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VALUE ENGINNERING MODEL FOR CONSTRUCTION PROJECTS

مشروعات التشييد من منظور القيمة الهندسية

By

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ملخص البحث:

إن تخفيض تكلفة تنفيذ مشروعات البناء والتشييد دون المساس بالمتطلبات والاحتياجات اللازمة للأداء أمر ممكن من خلال استخدام تقنية الهندسة القيمية ، والتي أثبتت جدواها ومردودها العالي عند دخول هذه التقنية إلى صناعة البناء والتشييد و أصبحت مطلب رئيسي في الوقت الحالي خصوصاً في ظل الأزمة الإقتصادية العالمية.

و لما كان تطبيق هذه التقنية في نطاق ضيق جداً في مشروعات التشييد المصرية ، لذا فإن هذا البحث يهدف إلى معرفة أربعة محاور رئيسية و هي المبادىء التي تستند إليها الهندسة القيمية و أهمية المزايا التي تحققها هذه التقنية و معرفة المعوقات التي تحول دون تطبيق هذا المنهج و المقترحات الكفيلة بتسهيل تطبيق الهندسة القيمية في مشروعات التشييد في مصر و ذلك من خلال إجراء استبيان تم توزيعة على جهات مختلفة (ملاك و استشاريين و مقاولين و موردين) لها علاقة مباشرة بمشروعات التشييد المصرية. و قد تم معرفة أكثر العوامل المؤثرة على الأربعة محاور السابقة و هم ٢٤ عامل من إجمالي ٦٠ عامل هم مجموع عبارات الاستبيان. وتم تحليل النتائج باستخدام البرنامج الإحصائي SPSS حيث تم تقييم عبارات الاستبيان عن طريق معرفة معامل الثبات وكان مقداره ٠,٩٠٠ و معرفة أيضاً معامل الصدق و كان مقداره ٠,٩٤٩ حيث تعكس هذه القيم استقرار المقياس و عدم تناقصه مع نفسه و أنه يقيس ما وضع لقياسه.

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ABSTRACT

The possibility of reducing construction projects cost without affecting requirements necessary for performance is possible through applying Value Engineering technology that proved efficiency and high outcomes when applied on construction industry. It has become a basic requirement in the present time particularly during the world economic crisis.

Whereas the application of this technology is on a minor scale in construction projects in Egypt, therefore this research targets to recognize the recommendations leading to facilitate the application of Value Engineering in construction projects in Egypt. In addition to that, the research aims at recognizing three important focal lines which are: the basics that Value Engineering relies on, the importance of advantages achieves from using this technology and recognition of obstacles that prevent the applying of this method through performing a questionnaire distributed on different sectors (owners, consultants, contractors and suppliers) which have a direct relation with Egyptian construction projects.

The factors affecting the previous four focal lines are recognized to be 24 factors out of 60 factors of the total questionnaire items. Results were analyzed by using SPSS program where questionnaire items were evaluated through measuring Reliability Coefficient to be 0.900 and Validity Coefficient to be 0.949. These values reflect that the measurement is stable and not self-conflicting and that it measures what it claimed to measure.

1. INTRODUCTION

Value analysis (VA) developed during World War II in the United States at General Electric Company by Lawrence Miles, when shortages of materials and labors forced the introduction of many substitutes. It began as a search for alternative product components, a shortage of which had developed as a result of the war. Due to the war, however, these alternative components were often equally unavailable. This lead to a search not for alternative components, but to a means of fulfilling the function of the components by an alternative method. This process "function analysis" produced low-cost products without reducing quality and, after the war, the system was maintained as a means of both removing unnecessary cost from products and improving design. The two names Value Engineering (VE) and Value Analysis (VA) was used synonymously (Palmer et al.)[1].

The first question to arise is usually "what is Value Engineering?". Dell' Isola [2] defined VE, in general terms, as "A creative, organized approach whose objective is to optimize cost and/or performance of a facility or system". As for construction industry, Value Analysis/Engineering is "a disciplined programmed effort applied during the planning, design, and construction phases".

Zimmerman and Heart [3], defined VE by what is true and what is not true about the VE concept. They stated that VE is a systematic and multidiscipline management technique. On the other hand, they stated that VE is not a design reviewing, cost lowering, or quality control process.

