

To Apply Value Engineering in a Residential Building in Ahmedabad City

Pooja Gohil¹ Shaishav M. Patel² Akash Gajjar³

¹Assistant Professor ^{2,3}M. Tech Student

^{1,2,3}Department of Construction Project Management

^{1,2,3}Indus University, Ahmedabad, India

Abstract— 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. The essential difference between conventional cost cutting and Value Engineering is that it involves reducing the cost by improving the functionality through lesser consumption of energy in terms of manpower, material and machinery. The main aim of this case study is to improve a function of a Residential building by possibility of cost reduction. This study is limited to the particular project only. This paper covers role of value engineering as a Job Plan technique. After applying VE in project it reduces 2.01 % cost of overall project and building function can also be improving.

Key words: Value Engineering, Residential Building

I. INTRODUCTION

During the World War II, General Electric Company (GE) faced the problem of shortage of critical materials to fulfill the demand of the war equipment. To overcome that problem, GE had to use substitute materials for those in shortage. Many of the substitutes were less expensive and better in performance. In 1947, Lawrence D. Miles, a staff engineer for GE developed a number of ideas and techniques to select alternative materials that could be used internationally. His main attitude was to search for value in a product and he developed a function-based methodology that was successfully proven. The new methodology was so successful that it was possible to produce goods at greater production and operational efficiency and at lower costs. As a result of its success, GE formed a special group led by Larry Miles to refine the methodology. They called it "Value Engineering".

The U.S. Army and Navy, and other companies, soon realized the success of Larry Miles' methods. As the application of value analysis expanded, there was also a change in context—from review of existing parts to improving conceptual designs. This was one of two factors that marked the emergence of value engineering. The other was a desire by the U.S. Navy to use the Value Analysis techniques for project improvement in the early 1950s when there was a moratorium on hiring "analysts." Since engineering positions were available, individuals practicing this new discipline were employed as "Value Engineers."

In 1954, the U.S. Navy Bureau of ships used the Value Analysis process to cost improvement during design. They called it 'Value Engineering'. The Value engineering

was used formally in the U.S Department of Defense in 1961. (U.S. ARMY PEOSTRI). [1]

The Construction business incorporates a larger impact on the economy of all countries. It's one amongst the sectors that offer critical ingredients for the event of economy. Because of poor value and time management currently, the development business is facing an enormous quantity of cost. This has become quite a drawback for the development business. Poor value management and overrun square measure large drawback and extremely serious issue once it involves project value in each developed and rising countries. The increasing complexness of infrastructure comes and therefore the surroundings at intervals that they are created place larger demand on construction managers to deliver projects on time, at intervals the planned budget and with prime quality. It's known fact that a bigger variety of infrastructure projects in India are delayed because of numerous problems. Infrastructure plays a predominant role within the economic process of our country. Today, India is one amongst the leading outsourcing hubs within the world.

To overcome this problem organization uses many cost reduction techniques like material management, budgetary control, Waste management, Lean technology, value stream mapping and value engineering. Amongst all the technique Value Engineering is most widely used technique and give enormous result in cost reduction. But it is not that well known in India.

II. VALUE ENGINEERING

Value Engineering is Techniques to improve function of products, services & reduce Cost while assuring quality. VE is the system with lowest Life Cycle cost to meet the customer's requirements. It is multidisciplinary group of Designer, Project Manager & Consultants. It is known as System oriented techniques.

Value Engineering techniques can be applied to any product, process, procedure, system or service in any kind of business or economic activity including health care, governance, construction, industry and in the service sector.

Value Engineering is a powerful methodology for solving problems and/or reducing costs while maintaining or improving performance and quality requirements.

Three basic elements provide a measure of value to user:

$$\text{Value} = \frac{\text{Function} + \text{Quality}}{\text{Cost}}$$

A. When to Apply Value Engineering?

- Before commitment of funds, approval of systems, services or designs.
- VE must be applied after complete involvement of owner(s) and consultant(s) decision making, to achieve optimal results.

