Application of value engineering in the construction industry and its comparative study with conventional methods

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Abstract: Nowadays, the construction industry is seeking to adapt to new and workable methods instead of traditional methods. The new technique lowers the cost, saves time, and raises the level of excellence and productivity at the construction site. One of the provident and estimable techniques used in the construction industry is value engineering (VE). Value engineering lowers the excess cost and enhances the quality of the product. This research proposes materials that can serve as alternatives for implementing value engineering at construction sites. The study relies on data gathered from site visits to various locations in Mumbai. The study has taken into account six parameters, evaluated through both qualitative and quantitative methods. In addition to this, the project presents a comparison of the value engineering method with the traditional method for cost benefits. The analysis of time factors was conducted using Microsoft Project (MSP) software. It is concluded that the value engineering method proved to be a problem-solving tool, reducing the cost to meet people's needs, saving time without disturbing the quality and performance, and making the construction industry sustainable.

Keywords - Value Engineering, Construction Industry, Material Replacement, Time, Cost, Quality.

1. Introduction

In today's competitive world, it is very difficult to complete the project within the specified time and cost. So, it is very important to plan and schedule the project to achieve the goals. Among the many challenges facing the construction business are time and cost overruns, project delays, project losses, inadequate management, and more. The reason for such problems is due to the unavailability of materials, shortage of labor, conflicts in the project, unawareness of creativity, higher rates, and lack of knowledge about the new technique adoption [1]. Here, it is very crucial to overcome these difficulties, and this can be done by applying new and feasible techniques. Various technologies have been used to surmount problems, and one of the effective techniques used to exclude the unnecessary cost in a construction project is value

engineering (VE). VE is a cost-cutting technique that lowers project expenses without sacrificing the product's quality or worth. General Electric C developed value engineering during World War II and is widely used in industry and government organizations such as defense, transportation, construction, and health care [2]. The VE group looks for the greatest blend of scheduling, environmental awareness, execution, buildability, maintainability, safety, and cost consciousness [2]. Value Engineering is performed in a wide range to improve overall efficiency and net profit without compromising the quality, the value of the product, and the level of customer satisfaction. In the construction industry, the goal of the project is to ensure that the project is completed on time and within the intended expenditure. Reduction in the cost of construction is a consistent aspiration for the construction industry.

Industries have been going out of their way to minimize costs to save their financial resources, meet their budgetary limitations & reallocate this money to fund other projects. VE aims to achieve the best use of alternative, inexpensive material without compromising strength and quality, priced-off design, mass reduction, labor reduction, a new way of manufacturing, new ideas of construction, and a better understanding to achieve identical quality and efficiency at low cost [3]. Ravish and Vinoth (2016) carried out a case study of a residential building located in Dhaliyur, Coimbatore. The overall cost for the construction of the building was 6 61, 82,000.00 and the duration was 11 months. The VE applied to exposed walls, internal walls, windows, water tanks, sunshades, parking floor, terrace floor, plastering, painting, and putty works, and the feasible alternatives were adopted, which saved a total of 11,94,00. Partheeban et al. (2017) stated that VE is a function-oriented technique that has proved to be an efficient management tool to obtain enhanced design and cost of construction in various transportation fundamentals. The paper presented a questionnaire survey to find out how effectively VE is adopted in construction, and whether employees are aware of the concept of VE and its power. It was concluded that 20% of employees do not follow a specific procedure for implementing VE, and the remaining 80% follow VE. Rane (2016) stated that a cost-efficient solution is obtained by adopting the VE principle. Hence, he presented a case study in which VE is applied to the sheath enclave office complex and concluded that the value engineering method nobly aids the decision-making process for the designer, the owner, and the contractors. Successfully, this technique can be applied to a real construction project. Patil and A.C. Attar presented an evaluation and selection technique derived from value engineering principles for the door system. The sliding door alternative was selected as the best alternative, which saves up to 60-80% of the cost compared to the existing doors.

