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Probing of Concrete Specimens using Ground Penetration Radar

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Ground Penetrating Radar (GPR) has been used to image inside concrete specimens embedded with steel bars and delamination. An imaging algorithm has been developed to improve measurement output generated from a commercial radar system. For the experiments, laboratory size concrete specimens are made with the dimensions of 1,000 mm (W) x 1,000 mm (L) x 250 mm (D). The results have shown improved output of the radar measurements compared to commercially available processing methods.

Keywords : *radar, concrete, steel bar, delamination, imaging*

1. Radar measurements of concrete specimens with a steel bar

Concrete targets used for the measurements have the dimensions of 1,000 mm (width) x 1,000 mm (height) x 140 mm (thickness) with different inside configurations. A specimen with a steel reinforcing bar is modeled for a simplified reinforced concrete structure. The radar system used for the measurements has a center frequency of 1 GHz and bandwidth of 1 GHz. Measurement scheme is illustrated in Fig. 1

An imagery obtained by processing raw data from the measurements is shown in Fig. 2. The imagery represents a typical output from a commercially available radar system.[1] Improvement is made by using the measured electromagnetic properties of concrete.[2),3)] Thus, the vertical scale (range direction) in Fig. 2 is exact.

In Fig. 3, the data in Fig. 2 has been processed using a signal processing scheme developed and the mismatch between concrete and the steel bar is now clearly seen.

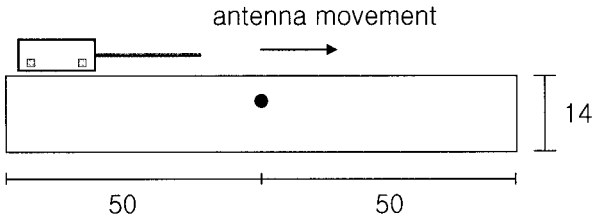

Fig. 1. Dimensions of concrete specimen for the radar measurements in cm. Locating the bar is much easier compared to Fig. 2.

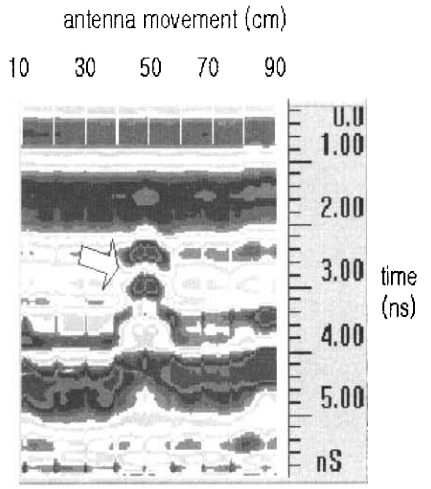

Fig. 2. Display of radar measurement.

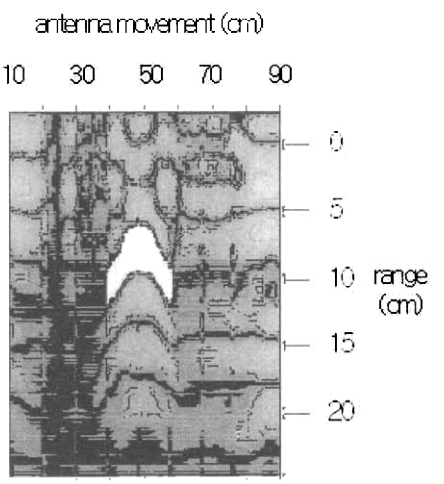

Fig. 3. Radar imaging with improved signal processing scheme.

2. Radar measurements of concrete specimens with two steel bars

Concrete targets used for the measurements have the dimensions of 1,000 mm (width) x 1,000 mm (height) x 140 mm (thickness) with different inside configurations. A specimen with two steel reinforcing bars is modeled for a simplified reinforced concrete structure. The properties of concrete specimens are same as the specimen with a steel reinforcing bar. Inside configuration is illustrated in Fig. 4.

The images obtained by processing raw data from the measurements are shown in Fig. 5. The imagery represents a typical output from a commercially available radar system. Improvement is made by using the measured electromagnetic properties of concrete. In Fig. 6, the data in Fig. 5, have been processed using a signal processing scheme developed and the mismatch between concrete and the steel bars are now clearly seen.[4] Locating the bar is much easier compared to Fig. 5.

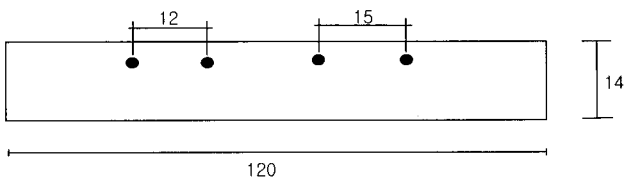

Fig. 4. Dimensions of concrete specimen for the radar measurements in cm.

