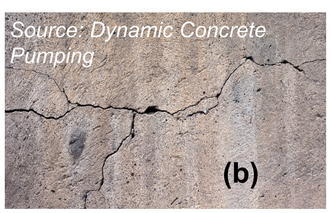
Remote Radar Inspection of Concrete Bridges for Moisture Estimation and Crack Depth Detection

T. Yu, S. Vinayaka, A. Alzeyadi, J. Wang, H. Gandhi, N. Peralta, R. Bates
Department of Civil and Environmental Engineering
University of Massachusetts Lowell

Introduction/Background

Aging and deterioration of concrete bridges is usually associated with either change in materials property (e.g., alkali-aggregate reaction) or change in geometry (e.g., cracking) or the combination of both. This research describes the development of a portable remote sensing radar system based on the principle of synthetic aperture radar (SAR) for characterizing subsurface moisture content and estimating crack depth in concrete structures. Fig. 1 (a) and (b) show real cracks in concrete bridges.

Specimen	Crack dimension		
	Length (cm)	Width (cm)	Depth (cm)
CNI	0	0	0
CNC	10	0.5	0.5
CNCW	10	2	0.5
CNCD	10	0.5	1.5



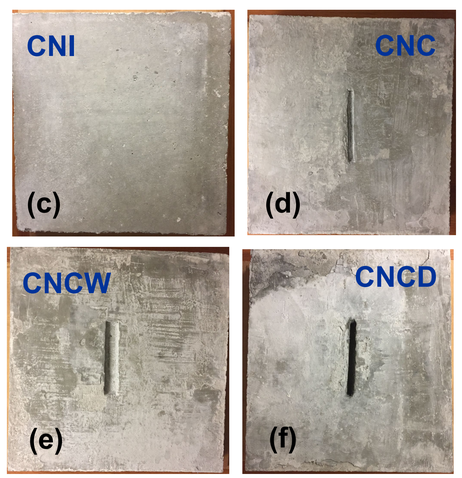


Figure 1. Real and artificial concrete cracks.

Research Approach

1) Understand background (moisture) effect in concrete on SAR images using intact concrete specimen as shown in Fig. 1 (c).
2) Estimate crack depth by SAR images of concrete using artificially cracked concrete specimens as shown in Fig. 1 (d)~(f) inside an anechoic chamber (Fig. 2).

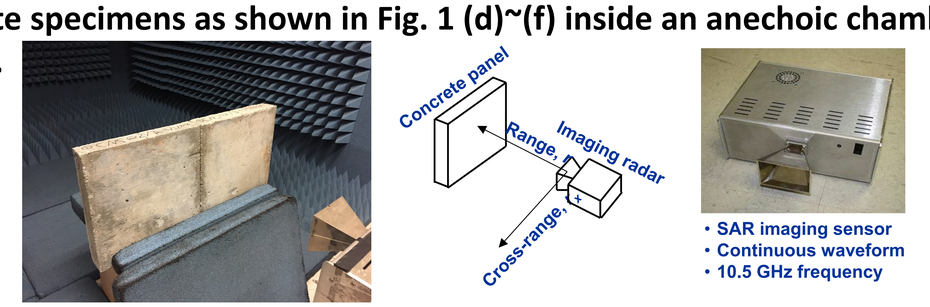


Figure 2. Laboratory SAR imaging facility at UMass Lowell.

Effect of Moisture Content on SAR Images

We have found that the increase of subsurface moisture content in concrete will change both the amplitude and its distribution in SAR images of concrete, with or without a crack. Fig. 3 shows effect of moisture content on SAR images.

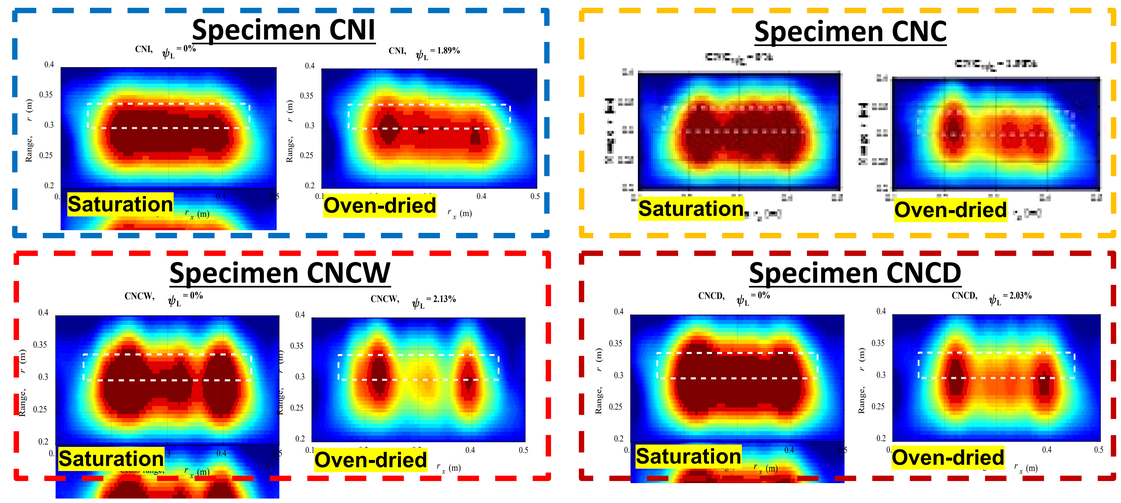
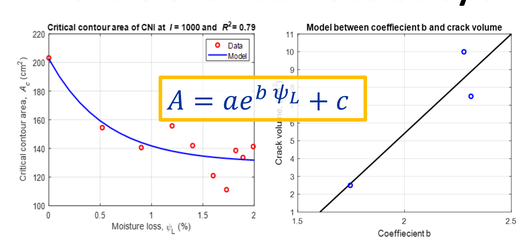


Figure 3. SAR images of saturated and oven-dried concrete specimens.

Estimation of Crack Depth

- We have found that the representative contour area *A* in SAR images of concrete can be modeled by an exponential function with moisture content.



$$A = ae^{b\,\psi_L} + c$$

- Crack volume *V* is related to model parameter *b*.

$$V(b) = 11.16\,b - 16.9$$

- Crack depth d can be estimated from crack length *L* and crack width *W* from *V*.

$$d\,(b, L, W) = \frac{11.16\,b - 16.9}{L\,W}$$

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References

A. Alzeyadi, T. Yu (2020), *J. Appl. Remote Sens.*, 14(2); doi: 10.1117/1.JRS.14 .024520.