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COST OPTIMIZATION OF A BUILDING USING SUSTAINABLE BUILDING CONCEPT: A REVIEW

Mohammad Qasim[1], Er. Shalika Mehta[2], Prof. Sandeep Salhotra[3]

[1]ME Research Scholar, CED, Chandigarh University, Punjab, India,
[2]Assisstant Professor, CED, Chandigarh University, Punjab, India,
[3] Associate Professor, CED, Chandigarh University, Punjab, India,

Abstract— This paper provides an overview of literature on the cost optimization of an existing building using sustainable building concept. Those strategies which are followed for a building to convert it to a sustainable building or green building whereas it reduce the long term running cost along with sustainability. Strategies are for sustainable site planning, Water conservation, Energy conservation, efficient use of material and thermal comfort for occupants. It concludes the importance of sustainability and cost optimization throughout the construction activities and operating which have impacts on environment throughout life cycle which cause greenhouse gases(GHG) emissions, climate change, global warming, ozone layer depletion, water scarcity and so on. These major environmental problems cannot be completely eliminated but can be significantly reduced with a high level. In addition to this these strategies are cost effective throughout long term use, initially are expensive but the premium costs can be paid after some years of use.

Key Words: Cost optimization, Sustainable Building, Water conservation, Energy conservation, GHG, Global Warming.

I. INTRODUCTION

Nowadays the world is facing many major problems such as environmental, social and economic. Environmental problems, especially climate change is now affecting all countries on every continent. It is disrupting national economies and affects lives, costing people, communities and countries today and even tomorrow. Weather is changing, sea levels are rising, greenhouse gas emissions, Ozone layer depletion, global warming, water scarcity, energy crisis and air pollution are now at their highest level. Without taking action, the average surface temperature of the earth could increase by 3 degrees Celsius during this century. The poorest and most vulnerable people are the most affected. These are the major environmental problems which is created by the daily activities of human on the earth. These problems have adverse effect on ecology and ecosystem. The environmental concerns cannot be fully eliminated but can be reduced by a high level through sustainable development (SD) and its goals. Sustainable Development has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs [1]. The three pillars of SD are sustainable development-economic, social and environmental [2]. The ecological stability of human settlements is an essential part of the relationship between man and the social, natural and built environment [3]. Environmental sustainability (ES) concerns the natural environment and its diversity to remain productive at present and even tomorrow. Particular concerns are of the state of air, water, climate and the natural resources form the environment. The environmental sustainability requires society to plan such activities to meet human needs at present, while maintaining comprehensive systems, preserving of life support of planet. This includes, for example, the sustainable use of water, the utilizing of renewable energy sources and the sustainable supply of materials. To implement the concept of sustainability in the construction sector, we design a sustainable building or green building with minimal impact on the built environment during its life cycle. Green building comes under the umbrella of sustainable development. A green building, is also called a sustainable building, and is a structure that is designed, constructed, rehabilitated, functioned or re-used in an environmentally friendly and resource-efficient manner. To build a sustainable building, we must take into account parameters of sustainable space, the rational use of water, energy efficiency, the use of environmentally friendly materials and the quality of the indoor environment. The key objective is a step towards sustainable development [4]. The construction sector is accountable for consumption of huge energy and natural resources and therefore rises pollution levels around the world. Construction sector has both direct and indirect impacts on climate change, global warming, air pollution and environment. Greenhouse gas (GHG) emissions from the construction sector are about 23%. Construction industry contributes 10% to the world's gross domestic product (GDP) [5, 6]. Green building strategy is couple with a focused approach of an extended lifespan of natural resources, reduced operating costs like the use of energy and water, offering human comfort, safety and efficiency. While experts believe that the occupants pay three to five percent more for such properties when compared to the conventional ones but they save 25-30 percent in water and electricity consumption bill. Hence, the additional expenses can be recovered within five years and in fact, profitable in the long run [7]. Market estimates suggest that India will be adding 11.5 million homes every year thus, making it the third largest world's construction market by 2020. With rapid urbanization and strong economic growth, the construction industry is becoming one of the fastest growing sectors in India. Providing employment to nearly 18 million people. The sector is becoming one of the highest contributors to the country's carbon emissions. It alone accounts for 22 per cent of India's total carbon emissions [8].

