Integrating Value Engineering for Cost Optimization in the Construction Projects

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***Abstract*—The construction sector, though contributing immensely to economic growth, is increasingly plagued by cost, time, and quality management challenges. To counter this, Value Engineering (VE) has risen to prominence as a strategic method of maximizing project value through function analysis to eliminate unnecessary costs without sacrificing quality. The current study emphasizes the increasing application of VE on mega projects, with indications of up to 20% cost reduction and improved sustainability. The research assesses major elements like masonry, plastering, and flooring, where replacements like AAC blocks, silica plaster, and Kota stone reported 15–25% cost savings and enhanced functional value. In items such as concrete, shuttering, plumbing, and ceilings, replacement materials added costs but immensely enhanced durability, performance, and sustainability. For instance, aluminum shuttering and Fly Ash + GGBS concrete enhanced long-term efficiency. Overall, application of VE to the chosen components resulted in 15–16% project cost savings, supporting VE's role in attaining cost-efficient, high-performance construction.**

***Index Terms*—Value Engineering, Cost Optimization, Material Substitution, Functional Performance**

I. INTRODUCTION

Construction, as a very resource-consuming sector, is under increasing pressures to provide quality projects on time and budget. In reaction, Value Engineering (VE) is a strategic approach that maximizes project value by methodically evaluating functions to eliminate wasteful costs while maintaining performance. VE is being used more and more in high-volume projects, with research demonstrating up to 20% cost reductions. In contrast to mere cost-cutting, VE optimizes function-to-cost through its examination of necessary performance, life-cycle expenses, and risk. Its multidisciplinary, team-based methodology generates innovation and enhanced decision-making. VE adopts a formal Job Plan with six stages: Informative, where project information and major functions are established; Functional, which classifies main and secondary functions; Creative, where brainstorming allows varied alternatives; Evaluation, where ideas are critically examined for practicality; Development, which refines alternatives with cost and technical analysis; and Implementation, where proposals are concluded and implemented. VE maximizes efficiency, sustainability, stakeholder satisfaction, and project performance. With construction becoming more complicated, VE works as a preventive means of maximizing cost, time, and quality to produce robust and high-value outcomes.

II. LITERATURE REVIEW

Senay Atabay and Niyazi Galipogullari show with an example of the Bregana–Zagreb–Dubrovnik Motorway that Value Engineering in the early stage improves cost effectiveness as well as time savings—especially in big, intricate projects—by linking cost management, quality, and performance. [1]Mabrouka Shahat Younis Elfargani shows that implementation of a systematic three-phase Value Engineering approach in the conceptual design phase enhances cost savings, performance, and project worth immensely through early execution and multidisciplinary collaboration. [2]Nitin L. Rane shows how systematic, inter-disciplinary Value Engineering lowers lifecycle costs and improves functionality—documented through a case study of a 4.65% saving on concrete cost by using a 50:50 river and crushed sand mixture and 58% material savings using mechanical couplers—

