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Improving Sustainability Concept in Developing Countries

The Influence of Value Engineering and Sustainability considerations on the Project Value

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Abstract

Value engineering is a powerful approach for cost saving and quality improvement; especially that the construction industry holds a significant weight with respect to the worldwide economy. Currently, value engineering does not influence just project costs and quality, but also it proved to have positive impacts on the environment and the worldwide trend of green construction. Value engineering takes into consideration both the initial and life-cycle costs. Sustainability is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The sustainability approach deals with all the surrounding resources such as water, energy, material lifecycle from its beginning as raw materials till their salvage cycle. This paper presents a case study of value engineering applications in the aforementioned sustainability disciplines in a real large-scale residential project. In this case study, the methodologies and calculations of the value engineering and sustainability studies are presented. The overall estimated savings of the project resulting from the full value engineering study ranged between 20% to 30% percent of the element cost; hence a significant reduction in the overall project cost as well as the saving in energy consumption that reached about 7%. The paper provides a good example on how value engineering and sustainability are inter-related; and how they have compounded economic and environmental impact when studied in parallel.
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1. Introduction

Historically, Project value where primary communicated in monetary terms, as a ratio of costs to benefits. Later other researches defined value in terms of use, exchange/replacement, esteem value and cost. In construction projects

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value can be looked at from owner or end user side. Project value has a utility dimension with an intrinsic property to satisfy [1]. Value Engineering (VE), also referred to as Value Methodology (VM) or Value Analysis (VA), is a systematic process to improve the value of a project through the analysis of its functions. Value is defined as a fair return or equivalent in goods, services, or money for something exchanged [2]. In other words, value is the ratio of function to cost; where the value is increased by either increasing the function or reducing the cost, or by both. Value Engineering was conceived in the days of World War II in the 1940s by Lawrence D. Miles; who was at that time the purchasing department manager at General Electric, which was a major defense contractor having shortage of strategic materials needed to produce their products due to the war. Mr. Miles formulated the concept of function analysis, which is the key foundation of VE. Mr. Miles studied the functions of products, and he indicated that clients purchase products either for the work they perform or for their aesthetic merits. So he investigated alternatives for the purpose of increasing the value while achieving the same functions without compromising the quality [3].

Climate change is a fact that have been discussed since decades when first time discussed in a scientific paper in 1827 [4]. In 1988 the IPCC (Intergovernmental Panel on Climate Change) was established to address the climate change issue and prepared assessment reports about the state of scientific, technical and socioeconomic economic knowledge on climate change including its cause's as well potential impacts and the required response strategies. Residential buildings are responsible for major energy consumption in Egypt where 45% of its population lives in urban areas. In 2009/2010 residential buildings consumed nearly 48% of the total nationally generated electricity [5].

In Egypt Many researches and scientific papers discussed the climate change issue, however the pace of climate change has accelerated globally in the last decade, at the same time economic, social and political disarray in Egypt in last few years threatened the achievement of a sustainable development. The combination of these factors has a dramatic effect on people and economy if not taken into consideration during the design and construction process.

Nomenclature

EEC	Egyptian energy code for residential buildings
FLC	foamed lightweight concrete
VE	value engineering
XPS	extruded polystyrene

1. VE Methodology

For any certain project, the VE study is applied by a multidisciplinary team to improve its value. SAVE International sets 6 sequential phases for performing a successful VE study. The phases are distributed in 3 stages; pre-workshop stage, workshop stage, and post-workshop stage. The methodology of the SAVE International VE studies, including stages and phases, is shown in Figure 1.

The scope of this paper covers the phases of the workshop stage (stage 2); which are the most technical stage in nature. VE study Phases in stage 2 are:

- Information Phase
- Function Analysis Phase
- Creativity Phase
- Evaluation Phase
- Development Phase
- Presentation Phase

The study went through the 6 phases of the VE study although the paper will highlight the Development Phase which is the most critical phase for any VE study.