II. GREEN BUILDINGS RATING SYSTEMS IN INDIA

There are three primary rating systems; Green Rating for Integrated Habitat Assessment (GRIHA), Indian Green Building Council (IGBC), and Bureau of Energy Efficiency (BEE) [9].

2.1. GRIHA (Green Rating for Integrated Habitat Assessment)

GRIHA is Indian own national green rating system. It was developed by The Energy and Resources Institute (TERI) in 2007, and is recently revised in 2015 for new buildings and in 2017 for existing buildings. This rating system is for two types of buildings:
1. New buildings rating system
2. Existing building rating system

2.1.1. GRIHA New Buildings rating system considers 31 criterions for new buildings and weightage is as per below; Sustainable site planning 21.2%, building planning and construction 7.7%, energy: end use 36.5%, energy: renewable-7.7%, health and wellbeing 9.6%, recycle, recharge and reuse of water 6.7%, waste management 4.8%, building operation and maintenance 1.9%, and innovation points 3.9%. The GRIHA rates the buildings according to the points achieved from the above criterions, if 50-60 points achieved one star rating certificated will be issued, if 61-70 two stars, 71-80 three stars, 81-90 four stars, and above 90 five stars respectively.

Points achieved	GRIHA Rating
50-60	★
61-70	★★
71-80	★★★
81-90	★★★★
91-100	★★★★★

Figure 1: GRIHA new building rating

2.1.2. The GRIHA existing building rating system is a 100-point system consisting of 12 criterion divided into seven sections: site parameters, maintenance and housing, energy, water, human health and comfort, social aspects and bonuses. Six of these 12 criteria are mandatory, others are optional. Each criterion, apart from the six mandatory criteria, for each criteria awarded some points. This means that a project that intends to fulfill this criterion will be suitable for the points. The minimum number of points required for certification is 25, all functional buildings with a surface area of more than 2500 m² are eligible for certification according to the GRIHA assessment for existing buildings. Typology of buildings includes offices, commercial spaces, institutional buildings, hotels, hospital buildings, health care facilities, residences and multi-storied buildings.

Threshold	GRIHA for Existing Buildings
25–40	★
41–55	★★
56–70	★★★
71–85	★★★★
86 and above	★★★★★

Figure 2: GRIHA existing building rating

A building is evaluated based on its predicted performance and functioning over its entire life cycle, from commissioning to demolition. The stages of the life cycle that have been identified for evaluation are: pre-construction, design, and construction of buildings, as well as building operation and maintenance. In these phases following issues are addressed:

- Pre-construction stage (intra- and inter-site issues)
- Stages of building planning and construction (issues related to resource conservation and resource efficiency through demand, recovery and reuse of resources and provisions for occupant health and well-being). The main resources under consideration in this section are land, water, energy, air and vegetation.
- Phase of operation and maintenance O&M of buildings (issues of operation and maintenance of building systems and procedures, monitoring and recording of consumption, health and well-being of occupant, as well as problems affecting the global and local environment)[10,11, 16].

2.2. INDIAN GREEN BUILDING SYSTEM (IGBC)

The Indian Green Buildings Council (IGBC), a division of the Indian Industry Confederation (CII), established in 2001, has made rapid progress in the field of green buildings. This rating system was successfully implemented in India in 4,794 buildings, with an area of 6.33 billion square feet, of which 1469 green Building projects are certified and fully operational in India. Today, all types of rating systems; IGBC new buildings, existing buildings, houses, residential communities, interiors, health care, schools, factory buildings, data centre, campus, green villages, cities, SEZs, landscapes, existing fast transit system, government initiatives to IGBC projects , green affordable residential housing, health and well-being rating systems [12].