2. Objectives of the study

1. To study and understand the phases involved in the Value Engineering Job Plan.
2. To identify the various parameters of value Engineering used in construction projects and to analyse the different parameters based on:
    a. Quality
    b. Feasibility
    c. Demand

d. Cost

3. To analyse and compare the cost of the alternative value-engineered parameters with the conventional method and give the advantages and disadvantages of both the traditional and VE methods.

3. Research Methodology

It consists of two phases; the first phase includes literature study, data collection of the traditional method, from research papers, the net, books, through contractors, a site in charge, etc. The second phase consists of a collection of value engineering data from sites through a questionnaire, personal meetings, interviews, mail, etc.

The methodology flowchart shows in Fig. 1 that the data of value engineering was collected through the case study. After the data collection, the analysis was done, and a comparative study was carried out.

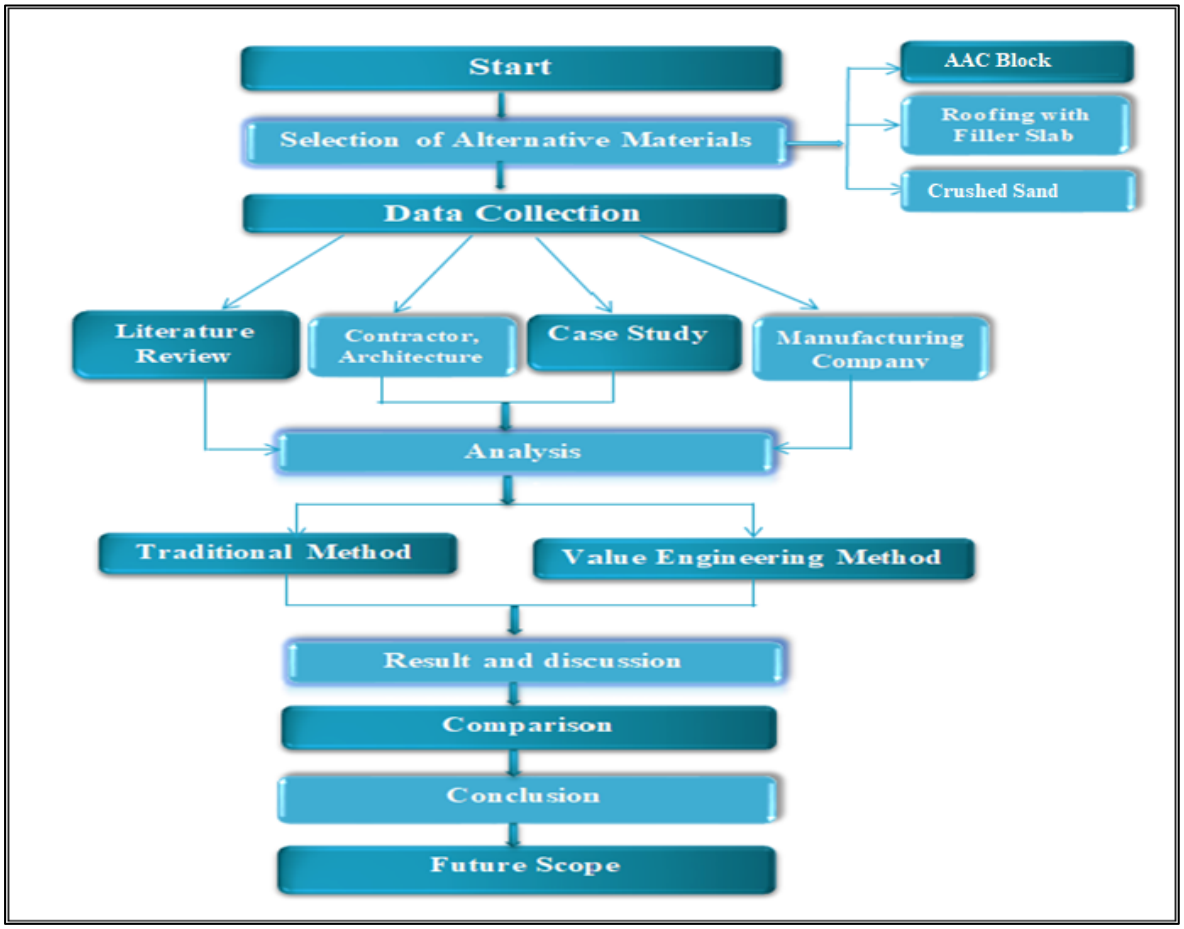

Fig.1. The Methodology Flow Chart

4. VE JOB PLAN ANALYSES

The value engineering job plan has eight phases depending on the VE application in the industry. Each phase has several tasks. These sequential phases have the highest level of project success. Step-by-step phases of a job plan are as follows:

4.1. Information phase

In this first phase, a large amount of information regarding the project is gathered, including project commitments and constraints. To minimize the losses in the project, preliminary value analysis is carried out in this phase. The VE team participates in finding the probable needs of the project.

4.2. Function analysis phase

This phase includes a detailed explanation of the function of every element of a project to direct a thorough understanding of what the project is supposed to furnish thoroughly [4].

4.3 Creative phase

In this phase, the various alternative ideas are generated by the VE team related to the project benefits and cost reduction. The ideas are generated through brainstorming and association of creative proposals. The team needs good ideas, a large number of ideas, which can be screened in the further phase of the job plan.

