A Project Report on

GREEN RETROFITTING OF PANVEL RAILWAY STATION

Submitted in partial fulfilment of the requirements

for the degree of

Bachelor of Engineering

by

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CERTIFICATE

This is to certify that the project entitled **"Green Retrofitting of Panvel railway station"** is a bonafide work of **Amrutraj Jadhav (15CE17), Shaikh Israr Ali (15CE44), Shreyans Zabak (15CE53), Satish Tiwari (15CE58)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of "Undergraduate" in "Civil Engineering"

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DECLARATION

We declare that this written submission represents my ideas in our own words and where others ideas or words have been included; we have adequately cited and referenced the original sources. We also declare that, we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

As per World Green Building Council, A ‘green’ building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources and improve our quality of life. IGBC Green Railway Stations rating system is the first of its kind holistic rating in India to address environmental sustainability in Indian railway stations. The overarching objective of the rating is to facilitate adoption of green concepts, thereby reduce the adverse environmental impacts due to station operation & maintenance, and enhance the overall commuter experience at station. The rating system will help the station management to understand their present position with respect to the 'green performance' of the station and the measures that need to be taken to enhance the performance on a continual basis.

Keywords—IGBC Rating system; Green Building; Panvel railway station, Efficiency

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ABBREVIATION NOTATION AND NOMENCLATURE

IGBC	INDIAN GREEN BUILDING COUNCIL
WGBC	WORLD GREEN BUILDING COUNCIL
SSF	SUSTAINABLE STATION FACILITIES
HHS	HEALTH, HYGIENE & SANITATION
SRI	SOLAR REFLECTIVE INDEX

Chapter 1

Introduction

1.1 GENERAL

World Green Building Council defines Green building as, A 'green' building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and create positive impacts, on our climate and natural environment. Green building preserve precious natural resources and improve our quality of life.

A Green Railway Station is nothing but a Railway station which reduces the adverse environmental impacts due to station operation and maintenance, and enhances the overall commuter experience at station.

There are a number of features which can make a building 'green'. These include:

- Efficient use of energy, water and other resources
- Use of renewable energy, such as solar energy
- Pollution and waste reduction measures, and the enabling of re-use and recycling
- Good indoor environmental air quality
- Use of materials that are non-toxic, ethical and sustainable
- Consideration of the environment in design, construction and operation
- Consideration of the quality of life of occupants in design, construction and operation
- A design that enables adaptation to a changing environment

Any building can be a green building, whether it's a home, an office, a school, a hospital, a community center, or any other type of structure, provided it includes features listed above.

However, it is worth noting that not all green buildings are – and need to be - the same. Different countries and regions have a variety of characteristics such as distinctive climatic conditions, unique cultures and traditions, diverse building types and ages, or wide-ranging environmental, economic and social priorities – all of which shape their approach to green building.

1.2 LIST OF GREEN BUILDNGS

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Figure 1-3Shanghai Tower, Shanghai, China

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Figure 1-5Manitoba Hydro Place, Winnipeg, Canada

Figure 1-6Apple Campus 2, Silicon Valley, USA

Figure 1-7Bullitt Centre, Seattle, USA

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Figure 1-11TCS Techno Park & Grundfos Pumps, Chennai.

Figure 1-14Olympia Tech Park, Chennai.

Figure 1-13ITC green centre,Gurgaon

Figure 1-12Patni (i-GATE) Knowledge Centre, Noida.

Figure 1-15Infinity Benchmark, Kolkata.

Figure 1-17Infosys, Pocharam, Hyderabad

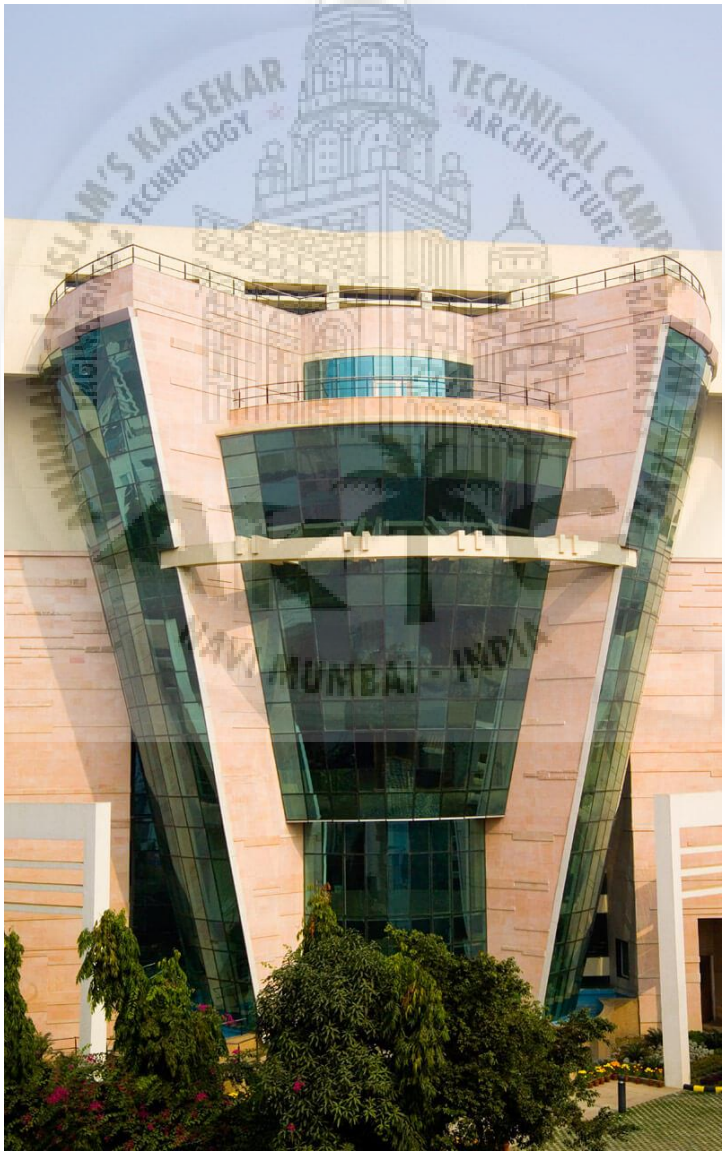

Figure 1-16Wipro Technologies, Gurgaon

1.3 GREEN RAILWAY STATIONS

CII-IGBC with the support of Environment Directorate of Indian Railway has developed the Green Railway Stations rating system. IGBC Green Railway Stations rating system is a voluntary and consensus based programme.

IGBC Green Railway Stations rating system is the first of its kind holistic rating in India to address environmental sustainability in Indian railway stations. The overarching objective of the rating is to facilitate adoption of green concepts, thereby reduce the adverse environmental impacts due to station operation & maintenance, and enhance the overall commuter experience at station. The rating system will help the station management to understand their present position with respect to the 'green performance' of the station and the measures that need to be taken to enhance the performance on a continual basis.

1.3.1 BENEFITS

By applying the green concepts in the design & construction, the following benefits are envisaged over conventional railway station.

1.3.1.1 INDIAN RAILWAYS

- Operational savings through
- Reduction in electrical energy consumption towards non-traction up to 40%
- Water consumption reduction for station applications up to 30%
- Effective Waste management during operation of station
- Improved station facility management
- Opportunity to increase environmental awareness among all Indian Railways staff.

1.3.1.2 COMMUTERS

- Improved accessibility to stations, thereby enabling easier first mile & last mile connectivity
- Effective ventilation & indoor environment quality
- Enhanced health, well-being & safety of commuters
- User-friendly design for differently abled & elderly people

1.3.1.3 OTHER ENVIRONMENTAL BENEFITS

- Reduction in energy consumption and hence the reduction in the associated environmental impacts.
- Increased use of renewable energy sources, thereby minimising the fossil fuel energy use
- Improved waste management, thereby avoiding waste being sent to land-fills
- Use of eco-friendly construction materials thereby reducing the dependency on the use of virgin materials

1.3.2 SCOPE

Green Railway Stations rating system is designed primarily for existing Indian railway stations. The stations under major redevelopment can also apply for Green Railway Stations rating.

The steps involved as part of Green Railway Station rating:

1. Training for the Railway Station operation and Maintenance personnel on 'Green Railway Station'.
2. Performance improvement study including detailed study on opportunities for:
   - Reducing energy & water consumption
   - Increasing renewable energy
   - Effective waste management
   - Enhancing passenger amenities, etc.
3. Guidance on implementation of green measures.
4. Facilitation of assessment by Third Party independent experts
5. Award of 'Green Railway Station Rating'

Chapter 2

Literature Review

2.1 General

Indian Railways, with 115,000 kms (71,000 miles) of track and 7,216 stations is one of the world's largest railway networks. Indian Railway carries more than 23 million passengers a day, roughly half of whom were suburban passengers. Its operations cover twenty-nine states and seven union territories and also provide limited international services to neighboring countries. The stations of Indian Railways have a wide coverage across various small towns & villages, touching lives of millions of commuters every day.

The operation of trains and the railway stations leads to significant impact on the environment. Apart from the environmental impact, some of the key issues to be addressed include Health, Hygiene, sanitation, energy and waste management in the stations. The rating is designed & developed to address the above issues and enhance the commuter experience.

At present, Indian Railways have taken many policy initiatives to sustainably manage environmental resources. Few such policies include provision for Environment related works in the Estimates for Works, Policy on formation of Environmental Management wing in Zonal Railways, Plantation of trees alongside track & vacant land areas, LED based lighting in service applications and Plans to set up solar PV panels on rooftops of Railway buildings for renewable power generation.

Adoption of Green concepts in Railway stations can significantly contribute for reduction in environmental impacts and enhance the passenger's experience. To implement the Green Concepts seamlessly across all the railway stations and monitor on a continuous basis there is a need for a comprehensive framework.

Against this background, the Indian Green Building Council (IGBC) with the support of Environment Directorate of Indian Railway has developed the Green Railway Stations rating system. The draft pilot version of Green Railway Stations rating system has been launched by Mr. Suresh Prabhu, Hon'ble Minister of Railways at IGBC's Flagship event on 8 October 2016. The overarching objective of the

Green Railway Stations Rating is to facilitate adoption of green concepts, thereby reduce the adverse environmental impacts due to station operation & maintenance, and enhance the overall commuter experience. It will also help to understand the need for relevant policies for existing and proposed setups with regards to its responsibility towards environment.

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2.2 Review of Literature

2.2.1 REFERENCE BOOK

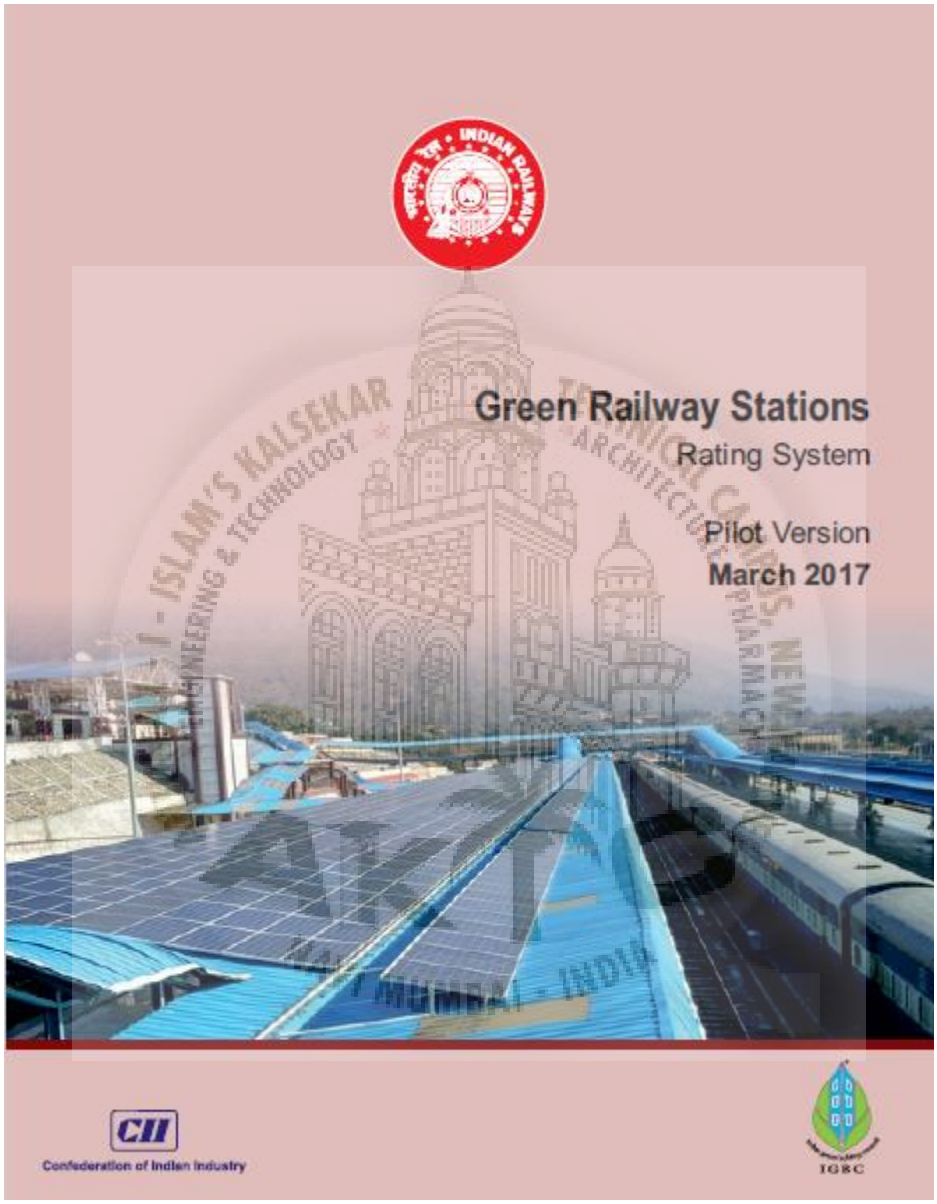

Figure 2-1 ISGBC GREEN RAILWAYS RAITING SYSTEM PILOT VERSION, MARCH 2017.

