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VALUE ENGINEERING IN CONSTRUCTION MANAGEMENT: A REVIEW

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ABSTRACT:-*Value engineering (VE) is an intensive, inter-disciplinary problem solving activity that focus on improving the value of the function that is required to accomplish the goal or objective of any product, service or organization. Value engineering methodology is used to analyze the function of the goods and services and to obtain the required function of the user at the total cost without reducing the necessary quality of performance. In Construction Management field, value engineering is an effective tool for fostering the construction quality with an aim to lower costs and improve services. Value engineering study is carried out with the analysis of basic functions of the project and based on that analysis unwanted elements in the project are scrutinized and eliminated. In this paper, a review on value engineering and its application in construction management/project has been done and value-engineering theory, practices and techniques has been discussed.*

***KEYWORDS*:** *Value Engineering, Construction Management*

1. INTRODUCTION

Value Engineering (VE) is a systematic method to improve the "value" of goods or products and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value therefore can be increased either improving the function or reducing the cost. It is a primary tenet of value engineering that basic functions be preserved and not be reduced as a consequence of pursuing value improvements.
Value engineering uses rational logic (a unique "how" - "why" questioning technique) and the analysis of function to identify relationships that increase value. It is considered as a quantitative method similar to the scientific method, which focuses on hypothesis-conclusion approaches to test relationships, and operations research, which uses model building to identify predictive relationships.

2. VALUE ENGINEERING: THEORY, PRACTICES AND TECHNIQUES

VE follows a structured thought process based exclusively on "function", i.e. what something "does" not what it is. For example, a screwdriver that used to stir a can of paint has a "function" of mixing the contents of paint can and not the original connotation of securing a screw into a screw-hole. Value engineering is also referred to as "value management" or "value methodology" (VM), and "value analysis" (VA). VE is above all a structured problem-solving process based on function analysis. Amruta [2014] has briefly explained the methodology of Value Engineering (VE) with suitable example in this paper. Also the Job Plan method is explained briefly. For case study, residential building has taken to study value-engineering application. In case study, it has been noticed that around 20% of the function constitute around 80% of the cost. These functions (20%) are the subject of value engineering. Value engineering can be applied during any stage of a project's design development cycle. It is a very useful tool to get good quality work in lower cost with using alternatives on that 20% functions. When we use VE in earlier stage of project, it is more beneficial than using it in development stage for saving resources. From the case study, they suggested to give alternative to the functions to reduce the project cost. Senay and Niyazi [2013] discussed about the importance of value engineering. The purpose of value engineering is not just reducing the costs, increasing the design standards, making it easier to build the project and saving time and money. VE must create a balance between all the needs of the project. The highest performance in VE is achieved especially when the purpose is mainly increasing the value rather than reducing the costs. Production methods developed with VE are carried out to reduce the cost of a product without sacrificing the quality, keeping the cost fixed by increasing the quality or shortening the production time. Amit and Belokar [2012] discussed how the cost of a product is minimized by applying the Value Engineering Methodology. Various worksheets are developed and thorough analysis is done to attain a concrete solution. In future changes can be done in the design so that the value of the product can even be enhanced. Value Engineering is the systematic application of recognized techniques by a multi-disciplined team which identifies the function of a product or services; establishes a worth for that function; generates alternatives through the use of creative thinking; and provides the

needed functions to accomplish the original intent of the project, reliably and at the lowest life-cycle without sacrificing project requirements for safety, quality, operations, maintenance and environment. According to Sivaloganathan [2000], "Value Engineering is a form of cost /benefit analysis where functions are viewed as the beneficial characteristics of the product." Value Engineering technique is centered on value concept and it show whether a cost is worth incurring or not. The framework in figure 1 shows the variables involved in this study, which are: value engineering as the predictor variable, profitability as the criterion variable, the proxies for the predictor variable (value engineering) are product design, and function analyses while that of the criterion variable (profitability) are Gross profit margin (GPM) and Earnings per share (EPS).

