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IMPLEMENTING VALUE ENGINEERING FOR STRUCTURAL WORKS DURING THE DESIGN PHASE FOR A RESIDENTIAL PROJECT

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ABSTRACT

To cut costs without sacrificing quality or performance, value engineering has been found to be a good way to do it. Value engineering is used a lot in construction projects as a way to make decisions about what to do. Value engineering has a lot of benefits and can be used in a lot of different ways, which is why more and more businesses are including the idea of value engineering in their projects. It is well accepted that value engineering should be undertaken early in the life of a project (feasibility and planning phases) in order to maximize the benefits. Some projects fail to address the notion of value engineering and, as a result, subsequently seek to achieve the project specifications in terms of cost and time but fail to do so. The purpose of this work is to shed light on how to incorporate value engineering into the structural component/item of work of a building construction project by examining a case study of an ongoing building construction project in Kolkata during the design phase and evaluating the cost savings that can be realized by substituting alternative items or components without sacrificing quality or performance.

KEYWORDS: ***Value engineering; Construction Project; Design Phase; Structural work; Pareto Law; Cost to worth ratio; Time and cost.***

1. INTRODUCTION

Value engineering is a multidisciplinary approach to problem solving that aims to maximize the utility of any product, process, service, or organization in order to meet its intended function or goal (Sharma and Belokar 2012). In order to get the greatest value out of a project, value engineering is used to help make decisions based on a systematic multi-discipline approach and function measurement. This may be done by determining the functions that are necessary to achieve the desired goal value. Additionally, value engineering can perform these duties at the lowest possible cost, with the greatest degree of quality consistency, and with the required performance (Ilayaraja and Zafar Eqyaabal 2015). Total project expenses can be decreased if we can uncover new alternatives that perform the same duties and deliver the same level of performance, if not better, at the lowest feasible cost without jeopardizing the project's quality or other criteria. Value engineering capacity to assist in decision-making throughout the design phase is one of its benefits, which helps to ensure that the cost-savings outcome is as ideal as possible (Joo and Park 2014). Approximately 28% to 30% of a project's overall cost is devoted to structural work. Thus, value engineering may be used to optimize the cost of structural work in a building project. Therefore, this study is based on a case of a building construction project team that had already completed the feasibility, planning stages and was working on structural designs in the design phase. Following the project's goals, the structural details and drawings were presented to the owner. The client was disappointed after reviewing the outcomes since the designs turned out to be more exorbitant and surpassed the anticipated budget. To overcome this situation, the client hired a value engineering team to implement the notion into their project and see how it would affect the final outcome. Experts in value engineering found that previous team members had no idea what value engineering was and had not included it into the project at an early stage. Thus the present study objective is to implement value engineering at the design stage and analyze the cost savings that may be gained by replacing alternative materials or structural components for those originally planned or specified, without sacrificing quality or performance.

2. BACKGROUND OF VALUE ENGINEERING

The phrase "Value Engineering" refers to the process of lowering the cost of products or services via the use of engineering techniques (Eneyo and Shah 2018). These solutions aim to provide a minimum level of quality at the lowest feasible cost. Value Engineering's planning methodology has always been driven by the function needed and the value achieved. As a consequence, value engineering is not considered to be (Weni Harini and Widyarti 2018):

- Cost-cutting procedure, reducing the project's cost through unit price compression or by sacrificing quality and attractiveness
- Design review, which entails revising the outcome of an existing design
- All designs must adhere to certain specifications, but it should not become mandatory for all designers to do value engineering projects
- Resolve mistakes resulting from planning errors
- Cost-cutting measures include decreasing the appearance and quality
- Value engineering aims to deliver at least the same level of quality as anticipated at the lowest possible cost.

Value engineering is a professional team's job to assess and increase the value of goods, designs, structures and technologies as well as services. In addition to addressing issues and decreasing costs, value engineering has the ability to increase performance or quality standards defined by the project. Based on the link between function, quality, and cost, the following options for value engineering may be used in the design process (Miladi Rad and Aminoroayaie Yamini 2016):

- Cutting costs without sacrificing functionality or quality
- Enhanced value or quality while keeping the price unchanged
- Increasing the expense to increase the function and quality
- Enhancing quality and functionality while keeping the price low

3. METHODOLOGY

This study is focused on the case study of a residential building project in the state of West Bengal. To stick to the objective of this research, value engineering is implemented only for the structural works of this project. The research approach used in this study is shown in Figure 1.

