EXPLORING CONCEPTUAL LINKAGES BETWEEN VALUE ENGINEERING AND SUSTAINABLE CONSTRUCTION

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There has been increased awareness of the importance of value engineering (VE) and sustainable development within the construction industry. Both subjects play crucial roles in realising quality, reliability and durability as well as enhancing performance throughout the life of a project. They also help to: improve service related outcomes within budget constraints: achieve a more efficient use of resources; and accomplish an optimum combination of whole-life cost and quality to satisfy the user requirements. This paper reviews VE and sustainable construction and explores conceptual linkages between the two that relate to achieving best value over the whole life of a building project. It also suggests six steps for applying VE principles and tools to help implement sustainable construction within early stages of a project. This paper also traces the belief that VE is an appropriate technique to diffuse sustainable construction principles among its team members. Furthermore, it explores the concern that many sustainable construction dimensions are already inherent as part of VE workshops, but with the level of consideration differing from one workshop to another depending on the knowledge of the team themselves. Moreover, the paper concludes that the degree of integration of between the two topics is relatively untapped due to a lack of information and understanding of the underlying concepts.

Keywords: best value, conceptual linkages, sustainable construction, VE.

INTRODUCTION

The construction industry has both positive and negative impacts on the environment and people. On a global scale, the construction industry and its products (buildings, bridges, dams, roads, etc.) contribute to environmental problems through resources depletion; energy consumption; air pollution and waste creation (Ngowi 2000). The construction industry's fragmentation creates many difficulties for its clients who must procure individual project elements from different sources (Egan 1998). It is estimated that the construction industry in Europe is responsible for approximately 40% of energy consumption, 30% of CO2 emissions and 40% of total solid production waste (Hajek 2002; Sjostrom 1999). However, the construction industry also: contributes 10-12% of GNP to the economy of most countries (Sjostrom 1999); and provides jobs for approximately 1.5 million people in the United Kingdom. Combined with the need for new construction, the industry also makes an important contribution to the quality of life (DETR 2000).

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If the construction industry is to provide the required buildings and infrastructure, and at the same time reduce environmental degradation, must adopt more sustainable practice and policies (Ngowi 2000). In the beginning of the 1970s, many considered that capability to achieve a task was dependent on the design of appropriate construction processes and the required resources would automatically be available. In today's economic environment, however, unlimited resources are considered unsustainable in the long term and the need for effective VE started to emerge (Land 1997).

Findings from interviews undertaken for ongoing PhD research at Loughborough University suggest that in Saudi Arabia, many people who work in the Saudi Public sector have little experience of sustainable development and sustainable construction is not a major consideration. Although there is considerable ignorance about sustainability, VE has been applied for more than two decades and practitioners have a considerable amount of VE related experience; probably due to the fact that the application of VE is compulsory for projects financed by the Saudi government.

There could be substantial benefits of using VE as road map for promoting and achieving sustainable construction. Additionally, the experience and skills of VE practitioners could be used to accelerate the understanding and implementing of sustainable construction. During the process of developing a project, VE principles and techniques aim to provide best value from a whole life perspective. This paper, in reviewing VE and sustainable construction, explores the conceptual linkages between the two topics and how assesses how these can be used to achieve best value over the whole life of building projects. It also suggests six steps for applying VE principles and tools, during the early stages of project, in the evaluation and improvement of sustainable construction.

UNDERSTANDING VE

Origins

Due to shortages of materials during World War II in 1947, General Electric Company appointed Mr. Lawrence D. Miles to produce a method that would both make changes in manufacturing techniques, or design, which led to substantial cost reduction. Mr Miles developed a systematic approach called value analysis. He conducted the first value analysis workshop seminar in 1952 (Younker 2003). In 1954, the US Navy bureau of Ships applied value analysis (VA) to cost improvement during design, calling it after VE. In the early 1970s, VE techniques were exported outside the US to many countries such as: Japan, Korea, India, France, UK, Germany, Hungry and Saudi Arabia in addition to Canada, South America, Taiwan and South Africa and other countries (Dell'Isola 1997).

VE definitions

In the construction industry, value engineering, value analysis and value management are used to describe a systematic process of appraisal of the function of a project to ensure that it is delivered in the most effective way. A number of definitions of VE have been presented below that are selected by the authors because this term is common in Saudi Arabia and usually used as a solve problem technique.

