Joint Transportation Research Program

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Risk-Based Bridge Inspection Practices

Introduction

The frequency and methods used to inspect highway bridges in the United States are mandated by the National Bridge Inspection Standards (23 C.F.R. § 650.301–650.317, 2004). Currently, most bridges in the United States are inspected at a fixed calendar interval of 24 months, without regard to the condition of the bridge. Newer bridges with little or no damage are inspected with the same frequency as older, more deteriorated bridges, thus creating inefficiency in the allocation of inspection resources. Because inspection resources can be considered fixed and finite, it is not possible to spend the necessary time examining bridges that are in poor condition and require extra attention without taking resources away from another bridge or area of inspection. In addition, bridges with characteristics that are known to perform poorly are treated identically to bridges with characteristics that are known to perform well. A rational risk-based method that takes into account design, material, and condition characteristics and the operational environment of the bridge would better match inspection requirements to inspection needs. Therefore, the goals of this project were to develop and evaluate a risk-based methodology in Indiana for future implementation that improves bridge safety, reliability, and optimizes the use of bridge inspection resources.

Findings

The proposed methodology was based upon the risk-based methodology presented in NCHRP 12-82 and evaluated in Oregon and Texas. The Indiana Department of Transportation's Risk Assessment Panel, developed during this research, incorporated reliability theory and expert elicitation to rationally determine bridge inspection needs. The panel consisted of INDOT officials, academic experts, and consultants. Assessments were made based on the likelihood and consequence of failure for specific bridge components. The likelihood of failure was determined through attributes based on design, loading, and condition characteristics while the consequence of failure was based on expected structural capacity, public safety, and serviceability. By combining the expressions of likelihood and consequence for each component, an optimum inspection interval for the entire bridge could be determined through the use of risk matrices. Inspection intervals may be longer or shorter than those specified by the current regulations.

Risk matrix for Indiana back-casting

Occurrence Factor	Low	Moderate	High	Severe
High	48 months	24 months	24 months	12 months
Moderate	48 months	48 months	24 months	24 months
Low	72 months	72 months	48 months	24 months
Remote	96 months	72 months	48 months	48 months

Consequence Factor

The methodology was evaluated through case studies involving 36 Indiana bridges. Over 30 years of historical inspection reports were utilized in the back-casting process to evaluate deterioration levels and assess the adequacy of the risk criteria. Back-casting involved monitoring deterioration progression through historical data, and then comparing the results with the risk-based approach. There were no cases where a serious progression of damage would have been missed as a result of the proposed methodology. Results of the case studies conducted during the research indicated that the risk analysis procedures provided suitable inspection intervals ranging from 24 to 72 months for Indiana bridges.

Families of bridges were created to recognize the similarity of design, condition, and loading attributes in the risk process. Bridges in a family have similar damage modes and are expected to deteriorate in the same fashion at nearly the same rate. Proposed families for the Indiana state-owned bridge inventory include the High Rated family, the Low Rated Family, the Fatigue Susceptible family, the SR 25 families, and the I-69 families. An evaluation of 36 bridges in the Indiana inventory was conducted, and 21 of those 36 bridges (60%) had extended inspection intervals at some point during the lifetime of the bridge.

An implementation strategy to provide a technical foundation for the methodology and develop community support was proposed to ease the transition period. The implementation of the risk-based inspection procedures may be a challenge in the short-term, but has outweighing payoffs in terms of increased safety, increased reliability, and increased efficiency of inspections in the long term. Challenges that exist are political, organizational, and developmental in nature.

Conclusions

Bridge inspection intervals of 48 and 72 months are suitable for typical highway bridges in Indiana. Had longer intervals been implemented in the past (i.e., using the back-casting process), it would not have adversely affected safety and serviceability. The same results were found in the parallel work of NCHRP 12-82, which looked at bridge inventories in Oregon and Texas. Further, “problem” bridges in need of shorter intervals were also properly identified.

Indiana can immediately benefit from the implementation of risk-based inspection practices. Based upon families of bridges, 20% of the Indiana inventory could have extended intervals of either 48 or 72 months. Hence, these bridges could be safely moved to a 48-month inspection interval with no adverse effect on safety. The FHWA permits a 48-month policy. Of the 36 bridges analyzed during the back-casting process, it was found that, for 21 bridges, extended intervals were possible, which is approximately 60% of the 36 analyzed. This suggests that, for bridges not falling into a family, extended risk-based intervals are also possible without compromising safety.

The proposed risk-based methodology could transform traditional calendar-based approaches and optimize the use of bridge inspection resources, as well as improving reliability and safety of highway bridges in Indiana.

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