Why Do Bridges Crack Prematurely?  
Analyzing Improved Bridge Deck Data

What Was the Need?
In Minnesota and throughout the nation, newly constructed bridge decks often develop cracks prematurely. While these cracks do not pose an immediate threat to a bridge’s structural soundness, they can cause durability and maintenance issues in the long term. Chlorides from deicing chemicals may penetrate these cracks and corrode steel rebar, ultimately causing a loss of structural capacity and concrete spalling above the rebar.

Many investigations have been conducted into the cause of early-age bridge deck cracking nationwide, including MnDOT Transportation Research Synthesis 1105, a literature search about factors cited as related to bridge cracking. MnDOT’s Bridge Construction Unit used Bridge Deck Placement Data forms since 2005 to create a database of cracking observed on state bridge decks.

What Was Our Goal?
This project sought to analyze the available data to determine how strongly various bridge characteristics correlate with deck cracking.

What Did We Do?
Researchers first evaluated the existing database. After finding several deficiencies in the database, they decided to collect additional data to identify variables that consistently lead to bridge deck cracking.

In coordination with MnDOT’s Bridge Construction Unit, researchers chose 20 representative and easily accessible bridges from the original database for a more detailed survey of cracking observable from beneath the bridge. They sketched crack patterns, measured or estimated crack lengths, and categorized the cracks by probable source: deck flexing/deflection or longitudinal restraint.

Researchers then analyzed this new data and created a matrix to identify variables that correlate with bridge deck cracking. In this analysis, variables included cement content, total cementitious materials content, as-batched water-to-cement content ratio, average estimated evaporation rate during placement, estimated evaporation at end of placement, maximum time before application of cure, duration of curing, longest deck span, abutment type and estimated deck age.

What Did We Learn?
The original database’s usefulness was limited because it did not differentiate between types of cracking, data collection methods were inconsistent, lacked information about deck mixture design or strength, and incomplete or improperly formatted entries.

When researchers analyzed the new data, one strong correlation observed was that restraint cracking was consistently—and almost exclusively—observed on bridges with integral abutments. Apart from that, however, the analysis generally indicated only weak correlation between the variables examined and the observed cracking.
In fact, some of the correlations were opposite of what was expected, although researchers suspect that in these cases the observed data may be acting as a surrogate for other relationships. For example, while increased cementitious material content would normally be expected to correlate with higher potential shrinkage and therefore cracking, the data showed moderate correlation between increased cementitious material content and decreased cracking. In this case, it is possible that the impact of increased material on concrete strength (which was not measured but would increase resistance to cracking) is greater than its impact on shrinkage.

While it is somewhat disappointing that no clear “smoking gun” for the cause of bridge deck cracking was identified, it is not particularly surprising. Bridge deck cracking is a complex problem, and this research helps to show gaps in the data that has been collected so far and what data needs to be collected in the future so that the causes of premature deck cracking can be better identified.

The researchers also offered recommendations for improving MnDOT bridge deck specifications based on a literature search, the current study and their own experience. These recommendations address structural design, deck preparation, mixture design, placement conditions, finishing, curing, construction sequencing, and deck cracking assessment and treatment.

What’s Next?
MnDOT will continue to collect bridge deck cracking data to enhance the existing database, and based on this research, it will ask for more information on its Bridge Deck Placement Data forms. In particular, MnDOT will ask for details about the type of cracking that develops and what the cracking looks like.

Ultimately, the expanded data set that this produces can be reanalyzed in hopes of finding new or stronger correlations between specific variables and bridge deck cracking. The correlation matrix developed for this project should be useful in future analysis efforts.

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