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Effective Use of Sawdust and Waste Glass Powder in Establishing a Sustainable Foamed Concrete Brick: A Review

Ravi Jagdish Depan[1], Prof. A. D. Raval[2], Dr. J. R. Pitroda[3]

[1]M.Tech. (Civil) Construction Engineering and Management, BVM Engineering College, Vallabh Vidyanagar, Gujarat
[2]Lecturer, Civil Engineering Department, B&B Institute of Technology Engineering College, Vallabh Vidyanagar, Gujarat
[3]Associate Professor, PG Coordinator Construction Engineering and Management, Civil Engineering Department, BVM Engineering College, Vallabh Vidyanagar, Gujarat
ORCID: 0000-0002-2869-3158

Abstract - *The light-weighted foamed concrete (FC) has been used efficiently in the construction sector, it also has the potential to become a substitute for normal concrete since it reduces dead loads on structures and foundations, saves energy, and lowers manufacturing and labor costs during construction and shipping. The fundamental benefit of foam concrete is that its light in weight, which allows for cost-effective lower-floor walls and foundations. It offers several benefits, including thermal insulation and significant material savings due to its porous structure. The ongoing fast process of urbanization gave a massive rise to the waste being disposed of, so the sawdust which is generated from timber as a by-product can be used in foamed concrete to improve its mechanical and physical properties. Also, the utilization of waste glass powder in foamed concrete brick is being effective and will be beneficial for load-bearing wall applications.*

Key Words: Foamed Concrete, sawdust, waste glass powder, light-weight

1. INTRODUCTION

Foamed concrete is originated from cement mortar that contains air bubbles created by a foam-generated chemical. Due to the air bubbles created the structure of concrete can also be called a cellular structure. It has less consumption of aggregate, great permeability, higher porosity, strong heat insulation, resistance to fire, lower self-weight, sound insulation, and a desirable compressive strength are only a few of the benefits. This type of Aerated concrete can be parted in two ways which are based on the manner of pore-forming: Foam Concrete and the other one is Air-entrained concrete. [1]

Foamed concrete can also be called a cost-effective way to manufacture the huge light-weighted materials and also the application to the partitions, grades to be filled and also the embankment of the road can be infill because of the simple production process from start to the end. [2]

To prevent pollution and global warming, light-weighted technology blocks may be utilized as a substitute for red bricks. Foamed concrete blocks are safe for the environment. Foamed concrete bricks use only a bit of a fraction of energy compared to the energy used to make red bricks, it releases no emissions, and produces no harmful compounds or byproducts. [3]

1.1 Production Method of Foam Concrete

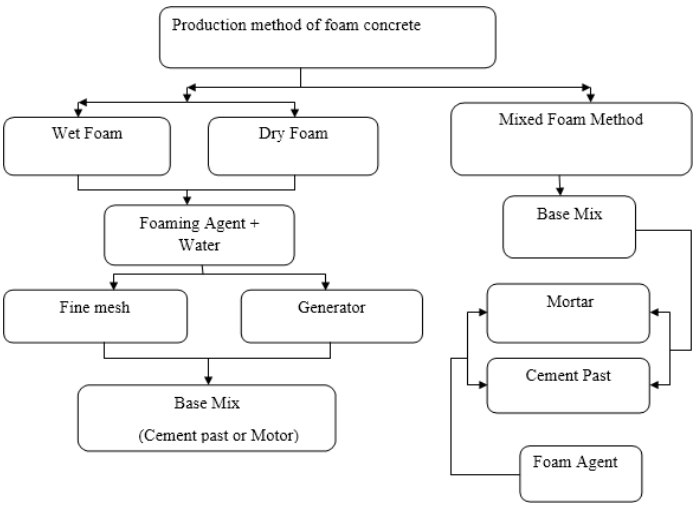

Fig-1 Flowchart of Production Method of Foam Concrete

1.2 Need of foamed concrete brick

Foamed concrete (FC) brick can be a viable replacement for normal concrete, since it minimizes dead loads on structures and foundations, helps energy conservation, and cuts manufacturing and labor costs during construction and shipping. Foamed concrete brick fills all cavities, spaces, and seams over a large distance without requiring vibration or compaction. It has a quick and easy installation process, as well as strong heat insulation and air content. It offers strong thermal insulation, freeze/thaw qualities, and fire resistance. Hardened foamed concrete brick, unlike certain synthetic

light-weighted materials, is resistant to hydrocarbons, bacteria, and fungus, as well as insects and rodents.

