OPTIMIZATION OF ENERGY IN PUBLIC BUILDINGS

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Abstract

Building construction and infrastructure industry is one the fastest developing industry and a major energy consuming sector in general. Public buildings which consists schools, colleges, corporate offices, government offices which are growing day by day, they require tremendous amount of energy resources for construction of buildings for utilization of service. This paper mainly focuses on the embodied energy of materials used in construction of college building located in Badlapur (West), Kalyan city of Thane district in Maharashtra and comparision is done with different alternative materials in order to reduce the energy of building.

***Keywords**: Energy Optimization, Public Buildings, Embodied Energy, Alternative Materials.*

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1. INTRODUCTION

The public buildings which include schools, colleges, and offices consume a considerable amount of energy and other natural resources. Buildings in India consume about 20% of the country's total electricity and have a significant impact on the environment and resources indicating the need to develop green buildings .Our country is witnessing tremendous growth in construction sector,so here it is considered to be one of the largest economic activites which grows at an average rate of 9.5% as compared to global average rate of 5%[4]. Use of those construction materials which are posing threat to the environment are also growing at a alarming rate . So construction industry therefore needs to contribute towards preserving environment. Minimising the consumption of the conventional materials by using alternative materials , methods & techniquies can result in scope for considerable energy savings as well as reduction of CO_2 emission[1]. A large quantity of CO_2 is emitted to the atmosphere through whole life cyce of a building , so choice of building material is very important in reducing the energy content of building

2. ALTERNATIVE BUILDING MATERIALS

The art and science of building construction commeneced with the use of natural materials like stone , soil ,leaves[2].Materials for earthen construction such as hydrated lime ,clay ,mud bricks compressed earth block sand rammed earth have been known and used many years allover the world .There is a growing interest in these Building materials as sustainable alternatives to traditional bricks, concrete and wood [4]. A high proportion of this energy is used to produce a small number of key materials such as concrete, mortar, plaster and bricks. The highest energy is used in the manufacture of aluminum, copper, stainless steel and plastics (primary energy requirements for production very from 250 Giga Joules (GJ)/ ton to 100 GJ/ton) followed by glass, cement and plaster boards (primary energy requirements for production vary from 60GJ/ton to 10GJ/ton). The energy embodied in a building is estimated to vary between 15 and 20 years of its energyconsumption in use[8].

3. EMBODIED ENERGY

The energy in buildings may be divided into two category Embodied energy and operational energy. Embodied Energy is the energy requirement to construct and maintain the premises for example, to construct a brick wall, the energy required to make the bricks, transport them to site, and lay them. Operational energy is the energy requirement of the building during its life from commissioning to demolition for example, the energy used to heat and cool the premises, run the equipments and light rooms .To calculate the energy consumption by public building, a college building is taken as case study which consists of two buildings of G+1 R.C.C. framed structure located in Badlapur near city of Kalyan in Thane district of Maharashtra state. The existing public building considered in this paper as an engineering institution having a total built up area of around 3701.2 m^2.

Energy consumption of any building depends upon the usage of building for which it is constructed i.e. the service which it provides to the people. This paper deals with the educational structure which consists of classrooms, laboratories, and machines etc. During the construction of structure the materials which are used for building requires huge amount of energy while manufacturing, transporting, assembling, installation and destruction of some structures if needed. This energy is termed as embodied energy of materials and Operational Energy is the total energy which is needed for maintenance of the building services during the entire life cycle of structure. Estimated embodied energy in the material is shown in Table 1 and Table 2 shows energy consumption per person and per square meter of the building and embodied energy index considering 150 personnel working at any moment of time.

4. METHODOLOGY ADOPTED

Methodology adopted for optimization of energy for college building is as follows:

- Estimation of energy and carbon emission of building material.
- Cost estimation of material used.
- Comparison with alternative materials for energy, carbon emission and cost.
- Selection of best option.

Table 1 Embodied energy coefficients

Material	**Energy**	**Type of Energy**
Clay Bricks	(3.75-4.75)per brick[1].	Coal /Wood /Rice Husk
AAC Blocks/Hollow Concrete blocks	(1.3-1.62)per brick[1]. (3.5)per brick[7]	Coal +Electricty
Fly ash Bricks	(1.00-1.35) /per brick[2].	Coal +Electricty
Cement	(4.2 -5.85)MJ/KG[1].	Coal +Electricity
Ceramics	180MJ/SQM[7].	Diesel
Kota	79.8MJ SQM[9].	Fuel oil
Terrazzo	92.7MJ/SQM[9].	Fuel oil

Table 2 Energy Estimation of Building (Case Study)

