iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: VII Month of publication: July 2018

DOI: http://doi.org/10.22214/ijraset.2018.7072

Analysis of Construction Delay due to Poor Planning using Fuzzy Logic Technique

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Abstract: Delays in construction projects are unavoidable; as a consequence claims and disputes arise among the various construction parties. Numerous factors can contribute to delays on a project and evaluating the causes of delays is an essential mission for improving any potential conflicts or claims , one of the most influential factors that which relates to poor planning . The terminology of poor planning used in this study means the lack of awareness of contracting companies and project management companies to the concept of planning ,the important of planning as well as the element of effective planning which are represented the main factors of the study. There is an insistent need to estimate the likelihood of delay by applying analysis methods. Many classical techniques and statistical methods were used to delay analysis, despite that, difficulties are still being encountered in construction projects to analysis delay. Therefore, it is important for construction managers to be familiar with the methods leading to analysis delay, using Fuzzy Logic Technique is a method suggested by this study to estimate the likelihood of delay, where fuzzy logic provides a very valuable flexibility for reasoning, which makes it possible to take into account inaccuracies and uncertainties .In the present investigation the model built by Fuzzy Logic Toolbox Mat lab Programing Software to evaluate and rank the factors of poor planning which cause a construction delay. In the first stage a questionnaire was conducted in which 100 construction project managers were asked to give values to the delay causes and factors ranging from 0 to 100, a questionnaire consists of 3 main factors group, of which 10 sub-factors group are subdivided, which in turn are divided into 40 causes .In the second stage the analysis and evaluation of study variables (factors, causes) were conducted using the developed model in which the probability output of delay was founded for each factor and cause for the collected data. The results are clearly provided a good indicator for analyzing the construction delay in the future with high degree of accuracy.. At finally concluded that the developed fuzzy logic model, named Mamdani model is more accurate and simple to use and efficient to analyze the delay in construction projects.
Keywords: Delay Analysis, Poor Planning, Fuzzy Logic Technique, Mamdani model

I. INTRODUCTION

The main problem experienced in construction work is the project delays, which cause projects to take longer time period than scheduled. A construction project is termed successful, when it is completed on time, within budget, and according to specifications. A successful project means that the project has accomplished its technical performance, maintained its schedule, and stayed within budgetary costs, Shruti and Trivedi, (2012) [1].The duration of contract performance has a direct influence on the profitability of construction projects from the perspective of all stakeholders, Nuhu Braimah, (2013) [2]. For project owners, lost profits or benefits prevents them from being able to make use of the project at the agreed date while to the contractors, extra cost will be suffered due to prolonged stay on site. The sole purpose of construction companies is to complete the projects on time and within the expected budget, as construction delays always enlarge project costs, Sweis et al., (2007[3]). Numerous factors can contribute to delays on a project and evaluating the causes of delays is an essential mission for improving any potential conflicts or claims. According to Schumacher , (1996) [4] , most delay claims are complex and where many researchers emphasize the high cost and the associated risk related to litigating delay claims, little emphasize the responsibility for project delays. Many techniques and statistical methods are used to delay analysis such as Relative Important Index (RII) and Important Index (IMPI) consisting of Frequency Index and Severity Index. Fuzzy Logic Technique provides a very valuable flexibility for reasoning, which makes it possible to take into account inaccuracies and uncertainties.

A. Objectives of Study

1) To Study and discuss various factors affecting construction delay due to poor panning in construction industry .
2) To evaluate and rank these factors according to its impact on the probability output of delay
3) To Develop optimization model for analyzing delay of construction project due to poor planning of construction companies using Fuzzy Logic technique.

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II. LITERATURE REVIEW

At the project level , time is frequently used to control performance and its importance can directly affect economic issues (Alwi and Hampson, 2003, Bramble and Callahan, 1992) [5] developed a relevant study that sampled 248 infrastructure projects from 20 nations around the world over a period of 70 years , finding " with very statistical significant , the cost escalation was strongly dependent on the length of the implementation phase". Hanouf AL-Humaidi, (2007) [6], studied a fuzzy logic approach to model delay in construction projects. This study determined that there are different reasons for delays, the identification and classification of these reasons is an urgent need to determine the delay in projects. To make the success of the project the primary requirement, it is necessary to estimate the delay due to various factors in the project .Aladdin AL-Diri, (2011) [7], studied the impact of poor planning on the delay in the implementation of construction projects, the researcher highlighted the impact of poor planning on the delay in the implementation of construction projects in Dubai between 2006 to2010 , also to identify the factors leading to poor planning, which in turn affect the duration of the projects and then delayed its implementation, the researcher was able to prove more than 42 reasons fall under a number of factors all fall under the poor planning in the construction companies and project management companies, which lead to delay the implementation of projects. Shruti and Trivedi, (2012) [1], studied the application of fuzzy logic in delay analysis in construction. And the objective of their research is to propose a schedule delay assessment model using fuzzy logic Toolbox of MATLAB Program Software, where the researchers explained that the delays in construction projects are unavoidable and may bring about outcome in claims and disputes among different construction parties.

