Adoption of Value Engineering: An Attribute Study for Construction Industry of Pakistan

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ABSTRACT

For economic reasons, engineers are compelled to explore low cost methods in construction industry to reduce the overall cost of a project. Research studies have been conducted in this regard throughout the world and value engineering is one of such approaches. Its effective use and applications reduces the project cost without compromising the project quality. Project cost, and efficient design alternatives can be identified using this technique, which will ultimately reduce the overall project cost. Client satisfaction, project reliability and quality can also be improved by the application of value engineering. It is also used for improving managerial performance, project schedule and reduced risks in a project. It is a powerful tool used to identify problems and recommend solutions. This paper highlights the importance of value engineering in general and with specific perspective of Construction Industry in Pakistan. Questionnaire based survey has been conducted by construction managers (i.e. project engineers, construction engineers, project managers, architects, etc.) through online web based system, as a result, random data sampling is achieved. The attributes are mapped to obtain goals for the project. The data has been analyzed through reliability and linear regression using SPSS while Z-Score and Average Index are conducted using MS Excel. The results showed that there is ample need to apply such techniques in initial phases of any project to get project benefits.

Key Words: Value Engineering, Construction, Project Performance.

1. INTRODUCTION

With the initiation of international and highly competitive market, project manages are paying serious attention to provide a best fit project to the clients utilizing optimal resources. This vision has brought success and the competition has led project managers to complete the projects at an early date, low cost and high quality. This approach needs continuous improvement throughout the life cycle of the construction project and discovers new methods to balance the cost and the application of the projects [1].

It has been evidenced by different studies that value engineering is a good method for cost reduction in the construction industry worldwide. It is carried out to achieve optimal performance and costs of construction projects by classification and elimination of unnecessary costs without compromising the quality of the project [2]. It is an organized effort aimed to study and analyze activities of project plan since the development of the primary thinking to the design and implementation phases with full implementation plan to realize the lowest time and cost [3].

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Value engineering is a structured problem solving process based on function analysis to improve the value of a system. It is more than "good engineering". It is a new look at problems starting from basic functional requirements of the project [4]. It promotes the replacement of materials and methods with less expensive alternatives, without compromising functionality of the project. It is focused exclusively on the functions of diverse components and materials, rather than their physical attributes also called value analysis. It's an approach of thinking and managing techniques, which aims to improve the value of project on the basis of systematic analysis and continuous innovation of the function and cost through cooperation of the various related areas [5]. Primarily, the concept of value engineering was seen to be cost validation exercise, which did not affect the quality of the project [6]. To provide the desired functional performance value engineering is the least expensive way [7]. It also plays a considerable function in pulling together construction team, making them more effective and more efficient - a benefit which cannot be unnoticed [8].

The value of the system is maximized for optimum balance between functions and the associated costs. In the context of construction, the aim of the value engineering study is to perform the necessary functions to lower down cost of the project. This can be done by using new materials, creative design, simplified building process, the innovative construction system, reduces construction costs and time, improving the quality and safety construction and minimal impact on the environment [9].

Since 1950s, value engineering became a standard practice for numerous private engineering firms, government agencies. It has been extensively adopted in the construction industry and turned into an integral component in the development of many civil infrastructure projects. It has been practiced for half a century in the construction industry with an aim to generate innovative ideas and solutions for improved project value. It is applied in all over the world with successful track record. With this, we can reduce the cost of the project up to 20% approximately [10]. Unfortunately, it's rarely adopted for the construction projects of Pakistan because little research has been done on this topic and stakeholders are not aware properly regarding the benefits of this approach, which can be grabbed after adoption of this technique. Thus, this paper aims to give awareness about the importance of value engineering with specific viewpoint of construction industry of Pakistan. The will help the stakeholders and constructors to get benefits after adoption of this approach.

2. APPLICABLITY OF VALUE ENGINEERING

Value engineering can be applied at early stage of a project because of the benefits and resource saving achieved generally during the conceptual phase of the construction project. At this stage, basic information about the project is established but resources for design and development are not yet dedicated. The reason is that this is the best time to apply this approach.

3. DATA COLLECTION AND ANALYSIS

The attributes (Table 1) are identified through a detailed literature review and shaped in to a set of questionnaire to get the priority ranks from the experts working in the construction industry of Pakistan on a five-point likert scale containing point 1 (strongly disagree) to point 5 (strongly agree). LSWS (Lime Survey Web based System) has been used to get the respondents opinion and it was sent to 120 experts throughout Pakistan. The data were collected in couple of months in the calendar year 2014. A total number of 88 questionnaires were successfully received. Respondent experience plays an essential role in the qualitative data analysis sets. Therefore, attention has been given to this feature in this study. Fig. 1 shows the respondent experience rate.

