Green Rating for Integrated Habitat Assessment

National Rating System - GRIHA

An evaluation tool to help design, build, operate, and maintain a resource-efficient-built environment

Ministry of New and Renewable Energy
Government of India

The Energy and Resources Institute

(Green Rating for Integrated Habitat Assessment)

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सत्यमेव जयते

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SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

29th July, 2008

Foreword

Our country is witnessing a boom in the construction sector and in real estate development. The construction sector contributes 10% of India's GDP and is growing at about 9%, as against the world average of 5.5%. This has led to a rapid rise in energy demand in urban areas. Urban areas have emerged as one of the biggest sources of Green House Gas (GHG) emissions, with buildings alone contributing to around 40% of the total GHG emissions. As per latest UN report, one million people are moving to urban areas each week. It is estimated that around two-thirds of the world population will be living in cities in 2050. This requires a tremendous shift in energy resources in urban areas.

Solar energy, in both the active and passive forms, has significant potential for replacing substantial amounts of fossil fuels and electricity currently used in our towns and cities, particularly in the housing and building sector. Energy efficient solar buildings, or green buildings, can reduce energy demand by as much as 40%. The designs can be such that the working and living environment in buildings is quite comfortable during different seasons without too much dependence on conventional energy.

Building Rating Systems have been quite effective in raising awareness and popularizing energy efficient and green building design. Most of the internationally devised rating systems have been tailored to suit the building sector of the country where they were developed. Keeping in view our climatic conditions, and in particular the construction of non-AC buildings, a National Rating System - GRIHA has been developed by the Ministry which is suitable for all types of buildings in different climatic zones of the country.

The rating system initially conceived and developed by The Energy & Resources Institute, TERI has been modified as a National Rating System after incorporating various suggestions by a group of architects and experts. It takes into account the provisions of the National Building Code 2005, the Energy Conservation Building Code 2007 and other IS codes, local bye-laws, etc. Through various qualitative and quantitative assessment criteria, GRIHA would be able to 'rate' a building on the degree of its 'greenness'. The rating would be applied to different types of new and existing buildings, whether commercial, institutional or residential.

The Ministry proposes to incentivise the National Rating System with a view to promote large scale design and construction of green buildings in the country. The incentive includes the re-imbursement of registration fee to applicant, cash awards to design architects/ consultants and support for installation of solar photovoltaic power plants. Energy efficient solar buildings has been identified as an important focus area of the Ministry and a target for construction of such buildings covering a floor area of 5 million square meters has been proposed in the 11th Plan.

This booklet provides the details of National Rating System-GRIHA and I am sure it will help the owners and architects/design consultants of the buildings to understand its qualitative aspects, thereby resulting in large scale promotion of green buildings in the country.

(Deepak Gupta)

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Foreword

The time has come where we can no longer ignore the benefits of green building practices that have a major impact on our environment. The Government is taking appropriate steps to ensure that green building practices are mainstreamed through a mix of regulations and voluntary schemes. The National Action Plan on Climate Change has, therefore, announced a mission on sustainable habitats. In addition, the recently launched *ECBC 2007 (Energy Conservation Building Code 2007)*, the appliance labelling programme of the Bureau of Energy Efficiency, and the rating system for appraisal and clearance of large construction projects by the Ministry of Environment and Forests are some of the significant steps to move towards green buildings. Several corporate organizations and institutions have mandated the use of green practices in their new construction. Development of a holistic framework that meets all the regulatory norms and responds to the needs of differing agro-climatic zones in India is felt to be an urgent need. GRIHA (Green Rating for Integrated Habitat Assessment) was developed in response to this need.

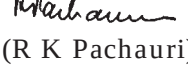
Keeping in view agro-climatic conditions in India and, in particular, the preponderance of non-air-conditioned buildings, the National Rating System – GRIHA – has been developed as a suitable system for all kinds of buildings in different climatic zones of the country. The system, initially developed by TERI as TERI-GRIHA, has been modified to GRIHA as the country's National Rating System after incorporating various modifications suggested by a group of architects and experts.

The GRIHA rating system takes into account the provisions of the National Building Code 2005; the Energy Conservation Building Code 2007 announced by BEE and other IS codes.

GRIHA – the National Rating System will evaluate the environmental performance of a building holistically over its entire life cycle, thereby providing a definitive standard for what constitutes a 'green building'. The rating system, based on accepted energy and environmental principles, will seek to strike a balance between established practices and emerging concepts, both national and international.

On a broader scale, this system, along with the activities and processes that lead up to it, will benefit the community at large with improvement in the environment by reducing GHG (greenhouse gas) emissions, improving energy security, and reducing the stress on natural resources.

This book provides a comprehensive understanding of GRIHA, its underlying criteria and the rating procedure. The book also covers best practices that could be followed to achieve desired GRIHA ratings.



(R K Pachauri)
Director-General, TERI

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Head, GRIHA Secretariat, The Energy and Resources Institute	Convenor

Preamble

1.0 Introducing TERI

TERI (The Energy and Resources Institute), a dynamic and flexible organization with a global vision and a local focus, was established in 1974. Initially the focus was on documentation and information dissemination. Research activities in the fields of energy, environment, and sustainable development were initiated towards the end of 1982. All these activities were rooted in TERI's firm conviction that efficient utilization of energy, sustainable use of natural resources, large-scale adoption of renewable energy technologies, and reduction of all forms of waste would move the process of development towards the goal of sustainability.

A unique developing-country institution, TERI is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy requirements to helping shape the development of the Indian oil and gas sector; from tackling global climate change issues across continents to helping conserve forests; from advancing solutions to the growing urban transport and air pollution, to promoting energy efficiency in the Indian industry, the emphasis has always been on finding innovative solutions to make the world a better place to live in. Although TERI's vision is global, its roots are firmly entrenched in the Indian soil. All activities in TERI move from formulating local- and national-level strategies to shaping global solutions to critical energy and environment-related issues. To this end, TERI has established regional centres in Bangalore, Goa, Guwahati, Kolkata, and Mumbai. It has set up affiliate institutes: TERI–NA (The Energy and Resources Institute, North America) in Washington, DC, USA and TERI–Europe, London, UK; and it also has a presence in Japan and Malaysia.

As an extension of its work on environment management, TERI has designed GRIHA (Green Rating for Integrated Habitat Assessment), a tool developed by TERI for rating the environmental performance of buildings, which is now a national rating system.

1.1 Role of TERI in recognizing environment-friendly initiatives

1.1.1 TERI Corporate Environmental Awards

The corporate sector is emerging as a critical player in India's development process. The environmental implications of India's industrialization process indicate that pollution has been rising with, and often faster than, the growth in industrial production. Driven by the rising scale and intensity of environmental pressures and the society's changing expectations from the corporate sector, business and the environment, traditionally seen as divergent issues, are steadily coming closer.

Realizing the increasing complexities facing the environment, corporate houses have begun to recognize their responsibility. In the recent years, a number of corporate houses have taken bold and visible steps to integrate sustainability elements into their overall corporate strategy.

In order to provide impetus to sustainable development and to encourage the ongoing process of environmental management and protection within the corporate sector, TERI instituted the Corporate Environmental Awards in 2000/01. Encouraged by the overwhelming response and sincere interest shown by the Indian corporate houses, TERI confers the awards annually.

1.1.2 TERI Corporate Social Responsibility Awards

TERI CSR (Corporate Social Responsibility) Awards seeks to identify best practices and innovations of Indian corporate houses in fulfilling their responsibilities towards diverse stakeholders. In the process, TERI also aims to sensitize corporate houses to their duties as responsible citizens of a developing world.

The prime objective of these awards is to assess the extent of integration of CSR concerns with corporate functioning, responsiveness to the needs of different stakeholders, and development of innovative partnership models to fulfil social responsibilities.

1.1.3 Eco-rating system – assessing, comparing, and tracking

Eco-rating – an indicator of corporate environmental performance/risk at a facility level – has been developed by TERI. This rating tool evaluates pollution/environmental impact, resource-use efficiency, work-environment contingency, and environment management systems on an eco-rating model. Based on the evaluation, an indicator of the overall performance of a unit is provided, a risk profile is assessed, and an assessment report is prepared.

1.2 What is a green building?

Buildings have major environmental impacts during their entire life cycle. Resources such as ground cover, forests, water, and energy are dwindling to give way to buildings. Resource-intensive materials provide structure to a building and landscaping adds beauty to it — in turn using up water and pesticides to maintain it. Energy-consuming systems for lighting, air conditioning, and water heating provide comfort to its occupants. Hi-tech controls add intelligence to 'inanimate' buildings so that they can respond to varying conditions, and intelligently monitor and control resource use, security, and usage of fire systems and other such systems in the building. Water, another vital resource for the occupants, gets consumed continuously during building construction and operation. Several building processes and occupant functions generate large amounts of waste, which can be recycled for use or can be reused directly. Buildings are thus one of the major pollutants that affect urban air quality and contribute to climate change. Hence the need to design a green building, the essence of which is to address all these issues in an integrated and scientific manner. It is a known fact that it costs more to design and construct a green building. However, it is also a proven fact that it costs less to maintain a green building that has tremendous environmental benefits and provides a better place for the occupants to live and work in. Thus, the challenge of a green building is to achieve all its benefits at an affordable cost.

A green building depletes the natural resources to a minimum during its construction and operation. The aim of a green building design is to minimize the demand on non-renewable resources, maximize the utilization efficiency of these resources when in use, and maximize the reuse, recycling, and utilization of renewable resources. It maximizes the use of efficient building materials and construction practices; optimizes the use of on-site sources and sinks by bio-climatic architectural practices; uses minimum energy to power itself; uses efficient equipment to meet its lighting, air-conditioning, and other needs; maximizes the use of renewable sources of energy; uses efficient waste and water management practices; and provides comfortable and hygienic indoor working conditions. It is evolved through a design process that requires input from all

concerned – the architect; landscape designer; and the air conditioning, electrical, plumbing, and energy consultants – to work as a team to address all aspects of building and system planning, designing, construction, and operation. They critically evaluate the impacts of each design decision and arrive at viable design solutions to minimize the negative impacts and enhance the positive impacts on the environment. In sum, the following aspects of a green building design are looked into in an integrated way.

- Site planning
- Building envelope design
- Building system design (HVAC [heating ventilation and air conditioning], lighting, electrical, and water heating)
- Integration of renewable energy sources to generate energy on-site
- Water and waste management
- Selection of ecologically sustainable materials (with high recycled content, rapidly renewable resources with low emission potential, and so on)
- Indoor environmental quality (maintain indoor thermal and visual comfort and air quality)

1.3 GRIHA: National green building rating system

1.3.1 The context

Internationally, voluntary building rating systems have been instrumental in raising awareness and popularizing green building designs. However, most of the internationally devised rating systems have been tailored to suit the building industry of the country where they were developed. TERI, being deeply committed to every aspect of sustainable development, took upon itself the responsibility of acting as a driving force to popularize green buildings by developing a tool for measuring and rating a building's environmental performance in the context of India's varied climate and building practices. This tool, by its qualitative and quantitative assessment criteria, would be able to 'rate' a building on the degree of its 'greenness'. The rating would be applied to new and existing building stock – commercial, institutional, and residential – of varied functions.

1.3.2 The challenges

The Indian building industry is highly decentralized, involving diverse stakeholders engaged in design, construction, equipment provision, installation, and renovation of buildings. Each group may be organized to some extent, but there is limited interaction among the groups, thus disabling the integrated green design and application process. Hence, it is very important to define and quantify sustainable building practices and their benefits. It is also imperative to delineate the role of each actor in ensuring that the building consumes minimal resources in its entire life cycle and leaves behind minimal environmental footprint.

1.3.3 The benefits

TERI's green building rating will evaluate the environmental performance of a building holistically over its entire life cycle, thereby providing a definitive standard for what constitutes a 'green building'. The rating system, based on accepted energy and environmental principles, will seek to strike a balance between the established practices and emerging concepts, both national and international. The guidelines / criteria appraisal may be revised every three years to take into account the latest scientific developments during this period.

On a broader scale, this system, along with the activities and processes that lead up to it, will benefit the community at large with the improvement in the environment by reducing GHG (greenhouse gas) emissions, improving energy security, and reducing the stress on natural resources.

Some of the benefits of a green design to a building owner, user, and the society as a whole are as follows.

- Reduced energy consumption without sacrificing the comfort levels
- Reduced destruction of natural areas, habitats, and biodiversity, and reduced soil loss from erosion, and other such destructive occurrences
- Reduced air and water pollution (with direct health benefits)

- Reduced water consumption
- Limited waste generation due to recycling and reuse
- Reduced pollution loads
- Increased user productivity
- Enhanced image and marketability

GRIHA's green design practices, and the array of individual and institutional professionals who put these in practice, would be publicized and promoted for the following reasons.

- It has immense replication probability for 'seeing is believing'.
- It motivates the user and the owner to fulfil their commitment to the environment by emulating the example it sets.
- It helps generate awareness on the concept of green building.
- It stimulates competition among peers to achieve the same performance or to endeavour to better it.

1.3.4 The development and operationalization process

GRIHA, the national green building rating system, was developed by TERI after a thorough study and understanding of the current internationally accepted green building rating systems and the prevailing building practices in India. The team has researched on several international rating systems. A few team members were also sponsored under a study tour by USAEP (United States Asia Environmental Partnership) to understand the eco-rating systems prevalent in the US. The team has vast experience in providing design assistance to green buildings in the country and long and varied experience in carrying out energy conservation studies in existing hotels, offices, and other commercial buildings. The team has effectively utilized the several multidisciplinary strengths and experiences of their colleagues at TERI to arrive at the tools that addresses crosscutting issues in the design, development, and operation of a green building.

The primary objective of the rating system is to help design green buildings and, in turn, help evaluate the 'greenness' of buildings. The rating system follows best practices along with national/international codes that are applicable to the green design of buildings.

The green building rating system devised by TERI is a voluntary scheme. It has derived useful inputs from the upcoming mandatory building codes/guidelines being developed by the BEE (Bureau of Energy Efficiency), the MNRE (Ministry of New and Renewable Energy), MoEF (Ministry of Environment and Forests), and the BIS (Bureau of Indian Standards). The rating system aims to achieve efficient resource utilization and to enhance resource efficiency and better quality of life in buildings.

TERI GRIHA has been adopted as a NRS (national rating system) under the MNRE, Government of India, as of 1 November 2007.

1.3.4.1 Operationalization of GRIHA – the national rating system

National Advisory Council

A NAC (National Advisory Council) has been constituted by the MNRE and is convened by the Advisor of the Ministry. It comprises eminent architects, senior government officials from the Central Ministry, the BEE, the Central Public Works Department, and select state nodal agencies; representatives from the IT sector, real estate sector and developers; and representatives from the GRIHA secretariat, TERI. The NAC is chaired by the Secretary, MNRE, and co-chaired by the Director-General, TERI.

The NAC provides advice and direction to the NRS and is the interface between the MNRE and the rating secretariat, which is located within TERI. Its broad functions are as listed below.

- Guide the administrative structure for GRIHA
- Decide a fee structure
- Endorse the rating
- Recommend incentives and awards by the Government of India/state governments
- Endorse modifications/upgrades periodically

Technical Advisory Committee

A TAC (Technical Advisory Committee) has been constituted by the MNRE for providing technical advice to the GRIHA team on modifications and upgradation of the GRIHA framework. The technical advisory team

comprises eminent architects and experts well versed with design and construction of green buildings.

The Ministry proposes to incentivize the NRS with a view to promote large-scale design and construction of green buildings in the country.

1.3.5 The basic features

At present, the system has been developed to help 'design and evaluate' new buildings (buildings that are still at the inception stages). A building is assessed based on its predicted performance over its entire life cycle — from inception to operation. The stages of the life cycle that have been identified for evaluation are pre-construction, building design and construction, and building O&M (operation and maintenance). The issues that are addressed in these stages are as follows.

- Pre-construction stage (intra- and inter-site issues)
- Building planning and construction stages (issues of resource conservation and reduction in resource demand, resource utilization efficiency, resource recovery and reuse, and provisions for occupant health and well-being). The prime resources that are considered in this section are land, water, energy, air, and green cover.
- Building O&M stage (issues of O&M of building systems and processes, monitoring and recording of consumption, and occupant health and well-being, and also issues that affect the global and local environment).

1.4 How to get your building rated?

All buildings, except for industrial complexes and housing colonies, which are in the design stage, are eligible for certification under the TERI GRIHA system. Buildings include offices, retail spaces, institutional buildings, hotels, hospital buildings, health care facilities, residences, and multi-family high-rise buildings.

1.4.1 Registration

- A project has to be registered with TERI by filling in an online registration form available on the TERI website.
- Registration cost details are available on the Web. Registration should preferably be done at beginning of a project, as there are several issues that need to be addressed at the pre-design stage.
- The registration process includes access to the essential information related to rating, application form, list of submissions, score points, and the weightage system. If desired by an applicant, a one-day training (for the design team) on the rating system is also included at a nominal additional cost.

During the training session, the following areas will be covered.

- Overview of the green building design
- Building project and project-specific guidance system
- Documentation process
- Evaluation process

1.4.2 Documentation

The evaluation system covers interdisciplinary areas. Submissions required for meeting any particular criterion are elaborated in specific sections.

1.4.3 Schedule for receipt of documents

All documents (in soft version) related to the attempted criteria should be submitted along with the application (pre-construction stage). Only the attempted criteria will be reviewed and a checklist of the same will be attached.

The document covers the details required for applying for certification. Queries on the rating, which will be responded to within two working days, should be sent to griha@teri.res.in.

1.5 GRIHA evaluation process

The buildings will be evaluated and rated in a three-tier process. The preliminary evaluation will be done by a team of professionals and experts from TERI. The TERI team will evaluate the project and award points. Documents should be submitted in the format prescribed by GRIHA and should be complete in all respects for all attempted criteria. Any attempted criteria for which the documentation is incomplete will not be evaluated. The documentation formats are provided in a CD along with the GRIHA documents.

The team will first review the mandatory criteria and reject a project in the event of non-compliance with such criteria. It will then evaluate the optional criteria and estimate the total number of achievable points. All compliance of documents will be checked and vetted through the appraisal process as outlined by GRIHA.

The evaluation summary report will be sent to members of the GRIHA evaluation committee comprising of renowned sector experts from landscape architecture, lighting and HVAC design, renewable energy, water and waste management, and building materials. The committee members will vet the points estimated by the technical team and independently review the documents for the award of points. The committee will use the evaluation summary report submitted by the technical team as a guiding document and will award provisional points and also comment on specific criteria, if need be. The evaluation report will be sent to the project proponent to review the same and, if desired, take steps to increase the score. The report will elaborate on the results of the evaluation committee along with its comments. The report will also list the criteria for which the documentation is incomplete, detailing all the required information. The client will then be given one month to resubmit the document with necessary modifications. The resubmitted report should comprise only of additional documents/information desired in the evaluation report, which will again be put through the vetting process as described above. The evaluation committee will then award the final score, which will be presented to an advisory committee comprising of eminent personalities and renowned professionals in the field for approval and award of rating. The rating will be valid for a period of five years from the date of commissioning of the building. TERI reserves the right to undertake a random audit of any criteria for which points have been awarded.

1.6 Synopsis of the criteria for rating

The criteria have been categorized as follows.

1.6.1 Site planning

Conservation and efficient utilization of resources

Objective

To maximize the conservation and utilization of resources (land, water, natural habitat, avi fauna, and energy) and enhance efficiency of the systems and operations.

Criterion 1 Site selection

Criterion 2 Preserve and protect the landscape during construction/compensatory depository forestation

Commitment

Proper timing of the construction, preserve topsoil and existing vegetation, staging and spill prevention, and erosion and sedimentation control. Replant on-site trees in the ratio 1:3 to those removed during construction.

Criterion 3 Soil conservation (till post-construction)

Commitment

Proper topsoil laying, stabilization of the soil, and maintenance of adequate fertility of the soil to support vegetative growth.

Criterion 4 Design to include existing site features

Commitment

Minimize the disruption of the natural ecosystem and design to harness maximum benefits of the prevailing micro-climate.

Criterion 5 Reduce hard paving on-site and/or provide shaded hard-paved surfaces

Commitment

Minimize storm water run-off by reducing hard paving on-site.

Criterion 6 Enhance outdoor lighting system efficiency

Commitment

Meet minimum allowable luminous efficacy (as per lamp type) and make progressive use of a renewable-energy-based lighting system.

Criterion 7 Plan utilities efficiently and optimize on-site circulation efficiency

Commitment

Minimize road and pedestrian walkway

length by appropriate planning and provide aggregate corridors for utility lines.

Health and well-being

Objectives

To protect the health of construction workers and prevent pollution.

Criterion 8 Provide at least the minimum level of sanitation/safety facilities for construction workers

Commitment

Ensure cleanliness of workplace with regard to the disposal of waste and effluent, provide clean drinking water and latrines and urinals as per applicable standard.

Criterion 9 Reduce air pollution during construction

Commitment

Ensure proper screening, covering stockpiles, covering brick and loads of dusty materials, wheel-washing facility, and water spraying facility.

1.6.2 Building planning and construction stage

Conservation and efficient utilization of resources

Objective

To maximize resource (water, energy, and materials) conservation and enhance efficiency of the system and operations.

