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Assessment of Value Engineering Technique in Dams

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Abstract- Value engineering has many applications to organize the values and costs, and to maximize value indexes in construction of the dam. Significant costs and multiple items in the cost of dam construction projects provides appropriate context for applying value engineering. Today, the majority of each country's wealth, especially developing countries, dedicated to its development projects and infrastructures and a factor of economic growth and development of any society is the country's success in implementing its development projects. The main problem faced by most large projects are lack of project value engineering to reduce costs, increase quality and reduce time. The aim of this study is using value engineering technique on dams of Kohgiluyeh (An area in Iran). Results show that with the help of value engineering in a dam (Kosar dam), in addition to select high-value options, managed to reduce costs by 14%, reduce the time by 19 percent and increase the quality by 8%. In this project as an example of extractive and infrastructure projects in the country, with people inside and outside the organization and the use of value engineering technology, while raising the value of the project, costs were saved.

Keywords- *Value Engineering, reduce time, reduce cost, increase quality, dam*

I. INTRODUCTION

Today, one of the most important things in society that less attention has been paid to, is the management of the construction and the related research. These things created so many issues in all processes of development projects, such as long-term implementation and several times cost more than the original estimation. To solve this problem, methods, techniques, and numerous theories have been proposed by different people. The invention of Miles (father of value engineering), with an age over 50 years, still retains its place in the scientific community. Looking at the history of this technique could be appeared reasons for the survival and sustainability of it. Results of many years of research and experience of the researchers, is now appeared by various names such as value engineering, value management, value analysis, value methodology, total quality engineering and total value management. Therefore, value engineering, as a technique to meet project objectives with minimum costs and maintain quality, has found better position than other techniques to improve the efficiency of construction projects in all developed and developing countries. On the other hand, because of flexibility and potential for development and improvements in this technique and currently there are ongoing investigations to enhancing the efficiency of this technique. Total quality management, techniques and related concepts, including approaches that have been considered by many researchers and is the main focus of this research. Value engineering is a process in which a design team, which they had been taught the value analysis, is employed to design products, services and new processes. In today's society, value engineering has proven to be a reliable risk. Value Engineering and Procurement has reduced costs by an average of 15 to 25% (including the cost of implementation method). Value engineering returns costs of research with ratio of 1 to 10. According to the SAVE international value engineering is "Systematic and creative use of certain methods based on teamwork, which aims to identify and remove unnecessary costs, increase the quality and efficiency of a product or service during its lifetime" (Arthur, 1971). Value engineering process is a logical and structured process that uses a multi-disciplinary expert group to use the following objectives:

1. Choose a project or suitable product for analysis according to the time of the study.

2. Identifying and measuring the current value of a project, product or component that provide the needs and goals of a project.

3. Develop and evaluate new options for assessing or improving the quality of related industries at a lower cost.

4 .Compliance new option with the best way to make it happen.

The concept of value engineering is conducting a working group with creativity. The result of this teamwork is offering new options to reduce costs and maintain or improve quality (Alphons, 1997).

TQM is a culture, as well as a set of guiding principles to show continuous improvement of organization, and in fact, the application of quantitative methods and human resources to improve all processes in the organization and overtaking of customer needs, both now and in the future. TQM can cover management techniques, improvements activities and technical tools. This is the fundamental concept of value engineering that do not confirm anything that is less effective than customer or user needs and avoid any extra thing, unless doesn't paid excess cost for it. Value engineering is primarily clarified the needs and customer requests, moreover, it also seeks to remove

or minimize unnecessary costs. Unnecessary costs, those that cannot provide quality, use, lifetime, appearance and customer satisfaction. As Mills claimed, these costs are 25% to 75% of product costs and these costs are usually hidden (Christopher). In this study, value engineering techniques and total quality management as the main point will be investigated. Then, relying on a strategic planning process, potential of engineering value can be identified using the techniques of TQM. For this purpose, strengths and weaknesses of value engineering are identified in project development from the perspective of quality issues, then in order to identify compound potentials, the relationships and dependencies between these two cases will be investigated. Finally, according to findings, the concepts and techniques with the highest and the best impact on value engineering will be selected for further development. This study provides a model to explore the reasons for the delay in construction projects and also determine the value engineering role in reducing the time and cost of development projects, especially dams.

II. MATERIALS AND METHODS

This study is a survey research and done in two ways of case studies and field surveys. Case study aimed to assess the value engineering (reduce time, reduce cost, and increase quality) in a dam construction project (Kosar Dam) is done using value engineering. Statistical population in this research includes all consultants, employers and contractors involved in construction projects in different parts of the dam.

