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Fuzzy analysis on factors of Time Overruns in Public Private Partnership Projects

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Abstract*— In recent years public private partnership projects are increasing all over the world due to its various benefits and key factors for successful project completion. Public private partnership projects (PPP) had been playing a major role in Indian construction as there is tremendous need for new and better infrastructure. However there have been relatively some problems in PPP projects which make the project more complicated in its implementation. Due to several factors time overruns occurs in every PPP projects. This is mainly due to its critical factors that delay the project to complete successfully. In this project I aim to identify and analyze the major time overrun factors in public private projects in India through extensive data collection, questionnaire survey and by conducting interviews. The analysis is done by using relative importance index (RII) scale. This paper also presents an application of fuzzy logic model in order to analyze the factors causing time overruns using Fuzzy toolbox of MATLAB Program Software. The results derived from this model indicate a systematic and effective way for the analysis.

Keywords- Public Private Partnership Projects; Fuzzy inference system; Time overruns; MATLAB; Fuzzy Logic Toolbox

I. INTRODUCTION

The Indian construction industry contributes more than five percent to the country's Gross Domestic Product. It includes highways, railways, ports, bridges, hydraulic structures, power plants, tunnels, municipal facilities like sanitation and water supply, and other facilities serving public needs. Completing projects on time is an indicator of efficient construction industry. In fact, a project is considered successful if it is completed on time, within budget and to the specified quality. Normally, when the projects are delayed, they are either extended or accelerated and therefore, incur additional cost. To the dislike of owners, contractors and consultants many projects experience extensive time overruns and thereby exceed initial time and cost estimates. The construction process is subjected to many variables and unpredictable factors. The clients in the construction industry are primarily concerned with quality, time and cost. But majority of construction projects are procured on the basis of the constraints time and cost. Time overruns are typically associated with poor management practices. Traditionally public infrastructure has been delivered by the public sector using the design-bid-build procurement system. With the increased demand for new developments and for maintaining existing infrastructure, public funding resources were unable to keep pace with the demand. Public-private partnerships (PPPs) were sought as alternative delivery systems to address some of the funding problems.One of the most important problems in the construction projects is time overruns. Especially it is a frequently occurring problem in Public private Partnership projects (PPP) and their magnitude of these time overruns varies considerably from project to project. Some projects are only a few days behind the schedule and some may get delayed over a year. So it is essential to define the actual causes of time overruns in order to minimize and it in any construction projects. The main objective of this study is to identify the major time overrun factors in PPP projects and present an application of the time overrun assessment model for Indian construction industry using Fuzzy Logic.

II. METHODOLOGY

The time overrun factors are identified through the extensive literature review and with the help of expert's opinion. The questionnaire survey is conducted among three categories say government officials, private contractors and consultancies. These time overrun factors are ranked and assessed using Relative Importance Index (RII) factor. After ranking the factors, a model is developed and analyzed using fuzzy logic method in MAT lab.

A. Relative Importance Index of Time Overrun Factors

The following procedure is adopted to calculate the rank and assess the importance index of time overrun factors: (i)The time overrun factors prevailing in the construction industry are identified. (ii)A questionnaire survey is conducted among experts in order to judge the level of importance of the above identified factors. The respondents are asked to indicate the relative importance of these factors. (iii)The five-point scale ranged from 1 (strongly disagree) to 5 (strongly

agree) is adopted to calculate the relative importance indices (RII) for each factor. The relative importance index (RII) is calculated by using the relation [15] given below:

$$RII = \frac{\sum W}{A*N}$$

where W is the weighting given to each factor by the respondent (ranging from1 to 5), A is the highest weight and N is the total number of respondent.

Table 1 Relative importance index for time overrun factor

S.No	Factors for Time Overruns	Weighted Average of RII	Rank
I.	Land Acquisition Problems	4.32	1
II.	Difficulties in diverting the traffic	4.06	2
III.	Poor communication & coordination	3.65	3
IV.	Delay in approving the design	3.66	4
V.	Problems in material delivery	3.80	5
VI.	Lack of high technology machines	3.64	6
VII.	Insufficient knowledge & experience of workers	3.40	7

B. Modeling In Fuzzy Inference System

In this step, the fuzzy logic model is designed for predicting the cost overrun in Mamdani type inference using the fuzzy toolbox of MATLAB. There are five primary graphical user interface tools for building, editing, and observing in the fuzzy inference systems toolbox.The identified time overrun factors are considered as input variable for the assessment model and the output variable is taken as the "time overrun probability". The membership function represents the fuzziness degree of linguistic variables. Membership functions give a numerical meaning for each label. There are different shapes of membership functions, viz, triangular, trapezoidal, Gaussian, bell-shaped, piecewise-linear etc. Triangular and trapezoidal fuzzy membership functions are widely used and in this paper I have used trapezoidal membership function. A trapezoidal fuzzy number x with membership function μA(x) specified by four parameters {a, b1, b2, c} having a lower limit a, an upper limit c, a lower support limit b1, and an upper support limit b2, where, a < b1 < b2 < c, can be defined as shown in the figure 1.