Water

Criterion 10 Reduce landscape water requirement

Commitment

Landscape using native species and reduce lawn areas while enhancing the irrigation efficiency and reducing the water requirement for landscaping purposes.

Criterion 11 Reduce building water use

Commitment

Reduce building water use by applying low-flow fixtures and other similar tools.

Criterion 12 Efficient water use during construction

Commitment

Use materials such as pre-mixed concrete for preventing loss during mixing. Use recycled treated water and control the waste of curing water.

Energy: end use

Criterion 13 Optimize building design to reduce the conventional energy demand

Commitment

Plan appropriately to reflect climate responsiveness, adopt an adequate comfort range, less air-conditioned areas, daylighting, avoid over-design of the lighting and air-conditioning systems.

Criterion 14 Optimize the energy performance of the building within specified comfort limits

Commitment

Ensure that energy consumption in building under a specified category is 10%–40% less than that benchmarked through a simulation exercise.

Energy: embodied and construction

Criterion 15 Utilization of fly ash in the building structure

Commitment

Use of fly ash for RCC (reinforced cement concrete) structures with in-fill walls and load bearing structures, mortar, and binders.

Criterion 16 Reduce volume, weight, and time of construction by adopting an efficient technology (such as pre-cast systems, ready-mix concrete, and others)

Commitment

Replace a part of the energy-intensive materials with less energy-intensive materials and/or utilize regionally available materials, which use low-energy/energy-efficient technologies.

Criterion 17 Use low-energy material in the interiors

Commitment

Minimum 70% in each of the three categories of interiors (internal partitions, panelling/false ceiling/interior wood finishes/in-built furniture door/window

frames, flooring) from low-energy materials / finishes to minimize the usage of wood.

Energy: renewable

Criterion 18 Renewable energy utilization

Commitment

Meet energy requirements for a minimum of 10% of the internal lighting load (for general lighting) or its equivalent from renewable energy sources (solar, wind, biomass, fuel cells, and others). Energy requirements will be calculated based on realistic assumptions which will be subject to verification during appraisal.

Criterion 19 Renewable-energy-based hot-water system

Commitment

Meet 70% or more of the annual energy required for heating water through renewable energy based water-heating systems.

Recycle, recharge, and reuse of water

Objective

To promote the recycle and reuse of water.

Criterion 20 Waste-water treatment

Commitment

Provide necessary treatment of water for achieving the desired concentration of effluents.

Criterion 21 Water recycle and reuse (including rainwater)

Commitment

Provide waste-water treatment on-site for achieving prescribed concentration, rainwater harvesting, reuse of treated waste water and rainwater for meeting the building's water and irrigation demand.

Waste management

Objective

To minimize waste generation; streamline waste segregation, storage, and disposal; and promote resource recovery from waste.

Criterion 22 Reduction in waste during construction

Commitment

Ensure maximum resource recovery and safe disposal of wastes generated during construction and reduce the burden on landfill.

Criterion 23 Efficient waste segregation

Commitment

Use different coloured bins for collecting different categories of waste from the building.

Criterion 24 Storage and disposal of waste

Commitment

Allocate separate space for the collected waste before transferring it to the recycling / disposal stations.

Criterion 25 Resource recovery from waste

Commitment

Employ resource recovery systems for biodegradable waste as per the *Solid Waste Management and Handling Rules, 2000 of the MoEF*. Make arrangements for recycling of waste through local dealers.

Health and well-being

Objective

To ensure healthy indoor air quality, water quality, and noise levels, and to reduce the global warming potential.

Criterion 26 Use of low VOC (volatile organic compounds) paints / adhesives / sealants

Commitment

Use only low VOC paints in the interior of the building. Use water–based rather than solvent-based sealants and adhesives.

Criterion 27 Minimize ozone-depleting substances

Commitment

Employ 100% zero ODP (ozone depletion potential) insulation, HCFC (hydrochloro-fluorocarbon) / and CFC (chlorofluoro-carbon), free HVAC, and refrigeration equipments / and halon-free fire suppression and fire extinguishing systems.

Criterion 28 Ensure water quality

Commitment

Ensure groundwater and municipal water

meet the water quality norms as prescribed in the Indian Standards for various applications (Indian Standards for drinking [IS 10500-1991], irrigation applications [IS 11624-1986]). In case the water quality cannot be ensured, provide necessary treatment of raw water for achieving the desired concentration for various applications.

Criterion 29 Acceptable outdoor and indoor noise levels

Commitment

Ensure outdoor noise level conforms to the CPCB (Central Pollution Control Board)–Environmental Standards–Noise (ambient standards) and indoor noise level conforms to the *NBC (National Building Code of India) 2005* (BIS 2005a).

Criterion 30 Tobacco and smoke control

Commitment

Zero exposure to tobacco smoke for non-smokers, and exclusive ventilation for smoking rooms.

Criterion 31 Provide the minimum level of accessibility for persons with disabilities.

Commitment

To ensure accessibility and usability of the building and its facilities by employees, visitors, and clients with disabilities

Criterion 32 Energy audit and validation

Commitment

Energy audit report to be prepared by approved auditors of the BEE, Government of India.

Criterion 33 Building operation and maintenance

Commitment

Validate and maintain 'green' performance levels / adopt and propagate green practices and concepts.

Ensure the inclusion of a specific clause in the contract document for the commissioning of all electrical and mechanical systems to be maintained by the owner, supplier or operator. Provide a core facility / service management group, if applicable, which will be responsible for the O&M of the building and the electrical and mechanical systems after commissioning. Owner / builder / occupants / service or facility management group to prepare a fully documented operations and maintenance manual, CD, multimedia or an information brochure listing the best practices / dos and don'ts / maintenance requirements for the building and the electrical and mechanical systems along with the names and addresses of the manufacturers / suppliers of the respective system.

Criterion 34 Innovation points

Commitment

Four innovation points are available under the rating system for adopting criteria which enhances the green intent of a project, and one can apply for the innovation points Some of the probable points are

- alternative transportation
- environmental education
- company policy on green supply chain
- enhanced accessibility for physically / mentally challenged
- life cycle cost analysis
- any other criteria proposed by applicant

Please note that these innovation points are beyond the 100 point and a project can apply for 104 points in all, while the scoring shall be given on a 100-point scale only.

1.7 Scoring points for GRIHA

GRIHA is a guiding and performance-oriented system where points are earned for meeting the design and performance intent of the criteria. Each criterion has points assigned to it. It means that a project intending to meet the criterion would qualify for the points. Compliances, as specified in the relevant criterion, have to be submitted in the prescribed format. While the intent of some of the criteria is self-validating in nature, there are others (for example energy consumption, thermal and visual comfort, noise control criteria, and indoor pollution levels) which need to be validated on-site through performance monitoring. The points related to these criteria (specified under the relevant sections) are awarded provisionally while certifying and are converted to firm points

through monitoring, validation, and documents / photographs to support the award of point.

GRIHA has a 100-point system consisting of some core points, which are mandatory to be met while the rest are optional points, which can be earned by complying with the commitment of the criterion for which the point is allocated. Different levels of certification (one star to five stars) are awarded based on the number of points earned. The minimum points required for certification is 50. Buildings scoring 50–60 points, 61–70 points, 71–80 points, and 81–90 points will get one star, two stars, three stars, and four stars, respectively. A building scoring 91–100 points will receive the maximum rating, which is five stars.

Points scored	Rating
50–60	One star
61–70	Two stars
71–80	Three stars
81–90	Four stars
91–100	Five stars

1.8 Evaluation procedure of criterion of GRIHA

List of criteria and points for GRIHA

Criteria No.	*Criteria*	*Points*
1*	Site selection	1
2*	Preserve and protect landscape during construction/compensatory depository forestation	5
3	Soil conservation (post construction)	4
4**	Design to include existing site features	2
5*	Reduce hard paving on-site	2
6	Enhance outdoor lighting system efficiency and use renewable energy system for meeting outdoor lighting requirement	3
7	Plan utilities efficiently and optimize on-site circulation efficiency	3
8**	Provide at least minimum level of sanitation/safety facilities for construction workers	2
9**	Reduce air pollution during construction	2
10	Reduce landscape water requirement	3
11	Reduce building water use	2
12	Efficient water use during construction	1
13**	Optimize building design to reduce conventional energy demand	6
14	Optimize energy performance of building within specified comfort	12
15	Utilization of fly ash in building structure	6
16	Reduce volume, weight and time of construction by adopting efficient technology (such as pre-cast systems, ready-mix concrete)	4
17	Use low-energy material in interiors	4
18*	Renewable energy utilization	5
19	Renewable energy based hot water system	3
20	Waste water treatment	2
21	Water recycle and reuse (including rainwater)	5
22	Reduction in waste during construction	2
23	Efficient waste segregation	2
24	Storage and disposal of waste	2
25	Resource recovery from waste	2
26	Use of low VOC paints/adhesives/ sealants	4
27**	Minimize ozone depleting substances	3
28**	Ensure water quality	2
29	Acceptable outdoor and indoor noise levels	2
30	Tobacco and smoke control	1
31	Universal Accessibility	1
32**	Energy audit and validation	
33**	Operations and maintenance protocol for electrical and mechanical equipment	2
	Total score	100
34	Innovation (beyond 100)	4
	Total points	104

* – partly mandatory; ** – mandatory

SECTION 1

Site selection and site planning

Resource conservation and efficient utilization of resources

The process of site selection for sustainable development involves identifying and analysing the site with respect to the sustainable building design criteria. The development of the site for building purposes requires disruption and disturbance of the existing natural system. The most sustainable and environment-sensitive development is one that entails minimal site disturbance. Thus, resource conservation in a given site is of prime importance. The criteria for getting points under this head have been elaborated below. The resource efficiency measures are aimed at applying appropriate site planning techniques, concepts and design interventions in order to enhance the efficient utilization of site resources, minimize on-site vehicular pollution, enhance energy efficiency of site lighting, and enhance functional efficiency of the utility lines.

Criterion 1 ▪ Site selection

Objective

Site selection is the first step to a sustainable habitat and needs to be done appropriately, prior to commencement of design phase. Site selection and analysis should be carried out to create living spaces that are in harmony with the local environment. The development of a project should not cause damage to the natural surroundings of the site but, in fact, should try to improve it by restoring its balance. Thus, site selection should be carried out in light of a holistic perspective of land use, development intensity, social well-being, and preservation of the environment.

1.1 Commitment

1.1.1 The selected site should be in conformity with the development plan / master plan / UDPFI (Urban Development Plans Formulation and Implementation) guidelines (mandatory). This should comply with the provisions of eco-sensitive zone regulations, coastal zone regulations, heritage areas (identified in the master plan or issued separately as specific guidelines), water body zones (in such zones, no construction is permitted in the water-spread and buffer belt of 30 m minimum around the FTL [full tank level]), various hazard prone area regulations, and others if the site falls under any such area.

Box 1.1 Guidelines/recommendations for site selection

Site selection process includes analysis of several site factors. These are land-use, ecosystem and diversity history and heritage, and urban context and environmental considerations.

Land use

The first concern while selecting the site should be its suitability. The proposed building(s) should be in conformity with the specifically designated use on the 'development plan' of the place. In places where the use of buildings or premises is not specifically designated on the development plan, it should be in conformity with the land-use zones in which they fall (as specified by the 'master plan'). The proposed building(s) should be in conformity with the 'development regulations' of that area as well.

Ecosystems and diversity

Sites for new developments should be carefully assessed in context of the wider environment, particularly in relation to the habitats dwelling on-site or in adjacent sites.

Analysis of urban context considerations

- *Analyse the city form*: The delineation of the city form due to layout of roads, open spaces or architectural forms should be analysed. For example, a building may be a visually unifying element, providing connections and continuity with adjacent buildings. Sites at the end of important vistas or adjacent to major city squares should be reserved for important public buildings.
- *Review the potential of views*: Important city views of plazas, squares, monuments, and natural features (such as parks and waterfronts) should be considered. It is important to design the proposed building in a manner that will enhance and preserve such views for the public.

Urban availability of water and other critical infrastructure

The design team should gauge whether the site takes maximum advantage of natural resources such as solar energy, natural vegetation, and geographical features. It should also analyse the proximity or remoteness of the site from existing transportation corridors, and its ability to match the needs of the building owner, users, and their occupancy patterns.

- Resource and needs' assessment of the project should be done at the pre-design stage. Issues which need to be identified at the pre-design and site selection stage are (1) connectivity to infrastructure and public transport network, (2) power requirement and power source, (3) water requirement and water source, and (4) waste management on the site.
- Urban infrastructure and facilities, public transport, infrastructure for power, water supply to meet the estimated requirement, and sewage system network should be made available nearby or should be made available with minimum negative impact on the environment. The existing drainage pattern of the proposed site should be surveyed, and the proposed drainage pattern should not alter the existing drainage pattern. It should comply with the master drainage plan of the place. It is desirable to integrate the existing utility and infrastructure, and identify whether additional infrastructure needs to be planned for the proposed project.
- The impact of proposed future development on the infrastructure should be considered while selecting the site.
- Efforts should be made to reuse negative urban spaces or industrial sites and brownfield sites, if possible, to reduce the pressure on undeveloped land. If possible and justified in terms of sustainable design goals, a site selected should offer the possibility of urban redevelopment (where development is constrained due to environmental pollution or increasing urban pressure) or it should use existing urban infrastructure confirming the desired density goals. This, to some extent, will help reduce the perennial pressures on the undeveloped land.
- Layout and form of the project must conform to the landscape of the area without unduly affecting the scenic features of that place.

Environmental consideration

In addition to the siting criteria listed above, the proposed project location should meet the standards prescribed by the CPCB (Central Pollution Control Board) and IS (Indian standards) for the following environment parameters.

- Ambient air, water and noise quality standards
- Natural disaster prone areas
- Ecologically sensitive areas

1.1.2 The selected site should be located within ½ km radius of an existing bus stop, commuter rail, light rail or metro station and/or select brownfield site (to rehabilitate damaged sites where development is hindered by environmental contamination, thereby reducing pressure on undeveloped land).

1.2 Compliance

The following documents are to be submitted.

1.2.1 Document to prove conformity to the development plan/master plan/UDPFI guidelines.

1.2.2 Site plan (one AutoCAD [computer aided design] drawing) showing the site and its surrounding areas (up to 2 km radius).

1.2.3 Site plan (one AutoCAD drawing) showing the site connectivity to public transport corridors and availability of basic services (up to ½ km radius), and details of the existing site and its feasibility to be converted for redevelopment if the selected site is a brownfield site.

Basic services should include (1) bank, (2) place of worship, (3) convenience store, (4) fire station, (5) library, (6) medical/dental facility, (7) park, (8) pharmacy, (9) post office, (10) restaurant, (11) school, (12) theatre, (13) community centre, (14) fitness centre, and (15) museum.

1.3 Appraisal (maximum points – 1)

1.3.1 The site plan must be in conformity to the development plan/master plan/UDPFI guidelines (mandatory). This should comply with the provisions of eco-sensitive zone regulations, coastal zone regulations, heritage areas (identified in the master plan or issued separately as specific guidelines), water body zones (in such zones, no construction is permitted in the water-spread and buffer belt of 30 m minimum around the FTL), various hazard prone area regulations, and others if the site falls under any such area (mandatory with no point allocation).

1.3.2 The site should be located within ½ km radius of an existing bus stop, commuter rail, light rail or metro station and/or the proposed site must be a brownfield site (to rehabilitate damaged sites where development is hindered by environmental contamination, thereby reducing pressure on undeveloped land) (1 point)

Criterion 2 ▪ Preserve and protect landscape during construction

Objective

To preserve the existing landscape and protect it from degradation during the process of construction.

Box 2.1 Pre-construction measures for the protection and preservation of landscape

Measures to be followed for the prevention of soil erosion, preservation, and protection of existing vegetation, sediment control, and management of storm water during construction.

Timing of construction

The timing of construction and application of erosion control measures include protection of slopes greater than 10%. Sedimentation collection systems, drainage systems, and run-off diversion systems shall be in place before the commencement of construction activity.

Preservation of existing vegetation

Preservation and protection of existing vegetation by non-disturbance or damage to specified site areas during construction is recommended. This practice enables retention of fully-grown mature trees and also reduces avoidable erosion of bare soil due to exposure to climate and human intervention during construction. All existing vegetation should be marked on the site-survey plan. The tree survey must be carried out and data must be recorded before starting construction activity as indicated in Table 2.1.

Table 2.1 Tree survey format

Serial no. identifiable in survey plan	Botanical name	Common name	Girth	Height	Spread	Condition	Protected[1] / preserved[2] / transplanted[3] / removed[4]

Box 2.2 Pre-construction measures for the protection and preservation of trees

Trees retained on the project site shall be protected during the construction period by the following measures.

- Damage to roots should be prevented during trenching, placing backfill, driving or parking heavy equipment, dumping of trash, oil, paint, and other material detrimental to plant health. These activities should be restricted to the areas outside of the canopy of the trees.
- Trees should not be used for support; their trunks should not be damaged by cutting and carving, by nailing posters, and advertisements or in any other way.
- Lighting of fires or carrying out heat or gas emitting construction activity within the ground covered by canopy of the tree should not be permitted.
- Young trees[5] or saplings identified for preservation within the construction site must be protected using tree guards of approved specification.
- Existing drainage patterns through or into any preservation area should not be modified unless specifically directed by the landscape architect/architect/engineer-in-charge.
- Existing grades of soil should be maintained around existing vegetation. Lowering or raising

Continued...

[1] Protected trees are those that are undisturbed during the construction.
[2] Preserved trees are the ones that are uprooted and preserved for replantation at the original location after the construction activity is over.
[3] Transplanted trees are those that are uprooted and replanted at a different location.
[4] Removed trees are those that are uprooted for construction.
[5] Young trees are those that have a height less than 2 m, and a 0.1 m trunk girth at 1 m height from ground, and a 2 m crown diameter.

Box 2.2 ***Continued...***

the levels around the vegetation should not be allowed unless specifically directed by the landscape architect/architect/engineer-in-charge.

- Maintenance activities should be performed, as and when needed, to ensure that the vegetation remains healthy.
- The preserved vegetated area should be inspected by the landscape architect/architect/engineer-in-charge at regular intervals so that it remains undisturbed. The date of inspection during construction activity and type of maintenance or restorative action followed should be recorded in a log book.

Staging areas

Staging is dividing a construction area into two or more sections to minimize the area of soil that will be exposed at any given time. Staging should be done to separate undisturbed land from land disturbed by construction activity and material storage. Measures should be followed for collecting drainage water run-off from construction areas and material storage sites and diverting water flow away from such polluted areas. Temporary drainage channels and perimeter dike/swale should be constructed to carry the pollutant-laden water directly to the treatment device or facility (municipal sewer line). The plan should indicate how the above was accomplished on-site, well in advance of the commencement of the construction activity.

Spill prevention and control

Spill prevention and control plans should clearly state measures to stop the source of the spill, measures to contain the spill, and measures to dispose the contaminated material and hazardous wastes. It should also state the designation of personnel trained to prevent and control spills. Hazardous wastes include pesticides, paints, cleaners, and petroleum products.

Preservation of topsoil

During construction, the soil becomes lose due to the removal of stabilizing material such as vegetation and disturbance of stabilized existing grade, resulting in loss of topsoil and its deposition in undesirable places. A soil erosion and sedimentation control plan should be prepared, prior to construction, and should be applied effectively. Measures for preservation of topsoil are given below.

- Collection storage and reapplication of topsoil

The topsoil removal and preservation (for areas where construction activity will disturb the topsoil) should be made mandatory for the development of projects within an area greater than 10 000 m^2 (square metre). Topsoil, which is rich in organic content and essential for new vegetation, should be stripped to a depth of 20 cm from the areas proposed for buildings, roads, paved areas, and external services. It should be stockpiled to a height of 40 cm in designated areas and reapplied during plantation of the proposed vegetation. The topsoil should be separated from the subsoil debris and stones larger than 50 mm in diameter. The stored topsoil may be used as finished grade for planting areas.

- Sedimentation basin

Sedimentation basin, a temporary dam or basin at the lowest convenient point of the site, should be constructed for collecting, trapping, and storing sediment produced by the construction activities. A flow-detention facility must also be constructed for reducing peak run-off rates. This would allow most of the sediments to settle before the run-off is directed towards the outfall.

- Contour trenching

Contour trenching is an earth embankment or ridge-and-channel arrangement constructed parallel to the contours, along the face of the slope, at regular intervals on the lengths and slopes greater than 10% (1:10). They are used for reducing run-off velocity, increasing the distance of overland run-off flow. They are also used to hold moisture and minimize sediment loading of surface run-off.

- Mulching

Mulch is a protective layer of material that is spread on the top of soil. Mulches can either be organic (such as grass clippings, straw, bark chips, and similar materials) or inorganic, (such as stones and brick chips). Mulching should be used with seedings and plantings on steep slopes (slopes>33%). Steep slopes are prone to heavy erosion and, therefore, netting or anchoring should be used to hold it in place. Other surface run-off control measures, like contour terracing, to break up concentrated flows should be installed prior to seeding and mulching. Materials such as straw, grass, grass hay, and compost shall be placed on or incorporated into the soil surface. In addition to stabilizing soils, mulching will reduce the storm water run-off over an area. Mulching when done with seedings or plantings aids plant growth by holding the seed, fertilizers, and topsoil in place. It retains moisture and insulates the soil against extreme temperatures.