This study has used the assessment of value engineering methodology to help Analytic Hierarchy Process (AHP), which includes the following steps to select the best options and solutions:

The first step: collecting the necessary information.

* Determine the purpose and define the correctly problem

* Evaluation criteria

* Provides various options for the realization of desires

The second step: forming the comparison matrix for criteria

The third step: a comparison matrix of options based on any criteria

Step Four: Determine the weight of analytic hierarchy process

* Relative weight

* The final weight

The relative weight is calculated of paired comparison matrix, as the total weight for each group of activities is calculated as a combination of options.

Step Five: group decision-making in AHP

III. RESULTS AND DISCUSSION

In order to study different parts of the project, it must be analyzed into subsets. Kosar Dam and power plant operations divide in six major sectors, including equipment workshop, the diversion of rivers, the implementation of the dam body, the construction of overflow and flood drainage systems, construction of underground spaces and the installation of power generating units. Each of the sectors divides into smaller parts to be easily study value engineering with more precision. In the proposed structure, has tried to maintain the integrity of the project and just main parts are presented, and other activities included in this structure. To evaluate the different parts of a project from value engineering perspective, weight of each of the projects should be determined. Since time and cost parameters have the maximum effects on the civil engineering projects, then to determine the weight of the components of the project two methods includes time distribution method and costs distribution method will be discussed.

A. Time distribution method

This method is done based on the time of each activity, so the weight of each component (activity) is equal to the percentage of time compared to the time of implementation of the project activities. In the method of distributing, the weight of each activity is determined on the basis of reasonable amounts of time for implementation. Since the real time of implementation of each activity are affected by many different factors, including budget allocation method, then time distribution method alone is not an appropriate technique for determining the weight of activities in value engineering study. Table 1 shows the weight of each activity in Kosar Dam and power plant project based on the time distribution method.

TABLE I. CALCULATION OF TIME WEIGHT PERCENTAGE OF EACH ACTIVITY IN KOSAR DAM AND POWER PLANT PROJECT

Row	Activity	Estimated Time (days)	Time weight	Rank
1	Site preparation	1260	9.52	7
2	Diversion operation	1440	10.9	6
3	Construction of dam body	2040	15.42	4
4	Construction of spillway and flood evacuation system	1980	15	5
5	Construction of submergence pond	2045	15.46	3
6	Construction of underground spaces	2310	17.4	1
7	Installation of power plant units	2160	16.3	2
Total		13230	100	-

B. Cost distribution method

In this method, the cost of each activity was calculated and the proportion of the total costs of the project is weighted. It is clear that any of the activities that have more executive costs, in the weight method, will be more important. But, in some activities, costs of materials and equipment have significant importance. Therefore, despite a small implementation costs or installation activities, the weight of these activities are very high, and this causes activities will be weighted unrealistically.

So distribution costs method as well as the time distribution method, would not be appropriate for weighting activities. Table 2 shows the weight of each activity of Kosar Dam and power plant project, based on time distribution.

TABLE II. CALCULATION OF THE PRICE WT. % OF EACH ACTIVITY FOR KOSAR DAM AND POWER PLANT PROJECT

Row	Activity	Cost estimation (Million Rials)	Weight cost	Rank
1	Equipping the workshop	3752.5	0.41	6
2	Diversion operation	54950.05	6.01	4
3	Construction of dam body	51635.73	5.65	5
4	Construction of spillway and flood evacuation system	1392.3	0.15	7
5	Submergence ponds	115421	12.63	2
6	Construction of underground spaces	58910.9	6.45	3
7	Installation of power plant units	628000	68.70	1
Total		914062.48	100	-

C. Calculation of weight percent (Integration method)

In integrated method, weight percentage of each activity is calculated based on weight percentage of time and costs distribution methods. Finally, according to the opinions of experts and those involved in the project, the percentage of the actual weight of each of the activities will be discussed. Tables 3 and 4 presents the weight of each project activity based on integration method (cost and time distribution method).

TABLE III. CALCULATION OF PERCENTAGE OF INTEGRATE WEIGHT (COST AND TIME DISTRIBUTION METHOD) FOR EACH ACTIVITIES OF THE PROJECT.