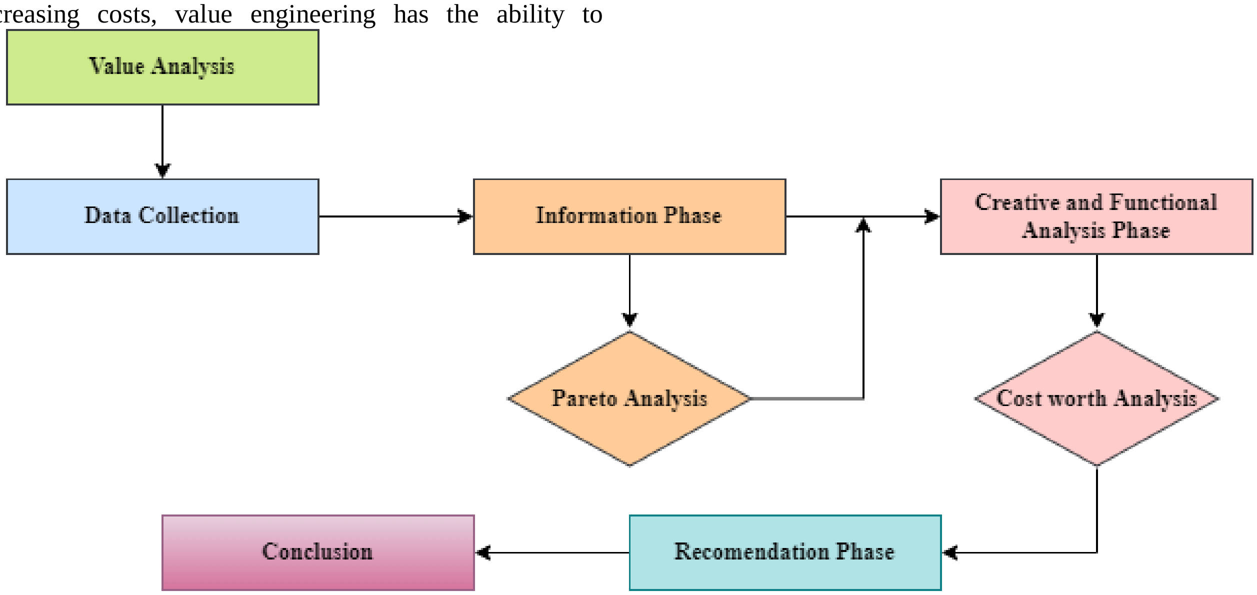

Fig 1. Job Plan for implementing Value Engineering

3.1 Value Analysis

Value analysis is analyzing and assessing existing products in order to enhance their functionality or reduce their cost. Value analysis is a subset of function analysis, in which a product is broken into components that are later reviewed. A step-by-step plan enables to evaluate several aspects of a product, including its functionality, alternate components, design, and cost.

3.2 Primary and Secondary data collection

Primary data are those that researchers obtain directly and include the following: mounted volumes volumetric calculation. Secondary data is information that has been obtained by researchers from previously existing sources and is formatted as follows: Budget Plan for the building that has been roused, specifications or quality of the material that has been determined that the normal poured into work plans and specifications and pictures for construction previously agreed upon by the owner.

3.3 Information Phase

The information phase collects the most information on the project, including background information, the project's potential for complexity, cost overrun parameters, and time

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overrun parameters. The team conducts a function analysis (Using Pareto Law) and ranking of systems and subsystems' relative costs to identify probable high-cost areas and assist in determining a systematic strategy for controlling cost overruns and completing projects on schedule(Akhter and Reza 2021). As part of this investigation, all of the project's detailed designs and budgets, along with the bill of materials, were collected.