2.2.2 REPORTS

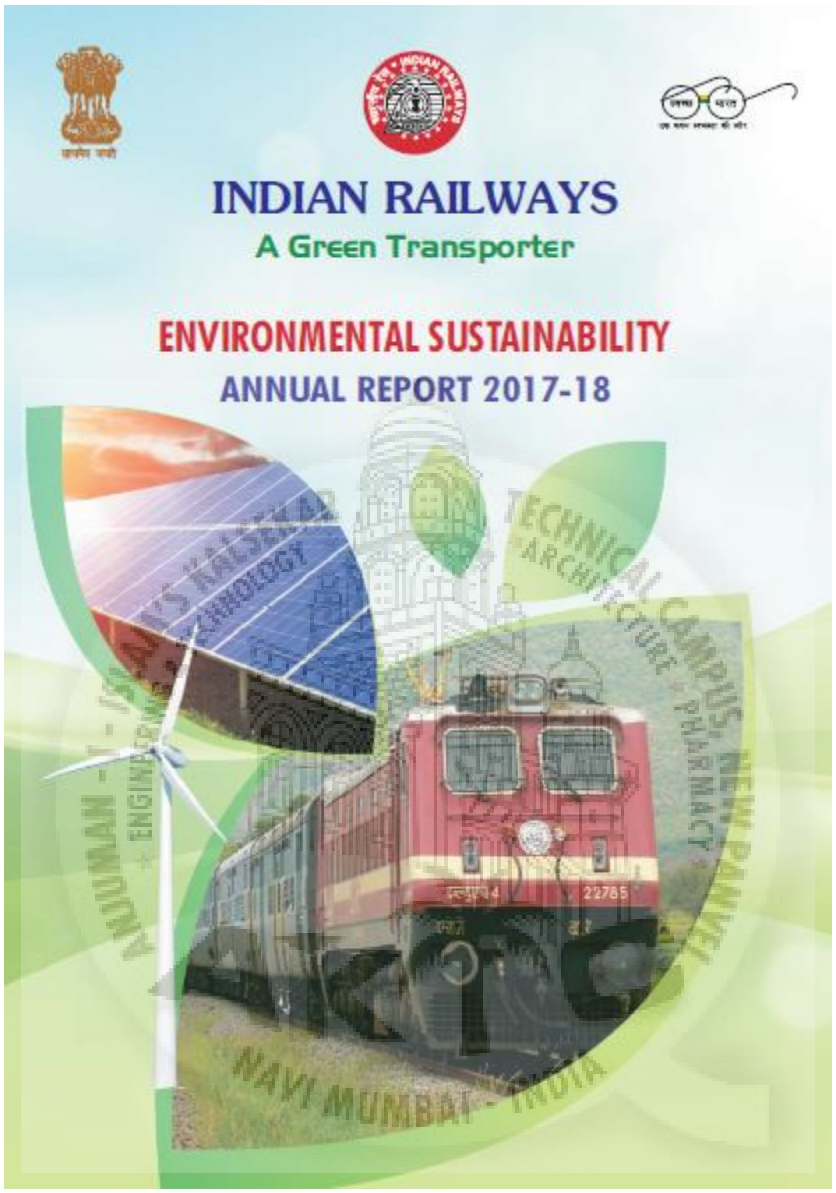

Figure 2-2INDIAN RAILWAYS ENVIRONMENTAL SUSTAINABILITY REPORT 2017-18

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2.2.3 MANUALS

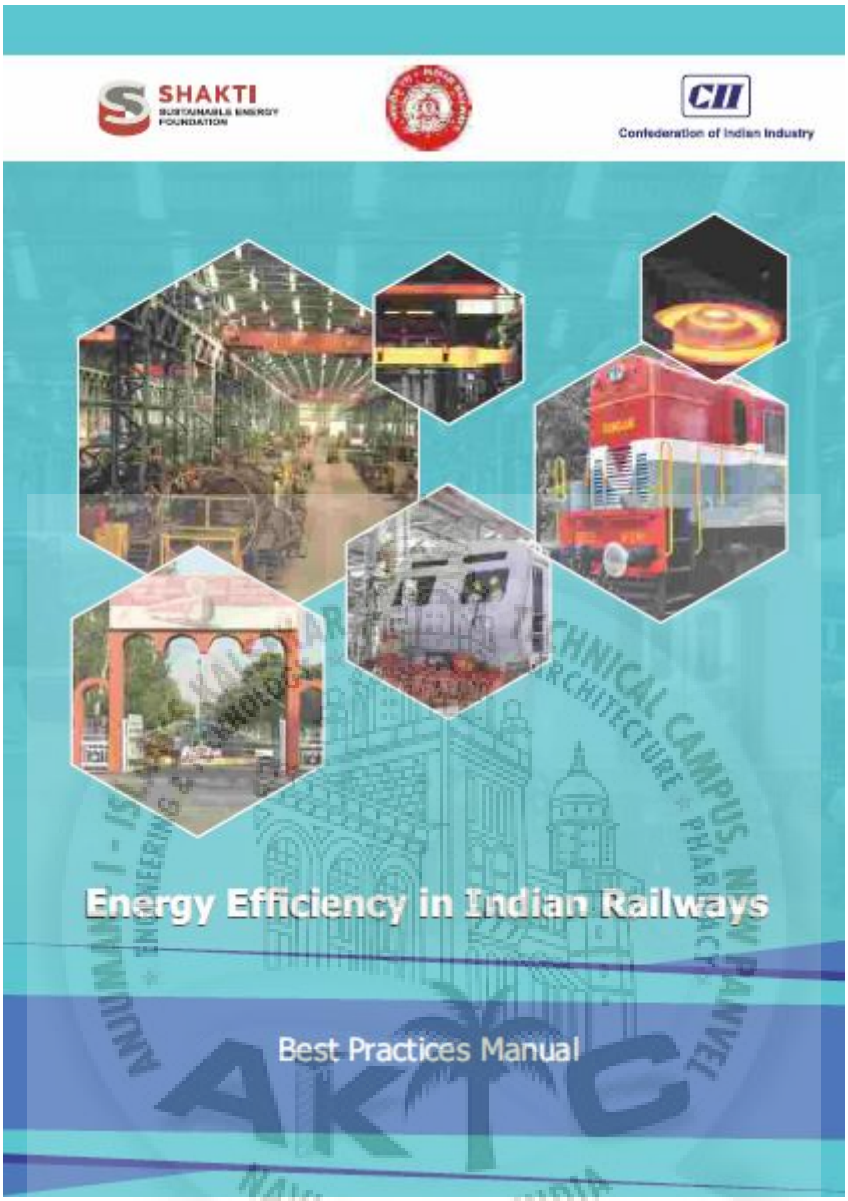


Figure 2-3ENERGY EFFICIENY IN INDIAN RAILWAYS

2.2.4 TECHNICAL PAPERS

2.2.4.1 THE APPLICATION, BENEFITS AND CHALLENGES OF RETROFITTING THE EXISITING BUILDING. – MUHAMMAD KHARI,AINI JAAPAR, ZAHARAH YAHYA

Abstract. Sustainable development has been the main topic of debate for years in some countries such as United Kingdom, United State of America and Malaysia. Depletion of natural resources, global warming, economics uncertainty and health issues are some of the reasons behind sustainable development movements, it is not just a political debate in the parliament but more towards collective works among sectors in order to minimizing the negative impact of development to the environment and other living organism. Retrofit an existing building is one of the solutions to reduce the dependency on constructing new buildings. There are huge numbers of existing building stocks that suitable to be retrofitted such as historical buildings, offices, residential, warehouse, factories, vacant buildings and other historical buildings. Therefore, the aim of this research is to provide information on the application, benefits and challenges of retrofitting an existing building. Two buildings were chosen as case studies following by site visits and observation to the buildings. The data were then compared in a table form. Primary and secondary sources were also used for this research.

The application of retrofit should be promoted across the construction and conservation industries since it has significant tangible and intangible benefits. It is one of the most environmentally friendly and efficient solutions to optimize the energy performance and could also help to extend the life of the existing building or historical buildings while ensuring optimum thermal comfort for the occupants which leads to higher productivity.

Introduction

The depletion of natural resources, global warming, economic uncertainty and health issues leads to sustainable development movements across the world. There's a need for mechanisms or approach that can reduce the negative effects of development, construction and urbanization to the environment.

Retrofitting an existing building is one of the most environmentally friendly, sustainable and efficient solutions to optimize the energy performance of building. As a matter of fact, when compared to new buildings construction, this kind of intervention reduces the consumption of land energy and could be applied to a large building stock .An in-depth interviews with 37 key players, Dixon et al., found that many instances a distinction was indeed made between retrofit, where a building(s) could be refitted with relatively "light touch" energy efficiency measures, for example, whilst a tenant was still in occupation, as opposed to the case of "refurbishment" which entails a much "deeper" level of refit with changes to the internal and

external fabric of the building, with the latter frequently occurring at lease renewal. However, in other cases refurbishment was used rather than retrofit.

National Refurbishment Centre (NRC) United Kingdom referred green refurbishments as the use of multiple sustainable fabric measures applications which are then applied to a specific space, room or even to the whole existing building, such as insulation mechanism or micro-generation solutions.

Retrofit in the other hand, refers specifically to the installation of micro-generation solutions to buildings or a single measure, such as fitting insulation to an external wall, while 'renovate' is more

commonly used in Europe including in the UK to specifically describe the improvement activities or repair works on dilapidated heritage buildings, which may also include the installation of new energy efficient system or to a whole house .

2. Methods

Two buildings were chosen as case studies, which is Kuala Lumpur performing art Centre (KLPac) and Shah Alam Royal Theater. Site visit and observation to the two buildings were carried out. The data were then compared in a table form followed by a discussion. Primary and secondary sources were also used for this research.

3. Retrofitting Mechanism and Application

Dixon *et al*., stated that retrofit measures not only focusing on energy, but also look into the usage of water and the production of waste as well. As an example, up to 30% - 40%energy cost per annum could be reduced by light-touch retrofit, such as installation of energy-efficient lighting and controls, building services and management systems and controls. In addition to that, recycling water and waste

(E.g. in shopping Centre, office, school and public buildings) could also bring significant and positive sustainability and cost impacts. Furthermore, research from UK by Dixon *et al*., and from USA

Institute for Building Efficiency also suggests the following retrofit measures are the most common in the commercial property sector:

• Energy-efficient lighting and controls;

• Management systems and controls; and

• building services.

However, the research studies done by Nils Kok *et al*., found out that there are other more expensive improvements and retrofitting measures such as replacing roofs, installing PV solar cells, changing floors, insulation, and operable windows or better glazing system that could be done to an existing buildings as shown in Table 1. This associate to thermal comfort of the buildings as well as making the space more usable and to improved productivity of the space.

The Benefits &

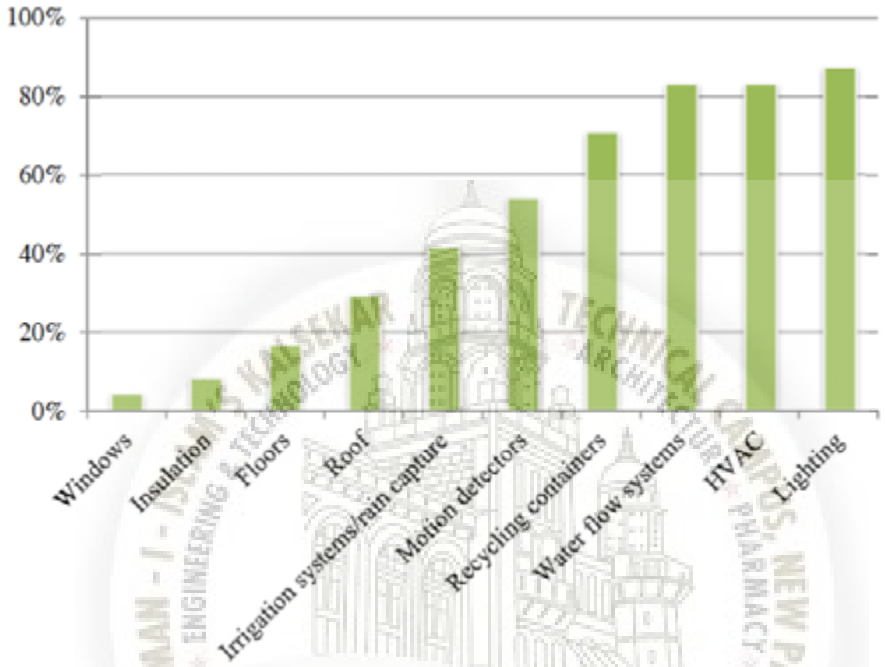


Figure 2-4MAJOR IMPROVEMENTS DURING RETROFITTING

Challenges of Retrofitting

The contribution of existing buildings in regards to sustainability should not be underestimating.

