NEW INTELLIGENT APPROACH FOR PROJECT MANAGEMENT IN CONSTRUCTION INDUSTRY

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ABSTRACT : The construction environment is dynamic in nature and is characterized by various degrees of uncertainties. The uncertainties such as lack of coordination, non availability of resources, condition of temporary structures and varying weather conditions have a significant impact on estimating the duration of activities. These are subjective, vague and imprecisely defined and are expressed in subjective measures rather than mathematical terms. Conventionally, various quantitative techniques such as CPM and PERT have emerged in construction industry. These techniques cannot solve the above problems and rely on human experts which may not always be possible. In such situations Artificial Intelligence tools such as fuzzy sets and neural networks handle such variables and provide global strategies. The present paper evaluates the effect of qualitative factors to identify the activity duration using new intelligent approach. The results are compared with conventional methods for effective project management. A case study is considered to demonstrate the applicability of fuzzy logic for project scheduling.

Key words: Fuzzy sets, qualitative factors, CPM, project scheduling.

1. INTRODUCTION

Every construction project is complex to some extent. Efficient and economical construction is particularly important because of the increasing complexity of the structures being built. The availability of resources, construction equipment, high labor cost, high level of competition in the industry, inflation make construction more challenging than ever before. In a large complex project there are hundreds or even thousands of activities. Construction engineers use several techniques, with varying degrees of complexity to handle project scheduling. Bar charts and milestone charts are effectively used for project scheduling earlier. Due to the shortfalls in the above techniques, quantitative techniques such as Critical Path Method (CPM) and Programme Evaluation and Review Technique (PERT) have emerged in construction industry.

However lack of flexibility and uncertainity considerations limit its effectiveness. PERT which is an improvement to CPM that incorporates uncertainity and risk analysis, still proves baffling because of its underlying theoretical assumptions. Fuzzy project scheduling acquired great importance in the past two decades. This approach is best suited in decision making in various activities involved in project scheduling. Fuzzy project scheduling approach is pragmatic enough to be understood easily and thus to be implemented in real world projects. Estimating the durations of construction activities requires experts' knowledge. Statements used by these experts usually contain some sort of imprecision. Fuzzy set theory is used for quantifying the imprecision associated with the durations of project activities. This paper deals with qualitative factors in the estimation of various parameters in project scheduling in addition to quantitative factors. The effects of qualitative factors are evaluated using fuzzy set concept.

2. LITERATURE REVIEW

Construction engineers use several quantitative techniques in estimation of project duration. Nguyen (1984) proposed a systematic procedure for the selection of bid contracts. The procedure is suitable for a general tender evaluation process. Tender evaluation process involves many decision making parties and multiple criteria. Hence fuzzy set theory can be applied effectively in this area. In this procedure it was given that tender selection process involving multiple criteria in general can be performed systematically by using basic fuzzy set operations.

Lorterapong and Osama (1996) proposed a method based on fuzzy set theory which is capable of providing schedules that can approximately account for the nature as well as the type of uncertainities normally encountered in construction projects. In the proposed method the calculations are simple and requires less computational effort. Hence the method is practical and can be easily computerized.

AbouRizk and Sawhney (1993) and Wu and Hadipriono (1994) demonstrated the use of fuzzy set theory for estimating the durations of project activities taking into account various qualitative factors such as site conditions, weather, labor performance, etc. Chanas and Kamburowski (1981) used the fuzzy set theory to provide early start and finish times along with fuzzy project durations.

Ayyub and Haldar (1983) translated the linguistic variables into mathematical measures using the fuzzy set theory. The estimation of duration of an activity is done using this theory in which various membership functions need to be estimated using judgement or with the assistance of experts. This technique can be easily implemented in real life problems. Bonnal et al. (2002) implemented the fuzzy set theory in many decision making problems. They suggested that the fuzzy set approach is more appropriate and they believe that this project scheduling approach the project managers are benefited. The above literature suggests various methods to identify activity durations. The present paper proposes a new intelligent approach for project management in construction industry.

