SOUTHERN PLAINS TRANSPORTATION CENTER

# HIGHLIGHTER

## MONITORING EXTREME LOADING AND CLIMATE IMPACT ON INFRASTRUCTURE

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**PROJECT TITLE**
MONITORING EXTREME LOADING AND CLIMATE IMPACT ON INFRASTRUCTURE


**FINAL REPORT**
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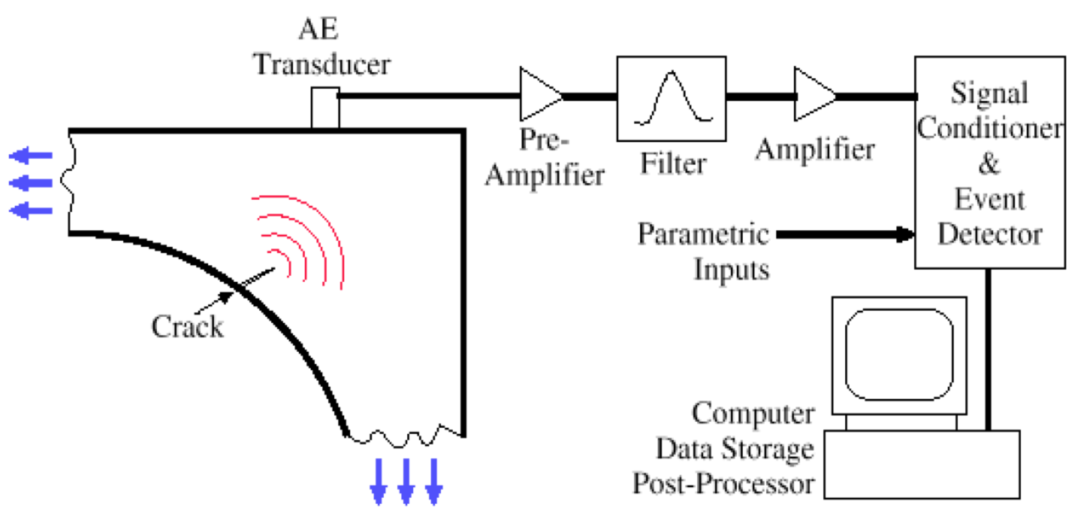
**OVERVIEW** From construction until the end of service life, all infrastructure must endure the aging effects of weathering and loading. In the case of concrete structures, extreme temperature changes and overloading are known to cause micro-damage, which reduce the material's capability to withstand design loads. Material degradation mechanisms are difficult to detect and assess as they initiate and cumulate. Typical condition assessment campaigns involve mobilizing personnel to conduct cumbersome, lengthy visual inspections and take multiple samples (e.g. cores) in areas manifesting problems, which offer limited information about the overall condition of the structure. These current methods are costly, destructive and inefficient. Moreover, when visual signs of material degradation start manifesting, the problem is often widespread and costly rehabilitation measures are necessary to maintain serviceability. Therefore, this project investigates and provides guidance for the use of advanced monitoring tools that can assess the overall condition of a structure rapidly and continuously without compromising the integrity of the structure.

