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Analysis of time overrun for flyover Bridge construction project in Indore using Fuzzy Logic

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Abstract—

Bridges Construction industry is measured as one of the most dynamic and risky industrial sector. Many bridge construction projects do not attain all their desired goals due to the presence of risks and uncertainties intrinsic in the project. Project failure takes place in terms of project delay, cost over runs and poor quality. This study aim to identify and analyze the major time delay factors for the bridge construction projects in Indore. A fuzzy logic based models were used for estimating time delay in bridge construction projects. The model use fuzzy set theory by taking into account the delay factors characterized in bridge construction projects. The developed models were applied on three fly over bridge construction projects in Indore. The model was calibrated for Kesarbagh Railway over bridge, validated for Rajendra Nagar Railway over bridge and testing on Teen Imli flyover bridge project.

The performance of the developed model was evaluated by comparing the predicted time delay by the model to the actual time delay. For the time delay model the prediction error was 7.25 % and 1.66% for Kesarbagh and Rajendra Nagar respectively. The fuzzy logic model tested for the ongoing Teen Imli flyover bridge. The estimated project completion time was 2 years whereas, the model predicted completion time was 4 year 5 months.

Keywords— Uncertainties ;Delay; RII scale.

I.INTRODUCTION

The Indian construction industry contributes more than five percent (5%) to the country's Gross Domestic Product (GDP). Construction industry includes highways, railways, ports, bridges, power plants, tunnels, municipal facilities etc (Maheshwari and Latha 2015). Timely completion of construction projects is a display of efficient planning, management and construction. A project is considered to be successful if it is completed on time and within budget. Normally, when the projects are overdue, they are either extended or accelerated and therefore, incur additional cost. To the dislike of owners, contractors and consultants many projects experience extensive time delay and thereby go over initial time and cost estimates. Bridg Construction industry is considered as one of the most dynamic and risky industrial sector. Many bridges 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 overruns and poor quality. Timely completion is seen as one of the important criteria of the bridges project success. Delay in completion of the project is a common problem in construction bridge preconstruction phase which is defined as the beginning from the origin of the project to the signing of the contract between the owner and the contractor however; some of them may occur in the construction phase that is the period when actual construction is in progress. These delays certainly create negative impacts on project performance. There are various methods available for delay analysis like Delphi survey method, additive approach of delay analysis method fuzzy theory etc. However, different analysis techniques provide different results for the same circumstances depending on the time and resources available for the analysis and the accessibility of project control documentation. Factors affecting time overrun for the flyover construction projects were analyzed using questionnaire survey and literature review.

Literature on time delay is very limited. Many of the factors that affect time delay have been identified and studied. Project management during the design phase is under-researched compared to the amount of research that has been done on project tracking, monitoring and control for the construction phase of a project. Various researchers has gone through various model for predicting time delay for their models some of them are: reported that construction delay was a main problem in huge construction industry (Afshari et al.,2011 & Haseeb et al., 2011).

Delays in construction projects using Fuzzy Logic technique. Delays in construction projects are expected and may result in claims and disputes among different construction projects analyzed by Singh and Trivedi (2012). Projects investigation included residential, office and administration buildings, and roads. A questionnaire survey was conducted to solicit the causes and effect of delay from consultants and contractors' viewpoint. The highlighted factors need to reduce delays by client, consultants and contractors (Pourrostam and Ismail 2012). The time performance of road construction projects in the West Bank in Palestine. They identified the causes of delay and their severity according to contractors and consultants through a questionnaire survey (Mahamid et al. 2012).

II. STUDY AREA

Case-I: Kesar Bagh Flyover Bridge:

The Kesar Bagh Bridge is a continuous span girder bridge. The work on the bridge started at 16 July 2007 to connect Annpurna Nagar with Keshar Bagh and Bhawarkuan area. The length of the bridge is 800 meter with 10 piers. The bridge was expected to complete in15 July 2008 and it gets completed till December 2015 and cost of the project has escalated from Rs 21.5 crores to Rs 36 crores. Till now IDA has extended the timeline of the work for 11th time, every time they give extension of three months. In last eight years Indore Development Authority (IDA) missed 11 deadlines and despite this it failed to construct 800 meter long Keshar Bagh Bridge to connect eastern part of the city with western parts causing huge inconvenience to the residents. IDA even missed the deadline of November 30, 2014 set by Indore bench of Madhya Pradesh High Court on the public interest litigation (PIL) of the residents and given yet another extension of three months to the contractor. Following in December 2014 the residents filed a contempt petition against IDA, railway, contractor and station government. On 19 December 2014, Friday IDA and state government filed their reply before Justice S Waghmare but the company, which has got the contract for construction of the bridge, failed to file their reply and no one from the company or its lawyer appear in court during hearing, irked with this HC issued contempt notice to the contractor company giving two week time. Petitioner Sanjay Kamle said still large amount of works is pending and they are not even complying by the order of the court.

