# Cost Benefit Analysis of Value Engineering In Construction

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***Abstract-*** *Infrastructure development in construction industry is a key driver in socio-economic development of the country. As construction industry plays a vital role in economic growth and development of the country. Globally, the predicted growth in construction industry is 70% more by 2025. It is in need to have proper construction techniques which are value effective.*

*Value engineering is a systematic application of recognized techniques which identify the functions of the product or service, establish the worth of those functions and the necessary functions to meet the required performance at the lowest overall cost. Value engineering concentrates on the effectiveness through stating functions, goals, needs, requirements and desires. Value engineering concept was started by Mr. Lawrence D. Miles during 1940's. He worked for General electric company (GEC), USA, which faced scarcity of strategic material needed to produce their products during world war-II. Indian value engineering society (INVEST) is a professional society established in October, 1977 and dedicated to the advancement of value engineering through education. INVEST is affiliated to the Society of American value engineers (SAVE).*

*Three basic strategies are employed to reduce the costs on capital projects- value engineering, alternatives and scope reduction. This provides a better understanding of the principles, methods and concepts of value technology. Value engineering is typically able to reduce the cost of a project by 5% to 10%, beyond which more aggressive methods must be used. Alternatives are portions of the work that can be deferred until later in the project when more is known about how much of the project contingency bidding can be applied to the desired work. They might also be areas of planned programmatic growth that will not be needed when the building is finished and can be 'shelled' for a future project. Alternatives are best applied at later stages of design. Because, history has shown that many alternatives at this stage cannot be afforded later in the project. Thus, they become de facto scope reductions. There is often a tendency on projects to try to gain more scope within budget, this is known as "scope creep" and so it is important to verify the design against the original program plan on which the budget was based, thus it is important that project team work diligently to contain project costs*

*Value engineering attempts to eliminate, without impairing essential functions or characteristics, anything that increases acquisition costs, operation or support costs. Value engineering is not just a term of art in the construction industry. It actually got its start in manufacturing and is proof of the saying that, necessity is the mother of invention in this 'current state' of the world.*

***Keywords***- value technology, INVEST, SAVE, capital project, scope creep, cost effectiveness

## I. INTRODUCTION

### 1.1 General

Infrastructure development in construction industry is a key driver in socio economic development of the country. As construction industry plays a vital role in economic growth and development of the country, it is in need to have proper construction techniques which are cost effective. Various cost reduction technique are as follows- Thinner walls or single brick thick walls, Load bearing brick work, Brick on edge cavity wall, Precast stone masonry blocks, Modular brick masonry walls, hollow clay blocks of shell type houses, Sundried brick walls with waterproof treatment, precast hyperbolic shell for roofing. These techniques come under 'value engineering.'

### 1.2 Value engineering

Value engineering is a systematic application of recognized techniques which identify the functions of the product or service, establish the worth of those functions, and provide the necessary functions to meet the required performance at the lowest overall cost. Value engineering concentrates on the effectiveness through stating functions, goals, needs, requirements and desires.
Value (V) = Function (F)/Cost (C).

Where, V is Value, F is sum of total function performance and C represents cost paid for it. The relation of F and C shows that lower the cost for optimum function, better the value.

**1.3 Stages applied in VE**

1. The job plan: Value engineering is often done by systematically following a multi-stage job plan. Larry Miles original system was a six-step procedure which he called the "value analysis job plan." Others have varied the job plan to fit their constraints. Depending on the application, there may be four, five, six, or more stages. One modern version has the following eight steps

    1. Preparation
    2. Information
    3. Analysis
    4. Creation
    5. Evaluation
    6. Development
    7. Presentation
    8. Follow-up

Four basic steps in the job plan are:

1. Information gathering - This asks what the requirements are for the object. Function analysis, an important technique in value engineering, is usually done in this initial stage. It tries to determine what functions or performance characteristics are important. It asks questions like: What does the object do? What must it do? What should it do? What could it do? What must it not do?
2. Alternative generation (creation) - In this stage value engineers ask: What are the various alternative ways of meeting requirements? What else will perform the desired function?
3. Evaluation - In this stage all the alternatives are assessed by evaluating how well they meet the required functions and how great the cost savings will be.
4. Presentation - In the final stage, the best alternative will be chosen and presented to the client for final decision.

