Dissertation on

APPLICATION OF VALUE ENGINEERING IN RESIDENTIAL BUILDING CONSIDERING SUSTAINABILITY ASPECT

Submitted for partial fulfillment of the requirement for the award of degree

MASTER OF TECHNOLOGY

In

Construction Technology and Management

By

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DECLARATION

I declare that the dissertation entitled **“APPLICATION OF VALUE ENGINEERING IN RESIDENTIAL BUILDING CONSIDERING SUSTAINABILITY ASPECT "** is the bonfire research work carried out by me, under the guidance of **Mr. Faraz Hasan Qadri Assistant Professor, Department of Civil Engineering, Integral University, Lucknow**. Further I declare that this has not previously formed the basis of award of any degree, diploma, associate-ship or other similar degrees or diplomas, and has not been submitted anywhere else.

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CERTIFICATE

It is Certified that the dissertation entitled **"APPLICATION OF VALUE ENGINEERING IN RESIDENTIAL BUILDING CONSIDERING SUSTAINABILITY ASPECT"** *is being submitted by* ***Mariyam Khalid (Roll No. : 2101103004)*** *in partial fulfilment of the requirement for the award of degree of Master of Technology (Construction Technology And Management) of Integral University, Lucknow, is a record of candidate's own work carried out by her under my supervision and guidance.*

The results presented in this thesis have not been submitted to any other university or institute for the award of any other degree or diploma.

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ABSTRACT

To increase the value of a project and minimizing its environmental impact, this study combines value engineering and environmental sustainability aspect together. Environmental sustainability is balancing the ecology and using the natural resources responsibly to conserve it for future generations. Value engineering is a methodical strategy to enhance the value of a project or its component by either enhancing its functionality and quality while keeping cost more or less same or by reducing the cost without compromising its functionality and quality. The traditional construction process, materials, and methods are the primary factor driving up project costs. Rapid advancement in construction materials and processes opened a window to reassess contemporary materials and processes used in the construction industry and replace it with most recent one to achieve the above objectives. In this paper various project items and process has been thoroughly analyzed based on their functionality. To full fill its functions other alternatives have been identified and compared. Our primary goal in making alternative suggestions is to reduce the project's life cycle cost, embodied carbon, environmental effect etc.

CHAPTER-1

BACKGROUND OF STUDY

1.1 INTRODUCTION

Value Analysis and Value Management are comparable to the concept of Value Engineering. Value Engineering was established by General Electric Co. during World War II in the 1940s. At the time, there was a shortage of skilled personnel, raw materials, and component components. Lawrence Miles, Harry Erlicher, Jerry Leftow, and other engineers at General Electric Co. looked into possible alternatives to lower production costs while enhancing product functionality, or both. It got off to an unusual start but developed into a methodical strategy. They referred to their method as "Value Analysis."

Any item, service, or good has a value based on how much money it is worth. By enhancing/increasing a product's function or removing extraneous costs without sacrificing the product's quality, value engineering is a systematic, organised, and function-based strategy used to increase the value of products, processes, or projects at the lowest possible cost.

Sustainability is the balance of environmental, social & economic issues to ensure a viable and valuable industry for future generation. In 2015 India including 193 countries committed to the Sustainability Development Goals (SDG). By 2030, Enhance safe, affordable and sustainable transport for all, reduce the adverse per capita environmental impact of cities, green public spaces for women, children, old people and disable

In this project we apply value engineering concept and technique on residential building project to reduce its life-cycle cost and improving its function by choosing alternative material, design, methodology and processes and also considering sustainability aspects in the project. In this project we use questionnaire and Function Analysis System Technique (FAST) to analyze data and use innovative ideas to reduce the cost of residential building project and improve its function with considering sustainability aspects.

To increase the value of a project and minimizing its environmental impact, this study combines value engineering and environmental sustainability aspect together. Environmental sustainability is balancing the ecology and using the natural resources responsibly to conserve it for future generations. Value engineering is a methodical strategy to enhance the value of a project or its component by either enhancing its functionality and quality while keeping cost more or less same or by reducing the cost without compromising its functionality and quality. The traditional construction process, materials, and methods are the primary factor driving up project costs. Rapid advancement in construction materials and processes opened a window to reassess contemporary materials and processes used in the construction industry and replace it with most recent one to achieve the above objectives. In this paper various project items and process has been thoroughly analyzed based on their functionality. To full fill its functions other alternatives have been identified and compared. Our primary goal in making alternative suggestions is to reduce the project's life cycle cost, embodied carbon, environmental effect etc.

1.2 DIFFERENCE BETWEEN PRICE, COST, VALUE.

Figure 1.2

1.3 PROBLEM STATEMENT

Construction industry is continuously improving in terms of knowledge, techniques, technology & material. But people are not adapting it because the lack of information, decisions based on wrong beliefs, habitual thinking, negative attitudes, and hesitate to seek advice, shortage of time, changing technology, old specifications and poor human relations which somehow affects them in terms of cost/ life cycle cost, quality, environmental, energy, waste and time. The Value Engineering method help people to adapt new technology, reduce cost, improve quality, generate less waste, achieve sustainability & reduce life cycle cost.

1.4 OBJECTIVE OF STUDY

- To understand the process of application of value engineering in construction projects.
- To identify the basic function of different items/processes involved in ongoing construction project of Faculty Residential building for application of Value Engineering.
- Compare the items/process for their values considering various parameters.

To assess their benefits and recommend them for improving the value of the project.

CHAPTER-2

DEFINITION

2.1 VALUE – The amount of money that something is worth.

2.2 VALUE ENGINEERING – As discussed above, the Value Engineering is a well-organized methodology for enhancing value of projects, goods, services, and organizations. Value engineering, another name for VM, is used to examine and enhance services and operations provided by both the public and private sectors, as well as design and building projects. For conducting a successful value engineering research six consecutive steps or phases are usually adopted which are given below.

2.3 PHASES OF VALUE ENGINEERING –

Information Phase	• collect all information to fully understand the project.
Function Analysis Phase	• clearly identify the functions and goals of the project.
Creative Phase	• idea generation/brainstorming to best achieve the project.
Evaluation Phase	• evaluate all ideas to determine which offer the best value and outcome success for the project.
Development Phase	• review and determine the best alternatives, with a focus on how to improve the construction project value.
Presentation Phase	• the value decision is presented to all stakeholders and invested parties.
Close-Out/ Implementation Phase	• The value decision is implemented on the project.

