2024

GOVERNMENT OF INDIA
MINISTRY OF POWER

DRAFT ECO NIWAS SAMHITA (ENS)

(Residential Buildings)

For Comments of Stakeholders

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ऊर्जा दक्षता ब्यूरो
(भारत सरकार, विद्युत मंत्रालय)
BUREAU OF ENERGY EFFICIENCY
(Government of India, Ministry of Power)

आज़ादी का अमृत महोत्सव

F.No. BLDS-13/1/23-BEE / 6578 **23rd January, 2024**

Subject: Invitation for Feedback on Draft Energy Conservation and Sustainable Building Code (Commercial and Office Buildings)

Dear Madam/Sir,

In view of the amendment to Energy Conservation Act in December 2022, Energy Conservation and Building Code (ECBC) is under revision to Energy Conservation and Sustainable Building Code-Commercial and office Building for the inclusion of sustainability features.

Enclosed herewith is the draft of the Energy Conservation and Sustainable Building Code (Commercial and Office Buildings). We value your expertise and invite you to meticulously review and examine the document.

Doc. No.	Title
ECSBC.Version 1:2024	**Draft Energy Conservation and Sustainable Building Code (Draft ECSBC) – Commercial and Office Buildings**

Your valuable insights are crucial to ensuring the effectiveness of this code. We kindly request you to provide your comments and suggestions on the document. Your expertise will contribute significantly to the enhancement of industry standards.

Submission Details:

Please email your comments, using the prescribed format enclosed with this message, to ecsbcfeedback@gmail.com & sdiddi@beeindia.gov.in by **12th Feb 2024.**

Presumed Approval:

If no comments are received by the stipulated deadline, it will be presumed that the document requires no further corrections.

Review Process:

In the event of comments and suggestions, the competent authority will thoroughly review and consider each input before finalizing the document. Your contributions will play a pivotal role in shaping the code's success.

We have attached the specified format for your convenience. Kindly adhere to this format, as any deviation will not be entertained during the review process. Thank you for your commitment to sustainability, and we look forward to your constructive feedback.

Yours faithfully,

(Saurabh Diddi)
Director

Encl:
1. Draft ECSBC-Commercial and Ofiice Building
2. Feedback Format

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4th Floor, Sewa Bhawan, R.K. Puram, New Delhi-110 066, दूरभाष / Tel. : 91 (11) 26766700, फैक्स / Fax : 91 (11) 20867402

FORMAT FOR FEEDBACK ON ECSBC- RESIDENTIAL BUILDINGS (ENS)

(Please use A4 size sheet of paper only and type within fields indicated. Comments on each clause/subclause/table/fig etc. be started on a fresh box. Information in column 7 should include reasons for the comments, and those in column 6 should include suggestions for modified wording of the clauses when the existing text is found not acceptable. Adherence to this format. {Please e-mail your comments to: ensfeedbackbee@gmail.com & sdiddi@beeindia.gov.in by 12th Feb 2024.

ECSBC Working Draft Chapter Name:
Name of Submitter :
Organization :
Email ID & Contact Number :
Date of Comment :
Last date of receipt of comment : 12th Feb 2024

Sr. No.	Clause/Sub-clause/Para No.	Line No.	Comment type Technical / Editorial	Comments /Suggestions	Modified Wordings of the Clause	Reasons/ Justifications for the Proposed Changes
(1)	(2)	(3)	(4)	(5)	(6)	(7)

Bureau of Energy Efficiency (Ministry of Power, Government of India)
www.beeindia.gov.in

Eco-Niwas Samhita (ENS) 2024
(Energy Conservation and Sustainable Building Code – Residential Building)

Published by

Bureau of Energy Efficiency

4th Floor, Sewa Bhawan, R K Puram, New Delhi, India`

1st Printed: xxxx 2024

Printed on 100% recycled paper.

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By Shri Saurabh Diddi (Director, BEE)

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1.

CHAPTER 1: INTRODUCTION

1.1 In 2022, India revised its Nationally Determined Contribution under the Paris Agreement. Among others, the revision had two significant components, the first was to put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LIFE'– 'Lifestyle for Environment' as a key to combating climate change and the second was to reduce Emissions Intensity of its GDP by 45 percent by 2030, from the 2005 level. Any effort to achieve these targets is contingent upon the increase in the adoption of low carbon, sustainable pathways across all sectors, but especially in the building sector.

1.2 As per Energy Statistics 2024[1] released by the Ministry of Statistics and Programme Implementation (MoSPI), total energy demand by various sectors for FY 2021–22 is about 525.7 Mtoe, out of which the residential (domestic) sector consumes about 58.8 Mtoe, which is 11.2% of total primary energy consumption. The energy demand in the domestic sector has been on the rise since the late 2000s, with increasing demand for appliance ownership, especially of fans and televisions in urban and rural areas, and an increase in refrigerators and air conditioners in urban areas. Further, it is estimated that domestic sector will consume about 98.6 million ton[2] of energy.

1.3 The building sector in India is responsible for over 30% of the total electricity consumed in the country, out of which about 70% is consumed in residential buildings. The total electricity demand for FY 2021–22 is about 1296 billion Units (BU)[3], out of which the residential sector consumed about 334 BU which is 25.8% of total electricity consumption. Electricity consumption increased from 183.7 BU in 2012- 13 to 334 BU in 2021-22 with a CAGR of 6.87%. Further, it is estimated that, the electricity consumption of the residential sector will increase to 769 BU[4] by 2031.

1.4 According to India Cooling Action Plan 2019, approximately 8% of the current households have room air conditioners. This is anticipated to rise to 21% and 40% in 2027-28 and 2037-38 respectively. The demand for air conditioning will continue its exponential growth with improvement in household incomes and will become the dominant contributor of GHG emissions nation-wide owing to increased electricity consumption. This situation calls for an immediate energy conservation action plan.

1.5 As of 2019, the Central Water Commission has assessed the average annual per capita water availability to be 1486 cubic meters and 1367 cubic meters for 2021 and 2031[5], respectively. According to standards, an annual per-capita water availability of less than 1700 cubic meters is considered as a water stressed condition (PIB, 2022). The per capita water availability in the country in reducing due to an increase in population, climate change, rapid urbanisation and uneven distribution of water. Both demand-side and supply side measures to ensure efficient water management, conservation, and augmentation are needed to avoid a water crisis.

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1 Energy Statistics India – 2024, Ministry of Statistics and Programme Implementation, National Statistical Office, Government of India

2 UNlocking NATional Energy-Efficiency potential (UNNATEE), Bureau of Energy Efficiency, Ministry of Power

3 Energy Statistics India – 2024, Ministry of Statistics and Programme Implementation, National Statistical Office, Government of India

4 UNlocking NATional Energy-Efficiency potential (UNNATEE), Bureau of Energy Efficiency, Ministry of Power

5 Reassessment of Water Availability in India using Space Inputs, 2019, Central Water Commission, Delhi

1.6 Excessive waste generation and improper waste management is a major environmental concern in India. The per capita waste generation in India varies between 0.2 Kg to 0.6 Kg per day in Tier 1 cities and is expected to increase at a rate of 5% annually. It is dependent on various factors ranging from the size of the city, season and income groups. As of 2021, a total of 1.6 Lakhs tonnes of waste is generated in India on a daily basis[6]. While 50% of this waste is treated, nearly 20% of the waste still reaches the landfill and over 30% of the waste remains unaccounted for.

1.7 Indoor environmental quality (IEQ) refers to the conditions inside a building that can affect the health, comfort, and productivity of its occupants. Several factors contribute to IEQ, including ventilation, air quality, thermal comfort, lighting, and acoustics. As we spend 90% of our time indoors, poor IEQ results in discomfort and potential health issues for occupants. Prioritizing and maintaining optimal IEQ within confined buildings is crucial, as it can save people from diseases like chronic obstructive pulmonary disease (COPD), which is the 3rd highest reason for global deaths according to the World Health Organisation (WHO).