- New designs are being introduced.
- Reduction in sales of the product manufactured by the company.
- The cost of manufacturing per unit is rising.
- As early as possible to ensure potential savings.

Hence, optimum results can be expected when resources are set aside for VE early in the design process, focusing on owner and consultant impact.

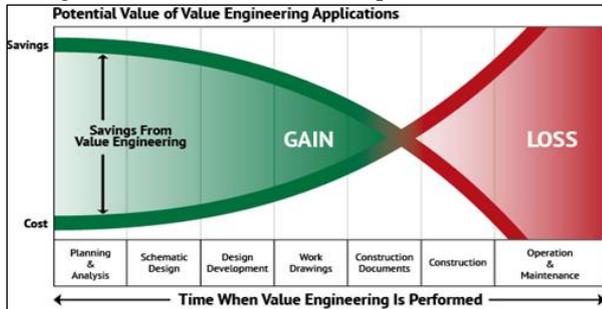


Fig. 1: Time to Apply Value Engineering

B. Research Objective & Scope

Main objective is to apply Value Engineering concept to improve function of Residential Building. To give suggestion on basis of application of Value Engineering. Research Scope is to improve a Function of Residential Building by application of value engineering.

III. VALUE ENGINEERING METHODOLOGY

A research method is a systematic plan for conducting research. For any certain project, the VE study is apply by a multidisciplinary team to improve its value. SAVE International Organization sets six sequential phases for performing a successful VE study. The main study aimed at finding out how Value Engineering process worked it in projects. [1]

The value methodology is a systematic process that follows the job plan. Job Plan is a tool to carry out the project from inception to conclusion. By observing to certain formalities. The job plan is normally organized by a Value team leader. It is conducted in six phase. It is shown in Fig.2

A. What is Job Plan?

The organized and systematic approach of the Value Engineering. It helps to identify the key areas of unnecessary cost and seeks new and creative ways of performing the same function as the original part, process or material. There are several version of VE Job Plan. The procedures are all similar in their approach.

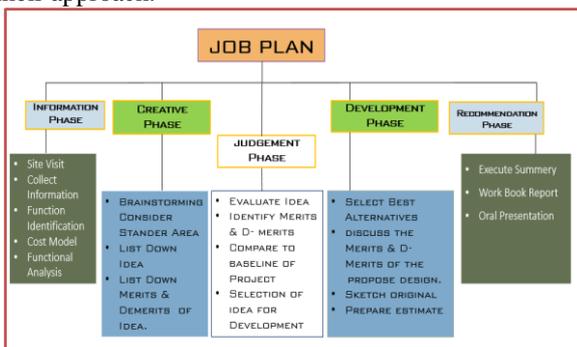


Fig. 2: Study Methodology

IV. DATA COLLECTION & DATA ANALYSIS

Data collection is the process of gathering and measuring information on targeted variables in an established systematic fashion, which then enables one to answer relevant questions and evaluate outcomes.

While deciding about the method of data collection to be used for the study, the researcher should keep in mind two types.

- 1) Primary Data
- 2) Secondary Data

A. Primary Data

There are several methods of collecting primary data.

- 1) Questionnaires
- 2) Observations
- 3) Interviews
- 4) Schedules

So my data collection method is based on Questionnaire and Interviewing. The Job Plan consist of five distinct phases. Briefly, these phases are:

1) Information Phase:

- Data gathered from interviewing and questionnaire of project related function from Site Engineers, Project Manager, Contractor and Designer concerned with the Project undertaken.

- The aim of the data collection is to identify the problems, objective for improvement. The Collected data in the Information phase of study is as follows,

- Basic building details
- Drawings
- Specification of site
- Estimated Quantity
- Design Elements
- Constraint executed on project
- Cost model for various Activities

- In the thesis work a residential tower of Shree Radheshyam Residency as a case study for the function improvement and if possible then reducing cost by application of Value Engineering. A Project is located near at Sai Darshan Flat, Sarkhej Bavla Highway, Bavla, Ahmedabad. Project details are shown in Table 1.

