

Masonry Materials for the Future: Comparison on Sustainability Factors of A Few Popular Masonry Materials

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ABSTRACT: The manifold increase in infrastructure developments and construction activities in the recent years has resulted in increased demand for building materials. This has led to depletion of natural resources causing threat to environmental balance. Uncontrolled exploitation of natural resources and excessive energy for manufacturing masonry materials is a serious environmental issue which has to be addressed. This paper focuses on a comparison on sustainability factors of various popular masonry materials used in construction industry in Kerala. The availability, efficiency, economic viability, embodied energy and sustainability of a few masonry materials are compared. The significance of efficient resource management of masonry material and need for a standardization is discussed. It has been found that most of the popular masonry materials are not in agreement in point of view of both sustainability and efficiency. Development of new standards for eco friendly, sustainable and economically viable masonry materials is very much significant.

KEYWORDS: Sustainable building materials, embodied energy, masonry materials

I. INTRODUCTION

Infrastructural development is a vital part of a Nations development. In a country like India which is standing second in population, the requirement for infrastructural facilities will keep on increasing. Construction industry is trying hard to meet this requirements. Demand for facilities increases, so do the demand for materials and resources. Utmost care should be taken while selecting the materials and technology for construction purposes as they should satisfy the technical requirements and also they should not leave any adverse mark on the environment. Climatic condition of the world is getting appalling day by day. As such the environmental and ecological parameters are given high priority in recent years. The mining, manufacturing and transporting of materials consumes lot of energy and also contribute much to the green house gases. The quantification and study of energy requirements for manufacturing and processing of different building materials, the CO₂ emission and effects on environment have been studied by Reddy and Jagadish [1], Buchanan and Honey [2], Suzki et al. [3], Oka et al.[4] and Debnath et al. [5]. In India, construction industry is responsible for the major input of energy resulting in largest share of CO₂ emission (22%) into the atmosphere [6]. Cement (> 75 million tonnes per annum), steel (> 10 million tonnes per annum), bricks (> 70 billion per annum) are the largest and bulk consumption items in Indian construction Industry in 2000 [1]. Concentrating more on sustainable materials and technologies could reduce the adverse effects on environment and reduce the energy usage. This paper presents a comparative study on sustainability factors of different popular masonry materials in Kerala and also discusses about the importance of efficient resource management.

II. SIGNIFICANCE OF THE STUDY

It is estimated in 2020 the demand for bricks will rise to about 89 billion [7] and subsequently, the CO₂ emission due to increase production of bricks will be huge. Also the natural resources available are exploited in an uncontrolled manner and the energy usage for this is very high. The conventional materials and technology used for masonry are older and uneconomical. Common man finds it difficult to meet the increasing cost of these conventional materials as

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the materials are scarce and production cost is high. Usage of alternate and composite building materials has a future in construction industry in view of sustainability and economy. Awareness of need of sustainable building materials among people is necessary.

III. SCOPE OF THE STUDY

Energy consumption for manufacturing of different masonry materials (embodied energy) is different in each depending on the type of material used, process of extraction of material, technique of manufacturing etc. The CO₂ emission into the atmosphere is also dependent on all the above mentioned factors. The choice of a building material obviously depends on the cost also. Also the availability of the material in the neighboring locality is another factor of concern. Transporting building materials from distant places is least preferred. In study deals with comparison of different popular masonry materials in Kerala considering the following aspects:

1. Economic viability
2. Embodied energy

The significance of alternate sustainable materials are discussed and it is hoped that the information in the paper will help people to choose the right building material considering the overall efficiency and environmental protection.

IV. MASONRY MATERIALS

Masonry materials is the most abundantly required building material in a construction site. The material may be load bearing or non-load bearing depending on the material used and technique of manufacture. There are many types of masonry materials available in the market. Five types of materials are considered for this study.

