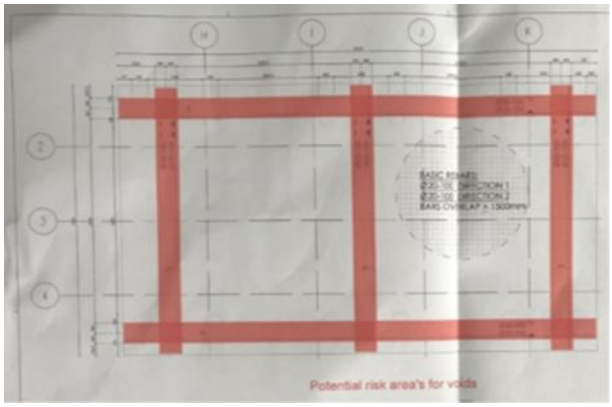
Case 10.4 Honeycombs detected by s´MASH Impulse Response and DOCter Impact-Echo in a heavily reinforced foundation for jet engines test bed

A foundation 13 m x 8 m, 0.9 m thick was constructed at a US military base in Holland for testing of F-35 fighter plane engines.

The slab is heavily reinforced with areas of the slab having extra reinforcement, making the risk of voids, honeycombs, even higher.



The reinforcement of the foundation with a drawing showing areas with extra reinforcement (red markings).

After completion, attachments had to made for the enginees, and during drilling of anchoring holes honeycoms very detected. Consequently, the whole foundation needed to be tested for honeycombs, and injected, before put into service.

A local NDT-testing company was hired to perform the testing. They used the most advanced ultrasound (MIRA) and GPR. After one week of testing they gave up.

Despite resistance from these local NDT-experts, s´MASH Impulse Response and DOCter Impact-Echo was ordered to be used by the US contractor.

The job was to test the homogeneity of the complete slab and locate voids and the extent of the voids. Two NDT methods were selected for testing

1. s´MASH – Impulse Response. Measures the mobility the stiffness and the voids index for anomalies
2. Impact-Echo. Measure thickness of the structure and depth to any anomalies.

A testing grid was defined with a spacing of 0.5 m x 0.5 m for both test systems giving 15 “columns” and 27 “rows” in the grid.

The results from the testing are shown in the following sections as colour plots with an evaluation for each plot. The colour chosen ranges from green (homogeneous) to red (internal anomalies).

NDTitans in action

s´MASH – Impulse Response.

The Average Mobility is a "relative" measurement and the scale is automatically set by the software depending on the data measured. A relative higher value compared with other measurements in an apparently homogeneous area is an indication of a delamination/void etc.

Figure 1 show a colour plot of the data, and the dominant indication of an internal anomaly is in column 1, row 15, where the known voids are located. There are a few "yellow" areas in the plot, which may indicate possible minor internal anomalies/voids.

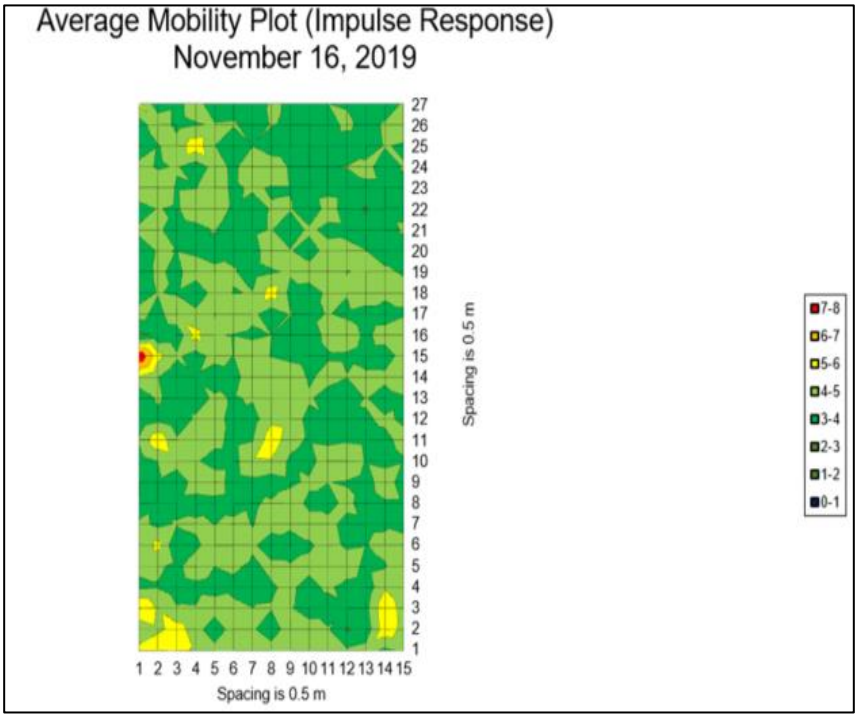


Figure 1. Plot of the Average Mobility. Location of the know void is identified with the Impulse Response, and is seen as the red point in column 1, row 15.

