REDUCING THE INFRASTRUCTURE CONSTRUCTION PROJECTS COST BASED ON VALUE ENGINEERING CONCEPT

Mohamed Abdel-Hamid Mohamed  
Civil Engineering Department,  
Faculty of Engineering at Shobra, Benha University, Egypt  

Hanaa Mohamed Abdelhaleem  
Civil Engineering Department,  
Delta Higher Institute for Engineering and Technology, Mansour, Egypt.

ABSTRACT

Infrastructure construction sectors are gradually being complained for producing projects that don't succeed to achieve the next goals: completing the project in a minimum cost amounts or completing the project within a logical duration. Value engineering (VE) approach can assist to obtain methods to develop solutions for the previous difficulties by keeping a quantified equilibrium in budget, time and function through creating a big number of new options. This needs a stimulated group of multi-disciplined experts in collaboration with the project team which is motivated and directed by the right method. This research presents the cost measurement of the infrastructure construction projects and is based on the value engineering concept and methodology. The study showed that the cost of the infrastructure construction project can radically decrease by applying the suitable value engineering procedure at the right time. Furthermore, this research paper displays an example of a value engineering case study - Wastewater Treatment Plant Extension project (WWTP) - that uses the cost measurement procedure for two items only (excavation and concrete casting). Thus, a decrease is produced in the total budget of the project from 1.7 billion Egyptian pounds (EGP) to 1.68 billion Egyptian pounds (EGP), so 1.2% of the total cost of the project is reduced, where the cost of excavation is reduced by 20% and the cost of the concrete casting is reduced by 6.5%. Finally, this paper summarizes the advantages and usefulness of the recommended method.

Keywords: Value Engineering, Infrastructure Construction Projects, Reducing the Construction Projects Cost.

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1. INTRODUCTION
The shortage of “project buy-in” is a general expression to indicate the project participants' shortage of the certainty in the project costs or the project duration. Egyptian infrastructure projects have lately gone under this attack. With the aim of avoiding this attack, attention should be driven to achieve an acceptable amount of “project buy-in” on infrastructure construction projects. The uses of the (VE) methodology for the construction projects can assist in achieving this. The general crises on the infrastructure construction projects are the delays of the schedule and the overruns of cost. Therefore, there is a need for a project method that well equilibriums the scope of the project with the project costs and schedule. Moreover, to guarantee “project buy-in” during the delivery of the project, project managers need to find and investigate a large number of project choices with considerable differences in the costs and the schedule of the project. Lately, increasing construction project costs and decreasing construction project profits produce an augmented awareness in (VE) by overall companies. (VE) assists to offer a service that achieves the customer’s requirement for cost effectiveness within a small timeframe. It is essential to recognize that the value engineering methodology concentrated on the construction projects, especially infrastructure projects, should have more stress on the project cost, as this feature on an infrastructure construction project is mostly the requiring feature of the project improvement. Value engineering concept finds methods to develop the clarifications to a problem. It develops an effective approach for decreasing the costs at the same time as increasing the quality. The main objectives of this research are to reduce the infrastructure construction projects cost based on value engineering concept, to apply the value engineering application for the Wastewater Treatment Plant Extension project (WWTP) as a case study, then finally to summarize the advantages and the benefits of using of (VE) method.

