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Cost Overrun Assessment Model in Fuzzy Environment

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Abstract: - This paper presents an application of fuzzy logic for developing cost overrun assessment model using Fuzzy toolbox of MATLAB Program Software. Construction industry is considered as one of the most dynamic and risky industrial sector. Due to risks and uncertainties associated with the projects, project objectives are not achieved as desired as has been stipulated. Project failure takes place in terms of project delay, cost over runs and poor quality. The cost is considered as one of the most important success parameter of any project. The cost overrun factors are identified based on literature review and expert opinion which is ranked using Relative Important Index (RII) scale. Graphs showing the variation of cost overrun for different combination of cost overrun factors are obtained. The method is illustrated with the help of an example.

Keywords: - *Construction industry, Cost overrun, Fuzzy logic, Modelling, Risk*

I. INTRODUCTION

Construction industry is considered as one of the most dynamic and risky industrial sector. Many construction projects do not attain all their desired goals due to the presence of risks and uncertainties intrinsic in the project. These lead to failure of project in terms of project delay, cost over runs and poor quality. Cost is considered as an important key parameter for the success of any project. Many authors have suggested that 'risk cost' should be adopted as an assessment scale [1,2,3,4]. In spite of the importance of this factor, construction industry is full of projects that functionally operate with extensive cost overrun. Cost overrun in projects generates a considerable financial loss to both contractor and owners. Hence, cost risk assessment has become an essential part of the construction industry. To avoid construction cost overrun, there is need to develop a cost overrun assessment model as a decision support tool for the project managers, cost estimators for the construction projects before the bidding stage.

Many researchers have studied for the identification of cost overrun factors in the construction industries [5, 6, 7, 8, 9, 10]. An extensive literature review has been conducted by Sharma and Goyal for identification of cost overrun factors in construction industry [11].

Risk assessment is considered as one of the most important part of the risk management process. The main objective of modelling of risks and uncertainty in forecasting construction cost is to analyse the effect of associated uncertainty on cost overrun. There are two approaches to develop a model (i) simple classical method (ii) advanced models. Examples of simple classical methods include sensitive analysis, fault tree analysis, event tree analysis, failure mode &effect critical analysis etc. Whereas, the models based on monte –carlo simulation for stochastic modelling analysis and fuzzy set theory are considered as advanced models of risk assessment. Fuzzy set theory is a branch of modern mathematics that is suitable for uncertain or approximate reasoning that involves human intuitive thinking .The fuzzy set theory is used to address the uncertainties associated with construction activities, which in itself has the potential to deal with the vagueness, uncertainty and subjective nature of any problems [12, 13, 14].

The main objective of this study is to present an application of the cost overrun assessment model for Indian construction industry using Fuzzy Logic. The method is applied to analyze a small survey from expert of construction field and indentify important cost overrun factors.

II METHODOLOGY

The cost overrun factors are identified through the extensive literature review and with the help of expert's opinion. These cost overrun factors are then ranked and assessed for their importance index. After ranking the cost overrun factors, model is developed in fuzzy inference system. The assessment model for the cost overrun factors is developed using fuzzy logic as per procedure explained here.

2.1 Ranking of cost overrun factors

The following procedure is adopted to calculate the rank and assess the importance index of cost overrun factors:

(i)The cost overrun factors prevailing in the construction industry are identified.

(ii)A questionnaire survey is conducted through personal interview for judging 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 (not important) to 5 (extremely important) 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.

2.2 Modelling 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 procedure to develop a model using Fuzzy Inference System (FIS) of MATLAB is shown in Fig.1.

2.2.1 Defining input and output variables

The identified cost overrun factors are considered as input variable for the assessment model and the output variable is taken as the "cost overrun probability".

2.2.2 Defining membership functions for variables

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 used in this study as they are widely used. A triangular fuzzy number x (see Fig.2) with membership function $\mu_A(x)$ is defined by

$$\mu_A(x) = \begin{cases} \frac{x-a}{b-a} & if \quad a \le x \le b \\ \frac{x-c}{b-c} & if \quad b \le x \le c \\ 0 & otherwise \end{cases}$$

A trapezoidal fuzzy number x (see Fig.3) with membership function $\mu_A(x)$ specified by four parameters {a, b_1, b_2, c} having a lower limit a, an upper limit c, a lower support limit b_1, and an upper support limit b_2, where, $a < b_1 < b_2 < c$, can be defined by

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

2.2.3 Defining rules

Rules, which connect input variables to output variables, are defined in order to perform inference. 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.