2.1 Commitment

2.1.1 Select proper timing for the construction activity to minimize site disturbance such as soil pollution due to spilling of the construction material and its mixing with rainwater.

2.1.2 Use staging and spill prevention and control plan to restrict the spilling of the contaminated material on-site.

2.1.3 Protect the topsoil from erosion. Use collection storage and reapplication of the topsoil, sediment basin, contour trenching, mulching, and soil stabilization methods to protect the topsoil from erosion during construction.

2.1.4 Specify and limit construction activity in pre-planned / designated areas.

2.1.5 Preserve existing mature trees on-site during the course of construction by preserving and transplanting them.

2.1.6 Compensate the loss of vegetation (trees) due to the construction activity by compensatory plantation. Replant the same number of mature or fully-grown trees as eliminated during the construction of the proposed landscape design. Replant the same native and / or non-invasive species, which existed on the site before elimination, in the proportion of 1:3.

2.1.7 Plant in excess of 25% to the minimum requirement (that is, in addition to the requirement prescribed in commitment 2.1.6) within the site premises (plantation to follow same criteria as above).

2.2 Compliance

The following documents are to be submitted.

2.2.1 Certificate of architect in prescribed format confirming the proper timing of construction.

2.2.2 A CAD drawing showing the site plan of existing and proposed buildings; existing vegetation and slopes; and drainage pattern. Demarcate areas on the site plan to which site activities will be limited.

2.2.3 Site plan showing existing vegetation, buildings, slopes, and site drainage pattern; staging and spill prevention measures; and erosion and sedimentation control measures.

2.2.4 One document to be submitted after construction of the building, giving a brief description along with photographic records to show that other areas have not been disrupted during construction. The document should also include a brief explanation and photographic records to show erosion and sedimentation control measures adopted. (A CAD drawing showing site plan details of existing vegetation, buildings, and slopes and site drainage pattern; staging and spill prevention measures; erosion and sedimentation control measures; and measures adopted for topsoil preservation during construction as given in Box 2.1).

2.2.5 Site plan (one CAD drawing), along with a narrative, to demarcate areas on-site from which the topsoil has to be gathered, the designate area where it will be stored, the measures adopted for topsoil preservation. The plan should indicate areas where the topsoil will be reapplied after construction is complete.

2.2.6 One CAD drawing showing proposed landscape plan with identification of trees (different colour coding for protected, preserved, transplanted, and removed trees) corresponding to the existing tree-survey table (to be included in the drawing), existing and new buildings, and proposed site drainage pattern. Explain in brief measures adopted for protecting existing landscape (limit to 250 words).

2.2.7 Certificate from the landscape architect confirming proper protection and preservation of existing trees during construction process.

2.2.8 Landscape plan, if applicable, clearly highlighting the tree-removed areas (indicating the number of trees) with the number of replanted trees in the ratio of 1:3 in the proposed landscape design. A list with details about the species that existed and the species that have been replanted on-site.

2.2.9 Landscape plan to show that plantation in excess of 25% than minimum requirement has been done carried out.

2.3 Appraisal (maximum points – 5)

2.3.1 Ensure proper timing of construction with respect to rain, as per clause 2.2.1.

2.3.2 Confine construction activity to pre-designated areas, as per clause 2.2.2 (1 point).

2.3.3 Proper implementation of staging and spill prevention plan.

2.3.4 Effective erosion and sedimentation control to prevent erosion, as per clause 2.2.3 (1 point – mandatory).

2.3.5 Preserve topsoil by employing measures described in Box 2.1, as per clause 2.2.4 (1 point).

2.3.6 Preserve existing vegetation by means of non-disturbance or damage to trees and other forms of vegetation, as per clauses 2.2.5 and 2.2.6 or

2.3.7 Trees / plants replanted within site premises in ratio of 1:3, as per clause 2.2.7 (1 point – mandatory).

2.3.8 Trees / plants replanted within site premises in excess of 25% than minimum requirement, as per clause 2.2.8 (1 point).

Criterion 3 ▪ Soil conservation (till post-construction)

Objective

Conserve topsoil till after completion of construction activity.

Box 3.1 Topsoil characteristics

Fertility

- Presence of organic carbon helps in soil aggregation and improves water-holding capacity, which helps in slowing down the flow of water through soil. The optimum level of organic carbon in the soil ranges from 0.5%–1.0%.
- Maintain a pH of 6.0–7.5; add lime where pH<6.0 to adjust to 6.5 or higher (up to 7.5). Any soil having soluble salt content >500 ppm (parts per million) shall not be used for the purpose of landscaping.
- Ensure presence of basic inorganic nutrients (nitrogen, phosphorus, and potassium) in adequate amount for healthy growth of vegetation. If required, ensure proper and timely application of fertilizers to enhance soil fertility.
- Deficiency of organic and inorganic material can be improved by application of fertilizers, but care should be taken so as to avoid over-fertilization. The soil should be tested at an ICAR (Indian Council of Agricultural Research)-accredited laboratory for primary plant nutrient and pH.

Table 3.1 Rating chart for soil test values of primary nutrients

Nutrient	Rating*			Recommended test**
	Low	Medium	High	
Organic carbon	<0.50	0.50–0.75	>0.75	Colorimetric method (Datta *et al.*)
Available nitrogen alkaline $KMnO_4$–N (kg/ha)	<280	281–560	>560	Kjeldahl apparatus
Available phosphorus Olsen's P (kg/ha)	<10	11–25	>25	Olsen method
Available potassium ammonium acetate – K (kg/ha)	<120	121–280	>280	Ammonium acetate extraction method

N – nitrogen; P – phosphorus; K – potassium
*Subject to minor variation as per local conditions
**Tests to be performed at ICAR (Indian Council of Agricultural Research) – accredited laboratory.

Box 3.2 Measures for the protection of topsoil

Landscape architect/horticulturist recommendations of improving deficient nutrient, timing of application of fertilizers, and warning of excessive nutrient levels should be adopted. Judicious and timely applications of fertilizers are more beneficial to a plant's health and are less likely to cause environmental damage than infrequent, heavy, and ill-timed applications.

Topsoil laying

Topsoil should be spread uniformly at a minimum compacted depth of 50 mm, on a grade of 1:3 or steeper slopes, and a minimum depth of 100 mm for shallower slopes (or 300 mm for flatter land).

Soil stabilization

- Water and dissolved chemicals move more quickly through coarse textured, sandy or gravelly soil, fine textured silt, and clay soils. Soils high in organic matter slow down the flow of water and vegetation cover is an effective means to stabilize disturbed soil. In areas where construction activity has disturbed the land,

Continued...

Box 3.2 Continued...

temporary/permanent seeding should be used till the final soil cover is established.

- Permanent plantation should be done in areas where high velocity of water flow poses a problem of erosion—like buffer, vegetated swales, and steep slopes (grade>1:3). The foliage effectively dissipates the energy of heavy rain and roots hold the soil, thus preventing soil erosion. The vegetation selected for the purpose should be an indigenous species.
- The use of mulches on slopes can help prevent run-off and erosion problems. Few of the organic mulch materials include shredded bark, wood chips (waste from furniture industry), straw and cottonseed hull, composted leaves or shredded cedar. Inorganic mulches such as pea gravel, crushed granite, and pebbles should be used in unplanted areas. Stone mulches should not be used in areas immediately adjacent to buildings as they can heat up and cause glare.

3.1 Commitment

3.1.1 Ensure adequate fertility of the soil to support vegetative growth.

3.1.2 Ensure adequate topsoil laying for vegetative growth.

3.1.3 Ensure stabilization of soil in areas where the topsoil is vulnerable to erosion.

3.2 Compliance

The following documents are to be submitted.

3.2.1 Site contour plan (one CAD drawing) showing drainage pattern and demarcating (1) areas where topsoil laying is done, and (2) areas where vegetation cover is provided for topsoil protection.

3.2.2 Narrative explaining the methods of soil stabilization used and, wherever required, accompanied by photographs with brief descriptions.

3.2.3 Certificate from the landscape architect on topsoil laying, soil stabilization, and adequate primary soil nutrient and pH (supported by tests results performed at an ICAR [Indian Council of Agricultural Research] – accredited laboratory).

3.3 Appraisal (maximum points – 4)

3.3.1 Proper topsoil laying for vegetative growth, as per clauses 3.2.1 (a), 3.2.2, and 3.2.3 (2 points).

3.3.2 Proper stabilization of soil, as per clauses 3.2.1 (b), 3.2.2, and 3.2.3 (2 points).

Criterion 4 ▪ Design to include existing site features

Objective

The natural functions of a plot of land (hydrologic, geologic, and microclimatic) can be disrupted by the placement of a building on it. The design of a green building will factor in ways in which the natural site features can be protected or even restored.

Layout the site activities and building requirements after carrying out detailed site analysis so as to ensure sustainable site development in tune with its topographical, climatic, and ecological character (Box 4.1).

Box 4.1 Analysis

Site analysis evaluates all the on- and off-site determinants that affect the development of site and building programme—whether environmental, cultural, historical, urban or infrastructural. The main objective is to allocate and define the use of various parts of the site in a manner that is most appropriate to specific activities to be carried on-site.

The purpose of site analysis is to determine the site characteristics so that proper drainage systems, circulation patterns, landscape design, and other site development features can be considered in relation to the building design parameters such as building form, solar orientation, shape, skin-to-volume ratio, materials, and structural and mechanical systems.

4.1 Commitment

4.1.1 Carry out a comprehensive site analysis to identify site characteristics that can be used to harness natural resources (like solar energy, wind, and water) and the potential qualities of the landforms that could contribute to making different areas of the site visually and thermally more comfortable for users.

4.1.2 Locate various activities of the scheme after careful site analysis and assessment so as to protect ecologically sensitive areas and reduce damage to the natural ecosystem.

4.1.3 Identify areas of the site that were damaged during construction and take steps to mitigate the harm and improve the natural site conditions.

Box 4.2 Recommended checklist for identifying site characteristics that affect the sustainable design

Render a site analysis on the basis of site inventory characteristics and establish a list of factors affecting the sustainable design (Table 4.1).

Table 4.1 Site inventory and design impacts

Site inventory characteristics	Building design element	Site design element
Geographical latitude and microclimatic factors such as wind loads	▪ Building layout for solar orientation ▪ Location of windows, entrances, and loading docks ▪ Location of air inlets ▪ Architectural elevations ▪ Surface to volume ratios	▪ Location of green and paved areas ▪ Selection of vegetation and integration with the native landscape ▪ Biodiversity ▪ Use of landscape elements as buffer zones

Continued...

Box 4.2 Continued...

Site inventory characteristics	Building design elements	Site design elements
Topography and adjacent landforms	▪ Building proportions ▪ Wind loads ▪ Architectural elevations ▪ Drainage strategies	▪ Gravity-fed sewer lines ▪ Land filling ▪ Natural site features for rain/storm water drainage ▪ Location of groundwater detention ponds
Solar access	▪ Building position for daylighting, photovoltaics, and solar passive techniques ▪ Construction of walls ▪ Selection of building materials and finishing	▪ Location of energy-efficient features such as solar pond ▪ Placement of selective species of trees (such as deciduous trees on the south of the site)
Geologic and seismic data	▪ Foundation type ▪ Structural specifications	▪ Structural considerations for site landscaping like retaining walls and fixed seating
Soil types, textures, and load-bearing capacity	▪ Foundation design and location	▪ Site-grading procedures that minimize erosion ▪ Plant selections as per soil type
Air movement patterns	▪ Placement of wind towers ▪ Location of fenestration on the basis of pressure differentials, passive solar cooling design	▪ Site layout of building structures to trap wind for ventilation
Parcel shape and access with adjacent land use and buildings	▪ Planning for the capacity to accommodate the proposed development	▪ Marking the potential access points that do not burden the lower density or adjacent land use
Neighbouring or proposed future developments	▪ Design flexibility for future extension	▪ Location of utility and infrastructure for future extension

Note The above is an indicative list of building design and site design measures for developing an understanding of possible measures for adequate site design.

Heat island effect

Size and density of the built-up areas cause heat island effect, wherein higher air temperatures are created in the dense urban areas as against the low-rise surrounding built-up areas.

Solar access

Solar access in the morphology of clusters can be understood in terms of utilization of direct (and not reflected or diffused) solar radiation, mainly for daylighting and heat gain. This defines the minimal distances between the buildings and the relations between built-up volume and open spaces.

Building types

Choice of building types depends mainly on the cost of the land, infrastructure, and land availability and suitability as per the requirements. Each building type and combination of different types forms a matrix of environmental conditions, which affect the macro- as well as the micro-climate around and inside the building. Building types may be detached/semi-detached, with courtyard/ patio, high-rise, and row house.

Open spaces

The proportion of open spaces and built-up edges should be designed such that it ensures winter

Continued...

Box 4.2 Continued...

solar access and summer ventilation. Vegetation may provide as shading and promote evaporative cooling. In hot and dry climates, evaporative cooling through appropriately sized wet surfaces or fountains have a desirable effect.

- Categorize the climate zone as per the geographical attributes of the site.
- Assess the existing air quality of the site if it falls under an industrial or commercial area.
- Judge the suitability of soil and groundwater.
- Study the native vegetation growth on the site.
- Examine the past trends of natural hazards, such as earthquakes and floods.

Data assessment

- Assess the data collected for site analysis to decide on the hierarchy of importance among the potential factors affecting sustainable design.
- Assess the impact of the proposed design for the topographical and hydrological site characteristics, after estimating the overall building footprint compatibility with site.
- Review the potential of any other alternative design scheme, which could mitigate upon resources, and merge the built form with reduced site disturbance.
- Analyse the efficiency model for the site on the basis of a set of constants, variables, and constraints.

Form an efficiency array with

- set of constants; that is, the factors which cannot be changed like the access road to the site, soil characteristics, and natural vegetation or the climate zone,
- set of variables; that is, the factors which might give efficient results when mingled in different patterns like circulation patterns, site materials, and so on, and
- set of constraints; that is, some factors that form the psychological constraint for design like the building by-laws or local area regulations.

The most optimal and compatible combination can then be considered for a specific site development fit.

Site development and layout[6]

After the potential factors affecting the sustainable design have been analysed and assessed, and site is selected thereof, the optimal patterns for a sustainable development should be layered upon each other to organize all the proposed building elements. This will result in an effective and operational site development fit.

The main intent is to optimize the use of resources and energy savings by reducing the site disturbance during constructional and occupancy phases of the project. The underlying goal can then be frozen through a generic design process; that is, conceptually arriving at the best design through project requirements versus sustainable development by sequential incorporation of various design factors. These design factors can initially be conceptualized through sections or sketches.

The site development can be done on the best practices followed in each of the potential factors.

- Land use and existing features
- Siting and orientation
- Landscaping
- Utility or infrastructure
- Pavements
- External lighting
- Construction management

4.2 Compliance

The following documents are to be submitted.

4.2.1 Drawings along with a narrative to demonstrate that the zoning of areas on-site is appropriate to the existing site features (such as slopes, vegetation, water bodies, and other natural formations). Support these with visual documentation such as photographs and land survey records (before and after construction).

4.2.2 Carry out detailed site analysis and provide narrative to demonstrate sustainable site planning as elaborated in Box 4.2.

4.3 Appraisal (maximum points – 2)

Two points if all compliances are fulfilled, as per clauses 4.2.1 and 4.2.2.

[6] ICAEN (2004b)

Criterion 5 ▪ Reduce hard paving on-site and/or provide shaded hard-paved surfaces

Objective

To reduce hard paving on-site (open areas surrounding building premises) and/or provide shade on hard-paved surfaces to minimize the heat island effect and imperviousness of the site (Box 5.1).

Box 5.1 Best practices to mitigate heat island effect

Dark coloured and constructed surfaces are prone to absorption and retention of solar energy. The retained solar energy also gets radiated to the atmosphere during times when ambient temperature gets cooler. This gives rise to warmer temperatures in urban landscapes, which have large areas of constrained surfaces of low reflectance. This phenomenon of increased temperature in urban landscape is called heat island effect. Principle surfaces that contribute to the heat island effect include streets, sidewalks, parking lots, and buildings. Heat island effect can be minimized by the use of shading or reflective surfaces. As mentioned, hard-paved surfaces are one of the major constraints of heat island effect. In addition to causing heat island effect, hard pavements also reduce the perviousness of a site. Enhanced perviousness of a site minimizes storm water run-off and is beneficial for localized aquifer recharge. This method aims to encourage design measures to minimize negative impacts of the paved areas. Design methodologies, which address the heat island phenomenon and provide control for desired conditions, should be considered.

Planting trees, bushes or a properly planned landscaping can help reduce the heat island effect by reducing ambient temperatures through evapo-transpiration.

- Plant vegetation around the building to intercept solar radiation and to shade the walls and windows of buildings (with South, South West or South East exposure) to prevent heat gain. This would also help in reducing air-conditioning load/use.
- Use light coloured, reflective roofs having an SRI (solar reflectance index) of 50% or more. The dark coloured, traditional roofing finishes have SRI varying from 5% to 20%. A fine example of higher SRI is the use of broken china mosaic and light coloured tiles as roof finish, which reflects heat off the surface because of high solar reflectivity, and infrared emittance, which prevents heat gain.
- Use commercially available, high solar reflective (albedo) roof coatings or heat reflective paints on roofs that shade paved areas. Do not use stone mulches such as fine gravel, crushed granite or pebbles in unplanted areas immediately adjacent to buildings, as they can heat up, reflect solar radiation inside, and also cause glare.
- Use high albedo or reflective pavements to keep parking lots, pavements, and the inside roads cool, because an increase in albedo of 0.1 decreases the pavement temperature approximately by 8 °F.
- Use light coloured aggregates or 'white top' the pavements with a layer of cement concrete, 50 mm thick. Stabilize the pavements with porous or permeable materials such as sand, crushed bricks, broken mosaic tiles or stones where the soil is stable or the traffic load is quite low. Recycled materials such as demolished concrete (rubble), broken china, and mosaic tiles could also be used.

5.1 Commitments

5.1.1 Total paved area of the site under parking, roads, paths or any other use should not exceed 25% of the site area or net imperviousness of the site not to exceed the imperviousness factor as prescribed by the *NBC 2005* (BIS 2005b), whichever is more stringent.

5.1.2 Total surface parking should not exceed the area as permissible under the local by-law and

- more than 50% of the paved area to have pervious paving/open-grid pavement/grass paver or
- a minimum 50% of the paved area (including parking) to have shading by vegetated roof/pergola with planters or
- a minimum 50% of the paved area (including parking) to be topped with finish having solar reflectance of 0.5 or higher.

Table 5.1 Run-off coefficient for various surfaces

Surface type	Run-off coefficient
Roofs conventional	0.95
Roof garden <100 mm thick	0.50
Roof garden 100–200 mm thick	0.30
Roof garden 200–500 mm thick	0.20
Roof garden >500 mm thick	0.10
Concrete/kota paving	0.95
Gravel	0.75
Brick paving	0.85
Vegetation (%)	
Slope 0–1	0.10
Slope 1–3	0.20
Slope 3–10	0.25
Slope >10	0.30
Turf slopes (%)	
0–1	0.25
1–3	0.35
3–10	0.40
>10	0.45

Table 5.2 National Building Code 2005: standards for imperviousness factor applicable to different types of areas

Type of area	Imperviousness factor (%)
Commercial and industrial areas	70–90
Residential areas (high density)	60–75
Residential areas (low density)	35–60
Parks and underdeveloped areas	10–20

Combination

Minimum 50% of the area to have any combination of the above-mentioned strategies for pervious, shaded paved area or area with SRI >50%, where common area having two or more strategies shall be calculated only once.

5.2 Compliance

The following may be submitted.

5.2.1 Calculations to support design commitment, as per Equations 1 to 6.

$$\text{Paved area (\%)} = \frac{\text{Impervious area on ground } (m^2)}{\text{Total site area } (m^2)} \quad \text{Eq. (1)}$$

Impervious paved on-site area to include areas such as parking, driveways, sidewalks, roads, boundary walls, and to exclude areas that have pervious paving (such as grass pavers, open-grid pavements, and gravel paving). The total site area is an area of the plot pavements minus the building ground coverage.

$$\text{Pervious paving (\%)} = \frac{\text{Pervious paving area } (m^2)}{\text{Total paved area } (m^2)} \quad \text{Eq. (2)}$$

$$\text{Impervious area on ground and roof } (m^2) = \text{surface area} \times \text{run off coefficient (Table in Box 4.1)} \quad \text{Eq. (3)}$$

$$\text{Imperviousness paving (\%)} = \frac{\text{Total impervious area as per Equation 3 } (m^2)}{\text{Total site area } (m^2)} \quad \text{Eq. (4)}$$

In Equation 4, the total site area is the area of plot used for calculation of floor area ratio/ floor space index.

$$\text{Shade (\%) by vegetated roof} = \frac{\text{Paving with vegetated roof } (m^2)}{\text{Total paved area } (m^2)} \quad \text{Eq. (5)}$$

$$\text{Area (\%) with SRI (solar reflectance index)>0.5} = \frac{\text{Paved area with SRI>0.5}}{\text{Total paved area } (m^2)} \quad \text{Eq. (6)}$$

5.2.2 Site plan (one drawing) with area statements clearly showing all paved areas (paved areas should be labelled as per use; for example, walkways, driveways, parking, sit-out) The following details as applicable.