Through retrofitting, existing buildings can be benefited for sustainability purposes hence lessening the wastage. The time has come to begin concentrating on retrofitting the existing buildings.

Tangible and intangible benefits from greening the existing buildings could be achieved through retrofitting. The tangible benefits are any benefits or advantages that can be measured in financial terms such as cost of construction and intangible benefits are any benefits or advantages that cannot be measured by financial term but it still has significant impact to business or project such as comfort level and satisfactory level.

According to Abdul Qayyum *et al*., one of the advantages of executing retrofit to an existing building compared to constructing new green buildings is that, the production of associated wastes could be prevented while conserving the embodied energy. It is also a cost-effective way to greening the existing buildings by cutting down the energy consumption, cost of

operation and the lifecycle cost thus creates higher investment returns to the client. As a result, retrofitting the existing buildings is a highly significant approach in achieving the aim of sustainability.

Another outcome of retrofit is related to productivity of building occupants. The productivity of the employee plays an important role in any organization and each company would want their employees to be productive. Surprisingly over 50% occupants who work in environmentally certified buildings found their employees to be more productive. A survey done by Coronet Global members in 2012 suggested that the tenants wanted more natural light, better ventilation and better temperature control in their buildings. These features are consistent with more sustainable and greener space.

Furthermore, greening the existing building through retrofitting could provide better indoor environment quality for the end users and the construction period could be completed in a shorter time compared to building up a new green buildings which takes longer time to be completed. In term of equipment, retrofitting existing equipment can be a cost effective, timesaving and technically sound solution, as opposed to purchasing new equipment. In addition to that, by reusing back the existing equipment to the maximum limit, may results in lower financial expenditure compared to the installation of new equipment.

Energy efficiency in buildings is often reported as one of the direct economic benefits for real estate investment companies when considering energy efficiency and sustainability in their portfolios. Jones Lang LaSalle reports stated that, 115 office properties in its portfolio managed to improve the building energy efficiency in 2006, which leads to an average savings of USD 2.24 Mil in 2007 and USD 3.0 Mil in 2008.

CIOB through its Carbon Action 2050 has listed down the benefits and the challenges of retrofitting as follows:

The benefit:

• Retrofitted buildings are more adaptable and suitable to existing activities or future activities if required, more comfort;

• Retrofitted buildings are more energy efficient, lower carbon emissions from the building operations;

• Greater sustainable use of embodied-carbon investment (capital carbon). The challenges of retrofitting:

• Expensive and inconvenient;

• Internal spaces may reduce upon installation of internal wall-insulation;

• Might cause negative impact to heritage and archaeological assets caused by usage of unproven methods, technologies or instruments;

• Further research is needed especially on insulation mechanism on walls and the effect on retrofit on buildings fabrics;

• More education, training and activities on maintaining and preserving the buildings need to be taught to address issues and to create awareness;

• The risk of retrofitting needs to be highlighted, not just focusing on the benefits of retrofitting and discussion between retrofit and refurbishment.

Other benefits of retrofit existing buildings includes; cost saving in long run by reducing the usage of energy and water by incorporating new technology, services or equipment; increasing the comfort level in a building by redesign the façade and interior to improve end users productivity and satisfaction through improving interior thermal comfort; lowering the greenhouse emission and optimizing the water usage in building; future-proof buildings which means the building will be use and last for many years when it is equipped with current technology based; and preserving cultural and heritage significance of an existing buildings by enhancing the building exterior and interiors to meet current standards and design based on the needs of end users.

2.2.4.2 SUSTAINABLE BUILDING MATERIAL FOR GREEN BUILDING CONSTRUCTION, CONSERVATION AND REFURBISHING – USMAN AMUINU UMAR, M. F. KHAMIDI, HASSAN THAKUR

Abstract—Materials are the essential components of buildings construction. Chemical, physical and mechanical Properties of materials as well as an appropriate design are accountable of the building mechanical strength. The design of green buildings should thus begin with the selection and use of eco-friendly materials with related or better features than traditional building materials. Building materials are usually selected through functional, technical and financial requirements. However, with sustainability as a crucial issue in the last decades, the building sector, directly or indirectly causing a considerable portion of the annual environmental deterioration, can take up the obligation to contribute to sustainable development by finding more environmentally benign methods of construction and building. Among the directions for solutions is to be found in new material applications, recycling and reuse, sustainable production of products or use of green resources, Careful selection of eco-friendly sustainable building materials may be the fastest way for builders to start integrating

sustainable design concepts in buildings. Ordinarily, price has been the primary consideration when comparing related materials or materials selected for similar purpose. Nevertheless, the price of a building element signifies just the manufacturing and transportation costs, not social or environmental costs. Substantial initiatives have been carried out by the research community globally, in order to discover alternative sustainable building materials and low technology techniques, which result in a more sustainable and affordable construction complying with the comfort standards required today. Embracing green building materials is a good alternative to meet to this objective. Therefore, Selection of construction materials that have minimum environmental burdens is useful in the sustainable development of a nation. The purpose of this paper is to highlight how sustainable building material can contribute to lessen the impact of environmental degradation, and generate healthy buildings which can be sustainable to the occupant as well as our environment.

INTRODUCTION

Buildings have a tremendous impact on the environment, using about 40% of natural resources extracted in industrialized nations, consuming virtually 70% of electricity and 12% of potable water , and producing between 45% and 65% of the waste disposed in our landfills . Additionally, they are responsible for a massive amount of harmful emissions, accounting for 30% of greenhouse gases, due to their operation, and an additional 18% induced indirectly by material exploitation and transportation. Simultaneously, the bad quality of indoor environments may result in health issues to employees in office buildings, hence, reducing efficiency. Also Building construction consumes 40% of the raw stone, gravel, and sand used worldwide annually, and 25% of the raw timber. From the environmental impact perspective, the building sector has a significant effect on the entire environment. Residential buildings represent a large percentage of the built environment, and the selections of materials and layouts are necessary for the general sustainability.

Considerable initiatives have been carried out by the research community worldwide, in order to find alternative sustainable building materials and low technology methods, which result in a more sustainable and affordable construction adhering to the comfort standards needed today. Adopting green building materials is an excellent approach to meet this target. Selection of construction materials which have minimum environmental burdens is useful in the sustainable development of a country. Therefore, building related contribution to environmental issues is large and therefore essential. Selecting environmentally preferable building products is an excellent method to boost a buildings environmental performance.

While there is obviously an immediate need for new technologies to optimize the application of low-impact building materials, it is also true that there are several technologies or systems, currently in use. Many have originated from an earlier influx of sustainable housing activism and development, prompted by the 1970s environmental movement, and then boosted by the force for better energy efficient buildings. their strategy has been referred to as effective in

spreading ideas about best practice to dedicated green advocates, builders and individuals seeking for an alternative means of determining the material-selection process, very few such systems are available that support the effective and substantial use of local and recycled building materials in the design-decision making phase of a building . The objective of the study is to possible explore and highlight how sustainable building material can contribute to lessen the impact of environmental degradation, and create healthy buildings which can be sustainable to the occupant as well as our natural environment.

DEVELOPMENT OF GREEN BUILDING

In order to mitigate the effect of buildings along their life cycle, Green Building (GB) has become a new building philosophy, pushing the application of more environmentally friendly materials, the implementation of strategies to save resources and lower waste consumption, and the improvement of indoor environmental quality, among others. This might lead to environmental, financial, economic, and social benefits. For instance, savings in operation and maintenance costs in GBs can be realized through the installation of high-efficiency illumination and insulation systems or through a suitable material selection process that considers, for example, the daylight roof reflection. Other primary advantages of GBs related to indoor environmental quality advancements are the reduction on health costs and the increase on employees' productivity through their perceived satisfaction towards work areas. Furthermore, intangible benefits, such as the building and builder's goodwill, and perceived added value must also be considered simply because they could guide the decisions of investors and future owners. Despite their demonstrated benefits, GBs are not yet regarded as attractive projects since most builders relate green features with expensive technologies that increase cost (e.g., photovoltaic panels, grey water reuse systems). Nevertheless, a careful design process and a comprehensive material selection method, rather than an elevated investment in technology, may be sufficient to accomplish ideal environmental objectives at a lower cost. In reality, some research supports the insufficient difference between the average investment cost per square foot for some GBs, such as academic buildings, laboratories, community centers, and ambulatory care facilities, and that of non-green buildings with the same characteristics. Moreover, GBs provide better dividends in the long run recovering up to 10 times the green premium through the realization of anticipated benefits. The achievements of a GB will depend on the quality and effectiveness of the installed green systems. Therefore, the market demands a common approach to distinguish GBs from traditional buildings through the use of standard, transparent, objective, and verifiable measures of green that will ensure that the minimum green requirements have been achieved.

A. Building materials problem

The material challenge for buildings usually takes various forms. As stated, the grey energy and emissions must be regarded, and the production of building materials involves the use of more high value energy and resources in comparison with building operations. There are also

environmental issues with the by-products of material used in buildings, and there are limitations on the extraction of resources used in numerous building ingredients. One should additionally consider the infrastructure used to support the built environment. There are lots of technological advances that need to be carried out to resolve the complications of resource depletion, corrosion, pollution, durability, lifespan, etc. related to building materials. Firstly, new construction needs to be constructed more sustainably so that it not just reduces negative aspects of construction and operations, but that it primary boosts building lifespan, which can be carried out by eliminating design features that will be rapidly outdated. Also all required factors with minimal lifespans should be designed for recycle or raw-material-recovery. This must be attained in all aspects by carefully breaking down the complexity of the building into its components, and comprehending virtually any trade-offs among integrated systems so that a completely sustainable solution can be achieved. This can be assisted by an awareness of the rapidly growing array of materials readily available for build structures, enclosures and systems.

Lastly, with regards to the end of lifetime of a building, there needs to be extremely careful consideration for the processing of the materials. This should be considered previously during the design stage of any building, where composites that are hard to handle are minimized. Materials should be used that can be immediately recycled without the need to remanufacture them. If they cannot be immediately reused, they can be recovered as raw materials. If they should be reused, they should be utilized at the same level of quality, thereby eradicating any down cycling or waste.

PRINCIPLES OF SUSTAINABLE BUILDING DESIGN

In the CIB report on agenda 21 on sustainable construction, states that different nations have their own different strategy and priorities regarding principle of sustainable construction. The report additionally suggests that the primary focus of sustainable construction and design in universal approach is ecological impact to the environment. Fisher outlined five principles of sustainable design in which sustainable building material had been highly recommended.

A. Healthy interior environment

All possible measures are to be taken to ensure that materials and building systems do not emit toxic substances and gasses into the interior atmosphere. Additional measures are to be taken to clean and revitalize interior air with filtration and planting.

B. Energy efficiency

All possible measures are to be taken to ensure that the building's use of energy is minimal. Cooling, heating, and lighting systems are to use method and products that conserve or eliminate energy use.

C. Ecologically benign materials

All possible measures are to be taken to use building materials and products that minimize destruction of the global environment.

D. Environmental form

All possible measures to be taken to relate the form and plan of the design to the site, the region, and the climate. Measures are to be taken to relate the form of building to a harmonious relationship between the inhabitant and nature.

E. Good design.

All possible measures are to be taken to achieve an efficient, long lasting, and elegant relationship of use areas, circulation, building form, mechanical systems and construction technology.

Additionally, Kim and Rigdon highlight about three major principles on sustainable design which are shown in figure 2, as the matter of fact, this principles deal with an economic sustainability, a functional sustainability, an environmental sustainability, a social and human sustainability.

2.2.4.3 GREEN BUILDING RESEARCH – CURRENT STATUS AND FUTURE AGENDA- JIAN ZU, ZHEN-YU ZHAO

ABSTARCT

Green building is one of measures been put forward to mitigate significant impacts of the building stock on the environment, society and economy. However, there is lack of a systematic review of this large number of studies that is critical for the future endeavor. The last decades have witnessed rapid growing number of studies on green building. This paper reports a critical review of the existing body of knowledge of researches related to green building. The common research themes and methodology were identified. These common themes are the definition and scope of green building; quantification of benefits of green buildings compared to conventional buildings; and various approaches to achieve green buildings. It is found that the existing studies played predominately focus on the environmental aspect of green building. Other dimensions of sustainability of green building, especially the social sustainability is largely overlooked. Future research opportunities were identified such as effects of climatic conditions on the effectiveness of green building assessment tools, validation of real performance of green buildings, unique demands of specific population, and future proofing.