3. FUZZY SET RHEORY

The concept of fuzzy set theory was introduced by Zadeh in 1965. The intension in introducing fuzzy set theory was to deal with problems involving knowledge expressed in vague, linguistic terms. Classically, a set is defined by its members and an object may be either a member or a non-member i.e., the characteristic of traditional (or crisp) set. This crisp set is extended to fuzzy set with the introduction of the idea of partial truth. Any object may be a member of a set 'to some degree' and a logical proposition may hold true 'to some degree'. Often, we communicate with other people by making qualitative statements, some of which are vague because we simply do not have the precise datum to our disposal.

Fuzzy set theory offers a precise mathematical form to describe vague terms. To represent such linguistic terms, the concept of possibility values of membership has been introduced. Qualitative factors or linguistic variables are routinely used in construction project scheduling. These linguistic measures add to overall uncertainity in the final outcome of any decision process. These linguistic variables are translated into mathematical measures in order to incorporate these uncertainities in the analysis.

4. NEW INTELLIGENT APPROACH

Based on fuzzy set theory, the duration of construction activity is estimated. A construction activity *brick work* is considered to demonstrate the new approach. There are many qualitative factors affecting the duration of brick work operation. The qualitative factors such as weather, classified into good, medium and bad and skill of the labor, classified into high, medium and low have been considered. The frequency of occurrence of each classification of the above mentioned factors and the adverse consequences of occurrence on the duration of an activity are estimated in linguistic terms and is shown in Table 1.
Now, using the above information, the total duration of brick work operation is estimated. The linguistic variables are translated into fuzzy sets. The membership values are assumed and these values vary from project to project.

Large = { 0.8/0.5, 0.9/0.9, 1.0/1.0 }
Small = { 0.0/1.0, 0.1/0.9, 0.2/0.5 }
Medium = { 0.3/0.2, 0.4/0.8, 0.5/1.0, 0.6/0.8, 0.7/0.2 }

The frequency of occurrence and the adverse consequences are combined and the total effect of all the factors on the brick work activity duration is obtained by the union of all the six relations using Eq. 1.1

$$\mu_{AUB}(x) = \text{Max}\,[\mu_A(x), \mu_B(x)]. \qquad (1.1)$$

Table 1. Quantitative description of frequency of occurrence and consequences

Factor	Frequency of occurrence	Adverse consequences
Weather, bad	Small	Large
Weather, medium	Medium	Medium
Weather, good	Medium	Very small
Skill of labor, low	Large	Medium
Skill of labor, medium	Medium	Quite small
Skill of labor, high	Quite small	Very small

Consequences

T =

Frequen

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.0	1.0	0.81	0.25	0.0	0.0	0.0	0.0	0.0	0.5	0.9	1.0
0.1	0.88	0.81	0.25	0.0	0.0	0.0	0.0	0.0	0.5	0.9	0.9
0.2	0.42	0.42	0.25	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5
0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0
0.4	0.8	0.8	0.42	0.2	0.8	0.8	0.8	0.2	0.0	0.0	0.0
0.5	1.0	0.88	0.42	0.2	0.8	1.0	0.8	0.2	0.0	0.0	0.0
0.6	0.8	0.8	0.42	0.2	0.8	0.8	0.8	0.2	0.0	0.0	0.0
0.7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0
0.8	0.0	0.0	0.0	0.2	0.5	0.5	0.5	0.2	0.0	0.0	0.0
0.9	0.0	0.0	0.0	0.2	0.8	0.9	0.8	0.2	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.2	0.8	1.0	0.8	0.2	0.0	0.0	0.0

Now, another relation is established between the consequences and the effect on duration. The duration of the activity is assumed to lie between 10 to 20 days. Accordingly, the following membership values are assumed.

Very large = { 15/0.4, 18/0.64, 20/1.0 }
Large = { 15/0.2, 18/0.8, 20/1.0 }
Small = { 18/0.2, 15/0.5, 10/1.0 }

Taking the union of the above relations using the basic fuzzy set operations mentioned earlier, the common relation 'R' is obtained as follows.