TABLE 1. QUESTIONNAIRES OF ATTRIBUTES

No.	Attribute
	Planning
1	Value engineering is performed on high cost and complex process. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
2	Insensitivity to the public needs results poor value engineering. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
	Design
3	Rigid application of standards results poor value engineering. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
4	Innovative design can save lot of money. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
5	Ill-design causes uneconomical construction. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
6	Unreasonable safety factors adds to the cost of construction. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
	Execution
7	Lack of proper information (Drawings) results delay in construction and ultimately increases the cost. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
8	Lack of proper communication leads to poor value engineering. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
9	Reluctance to seek advice in specialized aspects of project results poor value engineering. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement

No.	Attribute
	Execution
10	Use of sophisticated technology (machines) increases the cost. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
11	Negative attitudes and failure to recognize creativity results poor value engineering. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
	Maintenance
12	Poor construction results unnecessary maintenance. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
13	Bad quality of material leads to an unnecessary maintenance. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
14	Use of critical, exotic, hard to get and expensive material for maintenance work adds to the cost. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
15	Poor workmanship results unnecessary maintenance. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
	Repair
16	Assurance of safety of user is of prime importance in repair stage. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
17	Recycling of old material reduces the cost. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
18	Time consuming labor leads to poor value engineering. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement

No.	Attribute
	Repair
19	Aesthetic consideration should also be kept in mind while carrying out the repair work. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
	Demolish
20	Safety of laborers should not be compromised while carrying out the demolishing work. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
21	Old material can be sold to earn money. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
22	Use of proper method of demolishing leads to good value engineering. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
	Goals
23	It is a primary tenet of value engineering that basic functions be preserved and not be reduced as a consequence of pursuing value improvements. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
24	Value engineering is performed early in planning process to maximize potential product improvement and cost savings. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
25	Over specifying causes cost to increase as close tolerance and finer finishes are specified. ● Strongly Agree ● Agree ● Neutral ● Disagree ● Strongly disagree ● Irrelevant statement
	Demography
	Total Experience (in years) ☐
	Nature of organization ● Public ● Private ● Other ☐

The respondent with less than 5 years of working experience in the construction industry is 38% in total, respondent with more than 5 and less than 10 years of working experience is 21% in total and respondent with more than 10 years of working experience is 41% in total. This result shows the sound work experience rate of the respondents. Fig. 2 shows the respondents company's profile rate.

There were 20% respondents from clients' side in total, 33% from consultants' side in total, 30% from contractors' side in total, 3% were architects and 14% others in total.

4. RESULTS AND DISCUSSION

An interested reader is recommended to study Farrell [9] and Chavan [10] to explore applicability and uses of value