1.8 In the illustrated context, Energy Conservation & Sustainable Building Codes for Residential Buildings (ENS) 2024, is an important regulatory measure for ushering in sustainability and energy efficiency in the Indian building sector. The present code integrates the Eco Niwas Samhita 2018 (Part I: Building Envelope), Eco Niwas Samhita 2021 (Part-II: Electro-Mechanical & Renewable Energy Systems) along with measures for sustainable site planning, water conservation, waste management and, indoor environmental quality to ensure that residential buildings in India have a low carbon footprint and provide a healthy environment for the occupants.

1.9 The code also provides the following eight annexures which are recommendatory and envisaged to be added in future revision of the code.

- Annexure 1: Compliance Documents
- Annexure 2: Embodied energy
- Annexure 3: Good construction practices
- Annexure 4: Retrofitting of residential buildings
- Annexure 5: Improved air cooling
- Annexure 6: Smart Home
- Annexure 7: Guidelines to Design for Natural Ventilation
- Annexure 8: Cool Roof and Roof Gardens

6 Annual Report on Solid Waste Management (2020-21), CPCB, Delhi

CHAPTER 2: SCOPE

2.1 The amendment of the Energy Conservation (EC) Act in 2022, widens the scope of BEE's Energy Conservation Codes to include other sustainability features. The Eco-Niwas Samhita 2024 is a consolidated energy conservation and sustainable building code that integrates the ENS Part I (Building Envelope) and, Part II (Electro-Mechanical and Renewable Energy Systems) and includes new provisions to improve the overall sustainability of residential buildings.

2.2 The code applies to residential buildings or residential building complexes which has a minimum connected load of 100 kilowatt (kW) or contract demand of 120 kilovolt ampere (kVA)[7].

2.2.1 Where a 'residential building', as defined in National Building Code 2016, includes any building in which sleeping accommodation is provided for normal residential purposes with or without cooking or dining or both facilities. this definition includes:

2.2.1.1 **One- or two-family private dwellings:** these shall include any private dwelling, which is occupied by members of one or two families and has a total sleeping accommodation for not more than 20 persons.

2.2.1.2 **Apartment houses:** these shall include any building or structure in which living quarters are provided for three or more families, living independently of each other and with independent cooking facilities. this also includes 'Group housing'.

2.2.1.3 **Mixed-use building:** In case of a mixed-use building having both residential and commercial usage, the code shall apply to the residential part provided the residential area is more than 10% of the total Above Grade Floor Area.

2.2.2 The code shall apply to any building project which has more than 50% of the total built up area designated as 'residential building'.

2.3 In accordance with section 14(p) of the Energy Conservation (Amendment) Act 2022 the purpose of the Energy Conservation and Sustainable Building Code (Code) is to provide norms and standards for energy efficiency and its conservation, use of renewable energy and other green building requirements for a building.

2.4 The following are excluded from the definition of 'residential building' for of this code.

2.4.1 Lodging and rooming houses: these shall include any building or group of buildings under the same management in which separate sleeping accommodation on transient or permanent basis, with or without dining facilities but without cooking facilities for individuals, is provided. this includes inns, clubs, motels, and guest houses.

2.4.2 Dormitories: these shall include any building in which group sleeping accommodation is provided, with or without dining facilities for persons who are not members of the same family, in one room or a series of closely associated rooms under joint occupancy and single management. For example, school and college dormitories, students, and other hostels and military barracks.

2.4.3 Hotels and resorts: these shall include any building or group of buildings under single management, in which sleeping accommodation is provided, with or without dining facilities.

2.5 The code is also applicable for all additions and/or alterations made to existing residential buildings where the existing building exceeds the threshold defined in clause 2.2 of this document. For this purpose, the addition and/or alterations together with the

[7] or plot area of 3000 m^2, whichever is more stringent.

existing residential building are required to show compliance with the authority having jurisdiction.

2.6 If any existing building after additions or alterations exceeds the threshold defined in clause 2.2 of this document, it shall comply with the provisions of this code. Compliance shall be demonstrated in either of the following ways:

2.6.1 The addition shall comply with the applicable requirements, or

2.6.2 The addition, together with the entire existing building, shall comply with the requirements of this Code as applicable to the entire building, as if it were a new building.

Exceptions to clause 2.6: When space conditioning is provided by existing systems and equipment, the existing systems and equipment need not comply with this code. However, any new equipment installed must comply with specific requirements applicable to that equipment.

2.7 The following codes, programs, and policies will take precedence over the code in case of conflict:

2.7.1 Any policy notified as taking precedence over this Code, or any other rules on safety, security, health, or environment by Central, State, or Local Government.

2.7.2 BEE's Standards and Labelling for appliances and Star Rating Program for buildings, or any reference standard prescribed by the Code, provided both or either are more stringent than the requirements of this Code.

2.8 The code prescribes the three levels of energy conservation and sustainability:

2.8.1 **ENS compliance**: ENS compliance Buildings shall demonstrate compliance by adopting the mandatory requirements listed under each of the sections of this code.

2.8.2 **ENS+ compliance**: ENS+ compliance Buildings shall demonstrate compliance by adopting the mandatory requirements and gaining required incremental points from each of the sections of this code.

2.8.3 **Super ENS compliance**: Super ENS compliance Buildings shall demonstrate compliance by adopting the mandatory requirements and gaining required incremental points from each of the sections of this code.

CHAPTER 3: CODE COMPLIANCE

3.1 The mandatory provisions as per chapters 4, 5, 6, 7 and 8 are applicable to all building categories as per clause 2.2.

3.2 If a building project has more than one building block, each building block is required to comply with the code unless specified otherwise.

3.3 The code also provides incremental provisions should the project want to demonstrate enhanced compliance; ENS + and Super ENS as per Table 1

Table 1: Points required to achieve ENS+ and Super ENS compliance

Project Category	ENS+	Super ENS
All residential buildings	30% of all the total points applicable in each section (4.3, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 6.3, 7.3, 8.3)	50% of all the total points applicable in each section (4.3, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 6.3, 7.3, 8.3)

3.4 A summary of the incremental points available in each chapter is given in Table 2

Table 2: Maximum incremental points in each chapter

Section	Provisions	Maximum Incremental Points available	Compliance for ENS+ (30% of maximum incremental points available)	Compliance for Super ENS (50% of maximum incremental points available)
4.3	**Sustainable Site Management**	**30**	**9**	**15**
4.3.1	Landscaping	16		
4.3.2	Mitigation of Urban Heat Island	14		
5.3.1	**Building Envelope**	**40**	**12**	**20**
5.3.1.1	Roof	4		
5.3.1.2 / 5.3.1.3	Building envelope (except roof)	36		
5.3.2	**Building Services**	**28**	**8**	**14**
5.3.2.1	Common area and exterior lighting	6		
5.3.2.2	Elevators	9		
5.3.2.3	Pumps	8		
5.3.2.4	Electrical Systems	5		
5.3.3	**Indoor Electrical End-use**	**42**	**13**	**21**
5.3.3.1	Indoor Lighting	8		
5.3.3.2	Comfort Systems	34		
5.3.4	**Renewable Energy Systems**	**10**	**3**	**5**
5.3.4.1	Solar Water Heating	5		
5.3.4.2	Solar Photo Voltaic	5		

6.3	**Water Conservation and management**	**43**	**13**	**22**
6.3.1	Site Water Use Reduction	17		
6.3.2	Building Water Use Reduction	26		
7.3	**Waste Management**	**7**	**2**	**4**
7.3.1	Construction Waste management	2		
7.3.2	Post Construction Waste Management	5		
8.3	**Indoor Environmental Quality (IEQ)**	**10**	**3**	**5**
8.3.1	Cross Ventilation	4		
8.3.2	Daylight Availability (useful daylight illuminance)	4		
8.3.3	Air Quality in Car Parking (CO sensor)	2		

3.5 A building shall comply if the minimum specifications of all products installed under any category are met as prescribed by this code unless specified otherwise.