Case-II: Rajendra Nagar Flyover Bridge:

The Rajendra Nagar Railway over bridge is a continuous span girder bridge. Rajendra Nagar Railway over bridge has two lanes 40 meter wide and 1000 meter long and 24 piers. The Rajendra Nagar Railway over bridge conceived in 2009 and first tender for the project issued in 2010. The work on the bridge started in 2010 to connect Annapurna Nagar with AB road and ring road area. The proposed total project cost is Rs 37 cr. the project has escalated from Rs 37 crores to Rs 41 crores.The first project deadline was given dec.-2013. It was not completed so given new deadline- July 2014. The railway over bridge is a busiest junction for heavy vehicles passing round the clock, and this frequent vehicular movement near construction site also adds to delay. One side of the bridge was opened for traffic recently and given the pace at which works are going on the project. It might easily take another six months for completion. The bridge was expected to complete in 2013 but it delayed by 2 years. It was completed before six month and open for everyone. Rajendra Nagar railway over bridge was delay two years and also overall cost escalates from Rs 37 crores to Rs 41 crores.

Case-III: Teen Imli Flyover:

The Teen Imli Flyover Bridge is a continuous span girder bridge. The length of bridge is 700-metre Two-lane Bridge and number of piers are 8 at Teen Imli Flyover Bridge. Initial construction clearance of teen Imli Flyover Bridge on Eastern Ring Road was given in February 2011. A year later, in March 2012, the state government cleared financial decks for the project. Finally, the project took off in February 2013 and was slated to be finished by February 2015. But in March 2014, an accident led to collapse of the bridge, which added to the delay. 'It was a human error, which led to the collapse," claimed a committee set up to probe the accident. As per the personnel communication with RN Mishra, an executive engineer of public works department, the clearances of funds, availability of construction site are major hindrances for timely completion of the project. The Teen Imli square is a busiest junction for heavy vehicles passing round the clock, and this frequent vehicular movement near construction site also adds to delay, one side of the bridge was opened for traffic recently and given the pace at which works are going on the project. It might easily take another six months for completion.

III. METHODOLOGY

The methodology used to analyze time delay explains how the problem was investigated and describes the tools which were used to undertake the investigation. The time delay factors are identified through the extensive literature review, with the help of expert's opinion, interviews and questionnaires. These time delay factors are then ranked and assessed for their importance index.

Identification of factors affecting time delay:

The following methodology is used to identify factors affecting cost overrun and time delay:

1. A thorough literature review was done and the expert opinions from industry experts were taken, through which a number of time delay factors were identified for the fly over bridge construction projects. In total 94 factors of time delay were finalized to make part of the survey questionnaire.
2. A questionnaire form which consists of two parts A and B was been developed. In Part A contains personal Information of the respondents (for e.g. work experience, organization, annual volume of construction work). Part B was aimed to obtain information about causes of time delay Indore bridge construction industry. It was asked to rate those initially identified 94 factors of time delay according to their severity level on the given scale, Indore bridge construction site have been approached for this study. A total of 60 respondents were selected for the survey. (20 Site engineer, 10 contractors, 10 Govt.Engineer, 8 consultants, 12 Academician).
3. Ranking of factors were done using RII (Relative importance index) using the assessment of feedback from questionnaire survey.

Ranking of time delay factors

Data collection was carried out by conducting a questionnaire survey for identifying significant factors affecting flyover bridge construction projects. 94 delay factors were identified initially, through detailed literature review and interviews with experts in the construction industry. A total of 60 respondents participated in the survey process. The questionnaire survey was filled by different experts of fields like Field engineer, Consultants which were identified factors affecting time delay in the construction projects.

