Optimization of highway construction work zones: the agency and user cost tradeoff

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The infrastructure renewal efforts taking place all over the world are creating large volume of construction on highways and roads all over the globe. While these efforts are helping revitalize the ailing economies and infrastructures of nations, it comes with a cost to the traveling public. These costs present themselves in the form of prolonged congestions, and even more severely in the form of accidents leading to the death and/or injury of travelers. Previous research in this field has attempted to optimize each of these costs in isolation. Therefore, many studies have evaluated the cost of construction work zones to state highway agencies, and the corresponding costs to the traveling public. However, very few studies have evaluated the actual tradeoff between these two conflicting costs. The importance of creating these tradeoffs stems, not only from the responsibility that state highway agencies have towards the public, but also from the importance of public acceptance of the highway construction efforts taking place. Therefore, the objective of this paper is to develop a multi-objective decision support system that evaluates the tradeoff’s between agency and user costs in the design of construction work zones. The model is designed to optimize work zone dimensions, configurations, closure times, and dates for two lane highways. The model utilizes a robust multi-objective evolutionary algorithm and is capable of finding the optimal tradeoffs between minimizing agency and user costs of the highway work zone. It is proposed that the developed model creates a much needed decision support tool that facilitates decision making in highway work zone design. In addition this model is hoped to increase public acceptance of highway work zones and all the nuisances they cause to the traveling public.

In recent years transportation agencies have started giving more importance to the 4R projects i.e. restoration, resurfacing, rehabilitation and reconstruction rather than building new facilities (Lee and Ilbs. 2004). The deterioration in the condition of the facilities prompted this shift because of decreasing road user safety and ride quality and the high increase in not only the vehicle operating costs but also overall maintenance costs of the pavement. During maintenance of multilane highways, lanes are closed to carry out the construction activities, consequently the traffic flow slows down and the capacity reduces. This could be avoided by improving decision making processes concerning project phasing and cycles. This fact motivated the authors to analyze the recently developed lane closure models, and optimization models to establish the importance of integrating decisions concerning lane closures.

Work zones in a two or more lane highway represent the section of the highway wherein one or more lanes are closed to perform the requisite maintenance, rehabilitation activities while the others are open for traffic. Since the number of lanes in use for traffic in both directions decreases, a feasible combination of lane length, queuing delays and the lane closure phase is required to minimize the user costs. Studies related to this topic are few and limited as far as their scope is concerned (Chien et al,
These models addressed specific decisions that DOT’s have to constantly make, and designed a wide spectrum of solutions in order to better manage different components of the transportation infrastructure. These models, however, attempted to optimize these decisions with some degree of isolation. For example, there are models to determine the optimum work zone length, optimum starting time of a work zone, and the construction time-cost tradeoffs for pavement repair and maintenance projects, but without considering the impact these decisions may have on each other (Chien et al. 2002; Jiang and Adeli 2003; El-Rayes and Kandil 2005). The ideology behind this research is to combine traffic and construction management decisions to come up with integrated decision for any possible scenario and for all parties involved i.e. the agency, and the users. Therefore, this paper develops an integrated work zone optimization system using genetic algorithms that is designed to collectively optimize a number of major decisions concerning the maintenance and rehabilitation of a four-lane highway in order to find the optimum tradeoff between agency and user costs.

This paper starts with a review of some of the tools specifically developed to tackle the problems faced with respect to lane closure schemes. The paper then presents an optimization model which finds the best possible solution for a number of parameters vital in work zone management and minimizes the overall costs which include the sum of agency costs, user delay costs and accident costs. This model is envisioned to be able to establish work zone lengths and start times that lead to the optimal tradeoff between these two costs. As such, a multi-objective genetic algorithm is developed for this purpose. This algorithm was tested using an example problem that was analyzed by a number of previous studies. In addition to obtaining the optimal results depicted by those studies, the present model was also able to obtain 35 Pareto optimal solutions to the problem, representing 35 different work zone start times and lengths. In ongoing and future research efforts, the authors wish to expand the scope of the present model to include long-term and multiple work zone closure schemes. The authors also plan to address construction cost and scheduling using a more detailed approach such as using discrete even simulation.

References


