Chapter

Risk Mitigation: Sustainable Management in Construction Industry

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Abstract

Various parameters which are interactive in nature are exerting a negative influence on the existence of planet earth. Excessive urbanization, runaway global warming, unbridled generation of waste and pollution of air, water and soil has resulted in depletion of natural resources. As a result of threat to ecosystems and irreversible degradation, the growing evidence that the earth's ability to sustain life is getting eroded needs to be taken seriously. Major parameter which is responsible for substantial contribution to global warming and degradation of environment is the construction industry. The construction industry consumes about 40% of extracted materials and is responsible for about 35% of total carbon dioxide emissions. Rapid economic development coupled with unplanned construction has resulted in choking of cities/towns, with little or no lung space and over-exploitation of natural resources. This paper seeks to address the methods to mitigate the adverse effects on environment by way of implementation of sustainable management in the form of green and intelligent building which will facilitate the planet earth to be a liveable place for future generation while simultaneously pursuing the agenda of sustainable development.

Keywords: sustainable development, sustainable construction, sustainable design, green building, intelligent buildings

1. Introduction

The concept of sustainability is embedded in the fact that it enhances the quality of human life while carrying on our activities within the carrying capacity of supporting ecosystems. A responsible and proactive decision-making and innovation that minimizes negative impact and maintains a balance between ecological resilience, and economic prosperity to ensure a desirable planet for all species for the present as well as for the future is the core of sustainability. Sustainable development consists of balancing local and global efforts to meet basic human needs without destroying or degrading the natural environment.

Sustainable construction is the practice of creating a healthy environment that's based on ecological principles Sustainable Construction focuses on principles namely: 1) Conserve, 2) Reuse, 3) Recycle/renew, 4) Protecting nature and 5) Miinimising the use of toxic substances. The process of sustainable construction commences well before the start of actual on-site building activity and extends to post construction activities such as commissioning and asset management thus covering the entire project development cycle.

2. Literature survey

Albert Borgstein [1] conducted a research on Sustainability and concluded that sustainability is defined as a strategy for conducting operations in a manner associated with governance standards, which meet existing needs without compromising the needs of future generations.

Endersbee [2] conducted a study on Global Challenges and New Challenges for Civil Engineers and concluded that life cycle costing and life cycle management of resource splay an important role in development of a sustainable construction and that emergence of zero energy buildings and sustainable structures will reduce dependence on fossil fuels which is the primary source of global warming.

Hermawan et al. [3] conducted a study on Identification of Source Factors of Carbondioxide emissions in concreting of Reinforced concrete and the research findings show that there are seven factors namely scope, time, cost, quality, resources, procurement and material transfer which contributed to carbondioxide emissions in a construction project which will enhance the energy performance of buildings and thermal comfort as compared with light weight materials.

Nielsen [4] on Carbon foot print of Concrete Buildings seen in Life Cycle Perspective has researched that even though concrete has high carbondioxide emission during production, it is of paramount importance to include the service life of buildings in this type of calculations as at the end of service period, concrete will carbonate and will absorb carbondioxide from atmosphere.

Kim [5] researched on principles of sustainable design and findings indicate that per capita consumption of resource is linked with per capita income and has proposed three principles of sustainability namely: 1) Reduction, reuse, and recycling of the natural resources that are input to a building, 2) Life Cycle Design for analyzing the building process and its impact on the environment and 3) focus on humane Design for interactions between humans and the natural world.

Kilbert [6] has examined the future of sustainable construction and concluded that ecological design, the key concept in creating high performance buildings is in its infancy and needs to be articulated to be truly called as green building, the concept of green building needs to be further defined and methods for their evaluation needs to be developed and better conservation of resources and adjustments of social expectations will be an important factor in development of more sustainable built environment.

Planning Commission, Govt of India [7] in their study on Sustainable development has stated that in our society, every material is either derived from a mineral product or made using intermediate goods and may not be possible for the society without drawing mineral resource from our environment. Hence, the negative impact on the environment is to be limited and to reverse the damage done to the maximum extent possible through appropriate technological/management practices and procedures. The study concluded highlighting Sustainable development as an important concern for mankind.