A five point like scale ranging from 1-5 was adopted to assess the degree of agreement of each factor Where 1 means strongly agree, 2 means Agree 3 means Neither; 4 means Disagree and 5 means Strongly disagree.. This five-point scale was converted to a Relative Importance Index (RII) for each individual factor, using the following formula, as adopted by (Chan and Kumaraswamy 1997, 1998) and (Assaf et al 1995).

$$(RII) = \Sigma W / (H \times N) \qquad (1)$$

Where ΣW is the total weight given to each factor by the respondents, which ranges from 1 to 5 and is calculated by an addition of the various weightings given to a factor by the entire respondent, H is the highest ranking available (i.e. 5 in this case) and N is the total number of respondents that have answered the question. The RII value range from 0 to 1 (0 as not inclusive); and the higher the RII, the more important is the cause of the delays.

Fuzzy logic model to analyze of delay factors:

The constructed fuzzy assessment model was developed by using the fuzzy logic toolbox of the MATLAB program software. To construct the proposed fuzzy assessment model to be used in estimating the time delay, the following steps were followed:

1. The delay factors and groups which were identified in the previous sections were the main input variable of this assessment model.
2. The linguistic variables and fuzzy membership functions were determined.
3. The fuzzy rules (if-then rules) were constructed; the relative importance indices of the factors and groups of factors given in previous section were selected as the weights of the fuzzy rules; and the aggregation and defuzzification methods were determined to construct the fuzzy assessment model to estimate time delay.
4. The constructed fuzzy assessment model was calibrated on Kesarbagh railway over bridge. The model was validated and tested on Rajendra Nagar Railway over bridge and Teen Imli flyover bridge projects in Indore.

IV. RESULTS AND DISCUSSION

Time Delay Analysis

Fuzzy logic model for predicting time delay- A fuzzy logic model was developed to predict time delay. For the model, a Mamdani inference engine with a triangular membership functions was used Five fuzzy subsets namely, very low (VL), low (L), medium (M), high (H) and very high (VH) were used. Sensitivity analysis was used to select the topmost factors affecting time delay. The fuzzy model was calibrated for Kesarbagh Bridge; the model was validated for Rajendra Nagar railway over bridge and the model was tested for Teen Imli Flyover Bridge.

Sensitivity analysis for time delay:

Initially total 94 factors affecting time delay were established form the literature review. Prior to selecting the number of time delay factors for the fuzzy logic model, a sensitivity analysis was conducted. The factors affecting the time delay were varied from 5-8 and the error in the simulated time delay was computed. The number of factors which gave minimum error was selected. Table-I shows the results of sensitivity analysis for the Kesarbagh Bridge For the project, the estimated time of the completion was 3 year, but it took 8 years to get constructed therefore it had a time delay of 5 year. According fuzzy theory prediction if we consider five factors, the percentage error was 20.75%. If we consider six factor percentages error reduced to 17.72%. For seven factors the error was 14.50%. If we consider eight factors fuzzy prediction time delay was 8 year 7 month and error was giving a percentage error of 7.25%. Based on Fuzzy analysis for time delay, out of the 94 time delay factors, eight topmost factors which minimize the percentage error was selected and are shown in Table I

TABLE- I SENSITIVITY ANALYSIS FOR TIME DELAY FACTORS USING FUZZY MODEL.

Sr. No.	Factor's	Project Name	Estimated time	Actual time(A)	Time delay	Fuzzy Prediction For time delay(B)	Error (A-B)	Error in Percentage (%)
1	V	Kesharbagh Railway over bridge	3 year (2007-2010)	8 year (2007-2015)	5 year (2010-2015)	9 year,8 month	1 year,8 month	20.75%
2	VI					9 year,5 month	1 year,5 month	17.62%
3	VII					9 year,2 month	1 year,2 month	14.50%
4	VIII					8 year,7 month	7 month	7.25%

TABLE- II. TOP 8 MOST IMPORTANT FACTORS AFFECTING TIME DELAY OF BRIDGE CONSTRUCTION

Time delay using fuzzy controller:

The main causes of time delay are studied in this work, a fuzzy controller was used to analyze and predict the time delay based on the top eight factors. The five input and one output fuzzy based delay is discussed here. Table-III shows the sample fuzzy rules for the time delay assessment model for the rule weight very low. Table-IV shows sample fuzzy rules for the time delay assessment model and rule weight for the rule weight low. Table-V shows sample fuzzy rules for the time delay assessment model and rule weight for medium. The eight top most factors are used as inputs and delay as output of the fuzzy controller.