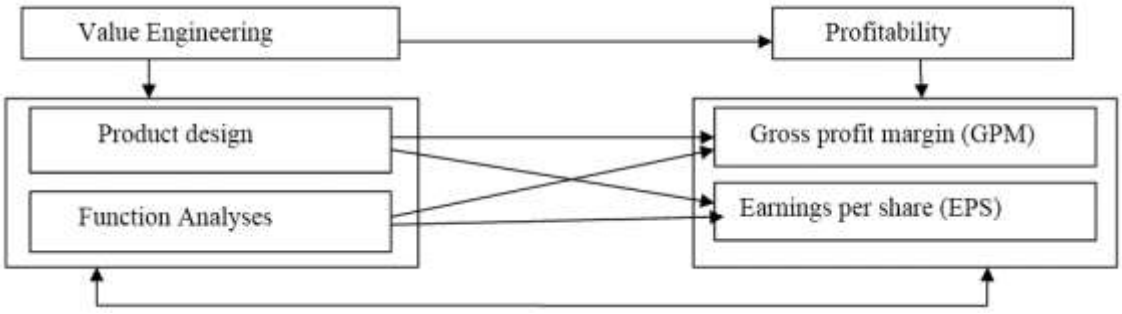

Figure 1: Conceptual framework

Value Engineering [VE] helps an organization in improving quality management; improving resource efficiency; simplifying procedures; minimizing paper work; lowering staff costs; increasing procedural efficiency; optimizing construction expenditure; developing value attitude in staff and competing more successfully in market place. The technique of VE is governed by a structured decision making process to access the value of procedure or services. Whenever unsatisfactory value is found, a value management plan is followed. This procedure involves 8 phases. The different phases are orientation, information, function, creativity, evaluation, recommendation, implementation and audit. Amruta et.al [2014] observed VE is an intensive, inter disciplinary problem solving activity that focus on improving the value of the functions that are required to accomplish the goal or objective of any product, process, service or organization. VE is essentially a process, which uses function analysis, teamwork and creativity to improve value. The greatest benefit and resource saving are typically achieved in the development and conceptual design stages. VE may applied more than once during the life of the project. Chougule and Kallurkar [2014] found that VE in the monograph of "technique of value analysis and engineering". VE with its different phases can be implemented in any product to reduce the cost. The material (household furniture product) is chosen such that the cost is reduced without affecting the value and its design. The possible alternatives and its choices, the tools used such as function analysis, functional evaluation and decision matrix, which gives the most appropriate results. Florian et.al [2014] observed that VE aspires the increase of value through either an increase in functionality or a reduction of resource (e.g. cost). VE is not focusing on cost reduction, but on an increased value. It is a function-oriented approach that illustrates the ratio between "what you get" (function) and "what it costs" (resource).

3. VALUE ENGINEERING IN CONSTRUCTION MANAGEMENT/ PROJECTS

Neetu and Rakesh [2013] discussed the history of value engineering related infrastructure development. Again, apart from the huge amount associated, construction sector has verities of construction projects involving large number of stakeholders, materials, construction and management techniques, et al. which states a wider scope of application of the value engineering/management. Considering the characteristics of the Indian construction industry, it would be possible through VE studies to identify and overcome the various loopholes with creative alternatives, which will result into higher productivity, cost reduction, better performance, better quality, simpler design and optimum project duration without affecting the function of any project or service. According to llayaraja and Eqyaabal [2015], Value Engineering (VE) is a management technique that seeks the based functional balance between cost, reliability and performance of a product, project, process or service. The application of VE in construction projects benefits in term of time, quality, efficiency and better management. The study of VE provides analytical descriptive method which is based on the reality or phenomenon described and collected information about them and then studied and analyzed. The study is done in order to get various performance used in those methods. Then a set of indicators are derived based on the measures identified in the methods and a questionnaire is to be prepared on the basis of the same. There are some types of Projects that benefit most for VE. They are costly project, complex project, repetitive costs, unique projects with few precedents or with new technology elements, projects with very restricted construction budgets, projects with compressed design programs and high visibility projects. According to Hayden and Pasloe [1996], Evidence abounds that cost savings of between 10 to 25% can be made from a careful application of VE methodology on building services installations and the cost of achieving these savings is estimated to be between 0.5 and 1% of the building services cost. Hunter and Kelly [2004] Since the objective of value engineering is

to achieve maximum value for client's money, then it can be argued that the process will deliver the following benefits: better business decisions; increased effectiveness; improved product and services; enhanced competitiveness; a common value culture; improved internal communication; multidisciplinary and multitask teamwork, and decisions which can be supported by all stakeholders. In addition to cost savings, VE can bring about the following benefits: improved communication and team working; a shared understanding among key participants; better quality project; better definition and design briefing, and increased innovation. While it is believed that VE approach brings about high degree of clients' satisfaction; improved functionality, and cost savings ranging from 5–15%. However, Witschey and Wulff [1998] observed that the greatest benefits of VE are the cost saving potentials, determination of project mission and identifying possible alternative directions. Despite the well documented benefits of value engineering. Recent research has identified a number of specific challenges that contribute to poor value being achieved. For instance, Cheah et.al [2005] observed the following challenges to the implementation of VE in South East Asia:

- Divided authority and decision making process among project stakeholders;
- Conflict of interests among the various parties;
- Lack of communication among the different stakeholders;
- Lack of time to implement especially when value engineering is applied to a specific project rather than a more permanent production management system;
- Lack of knowledge/ awareness about value engineering in the industry.

