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APPLICATION OF VALUE ENGINEERING DURING THE EXCEUTION STAGE OF A CONSTRUCTION PROJECT

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Abstract
The construction project delivery strategy incorporates Value Engineering (VE) exercises as a pivotal element, strategically integrated at multiple phases of the project lifecycle, commencing from the conceptual phase and extending through the schematic stage, design development, and execution stage. The implementation of value engineering practices during execution stage of a construction project is crucial for optimizing costs, time, and design efficiency if not carried out in the initial stages of the project. This manuscript details the execution stage's Value Engineering exercise, specifically targeting structural design aspects of foundation design during execution stage identified by the general contractor, supplemented by suggestions from the Project Management Consultant (PMC) and employer during rogramme optimization Workshops. The collaborative initiative commenced with a comprehensive meeting held at the contractor's headquarters, involving key stakeholders from the PMC, employer, and the contractor. Over the course of a three-day workshop, the first day was dedicated to deliberating structural and architectural points, while the subsequent days focused on Mechanical, Electrical, Plumbing, and Fire Protection (MEPF), facade, and finishing aspects. Proposed modifications underwent thorough examination to evaluate their technical feasibility, supported by assessments of associated time and cost impacts or savings. The culmination of these efforts yielded a significant cost savings, accompanied by a reduction in construction timeline, promising improved construction efficiency. Furthermore, the identification of additional float within activity durations provided an opportunity to expedite successor activities, facilitating smoother project progression.

Keywords:
Value engineering, Cost Optimization, Value engineering Job Plan, Execution stage.

I. Introduction

The construction industry faces a number of pragmatic and economic obstacles [1]. Construction projects are often executed in many stages, which are separated by decision points. Most decisions are taken during the planning and design stages [2]. These decisions lead to overlooked possibilities in subsequent phases of the project's lifespan [3]. A multitude of challenges are confronted by project administrators and other stakeholders throughout the duration of construction initiatives. Potential pitfalls include inadequate strategic planning, substandard materials, a workforce with insufficient skills, exorbitant material expenses, fluctuating deliverable and milestone deadlines, inefficient resource allocation, excessive expenditure, unanticipated weather disruptions, insufficient managerial oversight, equipment loss, and poor communication. The project's results are negatively impacted by disagreements, obstacles, and escalated costs. It is essential to examine project expenses so that strategies can be developed to reduce or maintain them within manageable limits, thereby assuring the successful completion of construction projects. In order to enhance the effectiveness of project management and cut down on the amount of time and resources that are wasted, it is necessary to develop appropriate techniques and tools [4]. Negligent oversight of cost reduction tactics could potentially lead to financial setbacks for the service provider(contractor) throughout the implementation of diverse project activities. As a result, a number of construction projects surpass their designated budgets, encounter schedule setbacks, fall short in adequately delineating their scope, and demonstrate inferior quality [2].As demands evolve and project complexity increases, construction firms must select the most effective method to complete them, according to research by Tung and Otto

[5]. Some of the tools that have been developed to enhance the quality of the design process and the overall performance of a project include value engineering, design assessment, and constructability [6]. In order to evaluate the inputs to the construction process and effectively attain the desired outputs, constructability and value engineering (VE) rely on knowledge management [7]. In order to achieve the required project output while keeping costs down, value engineering is used as a novel approach to feature problem-solving. Given value engineering's significance, this study intends to implement VE in the execution phase of a building project where the primary goal was to shorten the duration and lower costs associated with existing design and construction methodology of foundations as present in good for construction drawings.

1.1 Research Significance
The research demonstrates that cost and time reduction is crucial for achieving success in construction projects. Effective cost management throughout the stages of construction is crucial for achieving project success. Modifications and incorporations might provide significant points of reference. Companies often achieve success via the reduction of losses, the increase of earnings, the enhancement of competitiveness, and the reduction of expenses. Construction companies should explore and use cost reduction strategies.