4.4. Evaluation phase

The value engineering group screened and ranked the thoughts that have been created in the creative phase. Those ideas found relevant and cost saving are selected, and this idea shows the effective alternative for cost savings and better improvement in the work [4].

4.5. Development phase

During this phase, the VE team researches the selected ideas and prepares sketches, designs, descriptions, and life-cycle cost estimations to allow decision makers to determine if the alternative should be implemented [5].

4.6. Presentation phase

In this phase of the job plan, the best and feasible alternative is chosen and presented to the client for the final decision [4]

4.7. Implementation and follow-up phase

During this phase, management must assure that approved recommendations are converted into actions.

Parameters chosen as material replacements are Shown in Fig. 2 :

Fig.2. Flow Chart of Alternative Material

The above parameter was found through surveying at a different location in Maharashtra and through the internet, and the data was collected from various sources.

5. DATA COLLECTION AND ANALYSIS

Data regarding value engineering parameters was collected from various sites by visiting, contacting the contractors, site engineers, supervisors, labourers, etc. After collecting the data, the calculation of per square meter/Cubic meter of each parameter was done with the help of a Microsoft Excel Worksheet, and the mobile application has also been used for estimating the material known as material estimator and Material Analysis v1.06. The calculated value was then implemented for the plan of a bungalow made in the AutoCAD software, and the cost required for both methods, which helps to make the comparison between the two. After analyzing the data, the saving amount is calculated as a percentage.

The estimation of bungalows as shown in Fig. 3 was also done to calculate the cost required after adopting this technique and to suggest the relevant method to overcome the shortage of houses faced by a developing country like India. In this paper, the analysis concerning the material factor is only considered.