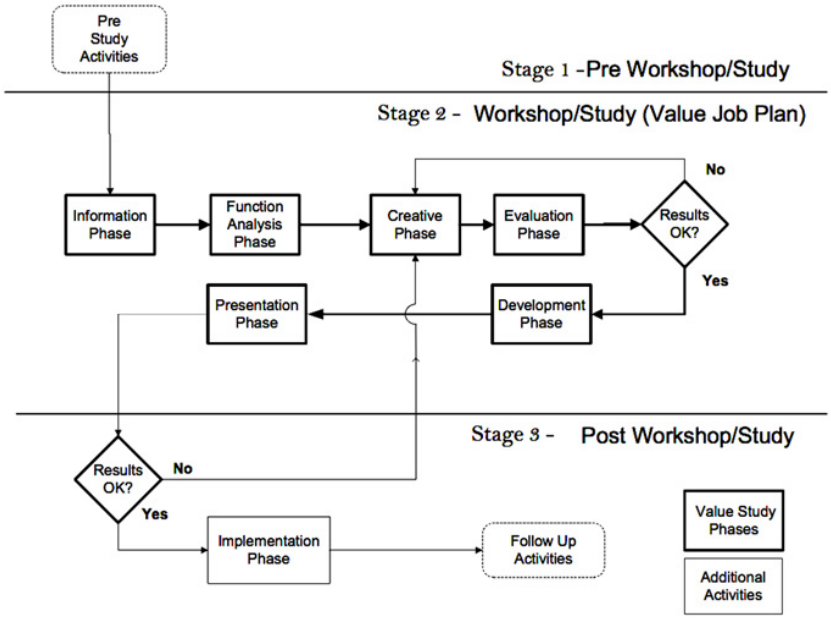

Fig. 1. Value Study Process Flow Diagram by SAVE International.

Value methodologies can be applied during any stage of a project development cycle, although the greatest benefit and resource savings are typically achieved early in development during the conceptual stages as shown in Figure 2. At this point, the basic information of the project is established, but major design and development resources have not yet been committed. The reason this is the best time to apply a value methodology is because the manner in which the basic function of the project is performed has not been established, and alternative ways may be identified and considered [6].

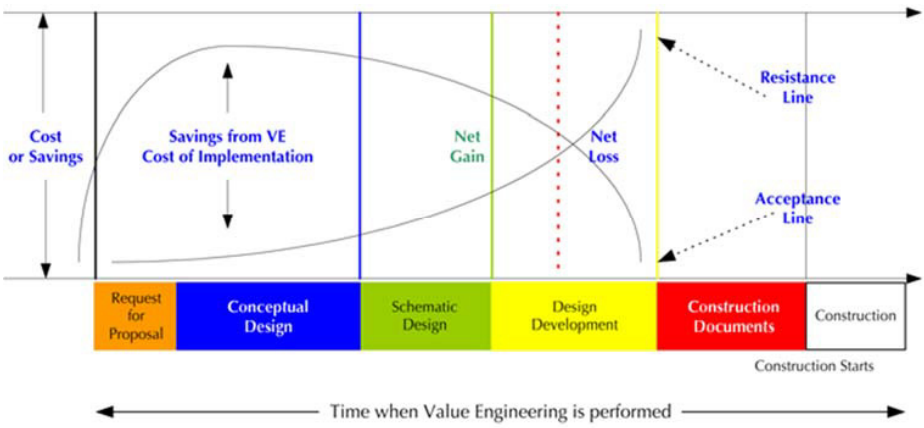

Fig. 2. The phases of the project and its relation with the expected savings by SAVE International

2. Case Study

The project under the study is a luxurious residential compound including 1700 residential units over 300,300sqm is located into the southwest corner of huge land Development and offers different designs and styles to meet all needs and tastes, ranging from duplex villas to single villas. The main reason for the VE workshop is due to the significance estimated Construction costs that caught the eye of executive management. The owner wasn't concerned at this stage with the environmental side and its effect on the project sustainability. The purpose of the VE workshop was to verify (or recommend improvement for) the base design case presented by the Project Team: Design criteria and Design approach for the Project.

2.1. The Value engineering Study

The VE study followed SAVE international methodology through all the study. The study emphasized the main objective of the value engineering which aims to improve the value of the project in terms of the following equation (1):

$$Value = \frac{Performance}{Cost} \tag{1}$$

The optimum case is to increase the performance and reduce the cost if possible, but however if cost still the same and the performance of the project is increased in terms of operations and client satisfactions, then the value of the project will increase too, which was the main objective of this study.

2.1.1. Information phase

Information Phase which is the first phase in a VE study, in which the VE team collected all the documents available as well as the project drivers. The VE team leader prepared a cost model from the cost estimate provided by the project team. The model is organized to identify major construction elements or trade categories, the designer's estimated costs, and the percent of total project cost for the significant cost items. The cost models clearly showed the cost drivers for the project and were used to guide the VE team during the VE study.