Sr. No.	Factors Causing Delays	RII	Rank
1	Incompetent project team	**0.953**	**1**
2	Financial problems (delayed payments, financial difficulties, economic problems) and Poor quality of construction material	**0.927**	**2**
3	Inadequate Project Planning/scheduling and Delay in approving design document	**0.920**	**3**
4	Poor site management/supervision and Lack of modern equipment	**0.910**	**4**
5	Delay in forwarding material and equipment to the site	**0.903**	**5**
6	Inadequate contractor experience	**0.897**	**6**
7	Original contract duration is too short	**0.893**	**7**
8	Low productivity level of labors and Unexpected surface and subsurface conditions.	**0.887**	**8**

TABLE- III. SAMPLE FUZZY RULES FOR THE TIME DELAY ASSESSMENT MODEL AND RULE WEIGHT FOR VERY LOW

Sr. No.	Rules	Rule Weight
1	If the probability of Incompetent project team is very low the Time Delay is very low	**0.953**
2	If the probability of Financial problems (delayed payments, financial difficulties, economic problems) and Poor quality of construction material is very low the Time Delay is very low	**0.927**
3	If the probability of Inadequate Project Planning/scheduling and Delay in approving design document is very low the Time Delay is very low	**0.920**
4	If the probability of Poor site management and supervision and Lack of modern equipment is very low the Time Delay is very low	**0.910**
5	If the probability of Delay in forwarding material and equipment to the site is very low the Time Delay is very low	**0.903**
6	If the probability of Inadequate contractor experience is very low the Time Delay is very low	**0.897**
7	If the probability of Original contract duration is too short is very low the Time Delay is very low	**0.893**
8	If the probability of very low productivity level of labors and Unexpected surface and subsurface conditions is very low the Time Delay is very low	**0.887**

TABLE- IV. SAMPLE FUZZY RULES FOR THE TIME DELAY ASSESSMENT MODEL AND RULE WEIGHT FOR LOW

Sr. No.	Rules	Rule Weight
1	If the probability of Incompetent project team is Medium the Time Delay is Medium	**0.953**
2	If the probability of Financial problems (delayed payments, financial difficulties, economic problems) and Poor quality of construction material is Medium the Time Delay is Medium	**0.927**
3	If the probability of Inadequate Project Planning/scheduling and Delay in approving design document is Medium the Time Delay is Medium	**0.920**
4	If the probability of Poor site management and supervision and Lack of modern equipment is Medium the Time Delay is Medium	**0.910**
5	If the probability of Delay in forwarding material and equipment to the site is medium the Time Delay is medium	**0.903**
6	If the probability of Inadequate contractor experience is medium the Time Delay is medium	**0.897**
7	If the probability of Original contract duration is too short is medium the Time Delay is medium	**0.893**
8	If the probability of Low productivity level of labors and Unexpected surface and subsurface conditions is medium the Time Delay is medium	**0.887**

Model calibration for Kesarbagh railway over bridge:

The fuzzy model was calibrated for the Kesarbagh railway over bridge. The estimated time of completion of project was obtained through interviews, discussions with construction managers and detailed study of project documents and contracts. Table-V shows the performance of the fuzzy logic model For the project, the estimated completion time was 3 year whereas; the actual completion time was 8 year thus having a time delay of 5 years. The completion time predicted by the developed fuzzy logic model was 8 year, 7 month .Predicting a percentage error of 7.25%.

TABLE- V. PERFORMANCE OF THE PROJECT

Sr.No	Project Name	Estimated time	Actual time(A)	Time delay	Fuzzy Pediction For time delay(B)	Error (A-B)	Error in Percentage (%)
1	Kesharbagh railway over bridge	3 year (2007-2010)	8 year, (2007-2015)	5 year* (2010-2015)	8 year, 7 month** (Aug2017)	7 month	7.25 %

*The bridge construction got complete in December 2015.

** The bridge got complete due to verdict of Hon. High court of M P bench at Indore so is complete before time expected.

The surface view of the Kesarbagh railway over bridge was used to understand the variation between two inputs to the output factor. The quantization factor and the scaling factor play a significant role in the performance of the fuzzy controller.

