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Delay Determination of Subway Construction Project by Fuzzy MCDM (Case Study, Karaj Subway)

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ABSTRACT: The most important indicator of a project's success is not only it should be cost-effective, but also it should be ended on the predicted time. In some projects like constructing subways, dams and so on, delay in construction causes big problems in financial, social or political levels in the countries. To reduce or eliminate delays in construction projects, time optimization should be planned. The main goal of this project is to study the time delay in construction of Karaj subway. In this regard the reasons are recognized and evaluated. In the first step, by reviewing project documents and designing a questionnaire which was completed by a set of experts, factors of delay in constructing Karaj subway were recognized. In the next step, by using multi-criteria decision-making methods, these factors were phased out, weighted and prioritized. At the end, by using Fuzzy logic and to estimate the delay of projects, a method was provided that according to it the project manager can use experts' ideas and recognizes how much this project has progress and do necessary actions to have a more rapid exploitation.

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1- Introduction

One of the indicators of project's success is that, it ends on the predicted time [1]. Time is one of the most valuable resources in construction projects [2]. Most of the time, projects have this problem that they won't end on time. Delays in construction projects are universal [3]. Delays means that project ends on a time that is more than what was predicted. Since construction projects are complex, so delay of them is undeniable [4]. Delays of different projects cause late completion of the project, increase the cost, stop the progress of the project, increase claims of consultants and other contractors and may leave the contracts [2]. Usually when the project is facing delays, its implementation is done in rush and increase the cost and decrease quality of project [4]. In this study the delays of Karaj subway construction are investigated. Limited financial resources, lack of proper equipments and expert forces in operational parts of Karaj subway project are reasons of recognizing delay factors in this project. Determination of delay factors, on one hand, helps to development of non-completed projects and on the other hand prevents the delay of them. So maintaining and using experiences in next projects is very important.

2- Review of literature

In similar study, Sambasivan and his colleagues investigated the reasons of delays and their effects on construction industry of Malaysia. They investigated the importance and ratio of influence of each these reasons and at the end they determined the casual relationship between delay reasons. They used questionnaires to obtain basic information. 150 experts answered these questions and it was cleared that factors such as improper planning of contractor, improper and weak management of workshop by contractor, insufficient experience of contractor, insufficient budget of employer, problems with sub-contractors, lack of materials and so on are the important reasons of delays in projects [3]. Sweis and his colleagues done a study to understand the delay factors on Jordan. They used questionnaires. The results showed that financial problems and changing of project's features by employer had caused delays. After that, weather conditions and changing of government rules play a role on project's delays [5]. In this study by using questionnaire, delay factors of Karaj subway construction are determined and ranked according to Fuzzy logic. At the end, by using Sugeno Fuzzy system, a framework was designed to predict possible delays in future projects of Karaj and it's expected that these results affect manager's decision-making for future of Karaj subway project.

3- Information Gathering

Questions were prepared by studying literature and existing documents of project including project's workshop reports and studying schedule of program by experts of Karaj

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subway project. Since the main goal is investigating delay factors in construction of Karaj subway project and few experts are working on this issue, the population experts are selected non-possible and targeted. Questionnaires were completed by the experts and its information was analyzed by SPSS 19 software, and the main factors of delay in this project were recognized. Final questionnaire has 50 questions in 5 part including: delay factors related to employer, consultant, contractor, environmental and climate factors and uncontrollable factors.

After collecting data and putting these data on the SPSS, factors were arranged according to the average effect of them on delay and the responses' criteria deviation. On one hand, to have a detailed investigation on delay factors of Karaj subway project and in regard to limitation of Fuzzy hierarchical analytical method, and due to limited capacity of people in data processing, threshold of paired comparisons was limited and was considered as 7±2 parameters [6]. On the other hand, according to Pareto principle, 20% of factors caused 80% of errors [7]. So 10 top factors (20% and 50 factor) that were more than average and had more influence on delay, the share of each of the factors causing delay among 10 main factors is shown on Figure 1 as a diagram.

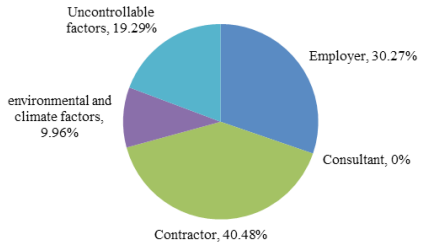

Figure 1. The share of each of the delay factors

4- Fuzzy logic in evaluating time progress of project

4- 1- Fuzzy analytic hierarchy process (FAHP)

The way of recognizing fuzzy analytic hierarchy process is based on the theoretical concept of fuzzy set that was provided by Prof. Lotfizadeh on 1965 [8]. Fuzzy analytic hierarchy process extended the saaty's analytic hierarchy process. In FAHP, after creating hierarchical structure, fuzzy comparisons were used to show the importance of delay factors associated with criteria. So, a fuzzy comparisons' matrix is created for ranking delay factors by final scores and for selecting more important delay factors.