The following conclusions were noted by the VE team regarding the project costs:

Table 1. Cost model – Baseline concept.

Items	Percent of the total
Architecture System	37%
Structure System	51%
Electrical System	6%
Plumbing System	4%
Elevators Work	3%

It was obvious from the above that the Structure System percentage is significantly high which helped the VE team through the rest of the VE workshop although it didn't restraint or limit the creativity phase.

2.1.2. Function analysis phase

Function analysis results in a unique view of the study project, it is the key activity that differentiates VE from other problem-solving practices. It transforms project elements into functions, which moves the VE team mentally away from the original design and takes it toward a functional concept of the project. Functions are defined in verb-noun statements to reduce the needs of the project to their most elemental level. Identifying the functions of the major design elements of the project allows a broader consideration of alternative ways to accomplish the functions. The

project has main basic functions which is housing people. As for the structure system it has two main functions which are Provide Stability and Perform Construction

2.1.3. Creativity and evaluation phase

During the creativity phase there wasn't any limitations, the VE team used many of the well-recognized techniques recommended to be used in this stage such as brainstorming, Gordon technique, nominal group technique, TRIZ, and Synetics. Then during the evaluation phase the VE team started to evaluate the obtained ideas and reduce their quantity to a short list of ideas with the greatest potential to improve the project. The VE team filtered out the non-beneficial ideas using the Pugh analysis, Kepner-Tregoe matrix, life-cycle costing, and choosing by advantages (CBA).

2.1.3.1. The evaluation of the Idea under study

One of the ideas discussed and shortlisted was the replacement of the lightweight concrete used in the roof layers to be Foamed Lightweight concrete (FLC). The VE team studied the possibility to omit the extruded Polystyrene layer (XPS) used for the heat insulation as well as the Water proofing membranes and to use instead the foamed lightweight concrete only as it is known with its higher thermal performance than the normal lightweight concrete. The idea was evaluated based on the following advantages and disadvantages:

- Advantages:
  - Reduce initial cost by omitting the extruded polystyrene layer.
  - Reduce dead load over the Structural slab, hence reduce the slab thickness which will have an impact over the cost.
- Disadvantages:
  - The FLC have especial method of application that could affect the construction time.

2.1.4. Development phase

The aim of this phase was to provide further analysis to the list of ideas with the highest merit into value alternatives from the evaluation phase. The ideas were developed further into value alternatives that clearly stated so that the stakeholders have clear understanding of their impacts, savings, and effects on value. During this phase the VE team had to get more familiar with the method of application of the FLC and to study its impact over the project cost and construction time.

It was declared by the material supplier that there are few contractors that have the know-how of the application of the FLC which can affect dramatically the cost and the time. Considering that the study was performed in an early stage it helped providing recommendations that helped to apply the idea of FLC instead of lightweight concrete without affecting cost and time.

The VE team went through the cost study, as the lightweight concrete, XPS and Waterproof membrane are applied over an area of 21,139 m2 and the XPS and the waterproofing membranes was estimated to use the same area.

Table 2. Comparison between the layers in before and after VE.

Layers	Roof Layers Before VE	Roof Layers After VE
Finish Layer	2cm mosaic tiles	2cm mosaic tiles
Under layer finishes	3cm cement mortar	3cm cement mortar
	5cm sand	5cm sand
Thermal Insulation	5cm XPS (Thermal insulation)	
Water proofing insulation	Primer Coat	Acrylic reinforced cement based waterproofing coat
	Bitunil 4mm membrane	
	Bituter 4mm membrane	
	Lightweight Concrete	Lightweight Concrete

Considering the above mentioned area and the unit rates for both XPS and water proofing membranes, and after calculating the unit rate for the new alternative after the VE study; the calculated direct savings were about 40% of

the original roof layers cost. After calculating the impact of the new alternative over the structure system (roof structure slab), the reduction of the structure slab thickness reached up to 5%.