- Demarcate areas that have vegetated roof. Provide details of vegetated roof.
- In case high reflectance surface is provided, submit details of reflectance of surface finish.
- Demarcate areas having pervious paving.

5.2.3 Certificate from the architect to certify that the total surface parking is as permitted by local by-law.

5.3 Appraisal (maximum points – 2)

5.3.1 Total paved area of site under parking, roads, paths or any other use not to exceed 25% of site area or net imperviousness of site should not exceed the imperviousness factor, as prescribed by *NBC 2005* (BIS 2005b), whichever is more stringent, as per clause Equations 1 and 4 (reference documents: 5.2.1 and 5.2.2) (1 point).

5.3.2 Total surface parking not to exceed as permitted by local by-law (mandatory) and

- more than 50% of the paved area to have pervious paving/open-grid pavement/ grass paver (Equation 2) or
- minimum 50% of the paved area (including parking) to have shading by vegetated roof/pergola with planters (Equation 3) or
- minimum 50% of the paved area (including parking) to be topped with solar reflectance of 0.5 or higher (Equation 4) (1 point). (reference documents: 5.2.1 and 5.2.2).

Criterion 6 ▪ Enhance outdoor-lighting system efficiency and use renewable energy system for meeting outdoor lighting requirements

Objective

Enhance energy efficiency of outdoor lighting and promote usage of renewable forms of energy to reduce the use of conventional/fossil-fuel-based energy resources.

6.1 Commitment

6.1.1 Luminous efficacy of external light sources used for outdoor lighting shall equal or exceed the specifications in Table 6.1.

Table 6.1 Minimum allowable values of luminous efficacy of lamps for outdoor lighting

Light source	Minimum allowable luminous efficacy (lm/W)
CFL (compact fluorescent lamps)	50
FL (fluorescent lamp)	75
MH (metal halide)	75
HPSV (high pressure sodium vapour) lamp	90

lm/W – lumen/watt

6.1.2 All outdoor lightings to be fitted with an automatic on/off switch.

6.1.3 A minimum of 25% of the total number or 15% of the total connected load of outdoor lighting fixtures (whichever is higher) to be powered by solar energy. Outdoor lighting system includes

- security lighting,
- street lighting,
- landscape lighting,
- façade lighting, and
- parking lighting.

6.2 Compliance

The following documents are to be submitted.

6.2.1 Luminous efficacy of each type of lamp used in outdoor lighting.

Luminous efficacy (lm/W) = {lamp lumen output (lm)}/{lamp wattage (W) + ballast power loss (W)}. The format is given in Table 6.2.

6.2.2 Outdoor lighting layout with manufacturers' details of lamps, ballasts, luminaires, and automatic controls. Wiring diagram and placement of automatic switch(es) for outdoor lighting.

6.2.3 Demarcate solar lighting systems for outdoor lighting in outdoor-lighting layout and give details of the same.

6.3 Appraisal (maximum points – 4)

6.3.1 Luminous efficacy of 100% of lamps used in outdoor lighting (Table 6.2) meets the corresponding lamp luminous efficacy as mentioned in Table 6.1, as per clause 6.2.1 (1 point).

6.3.2 Automatic controls for 100% of outdoor lights, as per clause 6.1.2 (1 point).

6.3.3 Percentage of total outdoor lighting fixtures with solar lighting system, as per clause 6.1.3 (25%–50% of total number or a minimum of 15% of total connected load, whichever is higher [1 point])

Table 6.2 Format for luminous efficacy calculation

Code	Luminaire		Lamps				Ballast			Luminaire	Luminous efficacy wattage	
	Make	Description	Type	Make	Lumen output (lm)	Wattage	Type	Make	Power loss (w)	(Lamp+ ballast)	Achieved	Minimum recommended
A-1	Philips	TBC-22	CFL	Philips	600	10	Electronic	Philips	2	12	50	50

Criterion 7 ▪ Plan utilities efficiently and optimize on-site circulation efficiency

Objective

To reduce site disruption due to laying, maintain utility lines, and minimize energy use by on-site utilities. To reduce transportation corridors on-site, thus reducing the pollution loads. (Box 7.1).

Box 7.1 Guidelines for efficient planning of utilities and site circulation[7]

The site infrastructure includes traffic, transportation, utility systems, and planning the pattern of movement for the above. Every site has a carrying capacity for human activity, which is based on the sensitivity of the site resources and the regenerative ability of the land. This capacity needs to be gauged during several phases of a development. Planning infrastructure for a sustainable site forms the foremost issue in deciding the carrying capacity of the facilities, the concentration of facilities versus their dispersal, their location according to natural site system so that site disturbance can be minimized, its ratio to gross site coverage, and dividing the site into impermeable areas and enabling the site design to be flexible enough for future extension or development. Under-used infrastructure waste materials, energy, and resources results in cutting down of natural habitat for plants and animals. Thus, optimal usage plan for the traffic flow, transportation, and utility become significant.

Recommendations and practices for utility/ infrastructure

- Integrate and use the existing utility and transportation infrastructure and capacity to minimize the need for new infrastructure
- Select utility systems in accordance with the established natural system on-site
- Use gravity sewer systems
- Plan utility corridors
- Site utility systems with the landscape
- Analyse the existing road system and networks for parking; pedestrians to form site circulation patterns
- Design the site plan to minimize the length of primary or secondary circulation, pedestrian walkways, utility lines, and building footprint
- Improve safety and security
- Plan for the alternative traffic/transportation strategies
- Incorporate the use of telecommunicating strategies

7.1 Commitment

7.1.1 Design a site plan to minimize road length and building footprint. Shade all pedestrian roads by vegetated roofs / any other shading devices.

7.1.2 Use aggregate utility corridors.

7.1.3 Consolidate utility corridors along the previously disturbed areas or along new roads, in order to minimize unnecessary cutting and trenching and to ensure easy maintenance. Local codes and requirements for water, sewer, and electrical / telecommunication lines should be considered.

7.1.4 Consolidate services, pedestrian, and automobile paths.

7.2 Compliance

The following documents are to be submitted.

7.2.1 A narrative (maximum 300 words) along with supporting drawings to prove that road lengths and building footprint are minimized and that all pedestrian roads have permanent shading.

7.2.2 Site plan (CAD file) showing section of aggregate utility corridor with utility lines.

7.2.3 Site plan (CAD file) showing that all services along with the pedestrian and vehicular paths are consolidated.

7.3 Appraisal (maximum points – 3)

7.3.1 Demonstrated use of minimization and consolidation of transportation / service corridors and shading of pedestrian roads, as per clause 7.2.1 (1 point).

7.3.2 Use of aggregate utility corridors, as per clause 7.2.2 (1 point).

7.3.3 Consolidation of utility corridors along the previously disturbed areas or along new roads in order to minimize unnecessary cutting and trenching and ensure easy maintenance, as per clause 7.2.3 (1 point).

[7] ICAEN (2004b)

Health and well-being

Construction activities are large polluters of environment. Large volumes of suspended particulate matters are released during construction work leading to air pollution. Unhygienic site sanitation facilities cause damage to the environment and to the health of the construction workers. Green buildings should address these issues.

Criterion 8 ▪ Provide minimum level of sanitation/safety facilities for construction workers

Objective

To ensure the health and safety of workers during construction, with effective provisions for the basic facilities such as sanitation and drinking water, and safety of equipments or machinery (Box 8.1).

Box 8.1 Some best practices for safety during construction

- Guarding all parts of dangerous machinery
- Precautions for working on machinery
- Maintaining hoists and lifts, lifting machines, chains, ropes, and other lifting tackles in good condition
- Using durable and reusable formwork systems to replace timber formwork and ensure that formwork, where used, is properly maintained
- Ensuring that walking surfaces or boards at height are of sound construction and are provided with safety rails or belts
- Providing protective equipment such as helmets
- Providing measures to prevent fires. Fire extinguishers and buckets of sand to be provided in a fire-prone area and elsewhere
- Providing sufficient and suitable light for working during the night
- Measures to protect workers from materials of construction, transportation, storage, and other dangers and health hazards.
- Safety policies of the construction firm/division/company

8.1 Commitment

8.1.1 Comply with the safety procedures, norms and guidelines (as applicable) as outlined in *NBC 2005* (BIS 2005c).

8.1.2 Adopt additional best practices and prescribed norms as in *NBC 2005* (BIS 2005).

8.1.3 Provide clean drinking water to all workers.

8.1.4 Provide adequate number of decentralized latrines and urinals to construction workers.

8.2 Compliance

The following documents are to be submitted.

8.2.1 Signed letter by competent authority (architect/contractor) to demonstrate compliance with *NBC 2005* (BIS 2005f) and proposed additions.

8.2.2 Proof in the form of relevant sections of tender document to show that the safety norms and procedures as committed to be complied with are included in the scope of work of the contractor.

8.2.3 Site photographs to demonstrate compliance by the contractor.

8.2.4 Detailed narrative (not more than 250 words) on provision for safe drinking water and sanitation facility for construction workers and site personnel.

8.3 Appraisal (maximum points – 2)

8.3.1 Compliance with National Building Code norms on construction safety for ensuring safety during construction (1 point), as per clauses 8.2.1, 8.2.2, and 8.2.3.

8.3.2 Provision for health and sanitation facilities as specified above (1 point), as per clause 8.2.4.

Criterion 9 ▪ Reduce air pollution during construction

Objective

The dust generated by various construction site activities can contribute significantly to air pollution. Dust and outdoor air pollutants can cause respiratory problems. Good construction practices involve major mitigation measures for prevention or minimization of air pollution from construction activities. This criterion aims to reduce air pollution due to on–site construction.

Box 9.1 Measures to reduce air pollution

Site preparation

- Clear vegetation only from the areas where work will start right away
- Vegetate/mulch areas where vehicles do not ply
- Apply gravel/landscaping rock to the areas where mulching/paving is impractical
- Identify roads on-site that would be used for vehicular traffic. Upgrade vehicular roads (if these are unpaved) by increasing the surface strength by improving particle size, shape, and mineral types that make up the surface and base. Add surface gravel to reduce source of dust emission. Limit amount of fine particles (smaller than 0.075 mm) to 10%–20%
- Limit vehicular speed on-site to 10 km/h

Water spraying

This could be done by wetting the surface by spraying water on

- any dusty materials before transferring, loading, and unloading,
- areas where demolition work is being carried out,
- any unpaved main-haul road, and
- areas where excavation or earth-moving activities are to be carried out.

Cover and enclosure

This could be done by

- providing hoardings of not less than 3 m high along the site boundary, next to a road or other public area,
- providing dust screens, sheeting or netting to scaffold along the perimeter of a building,
- covering stockpiles of dusty material with impervious sheeting,
- covering dusty load on vehicles by impervious sheeting before they leave the site, and
- transferring, handling/storing dry loose materials like bulk cement and dry pulverized fly ash inside a totally enclosed system.

9.1 Commitment

9.1.1 Adopt measures to prevent air pollution in the vicinity of the site due to construction activities. There is no standard reference for this. The best practices (referred in Box 9. 1) should be followed (as adopted from international best practice documents and codes).

9.1.2 Provision in the contract document that the contractor will undertake the responsibility to prevent air pollution (dust and smoke); ensure that there will be adequate water supply / storage for dust suppression; devise and arrange methods of working and carrying out the work in such a manner so as to minimize the impact of dust on the surrounding environment; and provide experienced personnel with suitable training to ensure that these methods are implemented. Prior to the commencement of any work, the methods of working, plant equipment, and air-pollution-control system to be used on-site should be made available for the inspection and approval of the engineer-in-charge to ensure that these are suitable for the project.

9.2 Compliance

The following documents are to be submitted.

9.2.1 Narrative (not more than 300 words) explaining the air pollution preventive measures that have been adopted on-site. Site photographs showing different stages of construction along with preventive measures to support the claim.

9.2.2 Relevant sections of tender document showing that air pollution prevention measures are mandatory are to be adopted by contractors during construction.

9.3 Appraisal (maximum points – 2)

9.3.1 Demonstrated use of air pollution preventive measures, as per clauses 9.2.1 and 9.2.2 (2 points).

SECTION 2

Building planning and construction

An integrated approach to building planning and construction is required to achieve maximum benefit in terms of the environment. Appropriate interventions at the design and construction stages are critical to any sustainable building. These interventions lead to reduced demand for depletable resources and efficient resource utilization. Options for recycling and reuse of waste adds to the sustainability of the building as a system.

Conservation and efficient utilization of resources

Appropriate interventions at the planning and design stage can save valuable resources (water, energy, and materials) throughout the life cycle of a building. The following criteria aim to ensure saving such valuable resources.

Criterion 10 ▪ Reduce landscape water requirement

Objective

To reduce the landscape water requirement so as to minimize the load on the municipal water supply and depletion of groundwater resources (Box 10.1).

10.1 Commitment

10.1.1 Design the landscape so as to reduce water consumption by 30% or more (up to 50%).

10.2 Compliance

The following documents are to be submitted.

10.2.1 Narrative demonstrating water saving measures adopted in the landscape plan.

10.2.2 Plan indicating the plants list, nature of species, and area covered.

10.2.3 Calculation of the water requirement after establishment for landscape in LPD (litres per day) for each month due to variation in PET (potential evapo-transpiration rate).

10.2.4 Provide cut sheets of the irrigation equipment showing technical specifications, such as flow rate and dimensions.

10.3 Appraisal (maximum points – 3)

10.3.1 Reduction in water consumption by 30%, as per clause 10.2.3 (1 point).

10.3.2 Reduction in water consumption by 40%, as per clause 10.2.3 (1 point).

10.3.3 Reduction in water consumption by 50%, as per clause 10.2.3 (1 point).

Box 10.1 Best practices to reduce water usage for landscaping

Xeriscaping

Xeriscape means the conservation of water and energy through creative landscaping. This word is derived from the Greek word, 'Xeros', meaning dry. These plants can live with little or no supplemental watering while some are even drought tolerant. Following are some recommendations to reduce water usage for landscaping.

- Pant a mix of native shrubs and xeriscape plants.
- Reduce the lawn area, and plant more trees that require no water.
- Plant palm trees, which are xerophytic, such as *Phoenix dactylifera* and *Yucca starlite*.
- Use ground covers such as *Asparagus sprengeri*, which is succulent; *Pandanus* dwarf, which is xerophytic; and Bougainvillea, which is a climber.

Drip irrigation

Drip irrigation system or sub-surface drip irrigation system saves water as it avoids loss of water due to run-off, deep percolation or evaporation.

Sprinkler irrigation

Sprinkler irrigation is a method similar to natural rainfall in which water is distributed through a system of pipes. For maintaining uniform distribution of water, the pump supply system, sprinklers, and operating conditions must be designed appropriately. Sprinklers are most suited to sandy soils with high infiltration rates. The average application rate should be less than the basic infiltration rate of the soil so as to avoid surface ponding and run-off. It is better to use sprinklers that produce fine sprays than those that produce larger water droplets.

Native vegetation

Native vegetation is original to a particular place, including trees, shrubs, and other plants.

Evapo-transpiration rate

The PET (potential evapo-transpiration rate) is the climate factor and refers to the amount of water required by a plant for its healthy growth (depending on the climate). Evapo-transpiration rate determines the rate at which plants lose water through evaporation. It is affected by humidity and temperature at a given time. These rates vary with the season. The data is available with the Indian Meteorological Department for each city and can be procured from the Additional Director General of Meteorology (Research), Shivajinagar, Pune – 411 005.

Efficiencies of irrigation systems

Irrigation efficiency refers to the ability of an irrigation system to deliver water to plants without any water loss.

Irrigation system	Efficiency (%)
Micro-drip	85
Micro-spray	80
Multiple sprinkler	75
Sprinkler, large guns	70
Seepage	50
Crown flood	50
Flood	50

Example of difference in base and design case from Jabalpur.

Table 10.1 Calculation of landscape water requirement for design case (for example, Hissar, Haryana)

Plant species	Evapo-transpiration rate (m/day)	Plant factor	Canopy area (m^2)	Irrigation system efficiency	Water requirement (LPD)
Lawns	0.0004	1	x	0.75	1000*×*1*0.0004/0.75 = 53.33
Native	0.0004	0.4	x	0.85	1000*×*0.4*0.0004/0.85 = 18.82
Newly planted	0.0004	0.7	x	0.75	1000*×*0.7*0.0004/0.75 = 37.33
Trees	0.0004	0	x		1000*×*0 = 0
Total daily water requirement					

m – metre; LPD – litres per day; x – corresponding conopy area

Table 10.2 Calculation of landscape water requirement for base case (for example, Hissar, Haryana)

Plant species	Evapo-transpiration rate (m/day)	Plant factor	Canopy area (m^2)	Irrigation system efficiency	Water requirement (LPD)
Lawns	0.0004	1	4x	0.75	1000*4x*1*0.0004/0.75 = 213.33
Total water requirement					
Total daily water requirement (litres)					
Total monthly water requirement (litres)					
Total annual water requirement (litres)					
Daily water requirement for base case (litres) = 1000*area of lawns (m^2)*1*0.002/0.75					
Monthly water requirement for base case (litres)					
Annual water requirement for base case (litres)					
Water use reduction (%) = [Annual water demand (base case) – annual water demand (design case) / annual water demand (base case)] *100					
Canopy area					
Canopy area is square foot area of plant – view of the plant					
a) assumed as 269 sq. ft. per tree and 162 numbers in an acre					
b) assumed as area covered by shrubs and grass					
Plant factor					
Plant factor refers to the water requirement of plants. Plants are classified according to the resistance to stress.					

LPD – litres per day; m – metre

Table 10.3 Calculation of landscape water requirement for design case (for example, Hissar, Haryana)

Plant species	Evapo-transpiration rate (m/day)	Plant factor	Canopy area (m^2)	Irrigation system efficiency	Water requirement (LPD)
Lawns	0.002	1	100	0.75	1000*100*1*0.002/0.75
Native	0.002	0.4	100	0.85	1000*100*0.4*0.002/0.85
Newly planted	0.002	0.7	100	0.75	1000*100*0.7*0.002/0.75
Trees	0.002	0	100		0
Total water requirement					
Total daily water requirement (litres)					
Total monthly water requirement (litres)					
Total annual water requirement (litres)					
Daily water requirement for base case (litres) = 1000*area of lawns (m^2)*1*0.002/0.75					
Monthly water requirement for base case (litres)					
Annual water requirement for base case (litres)					
Water use reduction (%) = [Annual irrigation water requirement (base case – design case)/base case] * 100					
Canopy area					
Canopy area is square foot area of plant – view of the plant					
a) assumed as 269 sq. ft. per tree and 162 numbers in an acre					
b) assumed as area covered by shrubs and grass					
Plant factor					
Plant factor refers to the water requirement of plant. Plants are classified according to the resistance to stress.					

Criterion 11 ▪ Reduce water use in the building

Objective

To reduce water consumption in the building by using efficient fixtures (Box 11.1)

Box 11.1 Best practices[8]

- Use of efficient plumbing fixtures, sensors, auto control valves, and pressure reducing devices wherever possible can result in significant reduction in water consumption.
- Water efficient fixtures
  - Conventional toilets use 13.5 litres of water per flush. Low flush toilets are available with a flow rate of 6.0 litres and 3.0 litres of water per flush.
  - Dual flush adapters can be used for standard flushing for solid waste and a modified smaller flush for liquid waste.
  - Flush valves with 20–25 mm inlets can be used for restricting the water flow.
  - Composting toilets .
  - Water-efficient urinals.
  - Conventional urinals use water at a rate of 7.5–11 litres per flush. Use of electronic flushing system or magic eye sensor can further reduce the flow of water to 0.4 litres per flush. Furthermore, waterless urinals do not use water.
- Auto control valves
  Installation of magic eye solenoid valves (self-operating valves) can result in saving water. Sensor taps have automatic on and off flow controls. These valves are not only convenient and hygienic but are also excellent water saving devices that can work under normal water pressure. They function with parameters such as distance and timing.
- Pressure reducing device
  Aerators and pressure inhibitors for constant flow. Use of aerators can result in flow rates as low as 2 litres per minute, which is adequate for washing hands. Flow regulators are installed when aerators cannot be installed.
- Composting toilets
  Another means of reducing water for flushing toilets is to use composting toilets. Composting toilets are based on the biological process of converting solids present in human waste into enriched manure. A composting toilet consists of two underground pits. The first pit will be filled with waste over one to two years. During this time, bacteria digest the sludge. After two years of digestion, the contents are odourless and safe to handle, and can be used as soil fertilizer. The second pit is used when the first is full.

11.1 Commitment

Reduce the total water consumption in the building (by 25% or more) by using conventional high flow fixtures.

11.2 Compliance

The following documents are to be submitted.