SR. NO.	DESCRIPTION	DETAILS
1	Name of Project	Shree Radhe Shyam Residency
2	Name of Architect	Rajiv Bhanot & Associates
3	Name of Structural Designer	Taknik Consultant
4	Nature of Project	1 & 2 BHK Flats
5	Number of stories	G + 5 BHK
6	Number of Building units	3
7	Number of Flats	80

Table 1: Basic Detail



Fig. 3: Elevation Drawing



Fig. 4: Typical Lay Out Floor Plan

- The Project has three towers of five stories which is 1 BHK and 2 BHK type Flats.
- Three towers of Typical Layout Plans are shown in Fig. 4.
- In that construction of block B & C are on finishing and block A is in Progress.
- My study area on block B is shown in figure 6 with all dimensions. So, I would like to apply Value Engineering on Block A.



Fig. 5: Floor Plan of Block B

Sr. NO.	ACTIVITY	COST (Rs.)	PERCENTAGE %
1	Infrastructure Development	21,56,304.92	9%
2	Consulting & other Fees	10,79,046.12	5%
3	Structural Work	1,03,17,414.52	43%

4	Masonry Work	24,94,605.94	10%
5	Electric Work	15,69,521.62	7%
6	Finishing Work	63,18,311.65	26%
7	Total Project Cost (Rs.)	2,39,35,204.77	100%

Table 2: Percentage & Cost of Various Activities

B. Creative Phase

During the creative Phase of VE Job Plan, the team brainstormed ideas on how to perform the various functions. These ideas were based on the available information given to them at the time of the study, taking into consideration the constraints and controlling decisions that were also given to them. As per the details of the cost distribution shown in the Table 2 Structural Work, Masonry Work and Finishing work are consuming more percentage cost to other function cost so that the Value Engineering team should have to think about the different or alternate materials which can be replaced and fulfill the requirement of that materials. There are so many advance materials which can be more beneficial for the project in terms of function and their cost.

C. Judgement Phase

At this phase, showing of the ideas developed in creative phase are carried out. Ideas are reviewed to see if they can be developing further for the recommendations resulting in increased value to the owner. The advantages and disadvantages of each of the creative ideas are listed in creative and judgement worksheet. [2]

The potential for the cost savings for each of the ideas should be evaluated. Cases with potentially high-cost savings and resultant savings in operation and maintenance costs of the facilities should be given high priority. [2]

D. Development Phase

This phase start with consideration of best idea(s) screened in judgement phase and further develops into workable solutions. Here, ideas are thoroughly researched, preliminary designs are prepared, sketches of the proposed solution are prepared and life cycle cost estimates are made to compare the original design and new proposed recommendation. [2]

Sr. No.	Material Used on site	Alternate Materials can be change
1	Brick	AAC Block
2	Cement Sand Mortar	AAC Block Jointing Adhesive Mortar
3	Inside Cement Sand Plaster	Inside Gypsum Plaster
4	Lap Splices	Mechanical Rebar Couplers

1) First Replacement:

As per the details of the data collected the function of the masonry is more comparing to other materials. The no. of bricks is consumed in the project. Around 1,60,000 bricks were used in the whole building. If the bricks are change by the another material having a same function or higher quality. It is feasible and the overall cost of the construction site can be minimized.

Cost Comparison B/W AAC Block & Brick			
Sr. No.	Specification	Material Used on site	Alteration Material
1	Material	Bricks(190 x 90 x 90)	AAC Block (650 x 250 x 100)
2	Number of Bricks	1,59,976.00	16706.00
3	Price/ Block	05.00	38.00
4	Material Cost	7,99,880.46	6,34,828.00
5	Labor Cost	2,90,492.16	2,33,696.87
6	Total Cost	10,90,372.62	8,68,524.87
7	Saving (Rs.)	2, 21,847.75 (79.65 %)	

Table 3: Comparison b/w AAC Block & Brick

Advantages and Disadvantages of AAC Blocks are mentioned below. [3]

a) Advantages:

- Versatile
- Thermal Insulation
- Moisture Resistance
- Environment Friendly
- Lightweight
- High Resistance to Water Penetration
- Fire Resistant
- Sound Proof
- Earthquake Resistant
- Faster Construction
- Long Lasting
- Cost Saving

b) Disadvantages:

- Very few contractors are familiar with autoclaved aerated concrete.
- Number of manufacturer is limited. So, cost will drastically increase in places far from the manufacturer and need to travel a long distance.