'VE is a professionally applied, function-oriented, systematic team approach used to analyze and improve value in a product, facility design, system or service – a powerful methodology for solving problems and/or reducing costs while improving

performance/ quality requirements' (JSVE 2005). *'VE is defined as proactive, creative, team approach to problem-solving in construction projects to provide the best value for money'* (Hayles and Simister 2000).

'It is an organized process with an impressive history of improving value and quality. The VE process identifies opportunities to remove unnecessary costs while assuring that quality, reliability performance, and other critical factors will meet or exceed the customer's expectations' (Dell'Isola 1997). Kelly and Male et al. (2004) defend VE is *'the term used to describe a subset of the value management process, where the focus is on improving value in the design and construction stages of the 'technical project'*.

The fundamental aspects that are identified below summarised the VE technique:

- a proven management technique;
- enhance value, quality, safety, reliability, maintainability and optimise whole life cycle cost;
- function oriented, analysis;
- improve decision making;
- meets user's requirements, needs, and expectations;
- multidisciplinary, proactive, creative teams approach;
- problem–solving technique; and
- system, techniques, approach.

VE objectives

The main objective of VE is to enhance value in addition to reducing time, improving quality, reliability, maintainability and performance. Furthermore, VE can modify human behaviour, for instance attitudes, creativity and teamwork. VE can also expand the use of financial, manpower and material resources by eliminating unnecessary or excessive costs without sacrificing quality and performance (Dell'Isola 1997). Zimmerman (1982) stated that the goal of a VE study is to realise true value for the owner. *'The value may come in the form of removing unnecessary cost to the project, or it may come in the form of providing a more workable product that would decrease the costs of owning and operating the facility. Value is that elusive commodity that we all attempt to achieve in our design. Value, in this context, is considered to be the value for money that is received in return of a project or service'*.

VE timing

It has been generally agreed that VE needs to be applied as early as and unnecessary commitments avoided. Dell'Isola (1997) suggested that VE should be conducted as early as possible if its full potential is to be realised, before commitment of funds, approval of systems, services, or designs. He also stated that when VE is applied later, two things increase: the investment required to implement changes; and resistance to change. Assaf and Jannadi *et al*. (2000) reiterated this viewpoint stating that during planning and design, choices can be made between reasonable estimates of alternative courses of action.

The VE job plan

Depending on different experiences, value practitioners have written VE job plans with different phases in its numbers. The VE job plan, which has been discussed in several papers and books, fluctuates from five to eight phases. The basic difference lies in the synthesis of phases or splitting them. VE job plan techniques remain the same in each. Table 1 provides a comparison of different VE job plans.

Table 1: Comparison of various VE job plans

Authors	Job Plan	Authors	Job Plan	Authors	Job Plan
MILES (1972)	Information Analysis Creativity Judgment Development	**Zimmerman (1982)**	Information Creative Judgment Development Recommendation	**Male *et al* (1998)**	Information Creativity Judgment Development Presentation
Dell'Isola (1997)	Information Function analysis Creativity & Idea Generation Evaluation and selection Development	**Fallon (1980)**	Information Analytic Creative Evaluating Presentation Implementation	**SJVE (2005)**	Information Creativity Evaluation Development Presentation
(1971)	Selection Information Function Creation Evaluation Investigation Recommendation	**SAVE (2005)**	Information Function analysis Creative Evaluation Development Presentation	**GSA (2005)**	Information Speculative Evaluation Development Report

UNDERSTANDING SUSTAINABILITY

Sustainable development

Sustainable development is defined as 'development that meets the needs of the present without compromising the ability of the future generations to meet their own needs' (WCED 1987). Sustainable development integrates a variety of subjects: environmental quality, economic constraints in addition to social equity and cultural issues (Hajek 2002).

Development implies changes and should lead to an improvement in the quality of life for humanity. Development encompasses not only growth, but also general services and welfare. Development involves the transformation of natural resources into productive output. Sustainable development is the balance between economic progress and environmental conservation, given that both are imperative to our future survival. Sustainable development thus implies using renewable natural resources in a way which does not eradicate or degrade them or otherwise decrease their usefulness to future generations. It also implies using non-renewable natural resources at a rate slow enough as to ensure a high probability of an orderly societal transition to new alternatives (Langston and Mackley 1998).