Mehta [8] in his key findings on study on reducing the Environmental Impact of Concrete is that in a finite world the model of unlimited growth, unrestricted use of natural resources, and uncontrolled pollution of the environment is ultimately a recipe for planetary self-destruction and that greatest challenge that the concrete industry faces during the 21st century is to achieve a sustainable pattern of growth.

The task is formidable but it can be accomplished provided we make a paradigm shift from the culture of accelerating construction speeds to a culture of conservation of energy and material.

Penttala [9] in study on concrete and sustainable development has stated that the global warming caused by the green house effect are visible and hence new evaluation of building materials according to their ability to fulfill the requirements of sustainable development may have to be done. Taking into consideration the production and operational phases, the energy consumption and green house gas emissions of concrete in residential buildings needs to be examined. The concrete buildings brings ab significant energy and emission savings compared to buildings in which light materials have been used. Which enhances improves the ecological balance of concrete and lifts it to the group of building materials which burden environment least.

Ambuja Technical Literature Series [10] in its study has stated that building industry consumes 40% of the extracted materials and is responsible for 33% of carbondioxide emissions. Use of green and smart buildings can reduce the impact of energy consumption and that a thorough life cycle analysis of and management of building materials is necessary for selection of materials for high performance green buildings. Use of fly ash, silica fume and slag can contribute of sustainable construction.

3. Methodology

The methodology adopted for this paper is depicted in **Figure 1**.

4. Contribution of construction industry to global emissions

The contribution of various materials of construction to carbon dioxide emissions is furnished in **Figure 2**.

One of the largest industries in developing and developed countries in terms of investment, employment and contribution to GDP is the construction industry. Consequently, the impact of the construction industry on the environment in terms of loss of soil/agricultural land, the loss of forests/wetlands, air/water pollution, etc. is considerable. Contribution of eight major categories to environmental burden varies from 12 to 40%. The details are furnished in **Table 1**.

The embodied carbon in various aspects of construction is furnished below in **Figure 3**.

The construction sector is having negative impacts on the environment in the following manner:

- Almost two fifths of the Demolition Waste and Green House Gas is produced by construction industry.
- The environmental impact on buildings is spread throughout their entire life cycle.
- Construction of buildings is having impact by way of depletion of resources such as ground cover, forests, water, and energy.
- In providing comfort to occupants, energy is consumed for lighting, space conditioning and water heating.

- Continuous extraction of raw materials like limestone and ground water has caused irreparable and irreversible damage to the environment in the form of:
- Water stress.
- Reduction in the availability of fresh water due to potential decline in Rainwater.
- Threat to agriculture.
- Food scarcity in regions of excess extraction.
- Threat to biodiversity with adverse implications for forest dependent activities.
- Unscientific and uncontrolled method of limestone mining in various parts of the country have caused various adverse environmental impacts on the surrounding area leaving the region scarred with irregular patches, loss of vegetation cover, emergence and growth of xerophytes, instability of the mountains and esthetic degradation of the area, depletion of forest cover, depletion in plant diversity due to the stripping off, random digging and quarrying.
- Mining has also affected water resources severely both in terms of its quantity and quality. Changes in water levels and flow, availability of potable and