Row	Activity	Cost estimation (Million Rials)	Time estimation (day)	Rank
1	Equipping the workshop	3752.5	1260	7
2	Diversion operation	54950.05	1440	5
3	Construction of dam body	51635.73	9300	4
4	Construction of spillway and flood evacuation system	1392.3	1980	6
5	Construction of submergence pond	115421	1080	2
6	Construction of underground spaces	58910.9	8370	3
7	Installation of power plant units	628000	2160	1
Total		914062.48	25590	-

TABLE IV. CONTINUED CALCULATION OF PERCENTAGE OF INTEGRATE WEIGHT (COST AND TIME DISTRIBUTION METHOD) FOR EACH ACTIVITIES OF THE PROJECT (CONTINUED TABLE III)

Row	Activity	Weight %		The average weight of cost and time(%)	Rank
		cost	*Time*		
1	Equipping the workshop	0.41	9.52	4.96	7
2	Diversion operation	6.01	10.9	8.45	5
3	Construction of dam body	5.65	15.42	10.53	4
4	Construction of spillway and flood evacuation system	0.15	15	7.58	6
5	Construction of submergence pond	12.63	15.46	14.05	2
6	Construction of underground spaces	6.65	17.4	11.93	3
7	Installation of power plant units	68.70	16.3	42.5	1
Total		100	100	100	-

After obtaining the integrated table of time-cost distribution, it is require determining the weight of each activity in the form of a survey of project experts. Weighting through the survey of experts causes that weight of each activity get closer to the executive realities, and also activities with the highest potential of savings are characterized by the experts. The above survey is used of the opinions of three experts familiar with the project's implementation. It can be seen, activities that are related to the submerged pond construction has the greatest weight by the project experts, and has the highest average of expert opinions. It can be seen submerged pond construction activity has been the highest weight and will be ranked first, in terms of potential of value engineering study. So submerged pond activity with final weight percent of 51.3% were selected as the main activity for review and value engineering study of Kosar Dam and power plant projects. The collecting of qualitative information (functional analysis) phase is the first and most important part of work plan of value engineering. The importance of this part is because of the fact that all decisions, investigation, analysis and value engineering workshop final statements will be carried out based on information collected at this stage. Quantity and quality of collected data in the first phase of value engineering will have direct effect on the results of the workshop of value engineering. At this stage all the functions, technical specifications and used standards will be analyzed, and current costs of each function will be calculated. Another important step of value engineering workshops that can provide an essential role by the various offers and make effective options is creativity phase. At this phase, value engineering team must be encouraged to offer different and low-value opinions. For this purpose it is necessary that members of the team inform each other's comments. In other words, it is necessary that members of the group participate actively in making their offers and, if necessary with respect to the exchanged information, complete or modified their opinions. At this phase, all the comments of value engineering team was gathered and summarized, and all comments regardless of practical or not, was presented.

D. The fifth phase report and results

This is the last phase of value engineering and in fact is the results of value analysis. In this phase, researcher put the final options to the employer and he choose the require option according to the company polities and requirements. In fact, analyzing the report has no impose role on the organization, but also, it offers scientific consulting and necessary recommendations to the employer. In order to select a special option, usually in the absence of high importance and least cost option with no significant difference costs, an option with the maximum importance is selected, but if there is significant differences in costs, an option with least importance and cost is considered. In the last phase, the proposed options and initial option of saving the project are determined. It means in addition to choose an option with high value, percent of the total price will be reduced. Tables 5 and 6 summarize the cost (Rials) calculations according to the final option selection. Figs 1 and 2 show graphs of saving rate in each of the activities of Kosar Dam and chart of percent of the time saving and quality in each of the activities at the submerged pond of Kosar Dam.

TABLE V. SUMMARIZED COST AND TIME CALCULATIONS ACCORDING TO THE FINAL OPTION

Activity	Cost (Million Rials)	Base cost (Million Rials)	The rate of saving	Reduced %
Excavation	630	630	0	0
Concrete pouring	86000	98041	12041	12
Systems installation	62375	74850	12475	17
Instrumentation	1161	1300	139	11
Total	15166	174821	24655	14

TABLE VI. CONTINUED SUMMARIZED COST AND TIME CALCULATIONS ACCORDING TO THE FINAL OPTION (CONTINUED TABLE V)

Activity	Value index	Time saving %	Increasing of quality %
Excavation	1	28	7
Concrete pouring	1.14	16	12
Systems installation	1.20	22	9
Instrumentation	1.12	10	4
Total	1.16	19	8