INTRODUCTION

Construction industry has significant environmental, social and economic impacts on the society. As one of key outputs of the construction industry, buildings largely reflect these impacts during its lifecycle. The positive impacts of construction activities include: providing buildings and facilities to satisfying human being's require-ments, providing employment opportunities directly or indirectly (through other industries related to the construction industry) and contributing toward the national economy. For instance, the construc-tion industry in Australia contributes 7.5% to the Gross domestic product (GDP) and provides more than 1 million jobs. Similarly, buildings and construction activities play a crucial role in urbanization. The negative impacts of buildings and construction activities are also well recognized. These include the noise, dust, traffic congestion, water pollution and waste disposal during the con-struction stage. A large quantity of natural and human resources will be consumed. Once completed, buildings continue their impacts on the environment. According to the World Business Council for Sustainable Development, building block accounts for 40% of total energy consumption. Apart from energy consump-tion, buildings produce Greenhouse Gas emission (GHG) emission which is responsible for global warming. The carbon emission of buildings across the world will reach 42.4 billion tonnes in 2035, adding 43% on the level of 2007 . In addition, the renovation, refurbishment and retrofitting of building will involve the con-sumption of natural resources and energy; GHG emission; produc-tion of noise and other pollutants as well. At the end of life of buildings, the disposal of buildings is also associated with energy consumption and waste production. In 2007, the waste generated from the construction industry in Australia reached 16.6 million tonnes. This accounted for 38% of total waste, of which 43% was sent to landfill . The increasing demand of landfill presents a new challenge to all countries that have issues with limited land. This is compounded by the prediction made by the International Energy Agency that the commercial buildings and institutional buildings will rise two times by 2050 . There are many definitions of green building. For instance, Kibert defined green building as: "… healthy facilities designed and built in a resource-efficient manner, using ecologically based principles" . It is worth noting that green building has been used as a term interchangeable with sustainable building and high performance building. Robichaud and Anantatmula pointed out that there are four pillars of green buildings, i.e. minimization of impacts on the environment, enhancing the health conditions of occupants, the return on investment to developers and local community, and the life cycle consideration during the planning and development process . Common elements of these defini-tions are: life cycle perspective, environmental sustainability, health issues and impacts on the community. There have been extensive researches on various aspects of green buildings in different contexts. However there is lack of systematic review of existing body of knowledge. Such systematic review plays a critical role to not only identify the common research streams but also highlight the future research trends. This research aims to critically review the green building related studies in a bid to highlight the state of art and future needs in this field. This paper provides a useful reference for both industry practitioners and academics that are interested in green building developments.

WHY GREEN BUILDINGS AND HOW MUCH BENEFIT?

There is no lack of studies investigating the costs and benefits associated with green building developments. The main purpose of these studies is to justify the value of going green which will assist decision making process. It is even more valuable under the context of Global Financial Crisis where clients have comparatively smaller finance capacity and financial institutions are more con-servative in terms of lending decision. In essence, these studies focus on pros and cons of green building developments compared to conventional buildings. A common approach adopted in existing studies is to compare the characteristics of green buildings to those of conventional buildings such as energy efficiency, water efficiency, indoor environmental quality, thermal comfort, health and productivity.

ENVIRONMENTAL

There is no lack of studies investigating the costs and benefits associated with green building developments. The main purpose of these studies is to justify the value of going green which will assist decision making process. It is even more valuable under the context of Global Financial Crisis where clients have comparatively smaller finance capacity and financial institutions are more con-servative in terms of lending decision. In essence, these studies focus on pros and cons of green building developments compared to conventional buildings. A common approach adopted in existing studies is to compare the characteristics of green buildings to those of conventional buildings such as energy efficiency, water efficiency, indoor environmental quality, thermal comfort, health and productivity.

ECONOMIC

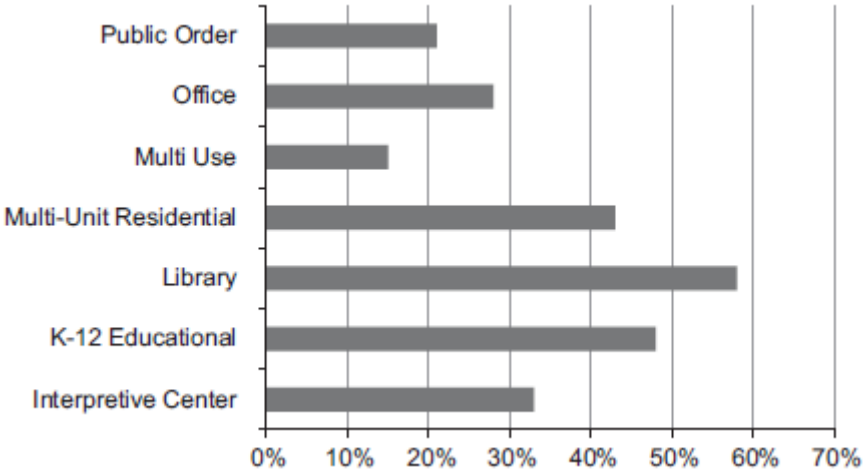


Figure 2-5 Energy savings from LEED certified buildings

The cost savings are also associated with the improved building performance, particularly from the life cycle perspective. As a result, the operation cost is optimized. According to Economist green building can save 30% of energy consumption than conventional buildings . The research report released by Davis Langdon showed that extra upfront cost is required for green office building than conventional office buildings . To achieve the GBCA Green 5 Star and 6 Star ratings, an extra construction cost of 4% and 10% are needed respectively. However, the cost of not going green is high as well, considering the carbon trade cost and rocket high energy price. The cost savings during the operation and maintenance stages will help to offset the upfront cost required for green building features. Construction component (including labor and materials) accounts for the largest proportion of green building cost . Ross et al.'s financial modeling also showed that LEED certified building will incur some 10% of extra cost . Their cash flow analysis showed that US$1.38/ft2 savings per annum will be derived from green building design compared to conventional building. From maintenance perspective, green buildings perform better than conventional counterparts in terms of energy efficiency, water efficiency and cost efficiency, found by a study commissioned by the General Services Administration . This is echoed by Lau et al.'s study which revealed that low energy office buildings with green features can save more than 55% of energy cost compared to conventional buildings.

Human aspects:

Some scholars argued there are other benefits associated with green building that are not directly cost related. These studies placed focus on human aspects and benefits from green buildings. This is due to the fact that human beings stay in buildings for a considerable amount of time.

Thermal comfort:

The satisfaction of building users is closely related to thermal comfort which is a complex dynamics of temperature and humidity. This has attracted extensive attention from researchers to simulating and measuring the thermal comfort level in green building compared to conventional buildings. As a result, the range of room temperature required could be proposed . Psycho-logical, physiological, cultural and behavioral factors may play a role as well which attributes to adaptive thermal comfort.

Indoor environmental quality (IEQ):

One of most critical components of human benefits associated with green building is the indoor environmental quality (IEQ). The IEQ, including volatile organic compound emissions and other contaminants is another critical issue in buildings .

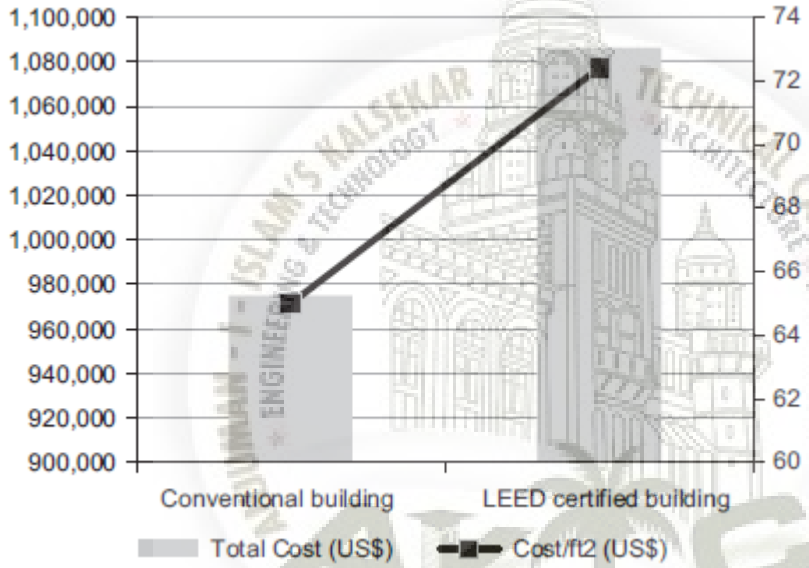


Figure 2-6 Total cost and cost per unit of floor area, conventional building vs. LEED certified buildings, source.

Therefore, IEQ features in all leading green building assessment tools . Extensive studies have suggested that green building can achieve higher level of IEQ than conventional buildings, which helps to improve the health and productivity of occupants. As a result, the level of satisfaction of building users is enhanced. In fact, Leaman and Bordass's study found that users of green building tend to be more tolerant than those of conventional building in terms of indoor environmental quality . Abbaszadeh et al. surveyed occupants of 180 buildings for their satisfaction of indoor environmental quality by utilizing 7 point Likert scale from _3 (very dissatisfied) to 3 (very satisfied) green building generally outperformed con-ventional buildings except acoustics, lighting, and office layout. Their follow-up study found that most complaints to lighting are: not enough daylight, reflections in the computer screen, too dark or too bright. Top acoustic related complaints are: People talking in neighboring areas, People overhearing my private conversa-tions, and People talking on the phone. It is worth noting that occupants in green buildings are satisfied with thermal comfort whereas those in conventional buildings showed more dissatisfaction. Lee and Guerin adopted a similar

methodology with Abbasza-deh et al.'s study to examine occupants' satisfaction and performance in green office buildings . Their study found office furniture affects both satisfaction and performance of occupants in LEED certified office building significantly. Indoor air quality plays a critical role to building users' performance rather than their satisfaction. Other indoor environmental quality measures, e.g. office layout, acoustic, and thermal comfort are not statistically significant in terms of impacts on occupants in green buildings. This is supported by Zhang and Altan's study which found that users of green building are more satisfied with thermal comfort and visual comfort than those in conventional building however the acoustic satisfaction does not differentiate in these two buildings . Frontczak et al.'s study also found a strong correlation between noise level, visual privacy and satisfaction with the workplace . Opportunities to interact with co-workers and sufficient amount of light also contribute toward higher level of occupant satisfaction.

Health and productivity:

Studies also found that the health conditions and level of productivity improve when occupants moved to green buildings. For instance, Ries et al. suggested that economic benefits of green building in terms of productivity and absentee-ism should not be overlooked . Their study found an increase of 25% of productivity and the absenteeism is significantly reduced when occupants moved from a conventional building to a green building.

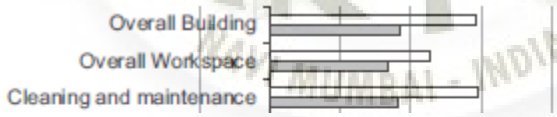
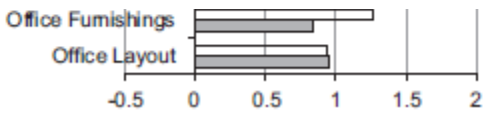


Figure 2-7Level of occupant satisfaction on indoor environmental quality, conventional buildings vs. green buildings

160)



Chapter 3

Case Study and Data Collection

3.1 General

The data is collected in the form of photographs and readings if necessary. The methodology for the rating system is by giving credit points for all the implementation points covered with photographs as proof.

IGBC has set up the Green Railway Stations Core Committee to develop the rating programme. This committee comprised of key representatives from Indian Railways and experts from the green building sector. The committee, with a diverse background and knowledge has enriched the rating system, both in its content and process.

3.1.1 SUSTAINABLE STATION FACILITIES

3.1.1.1 PASSENGER AMENITIES AT RAILWAY STATION

SSF CREDIT 1

POINTS: 6

Intent:

Provide access to facilities which will enhance the comfort for the passengers and visitors during their stay at station.

Implementation Options:

Demonstrate implementation of at least 3 of the following passenger amenities at the station complex as per IR code.

1	Platforms with lighting fixtures and level of illumination (lux level)
2	Firmly fixed waiting chairs/ benches on each platform
3	Waiting Rooms/ Halls with lighting fixtures, ventilation & well maintained facilities
4	Cloak Room
5	Booking Office with seating & lighting
6	Toilets (for Male & Female) at least at main platforms (1st and last platform) with daily maintenance plan
7	Retiring Rooms
8	Emergency medical care facilities
9	Foot-Over-Bridges or Sub-ways
10	Elevators & Escalators
11	Mobile charging points on every platform
12	Trolley Based System for Luggage Assistants
13	Pickup and drop-off points for vehicles
14	Snack Kiosks & Drinking water points on each platform

Documentation Required:

Submit the details of the implemented facilities with supporting photographs.

Implementation of each measure will gain 1 point and the station can gain maximum of 6 points under this credit.

Exemplary Performance:

Station is eligible for exemplary performance under Innovation category, if two additional passenger amenities are implemented over and above the specified requirements.

Sr.No.	Description	Points gained
1	Platforms with lighting fixtures and level of illumination (lux level)	1
2	Firmly fixed waiting chairs/ benches on each platform	1
3	Waiting Rooms/ Halls with lighting fixtures, ventilation & well maintained facilities	1
4	Cloak Room	1
5	Booking Office with seating & lighting	0
6	Toilets (for Male & Female) at least at main platforms (1st and last platform) with daily maintenance plan	1
7	Retiring Rooms	0
8	Emergency medical care facilities	1
9	Foot-Over-Bridges or Sub-ways	1
10	Elevators & Escalators	0
11	Mobile charging points on every platform	0
12	Trolley Based System for Luggage Assistants	1
13	Pickup and drop-off points for vehicles	1
14	Snack Kiosks & Drinking water points on each platform	1
	MAXIMUM POINTS GAINED	**6**

3.1.1.2 UNIVERSAL ACCESS

SSF CREDIT 2

POINTS: 4

Intent:

Ensure that station is designed to be commuter friendly for differently abled and senior citizens.