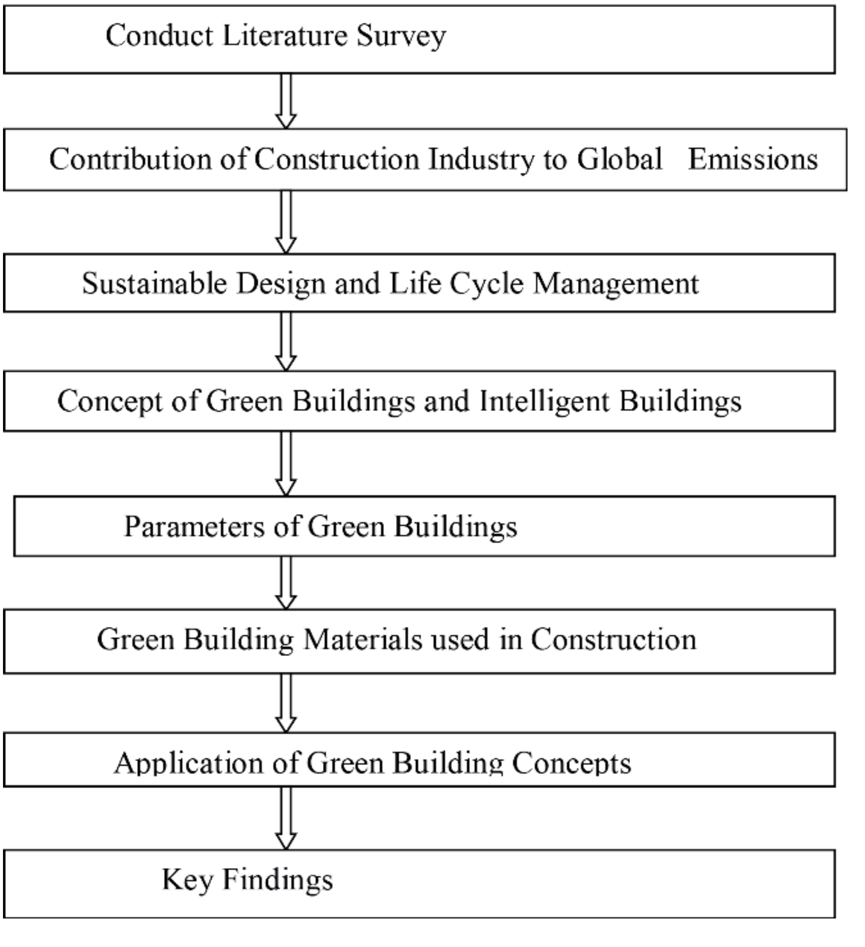

Figure 1.
Methodology Adopted.

irrigation water, degradation of water quality, reduction and degradation of habitat of aquatic flora and fauna and decrease in abundance and diversity of aquatic species are some of the adverse impacts of mining. In regions where mining is carried out, water resource are polluted, diverted/disturbed from their natural conditions as a result of mining activity making water unfit for consumption.

- There is high content of calcium, bicarbonates, sodium and chloride salts in the water of streams and rivers receiving a significant volume of mine water generated from open cast limestone mining areas.

- Cement on an average produces 0.9tonnes of carbon dioxide per ton of clinker and on an average, globally 3.5 billion tonnes of cement is utilized and hence the contribution to green house gas emissions is obviously quite large.

- Sand, Gravel and crushed rock is used at the rate of 10–11 billion tones every year which leads to excessive mining of soil components resulting in loss of water table.

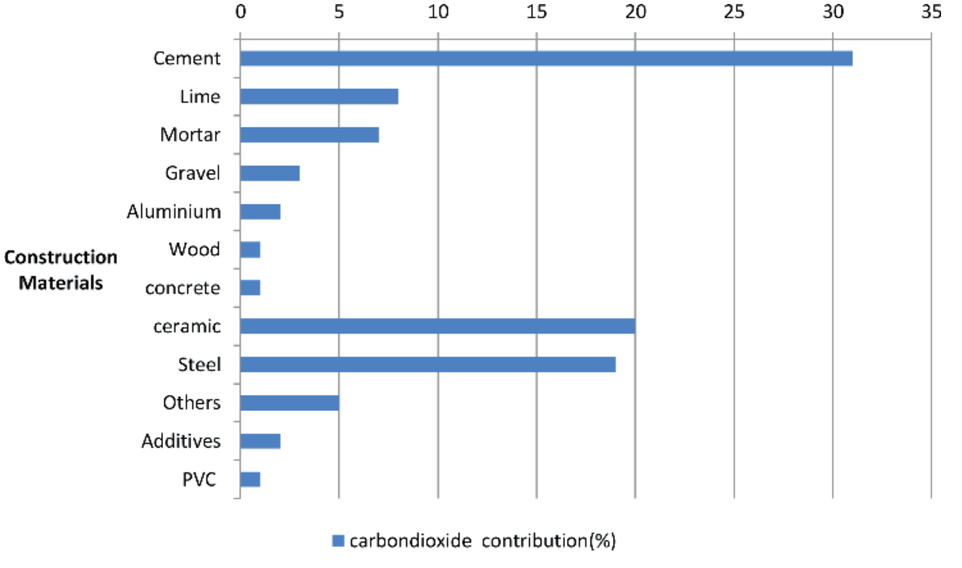

Figure 2.
Source: www.construct.com/carbon-emisisons-in-construction-materials.

