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A Comparative Study of Energy Consumption and CO_2 Emission in Mud and Concrete Construction Systems

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Abstract: ***Architecture involves use of various different construction materials that require a unique construction technique. But most of these construction techniques are energy intensive techniques. All the natural resources are depleting which has made it mandatory that we choose materials and construction systems which require less energy for its execution. The extraction of materials and the erection of buildings consume energy and emit carbon dioxide (CO_2) that impact negatively on the environment. Therefore, it is necessary to consider energy consumption and CO_2 amongst other factors in selecting building materials for use in building projects. Various theories have been proposed and various studies have been done by scientists time and again which shows that Mud construction system is less energy intensive and very effective in different climatic conditions than the brick, cement concrete construction system. The present work is an attempt to analyze the Energy consumption and CO_2 of Mud and Cement construction systems by presenting some of those theories/studies and the methodologies adopted and suggested.***

Key words: Energy saving, Mud Construction, CO_2 emission, Embodied energy

1. Introduction

Worldwide, buildings are significant consumers of energy, water, and raw materials. The building sector consumes between 30 and 40% of society's total energy and is responsible for roughly 1/3 of the total CO_2 emitted into the atmosphere. Adding to this problem, worldwide energy consumption is expected to double by 2030.The high level of CO_2 emissions from the building sector is due to high levels of energy consumption throughout the raw material extraction, production and transportation processes which are powered by fossil fuel sources. The environmental footprint of the building sector includes: 30% raw materials use, 25% output of solid waste, 25% water use, and 12% of land use, 10 to 20% of which is consumed during extraction and processing of raw materials, manufacturing of products, construction, and demolition. With rapid population growth, an increase in materialembodied energy and carbon emissions is expected due to ourenergy intensive construction techniques This problem is expected to escalate more rapidly in emerging countries, where urbanization rates and economic growth are rising annually between 1 and 3% compared with 0.3% in OECD countries. Furthermore, the issue has recently been raised that higher attention should be given to buildings embodied emissions which occur early in the life cycle, rather than focusing on use phase emissions which take place over a long time-span and might not yield energy savings that are as high as expected. In addition, energy savings are receiving high priority in the world today due to growing environmental and economic concerns.

Construction materials greatly affect CO_2 emissions. Energy consumption during the manufacturing and transportation of materials is directly related to greenhouse gas emissions. The embodied energy (EE) of buildings is divided into two main categories direct and indirect. Direct EE is the energy consumed during transportation and installation of building materials, while indirect EE is related to the energy used in acquiring, processing, and manufacturing of building materials, including transportation activities related to these processes. Thus, the correct selection of materials is essential in helping save energy and reduces CO_2 emissions Natural materials such as soil, stones, and timber or biomass are considered ideal building materials because they help keep emissions low, have the smallest carbon footprint and can be recycled and reused.

2. Significance of embodied energy and CO_2

Embodied energy describes the amount of energy consumed in all processes associated with the production of a building, from mining and processing of natural resources/materials to manufacturing, transport and then the delivery of the product. For many years, embodied energy content of a building was assumed to be small compared to operational energy. Consequently, most energy-related research efforts have been directed toward reducing operational energy largely by improving energy efficiency of the building envelope. Operational energy of buildings is the energy required to condition (heat, cool, ventilate, and light) the interior spaces and to power equipment and other services. Milne and Reardon observed that according to research by the Australian-based CSIRO (Commonwealth Scientific & Industrial Organisation), an average household contains about 1000 GJ of energy embodied in the materials used in the construction of the house, and this is equivalent to 15 years of normal operational energy. Weight and Rawlinson reported that the construction materials sector alone accounts for 5–6% of total UK emissions, with 70% of emissions being associated with the manufacturing and 15% being associated with the transportation of the materials. In addition to embodied energy, the production of building materials (e.g., extraction, transportation and manufacturing processes) releases CO2 mainly due to the use of fuel or

electricity. This is often called embodied CO2. Thormark reported that embodied energy in traditional buildings can be reduced by approximately 10–15% through proper selection of building materials with low environmental impacts [7]. González and Navarro estimated that the selection of building materials with low impacts can reduce CO2 emissions by up to 30% [8]. Thus, embodied energy and CO_2 are quite important in environmental building assessment.