highlighting the application of VE in evidence-based construction decision-making. [3]Dr. Mulay, Zolekar, and Ghongade's mixed-method research finds integrated process innovation and material substitution can deliver 20–30% cost reduction in residential, 10–20% in infrastructure, and 25–35% in industrial construction—indicating the necessity of detailed time-cost modeling and increased life-cycle analysis. [4]Sarmad Dashti Latif, Fathoni Usman, and Bilal M. Pirot show that Value Engineering applied in the initial stage of Malaysia's Main Electric Distribution Station provides cost savings of 17.1% through optimized room sizes, 69.8% through plaster ceiling replacement with painted finishes, and 41.6% through reducing the height of the wall paint—preserving performance and safety. [5]Wei Tong Chen et al. emphasize VE's transformation into a comprehensive methodology that integrates time, cost, quality, and sustainability—advancing beyond the economic measure of its value to social and environmental values and promoting future multidisciplinary, technology-based assessments. [6]Xiaobin Lina et al. offer a systematic review of 104 articles (2001–2021) of Value Management in construction, and based on identifying key themes—performance impact, strategies, influencing factors, and application status—recommend increasing VM's usage over varying project types for better value outcomes. [7] Dr. Al-Fadhli suggests a hybrid approach combining Value Engineering in the design stage with Constructability principles across project stages to promote collaboration among stakeholders, minimize cost and duration, and optimize infrastructure project quality. [8]Rania Essam Abdelrahaman Hassan Osman et al. offer a framework combining Value Engineering with sustainability principles to optimize construction project value and environmental responsibility by bridging stakeholder awareness and life-cycle costing gaps while highlighting the necessity of supportive policies. [9]Anuja Rajguru and Parag Mahatme analyze cost drivers of construction—such as material choices, schedule delays, and execution inefficiencies—and recommend integrated optimization strategies with alternative materials, mathematical modeling, and systematic planning that can prevent overruns without sacrificing performance. [10]Surendra Kumar Karn and Khet Raj Dahl's study grounded in site visits, formal interviews, and questionnaires—assesses nine factors of cost-efficiency (project details, design excellence, roles of stakeholders, materials, labor force, machinery, and ambient conditions) and establishes that strict cost planning, on-time monitoring with PDCA quality controls, coordination among stakeholders, prompt procurement, and simplification of the design are important for cost optimization of building projects. [11]The study of Khaled Ali Alabd Ahmed and R. K. Pandey illustrates that while Value Engineering—maturing from past cost-cutting to improving design quality and efficiency achieves cost-quality-time balance in addressing clients' demands, its broad application is hindered by industry fragmentation, reluctance to change, project complexity, and lack of interdisciplinary training. [12]The study of Pratik Mahajan, Manohar Chamarthi, Vaibhav Bangar, and Shital Patel offers a systematic, six-stage Value Engineering approach—Information, Functional Analysis, Creative, Evaluation, Development, and Presentation—that finds key functions and cost-efficient substitutes (illustrated through a bathing works case study) to realize substantial cost savings without compromising on quality, performance, or aesthetics, thus highlighting its increasing relevance to sustainable, competitive innovation. [13]Chirag Mehta, Parth S. Mehta, and J.R. Pitroda introduce a six-step Value Engineering process—covering information collection, function analysis, creative thinking, evaluation, development, and presentation—that, as illustrated in an example in which 35.71% of the functions generated 61.58% of the costs, rationally removes avoidable expenses to keep overall cost to a minimum without reducing performance, quality, or design integrity, thus positioning VE as a strategic platform for cost, time, and quality trade-offs during construction. [14]K. Ilayaraja and Zafar Eqyaabal suggest an holistic Value Engineering method—organised in the form of information gathering, functional analysis, creative options, evaluation, and implementation—to enhance function-to-cost ratios through smart design, effective utilisation of materials and labour, and continuous improvement and reconciliation of performance, safety, beauty, and sustainability for strategic utilisation of resources in intricate construction projects. [15](16) Kaveh Miladi Rad and O. Aminoroaya Yamini discuss Value Engineering as a systematic, team-based approach that—when applied early on – optimizes functional value, reduces life-cycle costs without sacrificing quality or safety, surpasses traditional cost assessments, and achieves sustainable socio-economic results in mega-scale construction projects. [16]

The main objective of this study is to explore how Value Engineering methods affect overall project performance through the systematic identification and elimination of non-essential costs. Using these procedures, the study endeavours to improve cost efficiency, where expenditures are maximized without sacrificing quality, functionality, or stakeholders' needs.

III. METHODOLOGY

The research methodology followed for the current study incorporated an in-depth and sequential methodology for determining the practical aspects of Value Engineering in the construction sector. The study began with a thorough literature review to gather information on the theoretical basis, historical context, methodologies, and field applications of Value Engineering. This facilitated the identification of the most important areas where cost optimization can be used effectively without sacrificing quality or performance. Subsequent to the literature review, real-time case study analysis was conducted on different mega-sized (Megha) construction projects. On these case studies, detailed analysis of particular items of work like Masonry Work, Flooring Work, Plaster Work etc. were made. Viable substitutions and cost-saving alternatives were suggested for each of these components based on Value Engineering principles. The focus was to prove how alteration in materials, technique, or design could contribute to enhanced overall project worth. To ascertain the findings and make them practical-oriented, 50 industrial experts comprising engineers, contractors, and consultants were surveyed. These experts were individually approached and interviewed to know if such Value Engineering methods are being implemented in live industry practices. Their comments played a key role in affirming the practicability, acceptability, and effectiveness of the suggested substitutions and cost-reduction measures.

