A Single-Objective Recovery Phase Model

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ABSTRACT

The Federal Emergency Management Agency (FEMA) has identified the four phases of disaster related planning as mitigation, preparation, response, and recovery. The recovery phase is characterized by activity to return life to normal or improved levels. Very little research considers the recovery phase, which encompasses restoring services and rebuilding disaster stricken areas of the highway transportation network. Existing recovery phase models deal primarily with travel times and do not focus on specific routes for reconstruction. This research proposes a plan for repair and restoration of bridges to restore a highway network that allows accessibility to key facilities in the area. This research differs from other recovery phase models in that actual routes are chosen for recovery based on given criteria. The single-objective optimization model developed in this paper is a flexible model that can be applied to a variety of natural disaster situations and other situations that involve damage to transportation components where decisions on recovery strategies must be made.

Keywords: *Disaster Recovery, Disaster Recovery Strategy, Optimization, Recovery, Response, Transportation Model*

INTRODUCTION

Recent natural disasters around the country have raised several questions about the preparedness of municipalities for repairing and restoring vital lifelines after a disaster. Much emphasis has been placed on evacuation plans and first response after the disaster. However, research is lacking in the recovery phase. Once public safety and well-being has been taken care of, what will be done to repair transportation systems to allow the population to recover economically? Experience has shown that the effects of disasters on highway components not only disrupt traffic flows, but also the economic recovery (Werner, Taylor, Moore, & Walton, 2000). When roadways are impassable, citizens cannot travel to their places of employment and industries cannot ship their products. Roadways that have been cleared for emergency personnel are not typically suitable for heavy vehicles and the shipment of freight. State and local transportation officials should have a plan for long-term recovery of the highway network.

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Until now, most studies have focused on the evacuation and first response efforts (Smith, Peoples, & Council, 2005). The shortest time period for emergency repair of damaged roadway components and avoiding isolation of city districts for evacuation has been studied extensively (Sakakibara, Kajitani, & Okada, 2004; Yan & Shih, 2008). These studies are concerned with evacuation of citizens and clearing the roadway for emergency personnel and supplies. A small number of studies have begun to appear that consider the long-term repairs of a roadway system. The idea of providing accessibility for a specific demographic was first introduced in 2003 (Chang, 2003). The researcher suggested that the current method for long-term repairs of highway networks was not the most efficient and beneficial to the area residents. In the past, transportation components such as bridges have been repaired from the least damaged to the most damaged. By comparing that strategy to the strategy of completing the repairs on an entire route, the researcher showed that the second strategy provided the most accessibility to the area residents and was thereby more beneficial to the recovery of the entire area.

This paper builds on the idea of accessibility as a measure of success for long-term restoration of transportation networks. This research proposes a plan for repair and restoration of bridges to restore a highway network that allows accessibility to key facilities. This research differs from other recovery phase models, as will be discussed in detail in the next section, in that actual routes for restoration are prioritized. The proposed model can be very beneficial to state and local transportation officials in planning routes for bridge retrofitting, maintenance dollars, and strategies for long-term repairs of the highway network. The model can also be useful after a disaster has occurred in coordinating construction scheduling for long-term repairs of transportation components.

The rest of the paper is structured as follows. First we provide a detailed literature review focusing on existing recovery phase models. Next, we present the model and discuss the data requirements for the model. The validation of the model and case study are presented. Finally, we discuss benefits and limitations, and present the conclusion

EXISTING RECOVERY PHASE MODELS

Research performed in 2002 established a mathematical model for comparing restoration strategies in the urban area of Seattle, Washington (Chang, 2003). The author developed an approach to post-disaster restoration of highway networks with performance measured in terms of transportation accessibility to the regional population. The region was defined as a 25 mile radius around the Seattle urban area. Two different strategies were compared for repairing highway networks to allow the greatest concentrations of the population in and out of the urban area. The first strategy evaluated was the repair of the least physically damaged areas to the most severely damaged areas. The second strategy was to repair an entire route no matter the variable damage states. The second strategy was shown to be the best for providing accessibility for the largest portion of the general population. The mathematical model used for comparing the two strategies measured accessibility loss in terms of changes to modeled travel times rather than in terms of approximated travel distances. The model also incorporated distance-decay effects. The author suggests further research is needed in refining the model with respect to post-disaster changes in origin-destination flows, destination opportunities and mode choice. Also recommended is further research into the technical and resource constraints on transportation repair and restoration in actual disaster situations (Chang, 2003).

Similar research using a topological index for quantifying road network dispersiveness/concentration in a disaster situation to prevent isolating city districts for evacuation was proposed by (Sakakibara, Kajitani, & Okada, 2004). The most robust networks were defined as the network that minimized the isolation of districts in a catastrophic disaster. The topological in-

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