Figure 2.3 Value engineering phases

2.4 VALUE ENGINEERING APPLICATIONS –

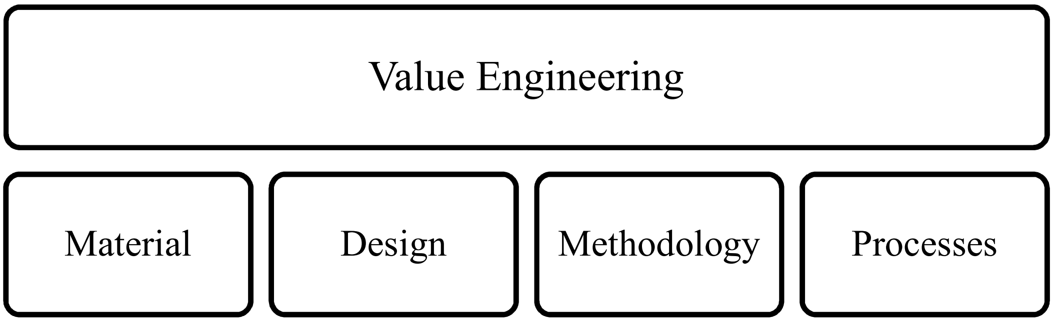

Figure 2.4 Value engineering applications

2.5 FUNCTION OF VALUE ENGINEERING –

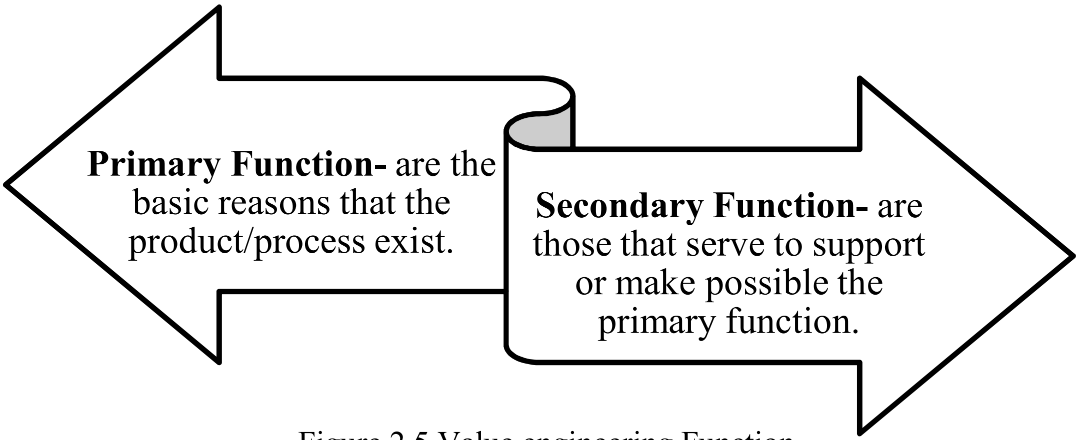

Figure 2.5 Value engineering Function

2.6 BENEFITS OF VALUE ENGINEERING –

a. Reduce Cost
b. Maintain High Quality
c. Opportunity To Use New Technology
d. Eliminates Waste
e. Encourage Innovative Ideas
f. Improve Brand Image
g. Improve Design

2.7 SUSTAINABILITY –

Is the balance of environmental, social & economic issues to ensure a viable and valuable industry for future generation.

Misconceptions – Only limited to environment or material

2.8 HOW SUSTAINABILITY ACHIEVED?

- Efficient use of energy & water
- Waste management
- Using recycled material
- Sustainability planning, design & management

2.9 WHAT SUSTAINABILITY IS?

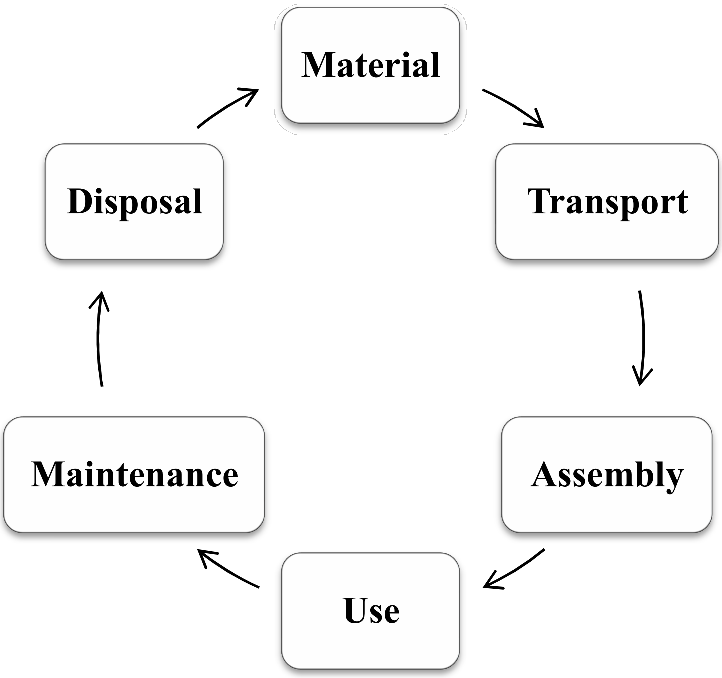

Figure 2.9 Sustainability

CHAPTER-3
LITERATURE REVIEW

- Mohamed Said Meselhy Elsaeed, Amira Hamdi Abdelhamed Gomaa (2022), Integration of value management and risk analysis in the construction project. The study aims to integrate value engineering and risk management simulate the best relations between the efficiency of functional performance, quality level and the building cost. The study methodology will integrate elements between value engineering and risk management, which is the restructuring of the management system of projects. The application of integrated risk and value methodologies makes the final cost of quality issues is more accurate results and analysis. It identifies the unnecessary cost elements and finds effective alternatives.

- Joseph Kwame Ofori-Kuragu (2021), An Exploration of the Potential for Using Modular Housing Solutions to Address the UK's Housing Shortage. This paper explores opportunities to use modular homes to address the UK's housing shortage. In this paper, a questionnaire-based survey was undertaken following a detailed review of relevant literature. The survey of industry professionals involved 70 structured questionnaires sent online. A lack of affordable new homes is identified in this paper as one of the most pressing issues within the sector. Again, a lack of investment in apprenticeships is identified to have led to skilled trades shortages in the industry. The survey reported in this paper found that modular homes would Enhance homes quicker and cheaper. Other benefits of modular housing are the use of eco-friendlier materials, waste reduction and reduced CO_2 emissions from construction processes and from reduced transportation. Reduced maintenance requirements also reduced life-cycle costs in modular homes however traditional housing was seen as having longer lifespans.

- Jerzy Rosłon, Mariola Ksiazek-Nowak and Paweł Nowak (2020), Schedules Optimization with the Use of Value Engineering and NPV Maximization. This paper presents the original concept of combining issues of construction project's utility and economic value optimization. The model enables the maximization of the utility value of the subject of the project, taking into account its economic parameters. To support the implementation of the model, a schedule optimization procedure was developed using metaheuristic algorithm. The model was demonstrated on the basis of a case study. The presented proprietary approach to optimize the construction schedule taking into account the economic and sustainability of a construction project can be used in “design and build” projects, with particular emphasis on projects managed in the sustainable Project Management system .

- Tariq Al Amri and Manuel Marey-Pérez (2020), Value Engineering as a Tool for Sustainability in the Construction Industry of Oman. The thriving construction industries continue to score poorly in terms of sustainability; thus, the necessity for sustainability measures arises. In this regard, this article proposes the incorporation of value engineering in the Omani construction sector to initiate sustainable measures for the industry. The article formulated some research questions elaborated using a systematic literature review to connect aspects of construction, sustainability, and quality.

- R. Janani, P. R. Kalyana Chakravarthy, Dr. R. Rathan Raj (2018), A study on value engineering & green building in residential construction. The literature deals about the value engineering in construction industry that is helpful to gain knowledge about the work study, value management, improvement techniques. This thesis based on qualitative and quantitative analysis, questionnaire, interview by the engineers, review of previous journals regarding value engineering. Hence these are the finding.
    - Value engineering methods and techniques
    - Implementation of value engineering in a green building
    - Important roles of value engineer and how to do effective value on cost
    - Recommendations and development in green building

- Pooja Gohil, Shaishav Patel (2018), Review of Value Engineering in Indian Construction Industry. This paper presents overview of Value Engineering and its different phases that can be implemented to a product/process for its optimization in construction industry. Because of poor value and time management, currently the construction business is facing huge cost problem. It’s known fact that a number of infrastructure projects in India are delayed because of various problems. To overcome these problems, study has been carried out by VE process to achieve the product/ process optimization.