2.2.4 Assigning the weights to the fuzzy rules

The relative importance indices for the cost overrun factors which are calculated in section 2.1 are assigned as fuzzy rules weight.

2.2.5 Defuzzification

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 cost overrun phenomenons 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. The complete procedure is shown in the form of flow chart as shown in Fig.4.

III NUMERICAL STUDY

For the numerical study, a small survey is conducted in Rajasthan(India) for illustration purposes of the above methodology. The cost assessment model is developed for the identified predominant cost overrun factors in the construction projects .These cost overrun factors are obtained through literature survey and consultation with ten engineers working in the leading construction companies in Rajasthan, who has vast and specialized experience in the specific project. The following seven important cost overrun factors are considered for this study as shown in Fig. 5.

3.1 Ranking of Cost overrun factors

For ranking the above identified factors, an expert opinion is taken from the ten 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 1 that the extremely important factor which affects the cost overrun is inadequate planning and scheduling and it has rank 1 according to Relative importance index. Whereas the hostile socio-economic condition has lowest rank among all cost overrun factors which are considered in the study.

3.2 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 cost overrun factors and “cost overrun ” are entered as input members and output member respectively. These are shown in the Fig.6

(ii) Membership functions associated with all of the input and output variables are defined in membership function editor. All the parameter related to their membership function of each variable is given in the Table 2. An example of membership function of fluctuation of price material is shown in Fig. 7.

(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 fluctuation in price of material is very low the cost overrun is very low
Rule2: if the probability of fluctuation in price of material is low the cost overrun is low
Rule3: if the probability of fluctuation in price of material is medium the cost overrun is medium
Rule4:if the probability of fluctuation in price material is high the cost overrun is high
Rule5: if the probability of fluctuation in price of material is very high the cost overrun is very high

(iv) The relative importance indices (RII’s) of cost overrun factors are assigned as weightage to the fuzzy rules to develop the assessment model to estimate the probability of cost overrun. Since the RII’s of the cost 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. These are presented in Table 3

(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. The Fig. 8 shows the rule view of the system.

(vi) Finally, the input-output mappings are obtained by choosing view menu and under it view surface. Fig.9 shows the variation of experience of contractor and fluctuation of material prices with respect to cost overrun. Similarly, variation of cost overrun for different combination of input variables can be obtained. Fig.10 shows the variation of short bid preparation time and experience of contractor with respect to cost overrun. Variation of experience of contractor and planning and scheduling with respect to cost overrun is shown in Fig.11. These types of three- dimensional graphical views can be analyzed by the owner and contractor easily and quickly.

IV CONCLUSIONS

A systematic procedure is presented for developing the cost overrun assessment model in fuzzy environment using Fuzzy toolbox of MATLAB Program Software. The procedure consists of identification of cost 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 cost overrun factors with the cost overrun. These graphs are directly useful for contractor and owner to understand the effect of combination of cost overrun factors over cost overrun.

