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Manufacturing of Reinforced Composite Fly Ash Bricks – Product Analysing and Development Using Value Engineering Techniques

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ABSTRACT

The key driver of Indian economy is structured by the infrastructure development. This sector is principally responsible for thrusting India's overall development and an intensive focus from government for initiating policies that would propose alternate methods and materials for which the end products ensuring high quality, non-degradable, time-bound creation of world class infrastructure in the country. Infrastructure sector includes power, bridges, dams, roads, and urban infrastructure development, which requires huge quantity of bricks, sand, cement, steel, and other infrastructure products. Over the last decade, plenty of research works have been demonstrated to develop fly ash bricks. This resource material has a profitable utilization for manufacture of fly ash bricks and blocks as a supplement to common burnt clay building bricks which encompass the potential of conservation of precious natural resources, improvement in environmental quality, and providing ecological balance, and thereby decreasing pollutants, and "fly ash" has successfully positioned itself as an alternate resource material through manufacturing and processing of fly-ash--based products. Even though eco-friendly fly ash bricks and blocks are extensively used and replaced red clay bricks, there are some difficulties and negative consequences of using fly ash bricks such as lower bonding due to smooth finish, lower mechanical strength, lower cooling effect, reduced crushing strength, low thermal and sound insulation, limitation of size, and they do not absorb heat during cold seasons. This paper demonstrates the application, theories, and methods of value engineering concepts to improve the quality of fly ash brick with low cost. To overcome the above difficulties, limitation, and to enhance the production of fly ash bricks, some naturally abundant waste materials are added as a reinforcement such as plastic crushes, coir, clay paper, quarry dust, white cement, manufactured sand, marble, and granite waste at an appropriate mixture ensuring higher mechanical strength, improved cooling effect, higher bonding between mortgage and larger size fly ash bricks without breakage can be made with high significance.

Keywords: fast technique, fly ash brick, reinforcement, functional analysis, value engineering

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INTRODUCTION

In the past two decades, there has been a growing awareness of the importance of both value engineering (VE) and sustainable development (SD) within the construction industry, especially in manufacturing of fly ash bricks. Both subjects play vital roles in realizing quality, reliability, and durability, as well as increasing performance and service-relating outcomes within limited budget. The VE is an intensive, interdisciplinary

problem-solving activity that focuses on improving the value of the functions that are required to accomplish the goal, or objective of any product, process, service or organization. VE states a reason that any technique is so useful and should be applied to every product, and at each stage, a creative and disciplined process seeks to offer the client a reliable opportunity for cost saving with functionalities of the normal day-to-day development of a building construction product. Achieving a more efficient use of resources and accomplishing an optimum combination fly ash bricks quality to satisfy the end-user requirements require a methodology of VE with its different phases can be implemented in any product to reduce the cost and sustainable construction that leads to achieving the best value over the life span of a project. [1-4]

The construction industry has vital impact on the environment and people. VE is a methodology that is comprised of many useful tools and techniques that create change on purpose rather than letting change happen accidental. The traditional approach to the design process begins with the architect's assets, core competencies, and desire to create a product that ideally matches the client's priorities. This more formalized decision-making approach allows a more holistic understanding of the project by all stakeholders. The new approach involves using a multidisciplinary team that includes representatives of the owner, user, facility manager, and constructor, if all stakeholders are not represented. Real-time decisions are reached using value-based methods in a team workshop setting. On a global scale, the construction industry and its products contribute to environmental problems through resources depletion energy consumption, air pollution, and waste creation. In our work, efforts are made to use waste products to reinforce with fly ash bricks for better strength with an organized process that can be effectively used by a wide range of companies and establishments to achieve their continuous goals.

The improvements are the result of recommendations made by multidiscipline teams from all concerned parties. VE can recover decision-making that is directly related to optimal expenditure of owner funds while meeting required function and quality level. VE concentrates on the effectiveness through stating functions, goals, objectives, needs, requirement, and desires with function and quality associated with it to satisfy end customer with delight.

Function
The specific work that a project must do.

Quality
Conformance to customer requirements, desires, and expectation, or fit for use.

Project Summary
To overcome the limitation of lower mechanical strength, lower cooling effect, lower heat absorption during cold seasons, and lower crushing strength, a new product has been proposed in an eco-friendly manner with a mixture of reinforced material added at appropriate ratio in fly ash brick manufacturing.