Degarmo, et al. [4], introduced a definition for VE as "it is a method for examining the value of a product or service in relation to its cost with the aim of providing the required function (s) at the lowest overall cost".

Basha [5] defined VE as "a systematic evaluation of a project design to obtain the most value for every dollar of cost". By carefully investigating costs, availability of materials, construction methods, shipping costs or physical limitations, planning and organizing, cost/benefit values, and similar cost influencing items, an improvement in the overall cost of a project can be realized.

Brandon [6] gave that in North America those carry out VA are termed value engineers areas in UK the terms value management (VM) and value manager have been adopted. Thus he defined VM as "A philosophy concerned with providing the product desired by a customer at the required quality and the optimum cost".

Hamdi et al. [7] introduced that VE can be applied throughout planning, design and construction phases and it is a construction industry cost effectiveness tool.

Fong et al. [8] presented one of the VM workshop's major benefits, namely, knowledge creation. A case study approach was used to explore the nature, processes, and issues associated with fostering a dynamic knowledge creation capability within VM teams. The results indicate that the dynamic knowledge creating process is embedded in and influenced by managing team constellation, creating shared awareness, developing shared understanding, and producing aligned action. The catalysts that can speed up

the processes are open dialogue and discussion among participants. This process is enhanced by the use of facilitators, skilled at extracting knowledge.

Fan et al. [9] presented a group decision support system (GDSS) prototype system, named the interactive value management (synonymous with value engineering and value analysis) system (IVMS), to explore its potential application in VM workshops and to investigate the effect of the application. The results show that Web-based GDSS can improve the efficiency and effectiveness of VM workshops by supporting the VM team. The result of the validation of the system shows that IVMS is a useful tool in facilitating the information exchange process, encouraging interaction, and promoting active participation in VM workshops.

Mao et al. [10] presented that the creativity phase is critical to the success of a value engineering exercise, in which the brainstorming technique is deployed to generate ideas. One shortcoming of the brainstorming technique is its lack of direction in problem solving, and consequently the efficiency is low in generating innovative and useful ideas.

Most successful value engineering organizations follow a "Scientific method" to assure a planned, purposeful approach. This procedure is called a VE job plan. Several versions of a VE job plan can be found in current publications. Some texts list five phases, some six, and some refer to even more. However, the number of phases is less important than the systematic approach involved. a five-phase job as follow:

1) Information Phase,
2) Speculation / Creative Phase,
3) Evaluation / Analytical Phase,
4) Development / Recommendation Phase, and
5) Presentation and Follow-Up Report Phase.

An effective value engineering effort must include all phases of the job plan. However, the proper share of attention given to each phases may differ from one effort to another [11].

2. OBJECTIVES

The main objectives of this study are:

1- Identifying the most criteria required for get data about:
   - Basics of applying VE,
   - Advantages of applying VE,
   - Obstacles that prevent applying VE, and
   - Suggestions that facilitate applying VE.

2- Analyzing the pervious data by a statistics computer program to get scientific results about the application of VE in construction projects in Egypt.

3. SURVEY QUESTIONNAIRE

According to the nature of data to be collected, the method applied in the study, the time allocated and the available financial aid, the author found that the most suitable aid to achieve the study objectives is the questionnaire due to the lack of basic information availability related to the subject like published data, in addition to the difficulty in obtaining this data through other tools like personal interviews, field visits or personal observations.

Survey can not achieve success without a well-designed questionnaire.

The first part of the questionnaire includes the independent variables of the study related to general information about study respondents of workers in some constructional projects in Arab Republic of Egypt such as "age – education – job post – years of experience – number of training courses on value engineering".

The second part of the questionnaire includes basic variables of the basics that value engineering is based on and it includes 15 statements as Availability of authenticated database, forming teamwork of members able to analyze problems, Brain Storming, etc.

The third part of the questionnaire includes basic variables of the importance of advantages achieved through applying value engineering and it includes 15 statements as the performance of workers without errors, creating new work methods meeting the project requirements, ideal application of modern techniques, etc.

The fourth part of the questionnaire includes basic variables of the obstacles that prevent applying value engineering and it includes 15 statements as limitations of value engineering training programs, limitations of connection on internet networks, lack of motivation towards positive competitiveness in applying value engineering, etc.

