Investigating Thermal Imaging Technologies and Unmanned Aerial Vehicles to Improve Bridge Inspections

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INTRODUCTION

Bridge inspection is central to any transportation facilities maintenance program. One area of concern is concrete delamination along the underside of bridge decks, especially on overpass bridges and bridges that see vehicular, pedestrian, or boat traffic underneath. Thermal imaging and unmanned aerial vehicles (UAVs) are two innovative technologies that can be utilized to help improve delamination detection and overall efficiency.

The overall research objective is to develop UAV-based inspection and analysis protocols using infrared thermal imaging to determine the existence and extent of concrete delamination, with emphasis on the underside of bridge decks.

METHODOLOGY

The research focused on thermal imaging for concrete delamination detection with the use of drones as a method for data collection. The research included field testing of handheld and drone-mounted thermal cameras to determine effectiveness for delamination detection at five bridges in Massachusetts and Rhode Island. Varying approaches for data collection and analysis were utilized at each bridge. The delaminations identified using thermal imagery were compared to those identified through traditional manual soundings. The field testing and results (including accuracy of detection and weather conditions) were the basis of developing guidelines and protocols for the implementation of these technologies.

CONCLUSIONS

The research team verified that thermal imaging could detect varying degrees of concrete delamination under the right conditions. Guidelines and protocols for both thermal imaging and UAVs were developed to assist state transportation agencies in efficiently implementing these technologies. While these technologies offer benefits for efficiency and safety, they also have their own limitations and should not be considered a latch key solution to be implemented at every bridges, but rather as another tool for bridge inspectors.

Based on the field testing performed as part of this research project, a minimum of 10° F (for handheld) or 15° F (for drone-mounted) temperature swings over a 6-hour period is recommended. Even under ideal conditions, it is possible that not all existing delaminations will be detected by thermal imaging.

Experience in interpreting thermal imagery is necessary to accurately identify delaminations. Temperature differentials in thermal imagery caused by delaminations do not always line up with limits as determined by manual sounding. In some cases, the areas shown by the thermal image are smaller than that identified by manual sounding. Additionally, temperature variations can be caused by a variety of factors that can lead to false positive identification. For this reason, cross checks with visual imagery should be performed whenever possible to reduce the probability of false positives for defects.

RECOMMENDATIONS

There are several steps necessary for implementation of these technologies which include:

- Developing guidance documents to identify optimal scenarios for implementation for in-house inspection staff and consultants
- Develop drone pre-qualification or certification programs for consultants to ensure safe operation of drones
- Conduct trainings on thermal imaging and drone technologies for in-house staff
- Perform thermal imaging pilot projects to refine the included protocols and improve recommendations, specifically related to weather and temperature conditions
- Consider funding research for 3D photogrammetric modeling and machine learning for defect analysis to continue building on these innovative technologies.
- Continue to monitor new technologies and research projects for new applications

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