On 1996, a Chinese researcher called Yung Chang presented extent analysis method. In this methodology, all inputs were used as triangular fuzzy numbers in paired comparisons' matrix. This method is used on most of researches that solve problems on uncertain conditions, due to its simple calculations [9, 10].

FTOPSIS[1] method is generalized of TOPSIS[2] (similarity to ideal solution) method in fuzzy set. The underlying logic of TOPSIS is to define positive and negative ideal solutions. By positive ideal solution some criteria like profit are been maximum and some criteria like cost are been minimum. By negative ideal solution some criteria like cost are been maximum and some criteria like profit are been minimum. Optimized factor is nearest factor to positive ideal solution and farthest option to negative ideal solution. To evaluate the time performance, first of all we formulate a FMCDM (fuzzy multi criteria decision making) equation. This equation consists of a set of m factors that are evaluated by n criteria [11].

4- 2- Fuzzy inference and designing of fuzzy estimator system

To calculate and provide a fuzzy estimator system, we have used Sugeno fuzzy system. All data are entered into this system by fuzzy form and then it analyzed data by using fuzzy rules and at the end its outputs are sent to managers and decision makers.

To determine fuzzy rules, share of delay factors should be used. Another parameter that called membership function has also influence on determining fuzzy rules. Membership functions should be defined for all delay factors and in order to be determinant of all weights that are obtained by FAHP[3], these functions are defined the same. It means that experts' opinions will determine the outputs of fuzzy system, not partitions of membership functions. Partitions of membership functions are shown on Figure 2.

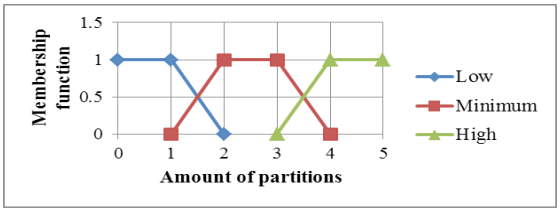

Figure 2. Partitions of membership functions

According to Iran's general conditions of contract and base on the breach of contract due to increase of delay more than a quarter of contract time, experts have made decision to select number 3 as the average of delay interval for determining delay constant. Results are shown on Table 1.

Average of delay intervals × delay constant × contract time = quarter of contract time

3× delay constant × T = 0.25 T

Delay constant = 0.0833

Sugeno final partitions are shown on Figure 3.

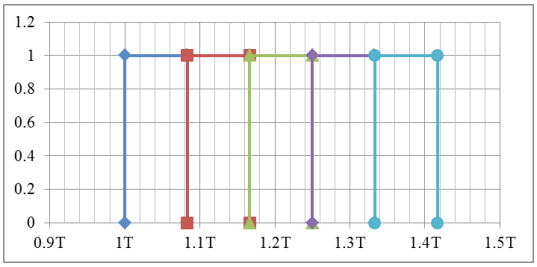

Figure 3. Sugeno output partitions

1 Fuzzy Technique for Order Preference by Similarity to Ideal Solution

2 Technique for Order Preference by Similarity to Ideal Solution

3 Analytic Hierarchy Process

Table 1. Sugeno final output partitions

Partitions	Very low	Low	Medium	High	Very high
Delay	1.0833T	1.1666T	1.25T	1.3332T	1.4165T

5- Conclusion

In constructing of Karaj subway, employer has caused delays via financial and social problems about the ownership of project's site, delay on decision making and not having enough credibility and not paying contractors on time. The consultant has avoided delays via proper management, on time checking of invoices and making necessary harmonies. Contractor has caused delays via weakness of financial strength, lack of proper management, lack of specialty and referring the project to sub-contractors and delay on paying personnel and sub-contractor. The most important uncontrollable factors are prohibitions and inflations that have caused delays. The most important environmental and climate factor is opponents that they have caused delays. Opponents in constructing of subway stations have made delay.

Results of fuzzy estimator systems showed that FTOPSIS is stricter than FAHP about delays of projects. While FAHP is more optimistic about delays. So it means that FTOPSIS will predict delays of projects more optimally. Also fuzzy estimator system can estimate delays of future projects of Karaj and it can prevent waste of time and cost.

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