2) Second Replacement:

Masonry Mortar is basically a binding agent that is composed of cementitious material, fine aggregates and water. The main purpose of the mortar is to sew masonry units (blocks/bricks) into single integral unit. Conventionally used mortar is cement sand mortar in the proportion 1:6 (Cement: River Sand). Over the past few decades' man has exploited the natural resources at a severe rate. Good quality Natural River Sand stands first in the list of construction materials that are in the limit of extinction due to excessive and unnecessary consumption in construction process. One has to adapt to alternative materials that can be used as an effective replacement over 'Natural River Sand' in Masonry Mortar without affecting its efficiency. [4] So we thought to provide Jointing Mortar Adhesive.

Cost Comparison B/W Jointing Adhesive & Conventional Mortar			
Sr. No.	Description	Mortar used on site	Alternate Mortar
1	Material	Cement Sand Mortar 10 mm Thick	Jointing Adhesive 2mm to 3 mm
2	Material Cost (Rs.)	1, 92,209.51	86,450.21

3	Saving (Rs.)	1, 05,759.30 (45 %)
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Table 4: Cost Comparison B/W Mortar & Adhesive

Specification	
Jointing Adhesive	Conventional Mortar
Compressive Strength /5N/mm ²	Compressive Strength 3 to 5 N/mm ²
Fast Application	Not Possible
Plastering Possible after 24 Hours	Mini. 7 Days Curing required
Negligible Shrinkage Cracks	More Shrinkage Cracks
Easy Handling & Storage	Difficult to keep stock of different components and high wastage

Table 5: Specification of Jointing Mortar and Conventional Mortar

a) Advantages of AAC Jointing Adhesive are mentioned below. [5]

- Thin Joints
- Less Quantity
- Time Saving
- Semi-Premix
- Easy Application
- Water Saver
- Minimum Process Time
- Negligible Seepage
- Eco-Friendly
- Prevention of Efflorescence

3) Third Replacement:

Gypsum is a soft sulfate mineral composed of Calcium sulfate dehydrate (CaSO₄:2H₂O). It is widely used as a fertilizer, in mould, in sculptures and as plaster material. Gypsum is a chalk like material and is very light in weight. It is available in crystalline form in nature.

Gypsum has proved to be a miraculous material aiding interior construction. Gypsum surface plaster is one form that has caught the attention on the sector and is growing in popularity. The oldest example of usage of gypsum as an internal plaster is found in the Pyramids of Giza in Egypt which were lined with gypsum stucco plaster centuries ago and are still intact, which is proof of the durability & performance of this product [6]

When a wall is constructed with brick or block, they are finished with a coat of plaster which is called internal plastering. Internal plastering has traditionally been done through a process of sand-cement plastering finished with POP punning. This is a two stage process and involves multiple elements like sand, cement and water which is mixed onsite. This form of plastering is being slowly replaced by a direct single coat application of gypsum plaster. So gypsum plaster is actually a replacement of two processes i.e. and cement plastering & POP punning. Gypsum plaster is produced as a result of calcinations of the raw gypsum in an automatic kettle under controlled temperature. [6]

Technical Specification of Gypsum Plaster	
Parameters	Values
Dry Bulk Density	650 - 710 Kg / m ³

1 day Compressive Strength @ 50 % Water without Vibration using 50 KN CTM	2.5 - 3.5 N/mm ²
Initial Setting Time	12 - 15 minutes
Sulphur Trioxide SO ₃ %	35 - 40 minimum
Consistency	38%
Residue of 150 micron Size	Max 2%
Expansion of setting @ 24 Hrs	0.50%
Transverse Strength	22 Kg/cm ²
Whiteness (Using Diffused Relicution Meter)	60 - 70

