OPTIMIZING SURFACE WORK OPERATIONS OF ROAD CONSTRUCTION USING COMBINED SIMULATION AND GENETIC ALGORITHMS

By

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ABSTRACT

In order to make a profit and obtain the maximum productivity in any surface work operations in road construction, it is important to plan the operations, locate the most suitable locations of materials sources, select the appropriate equipments and use the haul units efficiently. Maximizing productivity is one of construction project management personnel's primary objectives, but can also be one of their greatest challenges. To plan surface work operations in road construction, it is necessary to understand the problem of equipments selection. The equipments selection problem is not limited to determine the optimum formation of equipments, but also extend to locate the most harmonious materials' source(s) that feed the project. Thus, the problem can be categorized in two main problems: 1) selection of appropriate equipments and 2) selecting optimal site(s) of materials sources that satisfy the economic and compatible transportation between sources and project.

The objective of this research is to introduce a new methodology for optimizing surface work operations in road construction that combines simulation with genetic algorithms. It provides an efficient tool of analyzing and optimizing the fleet configurations and materials' source(s) locations. Not like previous works, this new methodology performs the optimization process in two levels. The interactions between the two optimization problems in the upper level and the lower level are considered.

In the first level of optimization (lower level), a hybrid intelligent algorithm that integrates stochastic simulation and genetic algorithms is developed to solve the problem of haulers' shortest paths through a stochastic network using the concepts of expected shortest path and α-shortest path. It plays as a decision-making methodology to find the best shortest paths of the haulers between all materials sources and project, considering the stochastic nature of the haulers' speed, which is function of numerous variables such as haulers' characteristics and network conditions and characteristics.

In the second level of optimization a new hybrid mechanism that integrates discrete event simulation (DEVS) and genetic algorithms to efficiently locate the best fleet combination for surface work operations of road construction. It also plays as an optimization tool to select optimum fleet configuration. Genetic algorithm has been developed to search for optimum set of fleet configuration that optimizes both project total cost and production under various constraints related to desired production, work conditions, and resource availability limits.

Furthermore; a Computer-Aided Design (CAD) application was integrated with the developed mechanism to: 1) automatically access real and accurate data from a design model to a simulation model; 2) ensure the accuracy of the data for simulation purposes, and 3) avoid several shortcomings associated with traditional historic models such as re-entry of data and information, inefficient storage and increased complexity of simulation.

Finally, a user-friendly prototype software system named "RoadSimCAD" is developed based upon this new hybrid mechanism to provide the construction planner an efficient tool of analyzing and optimizing surface work operations in road construction. The proposed system accounts for the non-stationary process on the productivity rates for road construction operations and consists of: 1) Road_CAD Module (RCM); 2) Shortest Path Simulation engine module (SP_Sim); 2) Surface Works SIMulation module (SWSIM); 4) Shortest Path GA module (SP_GA); 5) Road equipment GA module (Road_EQ_GA); 6) Cost Module (CM); 7) Equipment DataBase (EDB); 8) Road Database (RDB); and 9) Reporting Module (RM).

In order to validate and demonstrate the essential features of the system's components, several cases studies were analyzed. A comprehensive case study of an actual project, drawn from the literature (Farrar et al. 2004), was analyzed in order to test the performance of the developed system and to illustrate the practical features of the developed methodology. The project involves the construction of Anthony Henday Drive, which is a road located in Edmonton, Alberta, Canada.