Sustainable construction

Sustainable construction is generally used to describe the application of sustainable development in the construction industry. This may mean that for the construction industry to continue its business and growth under the premise of sustainable construction it will need to impede its growth in some areas, or grow in different ways (Plessis 2002). Kibert (1994) defined sustainable construction as *'the creation and*

responsible management of a health built environment based on resources efficient and ecological principles'. Hill and Bowen (1997) extend the definition to four pillars: social, economic, biophysical and technical.

To obtain optimal solutions to current difficult infrastructure problems, it is vital to consider environmental technical, social, political and economic aspects, their synergies and the inevitable balances between them. Sustainability in this way expresses solutions with regard to a whole system, with an entire combination of outcomes as expressed by a variety of comments and conclusions (Ferng and Price 2005). The UK Government published in May 1999 *'A better quality of life – a strategy for sustainable development for the UK'*. Due to this, sustainable construction has become both an essential and well-understood topic. The UK government has published a series of policy documents to stimulate the application of sustainable construction principles in the construction industry. *'Building a Better of Life: a Strategy for more Sustainable Construction'* was published in April 2000(DETR 2000). This is a key policy that illustrates UK strategies for sustainable construction. The Sustainability Action Group of the Government Construction Clients' Panel (GCCP 2000) produced *'Achieving Sustainability in Construction Procurement'*. Sustainable construction is summarised in a number of themes, written by several authors, as illustrated in Table 2.

Table 2: Various themes of sustainable construction

Authors	**SUSTAINABLE CONSTRUCTION THEMES**
MIYATAKE (1996)	• Minimisation of resources consumption; • Maximisation of resource reuse; • Use renewable or recyclable resources; • Protection the natural environment; • Creation of a healthy and non-toxic environment; and • Pursue quality in creating the built environment.
DETR (2000)	• The re-using of existing built assets; • Designing for minimum waste; • Target for lean construction; • Minimising energy in const; • Minimising energy in use; • Avoiding pollution; • Preserving and enhancing bio-diversity; • Conserving water resources; • Respecting people and their local environment; and • Setting targets.
GCCP (2000)	• Enhance the quality of life and offer customer satisfaction; • Offer flexibility and the potential to cater for user changes in the future; • Provide and support desirable natural and social environments; and • Maximise the efficient use of resources.
Hajek (2002)	• Decrease the use of raw materials and energy; • Optimise the consumption of renewable resources; • Decrease the amount of harmful emissions and waste; and • Increase serviceability, durability and reliability over all the entire life of the project.

Horn (2005)	• Optimising site potential; • Minimising non-renewable energy consumption; • Using environmentally preferable products; • Protecting and conserving water; • Enhancing indoor environmental quality; and • Optimising operational and maintenance practices.

VE AND SUSTAINABLE CONSTRUCTION

Correlation between VE and sustainable construction

As sustainable construction brings additional value to projects, VE can be used to ensure that these values are maximised (Addis and Talbot 2001). Sustainable construction is concerned with delivering better long-term value for the construction industry's stakeholders including end users. Sustainable construction means balancing value, risk and waste within project parameters; taking into account factors such as: land use, materials types, and construction techniques, regeneration and community needs. When considered in terms of sustainable development, construction projects may require a shift aware from tradition standpoints: tfrom short term to long term; from shareholders to stakeholders; from product to service; from local to global; and from cost to value (Hayles 2004).

VE can be used as a vehicle for achieving sustainable construction but must be applied during the early stages of a project. It is a reliable means for creating visions of new direction and obtaining objectives towards a base of desired output including formulating policy. Strategic planning is paramount carried out using VE principles in terms of creating a vision, establishing measurable goals and putting strategies in place. The significance of function analysis distinguishes needs from wants; very quickly and fundamental objectives can be collaboratively shaped. An important principle in accomplishing the triple bottom line (TBL) is the enhancement of living economic standards whilst increasing the overall quality of life for present and future generations. As beforehand mentioned, VE has essential role in realising the TBL and moving from: theoretical to practical; clarification to consensus; and machinations to mechanisms (Yeomans 2002).