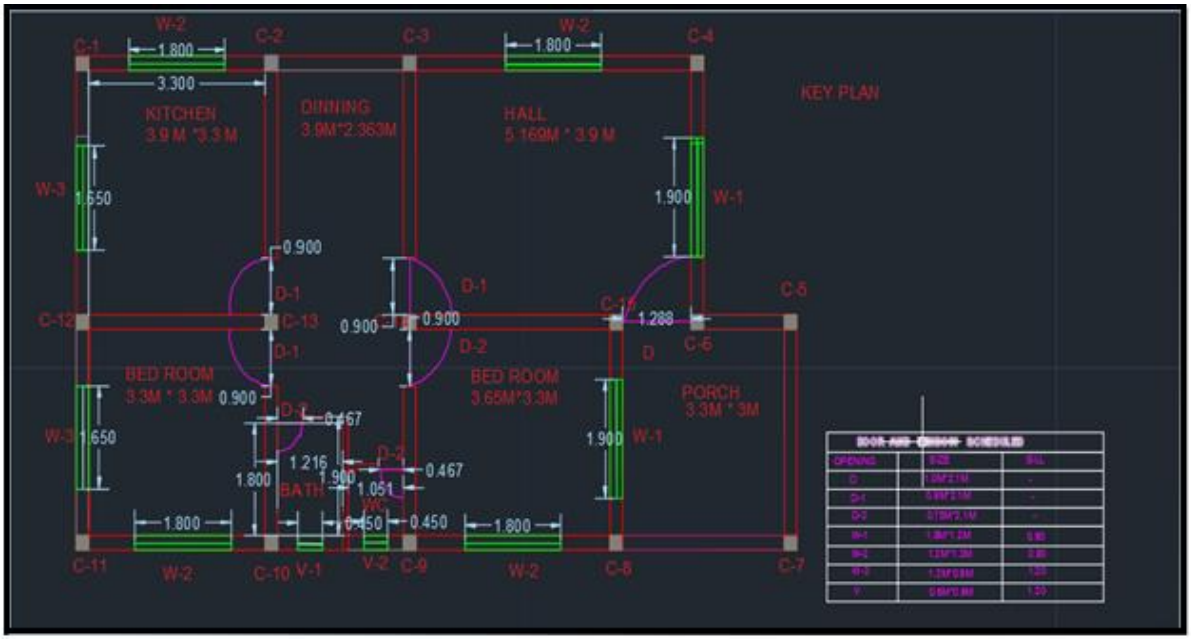

Fig. 3. Bungalow Plan

5.1 RATE ANALYSIS FOR ACC BLOCK, CRUSHED SAND, AND ROOFING WITH FILLER SLAB WITH CONVENTIONAL METHOD REQUIRED FOR 1 CUBIC METER.

Firstly, the three value-engineered parameters have been considered, i.e., AAC Block, roofing with filler slab (earthen pots), and Crushed Sand. The rate analysis was carried out for 1 cubic meter for both the conventional and value engineering methods and compared the results to find the feasible method amongst the two.

Table 1: Details of material for per cubic meter required in the Value Engineering Method

Sr No.	Material	Quantity	Units	Rate (Rs)	Amount (Rs)
1	**AAC Block**				
	Block (Nos)	80	Nos	55	4400
	Jointing Mortar	0.67	Bags	550	368.5
	TOTAL				**4768.5**
2	**Roofing with filler Slab (Earthen Pots)**				
	Cement	4.449	Bags	325	1445.93
	Sand	0.237	m^3	1700	402.9
	Aggregate	0.45	m^3	1000	450
	Pot	170	Nos	6	1020
	Steel	54	kg	65	3510
	Binding wire	0.785	kg	60	47.1
	Formwork	6.5	m^2	300	1950
	TOTAL				**8375.03**
3	**Concrete Using Crushed Sand 1 m^3**				
	Cement	8.016	Bags	325	2605.2
	Crushed Sand	0.54	m^3	1334	720.36
	Aggregate	0.844	m^3	1000	844
	TOTAL				**4169.56**

Table 2: Details of material for 1 m3 required in the Conventional Method

Sr No.	Material	Quantity	Units	Rate (Rs)	Amount (Rs)
1	**Standard Bricks**				
	Bricks	550	Nos	6	3300
	River sand	0.324	m^3	1700	550.8
	Cement	1.4935	Bags	325	485.388
	TOTAL				**4336.19**
2	**Concrete Using River Sand**				
	Cement	8.016	Bags	325	2605.2
	Sand	0.54	m^3	1700	918
	Aggregate	0.844	m^3	1000	844
	TOTAL				**4367.2**
2	**Conventional Slab**				
	Cement	8.24	Bags	325	2678

	Sand	0.4536	m^3	1700	771.12
	Aggregate	0.9072	m^3	1000	907.2
	Steel	84.78	Kg	65	5478.2
	Binding wire	0.785	Kg	60	47.1
	Formwork	6.5	m^2	300	1950
	TOTAL				**11831.6**

6. RESULT AND DISCUSSION

6.1 AAC BLOCK

Autoclave aerated concrete, also known as autoclaved cellular concrete, nowadays the application of AAC blocks has been widely used in construction, and is also suited for high-rise building construction. It can be used to build for both interior and exterior construction work. It is a lightweight precast block used for construction. AAC products include block, wall panels, floor and roof panels, cladding panels, and lintels. AAC blocks are available in different sizes, viz. 600x200x100mm, 600x200x150mm and 600x200x200mm. See Fig. 4, which shows the wall construction using AAC block. Larger size of AAC block can be used for exterior wall construction, and smaller size AAC block for the interior construction.