3.6 In a mixed-use building, having both commercial and residential building use, each category of a building use must be classified separately, and –

3.6.1 The residential above grade floor area as defined in clause 2.2.1 shall comply with this code.

3.6.2 Basement and common area services, designed for a particular building use or documented with respective buildings for compliance with authority having jurisdiction, needs to show compliance with the clauses for the respective building requirement.

CHAPTER 4: SUSTAINABLE SITE MANAGEMENT

4.1 SCOPE

4.1.1 The chapter provides requirements to minimize the impact of construction activity on the natural terrain and topography of the site during the construction phase. It consists of four parts- Site Preservation, Universal Accessibility, Landscaping and Mitigating Urban Heat Island.

4.2 MANDATORY PROVISIONS

4.2.1 SITE PRESERVATION

4.2.1.1 Ensure to protect or preserve existing mature trees naturally or as per guidelines of local byelaws/authority, whichever is more stringent.

4.2.1.2 Preservation of Topsoil:

a) Topsoil up to 150-200 mm (6-8 inches) must be preserved within the site to preserve the fertility of the soil.

b) The stored topsoil shall be used as finished grade for planting areas within the site or outside. In case the stored topsoil is not being used within the site, proper reuse of the soil must be ensured.

4.2.1.3 In compliance with the Model Building Byelaws, 2016, construction shall not hinder existing areas like water bodies, power or communication lines, sewerage lines that are located on or adjacent to the project site.

4.2.2 UNIVERSAL ACCESSIBILITY

4.2.2.1 Residential buildings shall be universally accessible with special provisions for children, the elderly and differently abled people in accordance with Chapter 8 of the Model Building Bylaws, 2016.

4.2.3 LANDSCAPING

4.2.3.1 Minimise disturbances to the topography & gradient of the site by retaining natural features of the site and developing vegetated landscaped spaces minimum of 20% of the total landscaped area.

4.2.3.2 In compliance with the National Building Code, 2016, If turf grasses are to be used, they should not be planted on more than 30% of the total landscaped area.

4.2.3.3 In compliance with the National Building Code, 2016 to preserve local biodiversity and ecology, a minimum of 30% of the landscaped area must be planted with native/adaptive species of plants/trees. The choice of species for plantation shall be as per Section 8 of the Urban Greening Guidelines, 2014 of the Ministry of Housing and Urban Affairs[8].

4.2.3.4 In compliance with the notification of the Ministry of Environment, Forest and Climate Change Notification dated 25th February 2022 a minimum of 1 tree for

[8] Source: https://mohua.gov.in/upload/uploadfiles/files/G%20G%202014(2).pdf

every 80 sqm. of land should be planted and maintained to ensure at least 10% of plot area under tree cover. The existing trees will be counted for this purpose.

4.2.3.5 In compliance with the Model Building Byelaws, 2016 compensatory Plantation for felled/transplanted trees in the ratio 1:3 within the premises under consideration must be ensured.

4.2.4 MITIGATING URBAN HEAT ISLAND

4.2.4.1 Limiting the net paved area of the site under parking, roads, paths, or any other use so as not to exceed 25% of the site area, as per the National Building Code, 2016.

4.2.4.2 More than 50% of the total paved area shall have pervious paving/grass pavers/open grid pavements, as per National Building Code 2016.

4.3 INCREMENTAL PROVISIONS (MAXIMUM 30 POINTS)

4.3.1 LANDSCAPING (MAXIMUM 16 POINTS)

4.3.1.1 Minimise disturbances to the topography & gradient of the site by retaining natural features of the site and developing vegetated landscaped spaces as per Table 3

Table 3: Points for increasing vegetated area on site

Minimum Vegetated Area	Incremental Points
30% of the total landscaped area	6
40% of the total landscaped area	8

4.3.1.2 Minimise the plating of turf grasses as per Table 4

Table 4: Points for Reducing the Turf Area

Maximum Turf Area	Incremental Points
20% of the landscaped area	2
15% of the landscaped area	4

4.3.1.3 Increase the plantation of native/ adaptive species of plants/ trees as per Table 5

Table 5: Points for Increasing the Landscaped Area planted with Native Plant Species

Minimum Area with Native Plants Species	Incremental Points
40% of the landscaped area	2
50% of the landscaped area	4

4.3.2 MITIGATION OF URBAN HEAT ISLAND (MAXIMUM 14 POINTS)

4.3.2.1 Limiting the net paved area of the site under parking, roads, paths, or any other *as per* Table 6

Table 6: Points for Reducing Paved Area on Site

Maximum Net Paved Area on Site	Incremental Points

Upto 20% of the site area	4
Upto 15% of the site area	6

4.3.2.2 Increase the pervious paving/grass pavers/open grid pavements as per Table 7

Table 7: Points for Increasing Pervious Paving

Minimum Pervious Paving	Incremental Points
60% of the total paved area	5
70% of the total paved area	8

CHAPTER 5: ENERGY MANAGEMENT AND CONSERVATION

5.1 SCOPE

5.1.1 The chapter provides requirements for energy management and conservation in a building post-occupancy through passive measures, active measures, and renewable energy integration. It consists of four parts – building envelope, building services, indoor electrical end use and renewable energy.

5.2 MANDATORY PROVISIONS

5.2.1 BUILDING ENVELOPE

5.2.1.1 OPENABLE WINDOW-TO-FLOOR AREA RATIO

The openable window-to-floor area ratio (WFR_{op}), (refer Daylight availability (Useful daylight illuminance) (Maximum 4 Points)

8.1.1.1 The building shall comply with the useful daylight illuminance requirement as prescribed by the ECBC 2017, clause no 4.2.3. Ensure above-grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 56 for 90% of the potential daylit time in a year. (Refer to **Error! Not a valid bookmark self-reference.**). Incremental points can be achieved as per Table 42.

Table 42: Daylight Requirement

Provision	Incremental Points
40% of the regularly occupied spaces meeting the UDI requirement	2
50% of the regularly occupied spaces meeting the UDI requirement	3
60% of the regularly occupied spaces meeting the UDI requirement	4

8.1.2 AIR QUALITY IN UNDERGROUND PARKING AREA (MAXIMUM POINTS 2)

8.1.2.1 Install a demand control ventilation system to limit CO levels in the underground parking area to ensure safety and air quality. The location of sensors should be followed as prescribed by the NBC 2016, Volume 2, Part 8, section 3, clause no 11.5.4. Incremental points can be achieved as per Table 43.

Table 43: Air Quality in Car Parking

Provision	Incremental Points
CO sensors are installed to control the ventilation system to limit CO level	2

Chapter 9: Calculations and Formula) for individual building blocks, shall comply with the values[9] given in Table 8.

Table 8: Minimum requirement of window-to-floor area ratio (WFRop)

Climatic zone	Minimum WFR_{op} (%)
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperate	12.50
Cold	8.33

SOURCE: Adapted from Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

5.2.1.2 VISIBLE LIGHT TRANSMITTANCE

The glass used in non-opaque building envelope components (transparent/translucent panels in windows, doors, etc.) shall comply with the requirements given in Table 9.