- Douglas Aghimien, Ayodeji Oke, and Clinton Aigbavboa (2018), Achieving Sustainability in Construction through Value Management. The study assessed the ability of Value Management to deliver sustainability in construction using a mini case study of two private constructions wherein VM was adopted. The study revealed that although VM exercise carried out were done in a semi-formal manner, the outcome shows that the use of VM helps in achieving sustainability within the bottom line of economic, environmental and social sustainability. It is done through identifying and eliminating unnecessary areas that will affect the sustainability of the project. Also, new ideas that will help promote sustainability in the project can be harnessed from participants during the exercise. The study also revealed that the inability of professionals to work together and see problems from a common stand, and client's unwillingness to fund separate gathering for VM exercise are major factors affecting VM. The study, therefore, recommends VM as a beneficial and sustainable project exercise, and advocates for its adoption as an integral part of sustainable construction within the country.

- Deepak Dhounchak, Lalit Kumar Biban (2017), A review article on value engineering. Value engineering is a basic concept which is generally used in automobile sector to increase the overall production of company and eliminate all unnecessary process so that the profit of a plat can be maximized. Production and demand of the product is limited for all groups because there is lot of choices available in market for a customer that is way not only the production is increases today but the demand of goods is also increases. So the idea of reducing the total manufacturing cost of running part and also reducing the amount of their wastage such as parts scrap, issue of quality of parts and other reason of rejection of parts i.e. value analysis of parts is to be done so that a group produces the same parts is of cheaper cost from their competitors in market. Over the last decade the interest in standardization of products has been increased.

- Nayana Tom V. Gowrisankar (2015), Value Engineering In Residential House Construction. The value engineering study is carried out with analysis of basic functions of the project and based on that analysis unwanted elements in the project are scrutinized and eliminated. The function analysis is carried out with the help of FAST tool and the projects study deals with a step by step process. This thesis deals with implementing the value engineering concepts in a residential building project in order to reach out better quality with lower cost.

- K. Ilayaraja and MD. Zafar Eqyaabal (2015), Value Engineering in Construction. Value engineering is a methodology used to analyze the function of the goods and services and to obtain the required functions of the user at the lowest total cost without reducing the necessary quality of performance. Many a time, Value Engineering (VE) is confused with cost cutting exercises in construction industry. The essential difference between conventional cost cutting and VE is that it involves reducing the cost by improving the functionality through lesser consumption of energy in terms of manpower, materials and machines. In the initial stages VE was used by production engineers for reducing the cost of manufacture. However, it was found that the benefit of VE is much greater if multidisciplinary teams of engineers were involved which would also influence the design team that is normally the case in construction.

CHAPTER-4

METHODOLOGY

4.1 METHODOLOGY BASED ON VALUE ENGINEERING PHASES

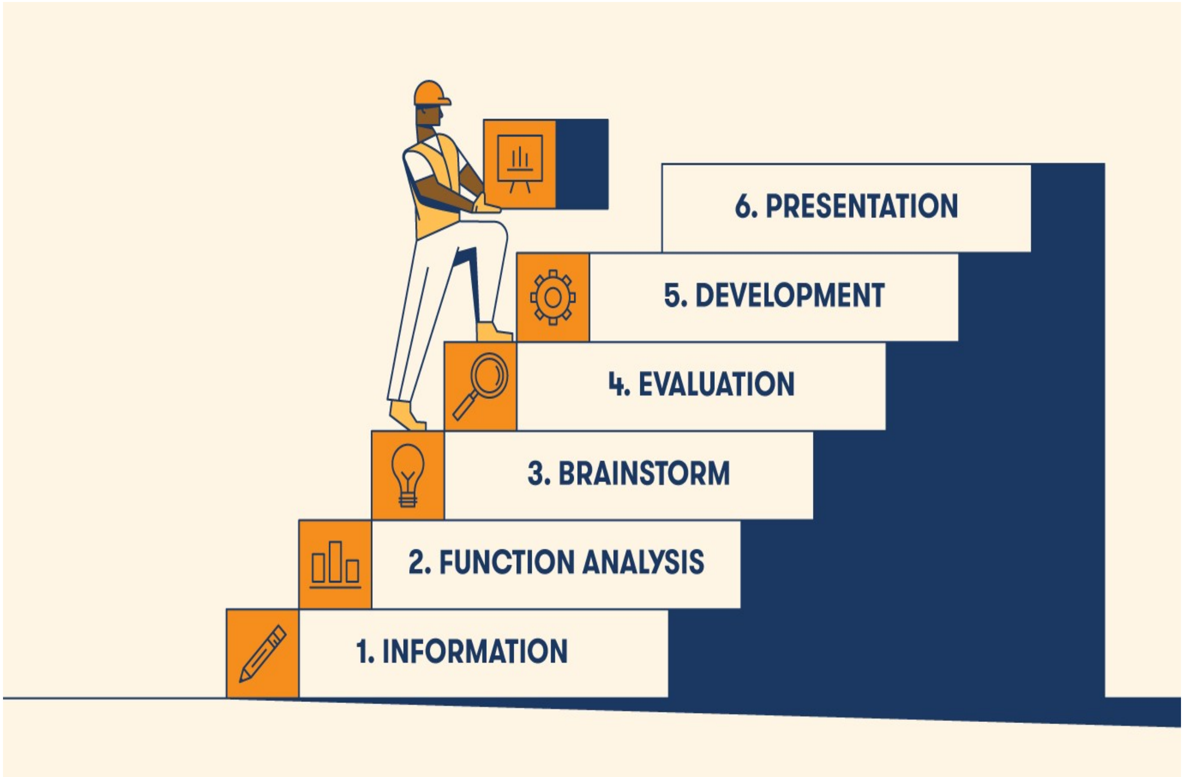

Figure 4.1 Methodology

4.2 INFORMATION PHASE

The first phase of VE comprises Information Phase. In order to get a better understanding of the issue and any potential solutions, a detailed study about the issue has been carried out in information phase. The relevant data related to the project such as information related to its location, architectural drawings, structural drawings, specification etc. has been collected. The level of effort and time committed to the Information Phase will depend on the project's complexity, the amount of information provided, and the available time. A VE study's success depends on obtaining reliable information that is pertinent to the project, goods, or service being studied. The primary goal of this stage is to make sure that everyone on the team is on the same page with regard to the project. This will help the team develop creative solutions more effectively and minimize mismatches in later phases.

4.3 FUNCTION ANALYSIS PHASE

In this phase, the actual functions of identified project, design, items or processes in which VE is to be applied, has been determined. Functions are two-word verb-noun sentences that specify the specifications of the project, goods or service under evaluation in function analysis, For example, one of the functions of exterior wall is to "Enhance Safety". The two terms that are utilized to describe a function are an active verb and a measured noun. A measurable noun describes an item that can be both described and measured. After identifying, various functions, using numeral evolution of Function technique the primary or basic function and secondary functions has been sorted.

