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Work-troop scheduling for road network accessibility after a major earthquake

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Abstract

The road network accessibility is an important issue for earthquake relief operations, since several roads may be damaged obstructing the access to certain areas. This work proposes a mathematical model and two heuristics for the road repairing work-troops scheduling in order to increase accessibility to the population as fast as possible after a major earthquake. Solutions for randomly generated instances given by the model are used to evaluate the heuristics' performance. The heuristics are tested on a graph with more than ten thousand vertices and edges from Port-au-Prince 2010 earthquake in Haiti.

Keywords: post-disaster relief, network rehabilitation, multiflow formulation, heuristics.

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1 Introduction

Although resources like helicopters are also deployed on post-disaster logistics after major earthquakes, the majority of the population receives assistance and supplies from road relief teams. Thus, road network accessibility becomes an important issue, since a large amount of the city structures might be strongly affected, with rubble blocking several roads. In such situations, it is necessary to elaborate a plan for Work-Troops (WT), composed of bulldozers, excavators and dump trucks, to clean and repair the roads, allowing relief teams to reach the maximum amount of the population in a minimum time. In this context, the Work-troops Scheduling Problem (WSP) consists of defining a road repairing plan for WT per time period to increase accessibility as fast as possible to places where the population gather after an earthquake.

Humanitarian logistics and emergency management have been considered in several papers as shown in the review presented by [2]. A static version of the problem, where the order in which edges are repaired is not considered, is presented in [4]. A max-flow based model to minimize the weighted sum of the shortest times to reach each destination is proposed, together with a GRASP combined with VND. A dynamic version of the problem is proposed by [1], where two mathematical models are introduced to determine a restoration schedule and the WT allocation among origins. The model requires a pre-calculation of shortest paths (SP), and is applied to two regions of Turkey.

Another dynamic representation of the problem is introduced by [5,6] using a time-space network where each node represents an origin, intersection or damaged area at a certain time. The highway repair presented in [5] considers the rescheduling of WT due to changes in the demand and offer of repairs. A hybrid global search based on ant colony metaheuristic is proposed. A model to minimize the maximum time necessary to both restore all damaged roads and distribute all the relief is presented in [6].

In this study, the WSP is formalized by means of a multi-flow mathematical model. We proposed two simple heuristics to solve real size instances with over ten thousand vertices and edges in a reasonable amount of time. Tests are performed on simulated instances and on the graph of the Port-au-Prince earthquake, 2010 (See Figure (1)).

2 Problem definition

The WSP is defined in a graph $G = (V, E)$, where V is the set of vertices ($|V| = n$) and E the set of edges ($|E| = m$). Let $O \subset V$ be the subset