REFERENCES

[1]. Franke, A., “Risk analysis in project management”, International Journal of Project Management, Vol. 5(1), 1987, pp. 29- 34.
[2]. Paek, J.H., Lee, Y.W. and Ock, J.H, “Pricing Construction Risks: Fuzzy Set Theory”, Journal of Construction Engineering and Management, 119(4), 1993, 743-756.
[3]. Williams, T, “A classified bibliography of recent research relating to project risk management”, European Journal of Operational Research,Vol .85,1995,pp. 18-38.
[4]. Taroun, A., Yang, J.B. and Lowe, D., “Construction Risk Modelling and Assessment: Insights from a Literature Review”, The Built & Human Environment Review, Volume 4, Special Issue 1, 2011, PP.87-97
[5]. Jackson, S. , “ Project cost overrun and risk management in Greenwood ”, Proceedings of Association of Researchers in Construction Management 18th Annual ARCOM Conference, Newcastle, Northumber University, UK, 2-4 September,2002.
[6]. Koushki, P. A., Al-Rashid, K and Kartam, N., “Delays and cost increases in the construction of private residential projects in Kuwait”, Construction Management and Economics, Vol.23 (3), 2005, pp. 285-294.
[7]. Creedy, G. , “Risk factors leading to cost overrun in highway projects. Sidwell”, Proceeding of Queenland University of Technology Research Week International Conference, 4–8 July, 2005, Brisbane, Australia.
[8]. Iyer , K.C. and Jha, K.N. , “Factors Affecting Cost Performance: Evidence from Indian Construction Projects”, International Journal of Project Management, Vol. 23,2005, pp. 283-295.
[9]. Azhar, N., Farooqui, R. U. and Ahmed, S. M., “Cost overrun factors in construction industry in Pakistan”, Proceeding of first international conference on construction in developing countries (ICCIDE-1) , 4-5 August,2008, Karachi, Pakistan.
[10]. Rahman,I.A., Memon,A.H. & Abd. Karim,A.T., “ Relationship between Factors of Construction Resources Affecting Project Cost”, Modern Applied Science; Vol. 7 (1),2013. pp. 67-75.
[11]. Sharma S and Goyal P.K.,“ Cost overrun factors and project cost risk assessment in construction industry- a state of the art review”, International journal of civil engineering,Vol. 3,issue 3,2014,pp.139-154.
[12]. Kangari, R. and Riggs, L.S, “Construction Risk Assessment by Linguistics”, IEEE Transaction on Engineering Management, Vol. 36(2), 1989, pp. 126-131.
[13]. Tah,J.H.M. and Carr,V. , “A proposal for construction project risk assessment using fuzzy logic”, Construction Management and Economics, vol. 18,2000, pp. 491-500.
[14]. Baloi, D. and Price, A.D.F., “Modelling global risk factors affecting construction cost performance”, International Journal of Project Management ,Vol.21 (4),2003, pp. 261-269.
[15]. Kometa ST, Olomolaiye PO, Harris FC. , “Attributes of UK construction clients influencing project consultants’ performance”, Construction Management and Economics 12, 1994, pp. 433–443.
[16]. Zadeh, L., “Fuzzy sets", Information Control, 1965, 8: 338-353.

Table 1: Relative importance Index for cost overrun factor

S.N.	Factors causing cost overrun	Number of respondents scoring					RII	rank
		Not important	Slightly important	Moderately important	High impor tant	Extremely important		
1	Fluctuation in price material	0	0	1	2	6	0.82	3
2	Lack of Experience in contract work	2	2	2	2	4	0.80	4
3	Short Bid preparation time	1	1	1	2	5	0.78	5
4	Lowest Bidding procurement procedure	1	1	1	3	4	0.76	6
5	Inadequate planning and scheduling	0	0	1	3	6	0.90	1
6	Poor management of site and supervision	0	0	2	3	5	0.86	2
7	Hostile Socio - economic condition	3	2	2	1	2	0.54	7

Table 2: linguistic variables used in model and their membership function

variables	Range	MFs	No of MFs	Name of the parameters
Input parameter				
Fluctuation in price material	[0 -1]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Lack of Experience in contract work	[0 -1]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Short Bid preparation time	[0 -1]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Lowest Bidding procurement procedure	[0 -1]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Inadequate planning and scheduling	[0 -1]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high

Poor management of site and supervision	[0 -1]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Hostile Socio - economic condition	[0 -1]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high
Output parameter				
Cost overrun	[0 -1]	trapmf	5	1.very low 2.low 3.medium 4.high 5.very high

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

S.N.	Rules	Rule weight
1	If the probability of fluctuation in price of material is very low the cost overrun is very low	0.82
2	If the probability of Lack of Experience in contract work is very low the cost overrun is very low	0.8
3	If the probability of Short Bid preparation time is very low the cost overrun is very low	0.78
4	If probability of Lowest Bidding procurement procedure is very low the cost overrun is very low	0.76
5	If the probability of Inadequate planning and scheduling is very low the cost overrun is very low	0.9
6	If the probability of Poor management of site management and supervision is very low the cost overrun is very low	0.86
7	If the probability of hostile economic condition is very low the cost overrun is very low	0.54

