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Providing the DAT Innovative Model to Estimate Time and Cost of Tunnel and Updating with the Data Acquired During Excavation

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ABSTRACT

Schedules are major concerns in construction planning and management. The mutual interferences among construction activities of tunnels are complicated, which will affect scheduling to some degree. Ground condition and construction (excavation & support system) time and costs are key factors in decision making during the planning and design phase of a tunnel project.
In this work the DAT innovative methodology for the probabilistic estimation of ground condition and construction time and costs is used. As construction progresses, geologic information is checked based on the excavated part of the tunnel and, therefore, the uncertainty about this part of the tunnel will disappears. This new information can be used to update the geology condition of the tunnel in order to obtain more precise prediction for unexcavated part.
In this paper, an engineering application to Garan road tunnel is well presented to demonstrate how the ground conditions and the construction time and costs are updated during construction. Finally, the results of simulations for the initial prediction and the updated prediction will be compared in order to see how the construction time and costs distributions of the given tunnel are changed after the geologic updating.Finally, reducing of uncertainty about the construction time and costs is resulted. It facilitates both the owners and the contractors to be aware of the risk they should carry before construction of unexcavated part, and it is useful for both tendering and bidding.

Summary

Firstly, each case of construction time and cost is obtained by using DAT innovative model; applying data before starting excavation. Then by providing new data according to the 100 excavated meters of both entry and exit of tunnel, the model is updated. Finally less uncertainty is achieved due to updating the model for produced time and cost.

Introduction

From among the significant discussions pertaining to the project design and planning, the minimizing of uncertainties is important issue. Usually the uncertainties in subsurface projects arise from the unknown ground conditions which may cause the designer fail to consider all the potential issues prone to occur during the construction procedure. total time and costs uncertainties can be considered as the most important uncertainties; the time and costs are directly connected with cognition of the subsurface conditions. Accordingly in subsurface projects the actual time and costs are not ascertainable, and hence the probability methods should be used to assess such factors[1].
Various commerical software for risk analysis of tunnel construction have been developed over the years, the most important of which is the DAT (Decision Aids for Tunnelling), developed at MIT in collaboration with EPFL (Ecole Polytechnique Federal de Lausanne). DAT tool primarily included only two construction and geological models, but later a further model was added to the DAT models called the resource model [2]. Afterwards a method for assessment of the full-face tunneling technology was introduced using the DAT method [3]. The DAT model was developed so that it capable to update the model during the construction if new more real data compared with the initial data was obtained and reduced the uncertainties about the final time and cost of tunneling in comparison to the previous model [4]. In

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order to estimate the total time and costs of tunneling, the DAT method employed in many projects such as Soocheon, Wonhyo and north Kenmore tunnels [5].
DAT model updating using new real geological data during tunnel excavation, first the total time and costs of a tunnel was estimated using the initial geological data through implementing the DAT method; Then a new estimation of total time and costs was obtained through updating the DAT model by new geological data collected during tunneling and finally the results were compared [5]. For modeling the uncertainty in the underground subway line of New York City and also estimating the total time and costs of the tunnels in the Portuguese Railway project the DAT model was also used. The most recent works using DAT model is the total time and costs estimation of well drilling for EGS [6.[

The DAT allow engineers to simulate tunnel construction considering uncertainties in geology and construction processes for a given tunnel and, as a result, obtain distributions of the total cost and duration of tunnel construction. The DAT model uses probabilistic modeling of the construction process to analyze the effects of geotechnical uncertainties and construction uncertainties on construction costs and time. This tool in geological model considers different geological conditions and defines every setting as a ground class that includes the special excavation method and support system. In the geological model the occurrence possibility of each ground class is obtained using Markov method in any location along the tunnel. In construction model by allocating the time and costs to each classes using the expert views and the experience from the previously carried out projects in similar conditions, the time and costs relating to each class can be estimated in different locations along the tunnel. Then the total time and costs of the tunnel can be probabilistically estimated from the sum of the times and costs in the all locations along the tunnel.