Table 9: Minimum visible light transmittance (VLT) requirement

Window-to-wall ratio (WWR)[10]	Minimum VLT[11]
0–0.30	0.27
0.31—0.40	0.20
0.41—0.50	0.16
0.51—0.60	0.13
0.61—0.70	0.11

SOURCE: Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

5.2.1.3 THERMAL TRANSMITTANCE OF ROOF (UROOF)

Thermal transmittance of the roof shall comply with the maximum U_{roof} value of 1.2 $W/m^2\cdot K$ as prescribed in clause 9.3 of this code.

5.2.1.4 RESIDENTIAL ENVELOPE TRANSMITTANCE VALUE (RETV) FOR BUILDING ENVELOPE (EXCEPT ROOF) FOR FOUR CLIMATE ZONES, NAMELY, COMPOSITE CLIMATE, HOT-DRY CLIMATE, WARM-HUMID CLIMATE, AND TEMPERATE CLIMATE

The RETV for the building envelope (except the roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate, shall comply with the maximum[12] RETV value of 15 W/m^2 as prescribed in clause 9.5 of this code.

[9] To comply with the Code, WFR_{op} (%) values shall be rounded off to two decimal places in accordance with IS 2: 1960 'Rules for rounding off numerical values'.
[10] To comply with the Code, VLT values shall be rounded off to two decimal places in accordance with IS 2: 1960 'Rules for rounding off numerical values'.
[11] To comply with the Code, WWR values shall be rounded off to two decimal places in accordance with IS 2: 1960 'Rules for rounding off numerical values'.
[12] BEE plans to improve the RETV norm to 12 W/m^2 in the near future and the building industry and regulating agencies are encouraged to aim for it.

5.2.1.5 TRANSMITTANCE OF BUILDING ENVELOPE (EXCEPT ROOF) FOR COLD CLIMATE (UENVELOPE, COLD)

For Cold Climate Zone, the thermal transmittance of the building envelope (except the roof) for the cold climate shall comply with the maximum value of 1.8 W/m2·K as prescribed in clause 9.7 of this code.

5.2.2 BUILDING SERVICES

5.2.2.1 POWER FACTOR CORRECTION

All 3 phase power systems shall be designed to maintain a power factor of 0.97 at the point of connection.

5.2.2.2 ENERGY MONITORING

A. Residential buildings exceeding the threshold defined as per clause 2.2 of this code shall monitor the electrical energy use for each of the following separately:

i. Total electrical energy
ii. Electricity consumption of the following applicable end-use
  a) Common area lighting (Outdoor lighting, corridor lighting, basement lighting)
  b) Elevators
  c) Water pumps
  d) Basement car parking ventilation system
  e) Electricity generated from power back-up.
  f) Electricity generated through renewable energy systems.
  g) Lift pressurization system

B. The electrical energy use shall be recorded at a minimum interval of 15 minutes and reported at least on an hourly, daily, monthly and annual basis. The monitoring equipment shall be capable of transmitting the data to the digital control system/ energy monitoring information system. The digital control system shall be capable of maintaining all data collected for a minimum period of 36 months.

a. The metering shall display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current in case of transformers.

5.2.2.3 ELECTRIC VEHICLE CHARGING SYSTEM

If an Electric Vehicle Charging Infrastructure is installed on the premises, it shall be as per revised guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles (EV) on 15th Jan 2022, or any subsequent amendments.

5.2.2.4 ELECTRIC SYSTEMS

A. The power cabling shall be sized so that the distribution losses shall not exceed 3% of the total power usage of the building. A record of design calculation for the losses shall be maintained and the load calculation up to the panel level shall be documented.

B. Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.

5.2.2.5 COMMON AREA AND EXTERIOR LIGHTING (IF APPLICABLE)

A. The Lighting power density (LPD) and Luminous efficacy (LE) of permanently installed lighting fixtures in common area shall meet the requirements of either maximum LPD or minimum LE given in Table 10.

Table 10: Common Area Lighting

Common Areas	Maximum LPD (in W/m²)	Minimum luminous efficacy (lm/W)
Corridor lighting & Stilt Parking	3.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt
Basement Parking	1.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt

B. In case of the exterior lighting load being more than 100 W, the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt or meet the maximum LPD requirements given in Table 11.

Table 11: Outdoor Lighting Requirement

Exterior Lighting Areas/ Zones	Maximum LPD (in W/m2)
Driveways and parking (open/ external)	1.6
Pedestrian walkways	2.0
Stairways	10.0
Landscaping	0.5
Outdoor sales area	9.0

5.2.2.6 ELEVATORS, IF APPLICABLE

Elevators installed in the building shall meet all the following requirements:

i. Install high-efficacy lamps for lift car lighting having a minimum luminous efficacy of 85 lm/W.
ii. Install automatic switch-off controls for lighting and fan inside the lift car when are not occupied.
iii. Install minimum class IE 3 high-efficiency motors.
iv. Group automatic operation of two or more elevators coordinated by supervisory control

5.2.2.7 PUMPS, IF APPLICABLE

Pumps that are either hydro-pneumatic having a minimum mechanical efficiency of 60% or BEE 4-star rated shall be installed in the building.

5.2.2.8 ELECTRICAL SYSTEM, IF APPLICABLE

A. Power transformers with a minimum efficiency of 50% and full load rating shall be installed. The permissible loss shall not exceed the values listed in Table 12 for dry-type transformers and the BEE 4-star rating in

B. Table 13 for oil-type transformers.

C. All measurements of losses shall be carried out by using calibrated digital meters of class 0.5 or better accuracy and certified by the manufacturer. All transformers of the capacity of 500 kVA and above would be equipped with additional metering class current transformers (CTs) and potential transformers (PTs) in addition to the requirements of Utilities so that periodic loss monitoring studies may be carried out.

Table 12: Permissible Limit for Dry-Type Transformers

Rating kVA	Max. Losses at 50% loading W*	Max. Losses at 100% loading W*	Max. Losses at 50% loading W*	Max. Losses at 100% loading W*
	Up to 22 kV class		33 kV class	
100	940	2400	1120	2400
160	1290	3300	1420	3300
200	1500	3800	1750	4000
250	1700	4320	1970	4600
315	2000	5040	2400	5400
400	2380	6040	2900	6800
500	2800	7250	3300	7800
630	3340	8820	3950	9200
800	3880	10240	4650	11400
1000	4500	12000	5300	12800
1250	5190	13870	6250	14500
1600	6320	16800	7500	18000
2000	7500	20000	8880	21400
2500	9250	24750	10750	26500
*The values as per Indian Standard/BEE Standard & Labeling notification for dry type transformer corresponding to values in this table will supersede as and when the Indian standards/ BEE Standard & Labeling notifications are published.				

Table 13: Permissible Limit for Oil-Type Transformers

Rating (kVA)	Impedance (%)	Max. Total Loss (W)					
		BEE 1 Star		BEE 3 Star		BEE 5 Star	
		50 % Load	100% Load	50 % Load	100% Load	50 % Load	100% Load
16	4.5	135	440	108	364	87	301
25	4.5	190	635	158	541	128	448
63	4.5	340	1,140	270	956	219	791
100	4.5	475	1,650	392	1,365	317	1,130
160	4.5	670	1,950	513	1,547	416	1,281
200	4.5	780	2,300	603	1,911	488	1,582
250	4.5	980	2,930	864	2,488	761	2,113
315	4.5	1,025	3,100	890	2,440	772	1,920
400	4.5	1,225	3,450	1,080	3,214	951	2,994
500	4.5	1,510	4,300	1,354	3,909	1,215	3,554
630	4.5	1,860	5,300	1,637	4,438	1,441	3,717
1,000	5.0	2,790	7,700	2,460	6,364	2,170	5,259
1,250	5.0	3,300	9,200	3,142	7,670	2,991	6,394
1,600	6.25	4,200	11,800	3,753	10,821	3,353	9,924
2,000	6.25	5,050	15,000	4,543	13,254	4,088	11,711
2,500	6.25	6,150	18,500	5,660	16,554	5,209	14,813
Total loss values given in the above table are applicable for thermal classes E, B and F, and have component of load loss at reference temperature according to Clause 17 of IS 1180 i.e., average winding temperature rise as given in Column 2 of Table 8.2 plus 300C. An increase of 7% in total for thermal class H is allowed.							
Permissible total loss values shall not exceed: - 5% of the maximum total loss values mentioned in IS 1180 for oil type transformers in voltage class above 11 kV but not more than 22 kV - 7.5% of the maximum total loss values mentioned in above IS 1180 for oil-type transformers in voltage class above 22 kV and up to and including 33 kV							

5.2.3 INDOOR ELECTRICAL END USE (IF APPLICABLE)

5.2.3.1 INDOOR LIGHTING

All the lighting fixtures shall have lamps with a luminous efficacy of a minimum of 85 lm/W installed in all the locations.

