

Global Need for Low Carbon Architecture

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Abstract

Low carbon architecture (Note 1) can be solution to reduce the global environmental impacts which affect all mankind. Huge amount of greenhouse gases emissions in last few decades are responsible for great part of global warming, climate changes, ozone layer depletion and other environmental issues. These vary from emissions during manufacturing of the building materials, to the emissions generated till the end of the building's life. The current research explores the necessity of carbon emission reduction at global scale and the different carbon emission reduction opportunities in the building industry. It states the various strategies which help in carbon emission reduction during different stages of building cycle including construction, operation and demolition. By following sustainable architecture techniques it is possible to minimize the negative impacts of buildings on the environment and to have healthier environment which allows future generations to benefit from it.

Keywords: low carbon architecture, carbon dioxide, sustainable architecture

1. Introduction

In the beginning of the industrial revolution, concentration of carbon dioxide in the atmosphere was 270 parts per million. This concentration, which has now risen to 377 parts per million, has been unprecedented not only in the past 740 thousand years, but also perhaps even 55 million years ago (Farshchi, 2009). There are two main reasons for climate change: natural reasons arising from changes in the orbit of the sun and in the parameter of earth orbit, and human related causes, the most important of which is excessive emissions of greenhouse gases through human activities (Azizi, 2004).

“Since industrial revolution human activity has increased the amount of greenhouse gases in the atmosphere, leading to increased radiations forcing from CO₂, methane, tropospheric ozone, CFCs and nitrous. According to work published in 2007, the concentrations of CO₂ and methane have increased by 36% and 148% respectively since 1750” (EPA, 2007). Estimates of future climate change, suggest further global warming, sea level rise and an increase in the frequency and harshness of some extreme weather events (IPCC, 2007). Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have agreed to “stabilize greenhouse gases concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (UNFCCC, n.d.)”.

Reducing the amount of future climate change is called mitigation of climate change (Fisher, 2007). The IPCC defines mitigation as activities that reduce greenhouse gases (GHG) emissions, or improve the size of carbon sinks to absorb GHGs from the atmosphere (IPCC, 2007). Studies show extensive potential for future reductions in emissions by a grouping of emission-reducing activities such as energy conservation, increased energy efficiency, and satisfying more of society's power demands with renewable energy and/or nuclear energy sources (IPCC, 2007).

The building sector is responsible for up to 30 per cent of global annual greenhouse gases emissions and consumes up to 40 per cent of total energy. It also provides the highest potential for significantly cutting emissions, at low price, in both developed and developing countries (<http://www.unep.org/climatechange/ClimateChangeConferences/COP18/Booklet/MAKINGTHEBUILDINGSECTORCLIMATEFRIENDLY.aspx>, 2013).

2. Necessity of the Research

Consumption of fossil fuels and emissions generated from burning of these fossil fuels are huge threats to the environment. Industrial revolution, sudden increase in consumption of natural resources and invention of technologies that use non-renewable energy sources all together affected our environment in many ways. The problems associated with global warming and climate change move us towards more sustainable approaches in architecture. These problems do not affect only our environment but our social and economic life as well. Therefore it is necessary to take global actions towards reducing these emissions specially in building sector which opportunities are numerous.

3. Zero and Low Carbon Buildings

Early description of low carbon architecture highlighted balance between the need of living organisms, architecture and climate. Throughout recent years the development of passive low energy architecture has referred low carbon architecture in the framework of sustainability. Henceforth, we may redefine the low carbon architecture as a sustainable architecture base on human ecology with the sustainable development of economy, society and architecture simultaneously (Li, 2011). The Brutland definition of sustainability is “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987). That is why it is important to construct buildings which have least possible impact on the nature, and to preserve natural sources for future generations too.

Zero carbon buildings are the core driver for sustainable design to mitigate against further climate change. That is, over time the net carbon dioxide emissions of a building will be zero dropping energy demand and using renewable energy supplies. The renewable energy system should be part of the progress and not come from existing green energy sources (al, 1989). Low carbon architecture brings harmony between human and nature.

