



The benefit/cost analysis
was performed in 2003



JTRP / INDOT RESEARCH PROGRAM

Research Pays Off

Implementation of Steel Bridge Protection Policy— SPR 2038

Many State Department of Transportation (DOTs) have made efforts to manage their civil infrastructure systems effectively and meet public demands for their performance and safety. The introduction of warranties helps each DOT keep its civil products healthy by shifting post-construction performance to contractors. To prevent deterioration of a bridge condition leading to structural deficiency through corrosive action, choosing and applying a suitable coating system on the steel bridge surface is important. This research focuses on applying warranties to steel bridge painting items.

The study found there are eleven elements that make up the warranty clause: defect definition, inspection schedule, repair procedure and progress schedule for correction work, season of work, liability insurance, traffic control, reward program, supplementary performance bond, supplementary lien bond, surety company, and work

permit.

Various conflicts can arise between INDOT and bridge-coating contractors regarding the accuracy and objectivity of the inspection. A Neuro-Fuzzy Recognition Approach (NFRA) for the nondestructive quality assessment of steel bridge coatings has been developed to enhance the warranty implementation practices in this study. It 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 assist the inspector's judgment and automate the process for determining the rust percentages on a steel bridge. Moreover, they provide better handling of low-quality images through their fault-tolerant characteristics.

Research Findings and Implementation

The study conducted a literature review and collected warranty clauses from other states that have used bridge painting warranty clauses. Furthermore, a 5-year warranty period, 50% bond value requirement and the developed NFRA system for objective defect identification were found to be the most effective measures to insure INDOT steel bridge painting quality.

For objective and consistent defect recognition, the NFRA system was developed in this study. The NFRA system segments a grayscale image of painted areas which are passed to a pre-trained neural network for generation of corresponding threshold values. A fuzzy adjustment system is utilized to smooth and adjust the gray levels of the image pixels along the boundaries between different areas. Finally, the image thresholding is applied to get a binary image consisting of the object pixels and the background ones. The rust percentage can be calculated quantitatively from the obtained binary image in real-time.

The study recommends that the proposed painting warranty clauses be im-

plemented on a large scale basis to INDOT steel bridge painting contracts. An appropriate random sampling plan for NFRA use is also suggested in the study for large-scale implementation. This combination of random sampling, image acquisition and processing, and real-time rust defect calculation establishes a whole system of the NFRA implementation.

Potential Benefits

The existing Zinc/Vinyl painting system has an average life of 15 years and a cost of \$2.5 per square foot. While, the proposed 3-coat paint system has a life of 25 years and an average cost of \$2.8 per square foot. A per square foot net present value analysis over 75 years of life at 5% discount rate determined \$0.82/sq. ft savings in the discounted cost by using the proposed

system. It is estimated that INDOT bridge painting tonnage per year is 6,750 tons. An average factor of 115 was used to convert tonnage to square feet. Hence, an estimated annual savings of \$638,115 were assessed using this system.

**Cost of
Research
\$101,468**

Estimated Annual Economic Value at 5% Discount Rate

Costing Method	Discounted Paint Cost (\$/sq.ft) [1]	Estimated Yearly Paint Work (Sq.ft) [2](6750*115)	Discounted Annual Savings [3] = [1 _a x 2] - [1 _b x 2]	Benefit/Cost Ratio [4] = [3] / \$101,468
Current	\$7.73 ^a	776,250	\$1,653,413	16.29
Proposed	\$5.60 ^b			

Assumptions

- That the total tonnage of INDOT bridges painted per year is 6,750 tons, obtained from INDOT Operations Support.
- A 75 economic life for a bridge.
- A 3% inflation is used.

References

- Chang, L. M. and Gregory, M. E., "Steel Bridge Protection Policy," Joint Transportation Research Project FHWA/IN/ JTRP-98/21 Volume V of V, Final Report, May 1999
- Chang, L. M. and Lee, S., Chen, P., "Implementation of Steel Bridge Protection Policy," Joint Transportation Research Project FHWA/IN/ JTRP-2001/29 Draft Final Report, January 2002