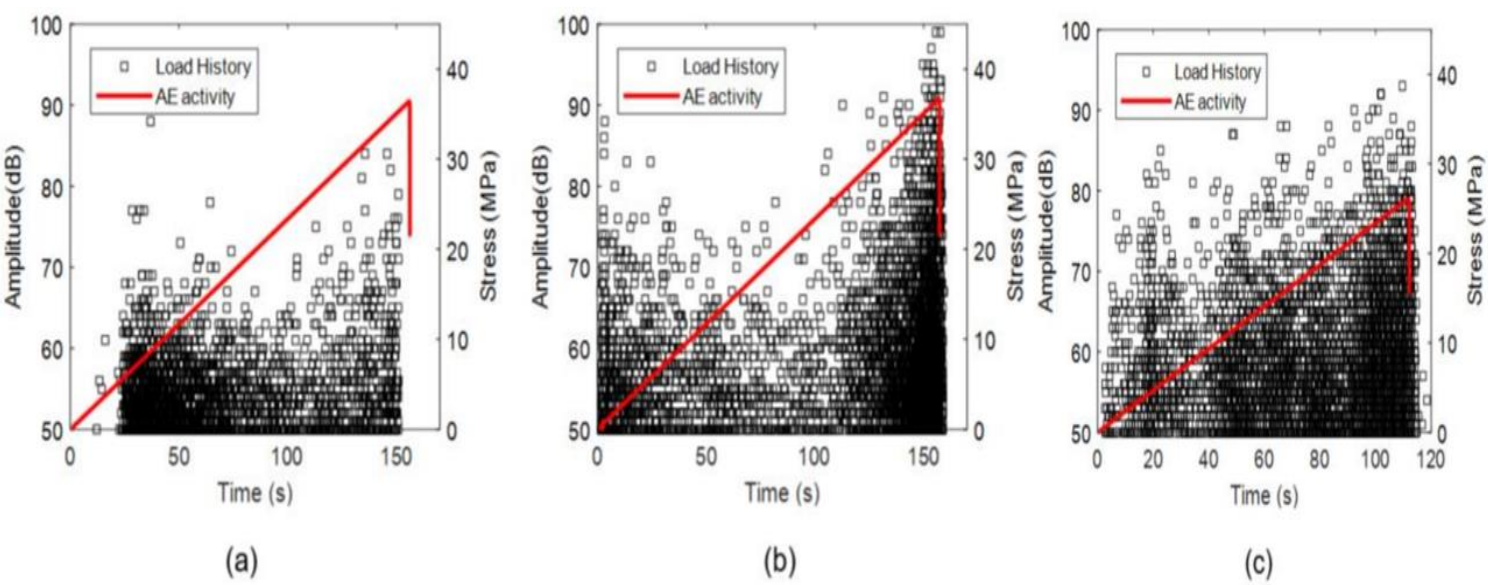
**RESULTS** This project develops evaluation and monitoring guidelines using ultrasonic evaluation and acoustic emission (AE) monitoring (schematic shown in the Figure, Huang 1998) as the primary sensing technologies to assess the impact of weather and overloading on infrastructure thus maintaining transportation infrastructure in a "state of good repair".




Nondestructive ultrasonic and AE evaluation techniques have been used worldwide to assess in-service infrastructure related problems. Numerous studies have demonstrated the applicability and versatility of the techniques to assess and to monitor damage initiation and evaluate its progression for various deterioration processes. The data gathered from such monitoring technologies can be transmitted via wireless networks and provide asset managers real-time information about the material's and structure's performance. No personnel mobilization nor traffic disruption are required. In addition, if a serviceability problem arise, correct actions may be taken immediately and target the affected area only (not the whole structure). The implementation of such technologies requires specialized skillsets but once in place, are easy to operate and maintain by stakeholders.

This study improves understanding of concrete degradation processes specific to Oklahoma weather conditions and how they may be assessed in service as well as identifies new evaluation tools and improves current guidelines for early onset detection, damage assessment and damage evolution caused by various climatic conditions. It develops climatological profiles for critical freight transportation regions in Oklahoma and reproduces the exposure parameters in a laboratory environment. Additionally, it qualifies and quantifies damage accumulation of a concrete material as sustained under the developed weathering and loading conditions relevant to Oklahoma. It also evaluates its residual performance using primarily acoustic emission and ultrasonic methods.

Actual Oklahoma climate conditions are evaluated instead of using national standard conditions, which may not be relevant to local settings nor realistic of field encountered deterioration mechanisms. Cyclic high temperature exposure, cyclic freezing and thawing exposure and cyclic wetting and drying exposure are considered (examples shown in the graphs below).




**Acoustic emission activity and stress history with time for cylindrical specimens under H-T exposure regimen: (a) after 30-cycle; (b) after 60-cycle; (c) after 90-cycle**

A total of five different test methods are compared to determine the efficacy and sensitivity of the techniques to determine damage initiation and its extent. Two destructive tests, compression and flexural testing, are compared with two nondestructive methods, ultrasonic pulse velocity and resonant frequency. It was found that resonant frequency testing might be more sensitive to changes in microstructure caused by microcrack formation while flexural testing was the least effective. Still, all methods discerned (with varying sensitivity) a change in properties after 30 cycles of freeze-thaw exposure, 90 cycles of high temperature variance and 90 cycles of wet-dry exposures. Acoustic emission monitoring was performed during mechanical loading. A simple AE parameter-based evaluation confirmed results from the destructive and nondestructive study. Therefore, the method was determined to be effective in discerning changes in material integrity if the member evaluated is subjected to varying levels of stress.

**POTENTIAL BENEFITS** The proposed tools and evaluation methodology for ultrasonic evaluation and acoustic emission monitoring can yield critical information to transportation officials that will facilitate early detection and correction of issues with the goal of infrastructure preservation. Implementation will result in improved public safety and reduced maintenance costs.