Sr. No.	**Material**	**Unit**	**Total Quantity**	**Total Embodied Energy (MJ)**
1	Brick	Number	225000	954000
2	Cement	Bag	28865	873166
3	Aggregates	Cu.m.	5660	848943
4	Sand	Cu.m.	849	22277
5	Steel	Kg.	350000	14735000
6	Paint	Sq.m.	6550	45522
7	Aluminium	Kg.	2000	340000
8	Glazing	Kg.	1000	1480
9	Ceramic tile	Sq.m.	6659	1198620
Total embodied energy for an engineering college building				19019008

Table 3 Energy Index

Sr. No.	**Embodied Energy**	**Embodied Energy (MJ)**	**Embodied Energy (kWh)**
1	Total Embodied Energy in all materials of the building	19019008	5135132
2	Energy Consumption per person	126793	34234
3	Energy consumption per square meter	2535	685

Table 1, 2, 3 depicts energy coefficients values and total energy estimation of said building and energy index respectively.Figure 1, 2 and 3 shows materials which have been used in the construction and is compared with the alternative energy efficient materials which have low embodied energy, carbon emission and cost. Table 4, 5 and 6 shows embodied energy, carbon emissions and cost of different materials of brick, cement and tile material. For brick masonry three options have been considered i.e. clay bricks which is normally used, fly ash bricks and autoclave aerated bricks (AAC). Figure 1 shows that cost of clay bricks is more as compared to fly ash bricks but is less costlier than AAC Blocks. Cement of two types are considered in this study i.e. ordinary Portland cement (OPC) and Portland pozzolana cement (PPC). It was observed that OPC has a higher embodied energy value than PPC and same is shown in Figure 2. When tiles are considered it was observed that ceramic tiles have higher energy value as well as higher cost compared to terrazzo tiles (Figure 3). Avg of Standard values of embodied energy and carbon emission in material (MJ/M3) are considered [1]. Cost of material is considered as per the local rates for locally available material.