General types of construction delays should be clearly examined before schedule delay analysis begins. Schedule construction delays are categorized in many ways. Saad Hegazy , (2012) [8] , according to liability , there are four main groups of construction delays , which are: Excusable or non- excusable ,Compensable or non- compensable, Concurrent or non- concurrent ,Critical or non- critical. Excusable or non- excusable delays may be non-compensable excusable and compensable excusable delays . Non-compensable excusable delays are delays that are not the fault of the owner or the contractor . They are Acts of God or other unforeseeable causes beyond the control of both parties, in which entitle a contractor to an extension of time only compensable. Compensable excusable delays can be delayed that are owner caused and that result in both a time extension and compensation to the contractor. These delays result from circumstances such as : Owner initiated change in work , Owner delays in issuing a notice to proceed , Architect/ Engineer supplied design which are defective , etc. Non-excusable Delays : Non- excusable delays can be attributed to the actions, or inaction of the contractor. Some of the more common contractor caused delays include : Failing to mobilize work crews and start the work in a timely manner , Failure to submit shop drawings and related materials to the owner for approval in a timely manner, poor workmanship , etc. on a typical construction project , delays do not always fall into one of the three previous categories, but quite often there are multiple factors that cause or contribute to delays. When more than one cause results in a delay to a project during the same time period the project is said to have incurred concurrent delays. Critical activity is one without any slack (or float). Any delay to a critical activity will produce a delay in the project's final completion date. A non-critical activity will not affect the project's final completion date .

III. METHODOLOGY AND MODEL DEVELOPMENT

A. Methodology

The study methodology can be divided into 3 main steps as illustrated in the following:

The field study and its procedures represented by the study society, the sample of the study, the distribution of the sample members according to the personal variables and the design of the research form (Questionnaire). As for this study, the researcher adopted the method of Steven Thompson ,. 1987[9] , to calculate the size of the sample as shown in Eq. 4.1.

$$\mathbf{n}= \frac{N\times p(1-p)}{[N-1\times(d^2\div Z^2)]+p(1-p)} \quad \text{…………………………………………..4.1}$$

Where: (N) represented population size = 200 (where the number represents the number of engineers working as project managers at the level of Iraq and registered in the Engineers Union Babel Branch. (Z) Represents standard value corresponding to confidence level at 95% = 1.96, (d) Represented proportion error = 0.05 ,(p) Represented the probability = 0.50 , (n) Represented sample size, where by compensated the values of the variables above in the equation we obtain the value (n) = 132 .The researcher distributed 150 questionnaire forms in the study community and only 100 forms were retrieved which represent the sample size of the study. The reasons for adopting 100 questionnaire forms only is due to the following reasons: (1) A number of these questionnaires contained a number of errors when filled out by the respondents. (2) A number of these questionnaires contained missing data that were not answered by the respondents and therefore were not approved. (3)As well as because a number of respondents did not return the questionnaire when returning for the purpose of recovery, and this may be attributed to the lack of culture and sense of responsibility.

B. Model Development

There are three types of fuzzy inference systems that are essentially dependent on the output part of the rules in them, which are Mamdani model and Tagagi-Sogeno model as well as the simple model. Since the type of inference Mamdani system is widely accepted and appropriate for human entries so this type have been adopted in this study. The process of model configuration by Fuzzy Logic Toolbox of MATLAB Program (2016a) can be illustrated in the following, as a Fig 1.

1) *FIS Editor:* It means Fuzzy Inference System Editor, which include input and output naming as well as entering the filename, this is done after selecting the type inference system. As shown in Fig. 2 .
2) *Membership Function Editor:* At this stage of model development the linguistic terms of the factors, causes and probability output of delay are converted into numerical values, thus making it easy to deal with the program.
3) *Rule Editor:* This phase involves editing the model rules for the input and output variables using the base (if – then), and the connection tools (and, or). 21 rules were written to cover the variables of study and in proportion to the functions of membership in these variables
4) *Rule Viewer:* In this window, the rules are displayed in the graphic forms, and at the bottom is a place to enter the values of the variables to obtain the results.
5) *Surface Viewer:* This window shows the input and output variables in the form of a three dimension graphic.

