LOW CARBON BUILDING – AN APPROACH TO SUSTAINABLE DEVELOPMENT

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Abstract

As far as construction sector is concerned, the construction industry is the most important for the Indian economy and it is growing at rapid pace. Hence it is necessary to give proper attention not only toward the economy but also towards environmental aspects of rapid construction which are ignored in many cases, leading to uncomfortable habitat and increased maintenance and energy requirement causing threat to environment. Hence it is necessary to find the solution to overcome environmental problem caused by rapid construction which is affordable and acceptable by the people. To overcome such environmental problem caused by rapid construction concept of sustainable development come in flash. Low Carbon Building is one of technique of sustainable development. Low Carbon Buildings is nothing but it is one of technique of "Green Building" in which attempt is made to reduce emission of carbon by using low carbon emission material and low carbon emission techniques for construction. This type of construction of buildings is must for environmental aspects in future. So it is required to adopt proper methods of construction and latest technology which will help to achieve economy, quality, safety and better output. In short the numbers of key elements are responsible for the success of this type of environmental friendly construction; so it is required to study the various aspects of these low carbon content buildings like materials used, various techniques used for construction, economy etc.

Keywords: Climate change, carbon foot print, low carbon building, design of low carbon building techniques for low carbon building

1. Introduction

India is developing country with amazing rate of economic development, in recent decade the rate of economic growth has been dramatic and is set in one of fastest developing economics in the world. Increasing urbanization has led to pressure on urban infrastructure and deteriorating services delivery in urban areas is worrisome trend. In India building sector is growing at rapid pace. Increasing urbanization and industrialization has given boost to construction industry and number of bungalows, apartments, commercials complexes, skyscrapers and many other structures including industrial building, dams, and roads are being designed by architects and engineers with innovative concepts and enhanced features .The construction industry in India is mainly dominated by Government bodies like CPWD, PWD, MHADA, Municipal Corporations, Other Civil Bodies and Builders ,Developers, Architects, and Engineers. However, it is observed that in many cases, environmental aspects are ignored leading to uncomfortable habitat and increased maintenance requirements causing threat to environment. The build environment has vast impact on the environment, human health and economy.

2. Carbon Footprint and Climate Change

2.1 Carbon Footprint

A carbon footprint has historically been defined as "the total set of green house gas (GHG) emissions caused by an organization, event, product or person. However, calculating the total carbon footprint is impossible due to the large amount of data required, the relatively recent attention brought to this issue within the last century, and the fact that carbon dioxide can be produced by natural occurrences. It is for this reason that Wright, Kemp, and Williams, writing in the journal Carbon Management, have suggested a more practicable definition:

A measure of the total amount of carbon dioxide (CO_2) and methane (CH_4) emissions of a defined population, system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest. Calculated as carbon dioxide equivalent (CO_{2e}) using the relevant 100-year global warming potential (Wright, L., Kemp, S., Williams, I., 2011).

Greenhouse gases can be emitted through transport, land clearance, and the production and consumption of food, fuels, manufactured goods, materials, wood, roads, buildings, and services. For simplicity of reporting, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted. The concept name of the carbon footprint originates from ecological footprint, discussion, which was developed by Rees and Wackernagel in the 1990s which estimates the number of "earths" that would theoretically be required if everyone on the planet consumed resources at the same level as the person calculating their ecological footprint. However, carbon footprints are much specific than ecological footprints since they measure direct emissions of gasses that cause climate change into the atmosphere.

Carbon footprint' has become a widely used term and concept in the public debate on responsibility and abatement action against the threat of global climate change. It had a tremendous increase in public appearance over the last few months and years and is now a buzzword widely used across the media, the government and in the business World.

2.2 Climate Change

Climate change is a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. It may be a change in the average weather conditions or a change in the distribution of weather events with respect to an average, for example, greater or fewer extreme weather events. Climate change may be limited to a specific region, or may occur across the whole Earth. According to the latest scientific assessment, the earth's climate system has demonstrably changed on both global and regional scales since the pre-industrial era. Further evidence shows that most of the warming (of 0.1°C per decade) observed over the last 50 years, is attributable to human activities. This unprecedented increase is expected to have severe impacts on the global hydrological system, ecosystems, sea level, crop production and related processes. The impact would be particularly severe in the tropical areas, which mainly consist of developing countries, including India.