2.2.1. IGBC Green New Buildings rating system covers green features under following categories;

- Site Selection and Planning
- Sustainable Architecture and Design
- Energy Efficiency
- Water Conservation
- Eco-friendly materials and resources
- Indoor Environmental Quality
- Innovation and Development

Certification Level	Owner-occupied Buildings	Tenant-occupied Buildings	Recognition
Certified	40 - 49	40 - 49	Best Practices
Silver	50 - 59	50 - 59	Outstanding Performance
Gold	60 - 74	60 - 74	National Excellence
Platinum	75 - 100	75 - 100	Global Leadership

Figure 3: IGBC new building rating

2.2.2. IGBC Green Existing Buildings O&M rating system covers green features under the given five categories:

- Site & Facility Management
- Energy Efficiency
- Water Efficiency
- Health & thermal Comfort
- Innovation

Certification Level	Points	Recognition
Certified	50 - 59	Best Practices
Silver	60 - 69	Outstanding Performance
Gold	70 - 79	National Excellence
Platinum	80 - 100	Global Leadership

Figure 4: IGBC existing building rating

2.2.3. IGBC Green Campus rating system addresses green features under the following categories:

- Site Planning and Management
- Sustainable Transportation
- Water Conservation
- Energy Efficiency
- Material and Resource Management
- Health & Well-being
- Green Education
- Innovation in Design

Certification Level	New Campus	Existing Campus	Recognition
Certified	40 - 49	36 - 44	Best Practices
Silver	50 - 59	45 - 53	Outstanding Performance
Gold	60 - 74	54 - 66	National Excellence
Platinum	75 - 89	67 - 90	Global Leadership

Figure 5: IGBC campus rating

2.3. BUREAU OF ENERGY EFFICIENCY (BEE)

BEE has created its own rating system for buildings ranging from 1 to 5 stars. Most stars means more energy efficiency. BEE has developed based on the Energy Efficiency Index (EPI). The kilowatt hour unit per square meter per year is taken into account for the assessment of the building and in particular for air-conditioned and non-air-conditioned office buildings [9].

III. ENERGY EFFICIENCY

Marisa Long: has investigated converting of existing buildings into sustainable buildings. The optimized operations and maintenance is not only addressing the country's growing energy, water crisis and air quality, it is also enhancing companies' bottom line through reducing power & water bills and increasing occupant health, wellbeing and comfort [13].

International Energy Agency(IEA)(2017) has published a report that buildings represent approximately 40 % of the global energy demand and 40% of direct and indirect carbon dioxide emissions which means that they are the major responsible in energy consumption and suggested that green energy retrofit actions can reduce considerably the energy demand[14].

United Nations Environment Programme (2007) proposed that energy efficient and saving technologies can considerably reduce carbon dioxide (CO_2) emissions from the building sector which accounts for 30-40 % of global energy use. Simple solutions include sun shading and natural ventilation, improved insulation of the building envelope, the use of recycled building materials, the introduction of more sustainable solutions for building systems, ventilation systems, smart lighting, low temperature heating and cooling systems and energy saving devices [15].

Gulghane et al.(2018) have done a research on buildings long term benefits. It is found that the initial cost of green buildings are higher than conventional buildings which the extra amount will be paid back after some years of use. Going for green building will only increase the initial cost in the range of 12-15% compare to conventional. But is to live in better and healthier environment to be accepted. Optimized energy will not only reduce the use of natural resources, but will also reduce direct and indirect cost savings in water and electricity bills [16].

G.S. Vyas and K.N.Jha. (2017) have carried out a research on buildings which were constructed conventionally but later on converted to green buildings and achieved that green buildings are financially attractive over the lifecycle. The premiums cost are in the range of 2-5 % and 5-17% for three star and five stars rated buildings respectively. The discounted payback period for GRIHA three star rated green buildings are 2.04-7.56 years and 2.37-9.14 years for five star GRIHA rated building [17].

Zia et al.(2015) have investigated the initial incremental cost for energy efficient (EE) buildings and found from the result that is 0.8% to 2.8% higher compare to the traditional buildings. Energy savings up to 36% with a payback period of two to five years (2–4 years) and the life cycle cost of EE building is substantially lower than the conventional buildings up to 1.6% of investment cost [18].

Ahn et al.(2016) have also studied green building benefits and concluded that green building is a movement towards to achieving the short and long term goals of sustainability including conservation of water, energy and materials savings and improving indoor air quality (IAQ), in the built environment [19].

