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"View towards the Use of Energy Efficient Materials for Construction of Rearing House and Poultry House"

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Abstract

During a silkworm's and bird's life cycle, for maintaining ambient environment, operational energy services including heating, ventilation, air-conditioning, lighting, equipment and appliances etc. contribute to large amount of energy consumption. The presented research work focuses on the selection of energy efficient materials over the conventional materials for satisfying the energy demand in the silkworm rearing house and broiler poultry house. Energy efficient materials can support the constructions both ecologically and economically because of their environmental positive features as well as consuming less energy. For this reasons, taking energy efficient properties into account together with many criteria it is important to select the proper energy efficient material at the beginning of the design.In order to promote alternative energy efficient building materials, it is essential to evaluate the total performance of such materials in terms of strength, durability, cost, embodied energy and the environmental concerns. Hence in this research a comparison of traditional materials and energy efficient materials has been made. Different parameters of conventional materials and energy efficient materials like embodied energy, thermal conductivity, environmental impact, economy etc. has been discussed and compared. It has been shown that energy efficient materials are more suitable than the conventional materials.

Keywords:Broiler poultry house, Embodied energy, Energy efficient materials, Environmental impact, Silkworm rearing house, Thermal conductivity.

1. Introduction

The technological breakthrough in sericulture and poultry industry is a vital component of development of sericulture and poultry farming in the country. Sericulture is an agro-cottage, forest based industry, labour intensive and commercially attractive economic activity falling under the cottage and small-scale sector. India is the secondlargest producer of silk in the world[1]. It has been known as employment oriented industry [2]. As per the increased demand of Indian silk in domestic as well as global market effective rearing of silkworm is

must. Hiware Chandrashekhar Jalba [3] have studied present scenario of sericulture in Maharashtra state. In this study we come to know that the problems of sericulture industries such as open rearing without proper disinfection, hygiene and proper climate is not maintained during rearing which leads to disease outbreak and production losses.

The poultry sector in India has undergone a paradigm shift in structure and operation from a mere backyard activity into a major commercial agri based industry over a period of four decades. The poultry industry in India was mainly a backyard venture before the 1960s [4] and has been changed into an exciting agribusiness. India is the third largest egg producer in the world and the fifth largest broiler producer [5]. Hence commercial poultry farming is very necessary to meet up the demand of animal nutrition by means of eggs and meat. Poultry farming creates income and employment opportunities for the people.

The combined effect of temperature, humidity and proper ventilation, lightening largely affects on the satisfactory growth of the silkworm in rearing house and layers or broilers in poultry house. It directly influences the physiological functions of the silkworms and chickens. For maintaining ambient environment, amount of energy required for silkworm rearing house and poultry house is more.Catherine Baxevanou et al., [6] have conducted research in order to identify the energy consumption in poultry. The interest in energy consumption in poultry began due to energy crises. According to conducted research, large amount of energy is consumed for internal climate adjustment and for the operation of production equipment. Economy of Silkworm rearing house and broiler poultry house is depend on energy consumption as well as production. In current scenario cost of energy consumption is more hence to balance the economy, energy efficient structure plays important role. Energy efficiency of structure is achieve by minimising the consumption of the conventional materials by using alternative energy efficient materials.Energy efficient materials can support the constructions both ecologically and economically because of their environmental positive features[7]. Moreover, materials consuming less energy at the same time causes less harmful emissions and decrease the environmental pollutions resulted from the construction materials. Furthermore, with their various thermal properties like heat storage, heat retention they make contribution to the creation of comfort in indoor environment [8].For this reasons, taking energy efficient properties into account together with many criteria it is important to select the proper energy efficient material at the beginning of the design.

Izzet Yuksek [7] have discussed the amount of energy consumed by conventional materials used in construction during their life cycle is an important parameter in determining the energy efficiency of the structure. Therefore, the selection of building material and energy efficient features of building materials are important parameters for the provision of energy efficiency. In order to promote alternative energy efficient building materials, it is essential to evaluate the total performance of such materials in terms of strength, durability, cost, embodied energy and the environmental concerns. Chetan S. Dhanjode et al., [9] have analysed the conventional and non-conventional materials on cost, energy consumption and carbon emission parameters helps in highlighting suitable options for energy efficient construction. B.V. Venkatarama Reddy and K.S. Jagadish [10] have analysed that total embodied energy of load bearing masonry buildings can be reduced by 50% when energy

efficient building materials are used. They have also given a useful tips for selecting an energy efficient building materials leading to considerable reduction in embodied energy of the building as a whole.