3.3.1 Pareto Law Analysis

The cost values that will be used in value engineering will be calculated using Pareto's Law, which will be applied to the data. Through which the value engineering team can determine if it is feasible to save money by altering the execution technique or by employing new materials, as well as to determine the budget for the whole building's workforce throughout the construction process.

3.4 Creative and Function Analysis Phase:

The Value Engineering team devises alternative solutions for the project to carry out the stated functions. In this step, each component is examined individually, and a list of feasible solutions to carry out the function is generated(Wao et al. 2018)

3.4.1 Cost-to-Worth (C/W) Analysis:

Value is founded on the cost-to-worth concept, which describes the link between cost and worth. Equation 1 may be used to compute the cost-to-worth ratio. The high cost-to-value ratio suggests an area where a system might potentially save substantial money. A cost-to-value ratio larger than one implies that the organization has room to cut costs (Arumsari and Tanachi 2018).

$$Cost-to-\ worth\ (CW)=\frac{Cost}{Worth} \qquad \ldots\ldots \text{ Eq.1}$$

3.5 Recommendation Phase

The value engineering team conducts research on the ideas they've selected, developing descriptions and life-cycle cost estimates to accompany the proposals as official value engineering recommendations (Al-Yafei, Ogunlana, and Oyegoke 2017). Value engineering study begins with a concept and evolves into a practical solution through time. The process of development comprises a description of the pros and drawbacks of the offered solutions, as well as an evaluation of the recommended design, capital expenditures, and life cycle costs.

4. APPLICATION OF VALUE ENGINEERING FOR STRUCTURAL WORKS ALONE FOR THE PROJECT UNDER CONSIDERATION

4.1 Data Collection

Building Data: The project is located in the prime area of Kolkata, West Bengal. Project is residential scheme of G+23 floors, consisting 184 units of 3 BHK & 2 BHK. All the primary and secondary data regarding project designs, project history, project hurdles, and project cost were collected from the client.

4.2 Information Phase

Based on the information gathered during the first phase, provided by the client, the overall cost of the project was divided into five categories, with the cost breakdown of each category shown in Table 1. Value engineering employs the Pareto principle, which is used to assess the item of work with the greatest cost that has the potential to be studied in order to determine its value. This theory (Pareto Law), also known as the 80–20 rule, or "the law of essential few," "the law of factor sparsity," states that for many events, around 80 percent of the effect is generated by approximately 20 percent of the causes (machines, raw materials, operators, etc.). Only the cumulative cost of 80 percent will be further investigated via the use of value engineering techniques.

Table 1. Cost wise break down of each category

Si No	Work Items	Cost (In Rs)	% of overall cost of project	Cumulative %
1	Structural Works	16,97,44,370	41.26%	41.26%
2	Architectural Works	15,12,40,330	38.63%	79.89%
3	Mechanical/Electrical Works	4,80,26,103	12.62%	92.51%
4	Miscellaneous Works	3,12,68,569	6.85%	99.36%
5	Preparatory work	35,21,638	0.64%	100%

As can be observed in Table 1, only structural and architectural elements account for about 80% of the entire cost of the project; as a result, it is beneficial to implement value engineering for these two categories of items. However, since the focus of the research is confined to just structural work, the authors have only used value engineering for structural work in their implementation. Following the completion of the first Pareto analysis on the whole project for all items of work, a second Pareto analysis was performed exclusively on the structural work to further determine which structural work items are truly influencing the cost and time. Detailed cost and Pareto analysis for the project's structural components are included in the following Table 2.

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Table 2 Recapitulation of Structural works Budget according to Pareto Law

No.	Work Items	Cost	% Prices	% Cumulative
1	Slab	Rs. 5,89,68,123	35%	35%
2	Beam	Rs. 3,96,16,208	23%	58%
3	Column	Rs. 2,58,52,061	15%	73%
4	Wall Partition	Rs. 2,01,61,634	12%	85%
5	Staircase	Rs. 1,25,85,124	7%	93%
6	Footing	Rs. 87,42,928	5%	98%
7	PCC	Rs. 38,18,292	2%	100%