4.4 CREATIVE PHASE

Creating a variety of options to carry out the same functions is the goal of this phase. It is advised to apply several well-known approaches during this phase, such as brainstorming and nominal group technique. Brainstorming encourages creativity and gives the chance to consider all potential answers to the issues at hand or substitutes for the function. We must create a list of probable answers to the problem created by the verb-noun combination.

4.5 EVALUATION PHASE

The fourth stage of the Value Analysis process is the Evaluation Phase. Here, the concepts developed during the Creative Phase are methodically assessed, screened, prioritized, and short-listed for their potential to deliver cost- and/or value-saving effects. In this step , we assess the collected ideas and narrow down the number to a select group of suggestions that have the best chance of enhancing the project. Then, in the latter stages, one of the options on this short list will be thoroughly examined. As there are numerous ideas and many of them are not even good for the project value, it would be extremely inefficient to thoroughly examine each alternative right after the creative phase. This is why the evaluation step is necessary to weed out the unhelpful ideas.

4.6 DEVELOPMENT PHASE

At the development stage, each top choice is thoroughly examined to ascertain the life cycle costs and implementation requirements. It is possible to use technical analysis, cost projections, and other techniques to examine each possibility. The goal of this phase is to further analyse the list of suggestions with the best potential for becoming viable alternatives from the evaluation phase. The concepts are further developed into value alternatives that are spelt out in plain terms so that the stakeholders may comprehend their consequences, cost reductions, and effects on value.

4.7 PRESENTATION PHASE

In this phase the development phase data are presented to the decision-makers to help them fully comprehend the many VE possibilities and their advantages both in the short- and long-

term. A projected implementation strategy is presented in this phase as well. We meet with management and other stakeholders during the presentation phase to present their final report. The task is to persuade the decision-makers that the final concepts from the development phase should be put into action by presenting their findings to them using reports, flowcharts, and other presentation tools.The concepts should be thoroughly explained, along with any associated expenses, advantages, and any drawbacks. The final report serves as a
summary of the discussions and conclusions as well as a record of the accomplishments during the study.

It can also be used by the business as a reference tool for upcoming projects.

CHAPTER-5

DATA COLLECTION & ANALYSIS

5.1 INFORMATION PHASE - BASIC DETAILS OF THE PROJECT

Table 5.1: basic details of the project

Name of the project	Faculty Apartments construction project
Client	Integral University
Contractor	J R Constructions & Interiors
Architect	De- Design 19 Studio
Location	Integral University Campus, Dasauli, Kursi Road, Lucknow
Area	5581 sqft(100’3” x 55’8”)
No of Floor Proposed	7no.

5.2 FUNCTION ANALYSIS PHASE - AREAS OF STUDY

Table 5.2: Area/items of study

S. No.	Areas/Items of Study
1.	External wall
2.	Internal wall
3.	Project information flow (communication) process
4.	Flooring
5.	Shuttering & Formwork
6.	Curing
7.	Plastering
8.	Procurement and inventory process
9.	Rebar cutting process
10.	Door & Window
11.	Painting
12.	Ceiling

5.2.1 PROBABLE FUNCTION OF ITEMS/AREAS

Table 5.2.1: Probable Function of items/areas

S.No.	Area of study	Probable Function
1.	External Wall	a. Control Privacy b. Enhance Safety c. Resist Weather d. Prevent Noise e. Protect Health f. Enhance Comfort g. Resist Heat
2.	Internal Wall	a. Control Privacy b. Maintain temperature c. Prevent Noise d. Enhance Flexibility a. Resist Fire
3.	Plastering	b. Enhance appearance c. Increase Durability d. Protect Masonry e. Ease Painting f. Provide Insulation g. Resist Fire h. Conceal Defect i. Hide Services
4.	Flooring	a. Enhance Comfort b. Provide Stability c. Resist Fire d. Enhance Appearance e. Enhance Cleanness f. Prevent Dampness g. Resistance to were
5.	Shuttering & Formwork	a. Hold Concrete b. Provide shape c. Enhance Safety d. Improve Workability e. Provide access
6.	Painting	a. Protect Plaster b. Enhance appearance c. Improve Cleanness d. Enhance Durability e. Protect Health
7.	Door & Window	a. Enhance Safety b. Improve Ventilation c. Improve Lighting d. Provide access e. Control Privacy h. Resist Fire

5.2.2 IDENTIFYING FUNCTIONS AND EVALUATING IT BY USING NUMERICAL EVALUATION OF FUNCTION REVIEW (NEFR) TECHNIQUE.

Sample response for evaluation of basic function using Numerical Evaluation of Function Technique of items/areas

A1	B1	Important
A2	B2	More Important
AB	-	Both Important

Table 5.2.2: Sample response for Internal Wall

	Functions					
A	Control Privacy	A				
B	Maintain temperature	A2	B			
C	Prevent Noise	AC	C2	C		
D	Enhance Flexibility	A2	BD	C2	D	
E	Resist Fire	A2	BE	CE	E	E

Table 5.2.3: sample response for internal wall Flooring

	Functions						
A	Enhance Comfort	A					
B	Provide Stability	B2	B				
C	Resist Fire	A1	B1	C			
D	Enhance Appearance	AD	D2	CD	D		
E	Enhance Cleanness	AE	B1	CE	DE	E	
F	Prevent Dampness	F2	F2	F2	F2	EF	F

Table 5.2.4: Sample response for Shuttering & Formwork

	Functions					
A	Hold Concrete	A				
B	Provide shape	A1	B			
C	Enhance Safety	AC	C1	C		
D	Improve Workability	AD	D1	C1	D	
E	Provide access	A1	BE	C1	DE	E

Table 5.2.5: Sample response for Wall Finishes

	Functions					
A	Protect Plaster	A				
B	Enhance appearance	A1	B			
C	Improve Cleanness	A	BC	C		
D	Enhance Durability	D1	D1	C1	D	
E	Protect Health	A1	BE	CE	DE	E

Table 5.2.6: Sample response for Door & Window

	Functions					
A	Enhance Safety	A				
B	Improve Ventilation	B1	B			
C	Improve Lighting	C1	BC	C		
D	Provide Access	AB	B1	C1	D	
E	Control Privacy	AE	BE	CE	E1	E
F	Resist Fire	A1	B1	CF	DF	EF

5.2.3 OVER ALL RESPONSE SHEET

Table 5.2.7: over all response sheets of Internal Wall

Internal Wall				
Functions	Response 1	Response 2	Response 3	Average Score
A	7	5	7	6.3
B	2	3	4	3.0
C	6	3	2	3.7
D	1	3	2	2.0
E	3	6	5	4.7

Table 5.2.8: over all response sheets of Flooring

Flooring				
Functions	Response 1	Response 2	Response 3	Average Score
A	3	3	2	2.7
B	3	0	2	1.7
C	2	11	8	7.0
D	5	6	5	5.3
E	4	4	4	4.0
F	9	6	7	7.3
G	7	8	6	7.0

Table 5.2.9: over all response sheets of Shuttering and Formwork

Shuttering and Formwork				
Functions	Response 1	Response 2	Response 3	Average Score
A	4	4	4	4.0
B	1	4	4	3.0
C	4	4	5	4.3
D	3	3	3	3.0
E	2	4	4	3.3