Duration

"R"
consequences

	10	15	18	20
0.0	1.0	0.5	0.2	0.0
0.1	0.9	0.5	0.2	0.0
0.2	0.5	0.5	0.2	0.0
0.3	0.0	0.2	0.2	0.2
0.4	0.0	0.2	0.8	0.8
0.5	0.0	0.2	0.8	1.0
0.6	0.0	0.2	0.8	0.8
0.7	0.0	0.2	0.2	0.2
0.8	0.0	0.04	0.5	0.5
0.9	0.0	0.04	0.64	0.9
1.0	0.0	0.04	0.64	1.0

T_oR / Frequency	Duration 10	15	18	20	Row ummation
0.0	1.0	0.5	0.64	1.0	3.14
0.1	0.88	0.5	0.64	0.9	2.92
0.2	0.42	0.42	0.5	0.9	2.24
0.3	0.2	0.2	0.2	0.2	0.8
0.4	0.8	0.5	0.8	0.8	2.9
0.5	1.0	0.5	0.8	0.8	3.3
0.6	0.8	0.5	0.8	0.8	2.9
0.7	0.2	0.2	0.2	0.2	0.8
0.8	0.0	0.2	0.5	0.5	1.2
0.9	0.0	0.2	0.8	0.9	1.9
1.0	0.0	0.2	0.8	1.0	2.0

Based on the fuzzy sets basic operations, a subjective estimation of the duration is calculated by taking the composition of T and R

The above composition represents the membership values for different durations of the activity and frequencies of occurrence considering the total effect of factors. It is suggested to choose a row which maximizes the product of row summation given in the above table and also its corresponding frequency. The last row gives the maximum value of the product for the problem under consideration. Therefore, the following fuzzy subset of the activity duration is chosen.

Support value = { 0.0/0.0, 15/0.2, 18/0.8, 20/1.0 }

According to Zadeh, the probability mass function of the duration activity is

P = 0.0/(0.2+0.8+1.0) = 0;
P = 0.2/(0.2+0.8+1.0) = 0.1: and

P = 0.8/(0.2+0.8+1.0) = 0.4;
P = 1.0/(0.2+0.8+1.0) = 0.5

The mean value, standard deviation of the duration, variance of the activity duration is calculated .

Mean value, d = 15*0.1+18*0.4+20*0.5 = 18.7 days.

Standard deviation, $\sigma^2 = 15^2*0.1+18^2*0.4+20^2*0.5 - (18.7)^2 = 2.41$

Variance, $\sigma = \sqrt{2.41} = 1.552$ days, and

Coefficient of variance = variance/mean value = 1.552/18.7 = 0.083

The mean value indicates the expected or average value of duration. The standard deviation indicates the dispersion or scatter of the data from the mean value. The coefficient of variance (COV) is a non dimensional quantity which is a measure of uncertainity in the duration. Therefore, the duration of brickwork activity is estimated to be 18.7 days approximately taken as 19 days. The duration obtained using this technique is within the assumed range of duration in days. Similarly, the durations for each activity in a project can be estimated based on fuzzy set approach.

5. CONCLUSIONS

In the present paper a typical construction problem, brick work operation is taken into consideration and its total duration is estimated based on fuzzy set approach considering the various factors effecting it. To solve the problem various membership values are taken with the help of experts or based on experience. It was observed that the proposed technique is not sensitive to small variations in membership values. This is a very desirable property. This technique is very simple and can be easily applied in real life problems.

The success in incorporating the impact of weather conditions and skill of the labor is dependent on the

assumptions used in translating the linguistic variables into fuzzy sets. The more this technique is applied, the higher will be the level of success in choosing the proper membership values. This technique is not sensitive to small variations in membership values. On calculating the probability mass function, the mean value of duration is obtained as 18.791days, standard deviation is 2.035 and coefficient of variance is 0.108. The proposed technique is sensitive to the choice of fuzzy relation between the consequences and the duration of activity. In the fuzzy set approach the linguistic variables can be translated into mathematical measures.

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