The value methodology is a systematic process and is applied by a multi-disciplinary team to improve the value of a project through the analysis of functions. The team leader should complete Value Engineering study and should have additional Value Engineering experience as a team member of VE Project.

**Aim of study**

- To perform value engineering for residential and commercial building for better project tracking and cost efficiency

**Objective of study**

- To study value engineering and its implementation in construction industry.
- To identify cases for cost overrun and its reduction in all construction activities.
- To compare projects cost and schedule after application of value engineering

To check cost performance index and schedule performance index for value engineering

**2.1 VALUE ENGINEERING?**

Value engineering is a systematic application of recognized techniques which identify the functions of the product or service, establish the worth of those functions, and provide the necessary functions to meet the required performance at the lowest overall cost. Value engineering concentrates on the effectiveness through stating functions, goals, needs, requirements and desires.
Value (V) = Function (F)/Cost (C)
Where, V is Value, F is sum of total function performance and C represents cost paid for it. The relation of F and C shows that lower the cost for optimum function, better the value.

**2.2 HISTORY OF VE**

Value engineering concept was started by Mr. Lawrence D. Miles during 1940's. He worked for General Electric Company (GEC), USA which faced scarcity of strategic material needed to produce their products during world war-II. Mr. Mile was appointed in GEC in purchasing department. At that time there was shortage of steel, copper, bronze and other materials. GEC wanted to expand its production of turbo supercharger for B24 bombers from 50 to 1000 per week. Miles was assigned the task of purchasing material to permit this. Often he was unable to obtain specific material, so he thought to obtain an alternative which can

perform the same function. Miles observed that many of substitutes were providing equal and better performance at the lowest cost and from this incident evolved the concept of value engineering.

### 2.3 WHERE TO FIND MORE ABOUT VALUE ENGINEERING?

The best and most convenient way to learn the technique of Value Engineering and its application, is by becoming a member of Indian Value Engineering Society (INVEST).

INVEST is a professional society established in October, 1977 and dedicated to the advancement of Value Engineering through education. This provides a better understanding of the principles, methods and concepts of value technology. INVEST has members in virtually every state in India. It maintains a network of chapters throughout the country and provides its members with additional educational opportunities at the local level.

INVEST is affiliated to the Society of American value Engineers (SAVE).

## II. METHODOLOGY

### 3. METHODOLOGY

Construction projects are implemented in different countries with heavy costs and some of the projects have been relatively or absolutely unsuccessful and even faced with irreversible losses after construction. Maybe, it is due to complexities related to projects or other social-economic phenomenon. The present study revealed that value engineering can be used as a helpful tool from the beginning of studies to the end of designing, constructing, exploiting, and maintaining processes and overcome civil designs' challenges and complexities. Value engineering is a method experienced in management that has an organized approach. Value engineering has a systematic and cooperative mechanism to analyse function and systems with the aim of achieving desirable function with the least costs. This study has attempted to briefly introduce concepts and executive process of value engineering in construction projects. Also, the study has attempted to investigate conventional methods of evaluating projects function and compare them convergence with value engineering to improve projects. Based on the research findings, it can be found that if we can expect to achieve projects objectives by spending the least cost and ensure the efficacy of investment in construction projects management sector as a main challenge of development plans in the third world countries through using engineering in appropriate time periods and in different phases.

The value methodology is a systematic process which is applied by a multidisciplinary team to improve the value of a project through the analysis of functions. We are using some alternative parameter in our case study instead of traditional one in our case study. Now-a-days we saw some (2 or 3) of these parameters were implementing in construction industry but we are going to implement these all parameters in one building. So that we would know how these going to be beneficial to construction industry.