Parameter	% Contribution
Use of raw materials	30
Energy	42
Water	25
land	12
Atmospheric emissions	40
Water effluents	20
Solid waste	25
Other releases	13

Table 1.
Contribution of major categories of construction to environmental burden.

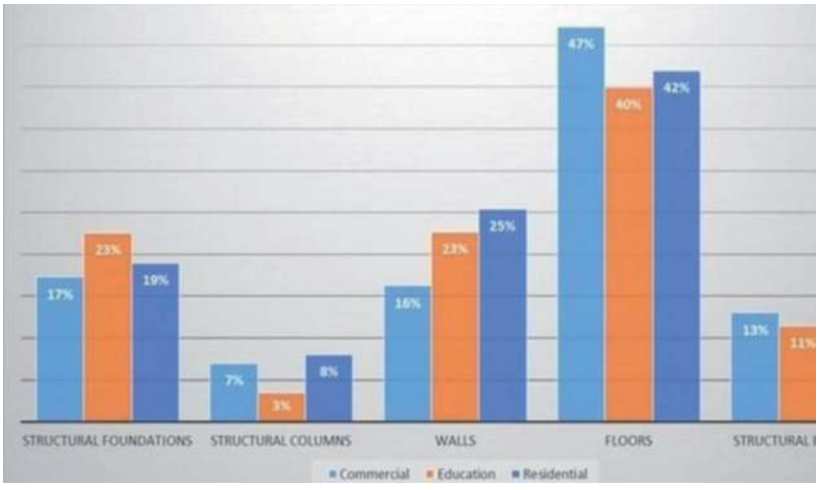

Figure 3.
Source: www.construct.com/carbon-emisisons-in-construction-materials.

Considering the above cited factors, it is imperative that in line overall objective of bringing down the green house gas emissions by 40% from the level of 1990 by 2030, the construction industry has no choice but to adopt innovative measures to bring down its carbon foot print substantially.

5. Sustainable design

In comparison to any human endeavor, the built environment had adverse and long lasting impacts on the environment. Approximately 10% of the global economy is earmarked for construction activities as it consumes 50% of global resources. On an average, buildings account for:

- 39% of total energy use
- 68% of total electricity consumption
- 30% of landfill waste
- 38% of carbon dioxide emissions
- 12% of total water consumption

Effective approaches for life cycle design and management of construction that will ensure their sustainability as regards improved physical performance, cost effectiveness and environmental compatibility is to be developed to address the challenges. This should achieve an optimal balance between the following criteria namely:

- Engineering Performance which encompasses Safety, Serviceability and Durability
- Economic Performance in terms of minimum life cycle costs and minimum user cost
- Environmental Performance by way of minimum green house gas emissions, reduced materials consumption, improved energy efficiency)

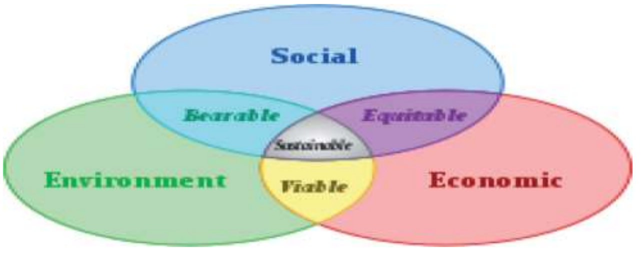

Figure 4.
Major aspects of sustainability.

Design professionals may be aware of the first two criteria but the last criteria has impact on the way the design is thought of. Sustainable design means developing products with improved performance in all phases of the product life cycle. Sustainable design has to consider three major aspects of sustainability, i.e., Social, Economic and Environmental. The relationship is depicted in **Figure 4**.