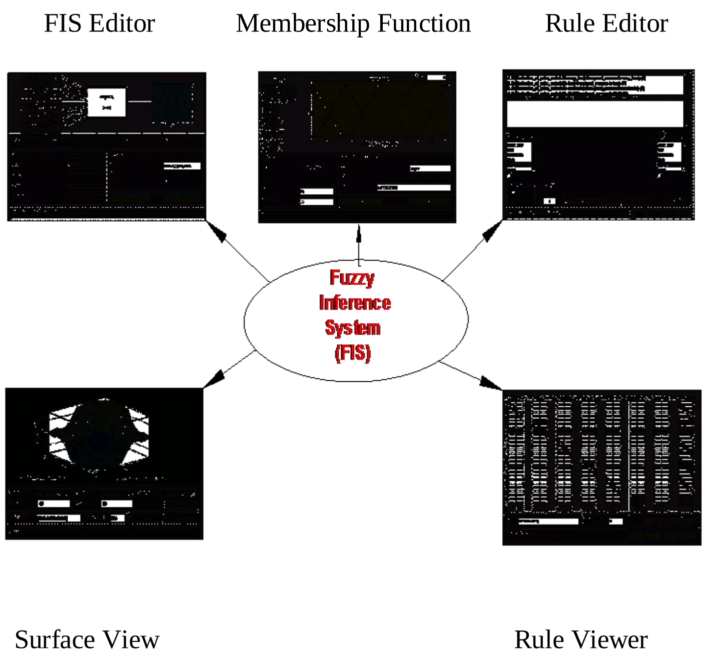

Fig. 1: Fuzzy inference process

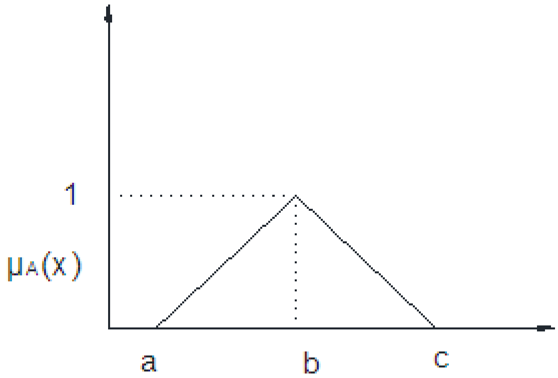

Fig.2 Triangular fuzzy number

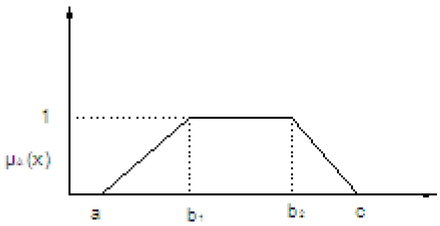

