Minireview Article

"Green Building": A step towards environmental and economic construction

Abstract:

Green building is one of the measures been put forward to alleviate remarkable impacts of the building stock on the environment, society and economy. This paper reports a critical review of different national and other proprietary system, GRIHA rating system and incentives provided in India, techniques and method for construction of green building, financial aspects of green building. The efficacy of different environment friendly models are broadly discussed in this study. The purpose of this paper is to explore the benefits of green building in order to proceed towards the sustainable construction in future.

Introduction

The buildings which reduces the negative impact and can create a positive impact on the climate and natural environment with its design, construction are known as green buildings. The main motive of green building is to improve the quality of life and preserve the natural resources.

Building industry is one of the industry which is responsible for demolition waste and greenhouse gases. The lifecycle of building have major impact on environment. The real-estate and construction sector has a share of 32% of globalenergy usage.[1]Due to construction and operation of buildings natural resources are depleted such as ground water, forest, water and energy. Nearly, 40% of global CO_2 is emitted from the buildings, India comes at 144th position in CO_2 emission rating.[2].It is estimated that by 2035 the carbon emission of buildings will reach upto 42.4 billion tonnes.Construction without concrete is hard to imagine, it is predicted that the production of cement will reach up-to 5 billion metric tons by 2030 which is a 40%increase from the current consumption.[3] Around 30,000 tons of carbon is dumped into the atmosphere from the cement factories in every eight minutes.[4] Cement industry generates about 7% of CO_2 into the atmosphere, Producing 1 ton of Portland cement causes the release of about 1 ton CO_2 into the atmosphere. Over 1 trillion gallons of water is consumed by the concrete industry worldwide, which does not even include the curing water and wash water. Disposal and demolition of any concrete structure, pavement inaugurate another environmental problem.[5]

Buildings consume large amount of nations electricity, material, water and generates huge amount of waste in our environment.The solution of these problems can be reduced by the construction of green building.

The construction and operating of homes, offices, commercial buildings contributes around one-tenth of the global economy, due to construction 40% of material flow enters in the

world economy.[6]According to the prediction made by International Energy Agency the commercial and institutional buildings will rise 2 times by 2050.

The market of green construction is growing rapidly because in green building use of energy, water and other natural resources can be efficiently performed. Renewable energy such as solar energy can be used, pollution reduction measures enables re-use and recycling of waste product.[7] It helps to create a good indoor environment which has a positive effect on health and the design evolved in making of green building which helps to adapt to the changing natural environment. As compared to conventional building the thermal and visual comfort of a green building is much higher.[8] Green building also helps to control construction and demolition waste.[9]Prefabrication technologies helps to reduce the amount of construction and demolition waste.[10]Prefabrication technologies also reduces the construction cost.[11]

Most of the people are not adopting the concept of green construction because they think that construction of green building is costlier than conventional buildings which is a myth. The cost of green construction is high but there are lots of financial benefits for long term.

Different National and other Proprietary Systems

The organisations such as World Green Building Council which was founded in 2002, aims to reduce the global temperature rise by 2 degree Celsius, reduce the emission of CO_2 from building and construction sector by 84 giga-ton and the net emission of all the building must be zero.