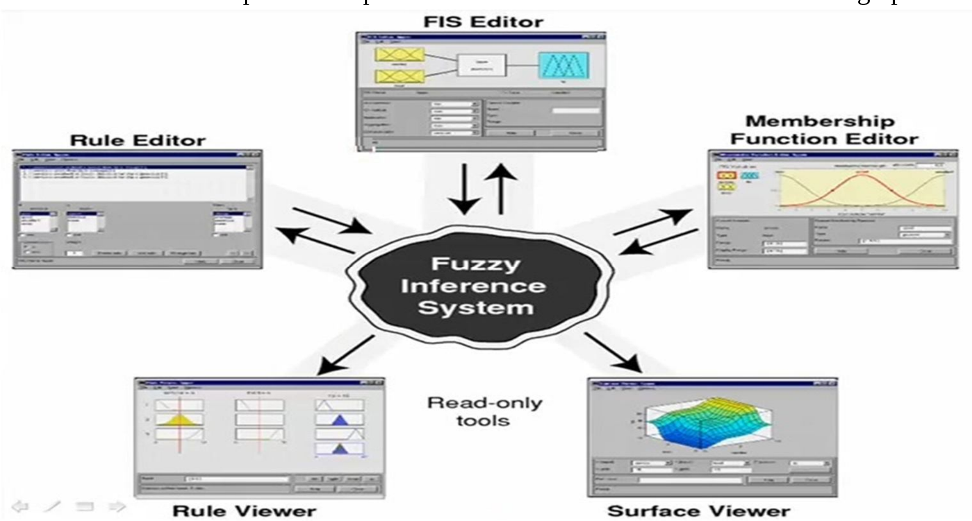

Fig. 1: The Process of Model Configuration by Fuzzy Logic Toolbox of MATLAB Program Software.

IV. CASE STUDY

The project of case study consists of the establishment of 12-class room primary school pre-fabricated steel structure building, which is located at AL- Hilla city, Babylon province in Iraq and it consists of three floors. The project details is following .

Project floors	3 Floors
Area of each floor	489 m^2
Cos of the project *	534,686,400 ID
Project Start Date	11 January 2009
Project schedule to completed	215 days , 13August 2010
The actual execution period	402 days
Duration of the project delay	187 days

an interview was conducted with the engineering staff of the project, to assess the causes of scheduled delays in the project, thereby causing delay in the planned duration of the project. They were asked to fill in the questionnaire and give a value to the delay main factors, as well as to the delay causes related to this factors , ranging from 0 to 100. Taking into account that Least causable factors take the value between (0-40)% , Medium causable factors take the value between (40-70)% and Highly causable factors take the value between (70-100) .Also Very least causes take the value between (0-20)% , Least causes take the value between (20-40)%, Medium causes take the value between (40-60)% , High causes take the value between (60-80)% and Very high causes take the value between (80-100)% .

V. RESULTS AND DISCUSSION

After applying the model established by FLTMPS to the questionnaire survey which was collected from school supervising staff representing the project manager and the resident engineer appointed by the government to follow up the project , the following results were obtained. Note that the first input of the model represents the average of the values entered by respondents for each factor which are :

First factors group “Lack of awareness of construction companies to the concept of planning” : 0.77 (Highly Causable Factor), Second factors group “Lack of awareness of the construction companies to the importance of planning” : 0.56 (Medium Causable Factor), Third factors group “Lack of awareness of contracting companies to the elements of effective planning”: 0.633 (Medium Causable Factor). As for the second input of the model, it represents the average of the values entered by the respondents for causes of delay (probability) as shown in the second column of the Table2.

Table 2: The Results Obtained by Applying FLTMPS.