Fig3: Trapezoidal fuzzy number

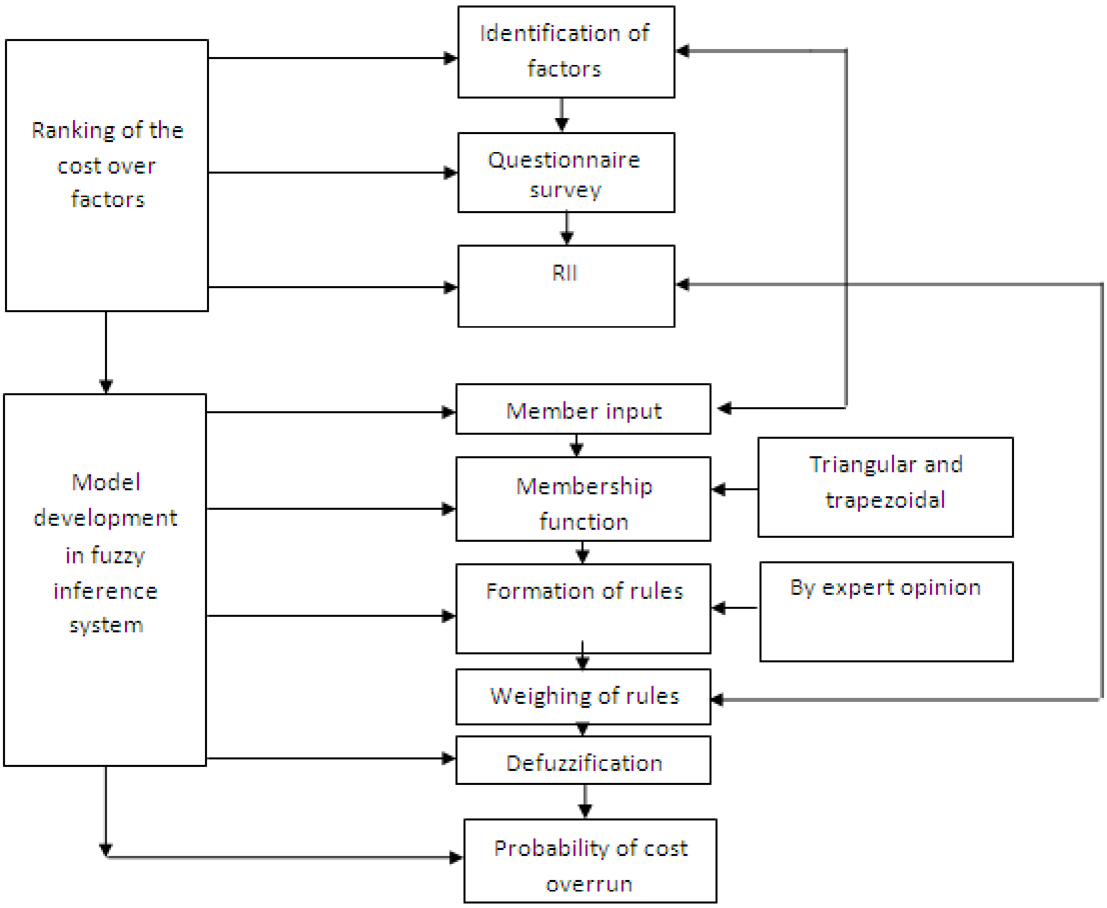

Fig 4: Flow diagram for the development of cost assessment model in fuzzy inference system