11.2.1 Narrative demonstrating adopted water-saving measures adopted.

11.2.2 Specification sheets from manufacturers for each fixture, indicating the flow rates (at design pressure of 80 psi for faucets).[9]

11.2.3 Bill of quantities from the plumbing tender indicating the number and flow rates of various fixtures.

11.2.4 Provide design basis calculations demonstrating the reduction in the building's water demand as 25% or more (Table 11.1).

11.3 Appraisal (maximum points – 2)

11.3.1 Reduction in water consumption by 25%. For calculation, refer to Table 11.1 (1 point).

11.3.2 Water-use reduction by 50%. For calculation, refer to Table 11.1 (additional 1 point).

[8] ICAEN (2004a)

[9] For a list of manufacturers of low-flow plumbing fixtures, refer to *Knowledge Bank For Sustainable Buildings*, published by TERI.

Table 11.1 Estimation of building water use (sample calculation sheet)

Present design case	Building occupancy		100	Working days	260
	Fixtures	No. of fixtures	Flow rates (lpf/lpm)	No. of uses (per person/day)	Water consumption (litres)
1	Water closets		6	4	
2	Kitchen faucets		7.5	3	
3	Water closets		3	4	
4	Waterless urinals		0	4	
5	Lavatory faucets		7.5	3	
			Daily water consumption (litres)		
			Annual water consumption (litres)		
Base case	Building occupancy		100	Working days	260
	Fixtures	No. of fixtures	Flow rates (lpf/lpm)	No. of uses (per person/day)	Water consumption (litres)
1	Water closets		9	8	
2	Kitchen faucets		15	3	
3	Lavatory faucets		15	3	
			Daily water consumption (litres)		
			Annual water consumption (litres)		

lpf – litres per flush; lpm – litres per minute
Number of uses (for kitchen and lavatory faucets):
In the present design case, number of usage/person/day = 6
Duration of single usage = 0.5 minutes
Therefore, number of uses (for kitchen and lavatory faucets) = 6 × 0.5 = 3

Table 11.2 Reduction in water use (in percentage)

Water use reduction (%)	[Annual water demand (base case) – annual water demand (design case)/annual water demand (base case)] × 100

Criterion 12 ▪ Efficient water use during construction

Objective

To minimize use of potable water during construction.

Box 12.1 Controlling waste of curing water

The following are guidelines to avoid wastage of curing water.

- Curing chemicals should be sprayed on concrete structures and free flowing water should not be cured.
- After curing on the first day, all concrete structures should be painted with curing chemicals. This will stop daily water curing and save water.
- Water should be sprayed on concrete structures after covering them with cloth/gunny bags. This decreases water rebound and ensures sustained and complete curing.
- Ponds should be made using cement and sand mortar to avoid water flowing away from the flat surface while curing.
- Water ponding should be done on all sunken slabs. This also highlights the importance of having an impervious formwork.

12.1 Commitment

12.1.1 Use materials such as pre-mixed concrete for preventing water loss during mixing.

12.1.2 Use recycled treated water.

12.1.3 Control the waste of curing water (Box 12.1).

12.2 Compliance

The following documents are to be submitted.

12.2.1 Certificate from architect confirming the initiatives taken to minimize the use of potable water during construction.

12.2.2 Narrative on the initiatives of water use minimization, indicating the various sources of water.

12.3 Appraisal (maximum points – 1)

12.3.1 Efforts to minimize potable water use for construction, as per clauses 11.2.1 and 12.2.2 (1 point).

Note This point is completely subject to the evaluator's discretion

Criterion 13 ▪ Optimize building design to reduce conventional energy demand

Objective

To apply solar passive measures, including daylighting, in order to reduce the demand on conventional energy for space conditioning and lighting systems in buildings.

13.1 Commitment

13.1.1 Arrange spaces with respect to favourable orientations; for example, place of buffer spaces like toilet, service areas, and staircases on the west/east façade of building and spaces with the requirement for natural lighting on the north.

13.1.2 Shade the east-west walls using shading devices, such as the louver system.

13.1.3 Conduct a solar path analysis to arrive at an appropriate size of shading device for each orientation or use shading norms prescribed in the *Handbook on functional requirements of buildings* (*other than industrial buildings*) (Tables 9 and 10) or the achieved SHGC (solar heat gain coefficient) recommended for fenestration as per the Energy Conservation Building Code.

13.1.4 Perform daylight simulation and ensure that all living spaces have a minimum of 75% area with a daylight factor, under overcast conditions, as prescribed in the *Handbook on functional requirements of buildings* (*other than industrial buildings*).

13.1.5 Perform lighting simulation to demonstrate that the lighting levels in indoor spaces are maintained as recommended in *NBC 2005* (Table 8) (BIS 2005d).

13.2 Compliance

The following documents are to be submitted.

13.2.1 Site plan in 1:500 scale giving north line.

13.2.2 Building plan with internal layout showing all functional spaces and interior layout in 1:200 scale (the plan shall be referred to during post-occupation review). Submit building sections in 1:200 scales.

13.2.3 Perform a solar path analysis (for each solstice and equinox day) of each building façade with window location and height, distance from the adjacent building, and any other obstruction.

13.2.4 Provide the window details in the following format (Table 13.1), along with floor plans (1:200 scale).

13.2.5 Provide cut sheet for each window, with shading size and type with clear dimension. The orientation should be marked along with each window cut sheet.

13.2.6 Daylight simulation result outputs, as in Table 13.2, for all living spaces to demonstrate compliance with BIS.

13.2.7 Lighting level simulation result outputs, as in Table 13.3, for all areas to demonstrate lighting level compliance with BIS.

Table 13.1 Format for window details

Space	Window details		Window height	Window sill	Solar heat gain coefficient	BIS recommended shading size or shading size determined by solar path analysis or ECBC recommended SHGC	Overhang multiplier	Adjusted SHGC	ECBC recommended SHGC
Air-conditioned/ non air-conditioned	Nomenclature	Orientation	(units)	(units)					

ECBC – Energy Conservation Building Code; SHGC – solar heat gain coefficient

Table 13.2 Format for daylight simulation results

Floor level	Room/area	Room dimensions (length × width)	Calculated daylight factor at the centre of the room	Recommended daylight factor (as per IS)

IS – Indian Standards

Table 13.3 Format for lighting level simulation resutls

Floor level	Room/area	Room dimensions (length × width)	Calculated average lighting (Lux) levels	Recommended lighting levels (as per NBC)

NBC – National Building Code of India

13.2.8 Certificates from architect / service consultant on compliance with clause 13.2.6.

13.2.9 Certificates from architect / service consultant on compliance with clause 13.2.7.

13.3 Appraisal (maximum points – 6)

13.3.1 Appropriate planning which reflects climate responsiveness, as per clauses 13.2.1–13.2.6 (2 points).

13.3.2 Adequate daylighting is provided, as per clauses 13.2.6 and 13.2.8 (2 points).

13.3.3 Over-design of lighting system is avoided, as per clauses 13.2.7 and 13.2.9 (2 points).

Criterion 14 ▪ Optimize energy performance of building within specified comfort limits

Objective

To optimize use of energy systems in buildings that maintain a specified indoor climate conducive to the functional requirements of the building.

14.1 Commitment

14.1.1 Follow mandatory compliance measures (for all applicable buildings) as recommended in the *Energy Conservation Building Code 2007* of the BEE, Government of India.

14.1.2 Show that utilization of energy systems in a building, under a specified category, is less than the benchmarked energy consumption figure, through a simulation exercise. The energy systems include air conditioners, indoor lighting systems, water heaters, air heaters, and air circulation devices.

14.1.3 The annual energy consumption of energy systems in a fully air-conditioned building (for day and 24 × 7 use) should not exceed the limits mentioned in Table 14.1 (benchmarked energy consumption figure).

14.1.4 The annual energy consumption of energy systems in a non-air-conditioned building for day use should not exceed limits mentioned in Table 14.1 (benchmarked energy consumption figure).

14.1.5 In a building that includes both air–conditioned and non-air-conditioned areas, the annual energy consumption of energy systems should not exceed the benchmarked energy consumption limits listed in Table 14.1.

14.1.6 Quantify energy usage for all electrical, mechanical, and thermal systems for which either electrical or thermal energy is used. Quantify energy usage for each system used in providing lighting, air conditioning, ventilation, heating (water and air), and air circulation. The necessary energy conversion factors are listed in Table 14.3.

Table 14.1 Energy performance index for air-conditioned/non-air-conditioned buildings

Air-conditioned buildings (commercial)		
Climate classification	EPI day-time occupancy @ 5 days/week	EPI 24-hours occupancy @ 7 days/week
Moderate	120 kWh/m^2/annum	350 kWh/m^2/annum
Composite/warm and humid/hot and dry	140 kWh/m^2/annum	450 kWh/m^2/annum
Air-conditioned buildings (residential)		
Climate classification	EPI day-time occupancy @ 5 days/week	EPI 24-hours occupancy @ 7 days/week
Composite/warm and humid/hot and dry	200 kWh/m^2/annum	
Non-air-conditioned buildings		
Climate classification	EPI day-time occupancy @ 5 days/week	EPI 24-hours occupancy @ 7 days/work
Moderate	20 kWh/m^2/annum	85 kWh/m^2/annum
Composite/warm and humid/hot and dry	25 kWh/m^2/annum	100 kWh/m^2/annum

kWh/m^2/annum – kilowatt hour per square metre per annum; EPI – energy performance index

Table 14.2 Format for calculation of energy performance index

Annual energy consumption data for the building

Type of space	Area (m^2)	Energy consumption (kWh/m^2 yr)
Air-conditioned	A_1	E_1
Non-air-conditioned	A_2	E_2

Calculation of benchmark energy consumption figure

$$\text{Benchmark energy consumption (kWh/m}^2\text{ yr)} = \frac{(140 \times A_1) + (26 \times A_2)}{A_1 + A_2}$$

Note The benchmark figure is valid for day use and/or 24 × 7 only
Day use buildings: occupied from 9 a.m. to 5 p.m. for 5 days a week
24 × 7 buildings: occupied round the clock for all days in a year

Calculation of building energy consumption figure

$$\text{Building energy consumption (kWh/m}^2\text{ yr)} = \frac{(E_1 \times A_1) + (E_2 \times A_2)}{A_1 + A_2}$$

Table 14.3 Energy conversion factors

Energy unit	Conversion factor for kWh
Litres of LDO (light diesel oil)	8.3
Litres of HSD (high-speed diesel)	8.5
Kilogram of LPG (liquefied petroleum gas)	13.9
SCM (standard cubic metres) of PNG (pipe natural gas)	7.0

14.1.7 Perform hourly calculations to show that in non-air-conditioned areas, the thermal comfort conditions as specified in NBC 2005 (BIS 2005d) are met for 90% of all occupied hours for buildings in composite, moderate, and hot and dry climate and for 60% of all occupied hours for buildings in warm and humid climate.

14.1.8 Perform hourly calculations to show that in air-conditioned areas, the thermal comfort conditions as specified in *NBC 2005* (BIS 2005e) are met for 100% of all occupied hours.

14.2 Compliance

The following documents are to be submitted.

14.2.1 A narrative from the architect/services consultant describing compliance of the building with the mandatory provisions (criteria 4.2, 5.2, 6.2, 7.2, and 8.2) of the *Energy Conservation Building Code 2007* of the BEE, Government of India.

14.2.2 Annual energy consumption data for the building, as per Tables 14.1 and 14.2, supported by the simulation results from the software used.

14.3 Appraisal (maximum points – 12)

14.3.1 Compliance with Energy Conservation Building Code, as per clause 14.2.1 (2 points).

14.3.2 Energy consumption index (as in Tables 14.1 and 14.2) and the thermal comfort criteria are fully met, as per clauses 14.1.7 and 14.1.8 (2–10 points). Achievement of the benchmarked EPI (energy performance index) shall fetch two points. Every 10% reduction in EPI for respective cases shall fetch two additional points, to a maximum of ten points (40% reduction in EPI from the benchmark).

Table 14.4 Annual energy consumption

Total air-conditioned area (m^2)	
Total annual energy consumption (kWh)	
Annual kWh/m^2	
Percentage reduction in energy consumption compared to the benchmarked energy consumption	
Total non-air-conditioned area (m^2)	
Total annual energy consumption (kWh)	
Annual kWh/m^2	
Percentage reduction in energy consumption compared to the benchmarked energy consumption	

Table 14.5 Unmet comfort conditions for non-air-conditioned area

Total occupied hours in a year	
Total number of dissatisfied hours in a year	
Dissatisfied hours as percentage of occupied hours	

Notes

- An hourly calculation shall be performed using standard building energy simulation software (such as DOE 2, TRNSYS, and Carrier). An hourly weather file shall be generated using weather data, acceptable by the ISHRAE (Indian Society for Heating Refrigeration and Air-conditioning Engineers).
- TERI shall vet all the calculations carried out by the energy consultant.
- Day use buildings perform between 9 a.m. to 5 p.m., for five days a week.
- The *NBC 2005* will be referred to for the definition of climatic zones.

Criterion 15 ▪ Utilization of fly ash in building structure

Objective

To use low-embodied energy industrial-waste fly ash as the construction material. Fly ash, an industrial waste with properties of cement and very low-embodied energy, is used in combination with cement that are high in embodied energy (Box 15.1).

Box 15.1 Best practices for fly ash

Use ready-mix concrete or high-volume fly ash concrete for construction (commercially available from LandT cement, ACC suraksha, and such other companies) or use PPC (Portland pozzolana cement) concrete for construction (commercially available from ACC suraksha, Lafarge cement, LandT cement, Jaypee Buniyad, Prism Champion, and other companies; PPC must meet the requirements of IS 1489: 1991).

Portland pozzolona cement

This cement is equivalent to OPC (ordinary Portland cement) in mechanical strength, setting, and hardening. It is an alternative to OPC, with an additional advantage of having mild sulphate resistance.

Pozzolana cement or PPC is a mixture of OPC (65%–85%) and a pozzolana (15%–35%). Sometimes, PPC concrete develops strength at a slower rate than OPC concrete. Calcined clay and fly ash are the most common pozzolana for PPC. Addition of fly ash significantly improves the quality and durability characteristics of the resulting concrete.

High-volume fly ash concrete

High-volume fly ash concrete develops sufficient strength and workability, in addition to low temperature rise and high ultimate strength. This is possible due to the high dosage of plasticizer and low W/C ratio (to the extent of 0.30–0.35), and the ratio of cement: fly ash: fine and coarse aggregates is 1:1.75:3.5 with the compressive strength reaching 40–45 Mpa on the 90th day.

Fly ash based building products in India

- *Cellular light-weight concrete blocks*
  CLC (cellular light-weight concrete) blocks are substitutes to bricks and conventional concrete blocks in buildings with a density varying from 800 kg/m^3 to 1800 kg/m^3. The normal constituents of this are foaming-agent-based-technology cement, fly ash (to the extent 1/4th to 1/3rd of total materials constituent), sand, water, and foam (generated from biodegradable foaming agent). CLC walling and roofing panels can also be produced.

  Advantages of cellular light-weight concrete blocks
  - Better strength to weight ratio
  - Reduction of dead load, which results in saving steel and cement and reduction in foundation size
  - Better acoustics and thermal insulation (air conditioning requirement is considerably reduced)
  - Saving in consumption of mortar and higher fire rating

Development of fly ash-based polymer composites as wood substitute

Fly ash-based composites is developed using fly ash as filler and jute cloth as reinforcement. After treatment, the jute cloth is passed into the matrix for lamination. The laminates are cured at specific temperature and pressure, and the number of laminates are used for required thickness. The technology on fly ash polymer composites using jute cloth as reinforcement for wood substitute material can be applied in many applications like door shutters, partition panels, flooring tiles, wall panelling, and ceiling.

With regard to wood substitute products, it may be noted that the developed components/ materials are stronger, more durable, resistant to corrosion and, above all, cost-effective as compared to the conventional material (wood).

- *Ready-mix fly ash concrete*
  Though ready-mix concrete is quite popular in developed countries, it consumes less than 5% of the total cement consumption in India. Only recently has its application started growing at a faster rate. On an average, only 20% fly ash (of cement material) in the country is being used. In ready-mix concrete, various ingredients and quality parameters are strictly maintained/ controlled, which is not possible in the concrete produced on-site. Hence, this cement accommodates still higher quantity of fly ash.

- *Fly ash–sand–lime–gypsum (cement) bricks/ blocks*
  Fly ash is used in the range of 40%–70% in bricks blocks. The other ingredients are lime, gypsum

Continued...

Box 15.1 Continued...

(cement), sand, stone dust/chips, and others. The minimum compressive strength (28 days) of 70 kg/cm^2 can easily be achieved, and this can go up to 250 kg/cm^2 (in autoclaved type).

Advantage of these bricks over burnt clay bricks
- Lower requirement of mortar in construction
- Plastering over brick can be avoided
- Controlled dimensions, edges, and a smooth and fine finish. The bricks can be in different colours (using pigments)
- Cost-effective, energy-efficient and environment friendly (as it avoids the use of fertile clay)

- *Clay-fly ash bricks*
  The fly ash content can be 20%–60%, depending on the quality of clay. The process of manufacturing is the same as for the burnt clay bricks.

  Advantages
  - Fuel requirement is considerably reduced as fly ash contains some percentage of unburnt carbon
  - Better thermal insulation
  - Cost-effective and environment friendly

Initiatives taken by various government departments in India

- *Initiatives by the Ministry of Environment and Forests, Government of India*
  The MoEF issued notification 8.0.763(E), dated 14 September 1999, containing Directive for greater fly ash utilization, some of which are listed below.
  i. Within a radius of 100 km from coal- or TPP lignite-based TPP (thermal power plants), manufacturers of bricks/blocks/tiles should use at least 25% of fly ash in their product.
  ii. Every construction agency engaged in the construction of buildings within a radius of 50–100 km of TPP had to use 100% fly ash-based bricks/blocks in their construction project by the end of August 2007. Construction agencies, within 50 km radius of TPP, had to use 100% fly ash-based bricks/blocks by the end of August 2005. Any brick/block containing more than 25% fly ash is categorized as fly ash brick/block.

- *Status of standardization in the country*
  - Several initiatives taken by the country's standardization body (Bureau of Indian Standards) regarding higher utilization of fly ash are given below.
  - Updating IS (Indian Standards) on 'Portland Pozzolana Cement – Specification Part 1 Fly Ash based' (IS 1489 (Part 1): 1991). In the amended form, the fly ash constituent shall not be less than 15% (from earlier 10%) and not more than 35% (from earlier 25%) by mass of PPC.
  - Revision of the basic *Indian Standard Design Code for Plain and Reinforced Concrete* (IS 456:2000). This revised code lays emphasis on the use of PPC/fly ash in concrete in non-conducive environmental conditions.
  - Revision of the IS on *Specification for fly ash for use as pozzolana and admixture* (IS 3812: 2003).

The standards have been updated keeping in view the change in technologies, which led to the generation of better quality of fly ashes and their wider applications. In the revised standard, the concept of improvement of fly ash properties through beneficiation/segregation/processing has also been introduced.

Quality and specifications

The fly ash used shall conform to specifications for use of fly ash as pozzolana and admixture to IS 3812: 2003. Moreover, percentage replacement of cement with fly ash in concrete shall not exceed the acceptable limits and exposure conditions, conforming to IS 456: 2000.
- PPC (fly ash based) should conform to IS 1489 (part 1): 1991.
- Certificate from an authorized structural engineer that the structural integrity of the construction conforms to the structural standards, as prescribed in the IS Codes.

15.1 Commitment

To achieve the objective, the following criteria can be applied to different components of the building.

15.1.1 RC (reinforced concrete) (including ready-mix concrete) to make use of fly ash by using PPC (Portland pozzolona cement) containing fly ash. A minimum of 15% replacement of cement with fly ash in PPC (by weight of the cement used) in the overall RC for meeting the equivalent strength requirements.

15.1.2 Use fly ash in building blocks for the walls.

Use of fly ash-based bricks / blocks (such as Fal-G stabilized, fly ash–sand lime bricks, load bearing and non-load bearing fly ash-based concrete blocks, and fly ash-based light weight aerated concrete walling blocks) in both 100% load-bearing and non-load-bearing wall systems, which utilize a minimum of 40% of fly ash by weight of cement.

15.1.3 Use fly ash in plaster / masonry mortar by employing PPC.

Use plaster and / or masonry mortar, which utilizes a minimum of 30% of fly ash in PPC, in 100% wall / ceiling finishes and wall construction, meeting the required structural properties.

15.2 Compliance

The following documents are to be submitted.

15.2.1 *Fly ash use in RC*: Minimum 15% replacement of cement with fly ash (by weight of cement used) in the total structural concrete. Provide supporting document from the manufacturer of cement specifying the fly ash content in PPC used in reinforced concrete.

15.2.2 *Fly ash use in building blocks of load-bearing and non-load-bearing walls*: Minimum 40% replacement of cement with fly ash (by weight of cement used), for 100% load-bearing and non-load-bearing walls. Provide supporting document from the manufacturer of the pre-cast building blocks specifying the fly ash content of the blocks used in an infill wall system.