The fifth part of the questionnaire includes basic variables of the suggestions to facilitate applying value engineering and it includes 15 statements as providing value engineering training programs for leaders and workers in projects, the necessity of linking internet networks the necessity of government support to applying value engineering, developing the awareness of managers, engineers and workers on the concept of value engineering, etc.

3.1 STUDY LIMITS

This study is limited to studying the usage and applications of value engineering in the field of construction engineering projects and limited to be applied during the period from 2005-2010 during which this study was done. This study is limited to number of workers in some constructional projects in Arab Republic of Egypt.

3.2 STUDY SAMPLE SIZE

The researcher selected a suitable sample to represent the study society in order to save time, efforts and money on basis that the sample will lead to the same results approximately if we perform this study on the whole society. This sample is selected according to methodical principles so that it represents the original society in an exact manner. The sample-size equation was determined using the following formula (Dutta 2006):

$$N = \frac{(Z\alpha)^2 \times (S)^2}{(d)^2}$$

Where: N is the sample size, $Z\alpha$ is the Confidence level, S is the standard deviation of the population, and d is the maximum acceptable error as fraction of the standard deviation.

For this research, $Z\alpha$ is equal 2.58 at the Confidence level 99% degree confidence. The standard deviation S was calculated from previous studies S= 0.88 and the maximum acceptable error was assumed to be .25 of S then, d = 0.25×0.88 = 0.22.

Substituting the values into the equation above, the minimum required sample is calculated to be approximately 107 to reach 99% confidence level.

3.3 CONSTRUCTION SECTOR APPLIED

To obtain the required sample size, the author distributed sample of one hundreds and fifty respondents from different companies working in various construction sectors in Egypt. The sample contains companies from medium to large scale to get a good view of the parties participating in a given construction project. These firms represent a combination of Owner, Consulting, Contractor, and Supplier. Each group has two divisions: General sector and Private sector. The distribution of questionnaire on the different construction parties is shown below in Table [1].

It is noted that 58% of the questionnaire sample were distributed among the public sector personal as it has effective role in the selection process according to contracting law.

4. ADJUSTMENT OF MEASUREMENT

One of the basic elements in questionnaires is testing before practically applying it. Measuring reliability and validity of questionnaire items is very important role for the judgment of the questionnaire items.

Reliability coefficient means stability of measurement and not contradicted with its items, which means giving the same results whenever applied on the same sample.

To perform test of reliability of questionnaire questions it used Cronbach's Alpha reliability coefficients (a) with the following formula, where k is the number of elements, s_1^2 is the elements variance and s_r^2 is the variance of total degree.

$$a = \frac{k}{k-1}\left(1 - \frac{\sum s_1^2}{s_T^2}\right)$$

Validity Coefficient measures what is claimed to measure; mathematically it equals the square root of reliability coefficient. The reliability and validity coefficients are determined by SPSS program which. The reliability coefficient has a value of 0.900 and the Validity Coefficient has a value of 0.949 which they are a good indicator of the questionnaire items as shown if table [2].

Table [1] Distributed Questionnaire Sample

Type of Service	General	Private	Total
Owner	25	17	42
Consultant	18	15	33
Contractor	24	20	44
Supplier	20	11	31
Total	87	63	150
Percentage to Total	58 %	42 %	

Table [2] Reliability and Validity Summary

No.	Line	N of Items	Reliability	Validity = Square Root of Reliability
1	Basics of applying VE	15	0.901	0.949
2	Advantages of applying VE	15	0.573	0.757
3	Obstacles of applying VE	15	0.843	0.918
4	Suggestions Facilitate Applying VE	15	0.800	0.894
Total		60	0.900	0.949

5. QUESTIONNAIRE RESPONSE

The researcher obtained a sample of 110 questionnaires suitable for analysis and which represent 100% of targeted questionnaires in the study society and it achieves the minimum required sample size.

For the basics of applying VE factors, forming teamwork of members able to analyze problems came out as the most important factors that affect of basics, it was received the highest average score of (4.51). This factor has a highest mark because the correct analysis of the problem is the main road toward the selection of the optimum solution. Brain Storming received the second (4.38) that is for the benefits of speculation to add new method(s) for solution or at lest merge existing methods to result a different method able to solute the problem.

For the importance of advantages achieved through applying VE factors, creating new work methods meeting the project requirements came out as the most important factors that affect of advantages, it was received the highest average score of (4.67). Better investment of available human resources received the second (4.64).