Implementation Options:

Demonstrate implementation of at least 2 of the following facilities at the station:

- Electric/ battery operated vehicles to ferry physically challenged & senior citizens
- Provision of wheel chairs at station
- Entrance with non-slippery ramps, handrails on at least one side (as applicable)
- Tactile path from all entrances/ exit points of station to platform, along with warning strip on platform edge.
- At least One Toilet designed for differently abled people at main platform & waiting rooms
- Adequate Signage system for guiding the person up to the lift / elevators and amenities
- Braille buttons inside and outside of all lifts.
- 'May I help you' Booth close to entrance of the station building
- E-booking service for wheelchairs with dedicated assistants at station.

Implementation of each measure will gain 1 point and the station can gain maximum of 4 points under this credit.

Documentation Required:

Submit the details of the implemented facilities with supporting photographs.

Exemplary Performance:

Station is eligible for exemplary performance under Innovation category, if two additional facilities are implemented over and above the specified requirements.

Sr.No.	Description	Points gained
1	Electric/ battery operated vehicles to ferry physically challenged & senior citizens	0
2	Provision of wheel chairs at station	1
3	Entrance with non-slippery ramps, handrails on at least one side (as applicable)	1
4	Tactile path from all entrances/ exit points of station to platform, along with warning strip on platform edge	0
5	At least One Toilet designed for differently abled people at main platform & waiting rooms	1
6	Adequate Signage system for guiding the person up to the lift / elevators and amenities	1
7	Braille buttons inside and outside of all lifts.	0
8	'May I help you' Booth close to entrance of the station	1

	building	
9	E-booking service for wheelchairs with dedicated assistants at station.	0
	MAXIMUM POINTS GAINED	**4**

3.1.1.3 ACCESS TO RAILWAY STATION

SSF CREDIT 3

POINTS: 4

Intent:

Improve the accessibility to the railway station, and thereby enhance the commuter experience during the pick-up and drop-off at the station complex.

Implementation Options:

Provide the following facilities to enhance accessibility to the railway station:

- Dedicated Drop-off zones for Intermediate Public Transport (e-Rickshaw, Auto Rickshaw, Cycle Rickshaw etc.) within the premises of the railway station.
- Parking facility for Intermediate Public Transport (e-Rickshaw, Auto Rickshaw, Cycle Rickshaw etc.)
- Parking facility for 2-wheelers and 4-wheelers
- Dedicated parking space for bicycles with provision of bicycle racks
- Electric charging points for 5% of parking spaces to encourage electric cars in parking lot.
- Well-lit footpaths for ease of pedestrians within the station complex
- Policy measures to prevent encroachment of footpaths by hawkers at entrance

Implementation of each measure will gain 1 point and the station can gain maximum of 4 points under this credit.

Documentation Required:

Submit the details of the implemented facilities with supporting photographs.

Exemplary Performance:

Station is eligible for exemplary performance under Innovation category, if the station demonstrates their efforts to integrate with public transport to the city and has at least one public transport facility (Metro station / Bus stand) within 1 km radius from the station.

Sr.No.	Description	Points Gained
1	Dedicated Drop-off zones for Intermediate Public Transport (e-Rickshaw, Auto Rickshaw, Cycle Rickshaw etc.) within the premises of the railway station.	1
2	Parking facility for Intermediate Public Transport (e-Rickshaw, Auto Rickshaw, Cycle Rickshaw etc.)	1
3	Parking facility for 2-wheelers and 4-wheelers	1
4	Dedicated parking space for bicycles with provision of bicycle racks	0
5	Electric charging points for 5% of parking spaces to encourage electric cars in parking lot.	0
6	Well-lit footpaths for ease of pedestrians within the station complex	1
7	Policy measures to prevent encroachment of footpaths by hawkers at entrance	0

	MAXIMUM POINTS GAINED	**4**

3.1.1.4 GREEN COVER AT STATION

SSF CREDIT 4

POINTS: 2

Intent:

Preserve existing trees and plant new saplings to protect habitat and promote biodiversity.

Implementation Options:

Demonstrate implementation of at least one of the following measures at the station premise:

- Preserve all existing trees within the station premise, without interfering with the expansion of railway lines.
- Retain natural topography or vegetation (AND/OR) design landscaped areas (with native/ adaptive species) for at least 15% of the station area.
- Plantation of at least 10 native plant saplings/ acre of station premise.
- Development of organic garden (or) vertical gardens within station premise.
- Use of organic fertilizers for all garden applications.

Implementation of each measure will gain 1 point and the station can gain maximum of 2 points under this credit.

Notes:

●Retaining 'Natural Topography' in its broad sense means preserving natural features of the terrain such as natural rocks, water body, etc.,

●For this credit, vegetation on the ground only shall be considered and vegetation over built structures such as roofs, basement, podiums, etc., cannot be considered.

●For this credit calculation, potted plants should not be considered as vegetation.

Documentation Required:

Submit the details of implemented measures with supporting photographs.

Exemplary Performance:

Station is eligible for exemplary performance under Innovation category, if more than 25% of the station area is covered with natural vegetation/ green cover.

Sr.No.	Description	Points Gained
1	Preserve all existing trees within the station premise, without interfering with the expansion of railway lines.	0
2	Retain natural topography or vegetation (AND/OR) design landscaped areas (with native/ adaptive species) for at least 15% of the station area.	1
3	Plantation of at least 10 native plant saplings/ acre of station premise	0
4	Development of organic garden (or) vertical gardens within station premise.	0
5	Use of organic fertilizers for all garden applications.	0
	MAXIMUM POINTS GAINED	**1**

3.1.1.5 HEAT ISLAND REDUCTION- ROOF & NON-ROOF

SSF CREDIT 5

POINTS: 2

Intent:

Reduce heat islands to minimize impact on microclimate.

Implementation Options:

Non-Roof Areas: (1 point for 50%, 2 points for 75% of exposed non-roof area)

For **at least 50%** of exposed non-roof impervious areas within the non-traction areas of the station, implement at least one or combination of the following:

- ✓ Shade from tree cover
- ✓ Open grid pavers, grass pavers
- ✓ Hardscape materials (SRI)

Roof Areas: (1 points for 50%, 2 points for 75% of exposed roof area)

Use material with high solar reflective index (SRI) value (or) vegetation (or) a combination, to cover at least 50% of the exposed roof areas:

- ✓ Minimum SRI value of 78 for Low-sloped roof (Slope: < 2:12)
- ✓ Minimum SRI value of 29 for Steep-sloped roof (Slope: > 2:12) and Maximum SRI of 64.

(OR)

Develop vegetation/ green roof/ solar PVs to cover **at least 50%** on the Exposed Station Roof Areas.

Notes:

●Heat island effect is a phenomenon where urban areas have higher temperatures than nearby less developed or rural areas. The increased temperatures above urban areas are a consequence of heat-retaining materials such as asphalt, concrete, rooftops, and other land surfaces. (Source:www.southwesturbanhydrology.com/urbanization-concerns/urban-heatisland-effect/)

●Solar Reflectance Index (SRI) is a measure of the roof's ability to reject solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100.

●For implementation under non-roof areas: Shade constructed surfaces on the site with landscape features and use open-grid pavers in impervious areas. Consider replacing constructed surfaces (i.e. roads, sidewalks, pathways, etc.,) with vegetation and/ or open grid paving or high-albedo materials to reduce heat absorption.

●For implementation under roof areas: All roof areas in the station building and the platforms, which are exposed to the sky should be considered for implementing the measures.

●Exposed roof area need not include equipment platforms, areas with solar photovoltaic & solar water heater and skylights

●The station can minimize heat and maximize energy savings by selecting materials that exhibit high reflectivity and high emissivity. Consider providing green roofs or using highly reflective materials over roof to reduce the heat island effect. Typical materials with high reflective

properties include china mosaic, white cement tiles, paints, roofing sheets with high Solar Reflective Index (SRI) values, etc.,

●SRI values of high reflectance materials should be as per ASTM Standards. China mosaic tiles are exempted from showing SRI value.

●SRI materials that are certified by 'GreenPro' – Green Product Certification programme supported by IGBC or having any other internationally accepted Eco Label, can be used by the station to show implementation.

Documentation Required:

Submit the details of the implemented measures with supporting photographs and manufacturer cut sheet of material indicating SRI value, if used.

Provide the manufacturers' name and the products details in case of using GreenPro certified products.

Exemplary Performance:

Station is eligible for exemplary performance under Innovation category,

i. If more than 95% of the exposed non-roof areas of the station are under tree cover (and / or) with open grid pavers (and / or) hardscape materials (SRI)

(OR)

ii. If more than 95% of the exposed roof area is covered with vegetation/ green roof/ solar PVs.

Sr.No.	Description	Points Gained
1	Non-Roof Areas: (1 point for 50%, 2 points for 75% of exposed non-roof area)	1
2	Roof Areas: (1 points for 50%, 2 points for 75% of exposed roof area)	0
	MAXIMUM POINTS GAINED	**1**

3.1.1.6 OUTDOOR LIGHT POLLUTION REDUCTION

SSF CREDIT 6

POINTS: 2

Intent:

Reduce light pollution from exterior and facade lighting to increase night sky access and enhance nocturnal environment.

Implementation Options:

- Upward Lighting: (1 Point)
  Provide exterior lighting such that no external light fixture emits more than 5% of the total initial designed fixture lumen, at an angle of 90 degrees or higher from nadir (straight down).
- LED Fixtures: (1 Point)

  Demonstrate 50% of the lighting fixtures installed in the station exterior areas are having LED lamps.

Documentation Required:

Submit the details of LED fixtures implemented vis-a-vis total number of fixtures (and) supporting photographs and purchase order of LED fixtures.

Exemplary Performance:

Station is eligible for exemplary performance under Innovation category, if more than 75% of the outdoor lighting fixtures installed in the station are downward LED lights

Sr.No.	Description	Points Gained

1	Upward Lighting	0
2	LED Fixtures	1
	MAXIMUM POINTS GAINED	**1**

3.1.1.7 STATIONS-OPERATIONS & MAINTAINENCE

SSF CREDIT 7

POINTS: 2

Intent:

Ensure sustained performance of the station facilities, so as to achieve benefits during the lifetime of the station operations.

Implementation Options:

Tin-House Team (2 Point)

- Have in place an in-house team at the railway station to handle the operation & maintenance(O&M) for Housekeeping, Water supply & Maintenance of Plumbing Systems, Electrical Systems, Mechanical Equipment, Solid waste management, as applicable
- Have a feedback mechanism in place to receive feedback from the passengers and take the corrective actions based on feed back

(OR)

- Maintenance Contract with External Agency (2 Point)

- Have an annual maintenance contract with external agency for the O&M of all building systems (energy, water & waste) and housekeeping.
- Have a feedback mechanism in place to receive feedback from the passengers and take the corrective actions based on feedback.

Documentation Required:

Option 1: In-House Team

Submit a detailed narrative on preventive and corrective actions taken by O&M team based on passengers' feedback.

Option 2: Maintenance Contract with External Agency

Submit a copy of the O&M contract with detailed scope of work and renewal plan.

Submit periodic reports (monthly or quarterly) on preventive and corrective actions taken by the external agency.

Exemplary Performance:

This credit is not eligible for exemplary performance.

Sr.No.	Description	Points Gained
1	Maintenance Contract with External agency	2
	MAXIMUM POINTS GAINED	**2**

3.1.2 HEALTH, HYGIENE & SANITATION

3.1.2.1 TOBACCO SMOKE CONTROL

HHS MANDATORY REQUIREMENT 1

Intent:

Minimize exposure of non-smokers to the adverse health impacts arising due to passive smoking at the station.

Implementation Options:

Demonstrate that smoking is prohibited in the station complex, and is in accordance with the regulations of Ministry of Health & Family Welfare, Government of India.

Install NO SMOKING signage at following locations in the station premise:

- All platforms
- Booking Office
- Waiting Halls
- Retiring Rooms

(AND)

Prohibit sale of tobacco products in the station premise.

Documentation Required:

Details of the initiatives taken to prohibit use of tobacco in the station premises with supporting photographs of signage installed at station.

3.1.2.2 SAFE DRINKING WATER FACILITY

HHS MANDATORY REQUIREMENT 2

Intent:

Ensure adequate quantity of clean and safe drinking water for all passengers to eliminate spread of water borne diseases.

Implementation Options:

Demonstrate that potable drinking water is available at all platforms for passengers, through piped water supply (or) through tube-wells with hand pumps (or) mobile or stationary water containers (In case, piped water supply is technically and economically not feasible)

Ensure implementation of the following measures at the station:

- Safe drinking water unit/ storage facility at Station
- Each platform should have provision of at least 2 taps per coach (As per IR Works Manual:

Chapter 4: 403 Minimum Essential Amenities Passenger Amenities, Stations and Yards)

- Quality of water to meet the prescribed standards as per IS 10500: 2012*
- Periodic check on quality of water and report by a competent authority from Indian Railways

** IS 10500: 2012 - Indian Standard for Drinking Water as per BIS specifications.*

Notes:

●In case of mobile water containers: the number, size and type should be installed and

Maintained as per IR Code & IR mandate.

●RO treated water or UV purified water or Water Vending Machines can be considered as Safe Drinking water.

Documentation Required:

Submit the details of implemented measures with supporting photographs of platforms (and) sample report on water quality parameters by competent authority.