15.2.3 *Fly ash use in plaster and masonry mortar*: Minimum 30% use of fly ash in place of cement (by weight) in overall plaster and mortar requirements. Provide supporting document from the manufacturer of the cement / ready-mix concrete specifying the fly ash content in the PPC used in plaster and masonry mortar.

15.2.4 Certificate from the architect specifying overall replacement of cement in the RC and pre-cast building blocks plaster and masonry in the specified format (in prescribed certificate format).

15.3 Appraisal (maximum points – 6)

15.3.1 Minimum 15% replacement of Portland cement with fly ash (by weight of cement used) in structural concrete, as per clause 15.2.1 — 1 point (additional 1 point if more than 30%).

15.3.2 Minimum 40% replacement of Portland cement with fly ash (by weight of cement used), for 100% load-bearing and non-load-bearing walls, as per clause 15.2.2 — 1 point (additional 1 point if more than 40%).

15.3.3 Minimum 30% replacement of Portland cement with fly ash (by weight of cement used) in plaster / masonry mortar, as per clause 15.2.3 — 1 point (additional 1 point if more than 30%).

Criterion 16 ▪ Reduce volume, weight, and construction time by adopting efficient technologies (such as pre-cast systems)

Objective

Replace a part of energy-intensive materials with less energy-intensive materials and/or utilize regionally available materials, which use low-energy/energy-efficient technologies. (Boxes 16.1 and 16.2).

Box 16.1 Energy-efficient technologies

Sustainably managed materials, when compared with equivalent products for the same application, have the characteristics of natural resource conservation – low-energy content, reduction in the content of primary/high-energy materials, regional availability, and low emission levels of pollutant – in each stage of their life cycle. The amount of materials used in the construction of buildings, for either structural or non-structural applications, represents a significant use of natural resources in terms of extracted raw materials and embodied energy.

The aim of this measure is to replace a part of the energy-intensive materials with less energy-intensive materials and/or utilize regionally available materials, which offers reduced transportation, with the use of low-energy/energy-efficient technologies (not based on the utilization of fly ash). Examples of such structural or non-structural applications (excluding wood) are pre-cast technologies for roofing or flooring, pre-cast infill wall panels, composite ferrocement system, and traditional mud walling techniques. These techniques cause reduction/over-use in the volume of concrete or steel used and, at the same time, save on-site construction time. This credit takes into consideration only those materials or technologies which are not based on the utilization of fly ash. The applicant, therefore, can accredit either in the credit for utilization of fly ash or use of low-energy technologies. However, if the accreditation overlaps on the aforesaid two credits, points will be awarded to any one of them.

Box 16.2 Best practices

Stabilized compressed earth blocks are made up of mud stabilized with 5% cement lime and other materials, and compacted in block making machines with no burning. A good material for walls such as burnt bricks is economical, energy saving, and simple to manufacture. The soil to be used for the blocks should have the requisite component of clay, silt, and sand. Soil-stabilized hollow and interlocking blocks can provide better thermal insulation.

Stabilized adobe is an improvement over traditional adobe or hand-moulded and sun-dried mud block in which mud is mixed with a small proportion of cement, lime, broken or cut dry grass (as reinforcing media to impart added strength and lower the permeability). It is appropriate for dry climates.

Pre-cast stone blocks are of larger size than normal bricks. These are manufactured by using waste stone pieces of various sizes with lean cement concrete and enable a rationalized use of locally available materials. This saves on cement, reduces thickness of stonewalls, and eliminates the use of plasters on internal/external surfaces. Use native or quarried (stone where available within the delivery radius <100–150 km), which has a very less embodied energy content, negligible transport energy costs, and needs only shaping. Lightweight stone, which is made from cement and recycled aggregates or furnace clinkers, can also be a resourceful option.

Pre-cast concrete blocks are made to similar dimension of stone blocks but without large size stone pieces. These blocks use coarse and fine graded aggregate with cement. They have excellent properties comparable to other masonry block.

Pre-cast hollow concrete blocks, manufactured using lean cement concrete mixes and extruded through block-making machines of egg laying or static type, need lesser cement mortar and enable speedy construction as compared to brick

Continued...

Box 16.2 Continued...

masonry. The cavity in the blocks provide better thermal insulation and does not need external/ internal plastering. These can be used as walling block or roofing blocks along with inverted pre-cast tee beams.

Rat-trap bond is an alternative brick-bonding system for English and Flemish bond. It saves 25% of the total number of bricks and 40% of mortar.

Composite ferrocement system is simple to construct and is made of ferrocement, that is, rich mortar reinforced with chicken and welded wire mesh. This system reduces the wall thickness and allows larger carpet area. Pre-cast ferrocement units in trough shape are integrated with RCC columns. Ferrocement units serve as a permanent skin unit and a diagonal strut between columns. Inside cladding can be done with mud blocks or any locally viable material.

16.1 Commitment

16.1.1 Structural application

Use of low-energy technologies / materials (not based on the utilization of fly ash), such as roofing / flooring, columns, and load-bearing walls, for structural applications. Such technologies cause a minimum 5% (by absolute volume) reduction in the use of high-energy materials (such as cement, concrete, and steel) when compared to equivalent products for the same application for a 100% structural system used in a building, thus meeting the equivalent strength requirements.

Examples of low-energy products and technologies used in structural applications

Pre-cast / pre-fabricated technologies such as pre-stressed slab, extruded structural clay joist and filler slab, hollow floor / roof slabs, pre-cast reinforced brick / tile panels, pre-cast waffle / cored units, pre-cast in situ thin-ribbed slabs, filler slabs or burned clay filler pots with RCC structure, micro-concrete roofing, pre-cast hollow plank roofing, funicular shells, zipbloc system, composite columns, reinforced grouted brick masonry, stone masonry, pre-cast stone blocks, pre-cast concrete blocks, pre-cast finished concrete blocks, light-weight concrete blocks over dense concrete blocks, and rat trap masonry.

16.1.2 Non-structural application: masonry/infill wall system

Use of low-energy technologies / materials (not based on the utilization of fly ash) for non-structural applications. Such technologies cause a minimum 5% by absolute volume reduction in the use of high-energy materials, such as cement, concrete, and steel, when compared to equivalent products for the same application, for 100% infill wall system used in a building, meeting the equivalent strength requirements.

Examples of low-energy product and technologies in non-structural applications

Infill wall system using traditional mud walling system, stabilized adobe walling, compressed earth blocks, hollow, perforated / modular bricks, interlocking bricks, traditional stone masonry, pre-cast non-load-bearing concrete blocks, finished concrete blocks, light weight concrete blocks over dense concrete blocks, pre-cast brick panels, composite ferrocement walling, interlocking concrete blocks, rat trap masonry, and so on.

16.2 Compliance

The following documents are to be submitted.

16.2.1 Cut sheets, specification sheets and bill of quantity demonstrating the percentage reduction in high-energy materials with the use of low-energy technologies.

16.2.2 Document to demonstrate the use of the aforesaid technologies in the relevant floor plans, with clear dimensions and enlisting of specifications.

16.2.3 Narrative showing how the selected technology has amounted to reduction in high-energy materials or regional availability when compared with equivalent products for the same application. On-site photographs and construction project management plan, which would clearly demonstrate the use / construction / specifications of low-energy technologies.

16.3 Appraisal (maximum points – 4)

16.3.1 Structural application

- Use of low-energy technologies in structural application clearly demonstrating a minimum 5% reduction in high energy materials such as cement, concrete, steel, sand, and bricks by absolute volume when compared with equivalent products for the same application, for 100% structural system used in a building, meeting the equivalent strength requirements, as per all compliance clauses (2 points).

16.3.2 Non-structural application

- Use of low-energy technologies/materials (not based on the utilization of industrial waste), which are used for non-structural applications such as infill wall system and cause a minimum 5% reduction in the use of high-energy materials, such as cement, concrete, and steel, by absolute volume when compared with equivalent products for the same application, for 100% infill wall system used in a building, meeting the equivalent strength requirements, as per all compliance clauses (2 points).

Criterion 17 ▪ Use low-energy material in interiors

Objective

To use low-energy/recycled materials/finishes/products in the interiors, which minimize the use of wood as a natural resource. To use low-energy materials and products, such as composite wood products/renewable materials/reused wood/low embodied energy products/products which utilize industrial waste/recycled products.

The various interior finishes used in the sub-system of the building or the interior, which serve the aim of the credit, have been divided into the following three major categories. If any interior finish, acclaimed for credit, falls beyond this classification, the applicant has to clearly confirm the criteria that meet the requirements of the credit.

- Sub-assembly/internal partitions/interior wood finishes/panelling/false ceiling/in-built furniture/ cabinetry
- Flooring
- Doors/windows and frames

Box 17.1 Examples of low energy materials for interiors

- Composite wood products such as hardboards, blockboards, lumber-core plywood, veneered panels, particle boards, medium/low density fibreboards made from recycled wood scrap from sawmill dusts or furniture industry bonded with glue or resin under heat and pressure.
- Rapidly renewable materials/products, which are made from small diameter trees and fast growing low utilized species harvested within a 10 year cycle or shorter such as bamboo, rubber, eucrasia, eucalyptus, poplar, jute/cotton stalks. The products include, among others, engineered products, bamboo ply boards, rubber, jute stalk boards.
- Products, which utilize industrial waste such as wood waste, agricultural waste and natural fibres like sisal, coir, and glass fibre in inorganic matrices like gypsum, cement, and other binders such as fibrous gypsum plaster boards.
- Salvaged timber and reused wood products such as antique furniture.
- Low embodied energy products, which use recycled materials like glass, crushed stone, and other waste, such as terrazzo, or which are resource efficient finishes such as finished concrete flooring, ceiling tiles, and ceramic tiles.

17.1 Commitment

A minimum of 70% of the total quantity of all interior finishes and products used in each of the categories mentioned above should be low-energy finishes/materials/products, which minimize wood as a natural resource or utilize industrial waste by using products in any category as listed in Box 17.1.

17.2 Compliance

The following documents are to be submitted.

17.2.1 Cut sheets, specification sheets, commercial brochures or certificate from the manufacturer of the low energy finishes or products used in each category.

17.2.2 For each category, clearly demonstrate and differentiate the use of the aforesaid finishes/products in the relevant interior layouts/plans in a CAD drawing, either by shading, rendering or highlighting with clear dimension and enlisting specifications.

17.2.3 The bill of quantity for each of the category, as applicable to the applicant, clearly demonstrating that minimum 70% of the total quantity of all interior finishes and products are low energy.

17.2.4 A narrative and photographs showing how the selected low-energy finishes or products have minimized wood as natural resource or utilized low energy material and products, when compared with equivalent products for the same application.

17.2.5 Certificate from architect/interior designer for use of low-energy material/ product in various categories meeting required criteria as described in the Commitment.

17.3 Appraisal (maximum points – 4)

A minimum of 70% of the total quantity (gross area) of all interior finishes and products used for each of the category, as applicable, to be low- energy finishes, for each of the following category.

17.3.1 Sub-assembly/internal partitions/panelling/false ceiling/in-built furniture (2 points), as per clauses 17.2.1–17.2.5.

17.3.2 Flooring (1 point), as per clauses 17.2.1–17.2.5.

17.3.3 Doors/windows and frames (1 point), as per clauses 17.2.1–17.2.5.

Criterion 18 ▪ Renewable energy utilization

Objective

To use renewable energy sources in buildings to reduce the use of conventional/fossil-fuel-based energy resources (Box 18. 1).

Box 18.1 Use of renewable energy sources

Renewable energy sources can provide the energy required for meeting the building energy demand. These sources are environmentally clean and non-exhaustible. Natural sources of energy, such as solar, wind, hydropower, tidal energy, ocean thermal, and hydrogen, are all renewable energy sources. Projected availability of fossil fuels in future and environmental degradation (including global warming) associated with usage of these fuels are the driving forces for increasing use of renewable energy.

18.1 Commitment

18.1.1 Energy requirement for a minimum 10% of internal lighting load (for general lighting) or its equivalent is met from renewable energy sources (solar, wind, biomass, fuel cells, and so on). Calculations of energy requirements shall be based on realistic assumptions, which are subject to verification.

18.1.2 On-site renewable energy system sized to meet the minimum of the above load. Feasibility of the proposed renewable energy system to be verified by the competent authority.

Note Internal lighting load is the total connected load in kW (kilowatts) for lighting equipment (lamp and accessories). In case it is proposed to use renewable energy sources for applications other than lighting, the criterion of energy consumption equivalent of energy consumption of 10% of lighting load should still be met. This shall, however, exclude the water heating loads for which each separate criterion applies.

18.2 Compliance

The following documents should be submitted.

18.2.1 Detailed listing of connected load for lighting in format as in Table 18.1.

18.2.2 Calculation of connected load for lighting and energy requirement for the same.

18.2.3 List of all loads that are being powered by renewable energy sources (other than lighting load) and their energy requirements.

18.2.4 Design calculations for renewable energy system sizing and performance including annual energy generation.

18.2.5 Cut sheets of renewable energy systems with necessary details.

18.2.6 Drawings in CAD format to show location of renewable energy systems.

18.3 Appraisal (maximum points – 3)

18.3.1 Rated capacity of proposed renewable energy system is equal to or more than 1% of internal lighting and space conditioning connected loads or its equivalent in the building (1 point–mandatory), as per all compliance clauses.

18.3.2 Rated capacity of proposed renewable energy system meets annual energy requirements of equal to or more than 5% of internal lighting connected loads or its equivalent in the building (1 point), as per all compliance clauses.

18.3.3 Rated capacity of proposed renewable energy system meets annual energy

Table 18.1 Detailed listing of connected load for lighting

Code	Luminaire		Lamps			Ballast			Luminaire wattage
	Make	Description	Type	Make	Wattage	Type	Make	Power loss (W)	(lamp + ballast)
A-1	Philips	TBC-22	CFL	Philips	10	Electronic	Philips	2	12

requirements of equal to or more than 10% of internal lighting connected loads or its equivalent in the building (1 point), as per all compliance clauses.

18.3.4 Rated capacity of proposed renewable energy system meets annual energy requirements of equal to or more than 20% of internal lighting connected loads or its equivalent in the building, as per all compliance clauses (2 points).

18.3.5 Rated capacity of proposed renewable energy system meets annual energy requirements of equal to or more than 30% of internal lighting connected loads or its equivalent in the building, as per all compliance clauses (3 points).

Note Lighting design shall be based on minimum requirements as per *NBC 2005* (BIS 2005d) (criterion 12.1.5).

Criterion 19 ▪ Renewable-energy-based hot water system

Objective

To use renewable energy sources to meet the hot-water requirement.

Box 19.1 Guidelines

Guidelines for sizing, installation, and use of solar collectors

- Solar collectors should face south for maximum solar radiation collection.
- The solar collector tilt should be equal to the latitude of the place for maximum annual energy collection.
- The solar collector tilt should be equal to latitude + 15^0, gives maximum energy collection in winter.
- The solar collector tilt should be equal to latitude -15^0, gives maximum energy collection in summer.
- Always check the load carrying capacity of the roof before placing the solar collector. Typically, each solar collector of 2 m^2 area weighs 50 kg. The solar tank, when filled with water, weighs 1.2–1.4 kg per litre capacity of tank. (For example, 100 litre capacity tank weighs 120 kg)
- Ensure proper anchoring of the system duly considering wind conditions.
- Solar collectors and tank must be easily accessible for cleaning and maintenance.
- A typical solar collector needs 1.3–1.5 times the collector area for installation. For example, a single collector system of 100-litre capacity, having 2 m^2 area, requires an area of 3 m^2 for installation.

Guidelines for solar collector selection and use

- Check hardness of water to be used in solar system/collector?. Solar collectors have small diameter pipes, which get chocked due to deposition of salt from hard water. In case of hard water, either water softener or heat-exchanger-type solar water heater should be used.
- It is a good practice to consider solar collector location and optimize the associated hot/cold water piping layout during the building design stage to reduce the cost and heat losses due to longer piping.
- Always use good quality and long lasting pipes and insulation for trouble-free working.
- It's important to check operating pressure of supply of cold water line, especially when pressurized water is circulated. Most solar systems available in India are not designed for pressurized water supply.
- Ensure continuous supply of water to the solar system for efficient and trouble-free operations.
- When not in use, during long periods always cover the solar collectors with non-transparent covers (such as an old bed sheet or jute cloth)/ to avoid overheating of solar system).
- It is a good practice to use the entire hot water at a time.
- Avoid using back up heater. Do not keep back-up heater switched on.
- Set the thermostat of back-up heater at 55–60 °C.
- Use proper vent or vacuum release valve and pressure relief valve for safe operation of solar system.
- Human body can tolerate temperature up to 45 °C. Human skin burns at water temperature above 55 °C. Storage water heater temperature can be set at 55 + 5 °C.

Guidelines for system sizing

- Typically, a solar hot water system is sized to meet one day's requirement of hot water during winter. Typical hot water consumptions for various activities are given below. These can be used as guidelines for calculating total hot water requirement. (The consumption figures may vary depending on life style, age, habits, and weather conditions.)
- For bathing using bucket water = 15 litre per person per day (one bucket).
- For shower bath = 25 litre per person per day.
- For bathtub = 35–50 litre per person per day.
- For cooking = 5 litre per person per day.
- For washing clothes = 10 litre per person per day.
- For washing utensils and other purposes = 5 litre per person per meal.
- For making tea/coffee = 150 ml per person per cup

19.1 Commitment

19.1.1 Ensure that a minimum 50% of the annual energy requirement for heating water (for applications such as hot water for all needs, like for canteen, washing, and bath rooms/toilets, except for space heating) is supplied from renewable energy sources.

19.2 Compliance

The following documents are to be submitted.

19.2.1 Detailed calculations of hot water requirements.

19.2.2 Detailed calculations on energy required for heating water for all needs except for space heating (in kWh or litres of fossil fuel).

19.2.3 Detailed design calculations for renewable energy system sizing and performance including annual energy generation.

19.2.4 Layout of the proposed renewable energy system.

19.2.5 Test reports from approved test centre for system performance and efficiency.

19.3 Appraisal (maximum points – 3)

19.3.1 Annual energy saved by proposed renewable energy system is 20% to 50% of annual energy required for water heating to meet the hot water requirements of the occupants in the building, as per all compliance clauses (1 point).

19.3.2 Annual energy saved by proposed renewable energy system is 50% to 70% of annual energy required for water heating to meet the hot water requirement of the occupants in the building, as per all compliance clauses (2 points).

19.3.3 Annual energy saved by proposed renewable energy system is more than 70% of annual energy required for water heating to meet the hot water requirements of the occupants in the building, as per all compliance clauses (3 points).

Recycle, reuse, and recharge of water

Recycle and reuse of resources enables us to reduce pressure on our valuable natural resources. Recycling of resources and putting these back into use for the building is significant.

Criterion 20 ▪ Waste-water treatment

Objective

To provide facility for the treatment of waste water generated in the building so as to have safe disposal and use of by-products (Box 20.1).

Box 20.1 Guidelines

Grey water: Any water used in households, except water from toilets, is called grey water. This includes washings from shower, sink, kitchen sinks, and laundry water. This can be reused for various applications, especially landscape irrigation.

Black water: Refers to sewage water from toilets.

Sewage treatment plants based on biological processes are commonly used for treatment of waste water that includes both grey water and black water. These are dependent on natural microorganisms, which utilize oxygen and the organic contaminants in the waste water to generate CO_2, sludge, and treated water. In the treatment systems, microorganisms exist in suspended form (for example, in an aeration tank, microbes are present freely in waste water without any support) or attached form (such as reed bed systems, where microbes are attached to the roots of plants, sand, and gravel). These systems normally require a pre-treatment step such as a settlement chamber before the aeration unit. Artificial wetlands or reed bed systems, which are based on natural processes, are beneficial due to simple and low O&M cost.

20.1 Commitment

20.1.1 Provide necessary treatment of waste water for achieving the desired concentrations for disposal.

20.1.2 Carry out water testing for various parameters prescribed in the Pollution Control Acts, Rules and notifications, CPCB, 1998, for disposal in surface water and on land.

20.2 Compliance

20.2.1 Narrative on the type of treatment system being employed. Drawings with specifications of the system indicating the capacity of water treated.

20.2.2 Indicate the quantum of treated water generated along with the use/disposal steps.

20.2.3 Provide the characteristics of waste water and expected characteristics after treatment from the supplier (Table 20.1).