5.2.3.2 COMFORT SYSTEM

A. Ceiling Fans:

All ceiling fans installed in all the spaces in all the dwelling units shall have a minimum of 3 star for all sweep sizes.

B. Air Conditioners:

All the bedrooms having air conditioners in all the dwelling units (either unitary, split, VRF, or centralized plant) shall have the following specifications and shall meet or exceed the minimum efficiency requirements under BEE Standards and Labelling Program as and when updated by BEE.

- Unitary Type: 5 Star
- Split AC: 3 Star
- VRF: 3.28 EER, or 4.36 IEER[13] (BEE Standards and Labelling requirements of 3 star for VRF shall take precedence over the current minimum requirement)
- Chiller: 3 Star

In case, air conditioners installed are of mixed type, the calculation of points will be based on clause number B of this document.

5.2.4 RENEWABLE ENERGY SYSTEMS

The renewable energy systems, Solar Water Heating as per section 5.2.4.1 or Solar Photo-Voltaic as per section 5.2.4.2 to be installed collectively, or any of them, at the project site as per the total renewable energy installation requirement.

5.2.4.1 SOLAR WATER HEATING

The installed solar water heater shall meet the minimum efficiency level mentioned in IS 13129 Part (1&2) and for the evacuated tube collector the storage tanks shall meet the IS 16542:2016, tubes shall meet IS 16543:2016 and IS 16544:2016 for the complete system, and shall comply with requirements as Solar water Heating system of minimum BEE 3-star label installed in at least 10% of the plot area[14]

5.2.4.2 SOLAR PHOTO-VOLTAIC

The Renewable Energy Generation Zone (REGZ) shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone. It shall comply with the requirements of installing Solar photo-voltaic: Equivalent to at least 10% of the plot area.[15]

5.3 INCREMENTAL PROVISIONS (MAXIMUM 120 POINTS)

5.3.1 BUILDING ENVELOPE (MAXIMUM 40 POINTS)

5.3.1.1 THERMAL TRANSMITTANCE OF ROOF (U_{ROOF}) (MAXIMUM 4 POINTS)

The thermal transmittance of the roof (U_{roof}) shall comply with the requirement as per Table 14.

[13] The revised EER and IEER values as per Indian Standard for VRF corresponding to values will supersede as and when the revised standards are published

[14] 100 lpd= 3 m^2 area as per MNRE guidelines

[15] 1 kW_p = 10 m^2 area as per MNRE guidelines

Table 14: Points for Thermal Transmittance of Roof (U_{roof})

U_{roof} (W/m²·K)	Formula for points calculation	Incremental Points
$0.28 \le U_{roof} < 1.2$	$(1.2 - U_{roof}) / 0.23$	Up to 4
RETV < 0.28	-	4

5.3.1.2 RESIDENTIAL ENVELOPE TRANSMITTANCE VALUE (RETV) FOR BUILDING ENVELOPE (EXCEPT ROOF) FOR FOUR CLIMATE ZONES, NAMELY, COMPOSITE CLIMATE, HOT-DRY CLIMATE, WARM-HUMID CLIMATE, AND TEMPERATE CLIMATE[16] (MAXIMUM 36 POINTS)

The RETV for building envelope (except roof) for four climate zones, namely, composite climate, Hot-Dry climate, Warm-Humid climate, and Temperate climate, shall comply with the requirement as per Table 15.

Table 15: Points for improved RETV

RETV (W/m²)	Formula for points calculation	Incremental Points
12 ≤ RETV < 15	30 – 2 x (RETV)	Up to 6
6 ≤ RETV < 12	66 – 5 x (RETV)	Up to 36
RETV < 6	-	36

5.3.1.3 THERMAL TRANSMITTANCE OF BUILDING ENVELOPE (EXCEPT ROOF) FOR COLD CLIMATE ($U_{ENVELOPE,COLD}$) (MAXIMUM 36 POINTS)

The thermal transmittance of the building envelope (except the roof) for cold climate ($U_{ENVELOPE,COLD}$), shall comply with the requirement as per Table 16.

Table 16: Points for Thermal transmittance of the building envelope (except the roof) for cold climate ($U_{ENVELOPE, COLD}$)

$U_{envelope, cold}$ (W/m².K)	Formula for points calculation	Incremental Points
$1.32 \le U_{envelope, cold} < 1.8$	$22.5 - 12.5 \times (U_{envelope, cold})$	Up to 6
$0.36 \le U_{envelope, cold} < 1.32$	$47.25 – 31.25 \times (U_{envelope, cold})$	Up to 36
$U_{envelope, cold} < 0.36$	-	36

5.3.2 BUILDING SERVICES (MAXIMUM 28 POINTS)

5.3.2.1 COMMON AREA AND EXTERIOR LIGHTING (MAXIMUM 6 POINTS)

A. All permanent lighting fixtures with a lamp luminous efficacy of at least 95 lm/Watt shall be installed in the areas, as per Table 17.

Table 17: Points for Common Area Lighting

Area/Zones	Incremental Points
Corridor parking and stilt parking	1
Basement Lighting	1

[16] The project shall meet the requirements of either section 6.4.2 or 6.4.3 depending on the climatic zone

Exterior Lighting Areas	1

B. All permanent lighting fixtures excluding emergency lighting installed in areas as per Table 18 shall:

i. Have a luminous efficacy of 105 lm/W

ii. Be controlled by a photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available, or the lighting is not required.

Table 18: Points for automatic control of exterior lights

Area/Zones	Incremental Points
Corridor parking and stilt parking	2
Basement Lighting	2
Exterior Lighting Areas	2

5.3.2.2 ELEVATORS (MAXIMUM 9 POINTS)

The installed elevators shall comply with the requirements as per Table 19

Table 19: Points for Elevators

Provisions	**Incremental Points**
Installing variable voltage variable frequency dives	4
Installing Regenerative Drives	3
Installing IE4 Motors	2

5.3.2.3 PUMPS (MAXIMUM 8 POINTS)

The installed pumps shall comply with the requirements as per Table 20

Table 20: Points for Pumps

Provisions	**Incremental Points**
Installation of BEE 5-star rated pumps	5
Installation of a hydro-pneumatic system for water pumping having minimum mechanical efficiency of 70%	3

5.3.2.4 ELECTRICAL SYSTEMS (MAXIMUM 5 POINTS)

The installed electrical system shall comply with the requirements as per Table 21

Table 21: Points for Electrical System

Provisions	**Incremental Points**
Providing all oil-type transformers with 5-star ratings	5

5.3.3 INDOOR ELECTRICAL END-USE (IF APPLICABLE) (MAXIMUM 42 POINTS)

5.3.3.1 INDOOR LIGHTING (MAXIMUM 8 POINTS)

All indoor lighting fixtures installed in all dwelling units shall have lamps luminous efficacy as per Table 22.