Assaf et.al [2000] found VE job plan is defined through special phases ranging from five to eight in various versions, all following the same concept. A typical version comprising of five phases is described in this study. Information- Information relating to cost, drawings, and specifications, manufacturing methods, sample and prototypes are secured in this phase. Creative Phase- Identification and classification of functions are carried out here. Evaluation Phase- Rank and rate ideas to select the best alternatives. Development phase- Benefit analysis is carried out to for final 'value engineering proposal' (VEP). Recommendation and approval phase- recommending VEP change and improvement proposal.

Generally, Green and S.D [1991] observed that value is the relationship between function, need and cost. However, when function meets the need at the lowest cost, then good value is considered to be obtained. The basic philosophy of value engineering is to eliminate the cost, which does not contribute to the performance of the required function. Witschey and Wulff [1998] found that the term value engineering sometimes referred to as value methodology, value analysis, and in some other countries value for money. Hayden and Pasloe [1996] studied that the VE is a structured approach defining what value means to a client in meeting perceived objectives. It addresses overall project objectives, questioning the need for the project in the first place and seeking to clarify the clients' priorities in achieving the project. Nayana and Gowrisankar [2015] studied value-engineering definition by the society of American value engineers as the systematic application of recognized technique, which identifies the function of a product or service, establish a value for the function and provide the necessary function reliably at the lowest overall cost. Application of VE/Value Analysis (VA) done by using job plan, which is a systematic and organized plan. VA job plan is the key of success for a value management exercise. There are different job plan existing and are selected as per suitability of the project and requirement, which are entitled as; Five phase job plan; Six phase job plan; Seven phase job plan and Eight phase job plan. The most commonly used phase for projects in India, which is considered as five-phase job plan also known as standard job plan and most suitable in Indian context. The VE implementation in a house building requires following data in information phase; Detailed estimation; Current resource price in market; Basic building and site data; Owner's requirements; Activities involved; Collection and study of drawings; Problem involved and Miscellaneous data. Nitin [2016] observed that the engineers have always tried to reduce the cost of construction without affecting the quality and functional utility. VE aims at functional cost effectiveness by avoiding unnecessary cost; it involves multi-discipline team effort and applies innovative and creative techniques to maximize. VE applied to the shreenath Enclave Offices Complex, Nashik by using following value engineering job plan phases that are information phase, function and creative phase, evaluation/analytical phase, development/recommendation phase, report phase. In evaluation phase, Crush Sand used instead of River Sand with characterization of the locally available materials used for the making of concrete. Prior to starting the experimentation, mix design of M25 were carried out as per IS 10262-2009. It resulted that, using 50% crush sand in concrete for R.C.C. work instead of river sand; cost is reduced by 3.90% for 1cu.m of designed M25 mixes of concrete. Also, Reinforcement Coupler was used instead of Lapping of Bars and the ultimate tensile test is conducted for couplers as per IS 1786:2008 which is the mandatory test compulsory for the manufacturer in house test laboratory. Instead of using lapping bars, use of reinforcement couplers resulted that cost is reduced by 47.95% for 16mm diameter bars, 49.39% for 20mm diameter bars and 58.09% for 25mm diameter bars. The results showed that the use of Crush Sand instead of river sand and reinforcement coupler instead of lapping of bars could be considered the most important methods of the new construction techniques, which achieves the best savings in the cost and time.

Kaveh and Aminoroaya [2016] study conclude that VE is a creative prospective to optimize lifecycle costs, save time, increase profit, improve quality, increase market share, solve problems and optimally use resources. VE presents practical results for rapid improvement. Methodology of using VE in construction projects management, it seems that using such

