Ohio Department of Transportation ORIL Research Project Fact Sheet

Development of Deterioration Curves for Ohio Bridges

Researcher(s)	Yoojung Yoon; Faysal Ahamed; Jai Lee; Travis Butz; Olya Watts.
Agency	West Virginia University Burgess and Niple, Inc.
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The Problem

Ohio faces a significant infrastructural challenge, managing the nation's second-largest inventory of bridges while striving for optimal bridge management strategies. The 2021 American Society of Civil Engineers (ASCE) report revealed mixed conditions of these bridge structures: 58% are in good condition, 36% are satisfactory or fair, and 6% are deemed structurally deficient. Despite a commendable 6% rate of structurally deficient bridges (below the national average of 7.5%), the 2020 ODOT bridge inventory identified 2,843 bridges as structurally deficient. Ohio possesses a rigorous annual inspection policy surpassing the Federal Highway Administration's biennial standard. Despite having a robust inspection and valuable historical data, a gap exists in understanding the deterioration processes specific to different bridge superstructure design types and how these processes impact overall bridge conditions over time within Ohio's unique context. This knowledge gap hinders the selection of optimal designs for new constructions and prioritizing maintenance across various bridge superstructure types. Therefore, such knowledge is crucial for developing targeted maintenance strategies and selecting appropriate superstructure designs for future constructions, ensuring the safety and longevity of Ohio's bridge infrastructure. This research was imperative to address these challenges, aiming to enhance Ohio's bridge management system by providing detailed insights into the deterioration patterns of bridge superstructures, considering primary superstructure design and material types. Therefore, this research aimed to develop deterioration curves for superstructures using the historical condition data from the National Bridge Inventory (NBI) for the common superstructure design types in Ohio.

Research Approach

The research methodology includes the following steps:

- **Data collection and processing:** The data processing step of this research was crucial for analyzing Ohio's historical bridge inventory, dating back to the mid-1980s, with a focus on accuracy and reliability. The process involved thorough cleaning and filtering of the data to remove unreliable data points, including those with inconsistent or missing condition ratings, incorrect entries, ratings below 3, and data affected by missing information on bridge reconstructions. Resetting bridge ages was a key approach to account for the development of 'pure' deterioration curves by removing the effectiveness of treatment activities. Additionally, a rigorous filtering process eliminated about 15% of outliers, particularly those data points showing extended periods of unchanged condition ratings or unusually low ratings at younger ages. The data processing step provided a clean and reliable dataset, essential for the development of precise deterioration models and comparative analyses of various bridge types.
- **Deterioration model development:** This study utilized a regression non-linear optimization (RNO) model, specifically a Markovian-based non-linear optimization approach, to develop deterioration curves for bridge superstructures. The methodology involved using a polynomial regression curve tailored for each superstructure type, which was determined using Python scripts. These regression models were designed to fit the actual condition ratings of the bridge superstructures closely. Additionally, the study employed a Markovian transition probability matrix, calculated by minimizing the differences between the expected condition ratings from the regression model and the transition

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probability matrix. The resulting curve from this optimized transition probability matrix provided the desired deterioration curve for each superstructure type.

- **Comparative analysis of deterioration curves:** The comparative analysis in this study aimed to understand the deterioration characteristics of different bridge superstructure designs. It involved a detailed examination of how deterioration curves vary across various age groups and under different maintenance responsibilities (state, county, and city/municipality). The study also compared the average annual degradation rates of these structures over typical five-year age spans. Another key element of this analysis was the focus on data strength: the volume of data points available for each age group. This consideration was essential for ensuring a thorough and accurate comparison, providing deep insights into the unique deterioration trends and maintenance requirements of different bridge superstructure design types.

Findings

The analysis of six bridge structure types owned by the state DOT reveals that stringer beam and slab designs offer greater durability over time, with box beam designs showing a rapid decline in condition ratings (CRs) as they age. Similarly, county superstructures display comparable deterioration patterns across different designs until approximately 30 years of age, after which variations emerge. In city/municipality, slab designs prove the most resilient over a 60-year span, with frame designs exhibiting early signs of deterioration. The importance of construction quality on initial bridge performance is noted, with certain designs consistently favored by city and municipal transportation authorities.
Overall, the study finds that Slab and Stringer structures, in both Steel and Prestressed forms, exhibit greater resilience across different maintenance authorities. Frame structures show significant variability, with City/Municipal structures facing higher degradation, suggesting a need for improved maintenance strategies. This comprehensive analysis provides valuable insights for strategic planning in bridge maintenance and highlights areas for potential improvement in bridge superstructure management.

Recommendations

Based on the findings of this research, the following recommendations are proposed to enhance bridge management practices for state and local agencies:

- Feedback through Stakeholder Engagement: Stakeholder involvement involves disseminating research findings to professional and governmental entities at different levels of administration, such as state, county, and city levels. This is accomplished via delivering presentations and publishing research findings, with the aim of gathering feedback to validate the research's relevance and applicability for Ohio.
- Investigation on the Necessity for Design Standard Revisions or Improvements: Analyzing the degradation characteristics of the selected superstructures yields valuable observations, facilitating the assessment of the existing state bridge design standards and ascertaining the necessity for any revisions or improvements.
- Integration into Bridge Management Planning: By integrating generated degradation curves into bridge management strategies, it strengthens the capacity to make well-informed decisions regarding maintenance, repair, and reconstruction. This integration guarantees a higher level of transparency in the allocation of funding and resources for the maintenance and administration of bridges.

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