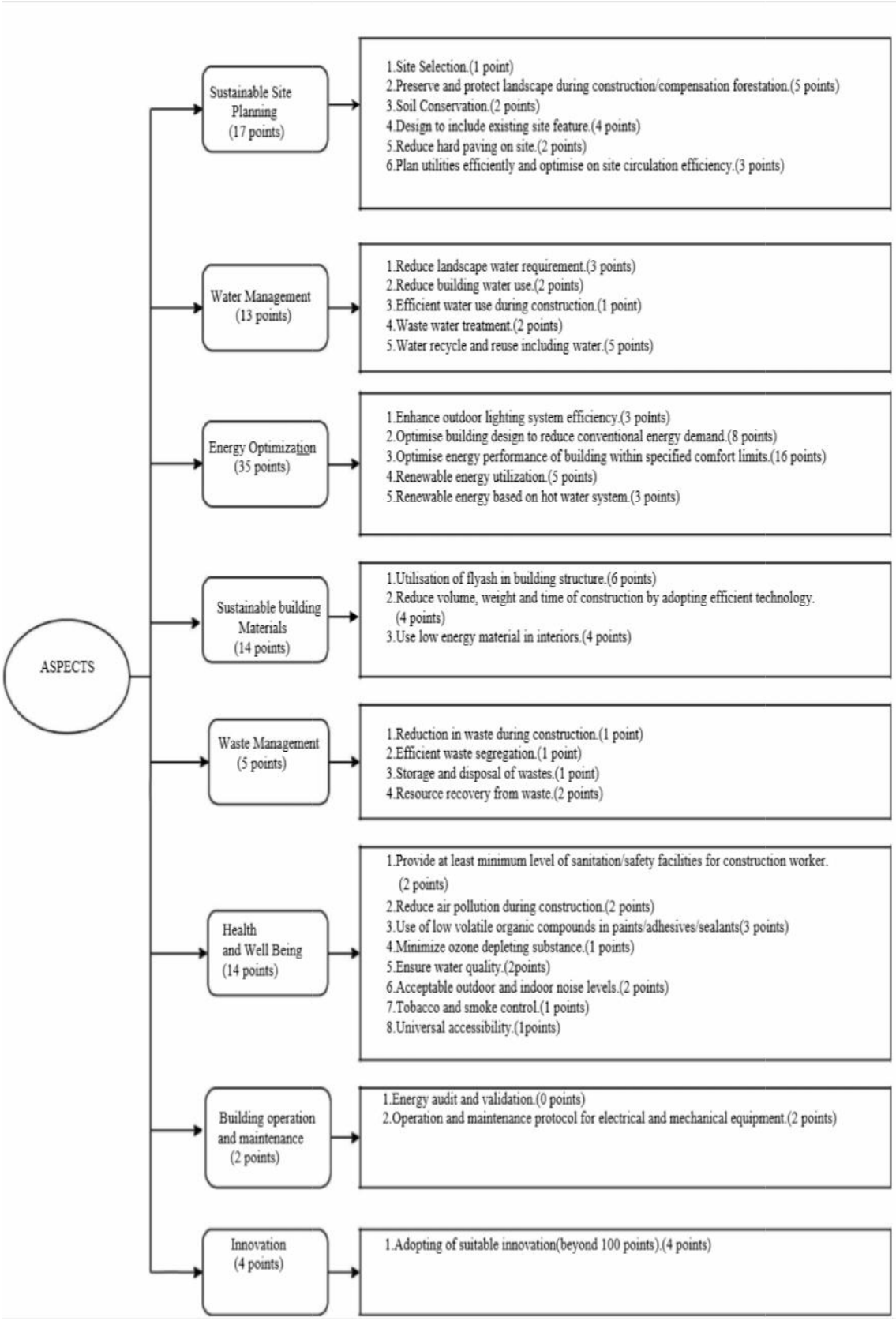
LEED, or Leadership in Energy and Environmental Design is the most commonly used green building rating system in the world which was developed by the US Green Building Council, it aims to help building owners and operators to be environmentally responsible and use resources efficiently. Rating system has been used in popularising the green building design because these green design are set in the specific social context, therefore most of the country uses their own national rating system based on different concern. In USA energy consumption in heating is a major concern, So LEED-USA system has high priority for energy efficiency. In Hong Kong indoor environment quality also requires minimum percentage points for keeping the highly urbanised environment.[12]Therefore, India has developed its own green building rating system whose major concern is to work on the emerging technologies and building practices to be followed.
Few national green building councils are:

1. LEED – US Green building council.
2. BREEAM-UK
3. BEPAC-Canada
4. IGBC,GRIHA-India

GRIHA RATING SYSTEM

GRIHA (Green Rating for Integrated Habitat Assessment) is a green building rating system of India which was developed by TERI (The Energy and Resources Institute).About 1200 projects are registered in GRIHA covering approximately 70 million sqm of area. It has 8 aspects which covers 34 different criterions of ratings.

