## ABSTRACT

A Lagrangean Relaxation and Network Approach to Large-Scale Optimization for Bridge Management Systems. (December 1994)

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The purpose of this dissertation is to develop a model and solution methodology for determining the most cost-effective rehabilitation and replacement activities for each bridge in a large-scale Bridge Management System along a specified extended planning horizon. A bridge *project* is defined as a chronological sequence of rehabilitation and replacement activities along the given horizon, including the "do-nothing" activity. Each activity in a project is associated with an estimated cost and a measure of effectiveness, which are assumed to be given.

The problem under investigation is that of selecting a project for each bridge among a given list of feasible projects without exceeding the available budget in each period. The objective of the optimization approach is to maximize the total effectiveness of bridge improvement activities in the entire set of selected projects. It is assumed that the unused portion of the budget given for a period can be carried over to subsequent periods.

The problem is formulated as a multi-dimensional 0-1 knapsack model with generalized upper bound (GUB) constraints. A specialized branch-and-bound procedure to obtain an optimal solution is developed. Before initiating the procedure, sensitivity analyses are conducted to reduce the problem size. To improve lower and upper bounds, a set of very simple valid inequalities is added. For bounding, the problem extended by the added inequalities is relaxed in a Lagrangean fashion so that the relaxed problem becomes decomposed into subproblems. The values of the Lagrangean multipliers are found by a subgradient optimization method. A set of GUB covers for generating valid inequalities are obtained by a heuristic procedure that employs a min-cost generalized network flow algorithm.

Tests for the proposed solution methodology have been conducted using a set of randomly generated problems. These problems were generated after identifying typical projects for typical bridges in studies conducted for Indiana, North Carolina, and Texas departments of transportation. Duality gaps of large-scale problems (problems with 1000 bridges) were remarkably small (0.05% maximum) and lower bounds were optimal or near optimal. By a sensitivity analysis using these bounds, from 68 to 99 percent of the original variables were reduced.