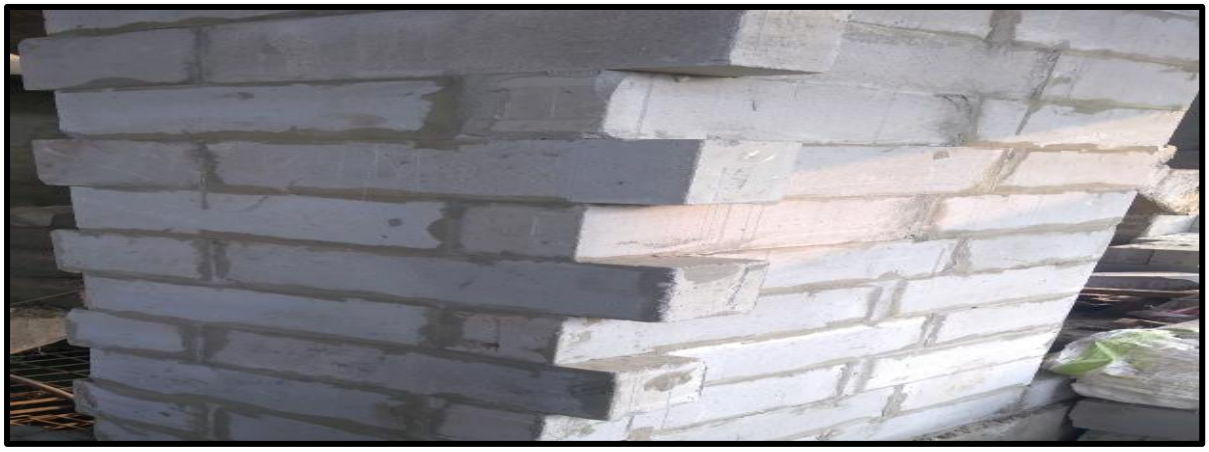

Fig. 4. AAC Block

Fig.5. Comparisons of Standard Brick with AAC Block

Fig. 5 shows the number of bricks required to cover the size of an AAC block; 8 bricks equal 1 AAC block.

