Combating global warming/climate change via reduction of CO₂ emission of buildings

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Abstract. There’s been a significant increase in Natural disasters in the world today, which is as a result of global warming /climate change. Besides other contributors, buildings are high contributors to this, studies have shown that they are the largest energy consumers and greenhouse gases emitters in both developed and developing countries. This study is aimed at determining the extent to which the CO₂ emission of a typical modern building can be reduced so as to help combat global warming/climate change, through reviewing related literature/data gotten from other researchers. Building embodied energy was critically analyzed, and it was observed that it can be more or less depending on the initial embodied energy of the building. The building materials embodied energy, which constitutes the initial indirect embodied energy of the building, can be significantly reduced by the use of environmentally friendly building materials which will in turn reduce the building initial embodied energy and eventually, the building embodied energy. This study tends to recommend that the commonly used ordinary Portland cement with high embodied energy should be totally replaced with fly Ash, as well as the replacement of the hollow concrete block with Autoclave Aerated Concrete (AAC) blocks which is a derivative of Fly-Ash. It also recommends the introduction of green vegetation within and around the building envelop, to help minimize the CO₂ emitted by the buildings as much as possible, in the course of running and maintaining them.

Keywords: Contributors, Embodied Energy, Emission, Modern

1. Introduction

The world today has encountered global warming which has led to climate change and environmental degradation. Global warming is as a result of excess/increased atmospheric greenhouse gases [1]. The composition of greenhouse gases is 76.7% carbon dioxide (CO₂), 14.3% methane, 7.9% nitrogen oxide and 1.1% fluorocarbons [2]. Therefore, CO₂ is a significant contributor to global warming and the United States Green Building Council, states that buildings account for 39% of carbon dioxide in the atmosphere. An evaluation of the greenhouse gas emissions associated with 3 building types was made, using as the practical unit 1m² of wall, and it was discovered that traditional buildings(mainly constructed with wood, stone, and mud) released about 1/4 of the greenhouse gas emissions released by semi modern buildings (which incorporated some modern aspects, including some degree of insulation material, polystyrene and cement) and less than 1/5 of the emissions of modern buildings (which were built primarily for tourism, also used imported Construction materials such as cement and glass wool) [2]. However, it was suggested that, the use of thermal insulation in the modern building walls would help to reduce the energy utilization for space heating and consequently to decrease the global warming potential of the building [2].
Furthermore, Sagheb et al. [7] describes how much a modern building is contributing to global warming by releasing CO$_2$, using a case study of a three story building constructed with commonly used modern building materials such as; glass, brick, concrete and stone. All the materials used in the three (3) storey building were evaluated, and the embodied energy of individual material was calculated in its lifecycle. The CO$_2$ emissions were estimated, to find the level of sustainability of the building and its effect on global warming, leading to the suggestion of alternative building materials.

2. Building embodied energy

The building sector consumes around 40% of energy a year in building’s life cycle [4]. To know the CO$_2$ emission of a building, it is very necessary to consider the building embodied energy as it is responsible for about 30% of the energy consumption of a building throughout its life time [5]. A building embodied energy, is the energy content of all the materials used in the building and technical installations and energy incurred in the time of erection/construction and renovation of the building [6]. Therefore, the emission from the building as an entity, includes the energy employed by the contractor on site (initial direct embodied energy), the emission from each material independently (the initial indirect embodied energy of the building) and the energy to maintain and renovate the building through its life time (recurrent embodied energy).

2.1 Initial embodied energy of buildings (direct and indirect)

Initial embodied energy of a building is the energy incurred for initial construction of the building [6]. It is therefore, the sum of the direct and indirect embodied energy of the building. In the initial stage of building construction, the direct energy is the energy used by contractors on-site or off-site to facilitate any construction, pre-fabrication, management and transport activities under their control, while the indirect energy of the building comprises majorly the energy embodied in building materials [7]. Together, these energies constitute the initial embodied energy of the building. The initial embodied energy can therefore be more or less, depending on the indirect embodied energy.

2.2 Embodied energy of building materials (initial indirect energy of buildings)

Varieties of materials are used for the building construction. These materials consume energy and need resources such as equipment to carry it from cradle to gate [8, 9] and this energy has to be considered when analysing the embodied energy of a building [10]. The embodied energy of a building material is the total energy required to construct, transport and refine the raw materials and then to manufacture components and assemble the product [7]. Therefore, these can very much affect the building embodied energy by increasing or decreasing it. For example, a concrete block that is manufactured near the construction site will have lower embodied energy than a concrete block manufactured at a far distance from the site. This is because the energy used for transportation of the concrete blocks is different.