Consideration for design of sustainable building:

- Resources should be discarded at the speed at which local eco-systems can absorb them and should be utilized ed. at the pace at which they naturally regenerate.
- Resources naturally available on the site such as solar and wind energy, natural shading and drainage, etc. should be incorporated in site planning to lessen the local and global impact.
- Minimisation of energy and material waste throughout the life cycle of a building.
- Considering factors such as day lighting, passive ventilation, efficient material and design strategies, internal load, local climate, etc. buildings should be designed.
- Occupant's health and productivity should be maximized by design.
- Waste reduction and recycling should be supported by operation and maintenance systems.
- Judicious use of water considering it as a finite resource.
- Location and systems should optimize employee commuting and minimize the use of single occupancy vehicles. These include alternative work modes such as telecommuting and teleconferencing, etc.

6. Green building

A green building is one which:

- Consumes less water
- Optimizes energy efficiency

- conserves natural resources
- generates less waste and
- Provides healthier spaces for occupants, as compared to a conventional building.

Research has shown that a green building can give benefits by way of:

- Reduced energy use by 20–40%
- Reduced Carbon dioxide emissions by 37%
- Reduced Water use by 40%
- Reduced Solid Waste by 70%
- Enhances and protects ecosystems
- Conserves and restores natural streams
- Enhances esthetic qualities
- Minimum strain on local infrastructure and reduced operating costs
- Optimizes life cycle economic performance
- Improves air and water quality
- Enhances the productivity of occupant

7. Intelligent buildings

An intelligent or smart building is one that uses technology and processes to create space that is safer and more productive for its occupants. In such a building, network of electronic devices monitor and control the mechanical and lighting systems to reduce energy and maintenance costs. Lighting is controlled by sensors, which can detect the presence of occupants and relative darkness and can modulate lights accordingly. To monitor the temperatures, sensors are placed in rooms and air ducts. Such buildings are provided with hot water systems for supplying heat to the air handling unit and chilled water systems for cooling its air and equipment with optimum level of temperature being maintained by sensors. Intelligent buildings also have alarm capabilities and alarms for reporting critical faults in mechanical and electrical systems.

8. Factors of green building

8.1 Location

- Selection of a green building site should be based on how easily it can integrate into the existing electric, gas, water and sewage utilities.
- It should have minimal impact on the existing energy, water, sewage and road systems.

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Figure 5.
Wool brick.

8.2 Orientation

- A green building should organically fit into the surrounding area, making best use of existing roads, sidewalks, alleys, site specific resources.

8.3 Daylight

- Day lighting is the controlled admission of natural light—direct sunlight and diffuse skylight into a building to reduce electric lighting and saving of energy. Day lighting is an important element of sustainable design (**Figure 5**).

8.4 Renewable energy

- A green building uses maximum of renewable energy like solar, wind, geothermal, biofuels, etc. thereby bringing down the quantum of usage of non-renewable energy.

8.5 Rainwater harvesting

- The main purpose of rainwater harvesting system is to collect and store rainwater falling on the ground which can be further be used during times of drought and scanty rainfall.

8.6 Waste water management

Waste water management has a direct impact on the biological diversity of aquatic ecosystems, disrupting the fundamental integrity of our life support systems, on which a wide range of sectors from urban development to food production and industry depends.

9. Various green building materials

9.1 Wool brick

- Obtained by adding wool and a natural polymer found in seaweed to the clay of the brick.

- 37% More strength than burnt bricks.

- Resistant for cold and wet climate.
- Researchers have added wool fibers to clay material used to make bricks and combined these with an alginate, a natural polymer extracted from seaweed. This resulted in bricks that are stronger and more environmentally friendly.
- Wool Bricks are comprised of clay, wool, and alginate.
- Clay can be found in estuaries, coastal plains, continental shelves and offshore islands.
- It can easily be found anywhere in the world.
- Unlike regular brick, wool bricks they do not crumble suddenly, they develop small cracks and deform slowly before giving way.
- In addition, since these bricks contain sodium aliginate it can easily become biodegradable.
- Wool Brick can be manufactured without firing which contributes to energy saving.
- Zero-carbon product.
- These fibers improve the strength of compressed bricks, reduce the formation of fissures and deformities as a result of contraction, reduce drying time and increase the bricks' resistance to flexion (bending) (**Figure 6**).

