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Fuzzy Assessment of Causes of Time Overrun (Delays) in Iran's Dam Construction Projects

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Abstract: On-time completion and conformity with assigned costs of every project or plan is one of the most important factors in success of that project or plan. No completion or overrun cost leads to not meeting the employer's requirements need or goals of the plan or the project. This issue is of greater importance in large and national projects in which the period of execution is long even in normal conditions and takes more than 6 years averagely. Dam construction projects are of especial importance regarding on-time completion and assigned funds because of their importance in operation size, great investment, complicated nature and many uncertainties in them like underground conditions, natural disasters and high cost of construction. So, inspection, identification and evaluation of causes of cost and time overrun and representations of solutions for obviating them have great benefits for economy of the country. Besides in most cases precise and sufficient information is not available for this purpose and opinions of experts and professionals in this project (in fuzzy theory framework) should be used. In this study, in addition to brief review of studies related to the issue of delays, fuzzy theory and method of using it is explained and real value of cost and time overrun in some dams of Iran is calculated and subsequently, fuzzy identification and evaluation of causes and cost and time overrun in these projects are dealt with.

Key words: Time overrun, fuzzy assessment, delays, dam construction projects

INTRODUCTION

Although nowadays there are great efforts for accomplishing projects on-time by people in charge, projects are accomplished with delays and costs that are higher than estimated. Cost and time overrun is sometimes higher than the value of contract more than 100% (Peter and Hough, 1987; Morris, 1990; Flyvbjerg *et al*., 1995; Office of Government Commerce, 1995; Pillai and Kannan, 2001; Said, 2005). Considerable studies are performed about the delays in projects and the causes which can be classified in two categories. In first part delays and methods represented to analyze it. Delay is an action or event which prolongs the time schedule of the contract, in other words, delays is the time between preplanned time and actual time of project activities (Arditi and Robinson, 1995).

Project delays can be divided into categories on the basis of one of the criteria of project main parts (Owner-Caused Delays (OCD), Contractor or Consulting-Caused Delays (CCD) and Third party-Caused Delays (TPCD), occurrence time state (independent delays, serial delays and concurrent delays) and compensability (impermissible delays and permissible) (Kartam, 1999; Stumpf, 2000). For identifying complete procedure of events in project and calculating quantity of delays and specifying location of occurring delays, base time schedule, base time schedule with delays in one of the elements of the project, actual time and anticipated time schedule can be used (Arditi and Patel, 1989; Abdulaziz and Cunningham, 1998; Michael, 1999; Terry, 2003). Methods for analyzing delays included, methods of comparing planned time schedule and actual time, increase in base time schedule and analyzing time intervals delay (Cher, 1995; Michael, 1999; Stumpf, 2000). Part 2 presents the precedent studies about causes of delay. Major Project Association researching for analyzing super projects classifies time and cost overrun into 2 categories: strategic decisions which are made by high-rank manager of organization (e.g., selecting the project delivery system, the way of selecting involving people, etc.) before concluding the contract and operational causes which are produced during the execution of the project (e.g., lack of material, incompetence of the contractor, etc.) (Peter and Hough, 1987).

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World Commission on Dams (WCD), through a complete research about 99 projects, represents that only half of the projects are accomplished on-time and 30% of the project with 1 to 2 years of delay and 4 projects with more than 10 years of delay. The main causes of these delays in projects are financial problems, incompetence of contractor and construction management, unreal time schedule, dissatisfaction of workforce, legal and constitutional objects and challenges (WCD, 2000).

Also, some other studies are done about the causes of project delays, some of which is as follows:

Causes of delay in large building construction projects (Sadi *et al*., 1995), delay in public utility projects in Saudi Arabia (Al-Khalil *et al*., 1999), construction delay: a quantitative analysis (Al-Moumani, 2000), causes of construction delay: traditional contracts (Abdalla and Battaineh, 2002), delays in construction: a brief study of the Florida construction industry (Ahmed *et al*., 2003), significant factors causing delay and cost overruns in construction of groundwater projects in Ghana (Frimpong *et al*., 2003) and factors affecting construction speed of industrialized building systems in Malaysia (Alaghbari, 2005).