To overcome the limitation of larger size bricks with less breakage, a combination of reinforced material with a redesign in brick size, shape, and structure with an octagonal hole, provision for better mortgage is suggested.

RESEARCH PROBLEM AND OBJECTIVES

The value methodology is used to identify new improvement ideas and develop these ideas into proposals that lead the enhancement of the project. Methodologies are conducted in three stages: pre-study, VE workshop, and post-study.

A major characteristic of VE is the function analysis phase synergistic way of developing, decomposing, and understanding the functions of any product, process, service, or organization.

Job Plan Approach

It is a systematic and organized plan of action for conducting a VE analysis and assuming the implementation of the recommendations. Figure 1-2.

A systematic process of review and analysis of a project, during the concept and design phases, by a multidiscipline team of persons not involved in the project that is conducted to provide recommendations for the following:

1. Providing the needed functions safely, reliably, efficiently, and at the lowest overall cost.
2. Improving the value and quality of the project.
3. Reducing the time of completing the project.

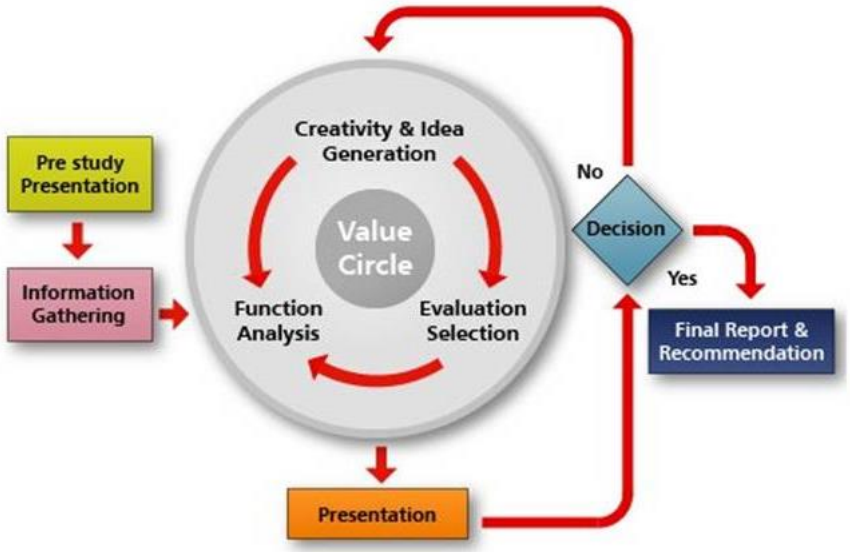

Fig. 1. *VE job plan approach.*

Value Engineering Job Plan

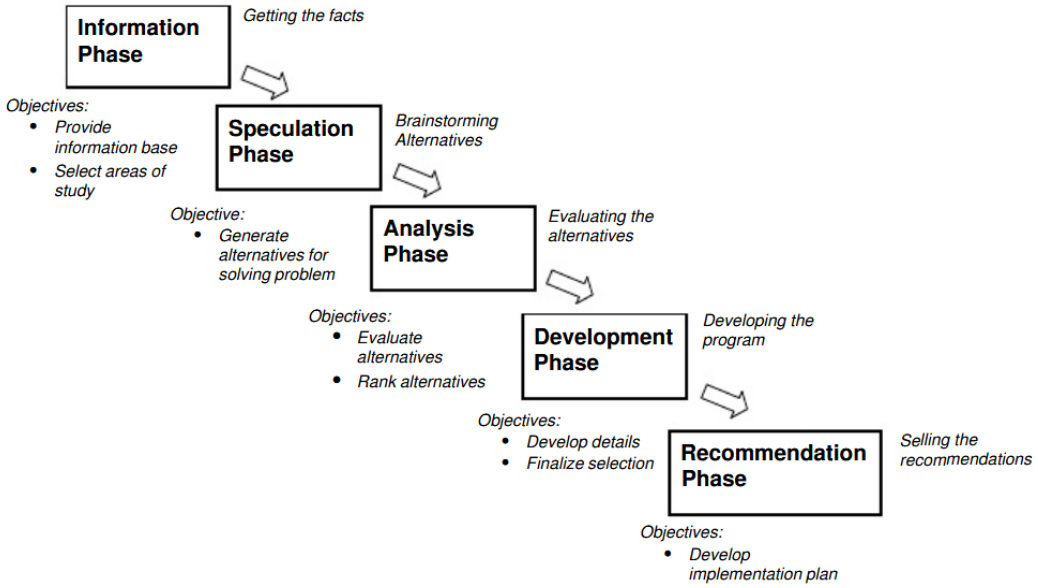

Fig. 2. *Explanation of seven phases.*

Aims/Objectives of the Project

- To develop of value added plastic reinforced Fibre composite fly ash bricks with cost effectiveness.
- To manufacture an eco-friendly fly ash brick using plastic wastage and other products which are naturally abundant in nature.
- To utilize the waste product and for making effective brick which can prolong the products a higher adhesive strength, compression strength, light-weight composite brick.
- To improve the productivity of a construction firm in terms of introducing value-added composite bricks which can help the compactness, anti-seismic, texture of the building.

To develop a composite brick in a global trade market with an appropriate design which can help to improve the durability of product with high-standard fireproof, thermal insulation, cooling effect, sound insulation, no breakage during transport, and use.[5-8]

METHODOLOGY

The VE methodology can be applied to any subject or problem. It is a vehicle to carry the project from inception to conclusion. The formal approach for VE is often referred to as the job plan. The VE job plan comprises several phases. Generally, although there are possible variations, the following five form the essence of the job plan.

Information Phase

Further acquaintance of the project by the team, all team members participate in a function analysis of the project as a whole and then of its component parts, to determine the true needs of the project. Areas of high cost and low worth are identified.

Function Phase

