ULTRASONIC IMAGING OF DEFECTS IN CONCRETE COMPONENTS BY PULSE-ECHO-TECHNIQUE

INTRODUCTION

Ultrasonic technique is a well established non-destructive inspection technique which is very successfully applied in mechanical engineering, motoring, aircraft and aerospace and enables imaging typical defects such as delaminations, porosity, inclusions and inhomogenities with high resolution. On the other hand, ultrasonic testing has been seldom used in the building construction.

The high specific non-homogeneity causes a considerable sound attenuation in concrete which means that extremely low test frequencies in the range of 50 to 250 kHz have to be used. The probes needed for this purpose transmitted surface (Rayleigh-) waves in addition to the desired longitudinal waves, which tend to "drown out" echoes from the interior. The pulse echo technique which is used so successfully for metallic and other materials could not be applied to concrete (1).

Efforts to determine the compressive strength of hardened concrete from the longitudinal sound velocity alone, have continued for many years but proved unsuccessful.

Only a few ultrasonic testings were performed with equipments which were inadequately suited to the particular requirements of concrete(2,3).

The aim of many investigations was to determine the strength of the hardened concrete by velocity measurements. But the manufacturing parameters of concrete - such as its compactions, water cement ratio, type and content of ament in the mix and the nature, quantity and grading of the aggregates affect the compressive strength and the velocity in different ways.

This paper describes the investigations in order to applicate echo-technique combined with ultrasonic imaging to concrete. There is only one transducer used being transmitter as well as receiver. Therefore the component under test only has to be handled from one side. These techniques can achieve a breakthrough of ultrasonic testing of concrete.

ULTRASONIC INSPECTION SYSTEM USPC 3041

Different types of ultrasonic pulsers were investigated for sandwich components. Best results delivered the rectangular pulser board ***HILL-SCAN 3100***. In comparison with the normally used broadband spike pulser (useful for high frequency ultrasonic testing of the skin) the frequency spectrum is more concentrated in a smaller range which is adjustable by the pulse width.

Best results delivered the broadband transducer ***NF100/0.1-0.3*** with an aluminium oxide protective layer. A special gel for coupling was used.

The ultrasonic hardware for sandwich components consists of HILL-SCAN 3100, HILL-SCAN 3041 and the ADC-board 20520 built-in an **USPC 3041Portable** The pulser-/receiver-board ***HILL-SCAN 3041*** with is used as an amplifier with band pass filter. The DAC (amplitude distance control) provides a constant sensitivity in a test range up to 50 cm. The application of the echo technique opens the possibility to a powerful ultrasonic imaging of defects in concrete components not only for laboratory use but also for field-inspections.

TYPICAL RESULTS

Fig. 1 presents a Bt-scan of a concrete specimen with a crack in a distance of 6 cm from the surface. The amplitude (bipolar) has been digitised and displayed in grey levels. The DAC makes it possible that the defect echo and the back wall echo (20 cm distance) both have the same amplitude. The distribution of the grey-levels for the Bt-scans can be changed with a computer mouse (real-time contrast enhancement).

The foundation of an underground car park with supposed hollow cavities had to be inspected. Fig. 2 gives a Bt-scan of the foundation. The Bt-scan indicates a hollow-space in a depth of 10 cm.

Fig. 3 presents an A-scan out Fig. 5 which clearly shows the echo coming from the defect. A bore hole taken at this position has given a practical proof of the ultrasonic result.