2.3 Recurrent embodied energy

Some of the materials used for building construction have a life span less than that of the building. As a result of this, they are replaced to rehabilitate the building. Building requires some regular annual maintenance as well. The energy incurred for such repair and replacement (rehabilitation) needs to be accounted during the whole life of the buildings. Recurring embodied energy, is the sum of the energy embodied in the material, used in the rehabilitation and maintenance of the building [6]. This are typically modelled by assuming replacement rates for items in the buildings (for example, paint, dilapidated furniture and fittings) and is known as the recurrent embodied energy.
3. Eco-friendly green building material

3.1 Fly-Ash

Fly ash is a fine powder that is a by-product of burning pulverized coal in electric generation power plants [11]. Fly ash is a pozzolan. A pozzolan is a siliceous material that in finely divided form and in the presence of moisture, chemically reacts with the calcium hydroxide released by the hydration of Portland cement to form additional calcium silicate hydrate and other cementitious compounds. The hydration reactions are like the reactions occurring during the hydration of Portland cement. This makes fly ash appropriate as a prime material in mosaic tiles, blended cement, and hollow blocks / autoclave aerated concrete blocks (AAC Blocks), among other building materials [11]. When used in concrete mixes, fly ash improves the strength and segregation of the concrete and makes it easier to pump. Class -F and Class-C are the two common types of fly ash.

Class-F fly ash: this class of fly ash, contain particles which is covered in a melted glass. There by reduces the risk of expansion due to sulphate attack, which may occur in fertilized soils or near coastal areas. It is usually low in calcium and has less than 5percent carbon content although 10 percent in some cases.

Class-C fly ash: this class of fly ash is resistant to expansion due to chemical attack, with higher percentage of calcium oxide than class-F. It is commonly used for structural concrete. Class-C is characteristically composed of high calcium fly ashes with a carbon content of less than 2 percent. presently, more than 50 percent concrete placed in the United States contains fly ash [11].

Benefits of Fly Ash:

- It is known as an environmentally friendly material, because it’s a byproduct with low embodied energy.
- Reduces heat of hydration
- It is considered to be a non-shrink material.
- It is cost effective, and can substitute for Portland cement.
- It requires less water than Portland cement and easier to use.
- It produces dense concrete with sharp details and smooth surface.
- It reduces co₂ emission
- It has a good workability
- And also Reduces permeability and crack problems

3.2 Autoclaved aerated concrete (AAC) block

Autoclaved aerated concrete (AAC) which is a derivative of fly ash is combined with cement, lime and water and an aerating agent. AAC is produced as block and panels and it can be used for both internal and external construction works. It is an approved eco-friendly building material that comes from industrial waste and is made from non-toxic ingredients [12]. Autoclaved Aerated Concrete (AAC) is an ultra-light concrete masonry product, it can weigh as little as 1/5 as much as ordinary concrete due to its distinct cellular structure containing millions of tiny pockets of trapped air It is a thermally insulating concrete-based material and is acoustics friendly [13]. It has one of the highest hourly fire resistance ratings per inch of any building material presently used in home building. This characteristics makes it ideal for fire protection around steel columns and beams and also in the construction of stairwells, shaft walls, firewalls as well as corridors [13]. It has a quick and easy installation process, since the material can be routed, sanded or cut to size on site with the use of standard carbon steel power tools.
3.3 Green vegetation (United States Department of Agriculture)

As plant breathe and perspire, they help cool the atmosphere. Plants consume CO\textsubscript{2} which is a significant greenhouse gas, in the process of photosynthesis. This is necessary for plants and trees to grow [14]. Forest plays very important role in global carbon circle by constantly absorbing CO\textsubscript{2} during photosynthesis. In the presences of increased greenhouse gases in the atmosphere, forests become much more vital in the removal of CO\textsubscript{2} in the atmosphere to alleviate the effect of climate change. Forests in the United States absorb and store about 750 million metric tons of CO\textsubscript{2} each year, an amount equivalent to 10 percent of the country’s CO\textsubscript{2} emission.

4. Conclusion and recommendation

The usage of modern building materials (especially cement) has become predominant in the construction industry, and this has a direct impact on the percentage increase in CO\textsubscript{2} emission from buildings. Considering that a high building embodied energy has massive contribution to building emissions due to the high carbon footprints of the materials, it is important to attempt a reduction of this by the use of environmentally friendly building materials (like Fly-Ashes and Autoclave Aerated Concrete (AAC) blocks) and techniques. In view of the enormous contribution of buildings to global warming and climate change, adoption of these low energy building materials can revolutionize our world’s approach to climate control. Fly-Ash being more environmentally friendly and easy to use, will serve as a good/total replacement for the ordinary Portland cement. Also, Autoclave Aerated concrete (AAC) block as a derivative of fly Ash should also replace the hollow concrete block and it should be cast in-situ or produced as close as possible to the construction site to further reduce its (AAC Block) embodied energy. Concrete mixed with fly ashes are good insulators, which helps to control the heating and cooling of the building envelop, during the cold and hot season, as less energy will be needed to maintain a comfortable indoor environment. Finally, when CO\textsubscript{2} is emitted from buildings, as a result of human activities, running and maintenance, they are taken in by plants and stored for photosynthesis and transpiration. Hence, we recommend that green vegetation’s/plants should be introduced and encouraged within and around the building envelop in order to reduce the CO\textsubscript{2} emitted by the building, during usage.

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