2.3 Why Should India Be Concerned About Climate Change

With more than one billion inhabitants India ranks second globally in terms of population and accounts for about three per cent of total global energy use — its per capita energy use as well as carbon emissions are much lower than the world average. Even then, its total carbon emissions exceeded 250 million metric tons of carbon equivalents in 2000. These emissions are expected to grow apace with further economic advancement in the coming years. In India nearly 700 million rural population directly depending on climate-sensitive sectors (agriculture, forests and fisheries) and natural resources (such as water, biodiversity, mangroves, coastal zones, grasslands) for their subsistence and livelihoods. Further, the adaptive capacity of dry land farmers, forest dwellers, fisher folk and nomadic shepherds is very low. Climate change is likely to impact all the natural ecosystems as well as socio-economic systems. Not all possible consequences of climate change are yet fully understood, but the three main 'categories' of impacts are those on agriculture, sea level rise leading to submergence of coastal areas, as well as increased frequency of extreme events.

2.4 Building And Climate Change

Buildings are the largest emitters of GHG. They are responsible for around 39 % of all GHG emitted by human activities. (Not include land use changes). Energy consumption in Indian buildings is expected to increase substantially due to economic growth, construction growth and human development. The demand for energy to run appliances such as TVs, air conditioning and heating units, refrigerators and mobile phone chargers will increase substantially as living standards rise in India. Also the growth in commercial sector and the shift from rural to urban living will continue to take place. This will result in a

substantial increase in resultant emissions from the buildings sector alone and need concrete efforts to bring down the energy consumption by buildings through various measures.

2.5 Carbon Emission from Building

A building emits GHG during its whole lifetime. The carbon is released in the atmosphere during following stages of building life.

2.5.1 Building Construction / renovation

Carbon emission associated with building construction is mainly coming from embodied carbon. Embodied carbon is nothing but carbon associated with the embodied energy used for manufacturing construction material. Embodied energy is defined as the commercial energy (fossil fuels, nuclear, etc) that was used in the work of making a product. Embodied energy is an accounting methodology which aims to find the sum total of the energy necessary for an entire product lifecycle. This lifecycle includes raw material extraction, transport, manufacture, assembly, installation; disassembly, deconstruction and/or decomposition. The most common building material used in construction activity today are cement, steel, bricks, stones, glass, aluminum, timber, paints etc.

2.5.2 Building Operation

India, the seventh largest country in the world, is having appreciable economical growth and provides home to over one billion people living in various climatic zones. Building sector consume a lot of energy throughout the life cycle and thus becoming a major contributor to greenhouse gas emissions.

Electricity is used in both residential and commercial sectors are primarily for lighting, space conditioning, refrigeration, appliances and water heating.

2.5.3 Building Deconstruction

Destruction carbon is nothing but the amount of carbon created at the end of the building lifespan looking at removing each material and product. This could be demolition, disposal and preparation of the land for the next construction or deconstruction and dismantling for salvage, recycling, reuse and reclaim incineration of demolition wastes, decomposition in landfills.

Beside the above carbon emission takes place in the building in the form of management / project management carbon and construction carbon. Management / project management carbon is nothing but the amount of carbon created for everything that happens off site from project concept to completion. This includes travel, administration, all personnel involved in the project: designers, architects, project managers, sales, contractors, suppliers and the client. Construction carbon is nothing but the amount of

carbon emitted through the building process – site development, construction, installation, site equipment, site labour, material delivery, energy used on site, vehicles used for transportation of material within the site, equipments use for various purposes on site like lifting materials, compaction, cutting machines etc. but the amount of construction carbon and management carbon is in small amount.

Hence the lifetime carbon emission of building E_{Lt} is the sum of its emission from construction, operation, and deconstruction.

$$\mathbf{E_{Lt} = Ec + Eo + Ed}$$

Where; Ec = Construction emission (Including renovation)

Eo = Operation emission

Ed= Deconstruction emission.

3. Low Carbon Building

Since the industrial revolution, the world has witnessed incalculable technological achievements, population growth, and corresponding increase in resource use. As we enter a new century, we are witnessing the "side effects" of our activities: pollution, landfills at capacity, toxic waste, global warming, resource and ozone depletion, and deforestation. These efforts are straining the limits of the Earth's "carrying capacity"—its ability to provide the resources required to sustain life while retaining the capacity to regenerate and remain viable. Hence it is necessary to find such solution which overcomes problems of environment due to built environments. To minimize the impacts of built environment "**Low Carbon Building**" comes in flash. Low carbon building is nothing but a building in which attempt is made for reducing emission of carbon by using low carbon emission materials and low carbon emission techniques for construction or low carbon content building. Low carbon building is a building which has been engineered to release significantly less GHG than a regular building over its lifetime. Typically a low carbon building will consume much less energy than a traditional building and integrate distinctive technologies, such as renewable energy system, which will reduce its GHG emission.

