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DEVELOPING AND IMPLEMENTING A HYBRID SD-DES MODEL FOR DECISION MAKING IN A TUNNEL CONSTRUCTION PROJECT

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ABSTRACT

Tunnel Boring Machines (TBMs) are very expensive machines and every hour of their idle time imposes a great cost on the project. In this regard, reducing the idle time of a TBM in a tunneling construction project is an important concern of the project manager. Regarding previous studies and statistical data from Ahwaz Urban Railway project, many hours of TBM idle time are related to locomotives and rolling stocks that should support the TBM with material and lining segments. The model presented here integrates System Dynamics (SD) and Discrete Event Simulation (DES) in order to develop a decision making model for managing the addition of extra rolling stocks to the project. The developed SD-DES model simulates the whole process of TBM tunneling including rolling stocks' movement and produces managerial decisions to help the project manager to add resources to the project appropriately.

1 INTRODUCTION

Tunnel Boring Machines (TBMs) are very expensive machines and every hour of their idle time impose great amounts of costs on project. In this regard, reducing the idle time of a TBM in a tunneling construction project is an important concern of the project manager. Rolling stocks are the primary equipment that support the TBM, deliver material and lining segments to the TBM and haul the excavated muck from the tunnel face to the tunnel portal. Based on the mentioned points, a TBM cannot work unless rolling stock is waiting beside it.

Previous studies show that the waiting time of TBMs for rolling stocks has a significant impact on the utilization factor of the TBM and consecutively on the project finish date. In Tarabya tunnel in Istanbul, the TBM was waiting for the rolling stock in 11% of the time (Bilgin et al., 2005). In Shiraz subway project in Iran, 37% of all delays are related to logistic system and rolling stocks (Farshchian, 2012).

This case focuses on the Ahwaz Urban Railway project located in Ahwaz in the southwest of Iran. The project contains two parallel tunnels, each 23Km long that are being excavated using two TBMs (the outer diameter of the TBMs is 6.8m). For the first and the second TBM in this project, 11.3% and 10.6% of the time was delayed due to rolling stocks delay, respectively.

The model presented here is a hybrid model consisting of discrete-event simulation (DES) and system dynamics (SD). The DES model aims to simulate the process of tunneling using TBMs in detail. The SD model tries to control the system dynamically, track its dynamic changes and make managerial decisions for the tunneling project. A TBM, its related rolling stocks, the gantry cranes and other equipment at the tunnel portal (tunnel entrance) and the railway track from the tunnel portal to the TBM form a dynamic system that each hour of excavation of the TBM changes its characteristics. Each hour of excavation makes the tunnel longer and each time the tunnel gets longer, the material hauling distance gets longer. This dynamically changing characteristic force the project manager to add rolling stocks to the project in order to reduce the idle time of the TBM. The SD-DES model of current presentation help the project manager with appropriate managerial decisions to reduce idle time of the TBM.

2 MODEL DESCRIPTION

The DES model simulates the whole process of tunneling process including excavation, segment erection, movement of rolling stocks in the tunnel, and handling material at the tunnel portal. The SD model tracks the key parameters of the system and their changes over time, and makes the managerial decision of adding a rolling stock to the system based on predefined criteria.

In order to find the best criteria for decision making, four different criteria were tested, results were compared and the best one was selected. In two criteria, the model controls the ratio between utilization factor of the TBM and utilization of rolling stocks. The third criterion focuses on the idle time of the TBM, and the forth criterion tracks the waiting time of rolling stocks. Each time a criterion being met, the model makes a decision and add resources to the project. After comparing the results, the best decision making criterion was *90% ratio of utilization factor of rolling stocks to the TBM*. The model was then simulated using the selected criteria.

Results of the simulation show that the model works properly and make managerial decisions in a timely manner. Based on the model suggestions, the project manager should add rolling stocks to the project on specific hauling distances. The results indicate that for an approximately 10 Km long tunnel, the excavation should begin with two rolling stocks and finishes with four of them.

3 CONCLUSIONS

The results of the model implementation show that the model can suggest appropriate decisions in order to reduce the idle duration of TBM in a tunneling project. The method of integrating system dynamics models with discrete-event models can be implemented in other projects in order to help the project managers with better managerial decisions.

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