Dam construction projects are of especial importance because of their operation size, great investment, complicated nature and many uncertainties in them like underground conditions, natural disasters and high cost of construction. Although nowadays there are great efforts for accomplishing Iran dams projects on-time by people in charge, but projects are accomplished with delays and costs that are higher than estimated. So in this study real value of cost and time overrun in some dams of Iran is calculated and subsequently, fuzzy identification and evaluation of causes and cost and time overrun in these projects are dealt with.

FUZZY SETS AND FUZZY NUMBERS

A fuzzy set approach, pioneered by Zadeh (1965), is useful for uncertainty analysis where a probabilistic data base is not available and/or when (interval) values of input variables are uncertain. The fuzzy set approach has been widely applied to represent the uncertainties of real-life situations (Bogardi and Bardossy, 1983; Anandalingam and Westfall, 1988).

Fuzziness or uncertainty represents situations where membership in sets cannot be defined on a yes/no basis because the boundaries of the sets are vague. The central concept of fuzzy set theory is the membership function, which represents numerically the degree to which an element belongs to a set. In a classical set, a sharp or unambiguous distinction exists between the members and nonmembers of the set. In other words, the value of the membership function of each element in the classical set is either 1 for members (those that certainly belong to the set) or 0 for nonmembers (those that certainly do not). However, it is sometimes difficult to make a sharp or precise distinction between the members and nonmembers of a set. For example, the boundaries of the sets of very risky words, nice houses or numbers much greater than 1.0 are fuzzy. Since the transition from member to nonmember appears gradual rather than abrupt, the fuzzy set introduces vagueness (with the aim of reducing complexity) by eliminating the sharp boundary dividing members of the set from nonmembers (Klir and Folger, 1988). Thus, if an element is a member of a fuzzy set to some degree, the value of its membership function can be between 0 and 1. When the membership function of an element can only have values 0 or 1, the fuzzy set theory reverts to the classical set theory.

A special class of fuzzy sets is described by fuzzy members, which are values that belong to a given set with a certain degree of membership only. As an example of fuzzy members, let Q be a fuzzy number and its membership function be denoted by (Fig. 1):

$$\mu(Q) = 1 - \frac{(q-Q)}{\delta}, \quad q-\delta \le Q \le q \tag{1a}$$

$$\mu(Q) = 1 - \frac{(Q-q)}{\gamma}, \quad q \le Q \le q+\gamma \tag{1b}$$

$$\mu(Q) = 0, \quad \text{otherwise} \tag{1c}$$

Where:

q = The center value of the fuzzy number Q and δ (δ>0) and γ (γ>0) represent the left and right fuzziness from the center value q. When the values of δ and γ are equal to zero

Q = A nonfuzzy number by convention. As the values of δ and γ increase, Q becomes fuzzier and fuzzier

Among the common membership functions in studies, we can mention triangle (Fig. 1) and trapezoid (Fig. 2) shapes.

In this study, 39 reasons, which are categorized in 5 groups, are identified as causes of time and cost overrun in Iran dam construction projects and the value of effectiveness of each reason and each group is calculated and presented by using fuzzy logic and triangular and trapezoidal membership functions on the basis of opinions of experts. For calculating and representing

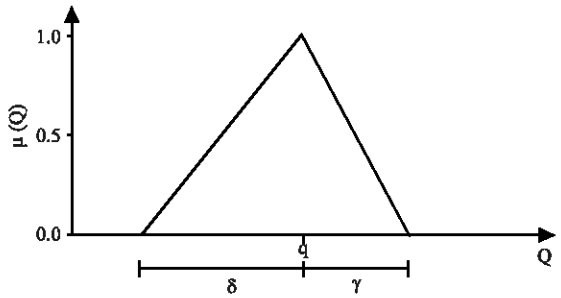

Fig. 1: Membership function of fuzzy number Q

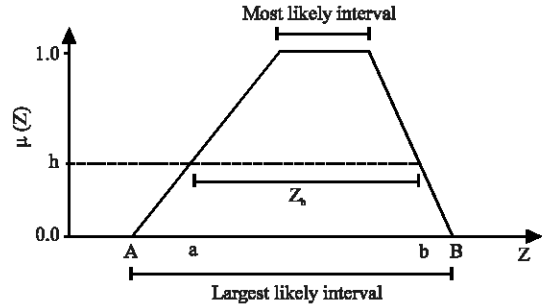

Fig. 2: Membership function of the value of effectiveness of each group of causes

value of effectiveness of each reason triangular membership function and for each group trapezoidal is used. Also in evaluation of cost and time overrun in 9 dam construction projects, trapezoidal membership function is used.