$$\mu_A(x) = \begin{cases} \dfrac{x-a}{b_1-a} & if \quad a \le x \le b_1 \\ 1 & if \quad b_1 \le x \le b_2 \\ \dfrac{x-c}{b_2-c} & if \quad b_2 \le x \le c \\ 0 & otherwise \end{cases}$$

Fig. 1 Trapezoidal fuzzy number membership function

Table 2 Linguistic variables used in model and their membership function

Variables	Range	Membership Functions(MFs)	No of MFs	Name of the parameters
Input Parameters				
Land Acquisition Problems	[0-5]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Difficulties in diverting the traffic	[0-5]	Trapmf	5	1.very low 2.low 3.medium 4.high 5.very high

Poor communication & coordination	[0-5]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Delay in approving the design	[0-5]	Trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Problems in material delivery	[0-5]	Trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Lack of high technology machines	[0-5]	Trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Insufficient knowledge & experience of workers	[0-5]	Trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Output parameter				
Time overrun	[0-5]	Trapmf	5	1.very low 2.low 3.medium 4.high 5.very high

C. Definition of rules

Rules, which connect input variables to output variables, are defined in order to perform inference process. Each rule is a logical inference and depends on the state of input and output variables. With the help of fuzzy rules values can be incorporated between the conventional evaluation of the precise logic 1 and 0. It also include logical operations such as "and", "or", "not" and "if-then". „IF ... THEN ..." forms are used in the present study to relate inputs to output variables in terms of linguistic variables. The number of rules depends on the number of inputs and outputs, and the required performance of the system. Mamdani type fuzzy inference method is used for the present study for their wide application in the construction industry. The rules defined in this study is displayed in the table 3. The relative importance indices for the cost overrun factors which are calculated in table 1 are assigned as fuzzy rules weight. Defuzzification is the process in which outcomes of control models in the form of fuzzy numbers can be converted to precise output numbers. Therefore, in this stage, fuzzy outcomes of fuzzy control model, including effects of all input variables of problem, and considering integrated effects of them by accessing various time overrun phenomenon by fuzzy rules, are undergone fuzzy removing process and probability of cost overrun is determined as an exact number in the interval of zero to one.

Table 3 Sample fuzzy rules for the of cost assessment model and rules weight

S.No	Rules	Rule weight
1	If the probability of land acquisition problems is very low the time overrun is very low	4.32
2	If the probability of difficulties in diverting the traffic is very low the time overrun is very low	4.06
3	If the probability of poor communication & coordination is very low the time overrun is very low	3.65
4	If the probability of delay in approving the design is very low the time overrun is very low	3.66
5	If the probability of problems in material delivery is very low the time overrun is very low	3.80
6	If the probability of lack of high technology machines is very low the time	3.64

	overrun is very low	
7	If the probability of insufficient knowledge & experience of workers is very low the time overrun is very low	3.40

III. NUMERICAL STUDY

For the numerical study, a small survey is conducted in Tamilnadu (India) for illustration purposes of the above methodology. The assessment model is developed for the identified predominant time overrun factors in the construction projects .These overrun factors are obtained through literature survey and questionnaire survey in the leading construction companies in Tamilnadu, who has vast and specialized experience in the specific project. The major seven important time overrun factors are identified and considered for this study.

A. Ranking of time overrun factors

For ranking the above identified factors, an expert opinion is taken from engineers/consultants in the field of construction industry. Relative importance indices (RII) are calculated for each factor, which are shown in Table 1. It is clear from the Table that the extremely important factor which affects the time overrun is land acquisition problems and it has rank 1 according to Relative importance index. Whereas the insufficient experience and knowledge of the workers is the least affecting factor and has got lowest rank among all time overrun factors which are considered in the study.

B. Analysis Steps For The Model Development

To develop the model, following steps are performed on fuzzy logic tool box of MATLAB.

(i) Construct a seven input, one output system in the FIS editor. The identified time overrun factors are entered as input members and time overrun is taken as output member respectively.

(ii) Membership functions associated with all of the input and output variables are defined in membership function editor.

(iii) In order to perform fuzzy inference, rules which connect input variables to output variables are defined. For the present model 35 rules are constructed in the form of IF-THEN. Five of them are given below.

Rule1: if the probability of land acquisition is very low the time overrun is very low

Rule2: if the probability of land acquisition is low the time overrun is low

Rule3: if the probability of land acquisition is medium the time overrun is medium

Rule4: if the probability of land acquisition is high the time overrun is high

Rule5: if the probability of land acquisition is very high the time overrun is very high

(iv) The relative importance indices (RII"s) of time overrun factors are assigned as weightage to the fuzzy rules to develop the assessment model to estimate the probability of time overrun. Since the RII"s of the time overrun factors have different values, the fuzzy rules weights will differ accordingly. So that each if-then rule will have different weights, showing relative importance of fuzzy rules. .