20.2.4 Quality checking frequency and sampling plan of the treatment plant (Table 20.2).

20.2.5 Narrative on disposal and reuse of other by-products such as sludge.

Table 20.1 Characteristics of waste water before and after treatment

Parameter	Before treatment	After treatment
Dissolved oxygen (mg/litre)		
Biological oxygen demand (mg/litre)		
Total coliform bacteria (MPN/100 ml)		
Total dissolved solids (mg/litre)		
Chloride as chlorine (mg/litre)		
Colour		
Boron (mg/litre)		
Sulphates (mg/litre)		
pH		
Arsenic (mg/litre)		
Fluorides (mg/litre)		
Iron (mg/litre)		
Copper (mg/litre)		
Lead (mg/litre)		

MPN – most probable number

Table 20.2 Annual testing plan and frequency

Date	Volume of sample	Sample collection site		Others (example, storage)	Test lab. name
		Inlet	Outlet		

20.3 Appraisal (maximum points – 2)

20.3.1 Treated water should meet the disposal standards (2 points).

Table 20.3 Maximum permissible limits (mg/litre) for effluent discharges

Parameter	Into inland surface waters Indian Standards: 2490 (1974)	Into public sewers Indian Standards: 3306 (1974)	On land for irrigation Indian Standards: 3307 (1974)
pH	5.5.–9.0	5.5–9.0	5.5–9.0
Biological oxygen demand (for five days at 20 °C)	30	350	100
Chemical oxygen demand	250	–	–
Suspended solids	100	600	200
Total dissolved solids (inorganic)	2100	2100	2100
Temperature (°C)	40	45	–
Oil and grease	10	20	10
Phenolic compounds	1	5	–
Cyanides	0.2	2	0.2
Sulphides	2	–	–
Fluorides	2	15	–
Total residual chlorine	1	–	–
Pesticides	–	–	–
Arsenic	0.2	0.2	0.2
Cadmium	2	1	–
Chromium (hexavalent)	0.1	2.0	–
Copper	3	3	–
Lead	0.1	1.0	–
Mercury	0.01	0.01	–
Nickel	3	3	–
Selenium	0.05	0.05	–
Zinc	5	15	–
Chlorides	1000	1000	600
Boron	2	2	2
Sulphates	1000	1000	1000
Sodium (9%)	–	60	60
Amoniacal nitrogen	50	50	–
Radioactive materials			
Alpha emitters (milli-curie/ml)	10^{-7}	10^{-7}	10^{-8}
Beta emitters (micro-curie/ml)	10^{-6}	10^{-6}	10^{-7}

Source CPCB (1998)

Criterion 21 ▪ Water recycle and reuse (including rainwater)

Objective

To utilize the treated waste water and rainwater for various applications (including groundwater recharge) where potable municipal water is normally used to reduce the load on both the municipal supplies as well as the sewerage system and to improve the groundwater level (Box 21.1).

Box 21.1 Guidelines

Grey water from bathrooms, kitchens, and other washings can be suitably treated and reused for non-potable applications such as irrigation and flushing. Separation of the grey water from black water by installation of dual plumbing lines at the time of construction is economical.

Rainwater can be harvested from rooftops, paved and unpaved areas, storm water drains, and water bodies. The basic components of a rainwater-harvesting system include the following.

- Catchment – surface where water falls directly (terrace, lawn, open ground, and roof).
- Coarse mesh – to prevent the debris from entering the water.
- Gutters – to collect and transport water to storage tank (galvanized iron sheet or PVC material).
- Conduits – pipelines or drains to carry water from the surface to storage.
- Filter – to remove suspended pollutants from rainwater collected (sand filter and charcoal filter).
- Storage – tanks of any shape and size depending on the capacity of rainwater that can be collected.

The basic concept of storing and recharging of water

The recharging or storing of water depends on the rainfall of a particular region, and the sub-surface geology. In regions where the rainy season lasts for three to four months, groundwater recharge is beneficial rather than storage, as the storage cistern would remain empty during other parts of the year. In places where the surface is impermeable and groundwater is saline or not of potable quality, it is not advisable to go for groundwater recharging.

Recharging can be done through dugwells, borewells, recharge trenches, and recharge pits. Filter material at the entry point is essential to maintain the quality of water. A settlement tank acts as a buffer to hold the surplus water during the course of excess rainfall.

Infiltration techniques

Trenches filled with rocks receive storm water run-off from grass swales and water percolates through the void space of rocks into soil.

Biofiltration swale/grass swale is a vegetated channel with slope less than 0.6%, so as to increase the flow residence time, increase the pollutant (suspended solids and trace metals) removal efficiency by effective infiltration, and reduce run-off.

Sand filter

Use of sand layer for filtering the storm water into drainage facility before storage in detention basins. This results in removal of total suspended solids. The efficiency is higher if the pre-treatment is achieved through trench and grass swales.

Detention basins

Wet ponds: constructed ponds to retain the filtered storm water.

Storm water wetlands: wet ponds integrated with wetland plants, which will also facilitate storm water treatment.

Wet vaults and storage tanks: underground storage facilities in reinforced cement concrete used for irrigation at a later stage.

Estimate the capacity of water that can be tapped after accounting for losses.

Design of capacity of water harvesting pond/ storage facility from the site for irrigation of landscape

To calculate the amount of rainwater that can be collected in any detention basin, the following data is required.

- Rainfall data for the area under consideration
- Area of the catchment feeding rainwater to the basin

Once the above data is available; calculate the total quantity of rainfall falling on the catchment (Equation 1).

Continued...

Box 21.1 Continued...

Collection (kilolitre) = Rainfall (m) × area of each catchment surface (m^2) × run-off coefficient of surface type ...(1)

Losses during and after collection due to evaporation and percolation are subtracted from the collection figure. Rainfall data is collected from local meteorological department and then tabulated for each month of the year.

Accumulation of rainwater on a monthly basis. Run-off for each surface – namely, roof, paver, gravel, forest, field, court, lawn, and water – is calculated according to the percentage of water withheld. The withheld water is eventually lost to percolation and evaporation. Maximum possible rainwater collection is calculated for each month by multiplying the run-off factor with the total quantity of rainfall falling on the catchment.

Source ICAEN (2004a) and <www.rainwaterharvesting.org>

Table 21.1 Run-off coefficients for surplus rainwater

Surface type	Run-off coefficient
Roofs conventional	0.95
Concrete/kota paving	0.95
Gravel	0.75
Brick Paving	0.85
Vegetation	
1%–3%	0.20
3%–10%	0.25
>10%	0.30
Turf slopes	
0%–1% 0.25	
1%–3% 0.35	
3%–10%	0.40
>10%	0.45

21.1 Commitment

21.1.1 Provide necessary treatment of waste water for achieving the desired composition for various applications (Boxes 28.1 and 28.2, and Table 28.3)

21.1.2 Implement rainwater harvesting and storage systems depending on the site-specific conditions. All necessary steps to prevent possible contamination of ground water by rainwater harvesting should be taken (design requirements as per Central Ground Water Board). This is a mandatory requirement.

21.1.3 Reuse the treated wastewater and rainwater for meeting the building water and irrigation demand.

21.1.4 Recharge the surplus water (after reuse) into the aquifer.

21.2 Compliance

The following documents are to be submitted.

21.2.1 Narrative along with drawings and specifications of the type of treatment and harvesting system being employed.

21.2.2 Drawings indicating the specifications of dual plumbing system.

21.2.3 Documents indicating the projected quality of water, as per specifications.

21.2.4 Drawings with specifications of the systems, along with delivery lines, indicating the capacity of water treated and harvested.

21.2.5 Calculation sheet (Table 21.2) representing the total quantity of water treated and harvested and the amount being used for different applications including use within the building, landscape, and fraction recharged into ground.

21.2.6 Details of filtration system to show that adequate preventative measures are being taken to avoid contamination of aquifer by the recharged rainwater (mandatory).

21.3 Appraisal (maximum points – 5)

21.3.1 Annual water reuse of 25%, as per clause 21.2.5 (1 point).

21.3.2 Annual water reuse of 50%, as per clause 21.2.5 (1 point).

21.3.3 Annual water reuse of 75%, as per clause 21.2.5 (1 point).

21.3.4 Recharge of surplus rainwater into aquifer, as per Table 21.2 (2 points).

Table 21.2 Water reuse datasheet

Month	Quantity of water treated (kilolitres)	Quantity of water harvested (kilolitres)	Water requirement of the building (kilolitres)	Landscape water demand (kilolitres)	Water reused for building (kilolitres)	Water reused for landscape (kilolitres)	Water recharged (kilolitres)	Water reuse (%)	Water recharge (%)
	A	B	C	D	x	y	z	(x + y)/ (C + D) × 100	(z/B) * 100
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

Waste management

Criterion 22 ▪ Reduction in waste during construction

Objective

To ensure maximum resource recovery and safe disposal of wastes generated during construction, and to reduce the burden on the landfill.

Box 22.1 Most commonly found toxic wastes on a building construction site

- Asbestos products – insulation, tiles, and so on.
- Fuels and heating oils and other volatile/ flammable liquids, such as coolants and grease.
- Tar and tar products (such as bitumen, felt, and water proofing compounds)
- Centering oil and formwork oil
- Wood dust
- Lead
- Plastics, acrylics, silica, and PVC
- Hazardous gases released on burning of waste
- Chemical admixtures, sealants, adhesives solvents, among others (should never be burnt)
- Paints, pigments, dyes, and primers
- Carbon black
- Pesticides
- Tarpaulin
- Explosives and related products and equipment used in excavations
- Product packaging (such as cement bags, cartons, containers, and plastic covers)
- Compressed gases/cylinders
- H_2S emission
- Mercury containing lamps and tubes – fluorescent lamps intact and crushed, halogen lamps, arc lamps, UV lamps, high-pressure sodium lamps, mercury vapour lamps, neon lamps, and incandescent lamps.
- Mercury containing devices – mercury switches, relays, regulators, thermostats, thermometers, manometers and debris containing mercury
- All types of batteries
- Electronic ballasts, PCBs, transformers, capacitors, switchgear, lead cable, and oil-filled/gel-filled cables.
- Electronic waste – computer products, circuit boards, CRTs, electronic parts, solder dross, and weld waste.

22.1 Commitment

22.1.1 Employ measures to segregate the waste on-site into inert, chemical or hazardous wastes.

22.1.2 Recycle the unused chemical/ hazardous wastes such as oil, paint, batteries, and asbestos.

22.1.3 Inert waste to be disposed off by municipal corporation/local bodies at landfill sites.

22.2 Compliance

The following documents are to be submitted.

22.2.1 Narrative indicating the quantum of waste generated during the construction activity, and the storage facility for segregated inert and hazardous waste before recycling and disposal

22.2.2 Layout (showing the location) and photo of the storage facility for segregated inert and hazardous waste. The capacity of the storage facility has to be provided.

22.3 Appraisal (maximum 2 points)

22.3.1 Segregation of inert and hazardous wastes, as per clause 22.2 (1 point).

22.3.2 Recycling and safe disposal of segregated wastes, as per clause 22.2 (1 point).

Criterion 23 ▪ Efficient waste segregation

Objective

To promote the segregation of waste for efficient resource recovery.

Box 23.1 Waste segregation

Composition of municipal solid waste indicates the percentage of biodegradable fraction as 52. Plastics and paper constitute 8% of the total municipal solid waste. It is clear from the composition that a combination of technologies is essential for managing waste efficiently. For this, the waste segregation at the source is the most important step. To facilitate this, a multi-bin system should be arranged for storing biodegradable waste (such as food leftovers, vegetable, and fruit peels), non-degradable waste (such as metal scrap and rubber) and recyclable wastes (such as paper and plastics). These bins should be in different colours to facilitate the disposal.

23.1 Commitment

23.1.1 Use different coloured bins for the collection of different categories of waste from the building (Box 23.1).

23.2 Compliance

The following documents are to be submitted.

23.2.1 Narrative along with photographs/ plan indicating space, locations, and capacity for multi-coloured bins.

23.3 Appraisal (maximum points – 2)

23.3.1 Provision of multi-coloured bins for waste segregation at source (2 points).

Criterion 24 ▪ Storage and disposal of wastes

Objective

To prevent the mixing up of segregated waste before processing or disposal.

Box 24.1 Waste storage and disposal

In addition to the segregation of wastes at the source, it is essential to provide for their storage before the appropriate disposal, which includes transportation to the recycling centres, the common collection centre of the local municipality, and the decentralized system in the locality. The storage facility should not create any unhygienic conditions. The capacity of the facility should be designed so as to accommodate the entire waste from the building depending on the population, the type of waste generated, and the frequency of waste removal from the site.

24.1 Commitment

24.1.1 Allocate a separate space for the collected waste before transferring it to the recycling / disposal stations.

24.2 Compliance

The following documents are to be submitted.

24.2.1 Narrative along with photographs / plan indicating space, locations, and capacity of the storage area.

24.3 Appraisal (maximum points – 2)

24.3.1 Provision of space for hygienic storage of segregated waste, as per clause 24.2 (2 points).

Criterion 25 ▪ Resource recovery from waste

Objective

To maximize the recovery of resources from the recyclable and biodegradable waste and to reduce the burden on landfills.

Box 25.1 Guidelines

The municipal solid wastes contain useful resources that can be recovered after recycling or after biological processing. Recycling and further processing would reduce the waste going to landfills and is beneficial due to the resource generation.

Most non-biodegradable wastes, such as plastics, old papers, newspapers, glass, cardboard, and metal scraps, can be recycled. Biodegradable wastes (such as food waste and horticulture), and other organic wastes can be processed through techniques such as composting or anaerobic digestion. Processed waste paper is converted into sheets of recycled paper, which can be sold to newspaper agencies. Glass and plastics can be converted into various household goods.

Horticulture wastes such as grass trimmings, leaves, and vegetable wastes can be composted in pits or heaps. Sufficient care should be taken to prevent pollution due to leachate generation, odour, flies, and bird menace by providing cover to the area. The compost generated should meet the standards prescribed in *Management and Handling Rules, 2000* of the MoEF.

Food wastes and other organic wastes, including the garden wastes, can also be processed through anaerobic digestion to generate biogas that can be used for cooking applications in place of liquefied petroleum gas. In addition, the digested sludge from the bio-digester has a good manure value.

25.1 Commitment

25.1.1 Employ resource recovery systems for biodegradable waste as per the *Solid Waste Management and Handling Rules, 2000* of the MoEF.

25.1.2 Arrangement for recycling of waste through local dealers.

25.2 Compliance

The following documents are to be submitted.

25.2.1 Narrative indicating the plan and arrangement with local dealers for recycling of materials generated.

25.2.2 Details of plan and design of the waste treatment plant along with capacity for the disposal of biodegradable waste.

25.2.3 Narrative indicating the generation and reuse of by-products from the waste treatment plant.

25.3 Appraisal (maximum points – 2)

25.3.1 Zero waste generation through appropriate resource recovery measures as per clauses 25.2.1, 25.2.2, and 25.2.3 (2 points).

Health and well-being

Building construction and its operation affects the health and well-being of people in many ways. Green building practices and measures should be integrated into the design process to ensure the health and well-being of the occupants.

Criterion 26 ▪ Use low-VOC paints/adhesives/sealants

Objective

Building materials such as paints, sealants, and adhesives form important finishes for the exterior and interior surfaces. They are, however, potential contributors to the poor indoor air quality and can have a bearing on an occupants' health. A wide variety of volatiles are released through oxidation by both solvent-based and water-based paints, and sealants and adhesives contain toxic chemicals that are released during construction and occupancy.

VOCs – especially formaldehyde, urea formaldehyde, and urethanes – and other chemical substances contained within the building materials can be injurious to health and can also be odorous. This measure aims to select materials with low to zero quantities of such chemicals so as to minimize the source of emission. In selecting low VOC materials, a practical thumb rule is to choose water-based products with low odour.

26.1 Commitment

26.1.1 Use only zero/low VOC paints. All paints used in the interior of the building must be certified to contain zero VOC or less than the limits specified as follows.

Table 26.1 VOC limits for paints

Paint applications	*VOC limits* (g of VOC per litre)	
Interior coatings	Flat	<50
	Non-flat	<150
Exterior coatings	Flat	<200
	Non-flat	<100
Anti corrosive	Gloss/semi gloss/flat	<250

26.1.1 Prefer water-based acrylics over solvent-based oil paints.

26.1.2 Ensure all the sealants and adhesives used are water based rather than solvent based or have a low solvent content. Most construction adhesives offer adequate bond strengths in water-based varieties. Acrylics, silicones, and siliconized acrylics are the safest sealants for use in the interiors and have the lowest solvent content. While solvent-based products, such as urethanes and butyls, should preferably not be used indoors, sealants used for exterior do not pose any concern.

26.1.3 Adhesives usually have a high-VOC emission potential. Hence, use adhesives with low-VOC or no-VOC emissions such as acrylics or phenolic resins (phenol formaldehydes indoors).

26.1.4 Ensure all the composite wood products/agri-fibre products do not contain any added urea formaldehyde resin.

26.2 Compliance

The following documents should be submitted.

26.2.1 Cut sheets, specification sheets, and commercial brochures of the low VOC-emission finishes or products used.

26.2.2 A certificate from the manufacturer for each of the category as applicable to the applicant, clearly stating that the materials used have zero VOCs or low VOCs (gms/litre), as specified under limits.

26.2.3 The bill of quantity for each of the category, as applicable, clearly demonstrating that 100% of all the interior paints, sealants, adhesives, and composite wood/agri-fibre products meet the mentioned criteria.

26.3 Appraisal (maximum points – 4)

26.3.1 *Zero/low-VOC paints:* Zero/low-VOC paints for 100% of all paint used in the interior of the building (2 points), as per clauses 26.2.1, 26.2.2, and 26.2.3.

26.3.2 *Low-VOC sealants and adhesives:* 100% of all the sealants and adhesives used are water based rather than solvent based/low in solvent content, as per clauses 26.2.1, 26.2.2, and 26.2.3 (1 point).

26.3.3 100% of composite wood products with no urea–formaldehyde resins, as per clauses 26.2.1, 26.2.2, and 26.2.3 (1 point).

Criterion 27 ▪ Minimize ozone depleting substances

Objective

Eliminate or control the release of ozone-depleting substances into the atmosphere. The ozone depleting materials commonly used in buildings are CFCs or HCFCs in refrigeration and air-conditioning systems, halons in fire suppression systems and extinguishers, and in insulation.

Box 27.1 Ozone depleting substances

Substances containing chlorine (or bromine) contribute to the breakdown of the ozone layer in the stratosphere, resulting in harmful UV radiation reaching earth's surface, and thus contributing to global climate change. Such substances are mainly used in refrigerating and air-conditioning equipment, fire suppression systems and extinguishers, and in insulation. This has been a growing cause for concern. Therefore, continued efforts are being made globally (in the form of international agreements) to minimize the use of ozone depleting substances, and gradually to replace them with environmentally friendly substances.

Trichlorofluoromethane (R11) is used as reference for measuring the ODP (ozone depleting potential) of a substance. The ODP of R11 is 1. The OPD of some of the commonly used substances in refrigerating and air-conditioning equipment are listed in the Table 27.1.

Table 27.1 Ozone depleting potential of some commonly used substances

Substance	ODP
R11	1
R12	0.9
R22	0.05
R134a	<0.0005
R143a	0
R717 (ammonia)	0
R744 (CO_2)	0

ODP – ozone depleting potential

27.1 Commitment

27.1.1 Use insulation with zero-ODP (ozone depletion potential) such as HCFC-free rigid foam insulation, mineral fibre cellulose insulation, glass fibre, wood fibre board, cork wool, expanded (bead) polystyrene, recycled newspaper, and jute and cotton. Avoid materials that do not inherently have a zero-ODP, such as polyurethane foams and polyisocyanurates.

27.1.2 Install CFC-free equipment for refrigeration and air conditioning.

27.1.3 Install halon-free fire suppression systems and fire extinguishers in the building.

27.2 Compliance

Following documents are to be submitted.

27.2.1 A certificate from the manufacturer/supplier, signed by the architect or the engineer, stating that 100% of the insulation used in the building is free of CFCs and HCFCs.

27.2.2 The bill of quantity clearly demonstrating that 100% or total quantity of all the insulation used in the building is free of CFCs and HCFCs.

27.2.3 A certificate from the HVAC consultant or supplier, signed by the architect or the engineer, stating that the HVAC and refrigeration equipments/systems installed in the building are free of CFCs.

27.2.4 A list showing each type of HVAC and refrigeration equipments/systems, their numbers and type of refrigerant used along with the manufacturers' brochures clearly stating the type of refrigerant being used in their products.

27.2.5 A certificate from the fire-fighting-service consultant or the equipment supplier, signed by the architect or the engineer, stating that the fire suppression systems and fire extinguishers installed in the building are free of halon.

27.3 Appraisal (maximum points – 3)

27.3.1 All the insulation used in building are CFCs and HCFCs free, as per clauses 27.2.1 and 27.2.2 (1 point).

27.3.2 All the HVAC and refrigeration equipment are CFCs free, as per clauses 27.2.3 and 27.2.4 (1 point).

27.3.3 The fire suppression systems and fire extinguishers installed in the building are free of halon, as per clause 27.2.5 (1 point).

Criterion 28 ▪ Ensure water quality

Objective

To provide the occupants of the building with good quality water as prescribed by local codes and standards and optimal use of water treatment measures.

Box 28.1 Critical parameters

COD (chemical oxygen demand) is the amount of oxygen required for the complete oxidation of biologically degradable and non-biodegradable organic matter.

BOD (biochemical oxygen demand) is the quantity of oxygen required by the aerobic microorganisms to stabilize organic matter.

Hardness of water is caused by dissolved polyvalent, especially divalent metallic ions like Ca^{+2} and Mg^{+2}. Iron, strontium, barium, and manganese also contribute to hardness. The degree of hardness has been classified as soft, medium, hard, and very hard, based on the $CaCO_3$ concentration.

Coliform bacteria are organisms that are present in the environment and in the faeces of all warm-blooded animals and humans. The presence of coliform bacteria in drinking water indicates that disease-causing organisms (pathogens) may be present in the water system. If it is detected in water, the source of contamination should be identified and the water quality should be restored.