3.1 Classification

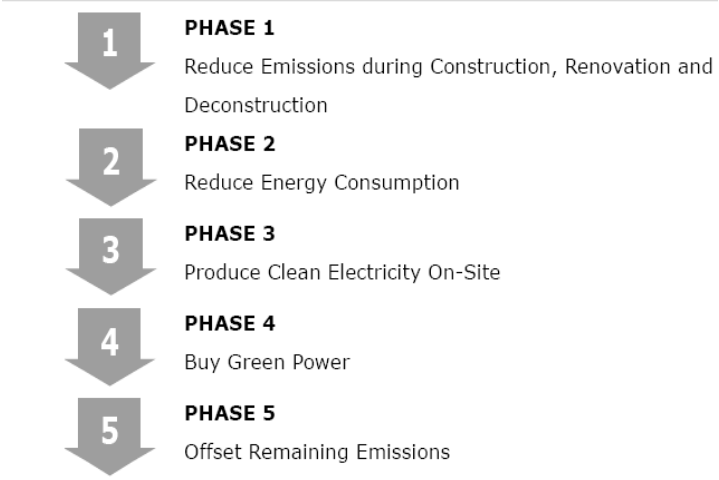
Although a growing number of green buildings integrated fancy wind turbines, solar systems, the concept of low carbon building is still relatively new to world. In low carbon building main aim is to reduce GHG emission from building construction to building operation to building deconstruction. Based upon the % of reduction of GHG emission through building compared to baseline building (building considering without GHG emission reduction strategies) low carbon building is classified as below.

3.2 Low Carbon Building:- A Step By Step Approach

With the fast growing construction industry which results in the climate change and carbon emission. In the context, reducing carbon emission from buildings through appropriate planning and design assume prime importance. Engineering low carbon building is process that concerns all stages of the building life i.e. construction, operation, and deconstruction.

The low carbon building (LCB) method recommended the following approach for achieving the desired emission reduction performance.

The designers or engineers should focus with priority on PHASE 1 to 3 of the process because the cost of low carbon building in PHASE 2 and 3 may ultimate generate long term money saving for building owners. PHASE 4 and 5 on contrary are pure spending / expenses and quantity of green power and carbon offset in market might not be enough in the future to cover the needs of all LCB method. PHASE 4 and 5 should be considered only if PHASE 1 to 3 cannot achieve the desired level of GHG emission reduction.



PHASE 1A –Reduce Construction Emission.

Estimating Construction Emission:-

The total amount of carbon emission associated with the building construction are calculated as follows

$$Ec = \Sigma E\ mat + \Sigma E\ trans + \Sigma E\ site + \Sigma E\ waste.$$

Further, with for each building construction material / product

E mat = Q mat x EF mat .

E trans = Q mat x (De-m x EFveh + Dm-s x EFveh

Estimating Construction Emission Reduction–Proposed Method

STEP 1 List assumption for material use reduction / substitution:-

STEP 2 Collect actual Emission Factor (EF) from product manufacturing:-

STEP 3 Collect distances traveled for building material / product:-

STEP 4 Estimate baseline and LCB emission**:-**

STEP 5 Estimate emission reductions:-

Estimate the construction emission reduction as follows;

$\triangle$ **Ec = Ecp – Ecb**

Where; Ecp = LCB construction emission

Ecb = Baseline building construction emission.

PHASE 1B –Reduce Renovation Emission:-

Estimating Renovation Emission:-

The emission associated with the replacement / renovation of each material are calculated as follows

$E_R = \Sigma$ (E mat + E trans) x (Lt / Rt)

Estimating Renovation Emission Reduction: Proposed Method

STEP 1 Estimate material / product lifetime:-

STEP 2 Estimate baseline and LCB emission:-

STEP 3 Estimate building emission reductions:-

Estimate the renovation emission reduction as below;

$$\triangle E_R = E_Rp - E_{R\,b}$$

Where; E_Rp = LCB renovation emission.