3.1.2.3 FRESH AIR VENTILATION

HHS CREDIT 1

POINTS: 4

Intent:

Provide adequate fresh air ventilation so as to avoid pollutants affecting indoor air quality

Implementation Options:

For Naturally Ventilated Rooms: (2 Points)

Demonstrate that the ratio of open able area (windows, doors, ventilators) to the carpet area is:

- At least 8% in all regularly occupied spaces in station.
- At least 10% in all regularly occupied spaces in station.

For Air Conditioned Rooms: (2 Points)

Demonstrate that the fresh air ventilation in all regularly occupied spaces in station:

- Meet the minimum ventilation rates as prescribed in Annexure I.
- Exceed the minimum ventilation rates by 10%.

Note:

●●Regularly occupied areas are those where people sit or stand as they work, irrespective of the number of days occupied in a year.

●Regularly occupied spaces in station include waiting rooms, retiring rooms, booking office, officer's rooms, canteen, restaurants, etc.

●●Sorting & storage room for soiled linen and Cloak room shall meet ventilation requirements as per IR Works Manual.

●●Doors, windows & ventilators can be considered as openings and should be kept open during occupancy.

Documentation Required:

Submit calculation confirming the fresh air ventilation in all regularly occupied spaces in the station with supporting photographs of respective areas.

Exemplary Performance:

This credit is not eligible for exemplary performance.

Sr.No.	Description	Points Gained
1	For Naturally Ventilated rooms	2
2	For Air Conditioned Rooms	2
	MAXIMUM POINTS GAINED	**4**

3.1.2.4 SOLID WASTE MANAGEMENT PLAN

HHS CREDIT 2

POINTS: 6

Intent:

Segregate station waste at source and facilitate recycling (Or) environment friendly disposal, thereby maintain a hygienic environment at station and avoid such waste being sent to land-fills

Implementation Options:

Demonstrate an ongoing solid waste collection and disposal system at station to include both organic and recyclable waste:

Segregation (3 points)

- Provide 2 separate bins for collection of food waste (organic) and recyclable waste (plastic & paper) at every platform at an interval of 100m.
- Have provision of a central waste collection area in station premise with separate bins for dry waste (paper, plastic, cardboard, metal, glass), wet waste (garden & food waste) and hazardous waste (e waste like batteries, lamps)
- Maintenance Plan for keeping the centralized waste collection area free from insects and mosquitos.

Reuse/ recycling (2 points)

- Station authority shall have a contract in place with recyclers for diverting paper & plastic waste for recycling.
- Have an organic waste management system in place within the station premise.

Environment friendly Disposal (1 point)

- Dispose the hazardous waste as per Hazardous Waste Management Guidelines of Ministry of Environment & Forest (MoEF), Government of India.

Documentation Required:

Segregation:

- Submit railway station plan indicating the 2 bin system implemented at platform level with supporting photographs of platforms with waste bins (marked as organic and recyclable waste)
- Submit railway station plan indicating the centralized waste sorting & collection area with supporting photographs of waste bins for dry, wet and hazardous waste.
- Submit a declaration letter on maintenance plan from station authority mandating the cleanliness measures at centralized waste collection area (OR) an extract of O&M contract with external agency, highlighting the scope of work.

Reuse/ Recycling:

- Submit a copy of contract with scrap dealers/ recyclers for diverting paper, plastic, glass, metal and cardboard waste for recycling along with renewal plan (and) letters from scrap dealers/ recyclers confirming the quantity of waste diverted in last 2 months.
- Submit details on implemented organic waste management system with supporting photographs

Environment friendly Disposal:

- Submit details on implemented disposal measures for hazardous waste (as per MoEF Guidelines) with supporting photographs.

Exemplary Performance:

Station is eligible for exemplary performance under Innovation category, if 100% of the solid waste generated at the station is diverted for any of the following approach:

- Waste to Electricity
- Waste to Cooking gas
- Waste to Diesel

Sr.No.	Description	Points Gained
1	Segregation	0

2	Reuse/Recycling	0
3	Environment Friendly Disposal	0
	MAXIMUM POINTS GAINED	**0**

3.1.2.5 PLASTIC FREE ENVIRONMENT

HHS CREDIT 3

POINTS: 2

Intent:

Encourage the use of recyclable bags instead of plastic bags within the station premises to reduce environmental impacts of handling plastic waste.

Implementation Options:

Option -1 (2 points)

- If the Ministry of Environment & Forest (MoEF) or local authorities prescribe ban on use of plastic bags, then the station complex shall comply with the respective criteria.
- Conduct Periodic supervision to check the plastic litter at station premise (and) Organize awareness programme about adverse effects of ‘plastic use’ periodically.

(OR)

Option -2 (2 points)

Demonstrate the following measures at station premise:

- Install permanent signage (or) play digital messages on screens at all the railway platforms to create awareness on adverse environmental impacts of plastic bags.
- Conduct Periodic supervision to check the plastic litter at station premise (and) Organize awareness programme about adverse effects of 'plastic use' periodically.

Note:

●Recyclable bags include paper bags, jute bags, cotton bags, canvas bags, non-woven and bamboo bags, which are alternative to plastic bags.

Documentation Required:

Submit the details of measures implemented with supporting photographs of signage (and) photographs of awareness programs conducted in last 2 months.

Exemplary Performance:

This credit is not eligible for exemplary performance.

Sr.No.	Description	Points Gained
1	Plastic Free Environment	2
	MAXIMUM POINTS GAINED	**2**

3.1.2.6 ENHANCED INDOOR AIR QUALITY

HHS CREDIT 4

POINTS: 4

Intent:

Avoid exposure to airborne contaminants and reduce the adverse health impacts on passengers & station staff during their stay at station premises.

Implementation Options:

Demonstrate the following measures to enhance the indoor air quality at station: (1 point for each strategy).

1. Carbon dioxide Monitoring & Control (2 point)

- For Air Conditioned Spaces:

Demonstrate that the station has installed CO2 sensors and a control system to maintain a differential CO2 level of 530 ppm in all regularly occupied areas. For densely occupied areas, have in place.

CO2 sensors at the breathing zone levels with monitoring systems.

- For Naturally Ventilated Spaces:

For each regularly occupied area in the station, demonstrate that the ratio of open able area to the carpet area is at least 12%.

Note:

●Regularly occupied areas are those where people sit or stand as they work, irrespective of the number of days occupied in a year.

●Regularly occupied spaces in station include waiting rooms, retiring rooms, booking office, officer's rooms, canteen, restaurants etc.

●Densely occupied space is any space with occupant density of 25 people or more per 1,000 sq. ft. (e.g. Waiting rooms, cafeteria)

●Doors, windows & ventilators can be considered as openings and should be kept open during occupancy.

2. **Isolation of Polluting Equipment & Systems** (1 point)

™. Isolate areas exposed to hazardous gases or chemicals (such as UPS room, printer rooms, chemical storage rooms, janitor rooms) from regularly occupied areas through design measures like exhaust system, self-closing door, deck-to-deck partition / hard ceiling.

Note:

●Each of these spaces shall be provided with exhaust systems. The exhaust rate should be at least 0.5 cm per sq.ft.

Use of Certified Green Products (1 point)

- Have a policy in place which mandates the use of certified green products during renovation, operation and maintenance of the station building.

Utilize the products & materials having minimal health impacts i.e., products having very low VOC Content, formaldehydes, aldehydes etc.

- Use paints and coatings (including primers) with low or ultralow VOC content
- Use adhesives in the interior work, which does not exceed the VOC limits.
- Use Composite wood/ Agri-fiber materials with no added urea-formaldehyde resins.
- New wood furniture items such as work stations, chairs, tables, cabinets, etc., with low emissions.
- Refer Annexure II for VOC limits of materials.

Note:

●Volatile organic compounds (VOCs) are carbon compounds that participate in atmospheric photochemical reactions (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonates, and ammonium carbonate). The compounds vaporize at normal room temperatures.

●Composite wood consists of wood or plant particles or fibers bonded together by a synthetic resin or binder. Examples include plywood, particle-board, and medium density fiberboard (MDF).

●Salvaged wood based materials shall not be considered under ‘New Wood Furniture’ category.

●Paints & Coatings, Adhesives and Composite wood that are certified by 'GreenPro' – Green Product Certification programme with the support of IGBC or having any other internationally accepted Eco Label, can be used by the station to show compliance.

Documentation Required:

Carbon dioxide Monitoring & Control:

Submit a narrative on implemented measures in air conditioned areas with supporting photographs of CO2 sensors and submit calculation confirming to the fresh air ventilation in all naturally ventilated spaces with supporting photographs of respective station areas.

Isolation of Polluting Equipment & Systems

Submit the details of implemented measures with supporting photographs

Use of Certified Green Products

Submit a copy of station policy mandating the use of certified green products and the details of products.

Exemplary Performance:

This credit is not eligible for exemplary performance.

Sr.No.	Description	Points Gained
1	Carbon Dioxide monitoring & Control	0

2	Isolation of polluting Equipment & systems	1
3	Use Of Certified Green Products	0
	MAXIMUM POINTS GAINED	**1**

3.1.2.7 DAYLIGHTING

HHS CREDIT 5

POINTS: 2

Intent:

Ensure adequate day lighting to improve visual comfort and reduce lighting energy consumption.

Implementation Options:

Demonstrate that the station achieves the following requirement for daylight in all regularly occupied areas.

Points are awarded as below:

If 50 % of the occupied areas are day-lit in the station (1 point)

If 75 % of the occupied areas are day-lit in the station (2 points)

Demonstrate through daylight luminance measurement that at least 50% of the regularly occupied spaces in the station achieve daylight luminance levels for a minimum of 110 Lux. Measurements shall be taken at floor level at 9 am, 12 noon, and 3 pm, on a 10 feet square grid. To show compliance, consider the average of the measurements taken at 9 am, 12 noon, and 3 pm.

Note:

●Regularly occupied areas are those where people sit or stand as they work, irrespective of the number of days occupied in a year.

●Regularly occupied spaces in station include waiting rooms, retiring rooms, booking office, officer's rooms, canteen, restaurants, cloak rooms etc.

●The station need not consider non-regularly occupied areas such as Toilets, Store rooms, Equipment/ Utility rooms under credit calculations

●The station can implement conventional or clerestory windows, skylights, transparent sheets for platform shelter, sunlight harvesting techniques (like sun pipe, glass block walls etc).

Documentation Required:

Submit a table with details on luminance levels (lux levels) achieved at all regularly occupied spaces

Exemplary Performance:

This credit is not eligible for exemplary performance.

Sr.No.	Description	Points Gained
1	75% of the occupied areas are day-lit in the station	2
	MAXIMUM POINTS GAINED	**2**

3.1.2.8 STATION HOUSEKEEPING PLAN

HHS CREDIT 6

POINTS: 3

Intent:

Encourage use of eco-friendly housekeeping chemicals so as to reduce adverse health impacts for passengers.

Implementation Options:

Demonstrate that station facility management team (or) external housekeeping agency is using housekeeping chemicals that meet GreenPro – Green Product Certification standard, or other internationally recognized equivalent standards, for all station applications. (1 Point) .

(AND)

Implement measures as per Environment and Housekeeping Management Directorate of Indian Railways, addressing the following measures, as applicable: (2 Points)

- Mechanized Cleaning
- Repairs to Amenities

- Pest & Rodent Control
- Linen Management at station
- Support Station for on board housekeeping services on platform.

Implementation of each measure will gain 1 point and station can gain maximum of 2 points.

Documentation Required:

Submit list of chemicals used and the manufacturer's details.

Exemplary Performance:

This credit is not eligible for exemplary performance.

Sr.No.	Description	Points Gained
1	Mechanized cleaning	1
2	Pest & Rodent control	1
3	Linen Management at station	0
4	Repairs and Amenities	1
5	Support station for on board housekeeping services on platform	0
	MAXIMUM POINTS GAINED	**3**

3.1.3 ENERGY EFFICIENCY

3.1.3.1 ENHANCED ENERGY PERFORMANCE – NON-TRACTION.

EE CREDIT 1

Points: 8

Intent:

Enhance energy efficiency of the station to reduce environmental impacts from excessive energy use.

Implementation Options:

1. Energy Efficient Lighting Fixtures (2 points)

Demonstrate at least 50% of the lighting fixtures installed in the station non traction areas are having

LED lamps

Points are awarded as below:

- 1 point will be awarded if 50 % of the total lighting fixtures are LED lamps
- 2 Points will be awarded if 75% and above of the total lighting fixtures are LED lamps

2. Lighting Controls (1 point)

All non-emergency exterior & common area lighting such as façade, pathways, landscaping, surface

and covered parking, street lighting, staircases should have at least one of the following:

- Daylight sensor
- Occupancy/ Motion sensor
- Timer

3. Energy Efficient Fans (1 point)

Demonstrate at least 50% of fans in the stations with minimum BEE 3-star rating or equivalent.

4. Energy Efficiency in Appliances & Equipment (1 point)

Demonstrate at least 50% of computers/ monitors/ printers used in station office & booking office

with Energy Star rating or equivalent program.

5. Energy Efficient Air-conditioners (1 point)

Demonstrate all unitary air-conditioners with minimum BEE 3-star rating or equivalent

6. Heating Systems (1 Point)

Stations having more than 150 Heating Degree days (HDD18) shall consider setting up heating

systems with a minimum COP of 2.5 (EER of 8.53).