Table 5.2.10: over all response sheets of Wall Finishes

Wall Finishes				
Functions	Response 1	Response 2	Response 3	Average Score
A	3	5	4	4.0
B	2	4	5	3.7
C	3	3	3	3.0
D	3	1	1	1.7
E	3	1	4	2.7

Table 5.2.11: over all response sheets of Doors and Windows

Doors and Windows				
Functions	Response 1	Response 2	Response 3	Average Score

A	3	5	6	4.7
B	5	6	6	5.7
C	4	1	2	2.3
D	2	7	7	5.3
E	5	5	7	5.7
F	3	0	1	1.3

5.2.4 OVER ALL RESPONSES RESULT

Table 5.2.12: over all response result of items/areas

S.No.	Area of study	Function
1.	External Wall	a. Control Privacy b. Enhance Safety c. Resist Weather d. Prevent Noise e. Protect Health f. Enhance Comfort g. Resist Heat
2.	Internal Wall	a. Control Privacy b. Maintain temperature c. Prevent Noise d. Enhance Flexibility e. Resist Fire
3.	Plastering	a. Enhance appearance b. Increase Durability c. Protect Masonry d. Ease Painting e. Provide Insulation f. Resist Fire g. Conceal Defect h. Hide Services
4.	Flooring	a. Enhance Comfort b. Provide Stability c. Resist Fire d. Enhance Appearance e. Enhance Cleanness f. Prevent Dampness g. Resistance to were
5.	Shuttering & Formwork	a. Hold Concrete b. Provide shape c. Enhance Safety d. Improve Workability e. Provide access
6.	Painting	a. Protect Plaster b. Enhance appearance c. Improve Cleanness d. Enhance Durability

		e. Protect Health
7.	Door & Window	a. Enhance Safety b. Improve Ventilation c. Improve Lighting d. Provide access e. Control Privacy f. Resist Fire

5.2 CREATIVE PHASE

Table 5.3: alternatives for items/areas

ITEM/AREA	ORIGINAL MATERIAL	ALTERNATIVES
External Wall	Red Brick Masonry Work	a. Aerated Concrete Blocks
		b. Fly ash Brick
		c. Red Mud Brick
		d. Compressed earth block
		e. Aerocon Panels
		f. Hollow concrete Block
Plastering	Cement Sand Plaster	a. Gypsum Board
		b. Rice husk Gypsum Board
		c. Laminated Bagasse Cement Board
		d. Bamboo Board
		e. Agricultural Fiber cement composite board
Internal wall	Red Brick Masonry Work	a. Aerocon Panels
		b. Hempcrete
		c. Besser Blocks
		d. Aerated Concrete Blocks
Flooring	Double Charge Vitrified Tiles	a. Bamboo Flooring
		b. Cork Flooring
		c. Natural Stone Flooring
		d. Cement or lime concrete
Shuttering & Formwork	Plywood	a. Steel
		b. Fabric Shuttering
		c. Stay in Place Formwork
		d. Aluminum
Painting	Acrylic Emulsion Paint	a. Paneling
		b. Tile
		c. Metal Wall Covering
		d. Cladding
Door & Window	Wooden Flush Door	a. UPVC Door
		b. Aluminum Doors
		c. Wood and Plastic Composite (WPC) Doors
		d. Membrane Doors

5.3 EVALUATION PHASE - EVALUATING CRITERIA

Table 5.4.1: evaluation criteria for external wall

S. No	Evaluation Criteria
A.	Initial cost
B.	Maintenance
C.	Aesthetics
D.	Durability
E.	Strength to weight ratio
F.	Damp proofing
G.	Rate of construction
H.	Material Availability
I.	Consistency in availability
J.	Sound insulation
K.	Heat Insulation
L.	Embodied carbon
M.	Recyclability/ Reuse

Table 5.4.2: evaluation criteria for internal wall

S. No	Evaluation Criteria
A.	Initial cost
B.	Maintenance
C.	Aesthetics
D.	Durability
E.	Strength to weight ratio
F.	Damp proofing
G.	Rate of construction
H.	Material Availability
I.	Fire Resistance
J.	Reusability
K.	Recyclability
L.	Sound insulation
M.	Heat Insulation
N.	Embodied carbon
O.	Embodied energy

Table 5.4.3: evaluation criteria for plastering

S. No	Evaluation Criteria
A.	Initial cost
B.	Maintenance
C.	Aesthetics
D.	Durability
E.	Damp proofing
F.	Rate of construction
G.	Material Availability
H.	Consistency in availability
I.	Heat Insulation
J.	Embodied carbon
K.	Recyclability/reuse

Table 5.4.4: comparing parameters for flooring

S. No	Evaluation Criteria
A.	Initial cost
B.	Maintenance
C.	Aesthetics
D.	Durability
E.	Damp proofing
F.	Rate of construction
G.	Material Availability
H.	Fire Resistant
I.	Heat Insulation
J.	Embodied energy
K.	Embodied carbon
L.	Reusability
M.	Recyclability
N.	Slip Resistance

Table 5.4.5: evaluation criteria for shuttering & formwork

S. No	Evaluation Criteria
A.	Initial Cost
B.	Maintenance
C.	Embodied energy
D.	Embodied carbon
E.	Surface finish
F.	Durability
G.	Waste Generation
H.	Workability
I.	Rate of construction
J.	Reusability
K.	Recyclability

Table 5.4.6: evaluation criteria for painting

S. No	Evaluation Criteria
A.	Initial cost
B.	Maintenance
C.	Aesthetics
D.	Durability
E.	Pace of application
F.	Material Availability
G.	Embodied energy
H.	Heat Insulation
I.	Embodied carbon
J.	Occupant health

Table 5.4.7: evaluation Criteria For Doors & Windows

S. No	Evaluation Criteria
A.	Initial cost
B.	Strength to Weight ratio
C.	Toughness
D.	Hardness
E.	Durability
F.	Fire resistant

G.	Damp proofing
H.	Reusability
I.	Recyclability
J.	Sound insulation
K.	Heat Insulation
L.	Embodied carbon
M.	Embodied energy
N.	Aesthetics

5.4.1 SAMPLE SHEET FOR COMPARING THE EVALUATION CRITERIA FOR WEIGHT DETERMINATION

Table 5.4.8: Comparing Parameters For Internal Wall

Parameters																
A	Initial cost	A														
B	Maintenance	AB	B													
C	Aesthetics	A1	C1	C												
D	Durability	AD	BD	D2	D											
E	Strength to weight ratio	E2	E1	E2	E1	E										
F	Damp proofing	F1	F1	F1	DF	E1	F									
G	Rate of construction	AG	G1	CG	D2	E1	F2	G								
H	Material Availability	A1	H1	CH	D1	E2	F2	GH	H							
I	Fire Resistance	I1	I2	I2	DI	EI	I1	I1	I1	I						
J	Reusability	AJ	J1	C1	D1	E2	F1	J1	HJ	I2	J					
K	Recyclability	A1	K1	C1	D1	E2	F1	K1	HK	I2	J1	K				
L	Sound insulation	A1	L2	L2	DL	EL	L2	L2	L2	I1	L2	L2	L			
M	Heat Insulation	A1	M2	M1	DM	EM	L2	M2	M2	I2	M2	M2	M1	M		
N	Embodied carbon	A1	N1	CN	D1	E1	N1	N2	N1	I2	JN	KN	L1	M2	N	
O	Embodied energy	A1	O1	ON	D1	E1	O1	O2	O1	I2	JO	KO	L1	M2	N1	O
Final Score		11	2	6	15	19	10	4	5	21	9	5	18	18	9	8