For the obstacles that prevent Applying of VE factors, Lack of support from the government to apply value engineering with all its different departments came out as the most important factors that affect of obstacles, it was received the highest average score of (4.49). Limited understanding from project managers of application basics of value engineering received the second (4.38).

For the Suggestions that Facilitate Applying VE factors, providing free awareness programs for beneficiaries to comprehend value engineering programs came out as the most important factors that affect of

suggestions, it was received the highest average score of (4.81). The necessity of government support to applying value engineering received the second (4.60).

6. METHODS OF STATISTICAL ANALYZING PROCESSING

The researcher obtained a sample of 110 questionnaires suitable for analysis and which represent 100% of targeted questionnaires in the study society and it achieves the minimum required sample size.

After collecting data and inputting them to the SPSS program, the author organizing, describing and analyzing data in a manner that renders it more understandable to the user. The author performed that through using the two branches of statistics: Descriptive Statistics and Inferential Statistics.

Descriptive statistics characterize the distribution of a set of observations on a specific variable or variables. Figs. (1), (2), (3), and (4) shows the frequency of the means of basics, advantages, obstacles, and the suggestions of the study.

Inferential statistics deals with generalization, estimation and prediction. The Person correlation coefficient between the four focal lines of our questionnaire study is defined in which line is stronger or weaker in respect to correlation as shown in Table [3]. After studying the previous table we notice that the correlation between the four lines is directional and has a high statistical significance and is notable also that the first line (Basics of applying VE) and the fourth line (Suggestions to facilitate applying VE) are the most related and they are marked a value of 0.750 for correlation. As for the first line (Basics of applying VE) and the third line (Obstacles that prevent applying VE) they are the least correlated of a value of 0.293.

Linear regression analysis is adopted to measure the range of effect of the factors basics that VE are based on, importance of advantages achieved through applying VE, and obstacles that prevent applying VE on the suggestions to facilitate applying VE in construction engineering projects in Egypt. Thus regression line equation of the first independent variable is $Y = -0.42 + 0.542X$ whereas $Y= -.0.42 + 0.403X$ of the second independent variable, and $Y= -.0.42 + 0.046X$ of the Third independent variable whereas Y is the dependent variable and X is the independent variable. When studying Sig. value we find that value 0.419 is refused because it leads to null hypothesis; where 0.000 and 0.001 are accepted because it leads to the alternative hypothesis so regression equations are: $Y= -0.42 + 0.524X$ and $Y= -0.42 + 0.403X$.

7. COCLUSION

Due to the minor application of Value Engineering technology in construction projects in Egypt, this research paper aimed to recognizing the obstacles and suggestions of reduce these obstacles leading to facilitate the application of Value Engineering. The basics and advantages of applying VE are recognition because of the lack of knowledge of VE in Egypt. The author performed that through a questionnaire survey distributed on different sectors in construction projects.

The researcher obtained a sample of 110 questionnaires suitable for analysis. Forming teamwork of members able to analyze problems came out as the most important factors