All the functions identified are classified as either basic or secondary. The basic function of an item is the primary purpose that the item must achieve to fulfil the owner's requirement. A secondary function, on the other hand, is not an essential feature to the owner and usually arises from a particular design configuration that makes the item look better. Sometimes, however, a secondary function may be required by regulatory or building codes. In this case, it is still a critical function essential to the performance of the item.

The categorization of the functions enables costs incurred for the non-essential secondary functions to be isolated from those required to provide the basic functional performance. In this way, the number of secondary functions with its associated costs can be reduced (or eliminated) without compromising required owner's functions. Moreover, focus can be placed on alternatives to reduce the cost of providing the basic functions.

Creative Phase

The creative phase is a prospect or chance for the team to use their creativity and produce alternate means of performing the functions associated with the product, service, or project. The goal is to generate as many ideas as possible in a short period of time.

Evaluation Phase

The proposed method should be analysed in feasible condition, which is to be evaluated for the expected result outcome.

Development Phase

The team develops these selected ideas into alternatives or proposals with a sufficient level of documentation to allow decision-makers to determine if the alternative should be implemented. This is the phase when a limited number of the ranked alternatives are taken forward for development.

The alternatives are designed in greater detail so that a better appraisal of their cost, performance, and implementation can be made. The cost should be computed based on life-cycle costing. At this stage, it may be necessary to conduct a trial or prepare a model or prototype to test the concept before re commending them to the decision-makers.

Implementation Phase

In this phase, a sound proposal is made to management. The effort in this phase can be crucial because all the good work done thus far could be aborted at this final stage if the proposal is not effectively presented.

The presentation must also include the implementation plan so that management can be fully convinced that the change can be made effectively and successfully without detriment to the overall project.

VE can be applied at any stage of a project. It must, however, be borne in mind that greater benefits can be reaped when it is implemented in the earlier stages of the project. In the earlier stages of the project, there are less hard constraints, so there can be greater flexibility for adopting innovative alternatives. As the project proceeds, more constraints are added. Then, there is less flexibility for variation, and superior costs will have to be incurred to make the necessary design changes. (Table 1)

Value Engineering Proposals at Requirements at Three Stages

Finally, VE proposals are generated that meet the studies as follows:

The First VE Study (VE 1) – Pre-study

Selection of Materials and Its Significance

This study is applied during the design planning stage to define project functions, goals, objectives, requirements, design criteria, and scope of work.

The Second VE Study (VE 2) -- Value Workshop

Methodology for an Eco friendly Reinforced Fly Ash Bricks.