Table 5.4.9: comparing parameters for flooring

Parameters															
A	Initial cost	A													
B	Maintenance	A2	B												
C	Aesthetics	A2	C2	C											
D	Durability	A1	D2	CD	D										
E	Damp proofing	E2	E2	E1	DE	E									
F	Rate of construction	A2	BF	C2	D2	E2	F								
G	Material Availability	A2	BG	C1	D2	E1	FG	G							
H	Fire Resistant	A1	BH	CH	DH	E1	H1	H2	H						
I	Heat Insulation	AI	BI	CI	DI	EI	I2	I2	H1	I					
J	Embodied energy	A1	B1	CJ	DJ	E1	FJ	J1	H1	J1	J				
K	Embodied carbon	A1	B1	CK	DK	E1	K1	K1	H1	K1	K2	K			
L	Reusability	A2	BL	C2	D2	E1	L1	GL	H2	I2	J1	K1	L		
M	Recyclability	A2	BM	C2	D2	E1	M1	GM	H2	I2	J2	K1	L1	M	
N	Slip Resistance	AN	N2	CN	DN	N2	N2	N2	HN	IN	N2	N2	N2	N2	N

Table 5.4.10: comparing parameters for shuttering & formwork

	Parameters											
A	Initial Cost	A										
B	Maintenance	A2	B									
C	Embodied energy	A2	B1	C								
D	Embodied carbon	A2	B1	D1	D							
E	Surface finish	A1	E2	E2	E2	E						
F	Durability	AF	F2	F1	F1	E1	F					
G	Waste Generation	A2	BG	CG	DG	E2	F1	G				
H	Workability	A2	H1	H1	H1	E2	FH	GH	H			
I	Rate of construction	A2	I2	I1	I1	E2	FI	GI	HI	I		
J	Reusability	A2	J1	CJ	DJ	E2	F1	GJ	HJ	I1	J	
K	Recyclability	A2	K1	CK	DK	E2	F1	GK	HK	I1	J2	K

Table 5.4.11: comparing parameters for painting

Parameters											
A	Initial cost	A									
B	Maintenance	A1	B								
C	Aesthetics	AC	C2	C							
D	Durability	AD	D2	CD	D						
E	Pace of application	A2	B1	C2	D1	E					
F	Material Availability	A1	B1	C2	D2	EF	F				
G	Embodied energy	A1	BG	C1	DG	G1	G1	G			
H	Heat Insulation	A2	B2	C2	D2	E1	F2	G2	H		
I	Embodied carbon	A1	BI	C2	DI	FI	H1	I1	I2	I	
J	Occupant health	A2	J2	CJ	DJ	J2	J2	GJ	J2	J2	J

Table 5.4.12: comparing parameters for doors & windows

Parameters															
A	Initial cost	A													
B	Strength to Weight ratio	B2	B												
C	Toughness	C2	C1	C											
D	Hardness	D1	D1	C2	D										
E	Durability	E2	B1	C2	DE	E									
F	Fire resistant	F2	F1	CF	F1	F2	F								
G	Damp proofing	AG	BG	C1	DG	E2	F1	G							
H	Reusability	AH	B1	C2	D1	E1	F2	GH	H						
I	Recyclability	A2	B1	C2	D1	E1	F2	GI	H2	I					
J	Sound insulation	AJ	J2	CJ	J1	EJ	FJ	J1	J2	J2	J				
K	Heat Insulation	AK	BK	C1	DK	EK	F1	GK	K1	K1	J1	K			
L	Embodied carbon	A1	BL	CL	DL	EL	F2	GL	HL	IL	J2		L		
M	Embodied energy	A1	BM	CM	DM	EM	F2	GM	HM	IM	J2	KM	L2	M	
N	Aesthetics	N2	N2	C2	DN	EN	FN	N1	N1	N1	JN	N1	LN	MN	N

5.4.2 CALCULATION OF WEIGHTS FOR EVALUATION CRITERIA

Table 5.4.13: calculation of weights for evaluation criteria – external wall

Evaluation Criteria	Criteria Code	Average Score (X)	Weight age (X*5 / 24.3)
Initial cost	A	8.9	1.8
Maintenance	B	7.6	1.6
Aesthetics	C	1.1	0.2
Durability	D	19.1	3.9
Strength to weight ratio	**E**	**24.3**	**5.0**
Damp proofing	F	13.7	2.8
Rate of construction	G	1.6	0.3
Material Availability	H	5.1	1.0
Consistency in availability	I	5.4	1.1
Sound insulation	J	6.9	1.4
Heat Insulation	K	22.9	4.7
Embodied carbon	L	18.6	3.8
Recyclability/Reuse	M	5.4	4.0

Table 5.4.14: calculation of weights for evaluation criteria – plastering

Evaluation Criteria	Criteria Code	Average Score	Weight age
Initial cost	A	10.6	3.2
Maintenance	B	6.9	2.1
Aesthetics	C	12.3	3.7
Durability	**D**	**16.6**	**5.0**
Damp proofing	E	10.9	3.3
Rate of construction	F	2.6	0.8
Material Availability	G	4.6	1.4
Consistency in availability	H	5.4	1.6
Heat Insulation	I	1.7	0.5
Embodied carbon	J	12.0	3.6
Recyclability/Reuse	K	14.6	4.4

Table 5.4.15: calculation of weights for evaluation criteria – internal wall

Evaluation Criteria	**Criteria Code**	**Average Score(X)**	**Weightage (X*5/15.3)**
Initial cost	A	13.0	4.24
Maintenance	B	8.0	2.61
Aesthetics	C	11.0	3.59
Durability	D	14.0	4.57
Strength to weight ratio	E	13.0	4.24
Damp proofing	F	13.3	4.35
Rate of construction	G	7.7	2.50
Material Availability	H	8.7	2.83
Fire Resistance	I	14.0	4.57
Reusability	J	8.3	2.72
Recyclability	K	7.7	2.50
Sound insulation	**L**	**15.3**	**5.01**
Heat Insulation	M	14.0	4.57
Embodied carbon	N	6.7	2.17
Embodied energy	O	5.4	1.06

5.5 DEVELOPMENT PHASE - COMPARISON OF ALTERNATIVES

After calculation of evaluation criteria weightage, each alternative are then evaluated with respect to the evaluation criteria to calculate the scores.

Comparison of alternatives with each evaluation criteria and assigning of average score for evaluation criteria against each alternative – External Wall. The score are on 1 to 5 scales.