4.3 Creative and Function Analysis Phase:
Following a study of the Pareto Analysis only for structural items present in the existing design, substitute items that do not compromise the component's function were explored. Each item was carefully selected by comparing its various properties to those of the originally proposed items. The following components were substituted with the suggested replacements as given in Table 3. When offering alternatives or replacements, the life cycle cost analysis should be performed. The LCC is defined as the total cost of ownership from planning to usage. A LCC comprises of the following components: investment, financing, operations, maintenance, replacement/repair, tax, and salvage value

Table 3 Alternate suggestions

No.	Category	Existing item in design	Proposed Alternative
1.	Slab	Cast-In-situ concrete Slab	Post tensioned Slab
2.	Beam	Conventional Beam	Precast Beam
3.	Column	Conventional Column	Precast Column
4.	Wall Partition	Conventional Wall Partition	Precast Wall Partition
5.	Staircase	Conventional Staircase	Precast Staircase

The LCC is calculated by converting the values of all the above mentioned elements to their current values. In terms of life cycle cost, Table 4 summarizes the results of current items of work and proposed alternatives.

Table 4 Comparison of Life cycle cost for existing and proposed alternatives

No.	Structural item	Existing item in design (Rs)	Proposed Alternative(Rs)
1.	Slab	5,89,68,123	7,56,00,158
2.	Beam	3,96,16,208	3,41,51,904
3.	Column	2,58,52,061	2,26,77,246
4.	Wall Partition	2,01,61,634	2,24,01,816
5.	Staircase	1,25,85,124	1,87,83,768
	Total	15,71,83,150	173614892

4.4 Cost-to-Worth (C/W) Analysis

The assessment of cost/value worth distinguishes value engineering (VE) from other approaches of cost reduction. Before any further alternatives can be considered, the primary goal of the project must be identified. Using an analytical method, the utility value (worth) of each subsystem or component must be weighed against its predicted expenses. This technique may be used by the VE team to determine the most cost-effective way to design a function and ways to decrease or eliminate the expenditures without sacrificing performance. Table 5 highlights the cost-to-value ratios for the various options under consideration.

Table 5 Cost to worth Analysis of proposed alternatives

Sl. No.	Work Items	Alternative Selected	Existing Item Cost (Rs)	Proposed Alternative Cost (Rs)	Cost/Worth	Result
1.	Slab	Precast Slab	5,89,68,123	7,56,00,158	0.78	Unworthy
2.	Beam	Precast Beam	3,96,16,208	3,41,51,904	1.16	Worthy
3.	Column	Precast Column	2,58,52,061	2,26,77,246	1.14	Worthy
4.	Wall Partition	Precast Wall Partition	2,01,61,634	2,24,01,816	0.90	Unworthy
5.	Staircase	Precast Staircase	1,25,85,124	1,87,83,768	0.67	Unworthy

4.5 Recommendation Phase:

A cost analysis was undertaken on structural work alone, comparing current items (that satisfied the Pareto criteria) to proposed replacements. The cost differential between the two groups is displayed in Table 6 in the first row, independent of cost-to-value analysis but incorporating all available options, and it is 9.93 percent more than the original design items which are not at all a viable option.

Whereas the second row depicts the differences between the two groups, but only for those items (beams and columns) that merited consideration for value engineering based on a cost-to-worth analysis, with a cost difference of 5.65% less than the original design items.

Table 6 Comparison of cost analysis

Total Cost	Existing Items	Proposed alternative items	Difference in cost	% Difference
Total Cost without considering C/W	Rs. 15,71,83,150	Rs. 17,36,14,892	Rs. 1,64,31,742	9.93
Total Cost by considering C/W	Rs. 15,71,83,150	Rs 14,85,44,031	Rs. 86,39,119	5.65

5. CONCLUSION

Based on the value engineering analysis of the structural work in the analyzed scenario of the residential building project, it can be concluded that the value engineering analysis identifies only beams and columns as items of work that may be optimized. Through value engineering analysis, the percentage of cost reduced by incorporating precast beams and columns is 5.65. This replacement saves roughly Rs 86, 39,119/- on the whole project's cost which is quite a considerable amount to the client. Furthermore, additional research in terms of time or delay analysis should be conducted in order to determine how quickly the project can be finished with the replaced items for the final conclusion to determine if they can be adopted or not.

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