DOCter Impact-Echo

The DOCter Impact-Echo measure the thickness of a structure in one point. If there are any anomalies in the concrete the depth to the defects can be measured as well.

During testing an acceptance criterion for a homogeneous concrete was set up, based on reflections of the generated P-wave from the bottom of the foundation using the equation $f = C_p /2T$.

This was the case throughout the entire foundation.

Fig.2 show a colour plot of the findings. The data shows a more accurate extent of the void detected by Impulse Response, later confirmed by coring.

No other defects were found.

In row 13 several points gave reflections from approximately 500 mm depth. In this specific row additional reinforcement is located so the reflections is due to the reinforcement located in a 250 mm depth (due to the behaviour of reflected P-wave from steel vs. air, equation $f = C_p/4T$). This was confirmed later by coring.

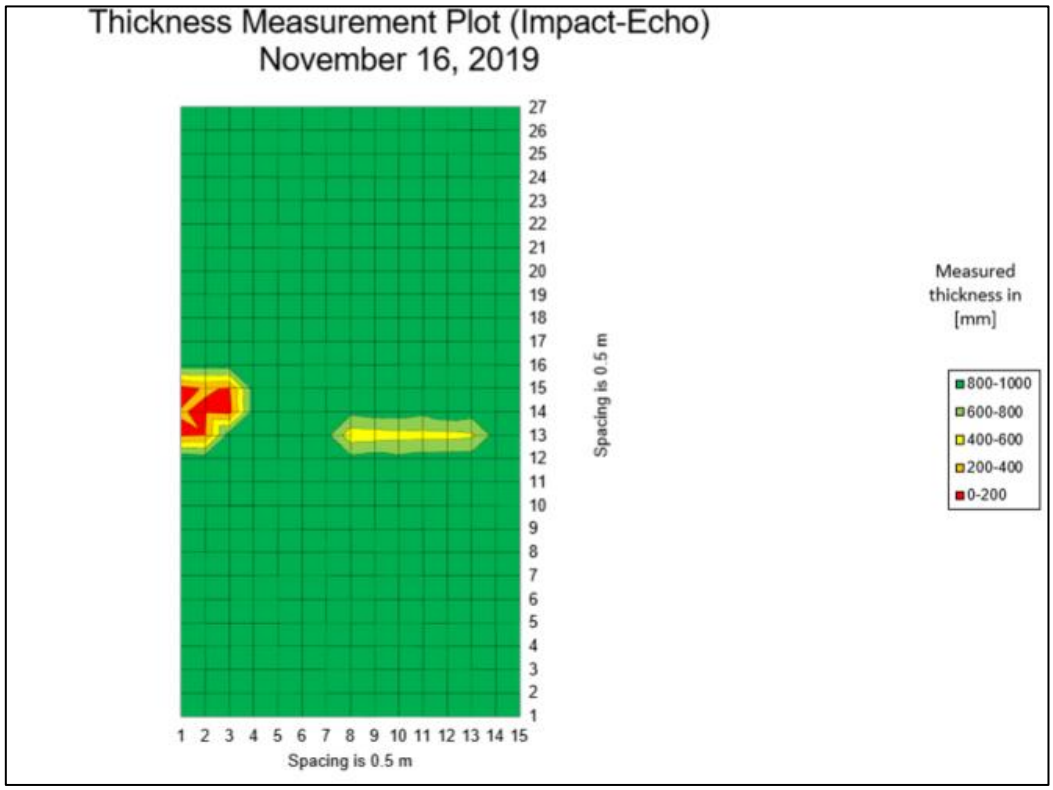


Figure 2. Plot for the Impact-Echo. The extent of the know void is approximately 1 m x 1 m (red area). Yellow markings in row 13 were due to additional reinforcement in the slab.

NDTitans in action

Coring was subsequently made, confirming the findings 100%, also in solid areas.

The testing reported lasted from 8:00-12:00 on a Saturday, and the testing was made by one man, only

The US contractor was very satisfied with the findings.

Testing and reporting by **NDTitan Mr. Jesper S Clausen**