7. Energy Efficient Pumps & Motors (1 point)

Demonstrate all pumps & motors with minimum BEE 3-star rating or equivalent.

Documentation Required:

Submit the details of LED fixtures implemented vis-à-vis total number of fixtures.

Submit the details of energy efficient fans, appliances, air conditioners, heating systems, pumps and motors indicating their make and the star ratings.

Sr.No.	Description	Points Gained
1	Energy Efficient Lighting Fixtures	2
2	Lighting Controls	0
3	Energy Efficient Fans	1
4	Energy Efficiency in Appliances & Equipment	1
5	Energy Efficient Air-conditioners	0
6	Heating Systems	0
7	Energy Efficient Pumps & Motors	0
	MAXIMUM POINTS GAINED	**4**

3.1.3.2 ON SITE, RENEWABLE ENERGY

EE CREDIT 2

Intent:

Encourage the use of on-site renewable energy systems, to minimize the environmental impacts associated with use of fossil fuels.

Implementation Options:

Demonstrate on-site renewable energy generation for at-least 1.25% of total energy consumption of the

station for non-traction areas.

Implement any of the following RE systems* at station premise for the credit compliance:

- Solar photovoltaics
- Electricity generation from solid waste
- Bio-energy technologies
- Mini wind turbines

*The list is illustrative and does not include all renewable energy system.

Percentage of on-site renewable energy generation out of total non-traction energy consumption of station	Points
>1.25%	1
>2.5%	2
>3.75%	3
>5%	4
>7.5%	5
>10%	6

Documentation Required:

The details of energy generation vis-a-vis total energy consumption of the station along with photographs of installations in the station.

Sr.No.	Description	Points Gained
1	Percentage of on-site renewable energy generation. [0%]	0
	MAXIMUM POINTS GAINED	**0**

Solar rooftop power system Estimate.

Sr. No.	Description	Unit
1	Power required by Panvel Station monthly	1,30,000 units

2	Power required daily on Non-traction section	4000 units
3	Suitable size Solar panel system	200 kWp
4	Daily output from Solar panel system(considering 5.5 sunshine hours)	1.1 mW
5	Cost of the plant	Rs. 53000/kW
6	Without Subsidy(based on current MNRE benchmark)	Rs. 1,06,00,000
7	With Subsidy 30% (based on current MNRE benchmark)	Rs. 74,20,000
8	Total electricity generation from solar plant: Annual: Over 25 years:	 3,00.000kWh 75,00,000kWh
9	Monthly reduction in Electricity bill(Tariff @ Rs. 7/kWh)	Rs. 1,75,000
10	Annual bill reduction	Rs. 21,00,000
11	Carbon dioxide emissions mitigated is	6150 tonnes
12	This installation will be equivalent to planting	9840 teak trees

POINTS GAINED BY INSTALLING SOLAR PLANT - 13

3.1.3.3 ENERGY MONITORING

EE CREDIT 3

Intent:

Encourage continuous monitoring to identify improvement opportunities to enhance energy efficiency.

Implementation Options:

1. Demonstrate sub-metering for and identify trends (energy monitoring) for the following energy use

applications in stations, as applicable: (3 points):

- Lighting
- Elevators & escalators
- HVAC equipment & systems
- On-site renewable energy systems
- Power back-up systems (Generator sets)

Points are awarded as below:

Percentage of total energy use applications are metered though sub-metering Points	**Points**
>50%	1
>75%	2
>95%	3

2. Demonstrate that the building management system is in place to control and monitor the above mentioned systems, as applicable. (1 point)

3. Carry out comprehensive energy audits once in three years and explore opportunities for Improvement . (1 point)

Documentation Required:

1. Submit a narrative on implemented measures with supporting photographs of installed meters and

calculation on percentage of total energy use applications covered though sub-metering (and) One

day log sheet of all the installed sub-meters.

2. Submit details on building management system implemented in the station (and) BMS screenshot.

3. Submit the copy of latest Energy audit report carried out by competent agencies (and) Declaration

from railway station authority confirming the energy audit to be done every 3 years.

Sr.No.	Description	Points Gained
1	Percentage of total energy use applications are metered through sub-metering. [0%]	0
	MAXIMUM POINTS GAINED	**0**

3.1.3.4 SOLAR WATER HEATING

EE CREDIT 4

Intent:

Encourage use of solar water heating applications, to minimize the environmental impacts associated with use of electricity or any other fossil fuels

Implementation Options:

Demonstrate the use of solar water heating systems in place of electric geysers to meet at least 25% of the hot water requirement of canteen and restaurants within the station premise.

Points are awarded as below:

- If 25% of the hot water requirement is met from solar water heating systems (1 point)
- If 50% of the hot water requirement is met from solar water heating systems (2 points)

Note:

- Solar water heating systems include solar water heaters, solar steam cooking system, etc

Documentation Required:

1. Submit the details of solar water heating systems and electrical heaters in operation for hot water generation.
2. Calculation on percentage of hot water requirement met by solar water heating systems with supporting photographs of installed system.

Sr.No.	Description	Points Gained
1	Percentage of Hot Water requirement is met from solar water heating systems [0%]	0
	MAXIMUM POINTS GAINED	**0**

3.1.4 WATER EFFICIENCY

3.1.4.1 WATER CONSERVATION METHODS

WE CREDIT 1

Intent:

Reduce potable water consumption in the station by implementing water conservation measures.

Implementation Options:

Water Efficient Fixtures

Demonstrate at least 50% of the plumbing fixtures installed in the station are efficient and whose flow rates are within the prescribed criteria of uniform plumbing code, as mentioned below:

Prescribed Maximum Flow Rates:

Fixture type	**Maximum Flow rate/consumption**
Water closets (Full-Flush)	6 LPF
Water closets (Half-Flush)	3 LPF
Urinals	4 LPF
Faucets/taps	6 LPF
Health Faucets	3 LPF
Shower head / Hand-held spray	10 LPF

Note:

● Water fixtures do not include irrigation systems.

● All Faucets / Taps installed in the station shall be considered

● Rain showers (if any) need to be considered in the calculations under Shower head.

● Plumbing fixtures that are certified by 'GreenPro' – Green Product Certification programme with the support of IGBC or having any other internationally accepted Eco Label, can be used by the station to show compliance.

Points are awarded as below: (2 points)

Percentage of total plumbing fixtures within the prescribed criteria	Points
>50%	1
>75%	2

Reduction in Water consumption for Coach Washing (1 Point)

Demonstrate at least 10% of water requirement for coach washing is sourced through use of treated waste water (OR) use of harvested rainwater (OR) use of Automatic coach washing plants.

Reduction in water consumption for Laundry Applications (1 Point)

Demonstrate at least 10% of water requirement for cleaning of linen is sourced through use of treated waste water (OR) use of harvested rainwater (OR) use of mechanized laundry systems.

Documentation Required:

- Submit the details water efficient fixtures along with the flow rates. In case of use of Green certified fixtures provide the details of manufacturer.
- Submit the details of measures implemented to reduce potable water requirement for coach was(and) calculation on percentage of water reduction with supporting photographs.
- Submit a narrative on implemented measures to reduce potable water requirement for lau applications (and) calculation on percentage of water reduction with supporting photographs.

Exemplary Performance:

Station is eligible for exemplary performance under Innovation category, if :

100% of the plumbing fixtures installed in the station are efficient whose flow rates are within the prescribed criteria of uniform plumbing code

(OR) 25% reduction in potable water requirement for coach washing is demonstrated

(OR) 25% reduction in potable water requirement for laundry applications is demonstrated.

Sr.No.	Description	Points Gained
1	Percentage of total plumbing fixtures within prescribed criteria [50%]	1
2	Reduction in water consumption for coach washing	0
3	Reduction in water consumption for laundry applications	0
	MAXIMUM POINTS GAINED	**1**

3.1.4.2 RAINWATER HARVESTING

WE CREDIT 2

Intent:

Enhance energy efficiency of the station to reduce environmental impacts from excessive energy use.

Implementation Options:

Rainwater Capture/ Recharge: (1 - 2 Points)

Design rainwater harvesting system to capture at least 'one-day rainfall*' runoff volume from roof and

non-roof areas

* One-day rainfall can be derived from 'percentage of average peak month rainfall' given in Table below:

To arrive at average peak month rainfall, consider an average of at least last 5 years peak month rainfall

(of the respective year).

Criteria to arrive at 'One-day Rainfall'

Sr.No.	**Average Peak Month Rainfall (mm)**	**One day Rainfall**	
		(% of Average Peak Month Rainfall)	
		1 point	**2 points**
1	Up-to 250	15%	18%
2	251-350	12.5%	15%
3	351-500	10%	12%
4	501-700	7.5%	9%
5	701 & above	5%	6%

Notes:

● For rainfall information, refer Indian Meteorological Department data at http://www.imd.gov.in

● Runoff volume = Surface area x Runoff Coefficient x Rainfall.

● Consider Rainwater Harvesting Guidelines (as and when available) from the National Building Code (NBC) of India, Part 11 - Approach to Sustainability, Section 7.2 - Rainwater Harvesting,Surface Runoff.

● In areas where capturing of water is difficult, consider water percolating structures to meet the above requirement.

● Filtering of suspended solids shall be ensured by providing suitable filtering media before letting the water into the collection tanks, water bodies, municipal storm water drains.

Use of Harvested Rainwater: (2 Points)

Use captured rainwater for at least 15% of the total water required for landscaping, flushing and station cleaning applications Points are awarded as below:

Application	Percentage of Total Water catered through Rainwater	Points
Landscaping, Flushing & Cleaning Applications at Station	>15%	1
	>25%	2

Documentation Required:

- Submit the station plan showing the location of rain water harvesting systems including capacity of rain water harvesting structures (number of pits and their harvesting volumes)
- Submit photographs of rain water harvesting system/ percolation pit.

Exemplary Performance:

Station is eligible for exemplary performance under Innovation category, if rainwater runoff from roof & non-roof areas is captured and / or recharged, as per the table listed below:

Criteria to arrive at 'One-day Rainfall' for Exemplary Performance

Sr.No.	Average Peak Month Rainfall (mm)	One-day Rainfall (% of average Peak month Rainfall)
1	Up-to 250	24%

2	251-350	20%
3	351-500	16%
4	501-700	12%
5	700 & above	8%

(AND)

Captured rainwater is reused to meet at least 30% of the total water required for landscaping and flushing.

Sr.No.	Description	Points Gained
1	Rainwater Capture/ Recharge	2
2	Use of Harvested Rainwater	0
	MAXIMUM POINTS GAINED	**2**

RAINWATER HARVESTING SYSTEM ESTIMATE:

Sr.No.	Description	Unit
1	Average Rainfall of Panvel	3.267 m
2	Roof Area of Panvel Railway Station	35500 m^2

3	Average Runoff Coefficient	0.6
4	Total Water collected	69,600 m^3
5	Panvel Station daily water usage	830 m^3
6	Water to be collected for washing and watering purpose daily	200 m^3
7	Water tank to be designed underground	125m^3
8	overhead water tank capacity	20 m^3 *4

Sr.No.	Description	Unit	Rate (Rs.)	Quantity	Cost (Rs.)
1	Excavation in soils	cu.m.	145	125m^3	**18125**
2	Excavation in rock	cu.m.	165	125m^3	**20625**
3	Brickwork with cement mortar (1:6)	cu.m.	4921	30 m^3	**147630**
4	Plain cement concrete (1:3:6)	cu.m.	5745	4m^3	**22980**

5	Reinforced cement concrete (1:2:4) cu. m. 4700.00Including steel bars, shuttering etc.	cu.m.	7026	22.5 m^3	**158085**
6	PVC piping for rainwater pipes				
	- 110 mm diameter	metre	129	100m	**12900**
	- 200 mm diameter	metre	477	100m	**47700**
7	Making borehole in metre 165.00Soft soil (with 150 mm diameter PVC casing)	metre	1364	10m	**13640**
8	LUMPSUM	-	-	-	**20,000**
9	Over head water tanks	units	1,10,000	4	**4,40,000**
	TOTAL				**9,01,685**

TOTAL POINTS INCREASED BY RAINWATER HARVESTING SYSTEM: 6

3.1.4.3 WASTE WATER TREATMENT

WE CREDIT 3

Intent:

Treat waste water generated at station so as to make it available for reuse or safe disposal and hence avoid polluting the receiving streams.

Implementation Options:

1. Have on-site treatment systems (or) community wastewater treatment system to treat at least 50% of waste water generated at the station, to the quality standards* suitable for safe disposal into water bodies / suitable for reuse. (2 points)

Points are awarded as below:

Percentage of Total Waste-water Diverted to treatment system	Points
>50%	1
>95%	2

2. Demonstrate that station authority shall conduct periodic assessment of the waste-water treatment plant to check the operations & maintenance of the facility (1 point)

3. Conduct periodic tests of the inlet & outlet parameters (BOD, COD and PH) every month as per Central (or) State Pollution Control Board guidelines. (1 point)

Notes:

● *Water quality standards suitable for safe disposal into water bodies / suitable for reuse shall meet the Central (or) State Pollution Control Board requirements, as applicable.

● Waste water here refers to both grey and black water.

● Water from sources such as bore wells, natural wells and municipal water systems is considered as potable water.