Model validation for Rajendra Nagar railway over bridge:

The fuzzy model was validated for the Rajendra Nagar Railway over bridge. Table- VI shows the performance of the fuzzy logic model For the project, the estimated completion time was 3 year whereas; the actual completion time was 5 year thus having a time delay of 2 years. The completion time predicted by the developed fuzzy logic model was 5 year, 1 month predicting a percentage error of 1.66%.

TABLE- VI. PERFORMANCE OF THE PROJECT CONSIDERED FOR VALIDATION.

Sr. No	Project Name	Estimated time	Actual time(A)	Time delay	Fuzzy Prediction For time delay(B)	Error (A-B)	Error in Percentage (%)
1	Rajendra Nagar Railway over bridge	3 year (2010-2013)	5 year (2010-2015)	2 year (2013-2015)	5 year, 1 month	1 month	1.66%.

Model Testing for Teen Imli Flyover Bridge:

The fuzzy model was tested on the Teen Imli Flyover Bridge Table- VII shows the performance of the fuzzy logic model For the project, estimated completion time was 2 year, whereas; the actual completion time and time delay was not available as the project is still in the running phase. The fuzzy prediction time is 4 year, 5 month and the percentage error was not computed.

TABLE- VII. PERFORMANCE OF THE PROJECT CONSIDERED FOR TESTING.

Sr. No	Project Name	Estimated time	Actual time-(A)*	Time delay*	Fuzzy Prediction For time delay-(B)	Error (A-B)*	Error in Percentage *(%)
1	Teen Imli Fly over bridge	2 year (2012-2014)	N.A.	N.A.	4 year 5 month (May2017)	N.A.	N.A.

***** Was not available as the project is still in the running phase

From various factors affecting the time delay we have selected 94 time delay factor we ranked them using RII and selected the top most eight factor with higher RII values. The eight affecting factors to the time delay are Incompetent project team –design watch, proper understanding of project, proper execution of work the following problem also appeared in previous studies Sharma &Goyal (2015). Financial problems & Poor quality of construction material –prices hike of material and labor wage, issue between contractor and owner ,external calamities are various issues which are dealt by us and also discussed by various researchers (Shreenath et. al. 2015). Inadequate Project Planning and scheduling and approving design document-proper planning of delay, proposed work is not done due to which proper execution of the work done not take place design approval validation was not done on time due to which how much to construct and what to construct will not be decided which causes further delay in the project (Pourrostam and Ismail 2012). Poor site management/supervision and Lack of modern equipment-improper utilization of recourses will lead to several issues on site like lack of skilled worker for same machine or lack of modern machine equipment for same skilled persons the following problem also appeared in previous studies (Pourrostam and Ismail 2012). Delay in forwarding material and equipment to the site-as contractor did the delay for providing material and equipment to the site due to any reason will lead to time delay of the project as it increases time to get the project completed (Sharma &Goyal 2015).

V CONCLUSION

This study identifies the factors affecting time delay occurs in bridge construction projects. There are 94 factors of delay which are accountable for the time delay in the construction industries was prepared based on data collection, questionnaire survey and by conducting interviews. A fuzzy logic based models were used for time delay in bridge construction projects. The model use fuzzy set theory by taking into account top eight delay factors characterized in bridge construction projects. In fuzzy logic controller, all membership functions are considered as triangular membership functions with five segments. The developed models were applied on three fly over bridge construction projects in Indore. The model was calibrated for Kesar Bagh Bridge and validated on Teen Imli Bridge & Rajendra Nagar bridge project. Based on the above analysis following conclusions were derived.

1. Based on the literature survey the main causes of time-delays were changing orders, owner's financial constraints and owner's lack of experience in the construction business. Factor affecting time delays were ranked according to RII. According to RII the most important factor affecting delay is incompetent project team, which is flowed by financial problems (delayed payments, financial difficulties, and economic problems) and poor quality of construction material. .
2. A detailed case study analysis of three fly over bridge (Kesar bagh Bridge, Teen Imli Bridge & Rajendra Nagar bridge) construction projects are carried out to validate the survey findings. The fuzzy logic model to predict the time delay for three flyover bridges namely Kesarbagh railway over bridge, Rajendra Nagar railway over bridge and Teen Imli Flyover Bridge. For the time delay model the prediction error was 7.25 % and 1.66% for Kesarbagh and Rajendra Nagar respectively.
3. The fuzzy logic model tested for the ongoing Teen Imli flyover bridge. The estimated project completion time was 2 years whereas, the model predicted completion time was 4 year 5 months.

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