2. LITERATURE REVIEW
Many researches describe the value engineering as the organized methods that recognize the purpose of the project item, determine a financial value for that purpose, and deliver the required purpose dependably at the least likely cost [1]. As a result, the objective of a value engineering method is good established when the operator is capable to identify and separate the essential purposes from the unwarranted purposes and, in this manner, create different ways of achieving the needed purposes at a lesser overall cost. The value engineering in the industry of the construction is primarily a planned work to test the plan and the construction stages of the projects to deliver the wanted service at the least total costs coherent with the necessities for functioning [2]. Assaf highlights “Value Engineering Job Plan (VEJP)” as an ordered method and is essential to success in the value engineering analysis. (VEJP) is the way plan for describing the needed job in defining the most inexpensive arrangement of functions to end the job. It is during the (VEJP) that the research paper finds the main parts of the excessive cost and obtains novel and innovative methods of doing the similar purpose [3]. Mudge states that different procedures have been applied with the value engineering researches; several researches use only 5 stages, while others could apply as many as 9 stages. Examining each stages of the job plan in turn appears that about 22 different methods are used [4]. Zimmerman describes the value engineering by what is real and what is not real about the value engineering theory. He declares that the value engineering is an organized and multi-disciplined administration system [5]. On the other hand, it is not a plan checking, cost decreasing or QC procedure. The Purpose Testing Method Procedure illustration is a forceful tool that assists to classify the item of purposes by solving the questions: What? Why? How?. This assists the value engineering crew to form several verb-noun purposes’ arrangement and their interrelationships. Furthermore, FAST charts help in the recognition of main scope [6].
The automated technique use for the value engineering system is presently in elaboration. The USACE formed a technique named the value engineering -TRIEVAL. This database gives operators data about stored value engineering searches by means of keyword approach [7]. Chansik formed VEPRO, a worksheet rule- founded method with record characteristics that contains forms similar to the value engineering job plan [8]. Lyubov establishes the enhanced construction projects cost and describes the main steps in the cost creation of value engineering [9]. VE can enlarge the price of the product by decreasing needless costs, related with the project. In value engineering some costs may be removed without influencing quality [10]. Syaiful applies the performance based VE to the infrastructures projects of the wastewater, water supply and electricity services. The design option was created while the purpose of each service had been clarified. [11]. On the other hand, insufficiently studies have denoted the significance of cost-measurement based the value engineering method for infrastructure construction projects.

3. VALUE ENGINEERING STUDY STAGES
Value engineering study stages pass through the following steps: data collection, unit price analysis, analysis of cost / worth, evaluation result and implementation alternatives methods. Data is acquired from the project plan. Recognizing the cost plan will give the information about the costs of the all items of the project. Providing different methods by studying the benefits and difficulties of each alternate is developed. Computing the costs of each alternate is produced by aggregating the costs of materials, hire or buying of equipment and labor salaries. Examining the alternative cost by means of investigation of cost for function value of the project as a total is verified prior to verifying the function of the different elements. Then appraise the value of each item to link it to the assessed costs. Finally, the outcomes of the alternative methods cost are used if it can result in the cost competence.

4. CASE STUDY
Latest rises in budgets on Egyptian infrastructure construction projects became the drive for using value engineering methodology in Egyptian construction industry. The October Wastewater Treatment Plant extension project, which is investigated by value engineering (VE) team now, shows in what way the (VE) aids save time and cost and improves functional performance. The main purpose of this project is to improve and enlarge existing services. The project of Wastewater Treatment Plant (WWTP) was located in six of October city, Egypt and constructed in 1998 with a design capacity equals 150,000 m³ per day. The actual flow entering the plant is 170,000 m³ per day, so an extension must be carried out to tolerate the over-capacity. A new extension would be constructed and managed by international company with a capacity equals 150,000 m³ per day with a total estimated cost 1.7 billion Egyptian pounds (EGP). As a result, the total capacity of the new and the old WWTP would be 300,000 m³ per day. The project has three modules, where each module contains nine processing units. The value engineering study produced several new options to save the project cost. The approach of VE is used on two items only in the project (the excavation and the concrete casting) items.

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4.1. Excavation
During the planning of the project, a complete study of the excavation process was carried out and it was found out that the excavation level was at 8 m below the ground level. Previously, it was decided to excavate each unit of treatment facilities separately with side shoring. The price of excavation was 30 LE/m³ including the transfer of the excavation output and side shoring. The total excavated quantity in the whole project was 2,500,000 m³ including sedimentation tanks with diameter 50m, rectangle aerated tanks with dimensions (60m x 80m), rectangle contact tanks with dimensions (20m x 60m) and rectangle filter house with dimensions (100m x 200m). The total excavation cost was 75 million Egyptian pounds (MEGP) as planned.