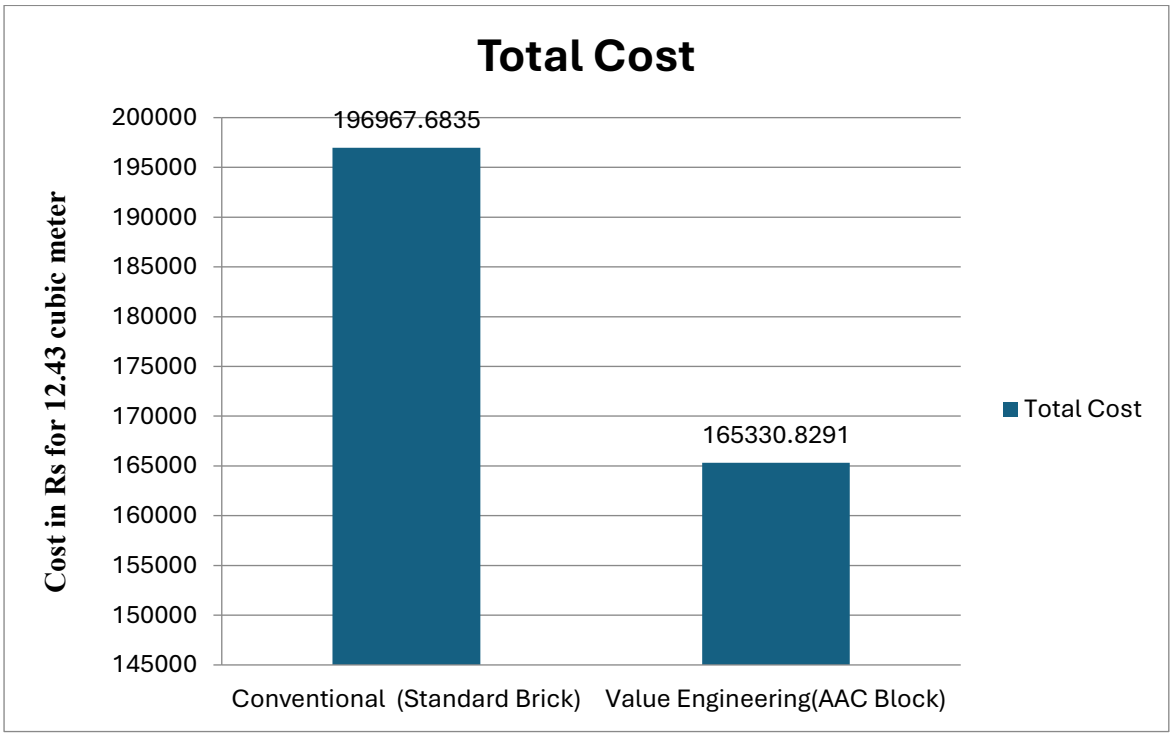

Fig. 6. Cost Comparison of Standard Brick with AAC Block

The construction with AAC block is only for the walls of the area 29.08 cubic meters, see Figure 6. AAC block found to be a feasible material compared with the conventional standard bricks. Nowadays AAC blocks are the relevant material for the cost reduction in construction projects. It has many advantages over conventional standard bricks. It is lightweight, easy to handle, requires less manpower, less time for the construction, and requires less maintenance than the conventional method. A Fig. 6 shows that it reduces

construction cost up to 16 %. The cost saving is calculated by considering labour charges and plastering required for both methods.

Compressive Strength test of AAC block:

A 150x150mm AAC Block was taken to carry out the compressive strength and oven dry density. Fig.7 shows the reading of the test for the AAC block, which gives a strength of about 4.4 N/mm2

Fig.7. Compressive Strength of AAC Block

Table No. 3 Strength of AAC Block (IS2185-Part 3 1984)

Sr. No.	Oven dry density	Compressive strength of AAC Block (N/mm^2)	Compressive strength of Standard Brick (N/mm^2)
1.	740 kg/m^3	4.4 (100/22.5)	3.5

6.2. Roofing with Filler Slab

Filler slabs are one of the cost-effective roofing systems in which filler material is placed to reduce the concrete volume in the tension zone, where the concrete is not needed. This construction technique reduces the self-weight of the slab, hence saving in cost. Fig. 8 shows that the air gap between the pots makes it a good heat insulator, and the ceiling looks attractive as well.