Table 6: Technical Specification

Comparison B/W Gypsum Plaster And Conventional Plaster		
Parameters	Gypsum Plaster	Conventional Plaster
Quality	Quality Consistency	Not Possible
Shrinkage Cracks	Negligible Shrinkage Cracks	Significantly high Shrinkage Cracks
Wastage	No Wastage	High wastage
Thickness	Lower Thickness Required	Higher Thickness Required
Coverage	Higher Coverage	Lower Coverage
Edges	Sharp edges Possible	Not Possible
Surface	Flat Surface & Attractive Workability	Not Possible
Water Curing	Not Require	Required
Thermal Insulation	High	Lower
Compressive Strength	> 4N/mm ²	> 4N/mm ²

Table 7: Comparison

Cost Comparison B/W Gypsum Plaster & Conventional Plaster			
Sr. No.	Description	Inside Plaster on site	Alternate Inside Plaster
1	Material	Cement Sand Mortar 15 mm Thick	Gypsum Plaster 15mm thick
2	Total Qty. (SQ.M)	6400.14	6400.14
3	Material Cost (Rs.)	2,50,769.96	748537.67
4	Labor Cost (Rs.)	6,88,654.66	76,801.63
5	Total Cost (Rs.)	9,39,424.62	8,25,339.3
6	Saving (Rs.)	1,14,085.32(88%)	

Table 8: Cost Comparison

4) Fourth Replacement:

Couplers are an effective and an economic replacement of lap splice. Thus by this saving a huge amount of money in a single joint and it is also the simplest type of coupler used in the reinforcement to connect two bars in field quickly and easily. Hence mechanical splices such as threaded couplers can be very effective since they ease the design parameters,

easy in installation and also reduce the amount of reinforcement required and thus by ensuring maximum cost saving. There is also other type of Splices system which are the future scope. One can also use other type of coupler. But in my case study there is less number of lap joints so cost benefit is in limited amount. The more number of Lap joints are available, the huge amount of cost saving by using mechanical rebar coupler.

Technical Specification				
Size(mm)	External Diameter (mm)	Internal Diameter (mm)	Length (mm)	Weight (Kgs.)
16	25	13.5	40	0.145
20	32	17.5	48	0.292
25	40	22	60	0.42
32	50	29	72	0.81
40	60	37	90	1.25

Table 9: Technical Specification

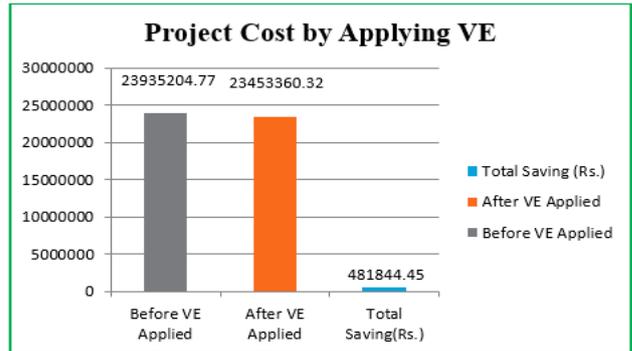
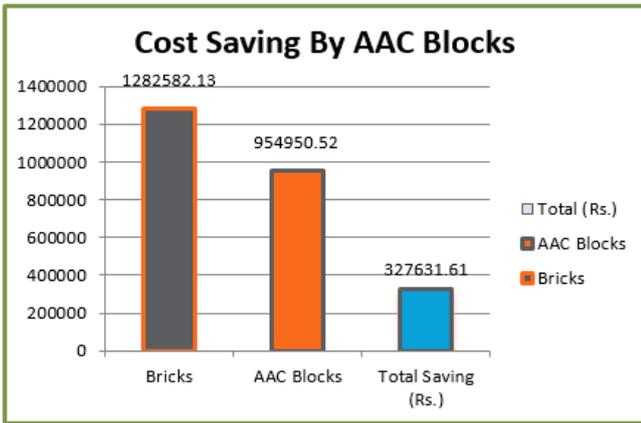
Sr. No.	Specification	Material Used On Site
1	Material	Overlapping of steel
2	Qty. of steel in (Kg)	2209.82
3	Total Used Binding wire For Lap Length (Kg)	20
4	Cost of Steel (Rs. /Kg)	40
5	Total Labor Cost (Rs. /Kg)	4
6	Total Cost (Rs.)	98112.08