9.2 Sustainable concrete

- Fine and coarse aggregates can be replaced with 10% of with recycled glass (Soda-lime glass used for bottles washed and crushed to fine and coarse aggregate sizes for use in the concrete mixes).
- Resulted in better properties in fresh and hardened states at ambient and high temperatures than those with larger replacement.
- Concretes made with Fine Waste Glass aggregates had satisfactory compressive strengths as well as initial and final setting time of concrete.
- 25% reduction in weight of concrete.
- 30% reduction in carbon dioxide emissions and 40% reduction in repair costs.

Figure 6.
Concrete made of FWG aggregates.

9.3 Cellulose insulation

- Recycled paper products and a very high recycled material content of 82–85% and forms the basis of cellulose insulation.
- The paper is reduced to small pieces and then fiberized, which creates a product that packs tightly into building cavities and inhibits airflow.
- Sometimes mineral borate is blended with the less costly ammonium sulfate, to ensure fire and insect resistance.
- Cellulose insulation typically requires no moisture barrier and, cannot settle in a building cavity (**Figure 7**).

9.4 Triple glazed windows

- A triple glazed window is a window that comprises of 3 layers of windows.
- Exhibits strong insulation performance.
- Triple glazing has grown in preference over the years, and has gradually gained a lot of acceptance.
- Triple-glazed windows are great at taking in the warmth of sunlight and then getting it into the rooms.
- Best suited for bigger windows, these windows also contain a glass pane that has solar control and self-cleansing characteristics.
- They are durable and rigid.
- Reduces sound transmission, saves energy and gives more comfort (**Figure 8**).

9.5 Pre-cast concrete slabs

- Saves energy, water and building materials
- Rapid construction on site

Figure 7.
Cellulose insulation.

Figure 8.
Triple glazed window.

Figure 9.
Pre-cast concrete slabs.

- Good quality control
- Safety and Protection
- Low impact construction
- Esthetically appealing structure (**Figure 9**)

9.6 Bamboo

- Bamboo is being used in columns, walls, beams, doors, roofs, fencing, staircases and boundary walls
- Bamboo fiber reinforced concrete is used for construction of sla bs which proves to be lighter than conventional concrete
- They are 3 times cheaper than steel and has great tensile strength
- Upto 70% of steel can be replaced by bamboo for a structure
- Disadvantages are that it can swell and rot if untreated and it can shrink which can lead to segregation of concrete (**Figure 10**)

Figure 10.
Bamboo reinforcement.

9.7 Concrete alternatives

- Papercrete and Hempcrete are two examples of concrete alternative.
- These two building materials also use cement or clay.
- This concrete uses more environmental friendly aggregates as against of the nonrenewable aggregates used in traditional concrete
- Concrete-like materials for building is produced by repulped paper fiber, hemp and even bits of wood or sawdust.
- Environmental impact would be amazing if f interior walls of new buildings were replaced with this material.
- For papercrete in particular, raw materials aren't expensive.
- The heat and sound insulation found in papercrete is much better than traditional concrete.
- Papercrete has a high compressive strength and is light weight enough to be used as a roofing alternative.
- Disadvantage is that there are waterproofing methods that can be applied to the materials, but it's still made of paper (**Figure 11**).

9.8 Acetylated wood products

- This is an eco-friendly material which is alternate to the use of toxic pressure-treated wood.
- Wood is modified through a acetylation to create a product which is resistant to rot and improved thermal insulation, stability and longer lifespan.
- This is gorgeous and certified non-toxic (**Figure 12**).

Figure 11.
Papercrete concrete.

Figure 12.
Acetylated wood product.

9.9 Polyurathenes

- The most important application of polyurethanes in buildings is insulation.
- Polyurethanes are regarded as an affordable, durable and safe way of reducing carbon emissions.
- Polyurethanes can dramatically reduce heat loss in homes and offices in cold weather.
- During the summer, they play an important role in keeping buildings cool, which means air conditioning is needed less.
- They can be used in cavity walls, roofs, around pipes and floors (**Figure 13**).

9.10 Green roofs

They are vegetated roofs consisting of a waterproofing membrane, growing medium (soil) and vegetation (plants) overlying a traditional roof (**Figure 14**).