We are using some alternatives in our case study, they are as follows:

**1 Partition wall**

Almost all exterior walls are load-bearing, meaning they bear the weight of the structure above and transfer it through lower walls to the ground. Interior walls consist of both load-bearing walls and walls that don't bear weight, called partition walls. You can build a partition wall almost anywhere.

We are using CLC bricks instead of burnt clay bricks with less thickness as compared to burnt clay bricks. Generally normal thickness provided in building is 6", we are providing 4" wall thickness in our plan. It will reduce cost of concrete, bricks and even cost of labours. Load on beam and column will be reduced, thus size of beam and column will also be reduced. And hence, we get more space for carpet area. Proper grouping is provided by partition wall.

**2 Increasing depth of beam**

We are increasing beam size so that we can going to remove the lintel and increase the size of beam up to lintel. As beam size increases, amount of steel requires decreases because, area of steel is inversely proportional to depth of beam; so when depth increases, area of steel is decreases thus, overall cost of construction decreases. When size of beam increased, avoid providing lintel, that will reduce use of steel required in lintel and cost of steel is reduced of overall construction.

Figure 1: Increasing Size of Beam

**3 Cavity wall**

We are using hollow CLC bricks for cavity wall. It will reducing the overall load of structure. It will be more beneficial because it gives better insulation resistance. Leakage can occur through the outer leaf through joints between bricks and mortar. It avoids moisture passing through the wall.

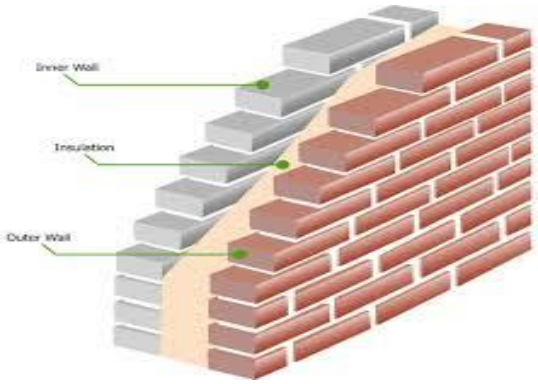


Figure 2: Cavity wall

**4 Eco-friendly paint**

We are using eco-friendly paint on external wall. Cost of plastering is reduced, as no plaster is applied on external wall. As the cost of paint is high but it increases the life span of external wall and overall structure. It will also resist the atmosphere effects. This paint increases the life span of external walls by 10 years more than normal paints of external wall and cracks will be automatically healed.

**5 CLC bricks**

Use of CLC (Siporex) bricks, will increase the total cost of construction but, it decreases total dead load, as they are lighter in weight. At the time of earthquake, total load of the structure on the foundation, will be less thus, the intensity of earthquake would act to a lesser extent. Time required to construct any structure is less i.e., construction is easy & construction cost n labour cost also less.


Figure 3: Siporex brick

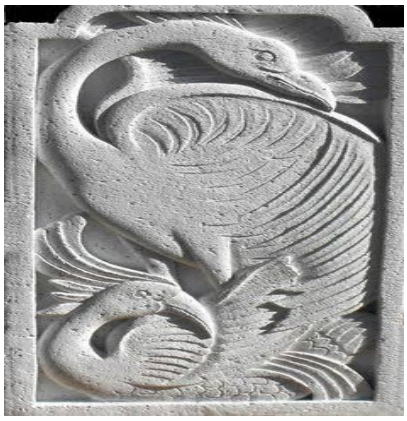

Figure 4: Carvings on siporex bricks

6 Large size windows: -We are increasing the size of windows i.e. providing large size windows. It will create elegant view. And it will also reduce cost of brickwork, cement, n labour work.

## III SCOPE OF VALUE ENGINEERING

**4.1 WHAT IS REQUIRED?**

If the cost estimate is over budget, the project is required to go through a cost reduction phase that brings the project back in line with the approved budget.