Trapezoidal membership functions and related calculations: As mentioned in fuzzy evaluation, the value of effectiveness of each group of causes (Table 4), with consideration of abundance of opinions in especial zone (the most likely zone) and iteration of them in this zone trapezoidal membership functions are used as shown in Fig. 2.

In the Fig. 2, the distance between A and B is the largest zone of experts' opinions which are located in the vicinity of A and B have the lowest level of membership to this set and the opinions located in the most likely zone have the highest level of membership.

In this case, the fuzzy number Z should be transferred into a crisp value that represents the fuzzy number Z. In this study, a ranking method is used to transfer the fuzzy number Z into the crisp value RC, making the ranking value of the fuzzy number Z equal to that of the crisp value RC. Using the ranking method developed by Chen (1985), the crisp value RC can be expressed as:

$$RC = \frac{V1 + V2}{2(W1 + W2)} \tag{2}$$

Where:

$$V1 = B^3(B + 3\alpha - 3A) - B^2(4\alpha A + \beta A + \alpha B) \tag{2a}$$

$$V2 = A^3(3B - 3\beta - A) + A^2(4\beta B + \alpha B + \alpha\beta) \tag{2b}$$

$$W1 = B^2(2B - 7A - \beta + 2\alpha) + 3(AB)(\beta - \alpha) \tag{2c}$$

$$W2 = A^2(7B - 2A - 2\beta + \alpha) - (\alpha\beta)(B - A) \tag{2d}$$

In formulas RC is the crisp value and other letters are the largest number, larger than medium number, less than medium and the lowest number, respectively.

Triangular membership function: In this study, in order to show the opinions of experts (interviewees) about the value of each cause, triangular membership functions are used. For example experts' opinion (interviewees) about the effectiveness of causes No. 32 in accordance with Fig. 3. According to the Fig. 3, the minimum value among participants (interviewees) is parameter 1, the medium value is 6.1 and the maximum is 15. Minimum, maximum and medium of opinions for each parameter is calculated and presented in Table 3, from the perspective of involved people in the project and the opinion of all experts.

IDENTIFICATION AND FUZZY EVALUATION OF TIME AND COST OVERRUN CAUSES IN IRAN DAM CONSTRUCTION PROJECT

Underway studies of project and time and cost overrun in them: In order to analyze the rate of occurrence of time and cost overrun in dam construction industry and analyze the causes, 9 large and medium projects of dam construction which have been accomplished were selected and scrutinized and been accomplished.

The basis for calculating cost and time overrun in these projects is the information included in agreement of preliminary contract, final statement and time of taking over of the works. Results of these calculations are represented in Table 1 and Fig. 3 in simple form and also in fuzzy form with trapezoidal membership function.

With consideration of results of Table 1, the value of the diagram of trapezoidal membership function, delay in dam construction projects is in accordance with Fig. 4. Actually Fig. 4 shows that dams of country trace the following function during construction from the perspective of delays, in a way that a project undergoes

Table 1: The rate of time and cost overrun in 9 dam project and fuzzy evaluation

Over rune	Dam 1	Dam 2	Dam 3	Dam 4	Dam 5	Dam 6	Dam 7	Dam 8	Dam 9
Time	73	40	100	122	106	311	114	195	106
Cost	199	48	282	98	62	241	161	115	292

Over rune	Min (A)	Max (B)	Average	Less than medium	Larger than medium	V1	V2	W1	W2	RC
Time	40	200	130	122	195	11811278357	506611200	40542271	-3520690	166.4
Cost	48	292	166	115	161	8154052112	591443712	28962896	-506396	153.7