1 – Alternate scoring **very Poor** on a particular evaluation criteria

2 – Alternate scoring **Poor** on a particular evaluation criteria

3 – Alternate scoring **Average** on a particular evaluation criteria

4 – Alternate scoring **Good** on a particular evaluation criteria

5– Alternate scoring **very Good** on a particular evaluation critter

Table 5.5.1: comparison of alternatives for external wall

	A	B	C	D	E	F	G	H	I	J	K	L	M
Red Brick masonry work	3.8	4.9	1.8	4.8	3.2	3.9	3.2	4.9	4.9	3.1	4.1	2.9	4.5
Aerated Concrete Blocks	2.5	4.8	2.5	3.7	4.2	3.2	4.5	4.2	3.5	4.8	4.9	2.9	3.5
Fly ash Brick	4.9	4.9	2.1	4.8	3.1	4.1	3.1	4.6	3.9	3.1	3.9	4.7	4.2
Red Mud Brick	4.9	4.9	1.8	4.6	3.0	4.1	3.1	2.5	2.5	3.2	4.2	4.7	4.2
Compressed earth block	4.9	4.0	1.5	4.0	2.4	1.5	3.5	4.9	4.9	3.5	4.2	4.9	2.0
Aerocon Panels	1.7	4.9	4.8	4.9	4.7	4.8	4.5	3.9	3.5	4.2	4.8	3.5	4.8
Hollow concrete Block	2.4	4.7	2.8	4.5	4.2	4.8	4.5	4.4	4.0	4.5	4.9	3.5	3.5

Comparison of alternatives with each evaluation criteria and assigning of average score for evaluation criteria against each alternative – Plastering

Table 5.5.2: comparison of alternatives for external wall

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Gypsum Board	4.3	4.0	3.5	3.7	2.0	4.5	4.8	4.8	3.8	3.8	4.6
Rice husk Gypsum Board	4.9	4.0	3.3	3.5	2.0	4.5	3.9	3.5	4.0	4.3	4.7
Laminated Bagasse Cement Board	1.8	4.3	4.0	4.0	3.0	4.2	3.9	3.7	4.2	4.2	4.2
Bamboo Board	1.5	4.9	4.5	4.5	4.0	4.2	4.0	3.7	3.5	4.2	4.8
Agricultural Fiber cement composite board	3.1	4.1	3.7	3.8	3.5	4.2	3.8	3.5	4.0	4.3	3.5

5.5.1 CALCULATION OF WEIGHTED SCORE FOR ALTERNATIVES

After calculating the weights of evaluation criteria (say X1, X2,…) and scoring of each alternative against evaluation criteria (Say Y1, Y2,…), final scores of alternatives against each criteria (say Z1,Z2…) have been calculated by multiplying X1,X2… with Y1, Y2… respectively (Z1=X1 x Y1). Then total scores of each alternatives has been calculated by adding Z1, Z2 and so on.

Table 5.5.3: Calculation of weighted score for alternatives– External Wall

	A	B	C	D	E	F	G	H	I	J	K	L	M	Total Score
Evaluation criteria Weightage	1.8	1.6	0.2	3.9	5.0	2.8	0.3	1.0	1.1	1.4	4.7	3.8	4.0	
Red Brick masonry work	3.8	4.9	1.8	4.8	3.2	3.9	3.2	4.9	4.9	3.1	4.1	2.9	4.5	
	6.9	7.7	0.4	18.9	16.0	11.0	1.1	5.1	5.4	4.4	19.3	11.1	18.0	125.2
Aerated Concrete Blocks	2.5	4.8	2.5	3.7	4.2	3.2	4.5	4.2	3.5	4.8	4.9	2.9	3.5	
	4.6	7.5	0.6	14.5	21.0	9.0	1.5	4.4	3.9	6.8	23.1	11.1	14.0	122.0
Fly ash Brick	4.9	4.9	2.1	4.8	3.1	4.1	3.1	4.6	3.9	3.1	3.9	4.7	4.2	
	9.0	7.7	0.5	18.9	15.5	11.6	1.0	4.8	4.3	4.4	18.4	18.0	16.8	130.7
Red Mud Brick	4.9	4.9	1.8	4.6	3.0	4.1	3.1	2.5	2.5	3.2	4.2	4.7	4.2	
	9.0	7.7	0.4	18.1	15.0	11.6	1.0	2.6	2.8	4.5	19.8	18.0	16.8	127.2
Compressed earth block	4.9	4.0	1.5	4.0	2.4	1.5	3.5	4.9	4.9	3.5	4.2	4.9	2.0	
	9.0	6.3	0.3	15.7	12.0	4.2	1.2	5.1	5.4	5.0	19.8	18.8	8.0	110.8
Aerocon Panels	1.7	4.9	4.8	4.9	4.7	4.8	4.5	3.9	3.5	4.2	4.8	3.5	4.8	
	3.1	7.7	1.1	19.3	23.5	13.5	1.5	4.1	3.9	6.0	22.6	13.4	19.2	138.7
Hollow concrete Block	2.4	4.7	2.8	4.5	4.2	4.8	4.5	4.4	4.0	4.5	4.9	3.5	3.5	
	4.4	7.3	0.6	17.7	21.0	13.5	1.5	4.6	4.4	6.4	23.1	13.4	14.0	132.0

Table 5.5.4: Calculation of weighted score for alternatives– Plastering

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**Total Score**
Evaluation criteria weightage	3.2	2.1	3.7	5.0	3.3	0.8	1.4	1.6	0.5	3.6	4.4	
Gypsum Board	4.3	4	3.5	3.7	2	4.5	4.8	4.8	3.8	3.8	4.6	
	13.7	8.3	13.0	18.5	6.6	3.5	6.7	7.8	1.9	13.7	20.2	113.97
Rice husk Gypsum Board	4.9	4.0	3.3	3.5	2	4.5	3.9	3.5	4	4.3	4.7	
	15.6	8.3	12.2	17.5	6.6	3.5	5.4	5.7	2.0	15.5	20.7	113.13
Laminated Bagasse Cement Board	1.8	4.3	4	4	3	4.2	3.9	3.7	4.2	4.2	4.2	
	5.7	8.9	14.8	20.0	9.8	3.3	5.4	6.0	2.2	15.2	18.5	109.86
Bamboo Board	1.5	4.9	4.5	4.5	4	4.2	4.0	3.7	3.5	4.2	4.8	
	4.8	10.2	16.7	22.5	13.1	3.3	5.5	6.0	1.8	15.2	21.1	120.21
Agricultural Fiber cement composite board	3.1	4.1	3.7	3.8	3.5	4.2	3.8	3.5	4	4.3	3.5	
	9.9	8.5	13.7	19.0	11.5	3.3	5.3	5.7	2.0	15.5	15.4	109.85

Table 5.5.5: Calculation of weighted score for alternatives– Internal Wall

	Initial cost	Durability	Strength to weight ratio	Damp proofing	Fire resistance	Sound insulation	Heat insulation	Total Score
Evaluation criteria Weightage	4.25	4.57	4.24	4.35	4.57	5.01	4.57	
Red Brick masonry work	2.2	2.4	2.2	1.8	2.2	2.0	1.8	
	9.5	11.1	9.2	7.8	10.1	9.9	8.1	65.6
Aerocon Panels	1.6	2.5	2.4	2.4	2.2	2.3	2.4	
	6.8	11.4	10.2	10.3	10.1	11.7	10.8	71.3
Besser Blocks	1.9	2.3	2.3	2.1	2.6	2.6	2.3	
	8.1	10.5	9.6	9.3	11.7	13.0	10.5	72.8
Hempcrete	1.7	2.2	2.1	2.3	2.3	2.3	2.5	
	7.1	9.9	9.0	10.1	10.6	11.7	11.4	69.9
Aerated Concrete Blocks	1.9	2.6	2.5	2.4	2.6	2.6	2.5	
	8.1	12.0	10.5	10.3	11.7	12.9	11.4	76.9