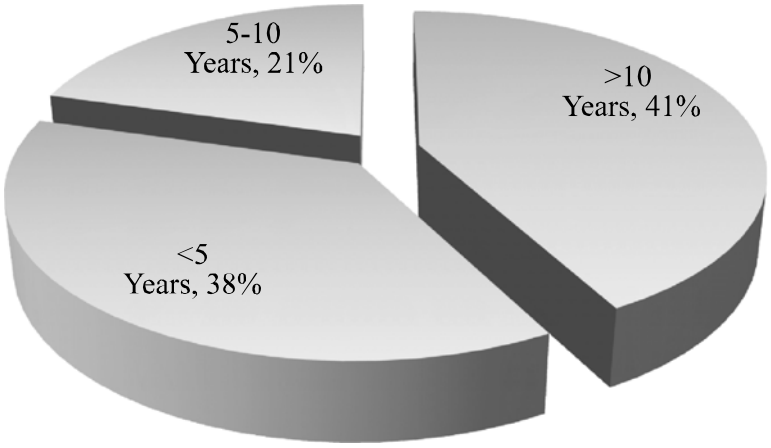

FIG. 1. RESPONDENTS EXPERIENCE CHART

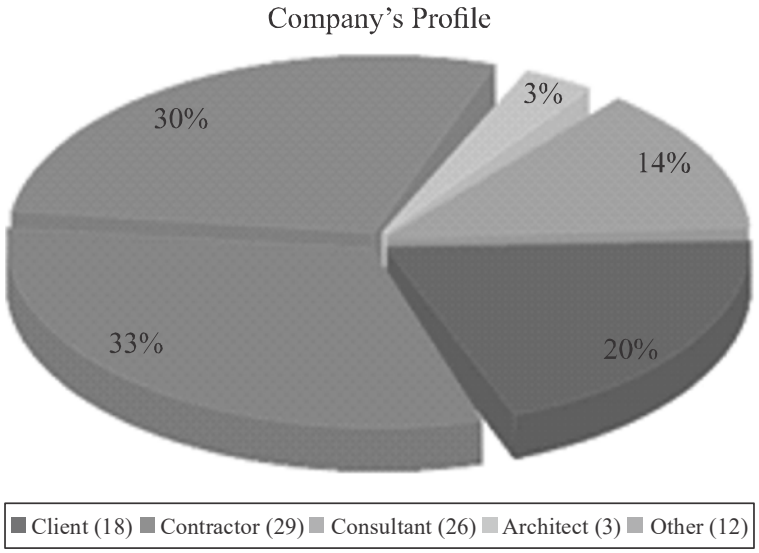

FIG. 2. COMPANY'S PROFILE

engineering in construction industry. Statistical results are altered by outliers [11]. Multivariate outliers are composed of such a strange value that the tendency of results moves away from their true representation. Trimmed mean value, standardized z-score and box plot has been successfully used in several studies for outlier test [11-12]. However, standardized z-score test has been used for this study to identify the outliers in the data sample. The cases with z-score that exceed 3.29, at $p < 0.05$, two-tailed test, are the potential outliers [13]. Fig. 3 shows the outlier test results.

Z-score test is a standard test to detect outliers. Absolute values of z-score of individual respondent are summed-up for the attributes. The respondent having minimum sum is considered the best one to average of the sample. The maximum sum indicates the outliers. In above study, two outliers were detected (ID No. 36 and 164).

It is essential to choose the scales that are statistically reliable. The scale reliability, the proportional of variance attributable to the true score of latent variable, can be defined as the extent to which a measure produces similar results over different occasions of the data collection. It was, thus, critical to examine the reliability of each scale whenever a measurement is involved [14].

Scale reliability concerns with the scale's internal consistency (Cronbach's alpha, α). In a good solution, Cronbach's alpha (α) ranges between zero and one; Large value will have better stable factors. A high value means that the observed variable accounts for substantial variance in the factor score, while a low value means the factor are poorly defined by the observed variables. Generally, the value of 0.70 is accepted as the minimum desired value of reliability [12]. In this study, the 25 attributes within the seven value engineering constructs are tested for internal consistency, using the retained 88 data questionnaires turned as α=0.712. The individual results of the test are shown in Table 2.

The results have value ranging from 0.185-0.730, all of which can be considered acceptable. Thus, this increases confidence in the contribution of the 3-4 attributes to the measurement of their respective constructs [13]. The final attribute ranking has been done by average index method. Table 3 shows the complete ranking of the factors benefits the construction project using value engineering approach.

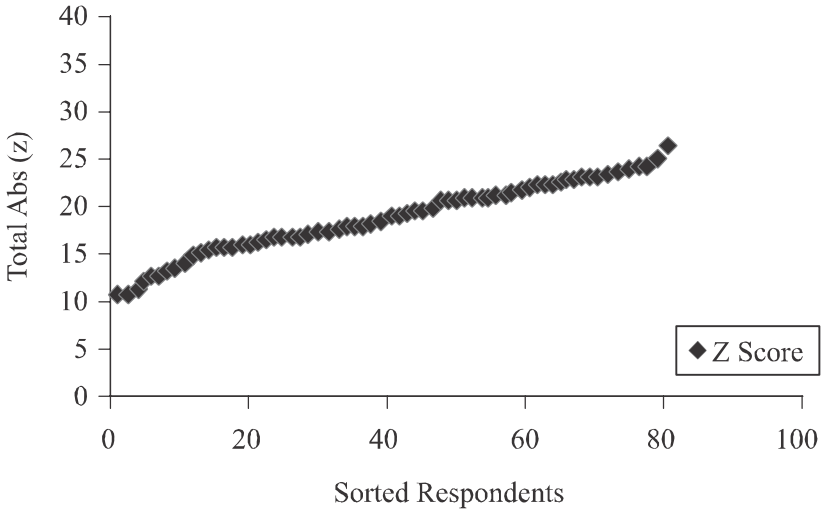

FIG. 3. Z-SCORES FOR OUTLIERS DETECTION [14]

Braking up data in seven constructs (Table 2) limits the values of Cronbach's á, which is well below its acceptable value of 0.7. However, the data when viewed holistically results value of Cronbach's α=0.712, which is acceptable and, hence, further analysis was justified and it is carried out.

The results show that availability of "Proper Information" is at the highest rank with the average mean score of 4.58 that means; most of the respondents consider that the availability of proper information is very necessary for a project. Proper communication between the staff onsite because the role of communication is very important for a perfect value engineered project is a second with an average mean score of 4.56 and material quality at third attribute with an average mean score of 4.53. Whereas, the others attributes ranking is shown in Table 3.