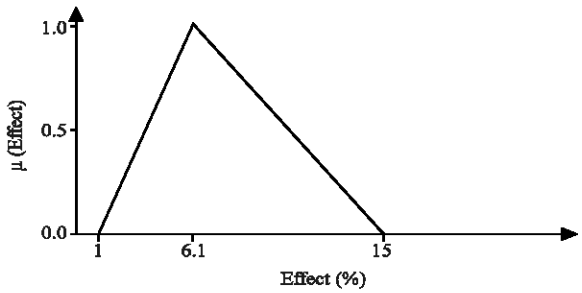

Fig. 3: Value of effectiveness of cause No. 32 on time overrun

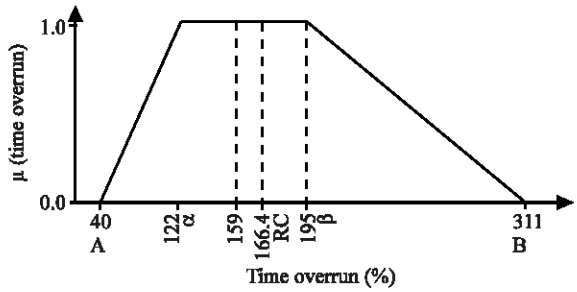

Fig. 4: The rate of time overrun in 9 dams project

less than 40% or more than 311% of delay is equal to zero. And the most likely delay is between 122 and 199% (most likely). And if it is supposed to represent one Number as the value of delays in dam construction industry of country, the number resulted from converting the following membership function to crisp number is equal to 166.6%. This number is larger than the Average number (130) calculated in the Table 1.

Identification and fuzzy evaluation of time and cost overrun causes: In this study, identification of causes of cost and time overrun in country's dam construction projects and the value of effectiveness of each element from the viewpoint of experts have been done in two stages:

Stage 1: Performing preliminary studies and designing questionnaire: In this stage, for the purpose of designing the appropriate questionnaire, in addition to the aforementioned projects, some of the underway or about-to-end projects which have undergone cost and time overrun are selected and studied completely in these projects which had increase in cost were fundamentally identified and scrutinized.

Table 2: The results of statistical society

Questionnaires	Employer	Consultant	Contractor	Sum
Sent or delivered	30	30	30	90
Collected	15	15	14	44
Collected (%)	50	50	46	49

Reports about time overrun of these projects were studied and inspected and superficial causes of cost and time overrun in theses projects are identified. With reference to involved managers and experts in these projects, a preliminary and comprehensive list (about 100 items) of causes of time and cost overrun is identified and collected.

With further study, it was understood that some of the causes have something in common and can be deleted and also some of them can be incorporated with each other. Thus, with final concluding of 39 items (items included in Table 5) as causes of cost and time overrun in dam construction projects are selected for starting consulting and a questionnaire is designed for taking opinions.

Stage 2: Collecting opinions of people in projects: In this stage, managers and some informed and experts who are involved in these projects in various parts (employer, consultant and contractor) were selected and questionnaire was sent to them and in some cases the form delivered to them in person while explaining and discussing about selected items. In this stage, the number of statistical society was in accordance with Table 2 and 90 questionnaires were delivered to the statistical society. After follow-ups, about 50% of questionnaires were collected and analyzed as in Table 2.

Collected results have been analyzed in two ways

Fuzzy effect of each cause: First, calculations related to value effect of each cause have been done with consideration of expert's opinions and the results are shown in Table 3, for the purpose of being presented as triangular membership function with containing 3 numbers

Table 3: Fuzzy effect of each cause on cost and time overrun in dam construction project