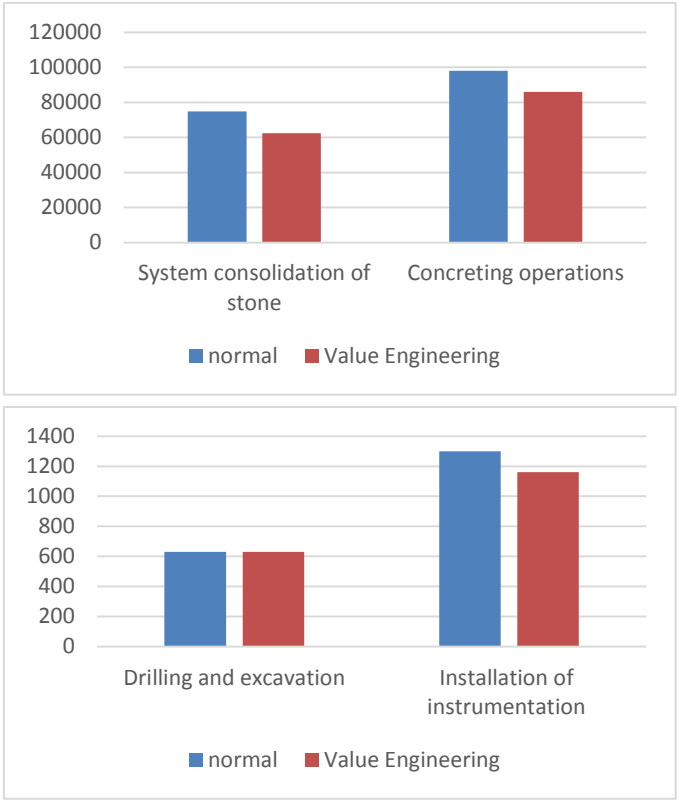

Figure 1. Graphs of saving rate in each of the activities of Kosar Dam.

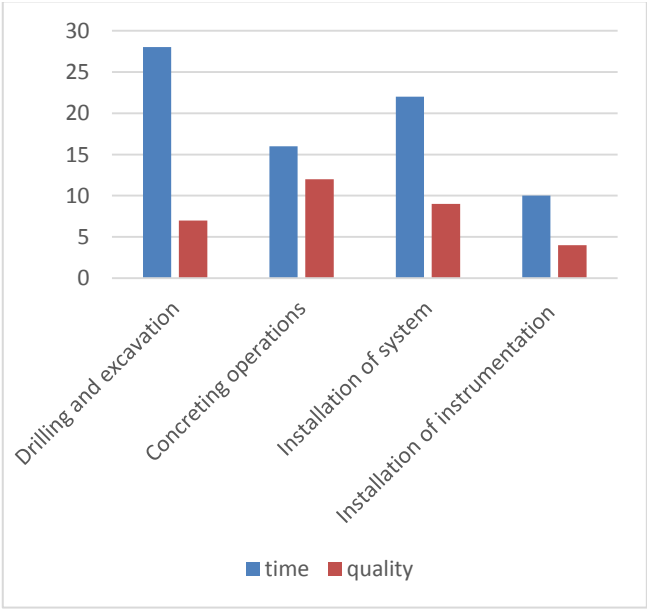

Figure 2. Chart of percent of the time saving and quality in each of the activities at the submerged pond of Kosar Dam

As it was shown, with the help of value engineering technology in a submerged pool of Kosar Dam, in addition to select high-value options, the time has decreased and the quality has increased. In this project as an example of

extractive and infrastructure projects in the country, with people inside and outside the organization and the use of value engineering technology, while raising the value of the project to save time and increase quality. Value engineering would increase the importance of the various options. Importance factor is the combination of quality, safety, speed and ease of implementation that was calculated in the each options. The difference of value engineering with other similar methods, is qualitative approach to executive issues, and only low cost of an activity is not considered.

IV. CONCLUSION

Since value engineering process should be done at the early phases of conceptual design project to maximize the savings potential achieved by value engineering. Considering that the data used in this study were at the percent of 70-80%, the rate of economic cost reduction is a function of quality, convenience, safety and speed. Results show that the value engineering has reduced costs and time up to 14 % and 19% respectively, and has increased the quality of execution up to 8%. Value engineering would increase the importance of the various options. Importance factor is the combination of quality, safety, speed and ease of implementation that was calculated in the each option. The difference of value engineering with other similar methods, is qualitative approach to executive issues, and only low cost of an activity is not considered

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