II. Literature
The majority of construction sector professionals, are interested in employing value engineering. In the recent decade, value management (VM) using well-known technologies and methodologies has been recognized as a viable strategy [8] for various reasons in construction projects. Empirical data from both developed and developing countries demonstrates that the use of value engineering substantially enhances the value of ideas and projects. VE should be implemented, when the design is fifteen to twenty percent complete during the conceptual design phase, when it is forty-five to fifty percent complete during the design development phase, and when it is nearly one hundred percent complete during the completion documentation phase. VE studies should also be conducted at each stage of the design process in order to verify or establish the functionality of the project, assess the choice of materials, systems, and equipment, and ascertain the project's economic and technical feasibility. During the schematic and development stages of the design process, the VE team conducts a comprehensive review of the pertinent technical documents. The VE team scrutinizes the comprehensive specifications and blueprints, alongside the increasingly precise specifications of equipment and features, as the project nears its culmination. Study of Amruta [9] on VE in construction, described the phases of Value Engineering, which can be implemented by any construction firm in an effort to maximize value. In this study, it was demonstrated that cost reduction can be achieved through material selection without compromising product value or design. Amruta Chougule et al. [10] investigated residential construction project using value engineering. The research identified value-engineerable items using pareto law. The study further revealed that the top six items of the whole project items accounted for 61.53% of the total cost. The study also suggested utilizing value engineering to analyze product functionalities, propose alternative concepts, and build a cost model. Rane and Attarde [11] investigated the use of value engineering in commercial construction projects. A case study of a commercial building was utilized to demonstrate Value Engineering methods in this project. The authors concluded that the functions would govern the study and investigation of value engineering. A study was undertaken by Li Ning [12], to investigate the application of Value Engineering during the design phase of construction projects, with a particular emphasis on cost control. The author advances the concept of value engineering and satisfies the evolving requirements of real estate design through the application of value engineering to project design in his work. In a question-and-answer survey, Stephen Mansfield and Philip D. Udo-Inyang [13] explored the merits and applications of Value Engineering. A survey form was issued to construction industry experts, asking for their value engineering knowledge and skills. The findings

revealed modern value engineering perspectives and applications. The survey indicated that the majority of respondents had neither studied or understood value engineering. This is despite the fact that 84% of respondents said they use value engineering on their initiatives. Al-Nsour et al. [14] evaluated VE in Greeted Amman Municipality in 2011. Abu Nseer's environment protection department, which spends the most, is the focus of this investigation. Results revealed 33.33% crusher route cost decrease and 45.56% presser path cost reduction. Based on the findings of Ankit Kumar S. Patel and Jayesh Kumar Pitroda [15], the implementation of value job planning and functional analysis could potentially reduce the costs associated with Aganwadi structures. This study demonstrates the application of VE in order to reduce construction expenses for the Aganwadi Building without compromising on aesthetics or value. Following the construction of an appropriate decision matrix to select the optimal option from the available alternatives, the following conclusions were reached: As a result of value engineering, the overall expenditure was diminished from Rs 5,50,000 to Rs 5,04,000. Each Aganwadi unit saves 46,000 rupees, or approximately 8% of the total cost, when compared to existing Aganwadi designs.

III. Research Methodology

The methodology employed in this study was predicated on the concepts outlined in the SAVE International Standard's Body of Knowledge. As per this methodology, value engineering adheres to a methodical approach. The value engineering team comprehensively catalogues all project tasks utilizing standardized tools and techniques. Subsequently, they devise innovative, cost-effective strategies to accomplish these tasks while maintaining quality standards. Figure 2 depicts the systematic process of applying value engineering in a project. Al-Yafei et al. [16] delineated that the value engineering methodology has three primary phases: pre-workshop, workshop, and post-workshop. The pre-workshop phase serves the objective of strategically planning and coordinating a value study in building projects. This phase encompasses six essential tasks: collecting user/customer perspectives, completing the data file, selecting assessment criteria, specifying the study's scope, creating models, and deciding the membership of the value engineering team. Ideally, this phase leads to a comprehensive comprehension of the requirements of senior management, strategic goals, and the methods for enhancing organizational value via improvement. At this stage, an assessment is made to see if the subsequent stages provide sufficient value to justify the expense of the research. Perhaps it is necessary to adjust the research parameters, either by raising or reducing them. The value engineering team members possess a clear understanding of the project objectives and are motivated to achieve them. The workshop, which is the second phase is most crucial and consists of five essential stages: information, speculative, analytical, development, and presentation stages. Most literature agrees with this three-phase categorization. The number of stages in the second phase may vary depending on the project, objectives of study, and goals. This might potentially lead to the augmentation of the current number of stages in second phase, from five to six, seven, or eight by extending the existing stages, or alternatively, it could be reduced to five by merging two stages into one. The information phase includes the acquisition of historical data and the evaluation of crucial operational factors, including time, costs, and repercussions. During the speculative phase, the objective is to provide the fundamental functionality at a reduced cost, leading to enhanced value for the client. The analytical process includes the establishment of assessment criteria, the examination of ideas, and the assignment of evaluation weights. Throughout the development process, concepts undergo refinement to become practical solutions via various evaluations, including cost comparisons, life cycle cost estimations, and assessments of their pros and cons in relation to the original designs. The management team, as well as any other project beneficiaries or decision-makers, will be provided with many value options at the presentation stage. The presentation's phase demonstrates the significant influence on time and expense. The post-workshop phase aims to confirm the feasibility of the validated value alternatives and implement the expected advantages of the value research.