1.3 Objective of Study

The objectives of the study are listed below:

1. To study the behaviour of sawdust and waste glass powder incorporating foamed concrete.
2. To evaluate the characteristics of foamed concrete brick based on physical and mechanical properties.
3. To produce a sustainable foamed concrete brick for construction need.

2. Literature Review

By studying literature review from various authors some were concluded which are follows:

2.1 Foamed concrete

Y.H. Mugahed Amran et al. (2015) Foamed concrete which is relatively light in weight has a greater strength by the weight. The use of Foamed concrete reduces the dead loads on the building & base, saving in energy, also it reduces construction labor costs. It can be utilized as a structural material and decreases the manufacturing & shipping charges of construction components when compared to traditional concrete. The bulk of studies focused on examining the foam concrete qualities rather than the features of the foam itself or how it influences the strength of the foamed concrete matrix, it was discovered. The form of foam agent used, in addition to the approach used to put together the frothing agent as a way to acquire a uniform or homogenous distribution of air spaces, are all vital factors withinside the advent of solid foamed concrete. [4]

Jinyan Shi et al. (2015) To make an environmentally friendly, less-carbon, and light-weighted concrete brick for exterior wall insulation. This work created a unique chemical foam thermally insulated concrete. The breakdown of H_2O_2 resulted in bigger polystyrene particles and a significant number of closed pores, which successfully reduced the total weight and thermal conductivity of foam concrete. Even though the strength of foamed concrete decreases as the number of river sediment and expanded polystyrene particle grows, it still outperforms insulating materials of equivalent density in terms of mechanical properties. River sediment and expanded polystyrene particles also reduce the overall weight of foam concrete while increasing its properties. [5]

Kundan Kulbhushan et al. (2018) Foam concrete blocks are much larger than the normal traditional brick, and their popularity is growing because of their inexpensive total cost, lightweight, sound, and thermal insulation capabilities. Because of the limited air intrusion, blocks provide great thermal and acoustic insulation. Furthermore, the thermal and acoustic insulation is improved by fewer joints and superior compacted (thin) connecting mortar. This results in well-insulated interiors that keep warm air out in the summer and cold air out in the winter. Blocks may save up to 30% on energy costs. [6]

Amritha Rajet al. (2019) With rising global temperatures, the building industry is looking for a replacement for regular concrete, which has a large deadweight and heat conductivity. Research is being conducted in a variety of approaches, although the usage of foamed concrete is now the most popular. The strength qualities are being mentioned based on the reports on the components, fresh condition, and physical qualities of foamed concrete. [7]

Seyed Navid Hashem Moniri et al. (2019) It was discovered that specimens with ten percentage fly ash and ten percentage foam were the most effective. In comparison to regular concrete, foamed concrete lightweight bricks have adequate compressive strength, according to the findings of this investigation. As a result, lightweight foamed concrete bricks may be employed in construction and building applications. Lightweight bricks may be utilized in the inside application of structures, such as partition walls, with good results. The optimum lightweight concrete will be found based on its maximum compressive strength and other mechanical properties. [8]

2.2 Properties

Tiong-Huan Wee et al. (2011) The impacts of the (w/c) ratio in which the air content is about 10 to 70 %, also what behavior or the effect they may have on their mechanical properties eliminating the sand in it, were investigated. Also, the factor of spacing between the water-cement ratio and the air concentration with the relation to the density seems to regulate various compressive strengths of foamed concrete. The results which were observed were that the air-voids addition can make a significant impact on strength properties. [9]

Avadhoot Bhosale et al. (2017) Foamed concrete can be called aerated concrete because of the gas being injected into it, which is determined by the strength requirements. A minimal amount of aluminum being in powdered form, when added with the cement reaction occurs, is one way to do this. The goal of this research was to see how the amount of powder in aerated concrete affected the mechanical properties of the material, according to the conclusion based on results, if the powdered aluminum content increment is there then the compressive strength and tensile strength reduction could be seen. Also, the decrement in the modulus of elasticity can be seen, but when the powdered content of aluminum increases, the increment of porosity increases but the density decreases. [10]

Chundakus Habsya et al. (2016) To see how fly ash affects the various properties like the mechanical & physical properties of the foamed concrete. The foam is required to lower the weight of the mixture by creating air spaces. To

make foam, the foaming ingredient incorporated in water and supplied pressure of the air was obtained using a foam generator. The various properties related to mechanical & physical decrease as the foam content increases. However, this causes it to absorb more water. Water absorption reduces as FA concentration rises, while physical & mechanical properties rise. [11]