Causes	Probability	POD
1. Lack of understanding of the nature of the engineering project	0.56	0.584
2. Inability to identify the objectives of the project	0.42	0.546
3. Lack of information needed for the plan and misanalysis of existing data	0.563	0.593
4. Poor experience in developing the project schedule	0.61	0.698
5. Lack of coordination between the planning engineers and the company's management and suppliers and subcontractors	0.52	0.55
6. Difficulty dealing with weaknesses and places of imbalance in the plan.	0.63	0.704
7. Failure to secure the necessary facilities to implement the plan	0.54	0.55
8. Lack of a specialized technical body contributes to the decision-making planning	0.61	0.698
9. Non-delegation of authority to the competent authorities in terms of distribution of work and use of resources to translate the plan into action	0.57	0.611
10. Failure to clarify and explain the plan to the workers and convince them and motivate them to implement	0.59	0.651
11. The Director's weakness in influencing the plan's implementers	0.753	0.706
12. Lack or weakness of the technical staff 's cost to follow up the plan	0.802	0.845
13. Did not update the plan according to the work done and not matching with the original plan.	0.84	0.855
14. Did not review the process of implementation and mismanagement of activities delayed.	0.454	0.55
15. Mishandling of the effects of external conditions in terms of finding alternatives.	0.602	0.695
16. Chaos and improvisation in the implementation	0.55	0.567
17. The contradiction between means and objectives, which leads to the loss of time and money	0.6	0.652
18. Poor planning engineer experience in developing possible future assumptions	0.63	0.704
19. The company's inflexibility in adapting to what is expected to occur.	0.614	0.699
20. Waste of resources due to lack of reliance on scientific methods in the organization of work.	0.733	0.724

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

21. Loss of coordination between the project staff and the various departments in the company.	0.57	0.609
22. Lack of readiness of technical staff in the project to deal with the surprises of work.	0.811	0.848
23. The lack of standards and criteria for measuring the performance of the project.	0.654	0.711
24. The inability to represent the project with a network plan	0.671	0.716
25. The inability to predict the time required to complete or control the project.	0.551	0.57
26. The inability to distinguish between critical and non-critical activities.	0.456	0.556
27. Misrepresentation of the actual cost of the project	0.78	0.724
28. Lack of comprehensiveness of the plan	0.712	0.726
29. Lack of clarity of plan.	0.543	0.576
30. The plan is unrealistic.	0.445	0.553
31. The plan's inflexibility.	0.762	0.734
32. Generalization of the plan, non-specificity and precise formulation of activities.	0.641	0.708
33. Lack of integration and harmony between plans and objectives.	0.822	0.851
34. Non-compliance with the time limit for implementing the activities.	0.57	0.613
35. Not mandatory planning in the company	0.556	0.589
36. lack of commitment of senior management of the company to support and encourage planning .	0.683	0.719
37. The inability of the company to provide the appropriate staff for the planning process.	0.701	0.724
38. Failure to communicate the contents of the plans to the employees and not explain them to them.	0.618	0.700
39. Absence of an incentive system to reward those who participate and commit to planning	0.577	0.623
40. Lack of statistics on planning results in previous projects.	0.577	0.623

By taking the average of probability output of delay for the causes under the main factors and sub- factors, it will get the two Tables 3and 4 as following as.

Table 3 :The Probability Output of Delay for the Main Factors .

Group of Main Factors	Probability Output
Lack of awareness of construction companies to the concept of planning.	0.66
Lack of awareness of the construction companies to the importance of planning .	0.67
Lack of awareness of contracting companies to the elements of effective planning.	0.7

Table 4: The Probability Output of Delay for the Sub- Factors

Symbol	Group of Sub-Factors	Probability Output
A	Lack of experience in preparing the project plan for the causes (1-4).	0.605
B	Lack of confidence in approving the plan for the causes (5-8) .	0.630
C	Poor implementation of the plan for the causes (9-11).	0.66
D	Tolerance in the follow-up implementation of the plan for the causes (12-15).	0.74
E	Waste of time and dependence on chance for the causes (16-17).	0.61
F	Lack of future expectations and surprises at work for the causes (18-20) .	0.71
G	Neglecting technical and administrative advantages of planning for the causes (21-23).	0.68
H	Lack of engineering planning principles for the causes (24-27).	0.675
I	Lack of plan for the elements of success for the causes (28-34).	0.68
J	Weak planning effectiveness for the causes (35-40).	0.70

A. *Discussion of Results of Case Study*

Factors related to the lack of awareness of construction companies to the concept of project planning .