A. LATERITE BLOCK

Laterite is a tropical weathered rock occurring worldwide, existing abundantly in parts of India. It is a masonry material predominantly used in western coastal area of India that includes Goa, Karnataka and Kerala. Laterite is generally used as a load bearing masonry material which is widely used in Malabar area of Kerala. Laterite is a rock which hardens as it is exposed to atmosphere. Laterite mining was done manually with axe previously, but new power cutting machines are developed for easy cutting and to get equal sized blocks. They are usually obtained in a size of about 330mmx200mmx200mm. Laterite blocks are heavy (about 35 to 40 kg) and this makes it difficult for masons to work with laterite. They contain mineral oxides of Iron and Aluminium. Laterite is generally reddish in color. As it is cut into required shape and size manually, thermal energy requirement for manufacturing of blocks is negligible. However, transportation cost is to be considered for the transportation of material from mining site to construction site. The expenditure for production of laterite blocks include the land cost, labor for excavation and labour for shaping and sizing. There is no need of transportation cost as the blocks are made from the mining site itself.

B. STONE BLOCK

Natural stones are of great use in construction industry in India. They are used as masonry material, foundation material etc. Stone blocks are generally obtained by breaking huge natural stones into smaller sizes. Stone blocks are usually available in sizes of 180mmx180mmx180mm and this size blocks are used for masonry purposes. The sizing is done manually. But the breaking of huge size natural blocks are sometimes done with the help of detonators. Hence, thermal energy required for manufacturing is very less. However, transportation cost is to be considered for the transportation of material from mining site to construction site. The expenditure for production of stone blocks include the quarry land cost, labor and machinery for breaking of huge natural stones and also labor for shaping and sizing. There is no need of transportation cost as the blocks are made from the mining site itself.

C. BURNT CLAY BRICKS

They are the most common masonry material used in India. It is estimated that about 70 billion bricks are produced annually. They are available in different sizes like 230mmx105mmx70mm, 200mmx90mmx90mm etc. They are manufactured from red clay. Manufacturing process involves high thermal energy for burning of bricks. Coal, coal

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cinder, firewood etc are commonly used as fuels for burning. For a size of 230mmx105mmx70mm, each brick requires 0.20 kg of coal or 0.25 - 0.30 kg of firewood for the burning process. This is equal to a thermal energy of 3.75 - 4.75 MJ per brick [1]. an average of 4.25 MJ per brick has been considered for the comparison of energy content of buildings. The expenditure for production of burnt clay bricks includes cost of clay and water, labor for mixing and moulding, cost of fuel and labor for high temperature burning of mix. Transportation charge of the materials from the extraction site to the moulding place also adds to the cost and expenditure.

D. SOIL-CEMENT BLOCKS

Soil- cement blocks are manufactured by pressurized pressing of wet soil-cement mixture in required sized mould. Mechanized pressing units and manual pressing units are available. Soil-cement blocks produced by employing manually operated machines in a highly decentralized fashion have become increasingly popular in India and elsewhere. [9,10]. As cement content is present in the blocks, the energy content depends on the cement percentage used. The thermal energy of cement is 5.85 MJ/Kg. Load bearing soil cement blocks will have a cement content of about 6 - 8%. Such blocks will have an energy content of 2.75 - 3.75 MJ per block of size 230mmx190mmx100mm [1]. The expenditure for production of soil - cement blocks contains the cost of materials which includes soil, cement and water, labor and machinery cost for mixing and moulding, and curing charges. Transportation charge of the materials from the extraction site to the moulding place also adds to the cost and expenditure.

E. HOLLOW CONCRETE BLOCKS

Hollow concrete blocks, generally called as hollow blocks are light weight blocks manufacture by pressing concrete of 6 -10mm coarse aggregates in sized moulds. Hollow concrete blocks are non-load bearing blocks used generally for partition and for masonry works of multi- storeyed buildings in India. Similar to soil cement block, the energy component of hollow concrete blocks depends on the cement content. Also the energy for crushing coarse aggregates to required size will also add to the total energy. Cement percentage of hollow concrete block is generally 7 -10% by weight. Hollow concrete blocks are usually available in size 400mmx200mmx200mm and the energy content of the block is 12.3 - 15.0 MJ. The expenditure for production of hollow- cement blocks contains the cost of materials which includes coarse aggregates, fine aggregates, cement and water, labor and machinery charges for mixing and moulding, and curing charges. Transportation charge of the materials from the extraction site to the moulding place also adds to the cost and expenditure.