4. Construction Materials

Cement is an important construction element around the world, and therefore, cement production is a significant cause of global carbon dioxide CO₂ emissions, making up to nearly 2.4 percent of global CO₂ emissions from industrial and energy sources (<http://blogs.ei.columbia.edu/2012/05/09/emissions-from-the-cement-industry>, 2012). Cement manufacturing is extremely energy demanding, because of the extreme heat required to produce it. Producing a ton of cement requires 4.7 million BTU of energy, equals to about 400 pounds of coal, and produces nearly a ton of CO₂. Given its high emissions and serious importance to society, cement is an obvious place to look to lessen greenhouse gases emissions (<http://thisbigcity.net/five-sustainable-building-materials-that-could-transform-construction>, 2013).

Therefore, use of cement should be reduced and instead utilization of sustainable building materials which have less environmental impacts should be increased. Application of materials which can be reused or recycled will also be helpful.

Construction with locally available materials helps in reduction of fuel requirement needed for transportation of materials to the site and consequently less emissions of CO₂.

4.1 Sustainable Building Materials

Materials which produce less pollution and waste during manufacturing and construction process are being considered as sustainable building materials. Natural materials are less toxic and their embodied energy is less as compared to artificial materials. Therefore, most of the natural materials are sustainable building materials. Recyclability and biodegradability are also important measures of sustainability. Some materials such as steel and glass are recyclable whereas concrete cannot be recycled, it can only be grounded up and used as aggregate in new concrete. From biodegradability point of view organic materials decompose rapidly, but steel for example takes much longer time. Another important factor is life span of the material. Materials which have longer life need not to be replaced therefore less natural resources are required for manufacturing and less landfill waste is generated. Some sustainable building materials are mentioned below:

4.1.1 Wool Bricks

Wool bricks are non-toxic materials which are produced by combination of wool, natural polymer and clay of brick. They are stronger than normal brick. Unlike traditional bricks they do not need firing of brick.

4.1.2 Solar Tiles

Roof tiles are used to act as shelter and protect the building. As they are in contact with direct sun light they are good for capturing the solar energy and meeting energy requirement of the inhabitants inside the building.

4.1.3 Paper Insulation

Paper insulation is insulation which is made up of recycled newspapers and cardboards. It is a better choice as compared to the chemical foams. It can be blown between the cavity walls.

4.1.4 Triple Glazed Windows

The three layer glass acts as better insulation as compared to double glazed windows. It avoids air infiltration. Therefore, keeps the building warm in winters, and cool in summers. In double glazed windows argon is injected in each layer of glass whereas in triple glazed windows krypton which is better insulation is injected.

4.1.5 Sustainable Concrete

While, 95% of a building's CO₂ emissions are outcome of the energy used during its life, there is ample that can be done to reduce that 5% related with construction. Concrete is a perfect place to start, partially because nearly every building uses it, and mostly due to the fact that concrete accounts for 7-10% of global CO₂ emissions. More sustainable forms of concrete exist, that use combination of recycled materials. Crushed glass can be added, as can wood chips or slag – a byproduct of steel manufacturing. Though, these changes aren't radically transforming concrete, by simply using a material that would have otherwise gone to waste, the CO₂ emissions related to concrete are decreased (<http://aac-india.com/aac-blocks-advantages.html>, 2013).

4.1.6 Aerated Autoclaved Concrete

Manufacturing of AAC blocks and panels does not have high energy requirements. Besides, since AAC is light weight, it also saves energy required for transportation and leads to reduced CO₂ emissions by transport vehicles. Since AAC blocks are made from fly ash – an industrial left-over product – produced by thermal power plants, it offers a low price and sustainable solution for present and future. AAC is a must for green buildings (RIBA, n.d.).

4.1.7 Bamboo

The versatility of uses to which bamboo can be put is very vast. It can be used in construction of walls, roofs and understructure. When one thinks of bamboo, 'low cost architecture', 'employment generation' are the first few things that cross one's mind. Due to the tradition of using untreated bamboo mostly in non-permanent applications, one tends to reinforce the idea of bamboo as a low-end material used mainly in temporary structures. Bamboo has great engineering potential. It is said to be the 'green steel' of nature.