All these criterion are represented in flow chart given below


ASPECTS
Sustainable Site Planning (17 points)
1.Site Selection.(1 point)
2.Preserve and protect landscape during construction/compensation forestation.(5 points)
3.Soil Conservation.(2 points)
4.Design to include existing site feature.(4 points)
5.Reduce hard paving on site.(2 points)
6.Plan utilities efficiently and optimise on site circulation efficiency.(3 points)
Water Management (13 points)
1.Reduce landscape water requirement.(3 points)
2.Reduce building water use.(2 points)
3.Efficient water use during construction.(1 point)
4.Waste water treatment.(2 points)
5.Water recycle and reuse including water.(5 points)
Energy Optimization (35 points)
1.Enhance outdoor lighting system efficiency.(3 points)
2.Optimise building design to reduce conventional energy demand.(8 points)
3.Optimise energy performance of building within specified comfort limits.(16 points)
4.Renewable energy utilization.(5 points)
5.Renewable energy based on hot water system.(3 points)
Sustainable building Materials (14 points)
1.Utilisation of flyash in building structure.(6 points)
2.Reduce volume, weight and time of construction by adopting efficient technology. (4 points)
3.Use low energy material in interiors.(4 points)
Waste Management (5 points)
1.Reduction in waste during construction.(1 point)
2.Efficient waste segregation.(1 point)
3.Storage and disposal of wastes.(1 point)
4.Resource recovery from waste.(2 points)
Health and Well Being (14 points)
1.Provide at least minimum level of sanitation/safety facilities for construction worker. (2 points)
2.Reduce air pollution during construction.(2 points)
3.Use of low volatile organic compounds in paints/adhesives/sealants(3 points)
4.Minimize ozone depleting substance.(1 points)
5.Ensure water quality.(2points)
6.Acceptable outdoor and indoor noise levels.(2 points)
7.Tobacco and smoke control.(1 points)
8.Universal accessibility.(1points)
Building operation and maintenance (2 points)
1.Energy audit and validation.(0 points)
2.Operation and maintenance protocol for electrical and mechanical equipment.(2 points)
Innovation (4 points)
1.Adopting of suitable innovation(beyond 100 points).(4 points)

FLOW CHART

These 34 criterions have been allotted 104 points which are used for the evaluation of any building, to attain at least one star rating the building must have 50 points. On the basis of points scored out of these criterions ratings of buildings are tabulated below-

Points Scored	Rating
50-60	1 star
61-70	2 star
71-80	3 star
81-90	4 star
91 and above	5 star

Techniques and methods for construction of green building

There are various methods, design and techniques by which any building can be made green, most commonly used methods for green construction are discussed below-

Civic Tree Plantation

As the world population continues to grow, the population density is gradually increasing inz the urban areas this is also because of the population shift from the rural area to urban area which is known as urbanization. The rapid expansion of urbanization has a damaging effects on forest and the green areas around the city, increase in pollution, extreme climatic changes and decrease in the availability of natural resources. Due to urbanization the emission of greenhouse gases such as CO_2 is increased, this problem can be temporarily reduced by planting trees in the urban areas and to attain long term reduction the population of trees must be constant. Over the lifespan of the tree several tons of CO_2 is absorbed by the trees for its growth.[13] Strategic placement of trees can help to reduce the heat island effect because of evapotranspiration. Now a days green roof is the one of the trending method used to reduce the heat island effect in the cities with high rise buildings. A green roof is a building roof where the vegetation is planted over a waterproof membrane designed as per the load capacity of the roof. Green roof will reduce the cooling energy consumption of air conditioning building because of the thermal insulated structure of the roof preventing excessive solar heat. Sedum plants and Turfgrass are the most commonly used plants for the construction of green roof.[14]By the increased plantation of trees the average day time temperature of a city is decreased due to which the electric energy consumption(use of electric appliances) and CO_2 emission is reduced. Plantation of about one million trees will reduce the atmospheric CO_2 by about 1 million tons of CO_2 over the next 35 years.[15]