On other hands the FLC needs to add an admixture to the Lightweight concrete that must be applied in combination with a water pressure of +2.5 bar, if less pressure is in place the foam will be too watery and it will be difficult to get a stable density for the Concrete Roof. Nevertheless, the admixture must be applied by using a Foam Gun where the input will be the Water under the 2.5 bar pressure and the Output will be the requested Quantity of Foam. The Quantity of required foam - to achieve a certain density - is a function of the pressure and the time: the lighter Concrete we need the more time we need plus a higher dosage of admixture will be used. It is impossible to apply the admixture without the Gun and without a truck mixer where the mixing procedure is homogeneous and density will become stable. Thus the VE team recommended to tender the Concrete works to the contractors having previous experience with the application of the FLC, which will save cost and will ensure to obtain the required quality of the FLC.

2.2. The Sustainability Impact of the New Alternative

Sustainability accounts over three main bottom lines which are economy, environment, and society. The economy was discussed through the value engineering study. Environment and society are progressively discussed by sustainability consideration. The environment is well considered through material selections, design considerations as well energy conservation.

Energy efficiency is a significant issue for high quality housing. Energy not only corresponds to high percentage of the running cost of buildings but it also has a main effect on the thermal comfort of the occupants. These days the demand for energy efficient design and construction has become progressively more vital with the growing of energy costs and increasing awareness on the effects of global warming.

One of the methods to decrease the energy content is through selection of building materials. Strain on conventional energy can be reduced by utilization of low energy materials and efficient structure design. The choice of materials also helps to maximize indoor comfort [7].

2.2.1. Thermal characteristics for FLC

The heat transport between two objects through three main methods: conduction (in direct contact), radiation, and convection. Conduction is done between solid objects thus this method characterized the different solid materials thermal characteristics. Thermal Conductivity (k) is the property of a material describing its ability to conduct heat. Thermal resistance (R-Value), is the material's resistance to conductive heat transfer. The R-value is a measure of an insulation sample's ability to reduce the rate of heat flow under specified test conditions. The higher the value of R, the better the building insulation's theoretical effectiveness [8]. To decrease the heat gain through the building envelope it is essential to choose materials with high R-value. The foamed concrete has been acknowledge for its superior performance in thermal insulation characteristics due to its cellular microstructure.

The density of the FLC is between 800-1000 kg/m^3, hence the thermal conductivity for FLC with this density is reported to be one-sixth the value of typical cement-sand mortar [9].

Researches and experiments showed that the thermal conductivity of the FLC with the required densities varies from 0.26-0.31 W/mK [7]. While the thermal conductivity for ordinary heat insulating materials range from 0.034to 0.173 W/mK [10]

2.2.2. Thermal performance of the VE alternative

As an important step it was presented to the project owner the importance of the sustainability considerations, as it will help improve the value of the project. It was discussed the effect of the high thermal performance of the FLC and its effect on reducing energy loads thus reducing electricity consumption and reducing the electric bills.

Following to the cost study further studies were conducted on the FLC alternative to ensure its effectiveness on all the aspects that can affect the project value. A comparative thermal calculation for both designs (original design and the VE design) were calculated and studied to measure the thermal performance of the two systems and the results was as shown in Figure 3 and 4.

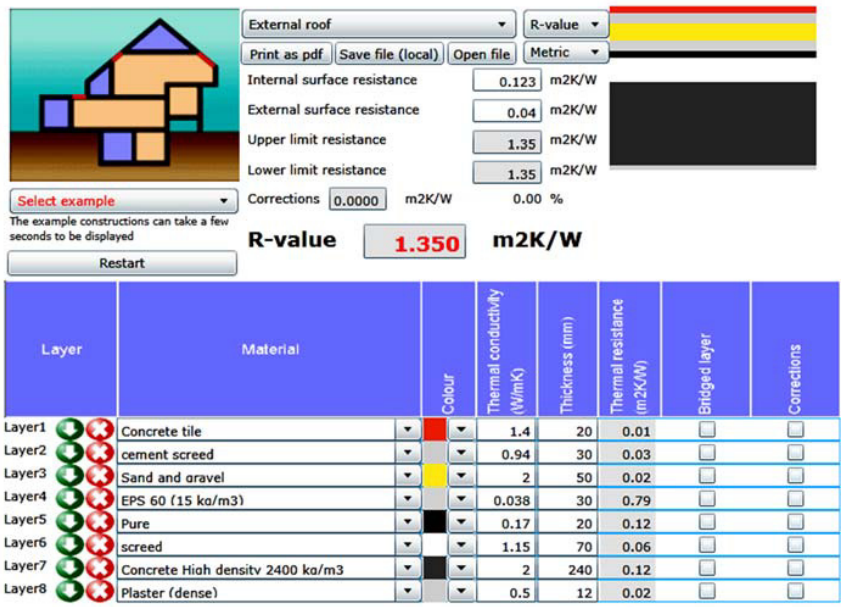

Fig. 3. The R-value for the original design.

