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Cost Overrun Prediction of Road Construction Project Using MATLAB Software

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Abstract - *The aim of this paper is to propose a model for predicting cost overrun in road construction projects using fuzzy logic. A questionnaire survey in Indian construction industry was conducted for data collection to calculate Relative Importance Index (RII) of the factors. On the basis of the relative importance index of the factors and clusters, a model is developed using the fuzzy logic tool box of MATLAB program software. The model shows graphs of variation of cost overrun for different combination of cost overrun factors. Finally, model validation is done using case study.*

Key Words: Construction industry, Cost overrun, Relative Importance Index, Fuzzy Logic System

1. INTRODUCTION

Construction industry is considered to be as the largest industry and also it includes many other types. Construction industry sectors are categorized into Building construction (residential and non-residential), Infrastructure construction, and Industrial construction. Cost overrun, also known as a cost increase or budget overrun, involves unexpected incurred costs. When these costs are in excess of budgeted amounts due to an underestimation of the actual cost during budgeting, they are known by these terms. While in construction industry there are many types of mistakes and errors are occurring due to small changes.

MATLAB software providing Fuzzy logic system used for developing a model for analysis. The Fuzzy logic has made many things simpler and helped in saving time, cost and energy.Cost overrun can be predicted using different ways, Fuzzy logic system is used for analyzing cost overrun of a project.

2. METHODOLOGY

In this, the methods and steps used for the work are explained.

- Deciding cost overrun factors through a detailed literature and preparing a questionnaire for rating factors.
- Selection of topmost cost overrun factors by ranking them using Relative Importance Index (RII) method.
- Applying fuzzy logic technique for the development of cost overrun assessment model using fuzzy toolbox of MATLAB program software.
- Validation of model by applying it to a case study.

2.1 Questionnaire survey

In this research, 21 factors responsible for cost overrun in highway construction projects are identified through vast literature survey. A Questionnaire form which is consisting of factors has been developed. This was aimed to obtain information about causes of cost overrun in road construction industry. It was asked to rate those initially identified 21 factors according to their severity level on the given scale i.e. 1- Very low effect 2-Low effect 3-Medium effect 4-High effect

2.2 Relative Importance Index (RII)

The relative importance index (RII) is calculated by using the relation given below:

$$RII = W/AXN$$

Where

W is the weighting given to each factor by the respondent (ranging from1 to 4),

A is the highest weight and N is the total number of respondent.

e.g. Considering factor Material related problem,

$RII = 73/4X20 = 0.9125$

Relative importance index for all 21 factors are calculated and tabulated in descending order of RII. Table1 shows the causes rearranged in descending order according to their corresponding RII.

COST OVERRUN FACTORS	RII	RANK
Material related problems	0.9125	1
Time	0.9	2
Financial status of contractor	0.8875	3
Road length	0.875	4
Drainage problem	0.8625	5
Payment related problem from owner side	0.825	6

Table -1: list of identified top six important cost overrun factors

2.3 Fuzzy logic system

The term "fuzzy" refers to the fact that the logic involved can deal with concepts that cannot be expressed as the "true" or "false" but rather as "partially true". A fuzzy logic system (FLS) can be defined as the nonlinear mapping of an input data set to a scalar output data. A FLS consists of four main parts: fuzzifier, rules, inference engine, and defuzzifier. Firstly, a crisp set of input data are gathered and converted to a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. This step is known as fuzzification. Afterwards, an inference is made based on a set of rules. Lastly, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the defuzzification.

1) Analysis steps for the model development using fuzzy toolbox of MATLAB software. To develop the model, following steps are performed on fuzzy logic tool box of MATLAB.

(i) Construct a six 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.

(ii) Membership functions of 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 248 rules are constructed in the form of IF-THEN

(iv) The relative importance indices (RII‟s) of cost overrun factors are assigned as weight to the fuzzy rules to develop the assessment model to estimate the probability of cost overrun.

2) Cost Overrun Prediction Model using Fuzzy toolbox of MATLAB software.