		Opinions of consultant			Opinions of contractor			Opinions of employer			Total opinions		
Causes		Min.	Medium	Max.	Min.	Medium	Max.	Min.	Medium	Max.	Min.	Medium	Max.
Regulation	1	0.0	3.7	9.0	0.0	3.3	9.0	1.0	5.3	16.0	0.0	4.5	30.0
	2	0.0	3.5	10.0	0.0	2.3	6.3	2.0	4.3	12.5	0.0	3.9	30.0
	3	1.0	3.1	7.5	1.0	2.5	7.5	0.0	1.5	3.0	0.0	2.7	10.0
	4	0.0	1.8	4.2	0.0	0.8	2.3	0.0	1.7	5.0	0.0	1.5	5.0
	5	0.0	2.6	15.0	0.0	2.6	7.0	0.5	4.4	20.0	0.0	3.6	30.0
Employer	6	1.0	4.3	7.5	1.0	3.6	12.0	0.0	2.6	5.3	0.0	4.0	15.0
	7	0.0	3.1	8.0	0.0	3.3	9.0	0.0	1.6	3.0	0.0	3.0	10.0
	8	0.0	1.5	3.6	0.0	2.4	7.0	0.5	1.8	3.0	0.0	2.0	10.0
	9	0.0	2.4	5.0	0.0	2.9	8.8	0.5	1.9	3.8	0.0	2.5	8.8
	10	0.5	2.6	7.0	0.5	2.5	6.0	0.3	2.5	9.8	0.0	2.6	9.8
	11	0.5	2.1	5.0	0.5	2.8	6.0	0.9	1.9	3.0	0.5	2.3	6.0
	12	1.3	4.0	12.0	1.3	4.1	12.0	2.0	4.4	9.8	1.0	4.6	25.0
	13	0.8	2.6	8.0	0.8	1.9	5.3	0.0	1.4	3.0	0.0	2.2	8.0
	14	0.0	3.8	15.0	0.0	2.9	5.3	0.5	2.0	5.0	0.0	3.5	20.0
	15	0.0	1.5	3.5	0.0	1.1	3.5	0.0	1.0	3.0	0.0	1.2	3.5
Consultant	16	0.5	2.0	5.0	0.5	2.4	5.0	0.5	2.0	4.0	0.5	2.1	5.0
	17	0.4	1.6	3.0	0.4	2.0	5.0	0.5	1.8	2.7	0.0	1.8	5.0
	18	0.0	1.5	4.0	0.0	2.2	6.0	0.0	1.4	2.5	0.0	1.7	6.0
	19	0.4	1.4	4.0	0.4	1.9	4.0	1.3	3.6	11.0	0.0	2.4	15.0
	20	0.0	1.7	6.0	0.0	3.8	10.0	1.3	3.0	7.7	0.0	2.9	15.0
	21	0.0	1.5	2.5	0.0	2.4	10.0	1.0	2.3	4.0	0.0	2.1	10.0
	22	0.0	1.5	6.0	0.0	2.0	5.0	0.0	1.3	2.5	0.0	1.6	6.0
	23	0.0	1.7	6.0	0.0	2.5	5.0	0.0	1.8	4.3	0.0	2.1	10.0
	24	0.0	1.7	10.0	0.0	3.2	12.0	2.0	2.6	5.0	0.0	2.7	20.0
	25	0.0	1.2	2.1	0.0	2.0	5.0	0.0	1.5	3.0	0.0	1.5	5.0
	26	0.4	1.3	2.1	0.4	2.3	5.0	1.1	2.1	3.0	0.4	1.9	10.0
	27	0.0	1.1	2.4	0.0	1.2	2.0	0.0	1.6	3.0	0.0	1.3	5.0
	28	0.0	1.3	2.4	0.0	1.4	3.0	0.0	1.1	3.0	0.0	1.3	3.0
	29	0.0	0.7	2.0	0.0	1.7	4.0	0.0	1.5	3.0	0.0	1.2	4.0
	30	0.0	1.5	7.2	0.0	2.2	8.0	0.5	1.9	4.0	0.0	1.8	8.0
	31	0.0	0.8	2.4	0.0	1.2	2.5	0.0	1.1	2.5	0.0	0.9	2.5
Contractor	32	1.0	6.4	15.0	1.0	4.9	10.0	2.0	6.5	15.0	1.0	6.1	15.0
	33	1.0	4.9	10.7	1.0	2.4	5.0	2.0	3.6	5.3	1.0	4.0	10.7
	34	1.0	3.5	10.4	1.0	2.6	6.3	1.5	3.6	6.9	0.0	3.5	15.0
	35	1.0	4.7	12.5	1.0	2.9	6.3	2.0	4.2	8.8	0.0	4.3	15.0
	36	1.0	5.1	11.3	1.0	3.2	7.5	3.0	5.5	10.5	1.0	4.9	15.0
Others	37	0.5	2.4	12.5	0.5	4.2	18.0	1.0	2.1	3.0	0.0	3.4	25.0
	38	0.5	4.0	8.0	0.5	4.2	15.0	2.0	3.7	7.0	0.0	4.5	30.0
	39	0.6	3.9	15.0	0.6	2.5	6.0	1.0	3.3	6.0	0.6	4.3	45.0

Table 4: Fuzzy effect of each group on cost and time overrun in dam construction

	Opinions of consultant									
Causes	Min.	Max.	Average	Less than min.	Larger than max.	V1	V2	W1	W2	RC
Regulation	5	26	15	15	16	565136	60475	21346	-1165	15.5
Employer	13	40	28	25	26	1203200	1045603	22360	20813	26.0
Consultant	4	41	23	15	16	4352950	45683	120622	-5778	19.2
Contractor	9	50	25	20	24	6835000	558981	137900	4944	25.9
Others	3	25	10	13	14	621875	17973	25850	-2618	13.8