Hence in this research traditional materials and energy efficient materials used for the construction were studied, compared and selected. The objective of this study is to compare traditional materials and energy efficient materials used for the construction and select suitable energy efficient materials.

2. Methodology

The aim of this investigation was to reduce the energy consumption by using different energy efficient materials within the broiler poultry farm and silkworm rearing house. To achieve this aim, the methodology followed is listed as below.

2.1. Data Collection: The survey carried out in western Maharashtra. The following details collected from existing traditional broiler house and silkworm rearing house:

Materials used for the construction: It was constructed as per the conventional method i.e. construction using earthen bricks, clay bricks, OPC cement, wire mesh, shed net, bamboo, aluminium or light metal sheet, wire mesh floor etc.

2.2. The traditional materials and energy efficient materials were used and comparison was carried out.

2.3. Selection of suitable energy efficient materials for the broiler poultry farm and silkworm rearing house: Taking embodied energy, thermal conductivity, environmental impact and economy into account energy efficient materials was selected for better efficiency of structure.

3. Results and Discussion

In energy efficient building design, the use of energy efficient building materials is very significant since the construction materials can positively support the construction in which they are used by reflecting their environmental features with their all other features into the construction. For this reason, for energy saving, it is important to select energy efficient building materials in the beginning of design. Hence in this research traditional materials and energy efficient materials used for the construction were studied and compared.

3.1. Comparison between Tradition Materials and Energy Efficient Materials:

3.1.1. In this research study, the conventional materials and energy efficient materials have been compared by using parameters such as embodied energy, thermal conductivity, environmental impact and economy etc. Here we have figure out that how energy efficient materials are superior to the conventional materials in terms of overall energy saving criteria, thermal conductivity as well as eco-friendly nature of the materials.

3.1.2. The general information of conventional and alternative building materials were found out from data collected from various building material manufacturing industries, material suppliers and material manual. The technical data like embodied energy, dry density,compressive strength and thermal conductivity were found from building material codes and standards.

Table 1. Comparison between Ordinary Portland Cement (OPC) and Pozzolana Portland Cement (PPC)

Parameters	Ordinary Portland Cement (OPC)	Pozzolana Portland Cement (PPC)
General	OPC is produced simply by grinding limestone and secondary materials to a powder.	Pozzolana materials namely fly ash, volcanic ash added to the OPC so that it becomes PPC.
Embodied Energy	7.36 MJ/Kg [10-11]	4.09 MJ/Kg [10-11]
Environmental Impact	• It is not a green product. • More amount of CO2 is emitted during the manufacturing.	• Eco-friendly material. • Less amount of CO2 is emitted during the manufacturing.
Durability	OPC has higher permeability and as a result it has low durability.	PPC has lower permeability and as a result it has high durability.
Workability	Lower workability.	Higher workability.
Curing Period	Curing period is less.	Curing period is little higher than OPC.
Cost	• OPC is costlier than PPC. • 300-350/bag	• PPC is cheaper than OPC • 210-230/bag

- The data shown in above Table 1. were used conveniently for making selection of PPC on the basis of energy content, environmental impact and economy.
- After comparing Ordinary Portland cement and Portland Pozzolana Cement it was observed that Portland Pozzolana Cement is 23% cheaper than former one and saves energy to an extent of 44%.

Table 2. Comparison between Clay Brick, AAC Block, Fly Ash Brick and Solid Concrete Block

Parameters	Clay Brick	AAC Block	Fly Ash Brick	Solid Concrete Block
General	Clay material used in masonry construction.	Light weight building blocks cut into masonry blocks.	Fly ash brick made using fly ash.	Precast concrete block which are primarily made from cement and fine aggregate.
Embodied Energy	2100-2500 MJ/ m^3 [10-11]	550-625 MJ/m^3 [10-11]	1250-1550 MJ/m^3 [10-11]	515-550 MJ/m^3 [10-11]
Dry Density	1600-1920 Kg/m^3 (Varies according to class of brick) [12-13]	550-900 Kg/m^3 (Varies according to grade of block) [12-13]	1700-1850 Kg/m^3 (Varies according to class of brick) [12-13]	1800-2200 Kg/m^3 (Varies according to grade of block [12-13]
Compressive Strength	3.5-7.5 N/mm^2 [12-13]	2-7 N/mm^2 [12-13]	7.5-9 N/mm^2 [12-13]	4-5 N/mm^2 [12-13]