This study is applied at about 15%--30% of design, to create detailed VE proposals and substitutes to the design and to define technical systems and make sure that value engineering proposals (VEP) of VE 1 are implemented.

The Third VE Study (VE 3) Is a Mix of VE and Design Review – Post-Study

Redesign in Brick Size, Shape, and Structure

This study is applied at about 80%--85% of design to check the conformance to codes, standards, specifications, and make sure the optimal design with best functions and cost effective. (Table 1)

Table 1*. Priorities of VE analysis.*

Sl No	Priority of Studies	Descriptions
1.	The first VE study (VE 1) – Pre-study	Selection of materials and its significance
2.	The second VE study (VE 2) -- Value workshop	Methodology for an eco-friendly reinforced fly ash bricks.
3.	The third VE study (VE 3) -- Post-study	Redesign in brick size, shape, and structure.

Value Engineering Study 1 – Pre-study

Selection of Materials and Its Significance

With addition to fly ash, sand, lime, gypsum, bonding agents, and water, some of the following ingredients are selected for reinforcement for the manufacture of composite fly ash bricks based on their availability and properties.

- **Plastic crushes** – naturally abundant and possess high mechanical strength which fixed as reinforcement.

- **Coir --** naturally available at an enormous quantity and a cheaper material with enhanced cooling effect.
- **Clay --** possesses higher bonding properties and act as an adhesive in making fly ash bricks.
- **Paper** – possesses the characteristics of making low weight and less cost.
- **Quarry dust** – possesses higher mixture strength with magnificent mixing ability.
- **Cement** – can act as a bond activator and an adhesive to make product stronger.
- **White cement** – added in a little quantity for enabling compactness and texture.
- **Manufactured sand** – enhances the water absorption capability in nature and helps in making better crushing strength.
- **Marble waste** – added a little for improving hardness and added as a colouring agent with appropriate mixture.
- **Granite waste --** acts as an insulator and helps in bringing cooling effect.

Ratio Proportion for Existing Fly Ash Bricks. *(Table 2)*

Table 2. *Ratio proportion for existing fly ash bricks.*

Materials	Fly ash	Sand	Lime	Gypsum	Bonding agents
Existing design contribution ratio of fly ash bricks	65	15	10	6.5	3.5

Ratio and proportion of reinforced material of the proposed composite fly ash bricks. *(Table 3)*

Table 3. *Material requirements.*

Materials	Proposed design Contribution ratio of fly ash bricks in %
Fly ash	40--50
Sand	10--15
Lime	10--15
Gypsum	6.5--10
Bonding agents and water	3.5--5.5
Plastic crushes	8--12
Coir	4--9
Clay	4--8
Paper	4--8
Quarry dust	2--4
Cement	4--8
White cement	1--3
Manufactured sand	1--3
Granite waste	1--3
Marble waste	1--3