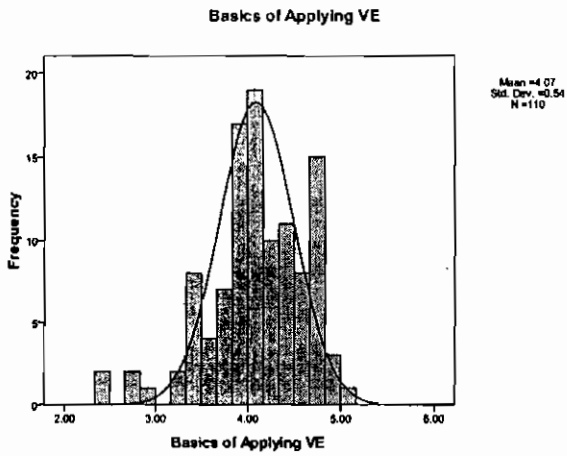

Fig. (1) Basics of applying VE Frequency

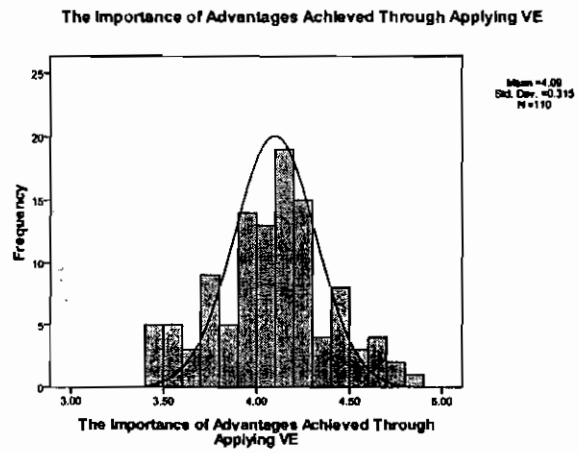

Fig. (2) Advantages of applying VE Frequency

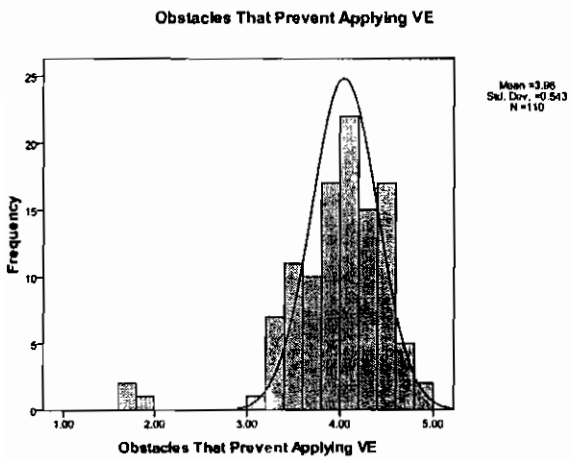

Fig. (3) Obstacles that prevent applying VE Frequency

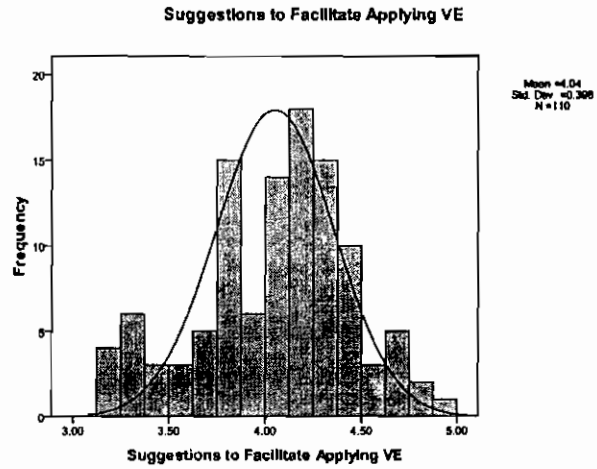

Fig. (4) Suggestion to facilitate applying VE Frequency

Table [3] Correlation

Correlations

		Basics of Applying VE	The Importance of Advantages Achieved Through Applying VE	Obstacles That Prevent Applying VE	Suggestions to Facilitate Applying VE
Basics of Applying VE	Pearson Correlation	1	.738**	.293**	.750**
	Sig. (2-tailed)		.000	.002	.000
	N	110	110	110	110
The Importance of Advantages Achieved Through Applying VE	Pearson Correlation	.738**	1	.316**	.701**
	Sig. (2-tailed)	.000		.001	.000
	N	110	110	110	110
Obstacles That Prevent Applying VE	Pearson Correlation	.293**	.316**	1	.299**
	Sig. (2-tailed)	.002	001		.002
	N	110	110	110	110
Suggestions to Facilitate Applying VE	Pearson Correlation	.750**	.701**	.299**	1
	Sig. (2-tailed)	.000	.000	.002	
	N	110	110	110	110

**. Correlation is significant at the 0.01 level (2-tailed).

That affect basics of VE. Creating new work methods meeting the project requirements came out as the most important factors that affect of advantages. Lack of support from the government to apply Lack of support from the government to apply VE with all its different departments came out as the most important factors that affect of obstacles.

The reliability coefficient has a value of 0.900 and the Validity Coefficient has a value of 0.949 which they are a good indicator of the questionnaire items. Statistical process analysis are applied by using SPSS program to facilitate analyzing the large number of the research data.

The research paper came out of important suggestions that facilitate applying VE as: (1) Providing free awareness programs for beneficiaries to comprehend value engineering programs. (2) The necessity of government support to applying value engineering. (3) Providing human personnel qualified to apply VE and information technology. (4) Providing VE training programs for leaders and workers in projects. (5) Motivating managers, engineers and workers in projects to apply VE.

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