During the execution phase, the value engineering team found that there are high costs, more time for the excavation item, the distances between the treatment units are very small, the other works must stop until excavation is completed and there is not overlapping in execution of excavation. Therefore, a modification was needed to decrease the cost of the project excavation. The (VE) methodology was applied to define the project problem, determine the causes of this problem and obtain the solution for it.

Therefore, an alternative study was carried out by excavating the entire area instead of excavating the treatment units separately. The price of new excavation is 20 LE/m³ without side shoring. The area between treatment facilities is 20% of the total excavated area. The alternative study was presented to the relevant committee for approval and the committee decided that the alternative solution is better, less cost and does not affect the implementation plan of the project. The most cost-effective alternative is carried out in the excavation with the same quality, safety plan and duration of the project. Accordingly, contractors were notified to change the excavation plan and prices to start excavation in the new way. The comparison between before and after using the value engineering methodology is presented in table 1. Applying of the VE methodology reduces the cost of excavation by 20 % of the entire cost of the excavation.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Old Method</th>
<th>New Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total excavated volume (m³)</td>
<td>2,500,000</td>
<td>3,000,000</td>
</tr>
<tr>
<td>Price of cubic meter (LE/m³)</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Total excavated cost (LE)</td>
<td>75,000,000</td>
<td>60,000,000</td>
</tr>
</tbody>
</table>

4.2. Concrete Casting
The required concrete quantity for the project was 90,000m³. The cost of one cubic meter of concrete was LE 900 including delivery from the ready mixed plant place to the project site. The total cost of the concrete quantity in the project was 81 million Egyptian pounds (MEGP). Moreover, the nearest Batch plant is 40 km away from the project site location. The concrete ready mixes would take a lot of time to reach the site of the project because of the long distance between the site and the supplier, taking in account, the risks that might happen such as accidents and delaying. A detailed study was carried out in the project. The study team found out that the quantities of the concrete which would be used in the project are very large. Therefore, the value engineering methodology would be applied to reduce the cost of the concrete. The project contains place that could be used for constructing a concrete plant. The company has skilled labor to operate the plant. A team was formed to conduct a complete study of the alternative solution by setting up a concrete plant and studying the construction costs, economic return, the possibility of having skilled labor and the time taken to construct the plant in a manner that does not contradict the project implementation plan.
After a complete study, a meeting was held to approve the study and implement the alternative solution. Operating the concrete plant to supply the site with the required concrete according to the specifications and the desired quality was started. Periodic follow-up of the concrete plant was done to know the needs, conduct periodic maintenance, supervision of the plant’s staff and the doing of concrete tests that are produced.

The alternative solution is accepted because it will save a lot of time and costs for the project. The cost of 1m³ using the batch plant can be estimated by calculating material cost, equipment cost and labor cost as follow: Material cost of concrete is 754 LE/m³ including the waste of the material. The equipment cost for each one m³ including batch plant, trucks, maintenance and operating cost is 87 LE/m³. Then, the total cost of one m³ concrete is LE 841. The total cost of concrete in the project is LE 75, 690,000. The comparison between before and after using value engineering methodology is presented in table 2. The applying of the VE methodology decreases the cost of concrete by 6.5% of the entire concrete cost. Moreover, the applying of the VE methodology decreases the total budget of the project from 1.7 billion Egyptian pounds (EGP) to 1.68 billion Egyptian pounds (EGP), which is 1.2% of the total cost of the project.