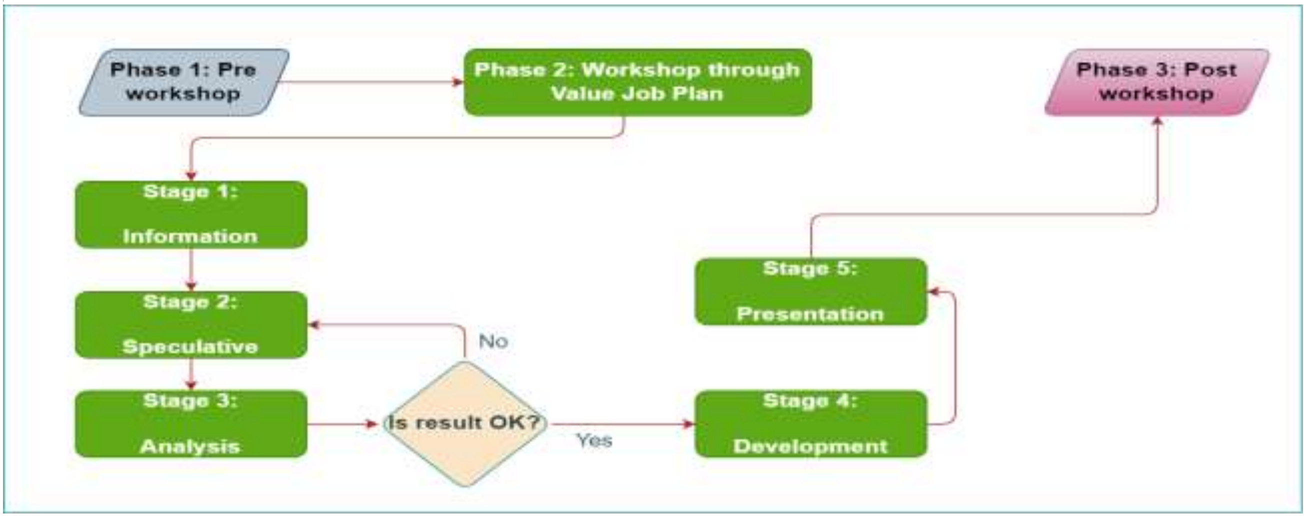

Fig 2. Schematic flow of implementing value engineering through value job plan

IV. Application of Value Engineering during execution stage—Case study

An instance of a real-life construction project was examined in which the execution phase had just begun, during which execution team discovered that the footing and foundation design proposed by the design consultant was both prohibitively expensive and time-consuming to implement. To maintain confidentiality, the project name, customer, designer, and contractor are not disclosed here, and just the facts of the issue are revealed. The ongoing building project necessitates the construction of 189 footings within a 5-month timeframe, at a cost of Rs 6 crore.

4.1 Problems identified with the existing design during the execution phase (Research Problem)

Figure 1 exclusively presents the design details for footings F8 and F9 alone. Although slight variations in dimensions were present, the design concept of the remaining 187 footings were identical.

