

## ABSTRACT

Murillo Hoyos, Jackeline. Ph.D., Purdue University, August 2016. A Methodology to Determine Non-Fixed Performance Based Thresholds for Infrastructure Rehabilitation Scheduling. Major Professor: Samuel Labi.

In an era of increasing demand and loading, aging infrastructure, and funding shortfalls, infrastructure agencies continue to seek cost-effective solutions to persistent and pervasive questions regarding the upkeep of their physical assets. One such question is the appropriateness of the current fixed condition thresholds used at several agencies for rehabilitation timing purposes, and whether there is value having flexible rather than fixed thresholds, and determining what these thresholds should be. A related question is how these flexible thresholds may vary depending on the objectives of the decision maker, the relative weight between agency and user cost, and the form of expression of the life cycle cost associated with the candidate rehabilitation schedules. Fortunately, a number of past researchers have developed inputs that are valuable for addressing this issue. Also, there exists data from in-service infrastructure that could be used to test the hypotheses regarding the sensitivity of the optimal schedules.

This dissertation developed a methodology to address this research question. This was done for each of two constraint scenarios related to the direction of successive threshold levels, unrestricted and restricted. For optimizing the rehabilitation schedules (strategies), the objective was to maximize the cost-effectiveness ratio, expressed as the change of the cost-effectiveness of a candidate strategy schedule compared to that of the do-nothing strategy. Cost was measured in terms of agency cost or user cost or both, incurred during infrastructure downtime (workzones) or during normal operations of the infrastructure. Effectiveness (or benefits) was measured in terms of the performance jumps offered by

the constituent rehabilitations over the life of the infrastructure, the infrastructure service life associated with the rehabilitation strategy, the infrastructure average performance, or the area bounded by the performance curve associated with the rehabilitation strategy, agency savings, and user cost savings. For the life cycle expressions of all costs, two alternative life cycle cost expressions were used: the present worth cost over a given service life or to perpetuity, and the equivalent uniform annual cost over a given service life or to perpetuity.

The results of the analysis suggest that compared to the restricted scenario, the optimal strategies developed using the unrestricted scenario generally yield superior levels of the objective function irrespective of the cost-effectiveness criteria, cost weight ratio, or life-cycle cost expression used in the analysis. The results for restricted and unrestricted scenarios provided valuable insight. For the unrestricted scenario, all the developed optimal strategies indicate that the subsequent rehabilitations should be applied at condition levels successively superior to the condition at the time of the previous rehabilitation, whereas the restricted scenario yielded the opposite trend: interventions are triggered when the infrastructure is in a condition worse than the previous intervention. This seems to reflect a tradeoff: while the unrestricted scenario generally yields superior cost-effectiveness values, its practical implementation may face obstacles from a public relations viewpoint. This is because the strategies offered by the restricted scenario (successively lower thresholds) gradually prepare the infrastructure users to be increasingly tolerant of successively lower levels of service. From the case study, it was also found that the optimal solutions developed using certain cost-effectiveness criteria such as the performance jump and user cost savings are the less sensitive to life-cycle cost expression and cost component weights, compared to other criteria. A close look at the optimal strategies for the former shows that they are identical, for a given life-cycle cost expression and cost component weight ratio. Finally, this dissertation discussed the consequences of hastened or deferred rehabilitations from an optimal strategy for which was found that deferring rehabilitation has greater adverse consequences compared to hastening.