approaches by companies involved in large construction projects not only causes an evolution in qualitative and quantitative results but it creates prosperity in business space and even provides engineering services at international level. From figure 2 it is observed that value engineering can be implemented in all stages of a construction project; however, its highest profit belongs to the preliminary stages of planning and designing the project where employer and designer are more flexible; changes are applied simpler; changes less influence the project, and impose less cost to the project. According to Seyed et.al [2014], the purpose is for understanding the definition of VE and identification of reason of unnecessary cost in construction industry and for development and applying and implementation of VE in construction. The purpose of the paper defines to minimize the cost, development of project quality and function, optimization of resources, significant cost savings, avoidance, transfer innovative technologies, etc. VE studies have benefit to all types of construction projects to ensure added quality within available resources. VE studies on design build Request for Proposals (RFP) identify overly prescriptive conditions and contracting wording, which cause a contractor to bid unnecessarily higher. For the traditional design-bid-build type of procurements, VE studies on the design have resulted in cost avoidance used in increasing the quality or reduce unexpected cost overages. VE is neither a different nor a sufficient way to design, but a parallel and necessary process for good conceptual design. In addition, for the development of the coordination between owner, contractor, designer, supervisor and all of the members who have any duties in construction project. According to evaluated experiments, there is lack of co-ordination, which is major problem, and unnecessary cost in construction industry. VE helps Architecture Engineer and Construction Manager in better understanding of their jobs, for coordination, scheduling, and trying to suggest to architectural engineers for enhancing the required knowledge in designing.

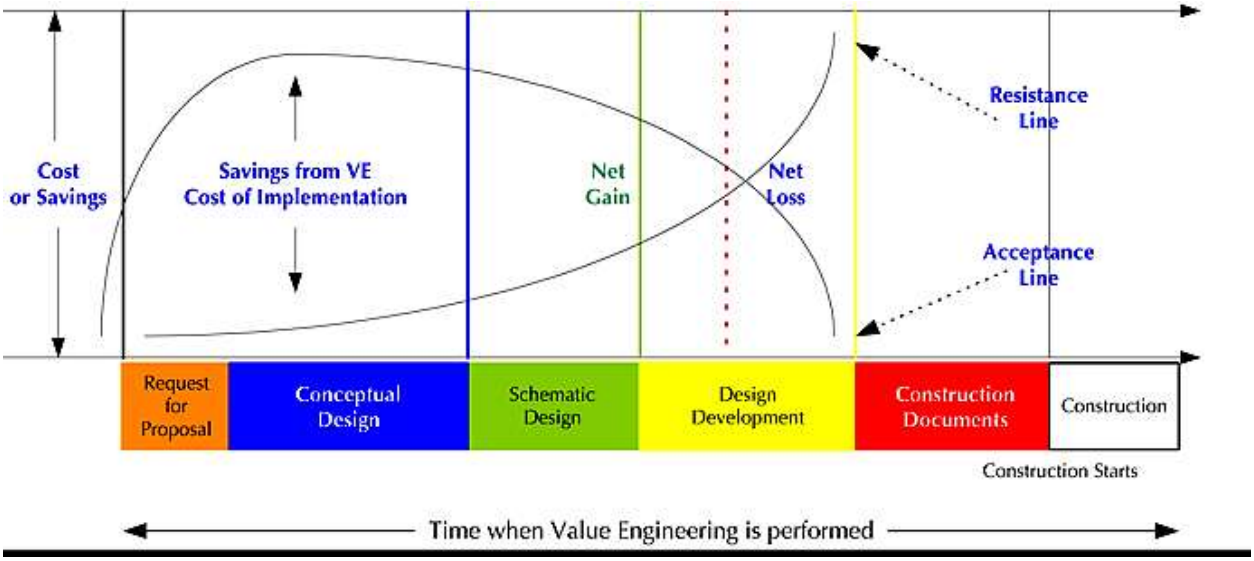

Figure 2: Time when value engineering performed in construction projects

Dhayalkar and Ahire [2016] found that VE could play a key role in ensuring that programs stay within budgets or even save money. VE, being a very creative and effective approach, must be appreciated and understood at all level of project management and must be accepted worldwide. VE can be applied during any stage of a project's design development cycle. It is important, available and compares quality elements of the design with the owner's requirements. The application of Pareto law 20/80 states that around 20% of the functions constitute around 80% of the cost. These functions (20%) are the subject of VE. From a Cement Concrete Road Construction Site, it has been noticed that the first three items i.e. Granular Sub-Base (GSB), Wet Mix Macadam (WMM), Dry Base Macadam (DBM) (out of 13) forms 73.3% of the total cost, which is very close to Pareto Law. The area of VE analysis and study was controlled by the first three functions. Renata [2016] observed that the Programs in the public work, sectors such as highway construction are being criticized for delivering projects that failed to hit the following targets i.e., expected project objective, delivery within a reasonable amount of time and costs not exceeding their budgeted amounts. Government agencies that apply VE to their construction programs can achieve the benefits like resolve technical problems of complex projects, gain additional technical expertise, give emphasis to efficient use of resources, improve project performance and achieve cost savings. Through VE programs use in the public sector, significant improvement in project performance and cost savings has been experienced. Most importantly, using VE could accelerate construction because it creates a consensus-building foundation. VE studies carried out in the public sector have allowed for the development of consensus on what the project scope, budget and delivery should be. This consensus has been formed within project stakeholders, such as local governments, transportation and regulatory agencies and the communities involved or affected. The three main stages of a project and a VE application are planning, design and