Table 10: Cost of Lap Splices

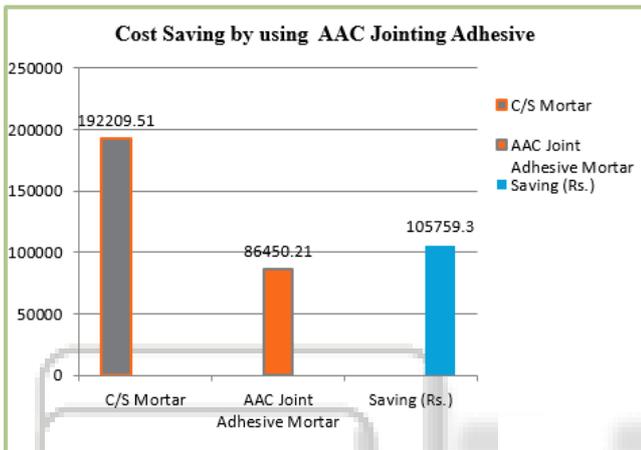
Sr. No.	Specification	Change Material
1	Material	Rebar Coupler
2	Qty. of Coupler in (Nos.)	1380
3	Cost of Couple 16 mm Dia. (Rs. /No.)	30
4	Total Labor Cost (Rs./Kg)	12
5	Total Cost (Rs.)	57960.00

Table 11: Cost of Mechanical Rebar Coupler

Recommendation Phase: After considering the result of above idea it has been found that the project function can be improved by changing the material which doesn't affect the primary function of the building. For the big project Value Engineering can make benefits to improve other functions in terms of Cost, Quality and Time. Owner should use this advanced construction material. All materials are locally available in the market. These materials are more beneficial for the future and give a huge cost benefits to the project. So I recommend to the owner that in the future of new project they should appoint a VE Professionals that can give more beneficial.

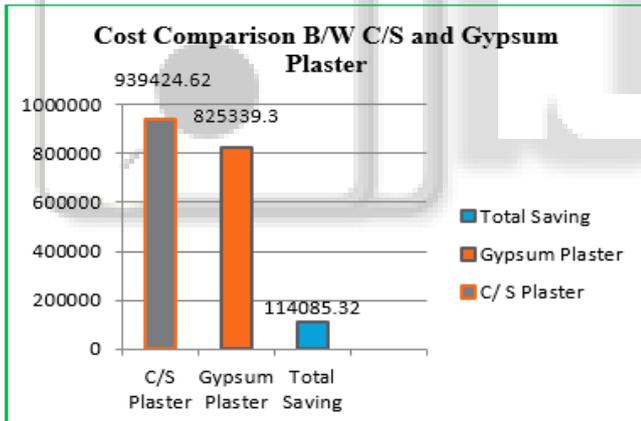


Implementation Phase: Recommendations are given by me which are yet to be implemented hence implement & audit phase does not exist for my case study.



V. CONCLUSION

Value Engineering is a kind of quantitative method creating project value, and it is the example of the maximum value of the whole system or product through the perfect matching of value and function. VE may be applied more than once during the life of the project. In this case study above we can see how the cost of a function is minimized by applying Value Engineering Methodology. In future, one can change the material for Masonry, Plaster and steel work by using alternate material. As a Conclusion, the area of value engineering analysis and study will be controlled by the six phase. More we can do investigation of these functions and suggest changes and calculate cost model after application of value engineering technique.



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