VE is effective in many areas of the construction industry and can be used at different stages in the life of a building project. Applied with flexibility and creativity, VE is relatively unrestricted in its ability to indicate areas of potential saving that are not readily apparent. Often, VE can generate significant funds in initial installation and operating costs (Dell'Isola 1997). It is not only a management approach for the construction industry in the 90s; it is also one of the best techniques for producing best results in achieving value for money for client (Fong 1996).

Austin and Thomson (1999) stated that the integration of VE might facilitate collaboration between organisations throughout project design and construction, especially VE is considered as a familiar technique in the construction industry. The sustainable decision is that which uses professional judgment and vision to distinguish between capital expenditure and operational expenditure. The vital objective is to give the client the maximum value for every the capital invested. VE plays a significant role in managing value to meet its goals. It can provide the networking required for improving coordination and communication. In other words, VE facilitates management of both value and costs (Dell'Isola 1997).

Using the VE methodology can result in improved profit and will continue to pay increased dividends to shareholders for years to come (Dell'Isola 1997). Isaacs and Kurtz (2004) stated that *'VE is a process that can be used to evaluate the functionality of any project, process or system. If you choose to apply it to first cost, it works great. If you choose to apply it to the sustainability elements of a project, it also works great. You choose your goals and let the VE process and the facilitator do the rest'*. Figure 1 illustrates conceptual objectives for VE and sustainable construction to meet best value under whole life value umbrella.

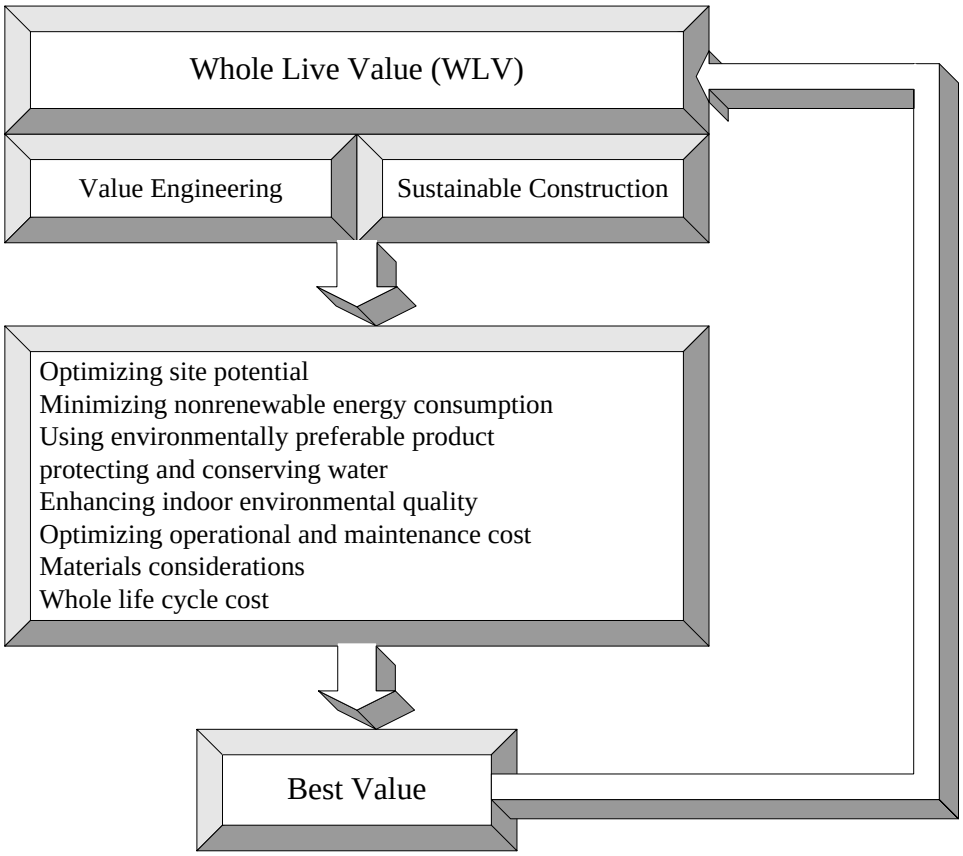

Figure 10: Conceptual aspects for VE and sustainable construction

Capability of VE to implement sustainable construction

It has been confirmed that the consideration of sustainable construction in VE workshops remains an under exploited topic because of a shortage of information. VE is an appropriate technique to diffuse sustainable construction principles amongst its team members (Abidin and Pasquire 2003). However, sustainable construction is inherent in most VE workshops, but the level of consideration differs from workshop to another (Abidin and Pasquire 2005). The environment of the VE workshop can help to spread the knowledge of sustainability among the team through the facilitator or sustainable construction/environmental instructor; or through sharing the experiences between members.