**4.2 WHO TO SEE**

The entire design team and project management team must be involved in balancing the cost and budget so that good decisions are made for the benefit of the entire project. This meeting(s) will be organized by the Project Manager.

**4.3 WHAT WILL HAPPEN?**

Three basic strategies are employed to reduce the costs on capital projects – value engineering, alternatives and scope reduction.

**4.4 VALUE ENGINEERING**

VE is the process of finding systems or methods of achieving the same programmatic goals using a different system that do not materially affect the desired outcome.

Some examples might be

- Looking at the cost differences between steel and concrete structural systems.
- Using different mechanical equipment with similar characteristics.
- Reducing the lighting levels due to day-lighting; combining office functions into one space.
- Changing the building shape to improve the exterior wall to floor area ration.
- Reducing finish allowances.

Value engineering is typically able to reduce the cost of a project by 5% to 10% beyond which more aggressive methods must be used Alternatives are portions of the work that can be deferred until later in the project when more is known about how much of the project contingency bidding can be applied to the desired work. Alternatives are often items that may have another source of funds such as Deferred Maintenance monies, which might be done separately. They might also be areas of planned programmatic growth that will not be needed when the building is finished and can be "shelled" for a future project. Alternatives are best applied at later stages of design because history has shown that many alternatives at this stage cannot be afforded later in the project, thus they become de facto scope reductions.

Scope Reductions are perhaps the most difficult aspect of any project because they are usually permanent reductions in quantity or quality of program space.

Scope reductions at this point might include

- Reducing the number or size of rooms
- Eliminating special features that would enhance a program
- Reducing the volume of space
- Eliminating special mechanical systems or features
- Reducing the site area impacts.

There is often a tendency on projects to try to gain more scope within the budget. This is known as "scope creep" and so it is important to verify the design against the original program plan on which the budget was based. The first round of scope reductions tend to be areas where the design exceeds the original program plan before moving into other reduction areas. Ultimately, most projects are able to achieve a balanced budget. If that is not the case, additional funds might be diverted out of project contingency or it may be necessary to raise the total project budget through a program plan amendment. This requires documentation and submission back through the Approval Phase causing a delay of four to six months, thus it is important that project team work diligently to contain project costs. Anyone concerned with the cost of a construction project has heard of value engineering. Does the original vision of a palatial structure threaten to exceed the budget? The answer is often, "Let's value engineer that "Sometimes, value engineering looks like the solution to every budget problem, the magic wand that makes costs shrink and budgets balance. But what is it really? Is value engineering just a marketer's spin on cost cutting, a way to make settling for less palatable? If so, the term is being misused. As the federal government defines it, "Value engineering attempts to eliminate, without impairing essential functions or characteristics, anything that increases acquisition, operation or support costs." So reducing the size of a building by 10 percent or eliminating a media centre would cut costs - but it would not be value engineering.

The Federal Highway Administration, long a proponent of value engineering, calls it "an organized application of common sense and technical knowledge directed at finding and eliminating unnecessary costs in a project". Value engineering is not just a term of art in the construction industry. It actually got its start in manufacturing and is proof of the saying that necessity is the mother of invention. During World War II, General Electric was trying to do more with less – less raw material, less skilled labour and fewer component parts. Two GE engineers, Lawrence Miles and Harry Erlicher, were given the task of finding acceptable substitutes. They were so successful that they noticed a surprising result: Often the re-engineered product was better than the one originally planned or was at least equally good at a lower cost to produce. Couldn't the technique used to solve GE's immediate problems be applied to any manufacturing challenge, with beneficial results? Miles and Erlicher thought so, and they set about describing what they were doing as a systematic process. They called it value analysis. The idea spread, and as others began to use it, they changed the name to

emphasize the context, not the analysis of a belief system, but engineering for improved value, or value engineering.