● Effluent Treatment Plant/ Sewage Treatment plant under construction and to be completed within 3 years can show compliance

Documentation Required:

- Submit details of the waste water treatment plant installed along with photographs (and) inlet meter reading installed to confirm the following :

✓ Quantity of waste water from the station diverted to the treatment system

✓ Quantity of waste-water generated at the station

- Submit periodical report (quarterly or semi-annually) to confirm that the waste-water treatment plant is maintained and serviced on a periodic basis.

- Submit extract of test reports indicating the inlet & outlet parameters on a monthly basis for last one year.

Sr.No.	Description	Points Gained
1	Percentage of total Waste water diverted to treatment system [>50%]	1
2	Conduction of Periodic tests of Inlet & Outlet	0
3	Operation and maintenance of Waste water treatment plant	0
	MAXIMUM POINTS GAINED	**1**

3.1.4.4 WASTE-WATER REUSE

WE CREDIT 4

Intent:

Use treated waste water thereby reduce dependence on potable water.

Implementation Options:

1. Have on-site treatment systems (or) community waste water treatment system to treat at least 50% of waste water generated at the station, to the quality standards* suitable for safe disposal into water bodies / suitable for reuse. (2 points)

Points are awarded as below:

Application	Percentage of Total Water	Points

	catered through Rainwater	
Landscaping, Flushing & Cleaning Applications at Station	>15%	1
	>25%	2

Notes:

● The credit point(s) can be claimed only if the treated water is reused at station.

● Water from sources such as bore wells, natural wells and municipal water systems is considered as potable water.

● The water requirement and average number of watering days for landscaping shall be considered as 6 liters per sq.m. per day (i.e. 6 liters / sq.m. / day) for a minimum of 300 days.

Documentation Required:

Submit the annual water consumption details indicating the water use for all type of activities and the quantity of recycled water.

Sr.No.	**Description**	**Points Gained**
1	Percentage of total water catered through treated water	0
	MAXIMUM POINTS GAINED	**0**

3.1.4.5 WATER METERING

WE CREDIT 5

Intent:

Encourage water metering to identify improvement opportunities and thereby reduce the usage of potable water.

Implementation Options:

Demonstrate sub-metering for all the water supply source and at least two major water consumption areas of the following, as applicable: (1 point)

Water Supply source, as applicable:

- Municipal water supply
- Water supply from bore wells
- Treated waste water supply

Water consumption areas: (at least two)

- Water consumption for landscape requirements
- Water consumption for coach washing
- Water consumption for laundry applications
- Water consumption for station cleaning applications
- Any other major source of water consumption

Carry out comprehensive water audits once in three years and explore opportunities for Improvement (1 point)

Documentation Required:

- Submit schematic plumbing diagram indicating location of water meters (and) photographs of installed meters for different water use applications.
- Submit the copy of latest water audit report carried out by competent agency (and) Declaration from railway station authority confirming the water audit to be done every 3 years.

Sr.No.	Description	Points

		Gained
1	Sub-metering for all the water supply source	1
2	Water audits once in 3 years	0
	MAXIMUM POINTS GAINED	**1**

3.1.5 SMART & GREEN INITIATIVES

3.1.5.1 SMART PASSENGER SERVICES

SGI CREDIT 1

Intent:

Encourage smart passenger information systems & services at the station for convenient and comfortable commuting experience.

Implementation Options:

Demonstrate implementation of at least 3 smart facilities at station:

1	Wi-Fi facility at station	**2**	Pharmacy & Medical Facility
3	Multilingual e-Ticketing portal	**4**	Prepaid Cab Facility
5	Automatic ticket vending machine	**6**	Hotel Facility at Station
7	CCTV surveillance for safe	**8**	Shopping Area at Station
9	Portable structures with bio toilets for senior citizens at platforms	**10**	Food Court at Station

11	Smart Card Ticketing	**12**	Tourism Information & Booking Centre
13	Laptop Charging station with seating facility	**14**	Touch screen information kiosk

**The list is illustrative and does not include all smart facilities. All the smart facilities should be functional.*

1 point will be awarded for implementation of each measure and a station can gain maximum of 8 points as part of this credit.

Documentation Required:

Submit the details of the implemented facilities with supporting photographs

Sr.No.	Description	Points Gained
1	Wi-Fi facility at station	1
2	Pharmacy & Medical Facility	0
3	Multilingual e-Ticketing portal	1
4	Prepaid Cab Facility	0
5	Automatic ticket vending machine	1
6	Hotel Facility at Station	0
7	CCTV surveillance for safe	1
8	Shopping Area at Station	0
9	Portable structures with bio toilets for senior citizens at platforms	0
10	Food Court at Station	0
11	Smart Card Ticketing	1
12	Tourism Information & Booking Centre	0
13	Laptop Charging station with seating facility	0
14	Touch screen information kiosk	0
	MAXIMUM POINTS GAINED	**5**

3.1.5.2 GREEN OUTREACH & AWARENESS

SGI CREDIT 2

Intent:

Adopt measures to spread awareness on Green Railway Station amongst all the users of rail way services.

Implementation Options:

Demonstrate implementation of green awareness initiatives at station:

- Install Green Information Signage (printed or digital) at various locations highlighting the key green features implemented in the station
- Conduct Green Awareness campaigns on Environment Day, Earth Day, Green Building Week, etc.,
- A Digital display of green impacts (in terms of reduction in energy consumption, renewable energy generation & water savings) at entrance/ prominent location of the station.

1 point will be awarded for each of the measures implemented and the station can gain maximum of 2 points as part of the credit.

Documentation Required:

- Submit a narrative on implemented green awareness initiatives with supporting photographs of installed signage
- Submit photographs of environmental awareness campaigns held at station in last 1 year.
- Photographs of installed digital display at the station displaying quantified green impacts

Sr.No.	Description	Points Gained

1	Install Green Information Signage (printed or digital) at various locations highlighting the key green features implemented in the station	1
2	Conduct Green Awareness campaigns on Environment Day, Earth Day, Green Building Week, etc.,	0
3	A Digital display of green impacts (in terms of reduction in energy consumption, renewable energy generation & water savings) at entrance/ prominent location of the station.	1
	MAXIMUM POINTS GAINED	**2**

3.1.5.3 GREEN RAILWAY STATION COMMITTEE

SGI CREDIT 3

Intent:

To sustain & enhance the green measures implemented at the station on a continuous basis, thereby reaping the environmental benefits.

Implementation Options:

The station shall constitute a formal committee 'Green Railway Station Committee' for regular monitoring of implemented green features at railway station (1 point)

(AND)

The committee shall convene a meeting every two months to discuss on : (1 point)

- Operation & maintenance of existing green features at station
- New green initiatives for the Railway Station.

Documentation Required:

- Submit a declaration letter from railway authority indicating the formation of 'Green Railway Station Committee' (and) list of committee members with responsibility in terms of monitoring of implemented green features at railway station.
- Submit photographs of at least 2 meetings held in last 6 months (and) details on minutes of meeting and activities initiated after the meetings.

Sr.No.	Description	Points Gained
1	Green Railway Station Committee	0
	MAXIMUM POINTS GAINED	**0**

3.1.6 INNOVATION & DEVELOPMENT

3.1.6.1 INNOVATION

ID CREDIT 1

Intent:

Award points for innovative performance not specifically addressed by the Green Railway Station Rating System (and/ or) exemplary performance in any of the criteria addressed by the rating system.

Implementation Options:

Station can attempt for maximum of 5 innovative measures and 1 point shall be awarded for implementing each measure as per the following options:

- **Innovation**

Identify the intent of proposed innovation credit, proposed requirement for implementation options, and proposed documentation to demonstrate implementation, and the design approach used to meet the required measures.

(Or)

Exemplary performance

The station is eligible for exemplary performance, if the implemented measures greatly exceed the credit requirements of the Green Railway Station rating system.

Notes:

● As a general rule, points for exemplary performance are awarded for achieving the next incremental percentage threshold.

● Eligibility criteria for various credits in the Green Railway Station rating system are defined in respective credits and Exhibit - B.

General Notes:

The station shall also meet the following criteria for achieving an Innovation point:

● Quantitative performance improvements (comparing past and present performance).

● Strategy must be significantly better than standard sustainable design practices.

● Measures must be voluntary. Measures that are mandated by the Indian Railways and not addressed in the rating system are not eligible for Innovation.

Sr.No.	Description	Points Gained
1	Innovation	0
	MAXIMUM POINTS GAINED	**0**

3.1.6.2 IGBC ACCREDITED PROFESSIONAL

ID CREDIT2

Intent:

Support and encourage involvement of IGBC Accredited Professional in green building projects, so as to integrate appropriate design measures and streamline the certification process.

Implementation Options:

At least one principal participant of the station team shall be an IGBC Accredited Professional (IGBC AP)

Sr.No.	Description	Points Gained
1	IGBC Accredited professional	0
	MAXIMUM POINTS GAINED	**0**

MINIMUM LIMITS OF RATING SYSTEM:

Modules	Total points	Minimum Weightage for prequalification	Minimum Points Required
Sustainable Station Facility	24	40%	10
Health, Hygiene & Sanitation	21	40%	8
Energy Efficiency	21	40%	8
Water Efficiency	16	40%	7
Smart & Green Initiatives	12	40%	5

The Station applying for Green railway Station Certification has to gain minimum 40% of the available points under every module of the rating system.

THRESHOLD LIMITS FOR CERTIFICATION:

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

GREEN RAILWAY STATION CERTIFICATION OF PANVEL RAILWAY STATION:

Modules	Total points	Minimum Weightage for prequalification	Minimum Points Required	Points acquired by Panvel railway Station	Points after adding implementation methods
Sustainable Station Facility	24	40%	10	19	22
Health, Hygiene &	21	40%	8	11	19

Sanitation					
Energy Efficiency	21	40%	8	4	18
Water Efficiency	16	40%	7	5	13
Smart & Green Initiatives	12	40%	5	7	11

IMPLEMENTATION METHODS:

SUSTAINABLE STATION FACILITY:

1. Development of organic Garden or vertical garden within station premises. (+1 point).

2. Heat Island reduction by Solar Panels fitting on Roofs. (+1 point).

3. Upward Lighting (better street lights with minimal night sky pollution). (+1 point).

HEALTH, HYGIENE AND SANITATION

1. Segregation of Waste (+3 points)

2. Environment friendly disposal (+1 point)
3. Isolation of Polluting Equipment & Systems. (+1 point).
4. Carbon dioxide Monitoring & Control. (+2 points)

ENERGY EFFICIENCY

1) Lighting Controls (+1 point)
2) On Site, Renewable Energy [Solar Power System]. (+6 points)
3) Energy monitoring. (+5 points)
4) Solar water heating (+2 points)

WATER EFFICIENCY

1. Increasing the number of water fixtures to be in prescribed criteria to 75% (+2 points)
2. Rain Water Harvesting (+2 points)
3. Conduct periodic tests for BOD, COD & pH (+1 point)
4. Use of waste water for cleaning and watering purposes (+1 point)
5. Water audits every once in 3 years (+1 point)

SMART & GREEN INITIATIVES

1) Adding charging stations & Prepaid cab services (+2 points)
2) Green Railway Station Committee (+2 points)

Sr.No.	Description	Increase in Green Rating	Approximate Estimated Cost
1	Rooftop Solar Power System of 200 kWp	16	74,20,00/-
2	Rainwater harvesting with 200m^3 water reserve	4	9,01,685/-

	TOTAL	**20**	**83,21,685**

GREEN RAILWAY STATION RATING BEFORE RETROFITTING OF PANVEL RAILWAY STATION [46 POINTS]	NOT APPLICABLE
GREEN RAILWAY STATION RATING AFTER RETROFITTING OF PANVEL RAILWAY STATION [83 POINTS]	**PLATINUM CERTIFICATION WITH GLOBAL LEADERSHIP RECOGNITION**

Chapter 4

Summary and Conclusions

4.1 Summary

Sustainability as an alternative criterion for building materials are generally chose through functional, technical and economical specifications. Nevertheless, with sustainability as a crucial challenge in the past decades, particularly in developed nations, the environmental load of building materials additionally become a more significant requirement. The construction sector, directly or perhaps indirectly creating a substantial portion of the annual environmental destruction, may take up the obligation to promote sustainable development by finding more environmentally kind approaches to construction and building. Among the directions for solutions is to be seen in new material applications, recycling and reuse, sustainable manufacture of products, or use of green resources.

Green Railway station is an efficient Railway station which is co-dependent of its energy & water resources. This Green railway station will use very less electricity of government and more of its own make it self-dependent.

IGBC rating system will rate the station on the basis of the credit points acquired and will grant them a Green Certificate mentioning Panvel railway station to be a Green Building and a sustainable structure.

4.2 Conclusions

After carrying out project work ,it is crystal clear that any existing structure can be converted into a green building and it is a step towards a brighter future and more eco-friendly environment.

After investigation, we have proposed certain things for implementing in Panvel Railway station to make it green structure.

As per Threshold limits criterion, Panvel Railway station will get 83 points subjected to fulfillment of our points of proposal.

Panvel Railway Station will be certified with Platinum Certification with total of 83 points. With Platinum Certification Panvel Railway Station will also be recognized as Global Leadership.

In today's era, there is need of creation of green structures which are energy efficient, water efficient. Such green Infrastructures are surely responsible for improvement in national economy.

This is our sincere attempt to look towards brighter future of our nation, India.

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