The energy content of the above mentioned masonry materials are given in table 1. The table contains details of type of blocks, size of blocks, energy content of the specified size, energy per brick equivalent and percentage of energy with respect to brick energy [1]. All bricks are of different sizes and for easy comparison they have been normalized by referring to an equivalent size. Equivalent size is chosen as 230mmx105mmx70mm.

TABLE 1: Energy in masonry blocks

Type of Block	Size (mm)	Energy in one block (MJ)	Energy per brick equivalent	Block energy %
Laterite Block	330x200x200	0	0	0
Stone Block	180x180x180	0	0	0
Burnt clay bricks	230x105x70	4.25	4.25	100
Soil cement blocks	230x190x100	3.5	1.35	31.7
Hollow concrete blocks	400x200x200	15	1.62	38.1

The following things are clear from data in the table:

1. Laterite blocks and stone blocks do not consume any energy in their production.
2. Burnt clay bricks consumes the highest energy during production.
3. The energy consumption by soil-cement block and hollow-concrete block is almost same with hollow concrete block having a little high value. Both comes to about 30 to 40% of burnt clay bricks.

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Fig. 1. Laterite blocks.



Fig. 2. Stone blocks



Fig. 3. Burnt clay bricks



Fig. 4. Soil-cement blocks



Fig. 5. Hollow-concrete blocks.

V. CONCLUSION

The embodied energy and factors affecting the cost and expenditure of different masonry materials has been discussed in this paper. The broad conclusions arrived after the study are as follows:

1. Stones which are formed naturally in nature are more energy efficient than other manufactured bricks. i.e. laterite blocks and stone blocks have zero embodied energy in their manufacturing process. But the availability of such natural materials in bulk quantities to meet the demand of the present world is impossible. The resources are depleting day by day and the formation of hard laterite takes years.
2. Burnt clay bricks has the highest embodied energy as compared to other masonry materials in the process of manufacturing. For a volume as less as 0.0017 M^3 of burnt clay brick, the energy is 4.25 MJ. That implies that the energy for 1 M^3 of burnt clay brick consumes 2500MJ of energy for production only.
3. Soil cement bricks are the most energy efficient masonry material among the artificially manufactured items. Their embodied energy is only about 30% of the embodied energy of burnt clay bricks. Cement content is the major reason for the consumption of energy in the manufacturing process. Energy can be considerably reduced if the cement content is decreased. New technologies has to be developed or new binding materials with lesser energy consumption has to be introduced as an alternative to cement.
4. Energy consumption of hollow concrete blocks are comparable with that of soil cement blocks. But the availability and production of raw materials for concrete is a challenge. Also requirement of cement adds to embodied energy. Use of energy efficient materials reduces the embodied energy to a considerable amount.
5. Environmental impact on mining, excavation, burning etc. has to be addressed during the manufacture of masonry blocks. High volume of CO_2 , which is a green house gas, is produced in such activities. Atmospheric pollution caused by this is a threat to eco system. Also production of high energy materials which requires fuel and raw materials causes depletion of non renewable natural resources.
6. Most of the masonry materials available in the market are uneconomical. The main reasons are that the raw materials are scarce and costly. Natural resources is depleting and demand is more. Also Cement content has a direct impact on the cost of masonry materials.
7. Need for standardization of masonry material is very much significant. The embodied energy has to be reduced as much as possible. Materials has to be energy efficient, economical, sustainable and structurally stable. Selection of materials has to be done considering all the mentioned factors.

The above conclusions give useful information in selecting masonry materials wisely such that the material is sustainable and efficient. Even though the study is concentrated on materials popular in Kerala, the situation and the results obtained is almost similar in all parts of India and even around the globe.

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