Predicting Bridge Deck Deterioration Rates

What Was the Need?
Bridge decks deteriorate as time passes, and the rate of this deterioration is important for estimating future repair or replacement costs. MnDOT inspects its bridges regularly and already has decades of data on the conditions of bridges in the state.

However, these data had not previously been analyzed to determine how quickly bridge decks deteriorate or what factors influence the rate of deterioration. This information is needed for long-term planning and to provide data-driven estimates of funding needed for rehabilitation and replacement efforts.

What Was Our Goal?
The goal of this project was to determine the deterioration rate of bridge decks in Minnesota and create deterioration tables that can be used to better predict the timing and costs of future bridge deck repairs and maintenance.

What Did We Do?
MnDOT provided National Bridge Inventory condition code data for 2,601 bridges with concrete decks. NBI condition codes range from 9 (excellent) to 0 (a failed bridge deck that must be replaced). A condition code of 4 is considered structurally deficient.

Researchers examined this data and compared condition code ratings with construction details about the bridges to determine the impact of factors such as type of deck reinforcement, depth of reinforcement below the driving surface, traffic levels and bridge location.

Using the condition code data, researchers created curves that show how long a bridge deck is likely to stay at a given condition code before dropping to the next lower one. They created separate curves for each of the variables that they found had a notable impact on deck deterioration rates.

What Did We Learn?
Several factors had a notable impact on how quickly bridge decks deteriorate:

- Bridge decks without epoxy-coated bars built between 1975 and 1989 deteriorate more quickly than other bridge decks. (Epoxy-coated bars were introduced in the early 1970s; they became standard for all Minnesota bridges in late 1989.)
- Bridges with less traffic showed slightly slower rates of deterioration than more-used bridges.
- Bridges in the Metro District drop to a condition code of 7 (good) more quickly than those in other parts of the state, possibly because the district uses more chemical deicers and because maintenance activities like crack sealing are more likely to be delayed on district bridges with more than two lanes because of the difficulty of accessing middle lanes.

Researchers analyzed several decades of bridge deck condition data to calculate how quickly bridge decks deteriorate in Minnesota. MnDOT will use the information in long-term planning for rehabilitation and replacement activities.
Based on these findings, researchers created deterioration tables for six combinations of construction year, bridge location, traffic level and presence of epoxy-coated bars. Researchers found bridge decks typically decline from a condition code of 9 to 7 fairly quickly—in six to 14 years, depending on the specific variables. Once the bridge deck reaches a condition code of 7, however, the drop in condition code slows, and bridges will typically stay at each condition code for 11 to 17 years.

Researchers found that when a new deck is installed on an existing bridge, its deck performs like a brand-new bridge and should use the deterioration table for the redecking year rather than the year the bridge was originally constructed.

**What’s Next?**

MnDOT plans to continue incorporating condition codes into this data set to enhance the predictive value of the deterioration tables, particularly as bridges get older. While one of the project’s goals was to provide information about how long it will take for a bridge deck to reach a condition code of 4, only one of the tables (for bridges built before 1975) offers information about how long a bridge deck will stay at condition code 5. There are not enough bridges built in 1975 or later that have reached a condition code of 4 to provide reliable durations. As more data are collected, however, MnDOT will be able to see how long a bridge deck stays at these lower condition codes.

MnDOT will incorporate information from this research into its Bridge Replacement and Improvement Management System, which helps to identify upcoming bridge repair needs. Specifically, the deterioration tables will serve as a long-term planning tool for MnDOT. While individual bridges will deteriorate somewhat faster or slower than their table predicts, MnDOT will use the tables to estimate overall bridge preservation and rehabilitation needs and costs. They will also be useful to help MnDOT communicate the funding needed to keep bridges in good condition.