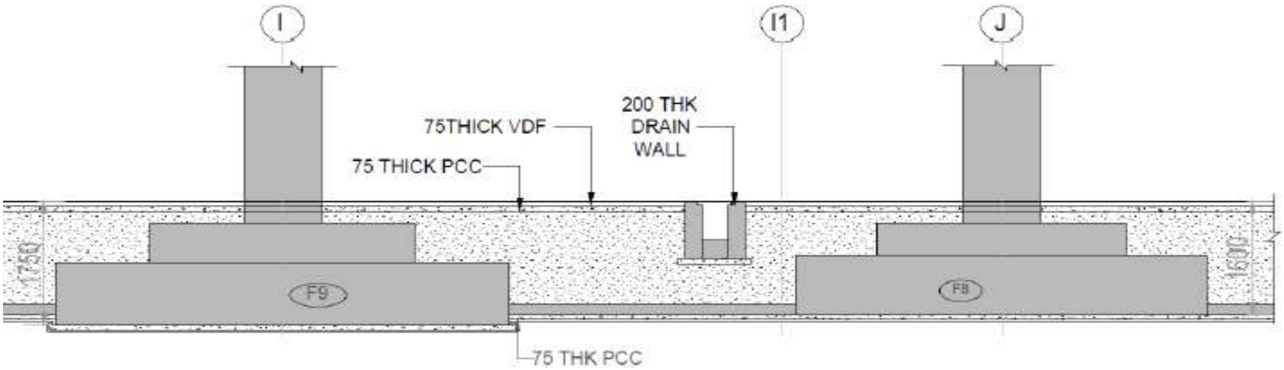

Fig 1. Details of foundation drawings released as good for construction as per design consultant

Figure 1 illustrates that both foundations F8 and F9 needed the construction of a 75 mm thick layer of PCC (Plain Cement Concrete) with a grade of M10, as well as a 150 mm thick layer of grade slab with a grade of M20, at the lowest level of the foundation. In addition, a 75 mm thick layer of PCC with a grade of M10 and a 75 mm thick layer of VDF (Vacuum Dewatered Flooring) is required to be constructed at the lower basement levels as part of the basement floor. Additionally, there was a 150mm space between the top of the foundation and the bottom of the lower basement floor finish. Although the execution team was cognizant of the fact that the sole purpose of such an extensive design was to withstand the uplift pressure and arrest the ingress of water into the basement, the inquiry pertained to whether proceeding with such an expensive and time-intensive design was truly necessary.

4.2 Pre-workshop

The project used the SAVE 40-hour work plan-based VE task plan. The collaborative project was initiated by a comprehensive conversation held at the contractor's headquarters with stakeholders from

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the PMC (Project Management Consultancy), employer, and contractor. The three-day curriculum included a variety of disciplines. On the first day, the discussion revolved on the structural and architectural elements. The following days included MEPF, facade, and finishing aspects. The general contractor prioritized the structural foundation design. The programme optimization sessions included suggestions from PMC and employers. After considering proposals from all parties involved, it was decided to implement value engineering for this project only for structural element (foundations). Subsequently, members of the value engineering team were selected, appointed and informed about their objectives.

4.3 Work shop
4.3.1 Information stage
The pertinent data and information pertaining to the project were acquired, encompassing financial constraints, construction and operations expenditures, budgetary limitations, and background information utilized by the designers. Additional data was collected pertaining to the contractor's early proposals, bills of quantities, structural survey reports, and site inspection reports. Consultants and members of the execution team delivered a sequence of presentations in which they detailed the challenges they will be encountering during execution stage, due to the current design of the foundational element of the structure. In addition, the designer team was requested to provide justifications for the decisions they executed during the design phase. The soil test results indicate that the water table at the project site is 30 meters below the natural ground level, as reported by the designers. Moreover, statistical data on flood resilience indicates that this area is susceptible to intermittent inundation during the monsoon season. In order to mitigate the risk of inundation and prevent water infiltration into the structure, it is necessary to construct a diaphragm wall at a depth of nine meters below the foundation. However, in spite of the existence of a diaphragm wall, temporary inundation may result in an increase in water level due to capillary action. To assure safety, the design was meticulously executed with a 1.5-meter uplift pressure. An additional suggestion has been to mitigate water infiltration into the basement through the implementation of a grade slab beneath the foundation. In order to satisfy the moisture-free basement requirement of the employer, the installation of a vapor barrier beneath the grade slab atop the foundation was suggested. However, the grade slab was lowered from the top to the bottom of the footing in order to implement the vapor barrier. Figure 1 depicts the design details that the designers have proposed, considering all of these concerns. This information gathering exercise, which served as the first step of the value engineering job plan, resulted in the value engineering team reaching the determination that while the design complied with standards and employer requirements, it was excessively expensive, time-intensive, and challenging to implement.