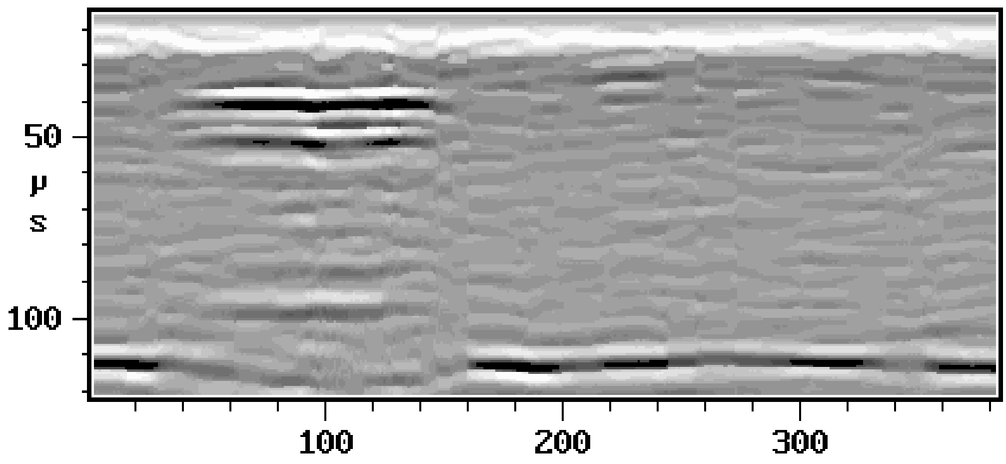

Fig. 1: Bt-scan of concrete specimen with crack

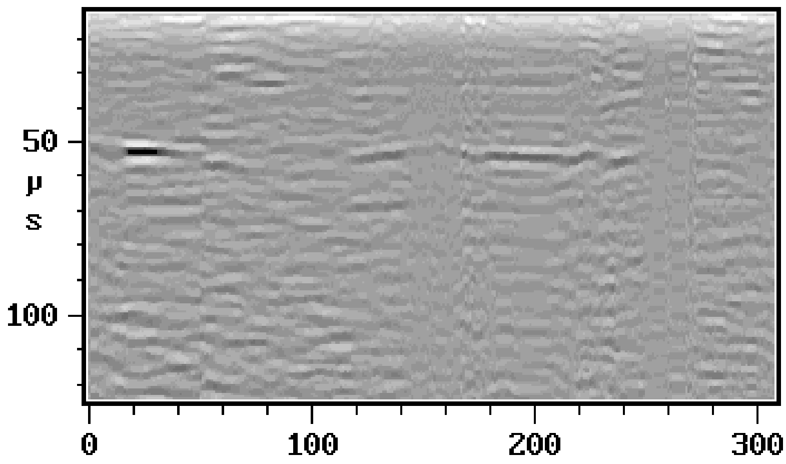

Fig. 2: Bt-scan of a foundation of an underground car parc

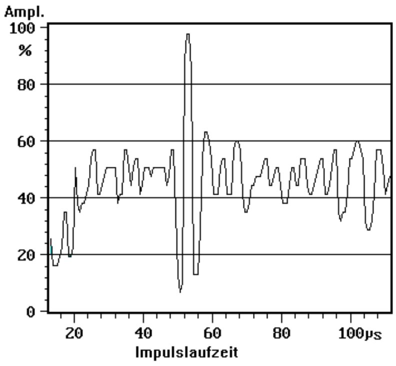

Fig. 3: A-scan showing the echo of the cavity

Fig. 4 presents a C-scan of 20 cm thick concrete specimen with crack. The specimen was scanned by a motor-driven scanning system (Isel). The coupling was carried out with water spit coupling. The c-scan clearly shows the position and the size of the defect.

SUMMARY

In the building industries, ultrasonic testing has been rarely applied. The high specific inhomogeneity requires extremely low frequencies. Also, the echo-technique which provides only an one side access was not practicable for concrete. Therefore, investigations have been done in order to applicate not only the echo-technique but also ultrasonic imaging to concrete structures. A new ultrasonic inspection system NFUS 2300 has been developed for this application. This system provides optimized test-pulse parameters for the inspections. The high sound attenuation is compensated by a distance amplitude control with a 60 dB dynamic range programmable in 512 points with any function. A special broad band transducer with 40 mm crystal diameter has been used for testing. Typical results such as Bt-scans of a specimen with a crack and of a foundation are shown in this article.

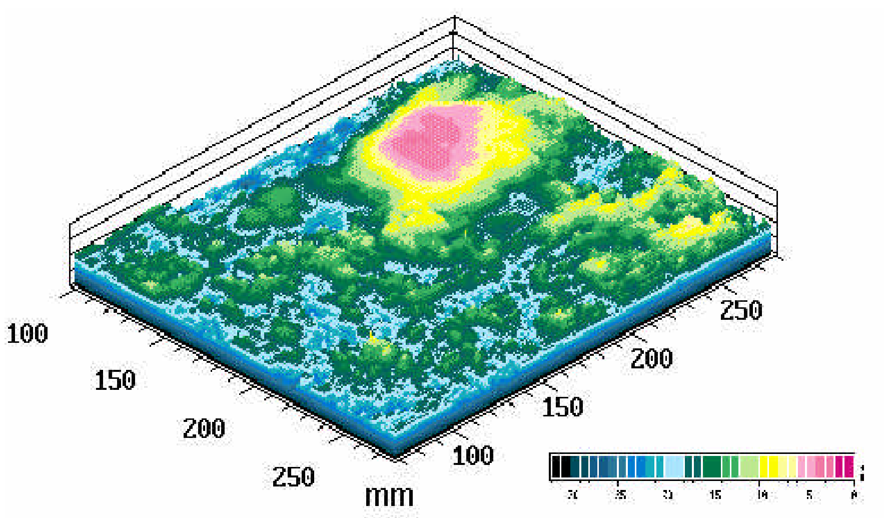

Fig. 4: C-scan of a concrete specimen with crack

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