3. Building Material and Structure of Mud Building

Mud house is made of the mixture of clay, mud, sand, water and binding materials such as rice husks or straw. The main ingredients for making cob are clay, sand and straw. Both burnt bricks and stabilized mud blocks were used for mud wall construction. Stabilized mud blocks are made in India from soil, sand, cement/ lime and water. Moulds of brick are filled with the right mix of wet mud. The mould is then removed and the brick dried in the sun. This is the most popular form of brick making since it uses only solar energy, which is free. The building material for walls is mud and roof material is khapra. Brick is the common material used for the construction of external walls. To minimize the heat loss the insulation can be placed on the inside surface, outside surface or in between the wall. In this analysis, the insulation is placed on the outside surface of the wall cold region of India, the external wall insulation applications are generally made by the sandwiches wall types.

Mud house with pitched roof structure building as shown in Figure:

Mud house with pitched roof structure building

4. Comparison of Embodied Energy and CO2 of Mud-brick and Cement block

Current available data or computation results about embodied energy and CO_2 for houses are scarce, and when they exist, they are very diverse and lack consistency. Hence, it is often too difficult to compare results from different research and draw generalizations. These disparities in results are often caused by differences in computational methods and boundary systems and differences in construction materials, technologies and techniques used and discrepancies in the various database inventories used. However, to appreciate the findings of this study, results from other studies will be discussed. Pullen [1] has reported an embodied energy value of 3.6 GJ/m2 for a residential building. Hammond and Jones [2] reported a mean of 5.3 GJ/m2 and 403 KgCO2/m2 embodied energy and CO2 respectively for 14 residential case studies. Twelve of the 14 case studies are in the UK while the other two are in the US. Dixit *et al.* [3] also reported a mean of 5.506 GJ/m2 of embodied energy for residential buildings. In India, Reddy and Jagadish [4] reported embodied energy values of 4.21 GJ/m2, 2.92 GJ/m2 and 1.61 GJ/m2 for a clay brick masonry walls building with reinforced concrete structure, load bearing brickwork and a soil-cement block house respectively. Also, another study in India revealed the embodied energy for reinforced cement concrete and mud houses are 3702.3 MJ/m2 and 2298.8 MJ/m2 respectively [5]. What emerges from these studies is the fact that the values obtained for embodied energy and CO_2 are in the same range for almost all countries. The results reveal that a cement block house expends at least 1.5 times more embodied energy than earth or mud brick houses. Furthermore, a cement block house emits at least 1.7 times more embodied CO_2 than a mud brick house.

While embodied energy and CO_2 are important factors, it is also important to consider the effects of material choice on the energy requirements for cooling and heating over the lifetime of the building. Some studies have revealed embodied energy to be equivalent to a few years of operating energy [6], although cases in which embodied energy can be much higher have also been reported. In particular, in most developing countries, embodied energy of most traditional buildings can be largely compared to operating energy [6]. What these discrepancies suggest is that a holistic approach should be undertaken where embodied energy and operational energy should be considered in assessing the energy use and environmental impacts of a building.

5. Conclusion

Thus, from this study it can be concluded that Mud construction system is less energy intensive and very effective in different climatic conditions than the brick, cement concrete construction system. It can also be concluded that Mud house will open our eyes to an architectural alternative design for preserving the natural world not solely for its own sake but to provide an environment hospitable to man which should be environmental friendly design. Today, common man is lost in the glory of newly introduced materials. These materials have specific qualities but, still they are not best as compared to the locally developed materials. It is finally concluded that the potential of mud as a building material is undoubtful and immense provided that it should be promoted and practised with prime importance given to the concepts of sustainable development.

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