Table 22: Points for Lamp Lumen Efficacy of Indoor Lighting

Provisions	Incremental Points
Lamp Lumen Efficacy >95 Lm/W	3
Lamp Lumen Efficacy >105 Lm/W	8

5.3.3.2 COMFORT SYSTEM (MAXIMUM 34 POINTS)

A. Ceiling Fans installed in all the bedrooms and hall in all the dwelling units shall comply with the requirements as per Table 23

Table 23: Points for BEE star rated ceiling fans

Provisions	Incremental Points
Ceiling fans in all the bedrooms and hall with BEE 4-Star	1
Ceiling fans in all the bedrooms and hall with BEE 5-Star	4

B. Air Conditioners (either unitary, split, VRF or centralized plant) installed in all the bedrooms in all the dwelling units, shall comply with requirements as per Table 24 and shall meet or exceed the minimum efficiency requirements under BEE Standards and Labelling Program as and when updated by BEE.

Table 24: Points for BEE Star Rating of Air-Conditioners

Provisions	Incremental Points
a) Split AC: 4-Star b) VRF: 3.6 EER, however, whenever BEE Star labelling for VRF is launched, Star 4 will be applicable (BEE Standards and Labelling requirements of 4-star for VRF shall take precedence) c) Chiller: 4-Star	9
a) Split AC: 5-Star b) VRF: 3.8 EER, however, whenever BEE Star labelling for VRF is launched, Star 5 will be applicable (BEE Standards and Labelling requirements of 5-star for VRF shall take precedence) c) Chiller: 5-Star	30

In case, the air conditioners installed are of mixed types, the points shall be calculated based on the following formula:

$$\textit{Points achieved for AC} = \frac{\sum(\textit{Installed tonnage of particular system} \times \textit{points claimed as per Energy efficiency level})}{\sum \textit{Total tonnage installed in the dwelling unit}}$$

5.3.4 RENEWABLE ENERGY SYSTEMS (MAXIMUM 10 POINTS)

The renewable energy systems, Solar Water Heating as per section 5.2.4.1 and/or Solar Photo-Voltaic as per section 5.2.4.2 to be installed collectively or any of them, at the project site as per the total renewable energy installation requirement.

Table 25: Points for renewable energy systems

Provisions	Incremental Points
Installing Solar Water Heating system of minimum BEE 3-star label: Equivalent to at least 13% of the plot area[17] and / or Installing Solar photo-voltaic: Equivalent to at least 13% of the plot area[18]	4
Installing Solar Water Heating system of minimum BEE 3-star label: Equivalent to at least 16% of the plot area[19] and/or Installing Solar photo-voltaic: Equivalent to at least 16% of the plot area[20]	10

[17] 100 lpd= 3 m^2 area as per MNRE guidelines
[18] 1kW_p=10m^2 area as per MNRE guidelines
[19] 100 lpd= 3 m^2 area as per MNRE guidelines
[20] 1kW_p=10m^2 area as per MNRE guidelines

CHAPTER 6: WATER CONSERVATION AND MANAGEMENT

6.1 SCOPE

6.1.1 The chapter provides requirements for water conservation and management post-occupancy of a building to reduce water demand and optimise the supply of water. It consists of five parts- site water use reduction, building water use reduction, water usage monitoring, rainwater harvesting and recycle & reuse of wastewater.

6.2 MANDATORY PROVISIONS

6.2.1 SITE WATER USE REDUCTION

6.2.1.1 Up to 40% of the total water required for irrigation shall be provided through recycled water or rainwater harvesting.

6.2.1.2 As per the National Building Code, 2016, irrigation systems must be designed in a manner to provide 8 litres/sqm/day of water to all landscaped areas.

6.2.1.3 At least 70% of the landscaped planting beds to have drip irrigation, to prevent evaporation.

6.2.1.4 At least 60% of the planted turf grasses must be provided with sprinkler systems.

6.2.2 BUILDING WATER USE REDUCTION

6.2.2.1 SANITARY FITTINGS

Sanitary Fittings such as faucets (taps) and showerheads for their performance based on water efficiency shall comply with the specifications of 1 star rating criteria of the fixtures, laid down in IS 17650 Part 1, 2021, as specified in Table 26:

Table 26: Sanitary Fittings

SI No.	Water Consumption Per Unit	Water Consumption Per Unit	Water Efficiency Rating Criteria		
			1- Star	2- Stars	3- Stars
(1)	(2)	(3)	(4)	(5)	(6)
i)	Metered faucets for basin use	litres/use	Not more than 1.0	Not more than 0.8	Not more than 0.6
ii)	Wash basin/ lavatory faucet (also applies to sensor faucets)	litres/use	Not more than 8.0	Not more than 6.0	Not more than 3.0
iii)	Sink faucet	litres/use	Not more than 8.0	Not more than 6.0	Not more than 4.5
iv)	Overhead shower	litres/use	Not more than 10.0	Not more than 8.0	Not more than 6.8
v)	Hans held shower	litres/use	Not more than 8.0	Not more than 6.0	Not more than 4.0
vi)	Handheld ablution spray	litres/use	Not more than 6.0	Not more than 5.0	Not more than 4.0

6.2.2.2 SANITARY WARE

Sanitary ware such as water closets, squatting pans, flush valves, flushing cisterns, and urinals for their performance based on water efficiency shall comply with the specifications as outlined for 1 star rating in IS 17650 Part 2, 2021, as specified in Table 27:

Table 27: Sanitary Wares

Sl No.	Product	Water Consumption Per Unit	Rating Criteria		
			1-Star	2- Stars	3-Stars
(1)	(2)	(3)	(4)	(5)	(6)
i)	Water closet, squatting pan, flushing cistern, and flush valve	a) Full flush, liters/flush	Not more than 6.0 *l* per flush	Not more than 4.8 *l* per flush	Not more than 4.0 *l* per flush
		b) Reduced flush, liters/flush	Not more than 3.0 *l* per flush	Not more than 2.8 *l* per flush	Not more than 2.0 *l* per flush
ii)	Urinal	liters/flush	Not more than 3.0 *l* per flush (inclusive of pre-flush and post-flush, in case of sensor urinal)	Not more than 2.0 *l* per flush (inclusive of pre-flush and post-flush, in case of sensor urinal)	Not more than 1.0 *l* per flush (inclusive of pre-flush and post-flush, in case of sensor urinal)

6.2.3 WATER USAGE MONITORING

6.2.3.1 Buildings exceeding the threshold defined under clause 2.2 of this code shall install smart meters and monitor the water use for each of the following separately:

A. Total water consumption of the building complex

B. Water consumption of the following:
   I. Common Landscaping areas
   II. Common area water usage (common toilets, housekeeping, etc.)

6.2.4 RAINWATER HARVESTING

6.2.4.1 Residential buildings shall have a rainwater harvesting system consisting of:

a) Roof catchment
b) Gutters
c) Downpipes
d) Rainwater/ Storm water drains
e) Filter Chamber
f) Storage Tanks/ Pits/ Sumps.
g) Groundwater recharge structures like pits, trenches, tube wells or a combination of above structures.

6.2.4.2 At least 80% of the rainwater (adjusting the coefficient) falling on the roof of the building shall be harvested and stored in a tank for reuse in households through a provision of separate water tanks and pipelines to avoid mixing with potable municipal water supply.

6.2.4.3 The remaining rainwater harvested should be linked to the tube well bore in the premise through a pipeline after filtering of the rainwater.