Fig. 8. Roofing with Filler Slab

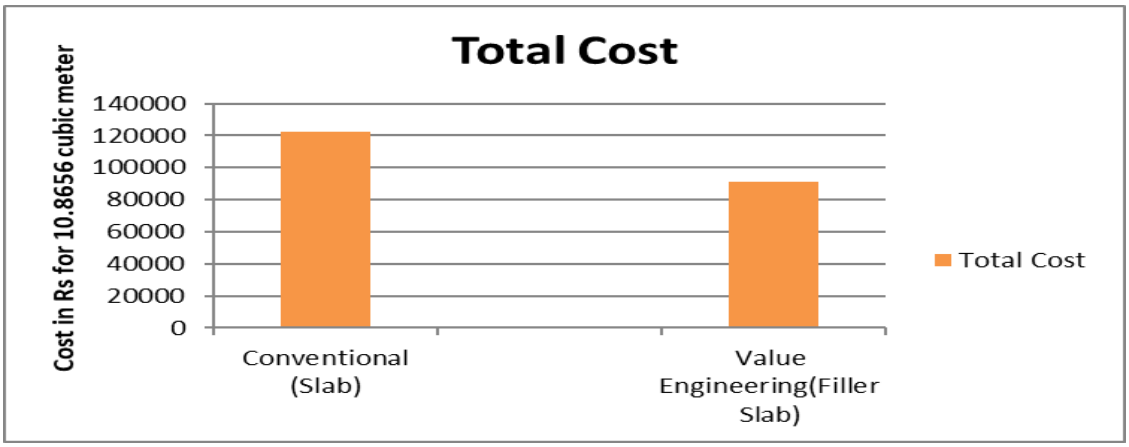

Fig. 9. Cost Comparison of Conventional Slab with Roofing with Filler Slab

From Fig. 9, it can be seen that about 17.11% of the cost can be reduced by adopting this technique. As the self-weight of the structure is reduced by reducing concrete and steel, it reduces the excess cost of the construction. The site is located in Kalyan, where this technique was successfully adopted and saved the project cost of about 30%

6.3. Crushed Sand:

The construction industry is facing problems due to the shortage and unavailability of river sand. Due to this, construction work gets delayed and causes many issues. The construction industry has been facing problems with river sand for many years, and this problem needs to be solved to overcome the issues in construction.

The quarry is the main source of crushed sand and is manufactured by crushing rocks, quarry stones, or large aggregate pieces in the factory or quarry, as shown in the Fig.10 The river sand is extracted from the riverbed and causes damage to the environment in many ways. The compressive strength of both crushed sand and river sand is the same, so the construction industry prefers washed crushed sand to avoid losses

and delays in construction. Washed crushed sand is of good quality compared to crushed sand, as crushed sand contains dust in it, but washed crushed sand is free from any dust, hence giving higher strength to concrete. To improve the strength or to achieve a higher strength, chemical admixtures may also be added to it.

Fig. 10. Crushed Sand

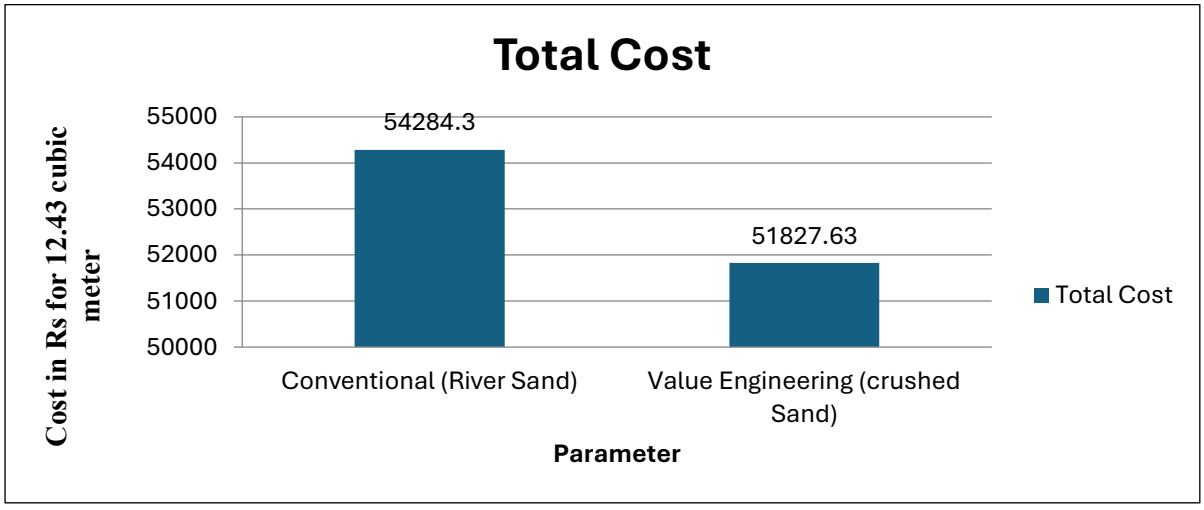

Fig.11. Cost Comparison of River sand and Crushed sand

As we know, there is a shortage of river sand at every location in the construction industry, and for this reason, the construction industry is suffering a lot. Instead of river sand, it has been found that washed crushed sand is a feasible option and it also saves in the cost of about 4.53 %, see Fig.11 Though this alternative material won't save much cost in the construction, it would be the best alternative material in construction. The washed, crushed sand does not compromise the strength, so this material can be applied in construction work. Figure 4.8 shows the cost comparison of washed crushed sand and river sand.