(v) The rule viewer displays a roadmap of the whole fuzzy inference process. The rule viewer shows how the shape of the certain membership function influences the overall result.

(vi) Finally, the input-output mappings are obtained by choosing view menu and under it view surface. It shows the variation of different factors with respect to time overrun. Similarly, variation of time overrun for different combination of input variables can be obtained. These types of three- dimensional graphical views can be analyzed by the owner and contractor easily and quickly.

IV. CONCLUSION

A systematic procedure is adopted for studying the time overrun factors in fuzzy environment using Fuzzy toolbox of MATLAB Program Software. The procedure consists of identification of time overrun factors and assesses their rank according to relative importance index. Using these relative importance indexes, model has been developed in fuzzy inference system (FIS).Different graphs are plotted to show the variation of different combination of time overrun factors. These graphs are directly useful for contractor and owner to understand the effect of combination of time overrun factors over time overrun.

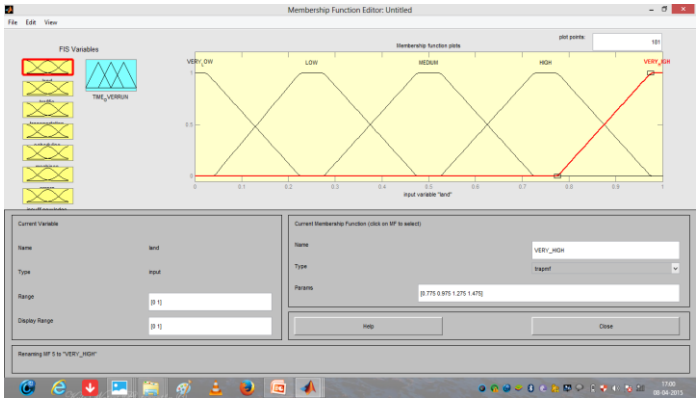

Fig.2 Input and output members for time overrun assessment model

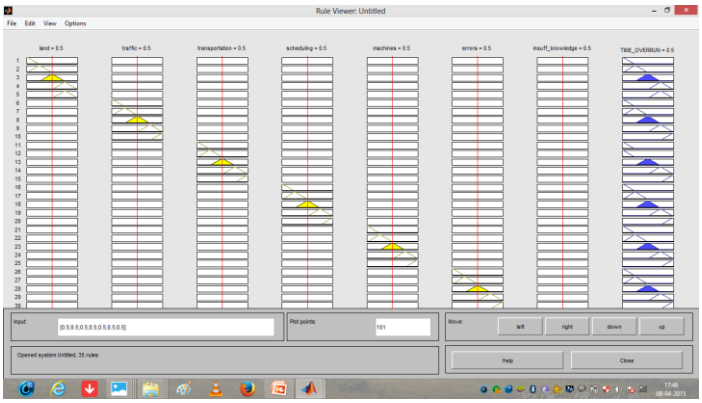

Fig.3 Defuzzification process for the time assessment model

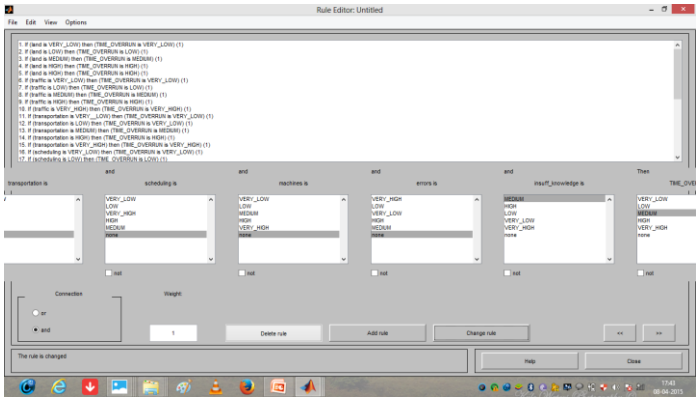

Fig.4 Assignment of rules for the time assessment model

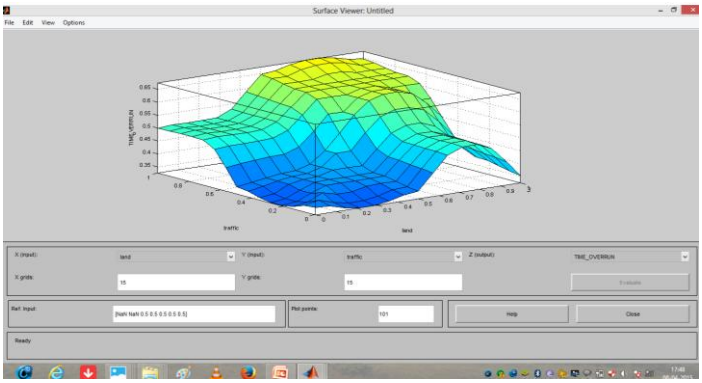

Fig. 5 Variation of traffic diversion problems and land acquisition problems with respect to time overrun

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