Probability output was calculated as 0.66 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.42 to 0.84, which are represented in the cause # 2 “Inability to identify the objectives of the project” and the cause # 13 “Did not update the plan according to the work done and not matching with the original plan” , respectively. Factors related to the lack of awareness of the construction companies to the importance of planning . Probability output was calculated as 0.67 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.456 to 0.811, which are represented in the cause # 26 “Inability to distinguish between critical and non-critical activities” and the cause # 22 “Lack of readiness of technical staff in the project to deal with the surprises of work” , respectively. Factors related to the lack of awareness of contracting companies to the elements of effective planning. Probability output was calculated as 0.7 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.445 to 0.822, which are represented in the cause # 30 “The plan is unrealistic” and the cause # 33 “Lack of integration and harmony between plans and objectives” , respectively. Sub-factors related to the lack of experience in preparing the project plan for the causes (1-4). Probability output was calculated as 0.605 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.42 to 0.61, which are represented in the cause # 2 “Inability to identify the objectives of the project” and the cause # 4 “Poor experience in developing the project schedule” , respectively. Sub-factors related to the lack of confidence in approving the plan for the causes (5-8). Probability output was calculated as 0.63 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.52 to 0.63, which are represented in the cause # 5 “Lack of coordination between the planning engineers and the company's management and suppliers and subcontractors” and the cause # 6 “Difficulty dealing with weaknesses and places of imbalance in the plan” , respectively. Sub-factors related to the poor implementation of the plan for the causes (9-11). Probability output was calculated as 0.66 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.57 to 0.753, which are represented in the cause # 9 “Non-delegation of authority to the competent authorities in terms of distribution of work and use of resources to translate the plan into action” and the cause # 11 “The Director's weakness in influencing the plan's implementers” , respectively. Sub-factors related to the tolerance in the follow-up implementation of the plan for the causes (12-15). Probability output was calculated as 0.74 showing low- high probability delay level. And the probability input values various from low to high i.e.0.454 to 0.84, which are represented in the cause # 14 “Did not review the process of implementation and mismanagement of activities delayed” and the cause # 13 “Did not update the plan according to the work done and not matching with the original plan” , respectively. Sub-factors related to the waste of time and dependence on chance for the causes (16-17).

Probability output was calculated as 0.61 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.55 to 0.6, which are represented in the cause # 16 “Chaos and improvisation in the implementation” and the cause # 17 “The contradiction between means and objectives, which leads to the loss of time and money” , respectively. Sub-factors related to the lack of future expectations and surprises at work for the causes (18-20) . Probability output was calculated as 0.71 showing low- high probability delay level. And the probability input values various from low to high i.e.0.63 to 0.733, which are represented in the cause # 18 “Weak experience of planning engineer in developing possible future assumptions” and the cause # 20 “Waste of resources due to lack of reliance on scientific methods in the organization” , respectively. Sub-factors related to neglecting technical and administrative advantages of planning for the causes (21-23). Probability output was calculated as 0.68 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.57 to 0.811, which are represented in the cause # 21 “Loss of coordination between the project staff and the various departments in the company” and the cause # 22 “Lack of readiness of technical staff in the project to deal with the surprises of work”, respectively. Sub-factors related to the lack of engineering planning principles for the causes (24-27). Probability output was calculated as 0.675 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.456 to 0.78, which are represented in the cause # 27 “Misrepresentation of the actual cost of the project” and the cause # 26 “Inability to distinguish between critical and non-critical activities”, respectively. Sub-factors related to the lack of plan for the elements of success for the causes (28-34). Probability output was calculated as 0.68 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.445 to 0.822, which are represented in the cause # 30 “The plan is unrealistic” and the cause # 33 “Lack of integration and harmony between plans and objectives”, respectively. Sub-factors related to the weak planning effectiveness for the causes (35-40). Probability output was calculated as 0.70 showing high- medium probability delay level. And the probability input values various from low to high i.e.0.556 to 0.701, which are represented in the cause # 35 “Not mandatory planning in the company” and the cause # 37 “Inability of the company to provide the appropriate staff for the planning process”, respectively . The low and high value of input as well as the probability output of delay resulting from the main and sub-factors can be illustrated in the graphs of Figs. 2 and 3.