6.2.5 RECYCLE & REUSE OF WASTEWATER

6.2.5.1 Residential buildings shall install on-site water treatment systems for greywater recycling and reuse, catering to at least 50% of the total wastewater generated from toilets and kitchens.

6.2.5.2 Separate storage tanks and plumbing lines shall be provided for the reuse of treated water from the on-site wastewater treatment plant following the criteria laid in Section 2 of the National Building Code of India, 2016.

6.2.6 WATER QUALITY REQUIREMENTS

6.2.6.1 Potable/domestic water quality shall comply with the requirements of IS 10500:2012, Drinking Water – Specification, as given in Tables 1 to 4.

6.2.6.2 Varied recycled applications of treated used water quality such as toilet flushing, vehicle exterior washing, non-contact impoundments, and landscape irrigation shall comply with the requirements of CPHEEO manual on Sewerage and Sewage Treatment Systems: 2013, Chapter 7 Table 7.19 issued by Ministry of Housing and Urban Affairs.

6.3 INCREMENTAL PROVISIONS (MAXIMUM 43 POINTS)

6.3.1 SITE WATER USE REDUCTION (MAXIMUM 17 POINTS)

6.3.1.1 Recycled/harvested water shall provide water for irrigation as per the requirements in Table 28.

Table 28: Points for recycled water used for irrigation

Provision	Incremental Points
Upto 50% of the total irrigation requirement	5
Upto 60% of the total irrigation requirement	8

6.3.1.2 Planting beds shall be provided with a drip irrigation system and shall comply with the requirements as per Table 29.

Table 29: Points for Drip irrigation System

Provision	Incremental Points
A minimum of 80% of the planting bed area has drip irrigation	3
A minimum of 90% of the planting bed area has drip irrigation	5

6.3.1.3 The turf area shall be provided with sprinkler systems and shall comply with requirements as per Table 30.

Table 30: Points for Sprinkler Irrigation System

Provision	Incremental Points
A minimum of 70% of the turf area has a sprinkler system	2
A minimum of 80% of the turf area has a sprinkler system	4

6.3.2 BUILDING WATER USE REDUCTION (MAXIMUM 26 POINTS)

6.3.2.1 RECYCLE AND REUSE OF WATER

Recycle and reuse of water shall be ensured on site and shall comply with the specification as per Table 31.

Table 31: Points for Reclamation of Wastewater

Provision	Incremental Points
A minimum of 70% of wastewater reclaimed	6
A minimum of 90% of wastewater reclaimed	10

6.3.2.2 SANITARY FITTINGS & WARE

Sanitary Fittings such as faucets (taps) and showerheads for their performance based on water efficiency shall comply with the specifications as per Table 32.

Table 32: Points for Star Rated Sanitary Fittings

Provision	Incremental Points
2- star rating as per IS 17650 Part 1, 2021,	5
3- star rating as per IS 17650 Part 1, 2021,	8

Sanitary ware such as water closets, squatting pans, flush valves, flushing cisterns, and urinals for their performance based on water efficiency shall comply with the specifications as per Table 33.

Table 33: Points for Star Rated Sanitary Ware

Provision	Incremental Points
2- star rating as per IS 17650 Part 1, 2021,	5
3- star rating as per IS 17650 Part 1, 2021,	8

CHAPTER 7: WASTE MANAGEMENT

7.1 SCOPE

7.1.1 The chapter provides requirements to minimise the waste generated both during the construction phase and post-occupancy to divert any waste from reaching the landfills. The chapter consists of two parts – Construction Waste Management and Municipal Waste Management.

7.1.2 **Classification of construction waste[21]:** The waste generated during construction shall be classified but not limited to the following categories:

i. **Non-Hazardous waste**: Including but not limited to Excavated earth excluding 150-200 mm (6-8 inches) of the topsoil, Land clearing debris, Metals (Reinforcement bars, Metal beams/girders, Window/Door frames, nuts and bolts, wires, etc.), Cement and Concrete, Masonry materials (Bricks, AAC blocks, stone, any other masonry, etc.), Flooring, Ceiling, Roofing materials, Insulation materials, Cladding materials (Tiles, stones, gypsum, etc.), Glass, Wood, etc.

ii. **Packaging waste**: Including but not limited to cement bags, Wooden crates and pallets, Cardboard boxes, Plastic wrapping and shrink wrap, Foam and bubble wrap, Strapping bands and steel wires, PE film or plastic sheeting, Plastic or metal drums/buckets/containers, Corrugated plastic sheets, specialized packaging etc.

iii. **Construction Hazardous waste:** Including but not limited to lead, tars, adhesives, sealants, broken glass.

7.1.3 **Classification of post-occupancy waste:** The waste generated post-construction shall be classified but not limited to the following categories:

i. **Dry waste:** Including but not limited to, *plastic* items (plastic bottles, containers, packaging, stationary items, etc.), *paper* items (newspapers, magazines, cardboard, packaging, etc.), *metal* items (aluminium cans, used aluminium foil paper/tray, *steel* containers, old metal utensils, pots, metal gardening accessories, etc.), *glass* items (glass bottles, jars, utensils, etc.), *Electronics* items (wires, computer accessories, fluorescents, lamps, other electronics, and electrical devices/appliances).

ii. **Wet waste:** Including but not limited to, vegetable peels, used tea, fruits, food leftovers, horticulture waste, etc. These are biodegradable organic waste that can also be composted.

iii. **Sanitary waste:** Including but not limited to, used diapers, sanitary pads, sweat pads, tampons, condoms, wipes, masks/ gloves, toilet paper, bandages, swabs, and other personal hygiene products etc.

iv. **Hazardous waste:** Including but not limited to, expired medicines, used syringes/needles, chemical containers, broken glass, batteries, etc.

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[21] **Construction Waste:** Construction waste is any substance, matter, or thing that is produced as a result of construction work. Wastes also include surplus and damaged products and materials arising in the course of construction work or used temporarily during on-site activities. (C & D Waste Management Rules, 2016)

7.2 MANDATORY PROVISIONS

7.2.1 CONSTRUCTION WASTE MANAGEMENT

7.2.1.1 SEGREGATION AND STORAGE OF WASTE

Designated areas shall be provided within the site/neighbouring site for collection, segregation, and storage of segregated waste as per the classification of waste mentioned in clause no. 7.1.2 of this code.

Note: No construction and demolition waste shall be littered or deposited to prevent obstruction to the traffic or the public or drains. (C&D Waste Management Rules, 2016)

7.2.1.2 MINIMIZATION OF NON HAZARDOUS WASTE

At least 50% (by either weight or volume) of non-hazardous waste generated, shall have to be reused/repurposed/recycled/salvaged [22]. For sample calculation refer to clause number 9.15 of this code.

Note: Some types of construction waste can be reused/repurposed on-site as fill material for levelling uneven terrain, filling excavated areas, or creating embankments, as a base or subbase material for road construction, for erosion control measures, constructing retaining walls, as bedding and backfill material for utility pipelines, etc.

7.2.1.3 RECYCLING OF PACKAGING WASTE

100% of the packaging recyclable waste, shall be handed over to manufacturers/ authorized recyclers or municipal entities for appropriate management and disposal.

7.2.1.4 DIVERT CONSTRUCTION WASTE FROM LANDFILL

Ensure that all (100%) the construction waste (by either weight or volume) generated during the construction process is either reused/repurposed/salvaged on-site, diverted to recycling facilities, or safely handed over to municipalities. Diversion efforts shall be tracked throughout the construction process. For sample calculation refer to clause number 9.15 of this code.

7.2.2 POST-CONSTRUCTION WASTE MANAGEMENT

7.2.2.1 WASTE COLLECTION, SEGREGATION AND STORAGE

Designated waste collection area on each floor of the building shall be provided with four colour-coded waste bins—Dry Waste, Organic Waste, Sanitary Waste, and Hazardous Waste.