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Water Absorption	Water absorption of brick should not be more than 20% of its weight.[12-13]	Water absorption of block should not be more than 10% of its weight.[12-13]	Water absorption of brick should not be more than 15-20% of its weight.[12-13]	Water absorption of block should not be more than 10% of its weight.[12-13]
Thermal Conductivity	0.6-1.0 W/mK [14]	0.13-0.19 W/mK [14]	0.3-0.4 W/mK [14]	0.7-1.28 W/mK [14]
Mortar Consumption	Require more mortar due to irregular surface and more number of joints.	Require less mortar due to flat and even surface and less number of joints.	Require less mortar due to flat and even surface and less number of joints.	Require less mortar due to flat and even surface and less number of joints.
Environment-al Impact	• It is not green product. • More amount of CO_2 is emitted during the manufacturing.	• Waste of the AAC block is recycled and used again. • Less amount of CO_2 is emitted during the manufacturing.	• It utilize fly ash waste which is generated from thermal power plants. • Very less amount of CO_2 is emitted during the manufacturing.	• Eco-friendly to environment. • Less amount of CO_2 is emitted during the manufacturing.
Cost	They are cheaper to other masonry units. However, overall cost is more, as it requires more mortar.	Individual block is expensive, but overall cost of masonry is low, as it consumes less mortar and less number of block as compared to clay brick.	They are cheapest to other masonry units. However, overall cost is more, as it requires more mortar.	Individual block is expensive, but overall cost of masonry is low, as it consumes less mortar and less number of block as compared to clay brick.
Price per Brick or Block	Rs. 7-8	Rs. 40-50	Rs. 5	Rs. 30

Table 3. Comparison between Hollow Concrete Block, Stabilized Mud Block and Soil Cement Block

Parameters	Hollow Concrete Block	Stabilized Mud Block	Soil Cement Block
Raw Materials	Portland cement, aggregate, sand, fine gravel and fly ash.	Soil, sand, water, stabilizer, straw or other fibres.	Soil or raw earth, water, cement, sand, crushed stone dust.
Embodied Energy	450-500 MJ/m^3 [11,15]	150-200 MJ/m^3 [11,15]	535-600 MJ/m^3 [10-11]

Dry Density	750-1200 Kg/m^3 (Varies according to grade of block) [12-13]	1700-2200 Kg/m^3 (Varies according to grade of block) [12-13]	1700-1900 Kg/m^3 (Varies according to grade of block) [12-13]
Compressive Strength	2.8-7.5 N/mm^2 [12-13]	3.5-7 N/mm^2 [12-13]	4-7 N/mm^2 [12-13]
Water Absorption	Water absorption of block should not be more than 15-20% of its weight.[12-13]	Water absorption of block should not be more than 10-11% of its weight.[12-13]	Water absorption of block should not be more than 8-10% of its weight.[12-13]
Thermal Conductivity	0.5-0.7 W/mK [14]	0.81-1.0 W/mK [14]	0.84-1.2 W/mK [14]
Mortar Consumption	Require less mortar due to flat and even surface and less number of joints.	Require more mortar due to irregular surface and more number of joints.	Require less mortar due to flat and even surface and less number of joints.
Environmental Impact	• Eco-friendly to environment. • Less amount of CO_2 is emitted during the manufacturing.	• Eco-friendly to environment. • Less amount of CO_2 is emitted during the manufacturing.	• Eco-friendly to environment. • Less amount of CO_2 is emitted during the manufacturing.
Cost	Individual block is expensive, but overall cost of masonry is low, as it consumes less mortar and less number of block.	Individual block is expensive, but overall cost of masonry is low.	Individual block is expensive, but overall cost of masonry is low, as it consumes less mortar.
Price per Brick or Block	Rs. 35-40	Rs. 20-25	Rs. 9-10

- The following points were observed fromdata given in the Table 2. and Table 3.:

1. Clay brick, Fly ash brick and Soil-cement block have higher thermal conductivity and consumes maximum amount of energy among the alternatives as shown in the tables.
2. Stabilized mud block is most energy efficient block consuming only 7% of clay brick energy but thermal conductivity of block is very high.
3. Hollow concrete block and Solid concrete block are also energy efficient, consuming only 18.5% and 21.32% of clay brick energy respectively but thermal conductivities are more than AAC block.
4. AAC block consuming 22% of clay brick energy and thermal conductivity of block is very low.
5. The data shown in above tables were used conveniently for making selection of AAC block for wall construction on the basis of energy content, thermal conductivity, environmental impact and economy.