Table 2 Comparison between before and after applied VE

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Buying concrete</th>
<th>Batch plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total quantity of concrete (m³)</td>
<td>90,000m³</td>
<td>90,000m³</td>
</tr>
<tr>
<td>Price of cubic meter ( LE/m³ )</td>
<td>900</td>
<td>841</td>
</tr>
<tr>
<td>Total cost of concrete in the project (LE)</td>
<td>81,000,000</td>
<td>75,690,000</td>
</tr>
</tbody>
</table>

5. BENEFITS THROUGH VE STUDY FOR INFRASTRUCTURE PROJECTS

Construction companies that use the value engineering to their projects can attain the following values:

1. Determination of the technical difficulties on construction projects:
Value engineering investigations assign the experienced, qualified and specialized whizzes in a situation that studies in the deepness of the problem with value engineering tools, and offers all the while assessing the outcomes of the project before applying VE and after. This methodology can get very inspiring consequences on complex projects.

2. Advance addition of specialized expertise:
Hiring specialized expertise on a value engineering analysis is an extremely successful way to use specialized expertise on call in a well-organized way.

3. Highlight effective usage of resources:
The interval of a value engineering analysis is very small as compared to the several time needed within the process of the project. Value engineering analyses take a few days, while the projects are in progress for years. The developments to the project that are able to get in this little quantity of hours are effective usage of resources.

4. Enhance cost savings:
Through the value engineering analyses used in the infrastructure projects, major enhancement in project price savings and performing have been felt. Successfully, the link between the project costs and the project performance has been a main advantage to the infrastructure projects leaders. This money has been re-distributed into other projects.
5. Provide major revenue on investment:
The ratio of money saving to study costs is 205:1, so for every 1 dollar spent in a value engineering analyses, 205 dollars were saved for the infrastructure construction projects (US (DOTs) as recognized on the FHWA, 2008). Study cost contains all analysis and employment phase prices, such as the expert value engineering crew cost. This research discovered that value engineering study costs a smaller amount than 1% of the entire project costs.

6. CONCLUSION
The value engineering analysis carried out in the infrastructure segment has been permitted for the improvement of the agreement on what the project budget, delivery and scope must be. The costs and the quality of infrastructure area projects can gain by the use of the well-developed value engineering approaches. Specially, the value engineering approaches offer a good procedure for examining the project characteristics and aims, which in turn, directs the elaboration of options in the study of the value. This research presents the following recommendations to apply a fruitful VE approaches in the infrastructure projects segment:

a) Value engineering tasks should be obviously outlined within the company, b) Value engineering rules and guides must be used, expanded and provided, c) Value engineering exercise must be delivered, and d) Value engineering experts must be used.

Three major delivers should permanently be contained in a value engineering analysis: a) Function investigation should be performed in the future studies, b) The essential logical step by step procedure explained by the value engineering plot should be occupied on analysis and carried out by an experienced team organizer, and c) It should contain multi- efficient crew members.

Those are very vital to achieve extreme quality value engineering results. To attain the rightest help of the value engineering system, it is necessity to create a value engineering program that assists the infrastructure projects organizations to produce the greatest combination of project schedule and cost. Many value engineering searches are not applicable because of failing to achieve all of the project concerns (i.e. scope, schedule and cost). Moreover, a suitable value engineering program must fix flawlessly into the organizations' project improvement processes. The above two concerns, the complete project tool and the combination of the value engineering program into the project activities improvement processes will guarantee that the value engineering program helps the managers of the project in supplying the great value. This paper displays how cost-based VE approach can develop the project. The study found out that the project can meaningfully save project cost by applying the suitable value engineering procedure at the right time. In addition, this research paper presents a sample of a value engineering studied case that uses the cost measurement procedure, which is directed to a very inventive and less costly method to provide improvements at wastewater treatment plant extension project for two items only (excavation and concrete casting). The applying of VE methodology decreases the total budget of the project from 1.7 billion Egyptian pounds to 1.68 billion Egyptian pounds (i.e. 1.2% of the total cost of the project) and reduces the cost of excavation by 20 % of its entire cost and the cost of concrete casting by 6.5% of its entire cost.

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