Bamboo is the building material which is environment-friendly, it is also a renewable resource. Bamboo can be developed commercially as bamboo composites as an alternative to wood. Bamboo sheets are five times stronger than other relevant building materials and they last five times as longer. The bamboo-corrugated mat also acts good regarding thermal comfort and noise resistance.

4.1.8 Adobe

Adobe is material made up of combination of sand, clay, water, and fibrous or organic material, builders make bricks out of adobe and dry it in the sun. Some of the advantages of adobe structures is that they have long life and great thermal mass, in hot climates. A disadvantage which can be mentioned is that they are not earthquake resistant and have poor behavior in case of earthquake.

5. Construction, Operation and Demolition

Following sustainable architecture regarding different issues such as thermal, luminous and acoustics at design stage, will have tremendous positive effects during the whole life cycle of the building. The initial aim is to reduce the demands for energy and the next priority is replacement of non-renewable sources with renewable sources of energy.

Some actions which help in energy reduction are listed below:

- High thermal mass (u value) of building envelope, which is useful in both cold and hot climates. In hot climates it keeps the inside temperature of the building low the building to escape easily, therefore reducing the energy required for heating and cooling.
- Building orientation and form with respect to the climate.
- Passive solar design.
- Efficient use of natural light for lighting purpose and reducing the need for artificial lighting during day. Using energy efficient light fixtures, and occupancy sensors in rooms which are not being used so often help in electricity saving.

- Ensuring proper natural ventilation of the rooms while designing the openings.
- Taking maximum advantage of solar energy (which is a renewable source of energy), by using technologies such as photovoltaic cells for electricity generation and solar panels for hot water supply.
- Overhangs can help to reduce solar heat gain in summers and improve solar gains in winters.
- Using Renewable energy sources and systems.
- Following energy management systems.
- Using energy efficient equipment.
- Optimum use of wind energy should be made. Wind energy which is renewable source of energy helps in electricity generation. Wind turbines can be placed on rooftops and windy locations of the site.
- Reducing air infiltration levels by using adequate insulation.
- Proper placement of trees in building site around the building reduce the need for air conditioning and therefore save energy.
- Using geothermal energy source (ground source heat pumps).
- Using biomass fuels instead of fossil fuels will reduce the carbon footprint as biomass (agricultural waste and wood) is carbon neutral.
- Applying new technologies, for example use of photo-chromic glass which under strong sunlight converts solar energy into electric energy.
- Recyclable, sustainable building materials should be used.
- Evaporative cooling towers in hot and dry climates help in reducing the energy demand for refrigeration cooling.
- Light colored surfaces can reduce heat gain.

Low carbon design is not sufficient, low carbon operation is also needed. Architects can enable efficient operation of building by ensuring that suitable metering and energy management systems are in place, and that the inhabitants are well educated about how the building and its services are proposed to be used (Hetherington, n.d.) Informing building occupants regarding different energy reduction policies is as important as providing the building with these energy efficient equipment and services. Proper installation of services and adequate maintenance is also necessary in order to reduce the energy consumption.

In addition to the energy required to light, heat or cool and run appliances within a building there is energy to construct, refit and demolish it. The energy embodied within the building. Embodied energy that is energy which is necessary for construction becomes more important as we reduce the operating energy. In some buildings the amount of embodied energy is almost equal to or greater than operating energy. A sustainable approach “cradle to cradle” would have the building processed into another building (<http://www.procellula.it/articolo-test/?lang=en>, 2013). The sustainable approach in demolition process is “deconstruction” of the building. Most of the buildings when reach to the end of their useful life are demolished. Implosion of the buildings is a fast way of demolition which is not expensive, but it does not allow usage of building components which were still usable and valuable. It also produces huge amount of waste. Deconstruction is the process of changing waste building materials into material which can be reused in construction.

