Microwave Imaging for Corroded Rebars and Delamination in Concrete Structures

M. Dvorsky, S. Barker, M.T. Ghasr and R. Zoughi

INTRODUCTION

Corrosion of embedded steel reinforcement bars (rebars) in concrete leads to concrete cracking and delamination, which in turn leads to increased salt and moisture permeation and further damage. This study aims to evaluate the effectiveness of **microwave imaging** for the characterization of this **corrosion** and **delamination** of **steel rebar** embedded in concrete.

Approach

Concrete blocks with embedded steel rebars were produced and imaged using microwave Synthetic Aperture Radar (SAR) imaging technique. The blocks were then soaked in saltwater and current was passed through the rebars to promote **corrosion**.

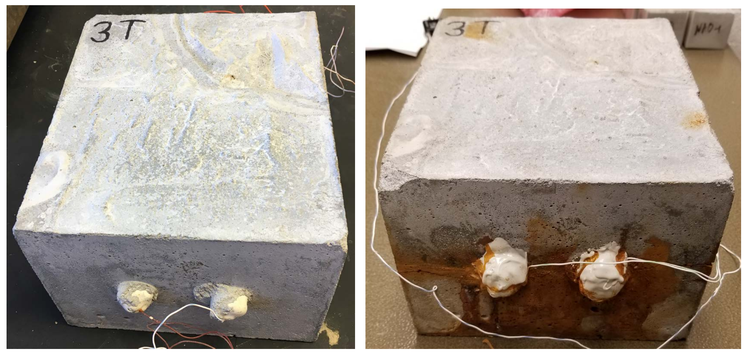


Figure 1: A concrete block before (left) and after (right) being soaked.

The experiment was repeated while varying several parameters to evaluate their effect on the microwave images, including **water to cement ratio** and **concrete cover thickness**.

These blocks were deemed small for some of the lower microwave frequencies, and it was determined that the corrosion process was not uniformly applied to each rebar. So, larger blocks were cast with a newly designed electrical circuit that promotes uniform corrosion on all embedded rebars.

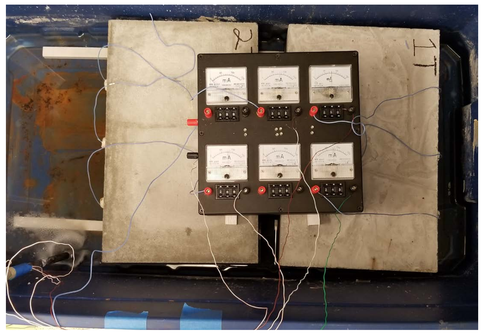


Figure 2: Larger concrete blocks and new electrical circuit to corrode all rebars uniformly.

RESULTS

Microwave images of the rebar embedded concrete blocks were produced. Examples are shown below.

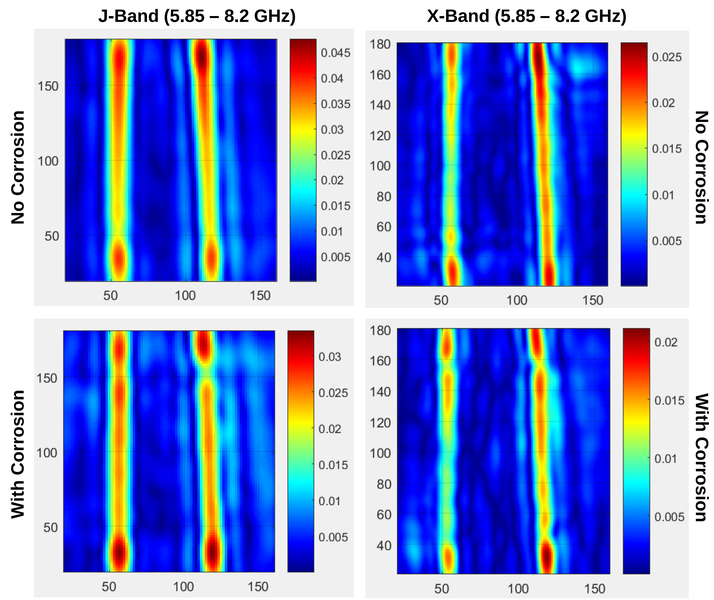


Figure 3: Microwave images of a small block at two frequency bands and under different conditions.

The effect of various parameters on the images can be summarized as follows.

- **Frequency**: Higher frequency gives higher image resolution but decreases penetration into the concrete
- **Corrosion**: More corrosion reduces rebar visibility
- **Water/Cement Ratio**: Less water content reduces rebar visibility

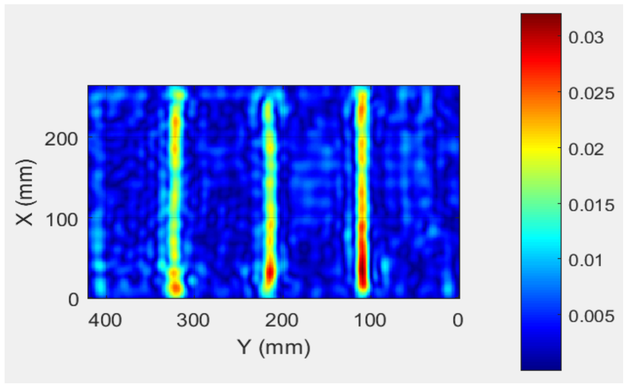


Figure 4: Microwave images of the larger block J-band (5.85-8.2 GHz)and before corrosion.

Pedestrian Bridge

Initiated scanning a pedestrian bridge on campus with potential corroded rebars and delamination. Initial scans showed some potential, but additional imaging works need to be conducted.



Figure 5: Pedestrian bridge with potential corroded rebars and delamination.

Future Works

We will continue cyclically corroding the rebars in the larger block and image from both sides. Destructive testing will be ultimately used to correlate microwave data with actual extent of corrosion.

After significant induced corrosion, and cracking/spalling of the concrete blocks, real potential for delamination detection will be investigated.

The pedestrian bridge will be scanned at several frequency bands and the results will be compared with those using different methods.

CONCLUSIONS

Microwave imaging, based on SAR approach, shows tremendous potential for detecting corroded rebars and delamination. Further testing will indicate optimal measurement parameters, such as frequency.

REFERENCE

Bois, K. J., Benally, A. D., Nowak, P. S., & Zoughi, R. (1998). Cure-state monitoring and water-to-cement ratio determination of fresh Portland cement-based materials using near-field microwave techniques. *IEEE transactions on Instrumentation and Measurement*, 47(3), 628-637.