Table 5.5.6: Calculation of weighted score for alternatives– Flooring

	Initial cost	Aesthetics	Durability	Damp proofing	Fire resistance	Heat Insulation	Slip Resistance	Total Score
Evaluation criteria Weightage	3.70	3.46	3.62	3.38	2.82	2.82	5	
Ceramic Tiles	1.87	2.5	2.6	2.53	2.53	2.23	2.13	
	6.9	8.7	9.4	8.6	7.1	6.3	10.7	57.6
Bamboo Flooring	2	2.1	2.13	1.67	1.67	2.33	2.5	
	7.4	7.3	7.7	5.6	4.7	6.6	12.5	51.8
Cork Flooring	1.67	2.13	1.9	1.83	1.8	2.23	2.4	
	6.2	7.4	6.9	6.2	5.1	6.3	12.0	50.0
Natural Stone Flooring	1.9	2.33	2.93	2.67	2.67	2.07	2.4	
	7.0	8.1	10.6	9.0	7.5	5.8	12.0	60.1
Cement concrete flooring	2.17	1.77	2.67	2.57	2.67	1.67	2.33	
	8.0	6.1	9.7	8.7	7.5	4.7	11.7	56.4

Table 5.5.7: Calculation of weighted score for alternatives– Shuttering & Formwork

	Initial cost	Surface finish	Durability	Workability	Rate of construction	Reusability	Total Score
Evaluation criteria Weightage	4.76	5.01	4.01	3.5	3.76	3.63	
Plywood	2.2	2.23	1.83	2.33	1.9	2.17	
	10.5	11.2	7.3	8.2	7.1	7.9	52.2
Steel	1.4	2.47	2.67	2.47	2.47	2.37	
	6.7	12.4	10.7	8.6	9.3	8.6	56.3
Plastic	2.27	2.23	1.97	2.5	2.23	1.93	
	10.8	11.2	7.9	8.8	8.4	7.0	54.0
Aluminum	1.4	2.9	2.7	2.87	2.73	2.43	
	6.7	14.5	10.8	10.0	10.3	8.8	61.2
Stay in Place Formwork	1.9	2.33	2.37	2.5	2.33	2.03	

	9.0	11.7	9.5	8.8	8.8	7.4	55.1

Table 5.5.8: Calculation of weighted score for alternatives– wall finish

	Initial cost	Maintenance	Aesthetics	Durability	Embodied carbon	Occupant health	Total Score
Evaluation criteria Weightage	4.58	2.92	5.00	4.3	2.36	4.02	
Acrylic Emulsion paint	1.7	2.43	2.47	2.03	1.87	1.87	
	7.8	7.1	12.4	8.7	4.4	7.5	47.9
PVC Panels	2.1	1.77	2.77	2.27	1.87	2.3	
	9.6	5.2	13.9	9.8	4.4	9.2	52.1
Ceremic Tile	1.83	1.9	2.37	2.6	1.8	2.63	
	8.4	5.5	11.9	11.2	4.2	10.6	51.8
Stone Cladding	1.43	1.77	2.53	2.73	2.07	2.63	
	6.5	5.2	12.7	11.7	4.9	10.6	51.6
MDF Panels	2.1	2.03	2.43	1.93	2.07	2.4	
	9.6	5.9	12.2	8.3	4.9	9.6	50.5

Table 5.5.9: Calculation of weighted score for alternatives– Doors & Windows

	Initial cost	Toughness	Hardness	Durability	Fire resistance	Sound insulation	Aesthetics	Total Score
Evaluation criteria Weightage	3.3	4.9	3.33	3.73	3.63	4.41	5	
UPVC Doors	1.3	2.33	2.27	2.43	2.4	2.23	2.43	
	5.8	11.4	7.6	9.1	8.7	9.8	12.2	64.5
Plywood flush Doors	1.8	2.17	2.33	2.2	1.63	2.27	2.37	
	6.4	10.6	7.8	8.2	5.9	10.0	11.9	60.7
Fiber Glass Door	1.73	2.2	2.33	2.4	2.23	2.57	2.67	
	6.1	10.8	7.8	9.0	8.1	11.3	13.4	66.4

Wood and Plastic Composite (WPC) Doors	1.77	2.37	2.07	2.27	1.9	1.97	2.53	
	6.2	11.6	6.9	8.5	6.9	8.7	12.7	61.5
Membrane Doors	1.97	2.2	2.43	2.43	2.17	2.3	2.5	
	7.0	10.8	8.1	9.1	7.9	10.1	12.5	65.4

5.6 PRESENTATION PHASE

Comparison of alternatives with each evaluation criteria and assigning of average score for evaluation criteria against each alternative. It is found that the best alternative for external wall, plastering, internal wall, flooring, Shuttering & Formwork, Wall Finish and Doors & Windows are **Aerocon Panel, bamboo board , Aerated Concrete Blocks, Natural Stone Flooring, Aluminum, PVC Panels and Fiber Glass Door.**

Aerocon panels are the inorganic bonded sandwich panels made of two fiber reinforced cement sheets sandwiching a light-weight core consisting of Portland cement, binders and a mix of siliceous aggregates. Though Aerocon board have higher initial cost but other advantages such as low maintenance, lower sound and thermal conductivity, higher durability, higher strength to weight ratio, higher rate of construction and reusability make it better alternative for construction of external wall. Due to high strength to weight ratio, there will less dead weight on the building which consequently minimizes earthquake load which ultimately results in material saving. The high durability, low maintenance and low thermal conductivity of the panel minimizes it life cycle cost. Low thermal conductivity not only ensures saving in HVAC cost but also save considerable amount of fuel to be consumed for generating electricity throughout its life and hence reduces significant carbon emission.

It can be further noted that if we use Aerocon panel than there is no need of plastering. This is a great advantage and results in a huge reduction of cost and material, making it not only economical but highly environmentally sustainable and justified its initial cost.

CHAPTER-6
CONCLUSION

Value engineering is a potent methodology for increasing value, cutting costs, and improving quality. The purpose of this study is to demonstrate the benefits of applying value engineering in the construction industry and to draw conclusions about how the technique functions. It is not properly used in India and is conflated with the idea of cost-cutting. One can utilize a variety of cost-cutting strategies, including material management, budgetary control, waste management, and value engineering, to solve the value, cost, and quality problems. Value Engineering is the most popular technique that has a significant impact on cost reduction. The primary goal of using VE in sustainable building construction projects has been to maximize benefit or value. The advantages can take many different forms, such as design enhancements, cost savings, ongoing improvement, the use of new materials, improved construction techniques, employee engagement in decision-making processes, enhanced skills gained from teamwork, optimized quality and performance requirements, and improved functional reliability and system performance. A well-organized VE job plan can help in developing alternatives for building systems that improve performance and quality outcomes while being less expensive from a life cycle assessment or analysis perspective. It is significant to emphasize that initiatives using VE may have better sustainability outcomes when system functions are well understood.

PAPER PRESENTATION CERTIFICATE

Sr. No.- 066-1/LU/FoET/RACMEE-2023

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To,
Dear MariyamKhalid and Faraz Hasan Qadri

Thank you for the sending your book chapter for publication. The book chapter titled **"Application of Value Engineering in Residential Building Considering Sustainability Aspect"** is very well written and has been accepted for publication in edited book titled **"Rethinking Construction Management Practices to Attain Sustainable Development Goals (Volume - 1)"**.

Yours Sincerely,

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CHAPTER-7

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