The VE job plan is systematic approach, which helps team members to identify problems and find the right solutions in a scientific environment. It can help to raise sustainable construction principles during the workshop and there are sufficient tools and techniques to help decision-makers take the appropriate actions in order to realise value for many in a project. Furthermore, the: function analysis phase enables the team members to apply sustainability issues in assigning the component of a project;

whereas the creativity phase generates many alternatives for accomplishing objectives and avoiding the unsuitable alternatives in terms of sustainability. When integrating sustainable construction themes early in the VE job plan, all processes such as function analysis, ideas evaluation and development can be used to help to meet the objectives. Table 3 illustrates the powers and limitations of VE as means to incorporate sustainable construction principles within its process (ibid).

Table 3: The powers and limitations of VE to integrate sustainable construction principles

Powers	Limitation
• Multidisciplinary teams; • Different skills to broaden knowledge of sustainability; • Structured job plan can deliver sustainable construction principles; • Creativity phase avoid initial idea developing that springs in mind; • Function analysis phase identifies sustainable diminutions as project functions; • The VE tools and techniques help decision maker to take correct actions; • The critical timing of VE conducting provides significant positive effects on whole project delivery; • VE is currying out in succession manner which enhances sustainable assessment; • VE can be used as quality assurance to meet sustainable principles; • VE proposals which are cost effective and concerned sustainability dimensions could be used to persuade clients' attitude in future; • Potential to reduce project whole life cost, even if it contains sustainable principles, via eliminating of unnecessary cost; • Facilitator helps to guide the process and its members.	• Time restriction; • Client commitment is a necessary to promote sustainability; • VE fees implementation for each workshop may decrease the number of workshop in projects; • It needs from the team members to have knowledge on both topics VE and sustainable construction.

Six steps to realising sustainable construction

VE principles and tools can be used to achieve and improve an environmental remediation process. The function analysis phase can be exploited to break down the difficult process into its functional units. In addition, many alternatives can be generated by using brainstorming techniques. The six steps identified below can help clients to implement sustainable construction principles during the early stages of a project.

1. Appoint an experienced VE professional to facilitate the VE study;
2. Consider the following potential goals and include where appropriate for the VE study in the project;
    - optimising site potential;
    - minimising non-renewable energy consumption;
    - using environmentally preferable products;
    - protecting and conserving water;
    - enhancing indoor environmental quality; and
    - optimising operational and maintenance cost.
3. Develop a qualified team that is dedicated to the VE process;

4. Develop invocative design solutions to accomplish the project goals;
5. Carry out the VE study; and
6. Implement the findings of the VE study.

CONCLUSION

VE is a systematic approach for achieving optimum value for money, while maintaining or improving quality, safety, reliability and maintainability. It is a problem-solving technique based on analysis of the project functions demanded by the owner in order to meet the end user's requirement and needs. VE uses multi-discipline teams to analyse a product design, an engineering concept or a construction approach. Sustainable construction is broadly created to explain the contribution of the construction industry to sustainability development. Literature suggests that the key targets for construction include: environmental impact reduction; cost minimisation; social improvement; economic and cultural quality throughout the whole life of the project. The problem of sustainable construction is very complex and includes a large number of various parameters and criteria from different areas of technical as well as non-technical sciences.

VE comprises powerful tools and techniques that can be used to adopt and diffuse sustainable construction principles amongst its team members. While concerns of sustainable construction dimensions are inherent in most VE workshop, the level of consideration differs from workshop to another depending on the knowledge of team members. Further research is needed to establish the barriers that could impede the further integration of both subjects. More conceptual linkages must be developed and those who have the knowledge encouraged, if an integrated approach to VE and sustainable construction is to emerge.

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