Table 4. Comparison between Incandescent Light Bulbs, Compact Fluorescent Light (CFL) and Light Emitting Diode (LED) Bulbs

Parameters	Incandescent Light Bulbs	Compact Fluorescent Light (CFL)	Light Emitting Diode (LED) Bulbs
Electricity Used (equal to 60W bulb □800 lumens)	60 W	13-15 W	6-8 W
Lumens per Watt	14	62	84
Saving	-	Upto 70% a year in energy cost.	Upto 80% a year in energy cost.
Life (in hrs.)	1200	8000	25000-30000
Bulbs needed for 25000 hours of use	21	3	1
Average cost per bulb	Rs. 70	Rs. 150	Rs. 300
Equivalent 25000 hours bulb expenses	Rs. 1470	Rs. 450	Rs. 300
KWh of electricity used over 25000 hours	1130	350	200
Cost of electricity (at Rs. 10.5 per KWh)	Rs. 11900	Rs. 3640	Rs. 2100
Total estimated cost over 25000 hours	Rs. 13370	Rs. 4090	Rs. 2400
Energy Efficiency	No energy efficient.	Energy efficient.	More energy efficient.
Cost	Low	Comparatively less	High
Durability	Not durable.	Fragile i.e., glass can be broken easily.	Highly durable.
Heat	It gets heated up very quickly.	It gets heated up quickly.	It remains cool.
Reuse And Recycle	Can't be recycled.	Can't be recycled.	The most notable feature of LED bulbs is that they can be recycled.

- The data shown in above Table 4. were used conveniently for making selection of LED bulb on the basis of energy efficiency, durability, savings and economy.

Table 5. Comparison between Aluminium Panel Plain Glass, Low-E-Glass (Low Emissivity Glass) and Double Glazing Glass

Parameters	Aluminium panel plain glass	Low-e-glass (low emissivity glass)	Double glazing glass/ Insulated glazing unit (IGU)
General	-	Low-e-glass has a special coating that reflects infrared radiation (heat) while still allowing light from the visible spectrum to pass through.	It is two sheets of glass that come as a sealed unit with a small air gap in between. The air gap acts as a buffer between the two materials that reduce the flow of heat energy through the IGU.
Durability	Less durable as compared to low e glass and double glazing glass.	Increases durability of glass as it provide protection against dirt and sand.	More durable as it provide protection against dirt and sand.
U value	5.8-6.8 W/m^2K [14] It has a high U-value because it loses heat and cold easily.	3.6 W/m^2K [14]	1.8-2.6 W/m^2K [14]
SHGC (solar heat gain coefficient)	0.86 [14]	0.51 [14]	0.75 [14] SHGC is 47% higher than low-e-glass.
Climatic Performance	• Aluminium is good thermal conductor which basically means that aluminium windows may not work well in cold climates as heat will be lost through the frame. • The aluminium panel plain glass provide inferior performance than low-e-glass and double glazing glass.	• Heat from the outside is kept out, reducing cooling load during the summer, and heat from the inside is kept in, preventing heat loss during the winter. Hence it is suitable for all climatic conditions. • Low-e-glass provide better performance than single and double glazed glass. So it is	• Double glazing is very good at reducing heat flow, this works to keep heat inside a building in winter but also to reduce heat flow into a building in summer. • As a SHGC higher than low-e-glass, it is not extensively used in all climatic conditions.

		extensively used in cold climates.	
Daylight effect	The aluminium panel plain glass lets in very less daylight.	The low-e-glass lets in less daylight than double glazing glass.	The double glazing lets in more daylight than low-e-glass that's a 35% increase in daylight
Energy Efficiency	Least energy efficient.	Low-e-glass can make any window significantly more energy efficient.	Double glazing glass window is more energy efficient.
Cost	Less expensive.	Expensive as compared to the normal glass. The initial cost of installing low-e-glass is high, but in the long run, it will be more economical as compared to normal glass.	Expensive as compared to the normal glass. The initial cost of installing double glazing glass is high, but in the long run, it will be more economical as compared to normal glass.