6.4. PERCENT CALCULATION OF ALTERNATIVE PARAMETERS

From Fig.12. alternative materials can save costs to some extent. If this technique is applied in the construction industry, the economy will be achieved at the same time. two parameters, i.e., AAC Block, Roofing with Filler Slab, and Crush Sand technique, are used in single construction, more economy will be achieved, and gives a better appearance to the structure.

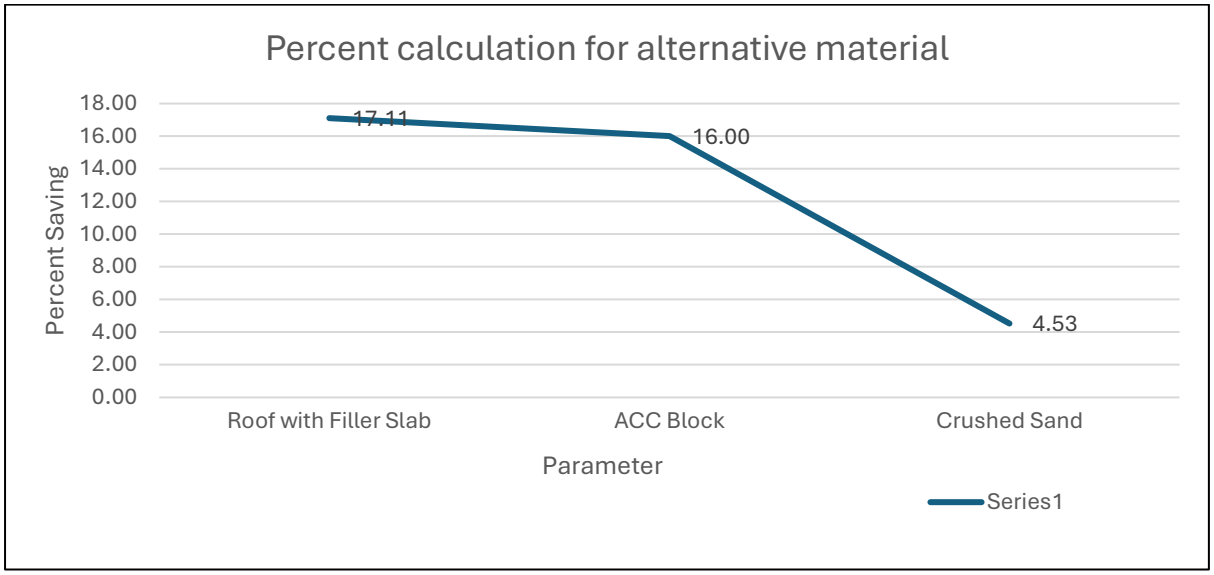

Fig.12. Percent Calculation of Value Engineered Parameters

7. Conclusion

In order to minimize the shortage of houses in India, a suitable alternative technique should be adopted. Instead of constructing low-cost houses with cheaper quality materials, the best alternative technique should be used that eliminates the cost of construction by about 16-20%.

The AAC Block technique construction costs save up to 16% without compromising its strength.

Roofing with filler slab is an alternative technology of slab construction in which the concrete volume can be reduced because in the tensile zone, concrete is not needed, and hence filler material can be used

to reduce the wastage of concrete. This technique reduces the cost and self-weight of the structure. About 17.11% of the cost can be reduced.

Crushed Sand technique, which is convenient and sustainable. The study shows that it saves the cost by about 5-4% and the technique has many advantages over the conventional method, and it may save more cost when the time factor is also considered.

The above research has been done for material and concluded that these parameters are relevant and save in cost when compared with the conventional method.

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