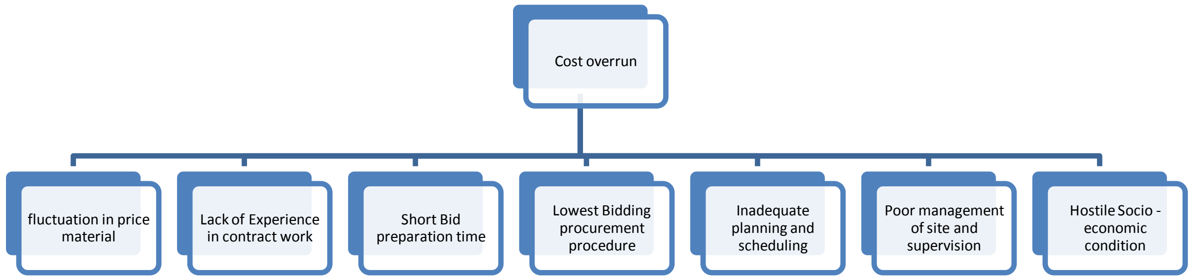

Fig. 5: Cost overrun factors

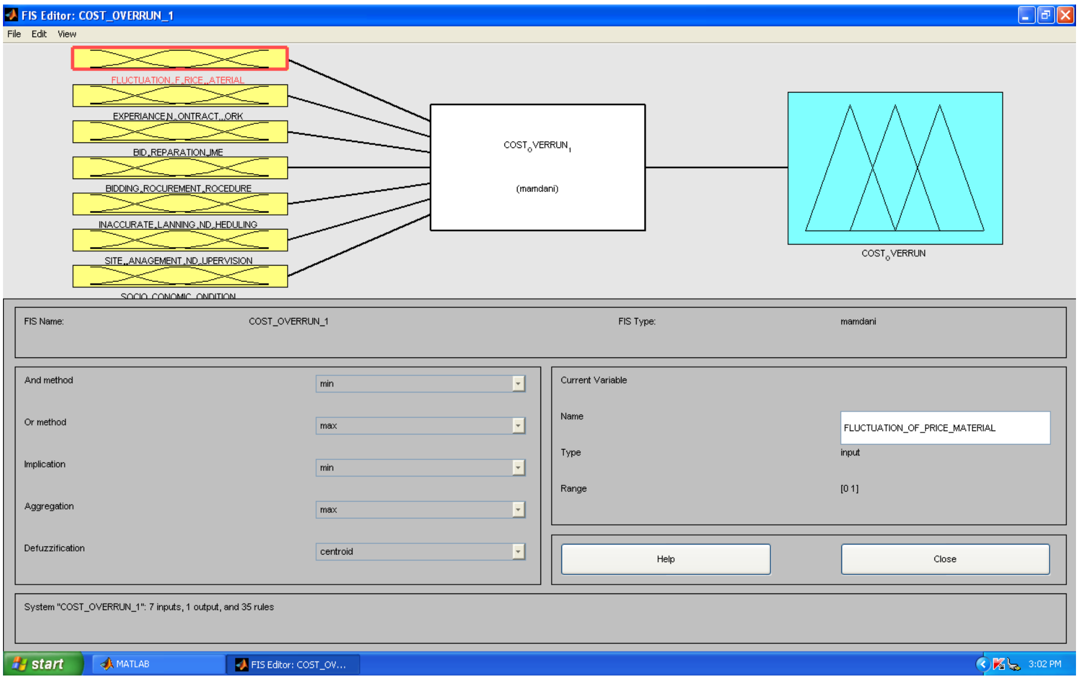

Fig 6: Input and output members for cost overrun assessment model

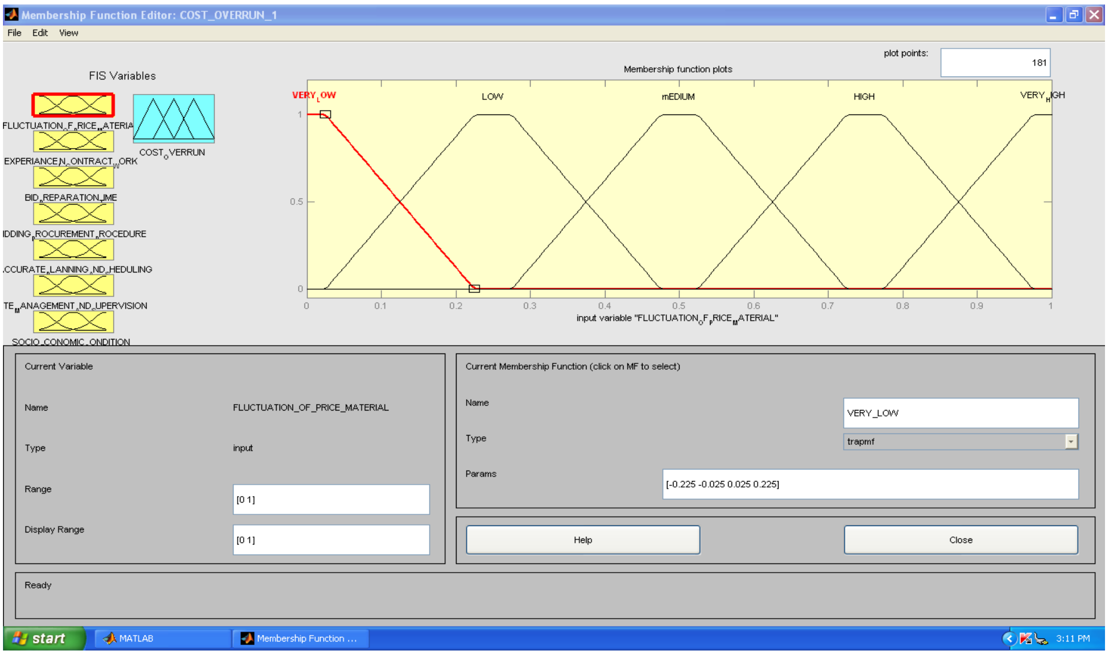

Fig. 7: Membership function for the cost assessment model