	Opinions of contractor					Opinions of employer					Total opinions				
Causes	Min.	Max.	Average	Less than min.	Larger than max.	Min.	Max.	Average	Less than min.	Larger than max.	Min.	Max.	Average	Less than min.	Larger than max.
Regulation	4	25	12	10	15	13.4	5	40	17	15	20	20.0	4	40	14
Employer	12	40	27	25	30	26.8	10	35	21	20	25	22.5	10	40	26
Consultant	20	60	34	30	43	38.0	20	43	30	27	35	31.2	4	60	28
Contractor	6	30	16	15	20	17.7	15	35	24	23	30	25.9	6	50	22
Others	5	20	11	10	18	13.5	5	15	9	5	10	8.3	3	25	10

of minimum, maximum and medium. With having these 3 afore mentioned numbers for each cause of triangular membership function. The value of effect of that cause in cost and time overrun in dam construction projects (Fig. 3) can be drawn.

In Table 3, the value of 3 numbers of minimum, maximum and medium is calculated and represented separately and by using the opinions of involved people (employer, consultant and contractor) and also with consideration of total opinions of 49 answer sheet.

Table 5: Affect of each causes on cost and time overrun in dam construction

Row N	Cause N*	Description of each cause	Average effect of each cause	Accumulation of causes
1	32	Giving priority to taking the project other than completion of project that leads to bidding low price and winning the tender and financial problems during execution	5.90	5.9
2	36	Incompetence of executive management of contractor	4.60	10.5
3	12	Not providing sufficient budget for project in appropriate time	4.20	14.7
4	1	Defects in rules and regulations related to assigning the work to contractors and inappropriateness between technical and executive abilities of contractor	4.10	18.8
5	38	Participation of governmental contractors and support of project agents (employer, consultant, etc.)	3.90	22.7
6	35	Inconsideration of method of execution and appropriate equipments by contractors	3.90	26.6
7	33	Wrong bidding in tender	3.60	30.2
8	6	Not having strategy in conducting research projects and making quick decisions and executing them and providing tender documents with incomplete studies	3.50	32.7
9	2	The limitation of 25% for variation of dam construction work with consideration of the works being unknown being insufficient	3.33	36.1
10	5	Decisions made in upper economical levels like rate of tax and …	3.22	39.3
11	34	Not equipping the construction site at appropriate time	3.21	42.5
12	39	Unknown underground parameters which were not predictable during study phase	3.20	45.7
13	37	Force Majeure like flood, quake, etc.	2.91	48.6
14	14	Technical and management weakness of employer's representative in coordinating consultant and contractor and obviation of technical and performance problems	2.87	51.5
15	20	Low accuracy in evaluation of project scale	2.83	54.3
16	7	Technical weakness of employer in reviewing studies performed by consultant engineer and commencing of execution phase with technical problems in studies	2.66	57.0
17	10	Out-of-contract requests of contractor and consequent compensation costs	2.54	59.5
18	24	Technical and management weakness of C.M in coordinating resident supervision and consultant and on-time obviation of problems	2.49	62.0
19	3	Low of coefficient of Adjustment for change in cost with respect to increase in costs during the period of execution phase	2.36	64.4
20	9	Contractual defects and as a result not identifying claims and accepting incorrect financial claims of contractors	2.36	66.7
21	19	Technical weakness of design sections that leads to changing of plan	2.33	69.1
22	11	Rush in inauguration of projects because of political and social issues	2.23	71.3
23	16	Not having sufficient and appropriate supervision during performing geotechnical studies and imperfect geotechnical studies and consequently changing in plan during execution	2.13	73.4
24	21	Lack of experienced personnel in field of execution that leads to unreal prices of items and cost overrun	2.05	75.5
25	23	Not predicting unpredictable works in price list	1.97	77.4
26	13	Employer fails to give right access to Site within time stated in the Contract	1.96	79.4
27	8	Unavailability of appropriate comprehensive plans with considering technical, economical and social effects of a project on other project and nonexistence of coordination between various consultants that perform studies of related projects	1.89	81.3
28	26	Nonexistence of sufficient execution vision in designers	1.88	83.2
29	30	Not using experiences of previous projects in new projects and defects in documentation in execution	1.86	85.0
30	17	Defects in planning studies, wasting time of studies and consequently accumulation of work at the end of studies and diminishing the quality of studies	1.79	86.8
31	18	Management and technical defects in management of study plan and discordance between professional parts and consequent technical faults in final plan	1.68	88.5
32	22	Discordance between different sections of contract and tender documents and claims of contractor	1.59	90.1
33	25	Lack of information of supervision department about technical, contractual and execution issues	1.58	91.7
34	4	Nonexistence of basic price list for dam construction tasks	1.44	93.1
35	27	Inaccuracy in notification of order and non-consideration of there cost by supervision department	1.30	94.4
36	29	Unpunctual awareness of employer of 25% limit of increase and decrease and 10% of new price and not providing value changes	1.28	95.7
37	28	Passive obedience of consultant engineer to illogical and illegal requests of some Employers	1.28	97.0
38	15	Misunderstanding of the real purpose of the limitation of 25% for variation of works by consultant	1.85	99.0
39	31	Misunderstanding of the real purpose of the limitation of 25% for variation of works by employer	0.99	100.0

