Designing Performance-Based Contracts for Pavement Construction and Maintenance

What Was the Need?
Most highway pavement construction work is performed by contractors. To ensure that these contractors produce high-quality pavements with long service lives, MnDOT contracts include performance-based specifications: Constructed pavements are tested to determine performance and life-cycle cost predictions, which are then compared to those called for in the pavement design. Bonuses are paid or penalties are assessed, depending on whether pavement quality exceeds or falls short of design expectations, respectively.

These contracts typically do not include long-term agreements for pavement maintenance. MnDOT either performs this maintenance or creates new agreements with contractors. Other transportation agencies and industries suggest that it may be beneficial to enter into longer term contracts that include such maintenance. Called performance-based contracts, or PBCs, these agreements give contractors leeway in how a pavement is designed but hold them accountable for its actual performance over the pavement’s entire service life. Instead of being paid in full upon completion of construction, contractors receive a series of payments that are modified with bonuses or penalties based on how well pavements meet desired performance targets over time. These payments are designed to encourage contractors to perform preventive maintenance during the life of the structure, which improves operational performance and prolongs pavement life.

Despite their potential, PBCs are not widely used by state transportation agencies, and their implementation requires complex calculations to estimate the expected performance of pavements and determine the timing and amounts of bonuses or penalties. Research was needed to establish guidelines for designing these contracts.

What Was Our Goal?
The objective of this project was to develop a method for designing PBCs for highway construction projects by estimating pavement life-cycle costs and determining the amount and timing of incentives and disincentives to influence contractor behavior.

What Did We Do?
Researchers began by investigating different kinds of procurement contracts and their use in a variety of industries, including health care, defense and transportation. Then they developed a method for predicting certain kinds of pavement distress, such as rutting and cracking, to determine a pavement’s expected service life and life-cycle costs. The method uses computer simulations allowing a variety of inputs, including pavement design specifications and such factors as expected weather and traffic. In developing this method researchers used closed form solutions—mathematical equations that take less computational time to arrive at predictions than those used in the Mechanistic-Empirical Pavement Design Guide, the typical method for predicting distress in pavements.

Finally, researchers developed a framework for implementing PBCs by determining the structure of penalties and bonuses to contractors that will provide the optimum control
What Did We Learn?

Results suggest that using PBCs would encourage contractors to implement the best construction methods and perform timely preventive maintenance activity, significantly improving the quality and long-term performance of their products. However, the implementation of these contracts is challenging, requiring more contract parameters and implementation effort than traditional contracts. The project report includes an inventory of performance metrics that agencies can use to evaluate contractor performance and a set of actions that contractors can use to control the quality of the final product and increase its usable life. To produce stronger pavements, contractors can control mix design, reduce variability in construction practices and control the timing and extent of preventive maintenance activities.

Researchers developed a mathematical model for selecting incentives that would elicit the desired responses from contractors without being too costly. Incentives would be smaller and disincentives larger near the beginning of a pavement life cycle, when good performance was expected. Incentives for good performance would grow as the pavement aged, when poorer performance such as cracking was expected. Researchers argued that if a competitive bidding mechanism were used to award contracts and optimal incentives were selected, agencies would pay only for improved quality and contractors would not earn unreasonable excess profits.

What’s Next?

MnDOT will continue to evaluate the possibility of using PBCs and other innovative contracting methods, but further research is required before implementation. Researchers recommend conducting a field evaluation of the effect of PBCs and maintenance activities on the performance lives of pavements. One possibility for implementing further research is a new pooled fund study involving MnROAD partners.