Deconstruction has strong ties to environmental sustainability. In addition to giving materials a new life cycle, deconstructing buildings helps to lesser the requirement for virgin resources. This in turn leads to energy and emission drops from the refining and manufacture of new materials. As deconstruction is usually done on a local level, many times on-site, energy is saved in the transportation of materials. In addition, solid waste from conventional demolition is diverted from landfills (Jackson, 2011). This is a major benefit because construction and demolition (C&D) waste accounts for approximately 20% of the solid waste stream (Blazer, 2011).

Many sustainable techniques can be applied to new buildings which are going to be built, this gives architects a better opportunity to take energy efficiency measures, as compared to buildings which are being used. They can start a design keeping in mind sustainable factors. But one of the important things which architects need to educate themselves, is about incorporating various energy reduction techniques in existing buildings, since reconstruction based on sustainable goals is expensive, time consuming, labor intensive and energy consuming. For having healthy ecofriendly city, just building the new buildings which are sustainable may not be enough.

Many of the existing buildings are cause of carbon emissions. Therefore, reducing the emissions caused by building industry should not be limited to future going to be built buildings but should be applicable to buildings which are now in use too.

The greenification of architecture is a mission demanded by the age of energy and climate change. It can be fully achieved through energy-efficient building designs and systemic support. More low-carbon green buildings will “breathe” to enhance our lives when necessary elements such as remodeling of existing buildings, sustainable energy consumption management, and environment-friendly building designs are joined, and when wise consumers make energy efficiency a principle when purchasing a building (Tae-yong, n.d.). Ecological architecture refers to minimum disturb to the environment; making full usage of environmentally natural resources to recognize high-efficiency utilization of resources and energy; satisfy people's demands with healthy, appropriate and effective living environment, to achieve harmony between man and architecture; it is a big and complex systematic engineering including nature, society, economy and civilization, etc. (Lan, 2011).

6. Conclusion

By following the suggested techniques during different stages of building's life cycle, lower carbon emissions from buildings could be achieved, which will help in development of more sustainable, ecofriendly environments. Fortunately, though buildings account for large amount of GHG emissions, there are also lots of opportunities to reduce these emissions. This is where low carbon architecture comes into the picture. Following the rating systems, such as LEED (Leadership in Energy and Environmental Design), Energy Star for homes, GRIHA (Green Rating for Integrated Habitat Assessment) and Green Globe Canada will be useful in reaching desired sustainability. To have sustainable environment friendly world, not only buildings need to be designed and operated based on sustainable considerations, but the whole communities and cities need to be sustainable. Today the focus of sustainable design encompasses entire cities, stakeholders include developers, lawyers, political leaders, business owners and citizens, and topping the list of concerns is to reduce carbon emissions (http://www.huffingtonpost.com/phillip-jones/zero-carbon-design-and-ar_b_174775.html, 2013). Planning of sustainable cities serves as an essential catalyst for change, enhancing environmental quality of the natural and built environments, and promoting conditions for development of green architecture (Huseynov, 2011). For achieving this goal we need contribution of all countries and governments.

Many countries have made efforts to decrease carbon emissions by framing development planning and taking measures from aspects of energy, transportation, industrial structure etc. (Su, 2012). Facing the increasingly serious challenge of environmental change (levels of carbon dioxide in the atmosphere have risen by more than a third since the industrial revolution and are now increasing faster than ever before) and decline of indigenous energy supplies (by 2020 the country could be dependent on imported energy for three quarters of its total primary energy needs), the UK government proposed a future scenario named “low carbon economy” in the energy white paper “Our Energy Future-Creating a Low Carbon Economy” issued by Department of Trade and Industry in 2003 (DOTI, 2003). With an annual GDP growth in excess of 10% in current years, China has become one of the biggest energy consumers and carbon emitters in the world (Jiang, 2009). It is known that China is facing great pressure both inside and outside the international climate negotiations to exhibit more ambition in combating global climate change (ZX, 2010). In order to have sustainable eco-friendly environment sustainable rules should be passed by governments which obligate builders to follow the rules regarding reducing the carbon emissions in building industry.

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Note

Note 1. Low carbon architecture deals with various types of buildings as a whole, whereas low carbon building deals only with a single building.

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