**4.6. BENEFITS OF VE**

Value engineering is used

- To determine best design alternative
- To reduce cost
- To identify problems and develop solutions for them
- To improve quality
- To increase reliability, availability and customer
- To save time
- To increase safety

**4.7 Value Engineering helps your organization in**

- Lowering Operation& Maintenance costs
- Improving quality management
- Improving resource efficiency
- Simplifying procedures
- Minimizing paperwork
- Lowering staff costs
- Increasing procedural efficiency
- Optimizing construction expenditures
- Developing value attitudes in staff
- Competing more successfully in marketplace

**4.8 ADVANTAGES AND DIS ADVANTAGES OF VE**

**ADVANTAGES OF VALUE ENGINEERING**

Value engineering is characterized by a branch of knowl¬edge and practical methods to solve problems for other quality improvement in the following

1. Job analysis distinctive way (function analysis).
2. Get appointed a large amount of good ideas that are applicable.
3. The action plan in place which consists of several sequential stages of a logical sequence.
4. Multi-disciplinary team working in the studies of col¬lective values.
5. Ensure coordination between the relevant authorities in the project.

**9.2 DISADVANTAGES OF VALUE ENGINEERING**

When using the external team may note some defects that can be summarized as follows:

1. The design team hard to accept the new team.
2. The design team for the absorber design and has experience in both advantages and disadvantages, which could take the time outside of the team for consider¬ation.
3. In some cases, the team may try to cash outside the current design to show his proficiency and his ability to accomplish the design better.
4. Use an external team better.

## I. DETAILS OF SOFTWARE

Taking lead from the literature review the present study aims at evaluating Earned Value Analysis function of three software namely Microsoft Project 07, Primavera6 and Develop Software. The following sections explain the software in brief.

**5.1 M.S. Project (MSP)**

Microsoft Project (or MSP or WinProj) is a project management software program which is designed to assist project managers in developing plans, assigning resources to tasks, tracking progress, managing budgets and analyzing workloads. The application creates critical path schedules, and critical chain and event chain methodology with third-party add-ons. Cost Variance and Schedule Variance are visualized in a Report.

Microsoft Project is a project management software product, developed and sold by Microsoft. It is designed to

assist a project manager in developing a plan, assigning resources to tasks, tracking progress, managing the budget, and analyzing workloads.

Microsoft Project was the company's third Microsoft Windows-based application, and within a couple of years of its introduction it became the dominant PC-based project management software.

It is part of the Microsoft Office family but has never been included in any of the Office suites. It is available currently in two editions, Standard and Professional. Microsoft Project's proprietary file format is mpp.

Microsoft Project and Microsoft Project Server are the cornerstones of the Microsoft Office enterprise project management (EPM) product.

### 5.2 STAGES FOR APPLICATION OF VALUE ENGINEERING

Value engineering can be applied during any stage of a project cycle. VE may be applied more than once during life cycle of construction project. Early application of VE helps in more organized implementation of project activities, thus reducing overall cost by avoiding any major changes right in the beginning. If the application of VE is done in later stages it may result in higher project cost.

VE is applied in an organized process known as VE job plan. The purpose of job plan is to assist a study team to identify and focus on key project functions in a systematic manner, in order to create new ideas that will result in value enhancements. The VE job plan consists of five phases as below

#### (a) Information Phase

In this phase maximum information is collected from various aspects of project regarding identification of problems to be solved and gathering of information on background, function and requirements of the project. At the beginning of VE study it is important to:

- Understand the background and decisions that have influenced the development of design.
- Define owner’s objective and criteria governing the project.
- To analyse issues of project
- To discuss project cost and schedule data
- To prepare cost and energy models

VE team recognizes low quality area and high cost area and sets target quality improvement and cost savings.

#### (b) Creative Phase

This phase involves generation of ideas and listing of those creative ideas from review of project. VE team thinks in creative way to provide necessary functions within the project. Large number of ideas are obtained through creative proposals and brainstorming. In team everyone is encouraged to participate. Evaluation of ideas is prohibited in this phase. The VE team is looking for quantity and grouping of ideas, which will be screened in the next phase.

