Abstract

Over the past few decades civil infrastructure have been deteriorating significantly and in a lot of cases, being a threat to everyday life. The damages can be severe and costly; maybe even irreparable by the time they are detected without intelligent diagnostics. The Gordon-CenSSIS center at Northeastern University and University of Puerto Rico are working on the Versatile Onboard Traffic Embedded Roaming Sensors (VOTERS) project which will allow for an intelligent and integrated method to detect these faults ahead in time to save lives, not to mention costs. In this presentation a couple of case studies will be done where bridge decks are simulated and analyzed using a two dimensional Finite Difference Time Domain code. The electromagnetic scattering resulting from different scenarios will be important because it gives an intuition which will be a key step in accomplishing the goal. The various electromagnetic interactions between bridge components hold information on defects. Finally potential methods of accurately identifying defects will be discussed.

Background of Intelligent Diagnostics

The original goal of nondestructive testing and nondestructive evaluations was to create a reliable and cost effective method of evaluating structural components, which would not affect their future usefulness. Many methods have since been developed, including visual and optical testing, radiography, magnetic particle testing, ultrasonic testing, electromagnetic testing, and acoustic emission testing. Two major difficulties with the majority of these techniques are that some depend on the qualitative opinion of the inspector and that most are only applicable for near surface inspections. The case studies presented, require a reliable source of subsurface sensing. In addition, the removal of the human element is pivotal to increasing the value of these inspections. This would create a uniformity that is currently lacking. This leads to the development and necessity of intelligent diagnostics, which use internal software to evaluate the structure quantitatively. Additionally developments are needed which can yield reliable results at a lower penetration.

Potential ID Technologies

Case 1 – Expansion Joint Failure and Hairline Cracks

- **Goal**: Localize small air pockets
- **Potential Difficulty**: Air pockets are very small in comparison to components of surrounding media. Current methods of GPR would disregard them as probable variations for the given operating conditions.
- **Technology**: Coming up with a way for the GPR system to read time domain characteristics resulting from an impulse response generated by the infrastructure.

Case 2 – Internal Concrete Cracks and Air Voids

- **Goal**: Localize larger air pockets
- **Difficulty**: Easy to locate using 3D GPR, but yields an unmanageable amount of data
- **Potential Technology**: Create a comparable system that would rid excess data without loss of information

Socio-Economic Impacts

Failing infrastructure imparts enormous negative impacts on society. For example, failure of the Point Pleasant, West Virginia bridge in 1967 caused significant losses of life and property (Irizarry and Stuer, 2009). Although national standards for bridge inspection were developed thereafter, infrastructure failures still occurs and a need exists to develop reliable diagnostic methods. Intelligent Diagnostic (ID) technologies, such as those presented in this work, show a large potential to improve diagnostic reliability and prevent future failures. Their applicability to a wide variety of structures can reduce costs and enhance social benefits.

Ground Penetrating Radar (GPR) Simulations

Illumination of a bridge deck using a narrow-width Gaussian pulse. These contour plots depict the scattering and interactions between various bridge deck components.

Conclusions

Intelligent diagnostics are the next step forward in nondestructive testing. Intelligent diagnostics have made huge advancements in the medical industry, and as infrastructure continues to age, the necessity for a quantitative evaluation system is increasing. Such developments will make a huge social and economic impact in that they will decrease the probability of failure and decrease the current costs of inspection methods. The GPR data that was analyzed demonstrates the applicability and feasibility of such technology.