IV. DATA COLLECTION & DATA ANALYSIS

For obtaining valid and applicable data, the study follows the Quantitative Questionnaire Survey Method, best suited to fill the form of diverse professional experiences. This method guarantees empirical data from architects, engineers, contractors, consultants, and site managers. The question sequence of the structured questionnaire was divided into three parts—demographics and working experience, assessment of awareness and application of Value Engineering, and assessment of alternate implementations for individual work items—tailored for simplicity and ease of interpretation. Based on existing literature and expert opinion, Value Engineering factors were ranked using real-world experience to produce accurate, actionable information about its use in construction.

In data analysis in this study, the Quantitative Grouped Frequency Distribution Method of grouping large quantities of numerical data into class intervals to enable underlying patterns to be made apparent and understandable. Through condensing large datasets into grouped frequencies, such analysis becomes simplified without compromising essential insights.

V. RESULTS & DISCUSSION

This study focuses around important items of building construction on which Value Engineering has resulted in cost saving as well as value addition. The study compares results from real case studies with expert perceptions obtained through surveys. Certain items of work were assessed: Masonry Work, Shuttering Work, Concrete Work, Plumbing Work, Plaster Work, Flooring Work and False Ceiling Work.

The bar chart depicts survey answers regarding the percentage value addition to masonry work in construction works through the replacement of brick masonry with AAC block masonry. Approximately 50% of those surveyed had a functional value addition of 0–20%, 30% had an improvement of 21–40%, and 40% had enhancement in the range of 41–60%. These results emphasize that AAC block masonry greatly enhances performance value in terms of being light in weight, simple to install, and allowing quicker construction. It also provides better thermal and sound insulation, improves energy efficiency, and allows for improved fire resistance, making it an economical and environmentally friendly option compared to conventional brickwork.

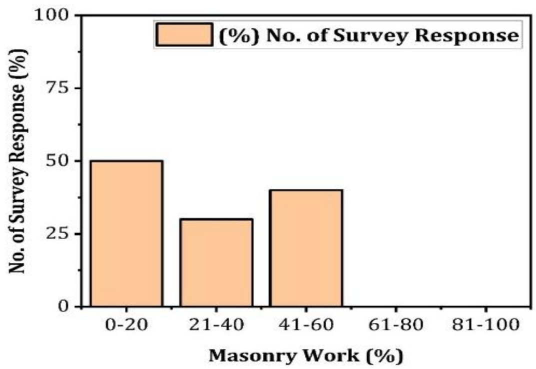

Figure 1 Brick Masonry Work – AAC Block Masonry Work (Value Enhancement)

The plotted graph displays survey answers on the cost savings of utilizing AAC block masonry instead of conventional brick masonry in building projects. With 40% of respondents saying that replacing AAC blocks lowers costs by 0–20%, 30% respondents saw a decrease in cost of between 21–40%, and 30% respondents cited a decrease of 41–60%. These results indicate that most of the stakeholders saw a cost saving of as much as 20% with this replacement. The utilization of AAC blocks is cost-effective because it reduces material weight, accelerates construction, decreases labour demands, and reduces waste, hence an economically sound option.

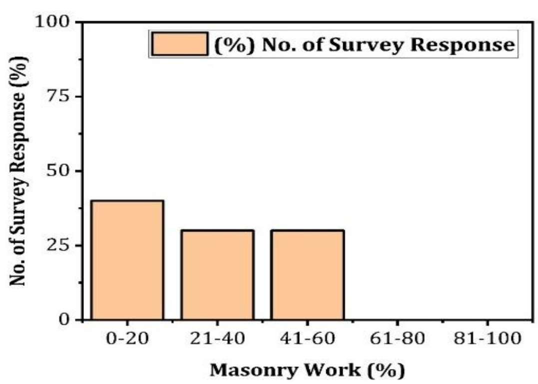

Figure 2 Brick Masonry Work – AAC Block Masonry Work (Cost Effectiveness)

Substituting conventional brick masonry with AAC blocks resulted in a 12.75% cost reduction, as found in the case study, while industry experts estimated potential savings between 0–20%. This indicates that AAC blocks not only offer cost efficiency but also contribute to enhanced performance and value.