$E_{R\,b}$ = Baseline building emission

PHASE 1C – Reduce Deconstruction Emission

Estimate Deconstruction Emission:-

The total emissions associated with the building deconstruction are calculated as below;

$$E_D = \Sigma \text{ E waste} + \Sigma \text{ E trans}$$

With for each material

$$Ewaste = Qland \times EFland + Qinc \times EFinc$$

$$E\ trans = Qland \times Ds\text{-}l \times EFveh + Qinc \times Ds\text{-}I \times EFveh + Qrec \times Ds\text{-}r \times EFveh$$

Estimate Deconstruction Emission Reduction:- Proposed Method

STEP 1 Collect waste quantities and diversion flow:-

STEP 2 Estimate building emission and baseline building emission:-

STEP 3 Estimate building emission reductions:-

From carbon emission from second step deconstruction reduction carbon emission is calculated as below,

$$\triangle E_D = E_{DP} - E_{DB}$$

Where; E_{DP} = Building deconstruction emission.

E_{DB} = Baseline building deconstruction emission.

PHASE 2 –Reduce Energy Consumption

Estimating Operation Emission:-

Total amount of carbon emission associated with the building operation are calculated as below

$$Eo\text{-}a = Eele\text{-}a + Egas\text{-}a + E\ steam\text{-}a + \Sigma\ Efuels\text{-}a$$

With for electricity,

$$Eele\text{-}a = Cele\text{-}a \times EFgrid$$

Where;

Cele-a= Annual electricity consumption.

EFgrid = Carbon emission factor associated with electricity production and distribution.

The total lifetime cycle carbon emission Eo associated with the building operation can be quickly calculated as follows

$$Eo = E0\text{-}a \times Lt$$

Estimating Operation Emission Reduction: Proposed Method:-

STEP 1 -Collect energy systems parameters:-

STEP 2-Gather local utilities EF (Emission factor):-

STEP 3 Estimate building emission and baseline building emission:-

STEP 4-Estimate building operation emissions reduction:-

Estimate the building operation emissions reduction as follow:

$$\triangle \mathbf{Eo = Eop - Eob}$$

Where; Eop= Building operation emissions.

Eob = Baseline building operation emission.

PHASE 3 – Produce Clean Electricity On –Site

Emission From Renewable Energy.

As we know that renewable energy is pollution free energy. If embodied emissions are excluded, the electricity produced from renewable energy is considered to be emissions free, and the associated emission factor is:

EF renewable = 0 g CO2-e / Kwh

Estimating Emission Reduction – Proposed Method

STEP 1 Calculate electricity generated on-site from renewable energy:-

STEP 2 Estimate corresponding building emissions reduction

PHASE 4 – Buy Green Power:-

PHASE 5 – Carbon Offset

4. Techniques of Low Carbon Building

4.1 Site Selection

Site plays a very important consideration in planning for a low carbon content building. An assessment of site should be made for its potential to provide natural resources such as solar energy, light, water etc. and the possible impacts of the projects oh these features

4.2 Building Material

Selecting environmentally preferable building materials is one way to improve a building's environmental performance. The concept of low carbon building incorporates and integrates a variety of strategies during the design, construction and operation of building projects. The use of low carbon building materials and products represents one important strategy in the design of a building.

4.3 Energy efficient Design for low carbon building

1) Day Lighting

Day lighting is the practice of bringing light into a building interior and distributing it in a way that provides more desirable and better-quality illumination than artificial light sources.

2) Wind Towers

Wind tower is generally used in hot and dry climates for cooling purposes The tower is meant to "catch" the wind at higher elevations and direct it into the living space.

4) Passive Heating

Passive heating measures are adopted to provide thermal comfort and also to reduce the demand for conventional heating.

4) Filler slab:-

This is a normal RCC slab where the bottom half (tension) concrete portions are replaced by filler materials such as bricks, tiles, cellular concrete blocks, etc.

5) **Rat-trap bond in wall construction:-**

The main advantage of this bond is the economy in use of bricks, giving a wall of one brick thickness with fewer bricks than a solid bond. It can save about 25% of the total number of bricks and about 40% of the mortar cost for a wall.

6) Renewable Energy:-

Systems based on renewable energy sources that are being used in the building sector include solar hot water systems, solar hot air systems, solar cookers, solar photovoltaic units, windmills, and biogas plants. These are commercially available and can easily be integrated into a building for reducing its dependence on conventional power and also help in reducing emission of carbon and pollution.

5. Conclusion

Day by day population is increasing and there is scarcity of resources, therefore to meet the requirement of growing population a proper planning is to be undertaken for fulfilling the demand in an eco friendly manner. Low carbon building would be the Mantra of the building industry in the near future.

Low carbon building would squarely address ecological and environmental impacts in a holistic manner and at the same time offer tremendous economic benefits. The constructions of such building results in reduced destruction of natural habitats and bio-diversity, reduced air and water pollution, less water consumption, limited waste generation and increased user productivity. Lastly we say only "We shape our building thereafter, our building shape us"

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