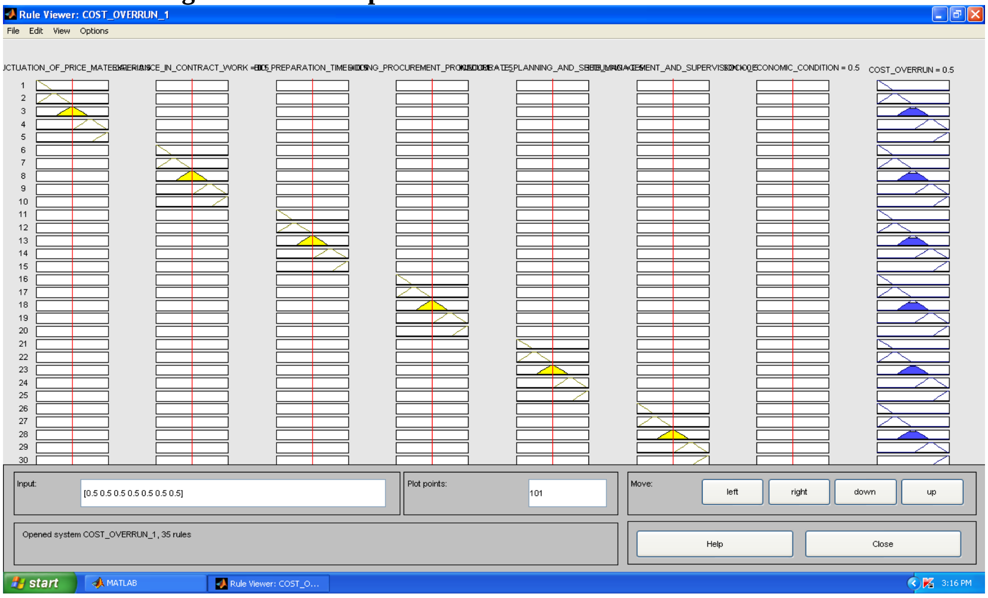

Fig. 8 : Defuzzification process for the cost assessment model

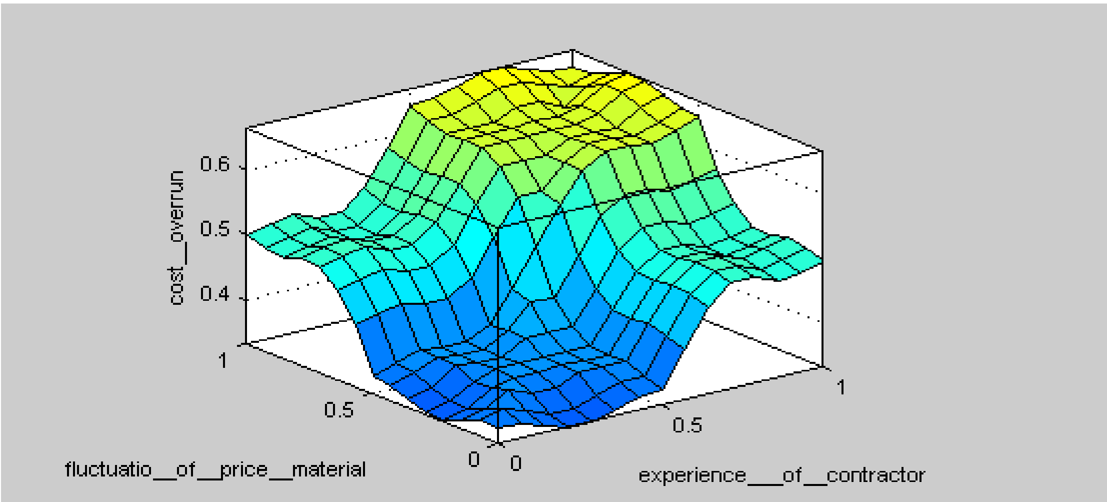

Fig.9: Variation of fluctuation of price material and experience of contractor with respect to cost overrun