*These number are in the order of list of causes in questionnaires

Referring to Table 3 and analyzing the results related to medium column, it is understood that the cause included in row 32" giving priority to taking the project rather than execution and as a result bidding lower price

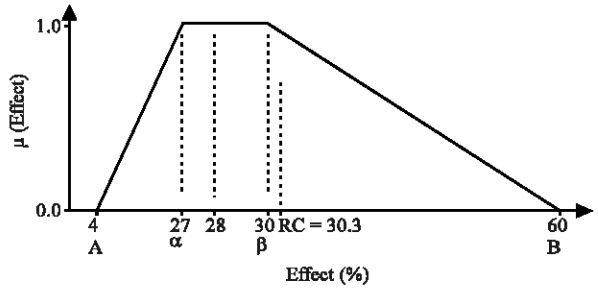

Fig. 5: The rate of cause related to consultant from the viewpoint of the whole interviewees

in tender" has the greatest effect in cost and time overrun in projects in opinion of involved people. Triangular membership function of this parameter with consideration of total opinion of interviewees is represented in Fig. 3.

Fuzzy effect of each group: At first, total effect of causes of each group is calculated with consideration of each expert's opinion and the values (minimum, maximum, Average, less and greater than Average numbers) are calculated and represented in Table 4, for calculation of trapezoidal membership function of each group of causes with regard to opinions of involved people (employer, consultant and contactor) as well as opinions of the whole interviewees. In Table 4 by using the formula in part 2, crisp numbers (RC) are calculated for each group of causes of cost and time overrun.

From the viewpoint of employer and contractor, the highest effect is related to the group of causes which is related to consultant .from the viewpoint of consultant the highest effect is related to causes which are related to employer and contactor respectively and from the viewpoint of whole interviewees, the highest effect is related to the group of causes which are related to consultant, employer and contractor respectively. The trapezoidal membership function of the cause related to consultant in cost and time overrun in dam construction project from the viewpoint of the whole interviewees is shown in Fig. 5.

In the Fig. 5 the largest zone is located between 4 and 60% which means that some interviewees consider the minimum value (4%) and some consider the greatest value (60%) of cause of cost and time overrun related to the consultant.

Also membership of these numbers to the above diagram is very low and about 0, there are few of them among the opinions experts (interviewees) and the zone between 27 and 30 is the most likely zone and the membership value to the diagram is 1.

CONCLUSION

In this study real value of cost and time overrun in some dams of Iran is calculated and subsequently, fuzzy identification and evaluation of causes and cost and time overrun in these projects are dealt with. After overall examination of value of causes from the viewpoint of main agents of dam construction projects in clause 3, in this clause, on the basis of PARATO law, parameters that have 80% of impact on cost and time overrun in dam construction projects are represented in order of the effect of each cause in rows 1 to 26 of Table 5.

Based on PARATO laws 20% of causes have the 80% of effect. Although in this problem PARATO law in not fully valid, about 70% of causes of cost and time overrun in dam construction projects are due to 20 causes and more than 50% of them are due to only 12 causes. So, Table 5 can be used in order to perform studies and represent solution to obviate or decrease the causes of cost and time overrun in Iran dam construction projects.

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