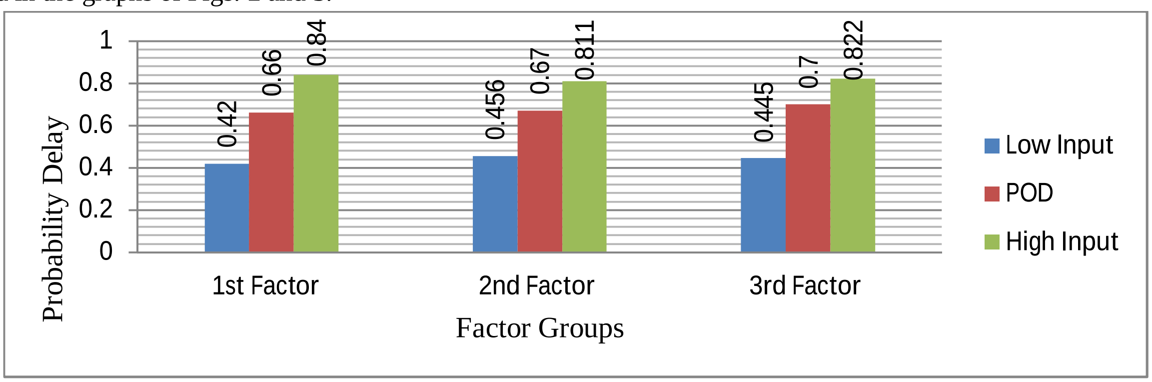

Fig. 2: Low and High Input Value , Probability Output of Delay of Main Factor Groups .

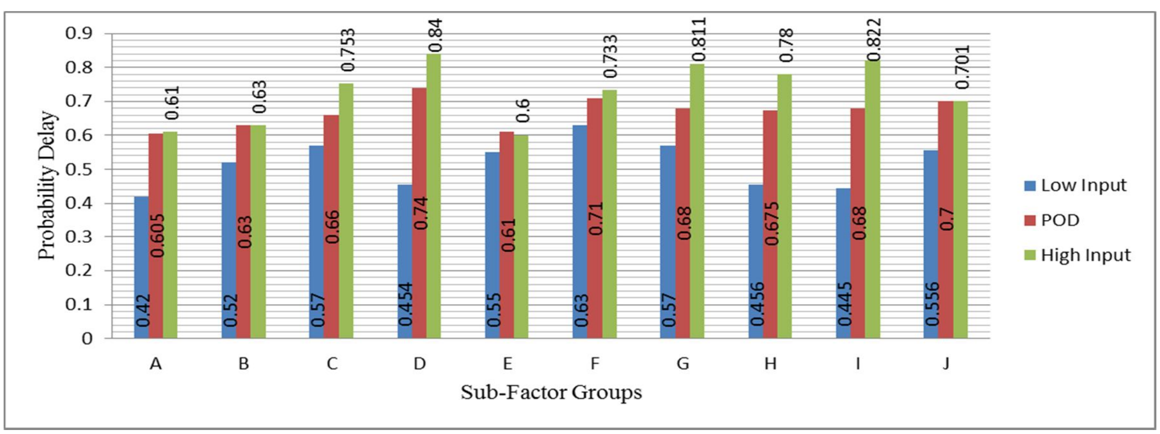

Fig. 3: Low and High Input Value , Probability Output of Delay of Sub- Factor Groups .

It can be seen from the previous Fig. that the high probability output for schedule delay is 0.7 shows the range of high-medium probability level , for the factors relating to the lack of awareness of the construction companies to the elements of effective planning and then the delay resulting from the second factors group “Lack of awareness of the construction companies to the importance of planning” is in second with 0.67 , and first factors group “Lack of awareness of the construction companies to the concept of planning” is last with 0.66 , for the project of case study of erect pre-fabricated steel school in Babylon province .

VI. CONCLUSIONS

The purpose of using fuzzy logic for construction simulation is to assist project manager to predict the potential delays and analyze them depending on the project's data and company policy. The specific conclusions derived from following study are as follows. It is found that the factors relating to the elements of effective planning placed first in terms of impact , the factors relating to importance of planning are in second and the factors relating to the concept of planning are third positon .It is shown that there is small discrepancy in the probability output of delay due to poor planning factors, which indicates the lack of awareness of construction companies to all of planning factors that have been studied, namely the factors related to the concept of planning, the importance of planning and the elements of effective planning. It is also found that the probability output of delay due to poor planning of contracting companies of sub-factors varies from 0.605 to 0.74, which is relating to the sub-factors group “The lack of experience in preparing the project plan”, and the sub-factors group “Tolerance in the follow-up implementation of the plan”, respectively .It can be drawn that the project schedule to completed is 215 days and the actual execution period after delay is 402 days .It is revealed that the variance between the planned and actual cost is 21.75%. Further a new classification of causes of project delay is introduced in this study and the developed model is simple to use, with much time saving compared to elements and other parametric models. In concluded that the developed fuzzy logic model is more accurate and simple to use and efficient to analyze the delay in construction projects.

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