TABLE 2. INTERNAL CONSISTENCY OF SIX ENABLERS AND GOALS

No.	Construct	α
1.	Planning (Attributes: Cost Process, Public Needs)	0.286
2.	Design (Attributes: Rigid Standards, Innovative Money, Ill Uneconomical, Safety Construction)	0.185
3.	Execution (Attributes: Information Delay, Communication Poor, Reluctance Specialized Sophisticated Increases, Attitudes, Attitudes Failure)	0.454
4.	Maintenance (Attributes: Unnecessary Maintenance, Bad Material, Critical Expensive, Workmanship Maintenance)	0.730
5.	Repair (Attributes: Safety Repair, Recycling Reduces, Time Labor, Aesthetic Mind)	0.450
6.	Demolish (Attributes: Compromised Demolishing, Old Sold, Proper Good)	0.239
7.	Goals (Attributes: Primary Function, Early Improvement, Over Tolerance)	0.561

5. CONCLUSIONS AND RECOMMENDATIONS

Designers are reluctant to make changes in the project not considering the merits of the proposal, principally if the change directly affects their plan or design. Whereas, other get best value in their approach by adoption of this approach, which will come up with various benefits as discussed below:

TABLE 3. BENEFITS OF VALUE ENGINEERING

Rank	Attribute	Mean	Standard Deviation
1	Proper information	4.58	0.69
2	Proper communication	4.56	0.66
3	Material Quality	4.53	0.71
4	Proper construction	4.45	0.86
5	Early improvement	4.40	0.84
6	Trained workmanship	4.33	0.90
7	Attitude and creativity	4.28	0.88
8	Laborers' Safety	4.21	1.36
9	Local material usage	4.20	0.84
10	Aesthetic consideration	4.16	0.91
11	Innovative design	4.13	1.13
12	Seek advice	4.12	0.79
13	Safety assurance	4.05	0.97
14	Adapting proper method	4.00	1.14
15	primary functions	3.99	0.77
16	safety factors	3.90	1.10
17	Well design	3.86	1.26
18	needs' awareness	3.81	1.06
19	recycling material	3.80	0.92
20	Selling old material	3.77	1.06
21	Cost control	3.71	0.92
22	Cost process	3.53	1.22
23	Efficient labor	3.51	1.30
24	Optimum standards	3.16	1.10

Proper information of the project should be given at the early stage of the project. Consultant should work in close coordination with client as the scope of the project should be clear enough to avoid changes in the later stage of the project. The constructors should be properly briefed about the project including drawings and specifications to carry out the construction work accordingly otherwise it will delay the project and will add additional cost in the project.

Unnecessary costs can be experienced by poor communication and misunderstanding. Failure to obtain adequate suitable facts can be caused by lack of knowledge or quarrel of the full requirements of the original project plan. Construction projects require the talents of many people and good working relationships are critical factors.

The constructions and consultant should make a proper communication mode to avoid delay in decision making. The constructors should avoid using low quality material to maximize their profit margin otherwise it will lead to reconstruction of the work because consultants do not pass it during inspection.

The constructors should use proper construction methods as specified in the specification. In the later stage, the quality of the project will be affected and in such cases early improvement measures should be taken to avoid delay and ultimately project cost as well.

Periodically, training programs should be arranged to enhance the workers skills and make them aware of the new procedures, functionality of machine and equipments. Project managers should use motivational skills to improve the workers attitude towards construction work.

There should be proper HSSE (Health, Safety, Security and Environment) policy and serious efforts should be taken to implement the policy on grass root level. This will not only save the money but also helps in getting the best human resource for the organization. Efficiency of the laborers should be calculated daily, monthly and yearly basis to monitor the regular performance of workers.

Use of local material should be given first preference as this will reduce the transport cost and saves money. Old useless material should be sold out and generated revenue should be utilized for any other work.

Negative attitudes and improper behavior to the staff will create hatred among the team and will affect badly on the work progress so it is better to have friendly environment. Working like a one unit will strengthen up the team and will make the team efficient.

Awareness of the client requirements should be properly managed before planning the project as this will help in proper planning and will discourage the changes in the design.

A designer should be well trained and experienced as he should be aware of project needs, which has to serve after construction and he should be capable enough to initiate innovative design which will help in reducing the construction cost.

To get the best results one should apply optimum standards, as usage of rigid standards will increase the cost of the project unnecessarily.

Value engineering is a helpful service available to management and promotes the significance of program teamwork. Effective value engineers are capable to see the large picture of the project including pros and corns. It will result in improved designs at a more reasonable cost.

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