construction. In the VE process, project stakeholder identifies the performance criteria, establish their relative weights and then rate the current project. Below, the formula shows the relationship between value (V), performance (P), and life cycle cost (LCC). The total performance rating is divided by the total project life cycle cost to produce a value index, and the difference between the value indices of the original design and the alternatives is expressed as a Value Improvement.

According to Bidiawati [2017], good planning will produce good work. Similarly, the design of the product cannot be separated from the efforts to pursue the best quality so that consumers can accept the product. Several stages in applying Value Engineering are information stage, creative stage, analysis stage and recommendation stage. Mohamad [2015] Increasing expansion of VE in architectural projects in the world can show the high potential of this approach for reduction of cost and improving the quality of development projects and specifically Housing projects. If housing projects constitute more than 60% of the VE application. In the meantime, considering systematic value engineering procedure in the design process of housing and the next step that is the construction phase of the housing seems to be important. If the design phase is accounted for the three parts of conceptual design, design development and construction documents, the more we go ahead from conceptual design section to the construction documents, modifications cost will increase and the potential to reduce costs is decreased and therefore the net potential of savings is reduced continuously. Therefore, VE in the early stages of design, or in other words, production of design options in the stage conceptual design and before the plan is engaged into, detailed phase will create more value saving. VE is a powerful approach for cost saving and quality improvement. Despite its worldwide known benefits, it is not applied in proper methodologies in Egypt and it is usually mixed-up with the concept of cost saving.

Racha et.al [2016] illustrate the VE methodology provided by SAVE International practitioners, and provided a case study which has been developed and studied over three main axes of sustainability: economically, environmentally, and socially. The paper showed that project value could improve when considering these three factors. The study of Foamed Lightweight Concrete (FLC) is done and founded that it 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. On the other hand, the use of FLC alone cannot replace the use of a thermal insulation material over a roof layers. This 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%.

According to Sanam and Abbas [2017], Service health care sectors such as hospitals are public agencies those have complicated business processes. These organizations are involved in something such as decreasing cost time and improving the quality of services. Therefore, they need to utilize new management techniques to improve their processes by using VE. This study presents a model using value engineering's process approach in public service to improve the quality of discharging process. After investigating discharging process and its weakness and wastes, a work plan for the improvement and change working conditions gas been provided, using value engineering is followed by both current and suggested procedures. After implementation of VE results revealed that focusing on this main component the quality of service would be improved. With this all other services can be improved like cashier activities, insurance department, services from nurse and head nurse as VE is an organized / systematic approach directed at analyzing the function of systems, equipment, facilities, services, and supplies for the purpose of achieving their essential function at the lowest lifecycle cost consistent with required performance, reliability, quality and safety.

4. CONCLUSION

In this paper a study was conducted on the importance of value engineering; theory, practices and techniques and value engineering in construction projects. It has been found that VE is a powerful problem-solving tool that can reduce costs while maintaining or improving performance and quality requirements. VE can be applied during any stage of a project's design development cycle. The greatest benefit and resource saving can be achieved in construction projects if VE is applied in the development and conceptual design stages. VE can be applied effectively more than once during the life of the project. It is observed that the unnecessary increase in cost is due to increase in inventory through use of expensive material, complicated design and increase in variety of hardware items. The quality (qualifications and experience) of the team leader and specialists is a key ingredient to the success of the VE program. It is more effective and influential on the performance, quality, and cost of a product when done relatively. The proposed technique in this paper assists the decision making process to the owner, designer, and the contractors. In addition, this method can be used for the evaluation and selection of any construction system by following the procedure presented in this paper. The importance of the discussed issue is achieving a new view about planning construction projects and generalizing construction management knowledge. It is also seen that VE is not only for cost saving of projects but it can also be applied to all section of the construction industries. Production of different design options in the stage of conceptual design and before the plan is engaged into detailed phase will create more value saving.

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