Green concrete

In the field of construction Portland cement concrete is widely used which is substantial because Portland cement concrete emits green house gasses such as CO_2 in the environment, as we know that 40% of global CO_2 is emitted by buildings that can be reduced by the use of green concrete. Large amount of CO_2 is emitted while manufacturing Portland cement because of heating of limestone and clinker at a large amount of heat.[2]We can decrease the CO_2 emission by replacing some amount of Portland cementitious material with Fly ash.[16] Fly ash is a residue of coal combustion which is an excellent cementitious material. Fly ash is

less expensive from Portland cement because it is by product of coal combustion that would be a waste product to be disposed off at great cost.

The study of green concrete by replacing some amount of cement content by Flyash as tremendous effect on the physical and chemical properties of concrete which are as follows-[17]

- Effect on workability- Replacing fly ash as a cementitious material increases the workability and reduces the water require attain consistency.
- Effect on Bleeding- It reduces the water content due to which bleeding is reduced but at the same time the mobility of the mix is increased, due to which the setting time is delayed, which increases the bleeding.
- Effect on setting time- It has both chemical and physical effect
    1. Physical effect: As the specific gravity of fly ash is less than Portland cement the replacement of cement on equal weight means that the volume of fly ash is increased.
    2. Chemical effect: It can affect the hydration process because some fly ashes react within itself.
- Effect on durability- Replacing with considerable amount of fly ash increases the durability and the compressive strength of the specimen.

If the Fly-ash content exceeds by 40% in concrete at lower temperature than it leads to slow strength development[18] , the early compressive strength of green concrete is less as compare to Portland cement concrete but under high air curing the compressive strength of green concrete is much more than that of Portland cement concrete.[19]Fly ash is not only use for the purpose of saving energy, infact it reduces the amount of landfill waste.[20]

Solar Photovoltaic Plant

Consumption of energy is one of the major factor for the growth of commercial and industrial areas. To fulfill the large energy demand it is essential to consume energy from renewable resources for the sustainable development, for fulfilling the large demand of energy the health and productivity should not be compromised.[21]In India, most of the power generation is due to the burning of fossil fuels which contributes to the emission of greenhouse gases.[22]Renewable energy such as wind energy, solar energy and bio-mass energy can be converted into electrical energy without emitting any greenhouse gas.[23]The energy demand of the world can be fulfilled by solar power if the needed technology is available.[24]Around 342 Wm^{-2}solar energy is received in the earth's atmosphere out of which 30% is scattered or reflected back to space and the remaining amount of energy can be consumed.[25]The estimated solar power capacity of India by 2022 is 100,000 MW.[25]Solar Photovoltaic Plants are used to convert the direct sunlight into electricity without emitting any greenhouse gas. Now a days it has wider application such as power generation, heating, water pumping, desalination etc. which has a major impact on green construction. It produces the required amount of electricity on site and it is the cheapest source of energy.

Waste water treatment

Water that has been already utilized for the domestic, industrial, commercial or agricultural use is known waste water. Waste water contain large amount of organic matter and toxic chemicals which cannot be directly disposed in the environment because it may lead to water born diseases or degradation of natural resources therefore it is essential to treat the waste water and dump only the unwanted toxic material present in it, so that the treated water can reused for the various purpose. In India 1086 km^3 water is utilized from the water resources[26] the utilized water must be reused for the sustainable growth. Aerobic waste water treatment methods are the most common methods centralized in the developed countries. In developed countries treatment can easily be differed between rural and urban users with respect to their income.[26]

The table given below are case study of few Green Buildings constructed in India that have used these methods.