4.3.2 Speculative stage
During the creativity stage, the goal is to generate a large number of ideas for efficiently carrying out each of the functions that have been chosen for investigation. The sort of endeavor being discussed here is, one that is creative in nature and is completely unrestricted by routine, tradition, negative attitudes, presumed constraints, and certain criteria. The value engineering team produced two separate proposals for the existing foundation design, focusing on reducing both cost and time. It is important to keep in mind that, at this stage of vale job plan, VE team does not carry out anything related to the assessment or appraisal of the ideas that have been developed. Figures 2 and 3 illustrates the two different generated ideas by the value engineering team. Figure 2 shows that alternative option 1 eliminates the 75-millimeter-thick vapor barrier and VDF floor covering on the lower basement floor. The basement floor instead is provided with PCC with a thickness of 50 millimeters of grade M10 and grade slab with a thickness of 150 millimeters of grade M20 on the lower level. To fulfill uplift pressure norms, a gap of 100 millimeters is still maintained between the foundation top and the bottom of the lower basement floor finish.

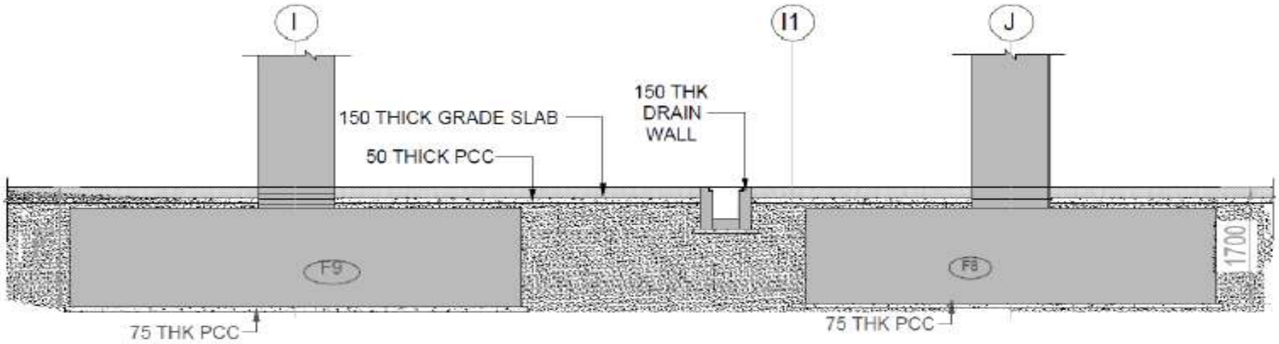

Fig 2. Generated alternative option 1 in creative stage for the foundation design

Figure 3 illustrates that alternative option 2 provides just 50 mm thick PCC of grade M10 on the bottom level of the basement, as well as an enhanced thickness of 250 mm of grade slab of M20 grade. Because of the increase in grade slab thickness to 250mm, the gap between the foundation top and the lower level of the basement was fully eliminated. To achieve design criteria, a gap of at least 100 mm is required to withstand uplift pressure. As a result, the whole basement required to be relocated to a depth of 100mm.

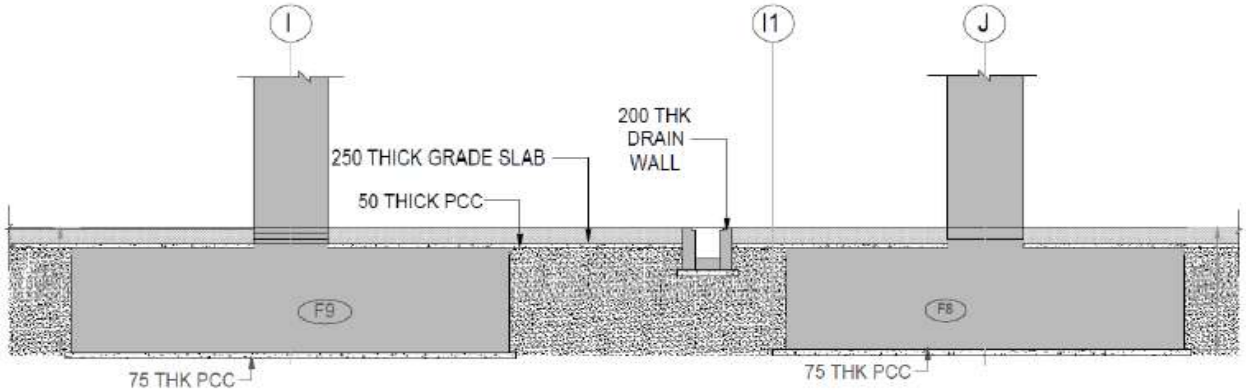

Fig 3. Generated alternative option 2 in creative stage for the foundation design