#### (c) Evaluation Phase

In this phase of project, VE team together with client defines the criteria for evaluation. It involves:

- Analysis of ideas resulting from creative phase.
- Ranking of ideas by VE team.
- Irrelevant or non-worthy ideas are discarded.
- Selection of ideas which represents greatest potential for cost saving and improvements.

A weighted evaluation is applied in some of the cases to account for impacts other than cost such as quality, safety, reliability, time, constructability, aesthetics, serviceability, durability, maintainability, etc.

#### (d) Development Phase

During this phase many of ideas are expanded into workable solutions. It consists of:

- Preparation of alternative designs and life cycle cost comparison of original and proposed designs.
- Description of recommended design change.
- Each recommendation is presented with description, sketches, basic design concepts, technical information and cost summaries.

- Selected ideas are developed into proposals so that owner and other project stakeholders understand the intent of proposal and benefits to the project.

**(e) Presentation Phase**

In this phase presentation of recommendation is prepared in the form of a report. The team for presentation consists of client, consultants and other stakeholder representatives. The VE team members describe the recommendations and basis that went during development phase. VE report is shared with client and designers. This begins the evaluation by the client and designer of the VE report. After incorporating client's comments a preliminary proposal implementation action plan is prepared

## V. CASE STUDIES

### 5 CASE STUDY

Fig 1: 3rd eye view of actual site


Google map location

**SITE DETAILS**

- Site name :Amar landmark
- Address: Near green park hotel prashan.
- Name of Builder: Amar Builder
- Name Contractor: SJ construction.
- Architecture: MOCO design
- Structural consultant: J+ W
- Total Area:2.8 acres
- Built-up Area:15570sq ft
- Type of building: Residential

## VI. ANALYSIS AND COMPARATIVE STUDY

### 9 .1 CLC bricks and partition walls

| PARAMETERS | Burnt Clay Brick | CLC Bricks |
|---|---|---|
| Basic raw material | Agriculture soil, core or wood for firing | Cement, Sand and Fly ash |
| Production Process and set up | Process in normal bricks kilns | Can be produce at project site or specially design plant with foam concrete station. |
| Technological tie up | None | SreesBrickolite-India |
| Dry density | 1800-2000kg/m3 | 450-600,800-1000kg/m3 |
| Compressive Strength | 30-40kg/cm2 | 4-10,24-35kg/cm2 |
| Applications | Load bearing and non-load bearing | Thermal insulation high rise and low rise, load and non-load bearing. |
| Cost of Place | Not feasible | Any shape, any size, any density. |
| Compaction during production | Yes | None |
| Aging | No | Gauge strength with age |
| Weight | 20kN/m3 | 8kN/m3 |
| Thermal Conductivity | 0.7 | 0.16 for 500kg/m3 |
| Sound insulation | Normal | Superior |

| | | |
|---|---|---|
| **Ease working** | **Normal** | **Can be cut sawn, Nailed, Drilled.** |
| **Eco-friendliness** | **Waste Agricultural Land** | **Pollution free, Green product , Can Consume Fly Ash** |
| **Water Absorption Capacity** | **Brunt Clay Bricks absorbs more water than CLC blocks** | **CLC is light weight block where water absorption is less as compared to red brick.** |

**9.1 TILES TYPES AND COST**

| **SR NO** | **BRICK TYPE** | **SIZE (INCH)** | **RATE/ PCS** |
|---|---|---|---|
| 1 | CLAY BRICKS | 9X4X6 | 4.3 |
| 2 | FLY ASH BRICKS | 225X100X75(MM) | 5.25 |
| 3 | CONCRETE HOLLOW BRICKS | 230X110X112.5 | 6 |
| 4 | RED CLAY BRICKS | 9X4X3 | 5 |
| 5 | WIRE CUT BRICKS | 9X4X3 | 7 |
| 6 | STONE RED BRICKS | 190X90X90 (MM) | 5 |

