INDOT Research

TECHNICAL *Summary*

Technology Transfer and Project Implementation Information

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Implementation of Steel Bridge Protection Policy

Introduction

To prevent deterioration of a bridge condition leading to structural deficiency through corrosive actions, choosing and applying a suitable coating system on the steel bridge surfaces are very important. Moreover, it can further protect the painted bridges to use explicit contract wording to warrant the quality of bridge painting work after the substantial completion of the painting project. This study is intended to further develop warranty clauses and computerized image processing system previously used on an INDOT steel bridge painting demonstration project.

The study found eleven elements essential for the successful warranty contract application. They are: warranty period, defects definition, inspection schedule, repair procedure and progress schedule for correction work, season of work, liability insurance, traffic control, supplementary performance bond, supplementary lien bond, surety company, and work permit.

Conventional visual inspection method does not provide accurate data for the steel bridge painting quality assessment. Various disputes may arise between INDOT inspectors and bridge-coating contractors over the reliability and objectivity of the inspection. Thus, digital image processing methods are developed to provide a more reliable and objective approach for painting quality assessment. In this report, various digital image processing methods are studied and they are compared with each other in terms of different environmental situations.

Findings

Researchers performed an extensive study through literature review and collected warranty clauses from other states that established and applied bridge painting warranty clauses. In the study, eleven elements were found in forming a successful warranty contract for the INDOT steel bridge painting projects. The eleven elements are:

- Warranty period
- Defects definition,
- Inspection schedule
- Repair procedure and progress schedule for correction work
- Season of work
- Liability insurance
- Traffic control
- Supplementary performance bond
- Supplementary lien bond
- Surety company
- Work permit

Furthermore, a 5-year warranty period, 50% bond value requirement and the developed digital image recognition method for objective rust identification are found as the most comparatively appropriate measures to better assure INDOT steel bridge painting quality when the warranty clauses are put into a large-scale implementation.

For objective and consistent defect recognition, NFRA (Neuro-Fuzzy Recognition Approach) system was developed in this study. NFRA utilizes image processing, fuzzy set and neural networks as tools for visual image capture, recognition, analyses, and defect determination. Therefore, it provides a more reliable and unbiased approach for paint condition assessment.

Fuzzy set theory and neural networks are incorporated into the developed system to simulate the inspector's eyeball judgment and automate the process for determining the rust percentages on the steel bridge. Moreover, they provide better handling of low-quality images through their fault-tolerant characteristics. To facilitate the practical application of NFRA, three other methods were further studied. They are: ISKA (Illumination-based Segmentation and K-means Algorithm), KMNS (K-means Algorithm), and SKMN (Simplified K-means Algorithm). The study found that SKMN method demonstrated comparatively better performance than the others under different conditions in terms of brightness, angle, distance, and cleanness. SKMN method divides the object area and background area from the captured image and uses the K-means algorithm for defect recognition. Thus, SKMN method is recommended for future large-scale implementations.

Implementation

(1) After consulting with many INDOT bridge inspectors, bridge painting contractors and surety companies regarding the use of the proposed warranty clauses, it is recommended that the proposed painting warranty clauses be implemented in a large-scale basis to INDOT steel bridge painting contracts.

(2) To fully make use of the advantages of warranty contracts, a follow-up study should be preceded in the future to continuously evaluate the large-scale implementation. The most contentious issues in warranty practice are to determine warranty period and warranty value. The use of warranty period ranges from 2 years to full service life and warranty value varies from 20% to 100% of total contract amount among many DOTs. To optimize the balance between warranty period and warranty value will be the focus of this task. Optimal warranty period and value will minimize the unnecessary cost and use of warranty clauses will enhance the accountability of painting contractors in the long run.

(3) The developed SKMN method uses digital image processing techniques to enhance the objectivity and consistency of the steel bridge painting quality assessment. An associated random sampling plan is also suggested in this report for the large-scale implementation. Since taking paint images from an entire bridge is nearly impossible, the proposed sampling plan will complement the effective use of SKMN. The combination of a random sampling plan, an image acquisition, and an image processing method for rust percentage determination lays a solid foundation for the large-scale implementation of SKMN method in the future to assure INDOT steel bridge painting quality.

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