4.3.3 Analysis stage

In the analysis stage, all the concepts generated during the speculative stage are assessed and refined to identify the ideas with the potential for success. An organized methodology for assessing alternatives and reaching reliable and justifiable final findings is crucial throughout the analysis stage of the job plan. The present research used a point-based methodology to determine the best choice among identified options. This was done by assigning weights to a set of criteria based on their assessed importance by the owner, which reflects the value of the project. The owners' choices for this project were generally classified into four categories: cost, time, quality, and buildability. The aim was to choose the most optimal choice for the foundation design. Two possibilities were developed, labeled as option 1 and option 2. The evaluation included an assessment of four distinct criteria (Cost, Time, Quality, and Buildability) as specified by the owner's needs. Each of these variables is given a value on a scale of 1 to 10, with 10 being the most desired. Therefore, the choice that is deemed the best will get the greatest score. Likewise, the preferences of owners are also given a numerical value, ranging from 10 to 50. Given the owner's primary concern for cost, a significant weight of 50 is allocated to the cost factor. Each option is evaluated based on these values, and the alternative with the highest rating will be suggested. Based on this analysis, option 1 is the suggested choice for this research under examination. Table 1 displays the assessment matrix for the specific aim being examined.

Table 1: Evaluation of alternatives during analytical stage of value job plan

Two options are under consideration for the present study

Objective: To find the optimal design for the foundation design with highest rating based on the following analysis				
Alternatives		Evaluation on a value(V) of score 1 to 10		
	Cost	Time	Quality	Buildability
1. Option 1	8	7	5	6
2. Option 2	6	5	7	8

The following weightings are based on the preferences of the decision-making stake holders

Criteria	**Weighting(W) (Scale 10 to 50)**
Cost	50
Time	40
Quality	30
Buildability	20

Evaluation:

		Option 1		Option 2	
Criteria	Weight	Value	W * V	Value	W * V
Cost	50	8	50 x 8 = 400	6	50 x 5 = 250
Time	40	7	40 x 7 = 280	5	40 x 3 = 120
Quality	30	5	30 x 5 = 150	7	30 x 7 = 210
Buildability	20	6	20 x 6 = 120	8	20 x 4 = 80
Rating (Weighted Value)		**810**		**660**	

4.3.4 Development stage

The development stage selects the best options and gathers narratives, specifications, and drawings to boost the project's value. The designer, customer, and other stakeholders collect technical, financial, and time-related data for all options to evaluate their feasibility. In this study for options 1 and 2, all design comparisons, complete sketches of original and proposed designs, life cycle costing, time, quality, and buildability were extracted after carrying out detailed estimation, preparation of construction schedule, risk in terms of quality issues, and execution feasibility.

4.3.5 Presentation stage

The presentation phase involves presenting the most optimal choices to the decision-makers who have the power to adopt the recommended solutions that are deemed acceptable. The value engineering team provided a detailed explanation advocating for option 1, supported by the necessary backup computations. The value engineering team either receives approval to proceed with implementation or is directed to sources of further knowledge via the presentation and subsequent interactive discussions. The overview of suggestions made and their influence on the whole project is shown in Table 2.

Table 2. Summary of recommendations

Description of idea	**Status**	**Details of discussion**	**Cost benefits**	**Time benefits**
Design change for grade slab at lower basement level (change in details of foundation design)	Accepted	• Foundation scheme was changed according to this new proposal • Vapor barrier has been eliminated • Bottom grade slab at foundation is shifted at lower basement slab level	Rs 2.53 Cr	15 days

4.4 Post workshop

During post-study activities, it is essential to ensure that the approved value study change recommendations are implemented into the project. Management, in conjunction with members of the VE study team, designates other individuals with the responsibility of carrying out the activities outlined in the approved implementation plan.

V. Conclusion

The study concluded that implementing value engineering during the start of execution phase, on the structural design of foundation elements for the project under consideration, resulted in significant cost savings, as well as a reduction in construction timeline, promising improved construction efficiency. Furthermore, the discovery of extra float within activity durations gave an opportunity to accelerate successor activities, allowing for smoother project advancement.

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