

Research at a Glance

Technical Brief

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**BUREAU OF
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Innovative Pothole Repair Materials and Techniques Phase II – Concrete Crack Repair, Ultrasonic Testing, and Automated Repair and Inspection

Research Problem Statement

Extending the life span of concrete bridge decks and pavements can save costs and significantly reduce lane closures and interruptions to traffic. Bridge engineers and contractors design and build bridge decks to last for many years with minimum maintenance. However, cracks in concrete bridge decks can form and as these cracks increase and become wider, further deterioration occurs leading to needed maintenance and repairs. Concrete decks and pavements mainly develop surface cracks due to demanding operational and environmental loads. These defects compromise structural integrity and expose internal elements such as reinforcing bars in reinforced concrete to degrading environments. Timely evaluation and repair of such defects are critical to achieving the intended service life of the infrastructure.

Research Objectives and Methodology

The first objective of this research is to enhance the crack repair process of concrete structural members to extend their service life by focusing on three major components: 1) innovative inorganic formulations that achieve repair compatibility and longevity for macro and micro-cracks, 2) effective placement and injection methods, and 3) quality assurance focusing on repair integrity and durability.

The second objective is to investigate the feasibility of using ultrasonic testing to evaluate concrete crack depth and repair quality. The effects of signal frequency, crack depth, and steel rebar on testing results are investigated based on laboratory specimens and reinforced concrete slabs.

The third objective is to investigate the feasibility and challenges of applying additive manufacturing, particularly 3D printing, to pothole repair in concrete pavements. Along with this objective, a low-cost, vehicle-mountable 3D scanning system is developed for rapid 3D reconstruction and quantification of potholes.

**Research Project
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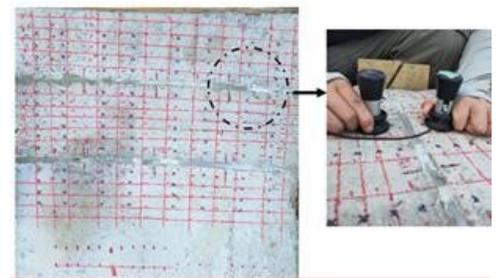
Trenton, NJ

Results

- Workable and flowable crack repair formulations (A, B, and C) for horizontal, vertical, and inclined crack repairs were developed for different crack widths. Formulations A and B filled 1/8 in.-wide cracks at least 1 in. into the crack depth. Pull off tests shows that Formulations A and B had adhesion strength more than the tensile of the parent concrete material.
- All crack injection directions require a very tight injection port to avoid leakage due to high injection pressure, especially when injecting vertical cracks. Vertical injection of 1/8 in.-wide crack was achieved up to 12 in. high with very tight injection ports using Formulations A and B.
- Formulation C was more suitable for coating micro/nano cracks. No shrinkage cracking was observed in the coating observed up to 30 days.
- An ultrasonic testing methodology was developed for concrete slabs that relied on the general pristine behaviour of concrete rather than point specific pristine profiles. Crack depth evaluation was conducted by comparing time of arrival. The signals from the cracked state were used as the reference and the shifts in time of arrival towards the pristine trend, along with amplitude gain relative to the cracked state, were used to assess repair quality.
- By integrating high-resolution laser scanning with 3D printing, customized patch geometries were successfully generated from artificial pothole models, yet its applicability in real-world practice requires careful evaluation.
- A low-cost 3D image scanning system prototype was developed for pavement pothole inspection and validated through benchmarking against a high-precision laser scanner for geometric accuracy.



Workability and flowability of crack repair material



Ultrasonic testing of crack repair quality on concrete slab