9.10.1 Benefits of green roofs

- Average life expectancy of a green roof is 40 years, as compared to an average expectancy of 17 for a conventional roof.
- Green roofs can act as an insulating layer and reduce heat flux by up to 72%.

Figure 13.
Polyurathenes in construction.

Figure 14.
Green roofs.

- The energy efficiency factor of green roofs reduces demand for power, thereby decreasing the amount of Carbondioxide being released into the atmosphere.
- Green roofs can reduce outside sound penetration by 40–60 decibels.
- Increased efficiency means an increase in property value. Also green roofs contribute to green building movement.
- Green roofs can retain 70–90% of precipitation in the summer and 24–40% in the winter.
- Green roof means added biodiversity, esthetic appeal, and more green space for relaxing, stress relief, and even gardening.

9.11 Environment friendly industrial by-products

- Iindustrial by-products such as flyash, blast furnace slag and silica fume as cementitious materials in concrete structures leads to significant reductions in consumption of energy, quantity of cement needed to make concrete and reduced emissions.

- Flyash which is difficult to dispose is substituted for over 30% of cement volume and blast furnace for more than 35%.
- High volume flyash concretes with 50–70% of cementitious content is found to be feasible in certain situations.
- Use of these products has resulted in substantial improvements in properties of both fresh and hardened concrete'.
- The proportion of blended cement has increased by more than 80% in a decade from 2005 onwards and is likely to increase further in the coming years.

10. Application of green concepts-landmark structures

- Biodiversity Conservation India Ltd. (BCIL), Bangalore (India).
- This is the first residential apartment in the world to be certified under 'Platinum Category' by LEED (Leadership in Energy and Environmental Design).
- No home at BCIL TZed (Towards Zero Energy Development) use incandescent lamps, halogens and fluorescent tube lights.
- Lighting reduced by nearly 70%.
- Green project spread over 5.5 acres (**Figure 15**).

Figure 15.
BCIL building.

11. ITC Green Centre-Gurgaon (India)

- This was the first 'Platinum' rated building in India with a built-in area of 1.8 lakhs sq.ft.
- The building features, storm water management system, solar thermal technology, reflective high-albedo roof paint, minimal exterior lighting, separate smoking rooms with exhaust system and zero-water discharge.
- About 10% of the building materials were refurbished from other construction sites and two fifths of the materials were procured with least transportation cost (**Figure 16**).

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Figure 16.
ITC Green Centre.

12. Druk White Lotus School, Ladakh (India)

- It is a school is situated in desert landscape of severe climatic conditions, 3,500 meters above sea level.
- This structure is recipient of the Best Asian Building, Best Education Building and best green building awards.
- It combines the best of traditional Ladakhi architecture with 21st century engineering excellence.
- Traditional mud brick masonry is used internally to provide increased thermal performance and durability (**Figure 17**).

13. Confederation of Indian industry, Hyderabad (India)

- Below mentioned are some Green features of this structure.
- Potable water use is reduced 35%.
- Energy savings to the extent of 50% and reduced lighting consumption by 88%.

Figure 17.
Druk White Lotus School.

Figure 18.
CII building.

- Four fifths of the materials used are recycled/recyclable.
- Photovoltaics provide one fifth the building's energy requirement.
- Use of aerated concrete blocks in facades resulted in 15–20% less load on AC.
- It's a Zero water discharge building.
- 90% of building uses daylight and 75% of the occupants have outside view (**Figure 18**).

14. Key findings

Our planet earth is at peril due to plethora of factors like population explosion, unplanned urbanization, excessive energy use, water scarcity and inefficient waste management. It is pertinent to note that construction industry substantially consumes energy and other resources produced by the world as well as a major contributor to Green House Gas emissions. Green and Intelligent buildings with LEED certification, life cycle costing and life cycle management of resources play an important role in sustainability of the construction industry. Unless strong and efficient measures are adopted to bring the concept of green buildings within the affordability of a common man, the concept of sustainable construction will be confined to mere pipe dream. It is the responsibility of the current generation to bequeath a liveable planet to the next generation by cutting down of carbon dioxide emissions and adoption of pro-green measures. The window of opportunity to cut down the emissions is closing on us and unless we act fast, it may be too late to reverse the damage that has been inflicted on the environment by the construction industry.

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