Regarding flooring, survey data revealed that replacing vitrified tiles with Kota stone significantly improved functional performance. Around 60% of respondents observed a 21–40% improvement, 34% reported a 41–60% gain, and 6% noted a 61–80% enhancement. The perceived benefits of Kota stone include its natural aesthetics, durability, slip resistance, heat reflectance, and suitability for heavy footfall areas, along with being eco-friendly and low maintenance.

Cost-wise, the majority of survey participants (50%) identified savings of 0–20% through this replacement, while 30% observed 21–40% savings and 20% reported 41–60%. These findings suggest Kota stone as a practical, cost-effective, and long-lasting flooring alternative in construction projects.

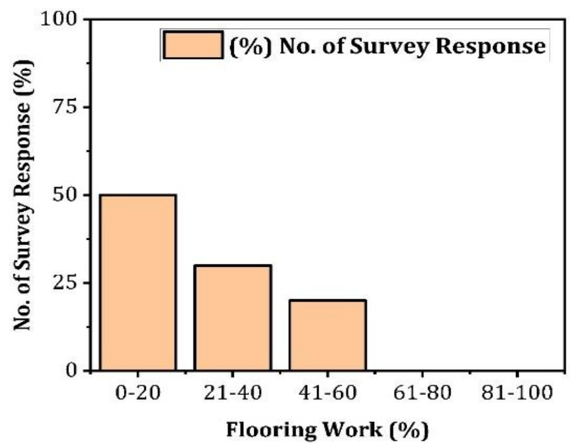

Figure 3 Vitrified Flooring Work – Kota Stone Flooring Work (Cost Effectiveness)

The study highlights that replacing vitrified tiles with Kota stone in flooring work led to a 13.65% cost reduction, with expert opinions suggesting potential savings of up to 20%, likely due to long-term maintenance advantages. In plastering, silica plaster proved the most cost-effective, offering a 19.13% saving and expert-estimated benefits of up to 40%, along with a notable 41–60% enhancement in functional performance. Shuttering with aluminum, while increasing costs by 69.21%, was validated by experts and justified by a matching 61–80% gain in value thanks to its durability, reusability, and efficient application. Fly Ash + GGBS concrete showed a small cost increase of 6.26%, but provided up to 20% performance improvement through better workability and sustainability. Plumbing upgrades to modern fixtures increased costs by 5.19%, yet delivered similar functional benefits, including improved durability and water efficiency. Replacing PVC ceilings with gypsum led to an 11.85% cost rise but added 21–40% value due to enhanced aesthetics, insulation, and fire resistance.

VI. CONCLUSION

The implementation of Value Engineering in this study demonstrated substantial potential for both cost reduction and performance enhancement across various construction components. Replacing traditional brick masonry with AAC block masonry achieved a cost saving of around 15–20%, with additional benefits such as lighter weight, faster construction, and improved thermal and acoustic insulation. Survey responses also reflected a similar 15–20% increase in performance value. Substituting cement plaster with silica plaster led to a 20–25% cost saving while significantly improving durability, strength, and resistance to cracking and chemicals. Its optimal thickness also supports long-term stability, with survey data indicating a 30–40% gain in functional performance. Similarly, switching vitrified tiles with Kota stone flooring resulted in an 18–20% cost saving, offering advantages like durability, better heat reflectance, slip resistance, and improved aesthetics—validated by a 20–30% performance enhancement. For elements such as shuttering, concrete, plumbing, and ceiling works, Value Engineering improved functional quality despite an increase in upfront costs. Fly Ash + GGBS concrete showed a 10–20% cost rise but delivered better strength, sustainability, and chemical resistance, with a 30–40% boost in performance. Aluminium shuttering, though 60–70% more expensive than timber, offered faster installation, reusability, and high-quality finishes, leading to a 60–70% improvement in performance. Upgrading to modern plumbing fixtures and gypsum ceilings also added 10–20% to the cost but resulted in significant gains in efficiency, durability, and fire resistance, with performance improvements of 20–30% and 20–40%, respectively. Overall, the study concludes that applying Value Engineering across key construction activities can yield an approximate 15–16% reduction in total project cost while enhancing long-term functional value.

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