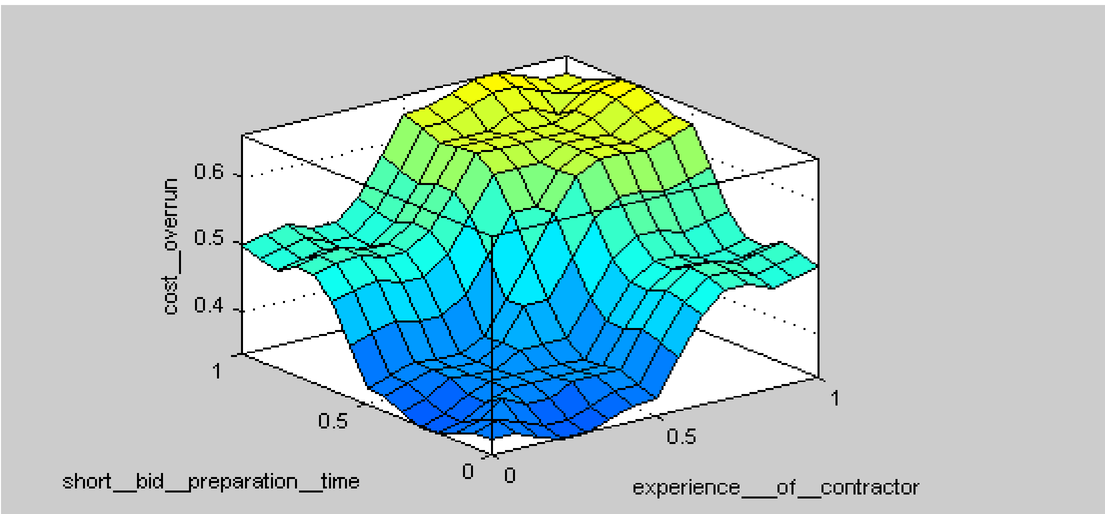

Fig.10: Variation of short bid preparation time and experience of contractor with respect to cost overrun

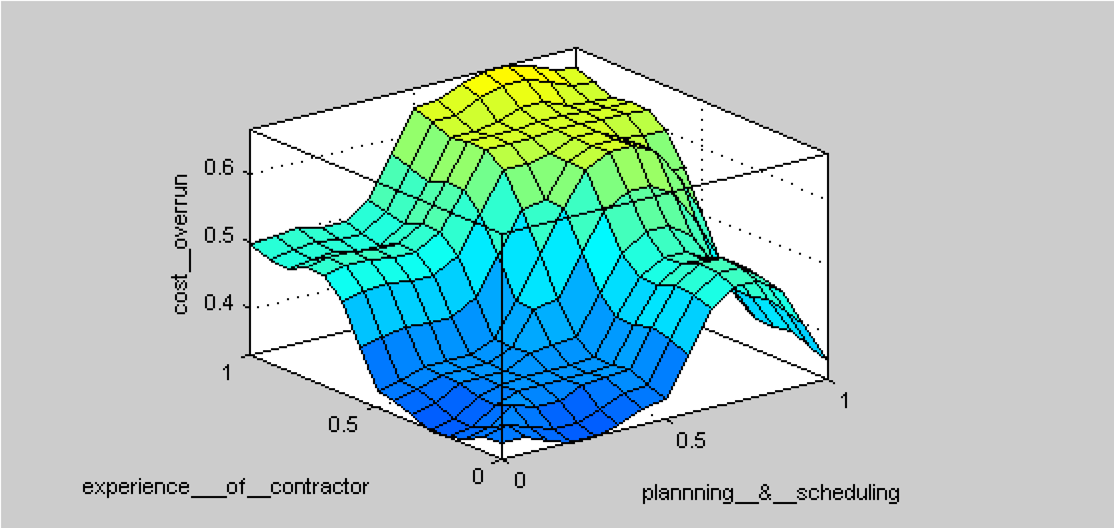

Fig.11: Variation of experience of contractor and planning and scheduling with respect to cost overrun