Building and location	**Civic tree plantation**	**Sustainable material**	**Solar plant**	**Waste water treatment**	**Rating**
Grape county resort, Nasik	Total 538 new native trees were planted.	Green Concrete (fly-ash content in the range of 15-35%.)	30 kW solar photo-voltaic system of capacity	STP (Sewage Treatment Plant) based on reed bed system treats 100% of sewage generated	5 star
Bel academy, Bangalore	260 new saplings were planted	Green Concrete(28% of cement is replaced with fly-ash)	90kWp capacity of solar Photovoltaic panel	-	5 Stars
Manipal county, Bangalore	130 new trees were planted	Green Concrete(30% cement is replaced with fly ash)	150kWp solar Photovoltaic system	-	5 Star
NHPC corporate office, Faridabad	Most of the existing trees were properly preserved	Green Concrete(33% fly ash content)	70kWp solar photovoltaic system	-	4 stars

New interim terminal building Vijayawada Airport	254 new trees were planted	Fly ash bricks were used	15kW solar Photovoltaic system	STP (Sewage Treatment Plant)with 200 KLD capacity	3 star

Financial aspects of Green Building

As we have already discussed that the major misconception about green buildings is that it cost more than conventional buildings. The conversation of cost of green construction is dominated by benefits and values of green construction because the decision makers are in dilemma, i.e. on one hand they want to provide facilities to enhance the organizational productivity but often they do not want to make investments in the kind of changes needed until they have proof that they will pay off. 30% of operating cost of a building is due to electricity and water consumption, when it comes to energy consumption green building are 25% to 30% more efficient.[27]Moreover green building reduces the demand of water.[28]Green building gives lots of financial profit in long term. The benefits of green building includes energy and water savings, reduced waste, improved indoor environmental quality, greater employee comfort/productivity, reduced employee health costs, these features also helps to increase rent and decrease the operating cost.[29]

Green building are 28% more efficient and generate 2% of their power on site by photovoltaics which makes it 30% more energy efficient than conventional building.[30]The green features of buildings can save upto 55% of energy cost as compared to conventional buildings.[31]Most of the people spend 90% of their time in indoor environment only, the concentration of pollutants in indoor environment is higher than outdoor environment.[32] Construction focuses on the interior environment and individual performance which helps to increase the health and productivity of an individual. Indoor environment of green buildings provide higher satisfaction of thermal and visual comfort as compared to convention building.[33]In a study it found that people living in green buildings are more mentally stable and tolerant.[34]1% of productivity and health is gained from buildings which are silver rated and 1.5% of productivity is gained by gold/platinum rated buildings and 1% increase of productivity is equal to about 5 mins per working day where as 1.5% increase in productivity is equal to 7 mins per working day.[30]Due to healthy interior environmental quality green building enhances the ability to rent or sell space.[35]

Building constructor who want green construction but don't want it to cost more than a conventional building need to have cost and environment awareness in their minds, based on the national proprietary systems rating the government of India provides certain incentives in different states.

The incentives provided in different states of India are:

States	Agencies	Incentives provided
Punjab/Rajasthan /Uttar Pradesh Government	Punjab Urban Development authority/Urban development and housing department/Housing and Urban planning department.	5% additional FAR(Floor Area Ratio) is provided free of charge on buildings which are gold rated or above.
West Bengal /Himachal Pradesh Government	Kolkata Municipal Corporation/ Town and country planning department.	10% additional FAR(Floor Area Ratio) is provided free of charge on buildings which are gold rated or above.
Andhra Pradesh Government	Industries and commerce department	Offers 25% subsidy on total fixed capital investment of the commercial, industrial project.
	Municipal administration and urban development department	20% reduction on permit fee.
Jharkhand Government	Urban Development and housing department	Additional FAR is provided for Silver rated-3% Gold rated-5% Platinum rated-7%
Haryana Government	Town and country planning department	Additional FAR is provided for Silver rated-9% Gold rated-12% Platinum rated-15%

Conclusion:

The world is moving towards the sustainable development, so in the field of construction, green building is a step towards sustainable development. It is important to recognize the benefits of green building, so that people can overcome their psychological barrier of a misconception that green buildings are not appropriate for construction. The developing countries like India need to avoid the mistake of not using sustainable building materials and must plan to make a building more energy and water efficient which will definitely lead towards a sustainable development of a country. According to GRIHA rating of a building different incentives are provided, which will help to gain more economical and financial benefits.

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