2.3 Materials

R Karolina et al. (2017) The mechanical properties of LFC decrease as the foam content increases. However, this causes it to absorb more water. Water absorption reduces as FA concentration rises, while density, thermal conductivity, and compressive strength rise. Stone ash may be used up to 15% of the time in place of sand and still be considered safe. Curing should begin after the lightweight concrete brick has been in place for 7 days. The foaming agent utilized determines the efficiency of lightweight concrete bricks. Once the mold samples have been extracted, they should be kept in a dark, out-of-the-way location. If comparing the cost between the normal conventional brick it is costlier. [12]

Sajan K. Jose et al. (2020) Due to the depletion of naturally accessible resources, producing bricks at a fair cost becomes very difficult. Excavation of soil for the manufacturing of bricks may hurt the natural ecological equilibrium. Furthermore, the government prohibits the exploitation of river sand, resulting in a shortage of material for the manufacturing of concrete and concrete blocks. All of this has compelled academics to seek a greener option for constructing blocks that produces the least amount of environmental and resource damage. For the manufacturing of concrete blocks, foamed concrete may be used as a unique and versatile building material. [13]

Ashfaque Ahmed Jhatial et al. (2020) The increased usage of waste by-products as supplemental cementitious materials has resulted from the increased demand for thermal insulating construction materials as a result of the Urban Heat Island effect and the carbon footprint associated with concrete owing to its binder, cement (SCMs). A large variety of waste materials are available that might be used as cement replacements and aid in construction. Developing environmentally friendly concrete, on the other hand, would be expensive and time-consuming. Therefore, for detailed, time-consuming, and costly experimental research, computer simulation offers a cost-effective and time-saving option. The goal of this project was to use finite element modeling to evaluate the performance of environmentally friendly products. [14]

2.3 Replacement fibers

Fayas C. Subair et al. (2012) Due to its lower density, stability, and superior thermal insulation capabilities. For nonstructural uses, light-weighted foamed concrete (LFC) is now the most competitive material in the construction sector. This study aims to provide an alternative to traditional concrete blocks for non-structural masonry applications. The mechanical qualities of foamed concrete may be improved by adding steel fiber and substituting the sand with a readily accessible by-product, such as fly-ash. Under pure compression, the mechanical behavior of light-weighted foamed cubes and various other blocks were examined. The utilization of fly-ash in place of sand almost quadrupled the compressive strength of the concrete. [15]

Sharipudin, S.S. et al. (2012) Recent attempts to produce ecologically friendly building materials, with a special focus on the use of industrial waste materials in their creation for long-term development, have been very desired. As a result, foamed concrete is an alternative concrete with the ability to reuse waste ingredients. Waste paper sludge ash (WPSA), a locally plentiful waste substitute for the paper newspaper industry, is one of the industrial wastes that is gaining popularity these days. WPSA includes significant amounts of alumino-siliceous material and may be employed as just an innovative cement substitute material, according to previous investigations. Furthermore, massive amounts of concrete trash are being created worldwide as a result of contemporary population expansion and fast urbanization. [16]

Manjit Kaur et al. (2016) GGBFS i.e., Ground Granulated Blast Furnace Slag which is a by-product of the various industrial materials that is a new pozzolanic material that has gotten a lot of interest in terms of study and use. It is a non-metallic substance made mostly of calcium silicates and aluminosilicates generated in a blast furnace concurrently with iron and granulated by cooling the molten material in water or steam and air. [17]

Ali A. Aliabdo et al. (2016) To carry out the information regarding the usage of wastage glass powder derived from the grinding from smashed containers and destruction of buildings to make a powdered form of glass blended in cement. Glass powder's pozzolanic activity and the qualities of glass powder mixed cement was investigated. In addition, the physical and mechanical features of employing glass powder as a cement substitute and as a cement addition were investigated. In addition, using glass powder as a cement substitute improved the characteristics of glass powder-modified concrete. Finally, using fifteen percent glass powder as a cement additive raised concrete compressive strength by sixteen percent on average and produced better results than using cement alone. [18]

3.0 Materials

The foamed concrete brick consists of OPC cement of grade 53, sand, cement, water, and stable foam. Foam is generated from the foaming agent used at a variety of chemically available. Also, materials like sawdust and waste glass powder have been used in this study. Major materials are discussed below.