Value Engineering Study 2 – Value Workshop

Methodology for an Eco-Friendly Reinforced Fly Ash Bricks. *(Figure 3)*

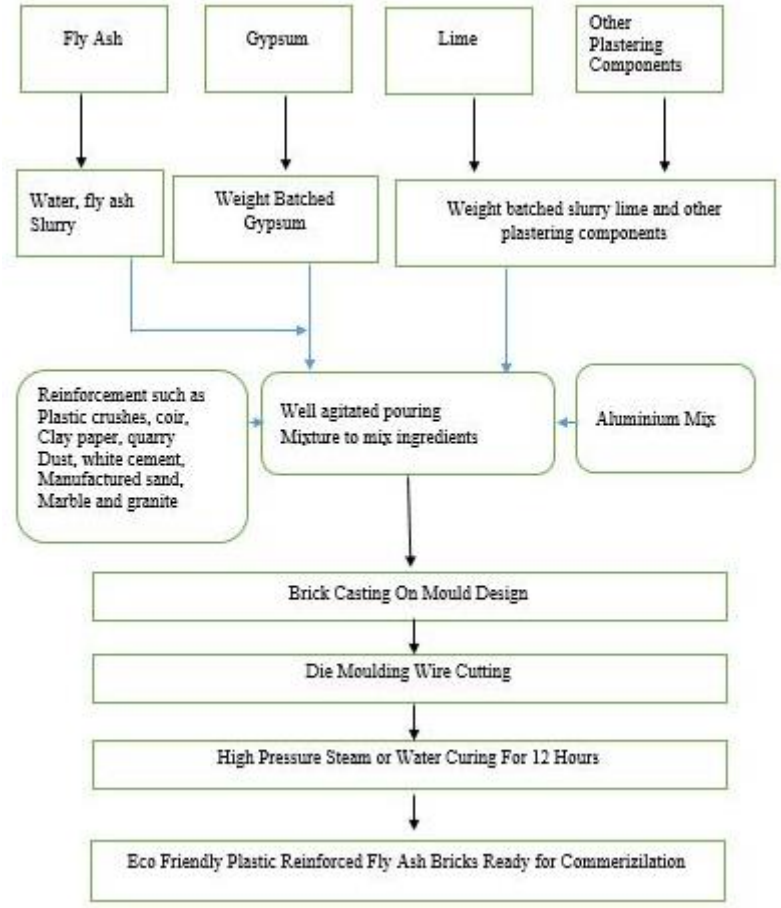

Fig. 3. *Explanation of seven phases.*

Value Engineering Study 3 – Post-Study

Existing Specification of Fly Ash Bricks as Per BIS Standards. *(Figure 4)*

No Special Holes or Provision:

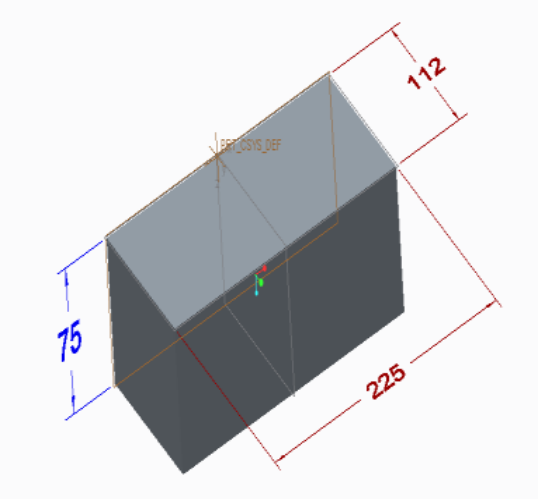

Fig. 4. *Existing design.*

Standard Brick Size as Per BIS Recommended Brick Size. *(Table 4)*

Table 4*. Standard design size.*

Length	225 mm
Breadth	112 mm
Width	75 mm

Recommended Redesign in Brick Size, Shape, and Structure. *(Figure 5)*

An octagonal hole and a parallel extruded provision for better mortgage.

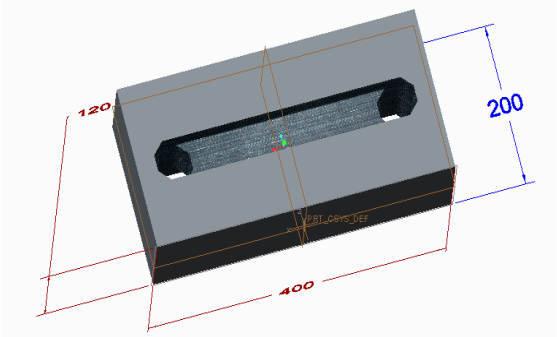

Fig. 5. *Proposed design.*

Table 5. *Proposed design size.*

Length	400 mm
Breadth	120 mm
Width	200 mm
Octagonal hole	40 mm
Extruded provision	25 mm

Reference (Table 5): BIS standard of hollow blocks.

CONCLUSION

VE could be applied as a "quick response" type of study or as a deeply united part of an overall organizational desire to stimulate innovation and recover quality. VE methodology and tools could be considered as an integral part of sustainability analyses to overcome the limitation of lower mechanical strength, lower cooling effect and lower heat absorption during cold seasons, lower crushing strength, and a new product has been proposed in an eco-friendly manner with a mixture of reinforced material added at appropriate ratio in fly ash brick manufacturing. Furthermore, VE lies under the umbrella of total quality management, quality assurance, and quality control programmes. VE enables the management of the team's thinking so that the best use of the knowledge and experience they have can generate new ideas to perform functions and propose alternatives to overcome the limitation of larger size bricks with less breakage. A combination of reinforced material with a redesign in brick size, shape, and structure with an octagonal hole, i.e. provision for better mortgage, is suggested.

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