Meghraj et al.(2008) have found the tangible and intangible benefits of green buildings and have mentioned that the tangible benefits are intelligent day-lighting, the improvement of indoor air quality, the health and well-being of residents and the conservation of natural resources. However, return on investment is much higher than the performance of unrated buildings, mainly due to reduced CO_2 emissions, savings in operating costs and possibly higher rents or capital value. Intangible benefits, such as social benefits, are due to the positive impact of sustainable buildings on the neighbourhood environment [20].

G.S. Vyas and K.N.Jha .(2017) have studied the importance of a green building that a green building is not just a fusion of ecological design, techniques and materials but it is a holistic solution to bring the concept of sustainability into the project lifecycle, including the design, design, construction, operation and demolition of the project [17].

Bureau of Energy Efficiency (BEE) (2001) has launched a project of replacing 400 million conventional 'light bulbs' or incandescent lamps (ICLs) with compact fluorescent lamps (CFLs) across the country. It is estimated that this project will save the country's 6,000 megawatts (MW) of electrical energy or in amount around Rs. 25,000 crore [21].

IV. WATER EFFICIENCY

Jain et al. (2015) have carried out their research on analysis of conversion of conventional building to green building. The existing construction of IIST, block A to the efficient use of resources and energy. Firstly, the overall consumption of water and energy was determined, later on energy and water efficient technologies were installed which save energy and water. Although initially it is expensive but reduces long term costs. 1200CUM/annum water is harvested which makes about 22.22% of annual water consumption and 40% of energy is saved by energy efficient electrical tools [22].

IGBC (2016) has studied green buildings and found that green buildings have tangible and intangible benefits. The tangible benefits of building green buildings are the reduction of water and energy consumption. Water savings can reach about 30% to 50% and energy savings can range from 20% to 100% (Net zero building), sometimes energy plus. [23].

The headquarters of the American Railways in Chicago reduced use of drinking water consumption by nearly 18 percent in one year, replacing 31 of the 91 building's toilets with water-efficient units and fixtures [24].

Anindita Sen (2017) has also suggested that recycling and reuse of wastewater with appropriate treatment, rainwater harvesting and the use of organic and inorganic solid waste for more useful purposes, such as composting and energy generation, can complement the transformation existing buildings into sustainable buildings [8].
Yongtao et al. (2018) have investigated and found that green retrofitting of aged residential buildings or existing residential buildings contributes to reduce global energy demand, consumption, greenhouse gas emissions and water consumption. The promotion of green retrofit and the performance of retrofitted buildings depends on applicable technologies [25].
Rastog et al. (2012) have conducted their research on residential buildings for reduction of water demand from Brihanmumbai Municipal Corporation (BMC) and proposed that rainwater harvesting is the best solution for reduction of water demand and controlling the limited resources of freshwater along with this is cost effective too [26].

V. RESULTS AND DISCUSSIONS

The results of researches show that construction industry is still a major concern for sustainability and environmental problems. Where the construction projects have negative impacts on environment throughout its life cycle. Therefore sustainable building is introduced in construction industry to reduce the negative impacts on environment. The only step towards sustainability in construction buildings projects is to build sustainable buildings. Building of sustainable buildings or energy efficient buildings are initially somewhat costly compare to conventional buildings but to go sustainably the extra amount should be tolerated for sustainability and comfort of inhabitants. The extra amount will be paid back after some years of use.

VI. CONCLUSIONS

It is concluded that converting of an existing building into sustainable building is a goal to achieve long and short term goals of sustainability. Where sustainable building significantly reduces the environmental concerns due to operation and maintenance process of a buildings.
Converting of an existing buildings into sustainable significantly solves the country's growing energy, air quality and water crisis.
Buildings only demand 40% of global energy and accounted for 40% of direct and indirect carbons dioxide (CO_2) emissions, where the sustainable building's demand for electrical energy and water is the lowest and with the lowest impact on the environment.
Going green is initially costly but the premium costs are paid after some years of use. The premium cost of converting an existing building into GRIHA five star rated building was in the range of 5-17% while the discounted payback period is 2-9 years.

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