3.1 Foaming agent

A foaming agent is a substance that aids in the production of foam. The Foam generated through the foaming agent can be considered as a fundamental component, and it may be created using just a pre-foaming or a combined foaming approach. The concrete base mixed & wet-chemical foam are formed separately and then completely blended in the foam which is generated before, while the foam generating agent is supplied to a concrete base mix directly in the made by mixing foaming process.

Fig-2 Foam

During the mixing process, foam is formed, resulting in a cellular structure in concrete. Foam agents control the rate at which bubbles of air creates inside the mixture of cement paste, hence influencing the density of concrete.

Fig-3 Foaming Agent

3.2 Sawdust

Sawdust or also called wood waste is a substitute by-product of timber cutting activities such as sawing, milling, etc. It is made out of small wood shavings. Timber manufacturing creates a lot of waste, such as sawdust, wood shavings, and other materials, the majority of which are not recycled and instead dumped or burned in the open, badly damaging the environment without providing any economic advantages. Sawdust comes in a wide range of particle sizes, chemical compositions, densities, and colors. cellulose, hemicelluloses, lignin, and extractives are the main components.

Fig-3 Sawdust

3.3 Waste Glass Powder

Vast amounts of recycled glass are created each year across the world. Glass is disposed of in landfills as rubbish, which is wasteful since it does not decompose in the environment. The utilization of waste glass as a substitute replacement to cement could be a big step toward building a more environmentally friendly, energy-efficient, and cost-effective infrastructure.

Fig-4 Waste glass powder

4.0 Applications of Foamed Concrete Brick

Foam concrete has various properties like it is self-compacting concrete because it doesn't need compaction or vibration, also a reduction in density can be seen due to its lightweight, also it has good thermal conductivity and the flowability is also great in it, foamed concrete can be used in a variety of civil & structure filed due to its properties & applications. As it tends to withstand the load it can be used in various load-bearing & non-load-bearing structures. It is great in the use of acoustic construction.

4.1 Comparison Between Traditional Brick & Foamed Concrete Brick

Following is the comparison table between the normal traditional brick i.e., red bricks, and the foamed concrete brick:

PARAMETERS	BURNT CLAY BRICKS	FOAM CONCRETE BRICKS
Basic Raw Material	Agricultural soil, coal or wood for firing	Cement, sand, foam & water
Dry Density kg/m^3	1800-2000	300-600/ 800-1000 /1200-1600
Compressive Strength kg/cm^2 (N/mm^2)	30-80{10}	4-10 / 25-65/70-160 {17.5}
Applications	Load bearing & Non-load bearings	Thermal insulation, Partitions, Load & Non-load bearings
Compaction during production	Yes	None
Aging	No	Gain strength with age
Eco Friendliness	Process creates smoke, uses high energy, wasting agricultural lands	Pollution free, Green product, Least energy, Reuse of Industrial wastes

Table-1 Comparison Between red bricks & foamed concrete bricks

4.2 Advantages of Foamed Concrete Brick

Following are the advantages of foamed concrete brick:

1) It is light in weight. The adjacent sub-structure is not subjected to much vertical stress.
2) It has minimal heat conductivity and excellent sound insulation qualities that regular concrete lacks.
3) It can be resistant to freezing and thawing properties.
4) It is compaction-free.
5) Foamed concrete can also be readily pumped over a long distance with relatively little pressure.
6) Foam concrete is a substance that lasts a long time.
7) It has a low permeability coefficient.

4.3 Disadvantages of foamed concrete brick

Following are the advantages of the foamed concrete brick:

1) The physical properties of light-weighted foamed concrete decrease as the overall weight decreases.
2) foam concrete has a high amount of slurry paste in it due to no coarse aggregate, so the shrinkage will be high than the regular concrete.
3) Because it contains more cement than regular concrete. It gets overpriced.
4) Foam concrete takes longer to mix.

5.0 Conclusion

Following are the conclusions from the review study:

1) Foam concrete has adequate durability to be employed as a replacement resource in the construction process.
2) For lower density mixtures, the durability of foamed concrete brick is minimal. Because due to the significant decrease in total weight, structural frames, footings, and piles may be saved, and construction can be completed quickly and easily.
3) Due to the increase in gaps all across the material generated by foam, the weight is lowered, and the compression strength is lessened.
4) Foam concrete fills all cavities, spaces, and seams over a long distance without requiring vibration or compaction. It has a quick and easy installation process & strong heat insulation and air content. It offers strong thermal insulation, freeze/thaw qualities, and fire resistance.

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