Development of cost overrun assessment model in fuzzy Inference system involves steps such as FIS editor, membership function editor, Formation of rules (Rules editor), Weighing of rules and defuzzification.

a) Fuzzy Inference Editor
The FIS Editor displays general information about a fuzzy inference system. In this step, input and output parameters are fixed. We have considered six input and one output system. So from edit option, six inputs are added. Editing and nomenclature of each of six inputs and single output is done. Thereafter, file is saved by exporting it to workspace. In this way, FIS editing is completed. Mamdani and sugeno are two types of inference systems used. Mamdani type of inference system is used here. FIS editor from fuzzy toolbox is shown in the figure 1.

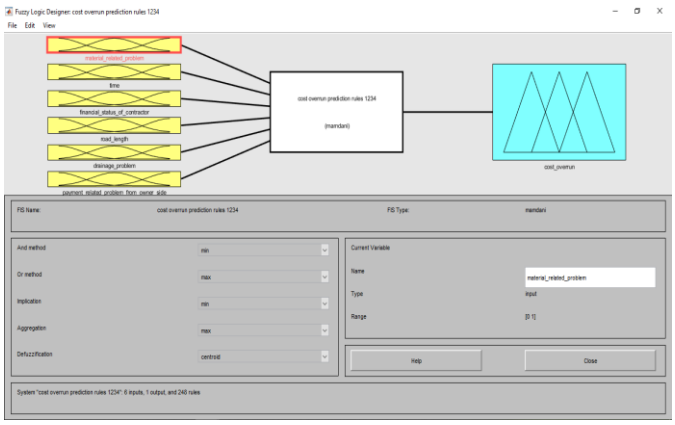

Fig -1: Fuzzy Inference Editor

b) Membership Function Editor
The Membership Function Editor is the tool that lets you display and edit all of the membership functions associated with all of the input and output variables for the entire fuzzy inference system. Membership function editor from fuzzy toolbox is shown in the figure 2.

Fig -2: Membership Function Editor

c) Rule Editor

At this point, the fuzzy inference system has been completely defined, in that the variables, membership functions, and the rules necessary to analyze cost overrun are in place. Total 248 rules are created using all six input variable factors and one output variable. While creating rules, as maximum as possible possibilities and combinations of input variable factors are taken as uncertainty involved is maximum. While inserting rules by combination of two input variable factors, assign weight as average of relative importance index of both the factors.

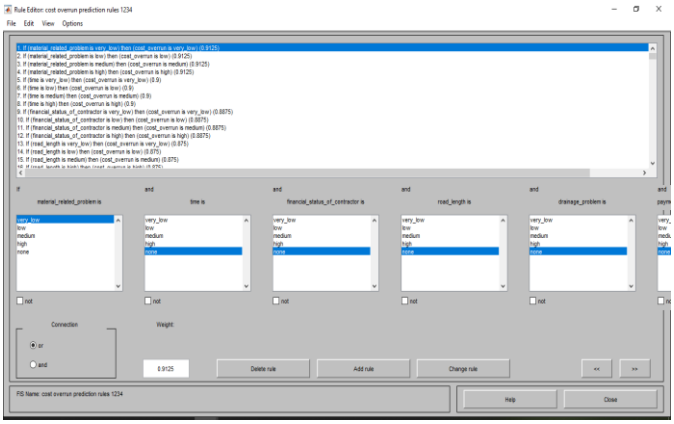

Fig -3: Rule editor

d) Rule Viewer
The Rule Viewer displays a roadmap of the whole fuzzy inference process. It is based on the fuzzy inference diagram described in the previous section. The Rule Viewer allows you to interpret the entire fuzzy inference process at once. The Rule Viewer also shows how the shape of certain membership functions influences the overall result.

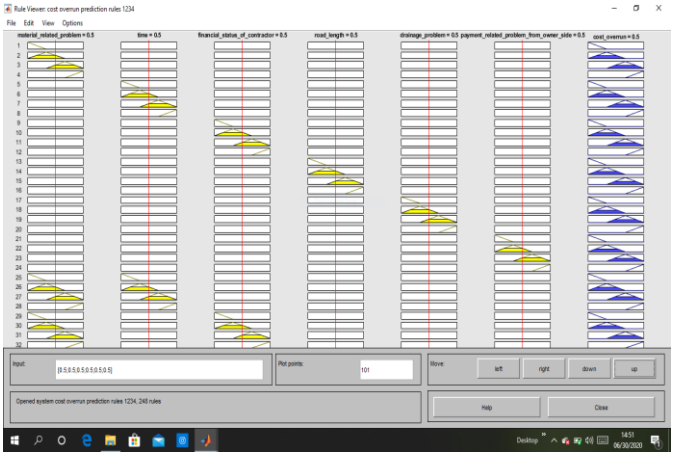

Fig -4: Rule Viewer

e) Surface Viewer
In surface viewer, we can see variation of any two cost overrun factors acting in combination with respect to cost overrun