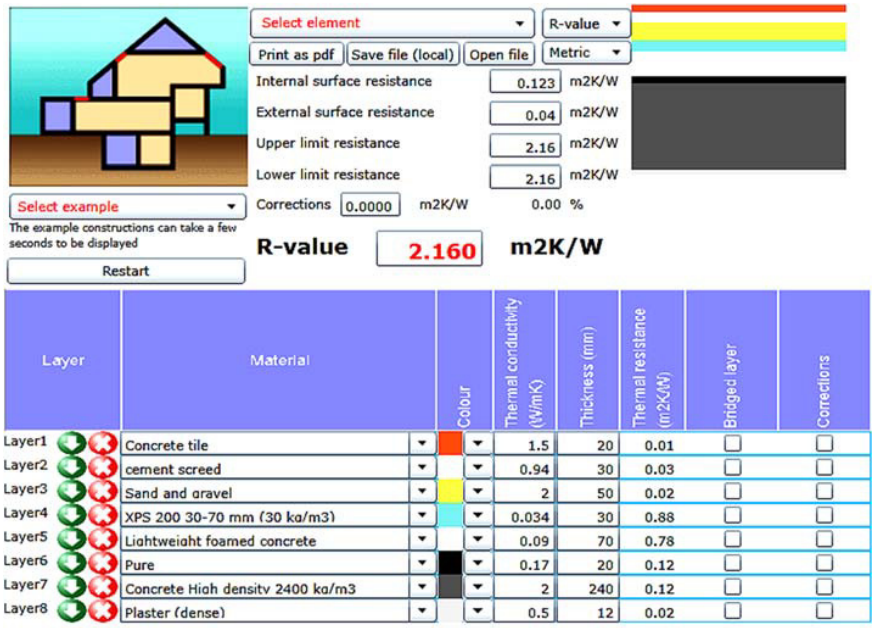

Fig. 4. The R-value for the VE proposal.

It was considered that the R-value for the roof layers meet the requirement of the Egyptian Energy Code for residential buildings which is required to be 2.7 m^2k/w [11].

3. Results Discussion

The study showed that the FLC has a higher R-value, hence a higher thermal insulation which will ensure a better thermal performance inside the building especially in the last floor. An optimized building design will help reducing energy use when it includes load reduction. The application of FLC with a waterproofing admixture will help giving away the use of bituminous membrane with all their negative impacts on the environment during the production and application as well.

On the other hand the use of FLC alone can't replace the use of a thermal insulation material over roof layers. The thermal calculator used in the study showed that R-value of roof layers when using FLC without the application of a thermal insulation layer was far lower than the value required to be achieved by the EEC which was around 1.7 m2k/w. Accordingly it was required to recalculate the R-value of the roof layers after adding a thermal insulation material as the XPS with a density of 30 kg/m3, the R-value of the roof layers in general improved to be 2.1 m2k/w which is close to the value required by the EEC.

A simulation study for the evaluation of energy saving for the same project showed that the R-value requested by the EEC helped reduce the energy consumption load for the last floor by 29% [12]. In this study the achieved R-value helped reduce the energy consumption load for the same floor by 20%.

4. Conclusion

Value engineering is a powerful approach for cost saving and quality improvement. Despite its world-wide known benefits, it is not applied in proper methodologies in Egypt and it is usually mixed-up with the concept of cost saving; thus practitioners find themselves reducing cost on by jeopardizing important elements such as quality and function. Sustainability as well is not yet categorized as an important factor for the project performance hence the project value. This paper illustrated the VE methodology provided by SAVE International, which is considered the official society for value engineering practitioners, and provided a case study which has been developed and studied over the three main axes of the sustainability: economically, environmentally, and socially. The paper showed that project value could improve when considering these three factors. This accentuated the integration and the effect of the Value engineering and sustainability goals over project value. The paper showed that the alternative proposed through the VE study integrated with sustainability considerations achieved 40% cost saving from the item as well as thermal insulation improvement of about 55%.

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