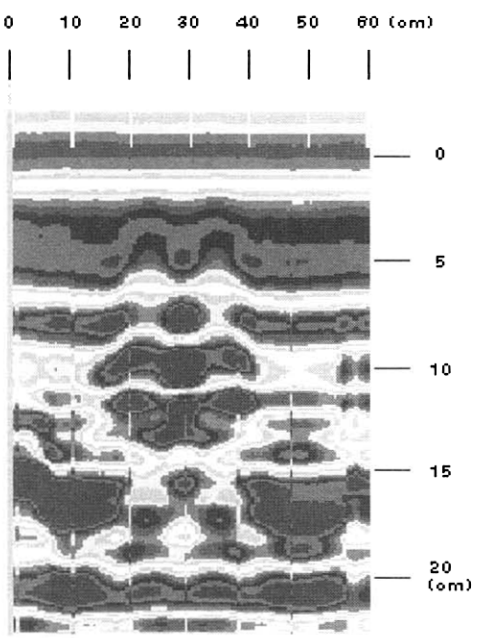

Fig. 5. Display of radar measurement(horizontal spacing is 12 cm).

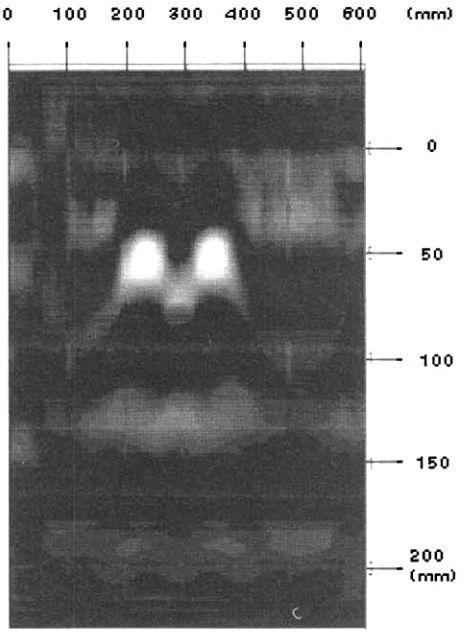

Fig. 6. Radar imaging with improved signal processing scheme (horizontal spacing is 12 cm).

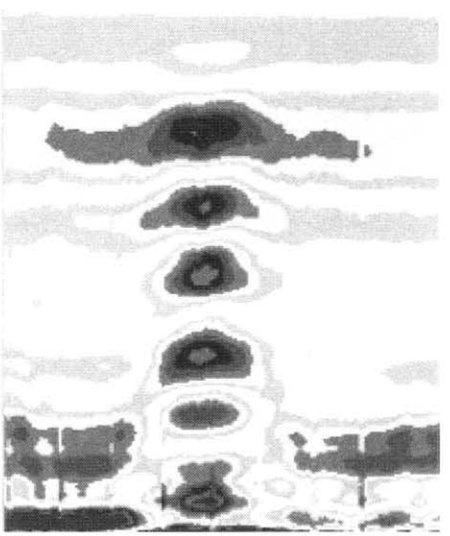

Fig. 7. Output of radar measurements(delamination depth is 25 mm)

3. Radar measurements of concrete specimens with a delamination

In detecting a delamination inside concrete, the factors relating to incident wave, measurement setup, and target are to be considered. The incident wave has a center

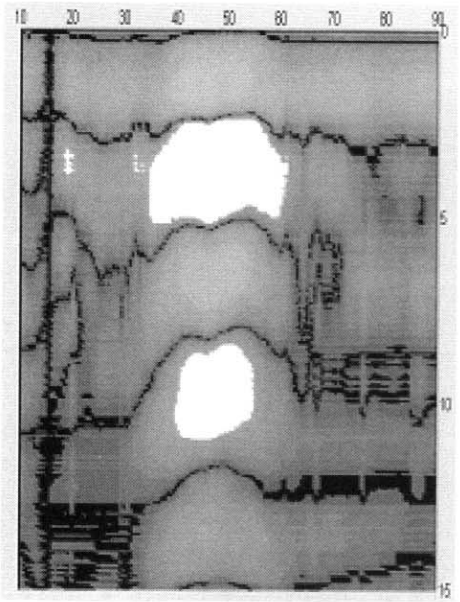

Fig. 8. Radar imaging with improved signal processing scheme (delamination depth is 25 mm).

frequency and frequency bandwidth which determine resolution and penetration capability. In this experiment, the center frequency of the radar wave is 1 GHz and the frequency bandwidth is also 1 GHz.

For the measurement setup, the radar is placed on the top of a concrete specimen. The dimensions of the specimens are 1,000 mm (width) x 1,000 mm (height) x 140 mm (thickness). The size of delamination, which models void is 200 mm (width) x 600 mm (height) x 50 mm (thickness) at 30 mm depth.

An imagery obtained by processing raw data from the measurements is shown in Fig. 7. The imagery represents a typical output from a commercially available radar system. In Fig. 8, the data in Fig. 7 has been processed using a signal processing scheme developed and the mismatch between concrete and the steel void is now clearly seen. Locating the void is much easier compared to Fig. 7.

4. Conclusion

An imaging algorithm has been developed to improve measurement output generated from a commercial radar system. With the improved signal processing scheme, a steel bar and doubly placed steel bars, and a delamination have been identified.

References

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