

The only image in a place 6-10 obtained in right side scanning shows a long reflection placed in the depth of around 560 mm it might be the prove of existing additional inserts in a specimen, but is impossible to verify the number of them.

The last scanned left side did not bring any new information. In the image 6-2, visible reflections in the depth of 240 mm indicates the inserted pipe, the reflection below is probably the “edge effect”. In all images from scanning left side, there were no strong echoes in the depth of 600 mm. Reflection at this elevation seen on an image below is not strong enough to prove the existence of additional inserts.

4.2.3. Conclusions

The probe number 10 was tested differently. Before scanning, additional information about two inserts were given. During conducting the study, scanning images from top side proved the localization and position of two inserted tubes. There were also extra reflections caused by “edge effect” [4] shown close to the ends of a probe and close to the boundaries of two different material’s density. It is easy to commit a mistake in identifying defects and insertions close to the “edge effect” reflections. Red spots visible in the elevation of 600 mm might be the result of attendance of other extra inserts. However, in testing every side of a probe, only in one scanning image of the right side, reflection was noticed. Conducted testing proves that there is an external obstacle in a concrete block at the depth of 600 mm, but it is impossible to define the number of them. Obtained reflections in that elevation are close to the edge, it may be a confusion. There are also many light spots at the top part of a specimen, it may occurs due to bad compacted concrete mix or due to the appearance of air voids or other defects.

References

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