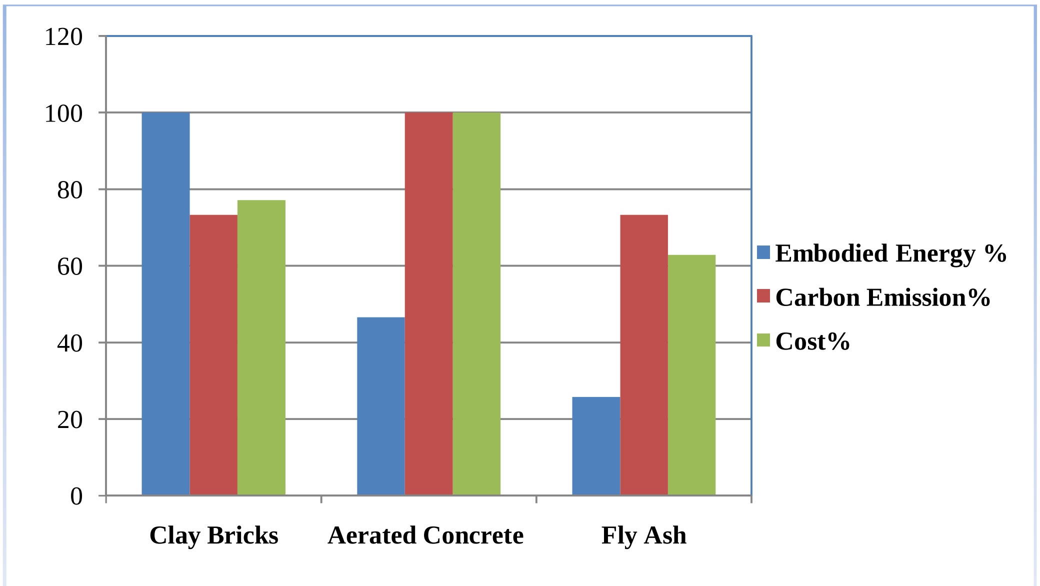

Figure 1. Embodied energy, carbon emission and cost of brick material

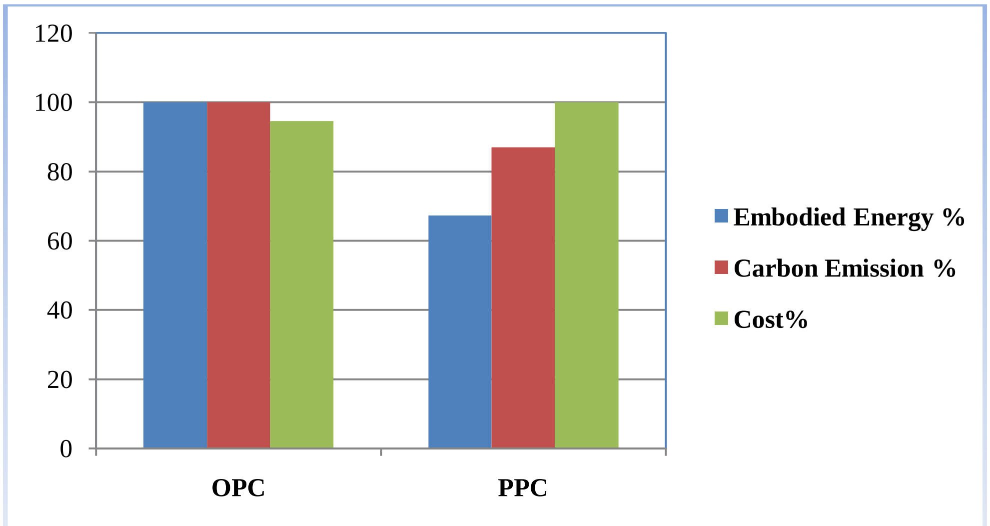

Figure 2. Embodied energy, carbon emission and cost of cement material

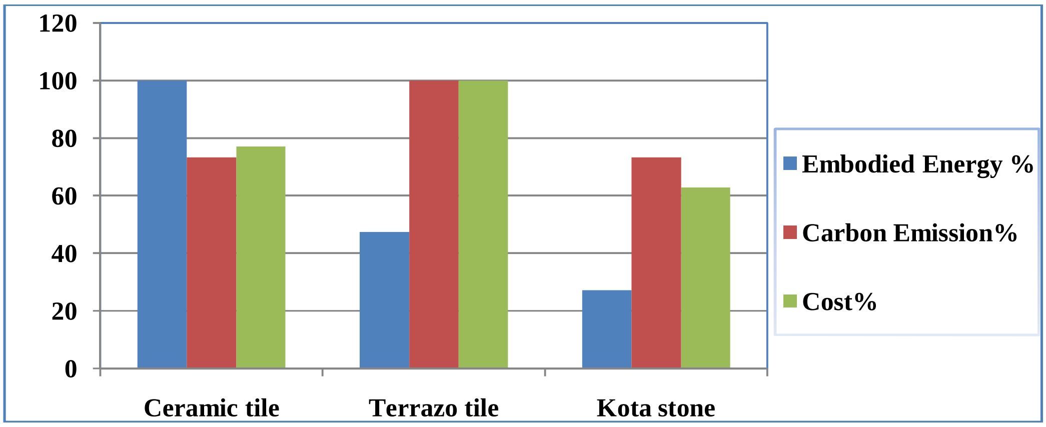

Figure 3. Embodied energy, carbon emission and cost of tiles

Table 4. Embodied energy and carbon emission and cost in bricks

Sr No.	Types of bricks	Quantity (Cu.m.)	Embodied energy (value) (MJ/M^3)	Embodied energy (MJ/M^3)	Carbon emission (CO_2/Kg)	Cost/ cum
1	Clay bricks	436.89	3950	1725715.5	96.11	2700
2	Autoclave aerated concrete blocks	436.89	2150	939313.5	131.067	3500
3	Fly ash	436.89	1020	445627.8	96.11	2200

Table 5. Embodied energy, carbon emission and cost of cement

Sr. No.	Types of cement	Quantity (Cu.m.)	Embodied energy value (MJ/M^3)	Embodied energy (MJ/Sqm)	Carbon emission (Kg /CO_2)	Cost /cum
1.	OPC	1010.275	840	848631	939.555	260
2.	PPC	1010.275	565	570805.37	818.322	275

Table 6. Embodied energy, carbon emission and cost of tile

Sr. No.	Types of tiles	Quantity of Tile (Sq.m.)	Embodied energy value (MJ/SQM)	Total embodied energy (MJ/Sq.m.)	Carbon emission (Kg /CO_2)	Cost per Sq.m.
1.	Ceramic tiles	3329.59	180	599326.21	2463.896	1200
2.	Terrazzo tiles	3329.59	92.7	308652.99	399.55	700
3.	Kota stone	3329.59	79.8	265701.82	299.66	1000

CONCLUSIONS

In this study embodied energy of a college building is estimated for different material. Comparision of embodied energy, carbon and cost of different material used is done with the traditionally used material. Based on the analysis of energy reduction of building materials by using available alternative material following conclusions are drawn.

- Total embodied energy of college building was found to be 19,01,9008 MJ for all materials.
- The use of flyash bricks if replaced by clay bricks saves around 1288825 MJ and reducing consumption of energy by around 74.6% and also cost decreases by 14% and reduction in carbon emissions by 26.6%
- AAC blocks reduces energy consumption by 45% but cost increases by 39%.
- The use of PPC over OPC reduces energy consumption by 33 % and carbon emissions by 13% with cost increament of 6%.
- The use of Kota stone reduces energy consumption by 7% and carbon emissions by 1.6% when compared to Terrazo tile with increase in cost by 13%.

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