**Window sizes and cost**

- A basic PVC Window with a simple profile will cost anywhere from Rs 500 per Sq.ft and could go all the way up to RS 2000 per sq.ft.

| **Component** | **Price Range** |
|---|---|
| PVC Profiles (major component that accounts for 20%-30% of overall Price) | Rs 100 per sqft to Rs 250 per sqft |
| The Reinforcement for a PVC window | Rs. 30 per sq.ft to 50 per sq.ft |
| Glass (another major component) | Rs 50 per sq.ft to Rs 300 per sq.ft |
| Hardware | Rs 30 per sq.ft to Rs 300 per sq.ft |
| Other Accessories | _ |
| Sealant & PU Foam | _ |
| Fly Screen (Addition) | Rs. 300 per sq.ft to Rs. 500 per sq.ft. |

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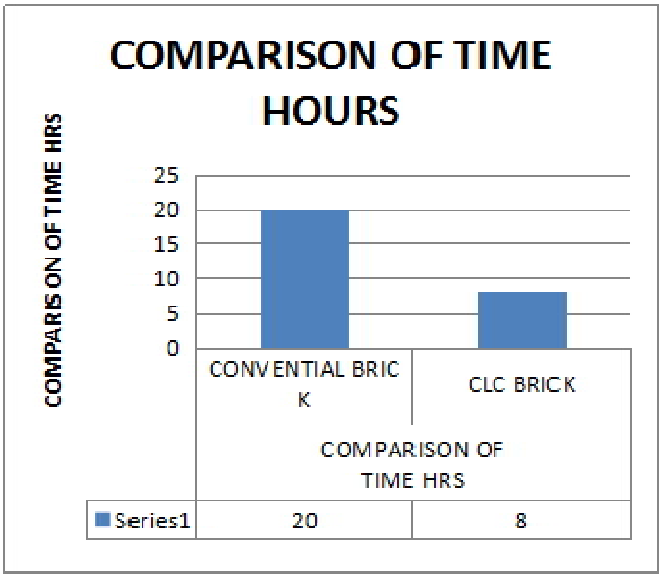
**RATE ANALYSIS OF CASE STUDY**

| Sl. No. | Description | Unit | Convention al formwork |
|---|---|---|---|
| 1 | Material cost | Sq. mtr | 500 |
| 2 | Labour cost | Sq. ft | 110 |
| 3 | Number of repetitions | | 15-20 times |
| 4 | Minimum duration of slab cycle | | 21 days |
| 5 | Total cost per slab (Material + Labors) | | =Total Area per slab* Labour cost * Material cost=966.67*10.1*500=4881683.5 |
| 6. | No. of days per tower | | 1065 |




Graph No.1

## VI.CONCLUSION

It was discussed that using value engineering methods by multidisciplinary team, value and economy are improved through study of alternative design concepts, material and construction methods without compromising functional requirement and quality. A second look at the design produced by architect and engineers gives the assurance that all reasonable alternatives have been explored. From study it is seen that different parameters of value engineering alternatives helps to find best solution. Thus, value engineering assures best value will be obtained over life cycle of the building or structure.

Success of a project, deciding on where and how a project will be built, completion of the structure according to desired design and building quality, within determined time and cost limits, are all possible with good estimations and solution. Carrying out correct estimations is closely based on the knowledge level of the team. Value engineer assumes regulating and analysing duties to increase the value of the project while preventing unnecessary costs. It is not possible to apply VE on each project a company produces. Much more successful value engineering studies can be carried out on complex and big projects which have high potential of restoring the investment.

### CLC BRICKS

- we can replace clc bricks with conventional for following reasons
  1. it reduces overall weight of building by 20% due to lower density
  2. its size is 40% higher than conventional bricks hence it increase the speed of masonry works

### Granite tiles

- we can replace regular tiles by granite
  1. it has more finishing and strength than regular tiles
  2. its rate is comparatively cheaper than regular size
  3. its size is larger than verified tiles hence increase in speed of masonry work.

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