Source <http://www.doh.wa.gov/ehp/dw/programs/coliform.htm>

Box 28.2 Various treatment techniques

One of the options for providing quality water at low cost is to use 'package plants'. Package plants consist of various components of the treatment process (such as chemical feeders, mixers, flocculators, sedimentation basins, and filters) in a compact assembly. As these units are assembled based on the standard designs, they are cheaper as compared to those built on-site.

Slow sand filtration is a technique, which is low energy consuming and does not require high-end technical expertise to operate.

Water-treatment systems based on ion exchange and reverse osmosis can provide high quality water after removal of heavy metals, suspended solids, and so on.

Source <http://www.oasisdesign.net/water/treatment/slowsandfilter.htm> and <http://www.aquatech.com/custom.htm>

28.1 Commitment

28.1.1 Ensure water from all sources (such as groundwater and municipal water) meets the water quality norms as prescribed in the IS for various applications (*Indian Standards for drinking [IS 10500–1991], irrigation applications [IS 11624-1986]).*

Note In case the water quality cannot be ensured, provide necessary treatment of raw water for achieving the desired concentrations for various applications.

28.2 Compliance

28.2.1 Provide water optimization plan (water flow diagram giving the complete collection, treatment, and distribution for different applications).

28.2.2 Provide the water quality details from various sources before and after treatment (Table 28.1).

28.2.3 Report/certificate from the local municipal authority for municipal water.

28.2.4 Provide the specification details indicating the capacity and components of the treatment plant along with drawings (product details from the manufacturer).

28.2.5 Quality checking frequency and sampling plan (Table 28.2) (signed template shall be provided).

Table 28.1 Testing of water quality before and after treatment

Parameter	Before treatment	After treatment
Dissolved oxygen (mg/litre)		
Biological oxygen demand (mg/litre)		
Total coliform bacteria (MPN/100 ml)		
Total dissolved solids (mg/litre)		
Chloride as chlorine (mg/litre)		
Colour		
Boron (mg/litre)		
Sulphates (mg/litre)		
Nitrates (mg/litre)		
pH		
Arsenic (mg/litre)		
Fluorides (mg/litre)		
Iron (mg/litre)		
Copper (mg/litre)		
Lead (mg/litre)		
Zinc (mg/litre)		

MPN – most probable number

Table 28.2 Annual testing plan and frequency

Date	Volume of sample (ml)	Sample collection site			Test lab. name
		Inlet	Outlet	Other	

28.3 Appraisal (maximum points – 2)

28.3.1 Water quality conforming to IS standards, as per clauses 28.2.1–28.2.5 (2 points).

Table 28.3 Water quality standards for various applications

Parameter	Drinking water (IS 10500:1991)	Irrigation, industrial cooling, and so on
Total hardness (as $CaCO_3$) (mg/litre)	300	—
Total dissolved solids (mg/litre)	500	2100
Chlorides as chlorine (mg/litre)	250	500
Colour (hazen)	5	—
Turbidity (NTU)	5	
Alkalinity (mg/ litre)	200	
Calcium (as Ca), mg/litre	75	
Boron (mg/litre)	1	2
Sulphates (as SO_4)(mg/litre)	200	1000
Nitrates (as NO_3) (mg/litre)	45	–
Conductivity at 25 °C (us/cm)	–	2.25
pH	6.5–8.5	6.0–8.0
Anionic detergents as MBAS (mg/ litre)	0.2	–
Arsenic (mg/litre)	0.05	–
Iron (mg/litre)	0.3	–
Fluorides (mg/litre)	1	–
Lead (mg/litre)	0.05	–
Copper (mg/litre)	0.05	–
Zinc (mg/litre)	5	–
Phenolic compounds (as C_6H_5OH) (mg/litre)	0.001	–
Cyanide (mg/litre)	0.05	–
Chromium (mg/litre)	0.05	–

Criterion 29 ▪ Acceptable outdoor and indoor noise levels

Objective

To use appropriate noise controls for providing acceptable levels of outdoor and indoor noise levels to enhance comfort.

29.1 Commitment

29.1.1 Ensure that the outdoor noise level conforms to the CPCB–Environmental Standards–Noise (ambient standards) as given in Table 29.1.

Table 29.1 Noise (ambient standards)

Area code	Area category	Limit in dB (A) Leq	
		Day time	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence zone	50	40

Notes
- Day time is reckoned between 6 a.m. and 9 p.m.
- Night time is reckoned between 9 p.m. and 6 a.m.
- Silence zone is defined as areas up to 100 m around such premises as hospitals, educational institutions, and courts. The silence zones are declared by a competent authority.
- Mixed categories of areas should be declared as 'one of the four above mentioned categories by the competent authority' and the corresponding standards shall apply.

29.1.2 Ensure that the indoor noise levels conforms to the levels described in the *NBC 2005* (BIS 2005a) as given in Table 29.2.

Table 29.2 Acceptable indoor noise levels for various buildings

Location	Noise level dB (A)
Auditoria and concert hall	20–25
Radio and television studios	20–25
Music rooms	25–30
Hospitals and cinema theatres	35–40
Apartments, hotels, and homes	35–40
Conference rooms, small offices and libraries	35–40
Court rooms and class rooms	40–45
Large public offices, banks, and stores	45–50
Restaurants	50–55

29.2 Compliance

The following documents are to be submitted.

29.2.1 The report on measured average ambient noise level at site. Noise measurement should be conducted by an organization recognized by a competent authority and it should follow procedures laid down by a competent authority.

29.2.2 The building site plan duly signed by the architect/applicant showing all the measures to control outdoor noise.

29.2.3 The drawings and narratives showing measures as described in NBC 2005 (BIS 2005a), to control indoor noise.

29.2.4 Cut sheets, specification sheets, commercial brochures of the sound absorbent materials, and bill of quantity demonstrating the use of sound absorbent materials in the building design.

29.2.5 The report on measured indoor noise levels at different locations. Noise measurement should be conducted by organization recognized by the competent authority and it should follow procedures laid down by the competent authority (report to be submitted after the building is occupied).

29.3 Appraisal (maximum points – 2)

29.3.1 The outdoor noise levels are within the acceptable limits as set in CPCB–Environmental Standards–Noise (ambient standards), as per clauses 29.2.1 and 29.2.2 (1 point).

29.3.2 The indoor noise levels are within the acceptable limits as set in *NBC 2005* (BIS 2005a), as per clauses 29.2.3–29.2.5 (1 point).

Criterion 30 ▪ Tobacco and smoke control

Objective

To put in place health strategies such as prohibiting smoking in the indoor areas/building or providing designated/isolated smoking zones within the building designed with separate ventilation systems with higher ventilation rates than the non-smoking areas. This will ensure zero exposure of the non-smoking occupants to passive smoking.

30.1 Commitment

30.1.1 In both an air-conditioned / non-air-conditioned buildings, ensure zero exposure of non-smokers to the tobacco smoke; prohibit smoking on the building premises supported with the company policy.

30.1.2 Ensure that both air-conditioned / non-air-conditioned buildings provide a designated smoking zone with a controlled environment that ensures restriction of the smoke to the designated area, preferably in the peripheral spaces of the buildings or within the buildings (for multiple-occupancy buildings such as hotels, non-smoking and smoking rooms to be clearly identified).

30.2 Compliance

The following documents should be submitted.

30.2.1 Company policy for the ban / prohibition on smoking within the building premises, if applicable, with the supportive documents verified and signed by a responsible authority or

30.2.2 The building plan / interior layout signed by the architect, demonstrating the internal planning for the smoke control by locating the designated smoking zone on the building periphery separated from the non-smoking areas by full height impermeable internal partitions.

30.2.3 For a conditioned space, clearly demonstrate with the help of the AC system design documents, signed by the HVAC consultant or the site engineer, that

- designated smoking area is independent of the non-smoking areas in the building.
- smoking zone is exhausted directly to the outdoors such that there is no recirculation of the tobacco smoke air to the non-smoking zone of the building.
- Smoking zone is operated on separate ventilation systems, with higher ventilation rates than the non-smoking areas, and is designed for at least 60 cfm (cubic feet per minute) / person.
- Smoking zone operates at a negative pressure in comparison with the surrounding non-smoking zone.

30.2.4 For a non-conditioned space, clearly demonstrate in the internal floor plans / interior layout that the designated smoking zone is properly ventilated with the appropriate location of the air inlets / outlets.

30.2.5 For a non-conditioned space, clearly demonstrate with the help of a design narrative

- Designated smoking zone if mechanically ventilated is designed for not less than 30 ACH (air changes per hour).
- Smoking zone is properly ventilated and at a minimum, exhausted directly to the outdoors, such that there is no recirculation of the tobacco smoke air to the non-smoking zone of the building.
- Properly enclosed with full height, impermeable internal partitions with respect to the surrounding spaces.

30.3 Appraisal (maximum points – 1)

The following documents are to be submitted.

30.3.1 Company policy for ban / prohibition of smoking within the building premises, as per clause 30.2.1. or

30.3.2 A signed template by HVAC / architectural consultant certifying that all compliances are met, as per clauses 30.2.2–30.2.5.

Criterion 31 ▪ Provide at least the minimum level of accessibility for persons with disabilities

Objective

To ensure accessibility and usability of the building and its facilities by employees, visitors, and clients with disabilities.

Box 31.1 Some best practices for incorporating accessibility for persons with disabilities

- All building maintenance programmes, renovations, and refurbishments to address and improvize accessibility features.
- Building management policies to ensure that existing access provisions are not undermined by housekeeping practices or by untrained staff.
- Periodically review the quality of accessibility by conducting user feedback surveys and access audits.

Examples of auxiliary aids/appliances

- Induction loop systems at all counters, reception desks, meeting rooms, waiting areas, and so on.
- All printed information, brochures, and maps to be made available in alternative formats such as large print, audio, and Braille.
- Evacuation chairs to aid in assisted evacuation of persons with impaired mobility.
- Audio/tactile signage and way finding systems to aid in orientation and navigation of persons with vision impairments.

31.1 Commitment

31.1.1 Ensure access to facilities and services by adopting appropriate site planning to eliminate barriers as per the recommended standards (*NBC 2005* [BIS 2005f]), layout and designing of interior and exterior facilities as per principles of universal design such as prescribed by the National Building Code of India, building management policies and procedures, provision of auxiliary aids and appliances, and staff training in disability awareness. and

31.1.2 Comply with planning and design guidelines as outlined in *NBC 2005* Annex D (Clause 12.21) (BIS 2005f).

31.2 Compliance

The following documents must be submitted.
31.2.1 Signed letter by competent authority (architect/access auditor) to demonstrate compliance with *NBC 2005* Annex D (Clause 12.21) (BIS 2005f) and proposed additions.

31.2.2 Site photographs to demonstrate compliance.

31.2.3 Detailed narrative (not more than 250 words) on provision of infrastructure accessibility features, auxiliary aids and appliances, and appropriate building management policies to ensure non-discrimination against persons with disabilities.

31.3 Appraisal (maximum points – 1)

31.3.1 Compliance with National Building Code norms on Requirements for Planning of Public Buildings Meant for Use of Physically Challenged, as per clauses 31.1.1 and 31.1.2 (1 point).

SECTION 3

Building operation and maintenance

The intention is to validate and maintain 'green' performance levels/adopt and propagate green practices and concepts. It is important to monitor and verify the measures and evaluate the criteria adopted in the green design process; its actual performance vis-à-vis predicted performance. It is also important to identify the need for upgradations/modifications in the systems.

Criterion 32 ▪ Energy audit and validation

Objective

Validate the predicted energy consumption, thermal comfort, and visual comfort criteria.

32.1 Commitment

32.1.1 After occupying the building, get an energy audit done by an energy auditor approved by the BEE, Government of India, and submit the report to TERI.

32.1.2 Further, TERI will carry out thermal performance monitoring and visual comfort monitoring for typically representative days. This is primarily to verify the data provided in various documents, and for which points have already been awarded. All necessary support in terms of travel, boarding, and lodging for carrying out the study has to be provided to TERI executives.

32.2 Compliance and appraisal (mandatory and no points)

The following documents should be submitted.

32.1.1 Energy audit report by an energy auditor approved by the BEE, Government of India.

Criterion 33 ▪ Operation and maintenance

Objective

To ascertain continued safety in the operation of the electrical and mechanical systems of the building through proper maintenance by the owner or the occupants. This will be ensured in the contract document by providing for the commissioning of all electrical and mechanical systems by the respective supplier or builder. Moreover, the maintenance facilities will be carried out by the respective facility management group, assigned by the owner or the occupants themselves.

33.1 Commitment

33.1.1 Ensure a specific clause in the contract document for the commissioning and systematic handing over of all electrical and mechanical systems to be maintained by the owner, supplier or operator.

33.1.2 Provide a core facility/service management group, if applicable, that will be responsible for the O&M of the building's electrical and mechanical systems after commissioning.

33.1.3 In case of small-scale/single-owner commercial buildings, the owner or the occupants themselves should undertake the responsibility for the O&M of the building's electrical and mechanical systems after commissioning.

33.1.4 Prepare a fully-documented O&M manual, CD, multimedia or an information brochure listing the best practices/dos and don'ts/maintenance requirements for the building's electrical and mechanical systems along with the name and address of the manufacturer/supplier of the respective system. This should be carried out by the owner/builder/occupants/service or facility management group.

33.2 Compliance

33.2.1 Applicant shall provide the proof of provision for commissioning of all electrical and mechanical systems to be maintained by the owner, supplier or operator in the contract document or/and supportive documents, verified and signed by the responsible parties.

33.2.2 Applicant shall provide the proof of provision for a core facility/service group responsible for the O&M of the building's electrical, and mechanical systems after the commissioning. This should be supported with the contract (mutually signed between the respective parties) document or supportive documents, verified and signed by the responsible parties.

33.2.3 Submit a copy of the fully documented O&M manual, CD, multimedia or the information brochure enlisting the best practices for O&M of the building's electrical and mechanical systems. The name and address of the manufacturer/supplier of the respective system, owner/builder to be given to the occupants or to the service/facility management group at the time of occupation.

33.3 Appraisal (maximum points – 1)

Appendage of specific clause in the contract document for the commissioning of all electrical and mechanical systems to be maintained by the owner, supplier or operator, as per compliance clauses. Provision of a core facility/service management group, if applicable, or the owners or occupants themselves (in the case of single owner commercial buildings) undertaking the responsibility for O&M of the building, documentation of the O&M best practices for the building's electrical and mechanical systems.

SECTION 4

Innovation points

Criterion 34 ▪ Innovation points

The enlisted criteria in the rating system are the most critical components contributing to the evolution of a green building. Green building design and operation extend beyond the boundaries defined by the rating system and may cover strategies and options that lead to environmental benefits. The purpose of this category of points is to recognize the measures adopted, which contribute to the overall objective of designing and maintaining of green buildings, and those that are otherwise not covered in the rating system. The following is an indicative list of innovation points. The applicant may submit any other criterion, which they consider as deserving for the award of points, under the rating system. The applied criterion will be evaluated on the merits and demerits of its sustainability benefits. Each Innovation Criterion will carry one point, subject to a maximum of four points.

34.1 Environmental education

34.1.1 Objective

To promote awareness of significant environmental issues by imparting environmental education to the owner or the occupants of the building and to the community as a whole.

34.1.2 Commitment

34.1.2.1 Formulate a company policy on environmental education that facilitates instructional or environmental tours by keeping the building open on weekends. The tours may be supplemented with a small video/multimedia presentation or a documentary focusing on sustainable measures taken in the building design to save energy and to reduce the degree of environmental impact.

34.1.2.2 Provide the owner/occupants or visitors with brochures, CD, information leaflets or a manual on environmental education and concerned issues.

34.1.2.3 Create environmental awareness through small efforts in the building itself such as showcasing energy-efficient building systems, technologies, and materials, and properly labelling or documenting their respective energy performance or savings. The building can also be equipped with data loggers and be put on extensive monitoring so that the performance data for various building systems can be used by students, researchers, and others, and the visitors can observe the same.

34.1.2.4 Adopt innovative strategies such as labelling the water fixtures for the water source. For example, 'this tap uses rainwater

harvested from the roof'. Also demonstrate different spaces connected with different waste-water treatment schemes with proper documentation.

34.1.2.5 A landscape labelled for native species or aromatic herbs, which would raise awareness towards low maintenance and low water-consuming native species as compared to high-maintenance exotic species.

34.1.2.6 Include a column on environmental awareness in the monthly newsletter or newspaper of the company/organization.

34.1.3 Compliance

34.1.3.1 Applicants shall provide the proof of the company policy for the promotion of environmental awareness, if applicable, with the supportive documents verified and signed by a responsible authority.

34.1.3.2 Submit the building brochures, CD, information leaflets or properly compiled manual, small video or documentary used to create awareness towards environmental issues in the owner or the building occupants.

34.1.3.3 If applicable, applicants shall have to provide a small narrative (300 words), supported with the photographs, demonstrating the innovative strategies incorporated in the building, which raises environmental awareness, such as labelling or documenting the low maintenance/less water-consuming species in landscaping and labelling, and documenting the building systems as per the efficient energy performance and savings, or labelling the water fixtures for harvested water source, and so on.

34.1.4 Appraisal (maximum points – 1)

34.1.4.1 Formulation of a company policy for the promotion of environmental education or awareness in the form of instructional/environmental tours to the building, as per clause 34.2.1. and

34.1.4.2 Preparation of the building brochures, CD, information leaflets or properly compiled manual, small video or documentary on environmental education, as per clauses 34.2.2 and 34.2.3 (1 point).

34.2 Company policy on 'green supply chain'

34.2.1 Objective

To encourage company policies on the 'green supply chain', so that the business uses the most efficient methods available for sourcing, manufacturing, and transporting and post-sales support for green building materials and products. This will serve as a 'corporate access system for sustainable development'– a single-source solution to meet the total logistics and distribution needs which, in turn, will ensure that the companies integrate the supply, manufacturing, and distribution of green building materials or products into sustainable development. As a result, this will facilitate a supply chain process to improve service, reduce or eliminate excess/fluctuating inventories, shortages/stockouts, longer lead times, higher transportation and manufacturing costs, and increase the flow of information between the supply chain partners by boosting supplier–to–customer relations.

34.2.2 Commitment

34.2.2.1 Formulate a company policy on the 'green supply chain', which will facilitate sourcing, manufacturing, transportation, and post-sales support for green building materials and products.

34.2.2.2 Set up a 'corporate access system for sustainable development', which will serve as an easy and single-source access to green resources that can help enlist and search green suppliers, vendors, and manufacturers across the globe. This system can be put online so that other corporate communities and research organizations working towards sustainable development and green building consultants can share and enhance the services.

34.2.2.3 Corporate houses can form a small group comprising of executives responsible for the development and management of the global supply chain for the promotion of sustainable development.

34.2.3 Compliance

34.2.3.1 Applicants shall provide proof of company policy on 'green supply chain' for

the promotion of sustainable development, terms of agreement with the single/ association of vendors, suppliers or manufacturers, if applicable, with the supportive documents verified and signed by a responsible authority.

34.2.3.2 Applicants shall provide the details of the 'corporate access system on sustainable development' in any mode, as applicable, either as a web page, database or a shared information service across the corporate communities.

34.2.4 Appraisal (maximum points – 1)

34.2.4.1 Formulation of a company policy on 'green supply chain' for the promotion of sustainable development, demonstrating the terms of agreement with the single/ association of vendors, suppliers or manufacturers, if applicable, with the supportive documents verified and signed by a responsible authority.

34.2.4.2 Development of a 'corporate access system on sustainable development' either in paper or electronic media, or a database or a shared information service across the corporate communities. Applicants shall have to certify their association with the other corporate houses.

34.3 Integrated pest management

34.3.1 Objective

To develop and implement an integrated pest management programme to control and manage weeds and pests within tolerable limits so as to achieve healthy growth for plants and people.

34.3.2 Commitment

34.3.2.1 Develop and implement a landscape management/maintenance plan with emphasis on non-chemical based/organic pest management.

34.3.2.2 Apply pesticides only 'as needed' after prevention and physical controls have been implemented in the interiors.

34.2.6.3 Select the least hazardous pesticides for the control of targeted pests.

34.3.3 Compliance

34.3.3.1 Applicants shall demonstrate the integration of pest management plan in the facility or service management contract, verified with supportive documents and signed by the responsible authority.

34.3.3.2 Applicants shall demonstrate the implementation of pest management plan, including a monitoring plan and schedule.

34.3.4 Appraisal (maximum points – 1)

34.3.4.1 Integration of pest management plan with the maintenance plan as submitted by the core facility or service management group.

34.4 Life cycle costing

34.4.1 Objective

To provide comprehensive lifecycle cost analysis of the project, considering the costs arising from owning, operating, maintaining, and others considered important for the project viability.

34.4.2 Compliance

Applicants to provide a detailed life cycle cost analysis supporting the decisions made for the project viability during its lifecycle.

34.4.3 Appraisal (maximum points – 1)

Life cycle cost analysis of the project.

34.5 Any other criteria proposed by applicant

Submit any other criteria proposed by applicant.

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