- The data shown in above Table 5.were used conveniently for making selection of Low-e-glass and Double glazing glass over an Aluminium panel plain glasson the basis of energy efficient, U- value, SHGC andclimatic performance.

Table 6. Comparison between Metal Sheet Roof System, PVC Sheet Roof System, Clay Tile Roof System and Micro-Concrete Roofing Tile System

Parameters	Metal Sheet Roof System	PVC Sheet Roof System	Clay Tile Roof System	Micro-Concrete Roofing Tile System
General	Metal sheet can be available in steel, zinc, aluminium and iron etc.	PVC sheets are produced by calendaring, spread coating or extruding, and typically are reinforced with polyester or glass-fiber mats.	Clay tiles are produced by baking molded clay.	Concrete tiles are made of mixture of sand, cement and water, which are molded under heat and high pressure.
Water Absorption	No chance of water absorption.	No chance of water absorption.	Clay roofing tiles have a water absorption of about 6 %.	Concrete roofing tiles have a water absorption of about 13%.

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Embodied Energy	Embodied energy of coated steel and aluminium sheet roofing is 290 MJ/m^2 and 550 MJ/m^2 resp. [11]	Embodied energy of PVC sheet roof is 78 MJ/m^2. [11]	Embodied energy in clay tile roof system is an average 410-450 MJ/m^2. [11]	Embodied energy in micro concrete roofing tile roof system is an average 130-160 MJ/m^2. [11]
Environmental Impact	Metal sheets are not environmental friendly.	PVC roofing sheets are eco-friendly and easily recycled.	Clay tiles are made from a natural earth derived material, they are environmental friendly and easily recycled.	Concrete tiles are reasonably eco-friendly. This is since concrete is constructed out of natural materials.
Energy Efficiency and Thermal Comfort	Least energy efficient	More energy efficient than metal roofing sheets.	Energy efficient. The heavy thermal mass of tiles will help to regulate indoor temperatures.	Energy efficient. The heavy thermal mass of tiles will help to regulate indoor temperatures.
Suitability	Suitable for all roof slopes.	Suitable for all roof slopes.	Not suitable for all roof slopes. Tile roofs are suitable only for roofs with relatively sharp slopes.	Suitable for all roof slopes.
Time Required For Construction & Ease in Construction	Quick installation feature. This can save you time, money and energy. Easy to install.	Quick installation feature. This can save you time, money and energy. Easy to install.	Slower construction system. Installing tile roofing requires professional roofing contractors with extensive experience.	Easy installation. The skills for production and installation of these tiles can be acquired by local masons.
Cost	Metal Sheets cost about Rs. 500-600/Sq. m.	PVC sheets are economical than metal sheets cost about Rs. 300-350/Sq. m.	Clay tiles cost about 30% more than concrete tile cost.	Concrete tile roofs are more economical than clay tile roof.

- The data shown in above Table 6. were used conveniently for making selection of PVC roofing sheet for the efficiency of structure on the basis of energy content, water absorption rate,environmental impact and economy.

4. Conclusion

4.1. In today's era where energy crisis is a major problem, energy efficient materials gives a brilliant and promising solution. We can save non-renewable energy sources like electricity, fuel, water, etc. by using the energy efficient materials over conventional materials.

4.2. In this research study, the conventional materials and energy efficient materials have been compared.Here we have figure out that how energy efficient materials are superior to the conventional materials in terms of overall energy saving criteria, thermal conductivity as well as eco-friendly nature of the materials.

4.3. The advantages in selection of energy efficient building material lies in the fact that they are not only economically viable but also reduce toxic emissions, global warming thereby reduce overall environment impact.

4.4. Energy efficient structure is a boon to the society where energy and water consumption can be reduced while still maintaining an increase in productivity for occupants, their health, safety and well-being.

4.5. The present study will help farmers to develop their rearing houses, poultry houses energy efficiently and sustainably by selecting proper energy efficient materials for the construction.

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