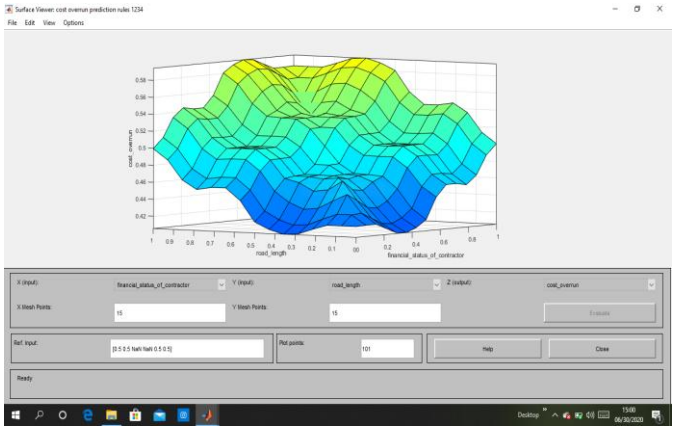

Fig -5: Surface Viewer

3) Model Validation
Model validity concerns the degree to which the variables, as measured by the research reflects the hypothesized construct. A detailed case study analysis of road construction project is carried out to validate the survey findings on most significant factors contributing to cost overrun. The completed road construction project located in Malappuram district.
Following are the major factors due to which project suffered cost overrun with the percentage loss caused by each factor.

i) Specification change- 20%
ii) Delay of approving design document during construction by consultant-15%
iii) Contractor or subcontractors problems- 9%
iv) Payments delay- 3%

3. RESULTS AND DISCUSSIONS

Results obtained by implementing the developed model to a case study. Results show that for different Percentage loss of each of the input variable i.e. factors responsible for cost overrun, the increase in estimated cost of the project (cost overrun) in percentage can be found out. This model gives us prediction about cost overrun due to worst activity of different factors. The estimated cost of project would have been predicted as 11.5 %.

In table 2 all the information regarding project such as estimated and final cost of the project, cost overrun estimated by the application of developed model to the mentioned state highway project and actual cost overrun is tabulated. Percentage error between estimated cost overrun and actual cost overrun is calculated as 9.56% which means model can give results with an accuracy of ±5-10%. As estimated cost overrun is less than and close to actual cost overrun, the proposed model holds good for prediction of cost overrun.

Project details	
Type of project	Road construction
Specification change	20 % loss
Delay of approving design documents during construction by consultant	15% loss
Contractor or subcontractor problems	9% loss
Payments delay cost	3 % loss
Estimated cost of Project	Rs.15000000
Final Cost of Project	Rs.16900000
Cost Overrun (estimated)	11.5%
Cost overrun (actual)	12.6%
% error=[(Actual-Estimated)/Estimated]x100	9.56%

Table -2: Final results of a case study

4. CONCLUSION

Cost overrun phenomenon is very common in road construction industry. Only some projects are completed within the budget. To avoid construction cost overrun, there is need to develop a cost overrun prediction/assessment model as a decision support tool for the project managers, cost estimators for the construction projects before bidding stage. The fuzzy logic has a great prediction capability given by many researchers; it has bright scope in civil engineering research (optimization).

1) Cost overrun can be estimated at the planning stage itself and suitable preventive measures can be adopted to overcome the situation and to avoid serious consequences.
2) The factors that are responsible for increase in cost are identified in this report. The percentage of affectability of factors changes from project to project. So for different projects, this model can be applied effectively only by allocating value of RII corresponding to factors considered keeping all parameters same.
3) The fuzzy logic handles the uncertainties which reside during construction projects and it can handle multiple inputs easily and quantify more realistically the classical problem analysis.
4) One of the shortcoming of this method is that as fuzzy rules are based on expert judgement and literature survey findings, it is clear that a completely different model may be proposed by other researchers based on different expert opinions.

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