In DAT method due to pre-constructional unknown state of the subsurface conditions, there are uncertainties concerning the input data of the tool; However by the commencement of the construction and drilling some parts of the tunnel, the DAT model can be updated through acquiring the actual data of the drilled parts, resulting in the reduction of the uncertainties concerning the time and cost of the tunnel construction. For updating DAT tool in case of obtaining actual data subsequent to drilling part of the tunnel, the previous data must be replaced with the actual data in the similar locations and then all of DAT method steps for the geological and construction models mentioned in previous sections must be performed entirely from the beginning to the end .

In this letter due to the unavailability of the DAT tool, the DAT innovative model is proposed. Where, the Matlab software is used to coding the Marcov model and the PertMaster is used for Monte Carlo simulation. In many cases through input data questioners, the opinions of experts are considered.

In this work, the Hamro road tunnel is selected as a case study. Firstly, each case of construction time and cost is obtained by using DAT innovative model; applying data before starting excavation. Then by providing new data according to the 100 excavated meters of both entry and exit of tunnel, the model is updated. Finally less uncertainty is achieved due to updating the model for produced time and cost.

Methodology and Approaches

In accordance with the research methodology, In the geological model first the total tunnel alignment was divided into several equal parts (cells) each with 10m length. A number of 6 cells that related to 4 borings' locations and 2 entry and exit positions were called as ‘observational cells’ due to specified to the probability of occurrence of the parameters' different states considered in this study (rock type, RQD and underground water). However in this study due to inaccessibility to the data pertaining to the exact location of the borings and also because initially a length of 200m relevant to the entry and exit portal of the tunnel had not been excavated, all the observations were considered as non-deterministic. Afterwards in order to find the occurrence probability of the parameters' statuses in other cells (unknown cells), programming of Markov model was performed in MATLAB software and with the aid of observational cells other cells were also predicted, consequently specifying a profile titled parameter profile for each parameter which could determine the occurrence probability of each status of the parameter inside each cell. Ultimately, through combining different statuses of the parameters, different geological settings for the tunnel alignment were obtained for which several ground classes (each including the special excavation method and support system) were introduced by 10 experts so that each one of the classes were responsible for a specific number of ground conditions obtained as described above. In the next stage a profile was obtained through combining parameter profiles which could determine the probability of each one of the ground classes inside each cell which was nominated as the ‘ground class .’

Because each ground class has a different time and costs, there is the possibility for occurrence of different time and

costs within each section. In the next stage to obtain the total time and costs of tunnel construction (construction model), the time and costs of the all sections were added up using Monte Carlo simulation method in the PertMaster program. Finally with the aid of cumulative graph, different total time and costs with specific occurrence probability (uncertainties) were obtained

Then through updating data during construction of 100m in each one of the tunnel entry and exit positions, the DAT innovative model was updated and consequently less uncertainties compared with pre-updating state was obtained concerning the cost and time of the project execution.

Results and Conclusions

The geological uncertainty is the main source of risk in underground construction, often leading to assumption of the worst ground conditions and thereby increasing in the cost amounts considerably. Decreasing the designing costs, conservative construction and selecting suitable drilling methods and support systems based on the existing geological conditions would result in considerable saving during construction process. Various commerical software for risk analysis of tunnel construction have been developed over the years, the most important of which is the DAT (Decision Aids for Tunnelling), developed at MIT in collaboration with EPFL (Ecole Polytechnique Federal de Lausanne). The DAT allow engineers to simulate tunnel construction considering uncertainties in geology and construction processes for a given tunnel and, as a result, obtain distributions of the total cost and time of tunnel construction. In this paper, using the DAT innovative model and considering the pre-construction data of Hamro road tunnel, the probabilistic construction time and cost of the entire tunnel was predicted. Consequently the minimum and maximum time were obtained as equal to 2182 and 2373 days respectively; also the minimum and maximum costs were obtained as equal to 74,175,354,696 and 78,435,268,015 Tuman respectively. In the next stage, by updating data during construction of 100m in each one of the tunnel entry and exit positions, the DAT innovative model was updated and consequently less uncertainties compared with pre-updating state were obtained concerning the cost and time of the project execution. So that the minimum and maximum time were obtained as equal to 2215 and 2321 days respectively; also the minimum and maximum costs were obtained as equal to 75,257,456,387 and 77,121,654,367 Tuman respectively.