[22] **Reusing** is a strategy to return materials for active use in the same or a related capacity.
Repurposing refers to items or substances that were originally intended for one purpose but have been creatively transformed, i.e. broken brick/blocks can be repurposed as road filling.
Recycling is a strategy to put used objects and materials through a process so that they can be used again.
Salvaged materials are construction materials recovered from existing buildings or construction sites / second-hand markets and reused in other buildings.

For calculation of waste generation quantity and area required for storage, refer to clause number 9.12, 9.13 of this code.

Note:

A. A daily waste collection schedule should be developed to collect the segregated waste from each floor and store at a designated centralized storage area in the premises until its transportation to respective recyclers.
B. Dry, sanitary, and hazardous waste shall be transported to/ collected by authorised recyclers/ Municipal Corporation.

7.2.2.2 ORGANIC WASTE TREATMENT

A. Projects having built up area ≥5000 sq.m, an onsite designated area shall be provided to compost (manually or mechanically) at least 50% of projected organic waste (kitchen & horticulture) generated on post-occupancy. The waste generation shall be calculated using the formula as given in clause number 9.10 of this code. The area shall be provided as per
B. Table 34.

C. Projects having built up area ≤5000 sq.m, the project authority may hand over the segregated organic waste to the concerned local body if the municipality has a garbage pick-up mechanism in place. If such an arrangement is inadequate or unavailable, the project authority shall engage a professional waste management organisation to pick up the segregated organic waste, where there is no alternate arrangement for disposal of biodegradable waste, Organic waste composter/Vermiculture pit with a minimum capacity of 1.0 kg/150 sqm. of built-up area/day shall be installed & operated.

Table 34: Area requirement for different strategies

S. No.	Type of waste treatment	Area required (m^2 per 10Kg)
1	Composting	Approx. 10 m^2 (including circulation area)
2	Vermi Composting	Approx. 15 m^2 (including circulation area)
3	Mechanical	8-12 m^2 (including circulation area)

7.3 INCREMENTAL PROVISIONS (MAXIMUM 7 POINTS)

7.3.1 CONSTRUCTION WASTE MANAGEMENT (MAXIMUM 2 POINTS)

7.3.1.1 MINIMIZATION OF NON-HAZARDOUS WASTE

Non-hazardous construction waste generated shall have to be reused/repurposed /recycled/salvaged, to comply with the requirements as per Table 35.

Table 35: Points for reuse of waste generated on-site

Provision	Incremental Points
75%of non-hazardous waste generated is reused/repurposed /recycled/salvaged	1
95% of non-hazardous waste generated is reused/repurposed /recycled/salvaged	2

7.3.2 POST-CONSTRUCTION WASTE MANAGEMENT (MAXIMUM 5 POINTS)

7.3.2.1 WASTE COLLECTION, SEGREGATION AND STORAGE (MAXIMUM POINTS: 2)

Different categories (organic, sanitary, Hazardous, plastic, paper, glass, metal, packaging) of colour-coded waste collection bins are provided for waste segregation in the centralized waste collection area, as per Table 36.

Note: Colour coding of wastebins can be implemented based on market availability, along with the installation of permanent signages.

Table 36: Points for waste segregation at the centralized unit

Provision	Incremental Points
100% of recyclable waste shall be segregated into **six** categories organic, sanitary, Hazardous, plastic, glass, and metal.	1
100% of recyclable waste shall be segregated into **eight** categories organic, sanitary, Hazardous, plastic, paper, glass, metal, and packaging.	2

7.3.2.2 ORGANIC WASTE TREATMENT (MAXIMUM POINTS: 3)

A designated area on the project site shall be provided to compost (manually or mechanically) to comply with the requirements as per Table 37. The calculation shall be done to calculate the designated area as per 9.12, 9.13, 9.14.

Table 37: Points for Composting of Organic Waste

Provision	Incremental Points
75% of organic waste generated post-occupancy is composted on-site	2
95% of organic waste generated post-occupancy is composted on-site	3

CHAPTER 8: INDOOR ENVIRONMENTAL QUALITY (IEQ)

8.2 SCOPE

8.2.1 The chapter provides provisions related to indoor air quality, thermal comfort, and visual comfort post-occupancy of a building. It consists of eight parts: ventilation potential, low-emitting materials, air quality in car parking, openings for kitchen and bathrooms/toilet ventilation, daylight availability, lighting adequacy for common areas and exterior lighting, lighting quality, and thermal comfort.

8.3 MANDATORY PROVISIONS

8.3.1 VENTILATION POTENTIAL

8.3.1.1 The building shall meet the minimum criteria for the openable window-to-floor area ratio (WFR_{op}) to ensure an adequate potential for natural ventilation as per Table 8 under provision number 0 of this code.

8.3.2 LOW-EMITTING MATERIALS

8.3.2.1 Paints used on the interior side of the building envelope shall comply with the VOC content limits as per Table 38

Table 38: VOC Limits of Selected Paints

Type of Material	VOC Limit (g/L less water)
Paints:	
Flat paints	50
Non-flat paints	50

8.3.3 AIR QUALITY IN CAR PARKING

8.3.3.1 For enclosed parking areas, a well-designed ventilation and exhaust system shall be installed that provides a minimum of 6 air changes per hour, as per the National Building Code (NBC), to effectively eliminate vehicle exhaust fumes and pollutants.

Air Change per Hour = Q / V

where,

Q = airflow rate (m^3/h)

V = volume of the space (m^3)

8.3.4 VENTILATION OPENING IN KITCHEN AND BATHROOMS/TOILETS

8.3.4.1 An opening and/or ventilator shall be provided, in addition to the window, above the lintel level for the installation of exhaust systems in the kitchen and bathrooms/toilets.

8.3.5 DAYLIGHT AVAILABILITY

8.3.5.1 The building shall meet the minimum criteria for Visible Light Transmittance (VLT) to ensure adequate availability of daylight as per Table 9 under provision number 5.2.1.2 of this code.

8.3.6 LIGHTING ADEQUACY FOR COMMON AREAS AND EXTERIOR LIGHTING

8.3.6.1 Artificial lighting systems complying with the minimum recommended lux levels specified in Table 39 shall be installed.

Table 39: Required Min. Lux Levels as per space

Area Name	Minimum lux level
Corridor Lighting & Stilt Parking	100
Basement lighting	70
Exterior Lighting Areas	
Driveways and parking (open/ external)	5-20
Pedestrian walkways	50
Stairways	100
Indoor Lighting (If applicable)	
Kitchen	200
Bathroom	100
Reading/ Study	300

(Source: SP 41 - Handbook on Functional Requirements of Buildings-Part 4 & NBC 2016: Volume 2, part 8, section 1, clause 4.1.4)

The lux levels shall be calculated using the formula as given in clause number 9.10 of this code.

8.3.7 LIGHTING QUALITY - COLOUR RENDERING INDEX

8.3.7.1 The Colour Rendering Index (CRI) values for each zone within the building shall comply with requirements as per Table 40

Table 40: Required CRI as per space type

Area Name	Ra (General Colour Rendering Index)
Corridor Lighting & Stilt Parking	80
Basement lighting	70
Exterior Lighting Areas	
Driveways and parking (open/ external)	70
Pedestrian walkways	70
Stairways	80
Indoor Lighting (If applicable)	
Kitchen	90
Bathroom	80
Bedroom	80
Reading/ Study	90
Living Room	90

8.3.8 THERMAL COMFORT

8.3.8.1 Buildings in all Climate Zones except Cold Climate shall comply with the following provisions of the code:

A. Maximum Residential Envelope Transmittance Value (RETV) (except the roof) as per provision number 0
B. Minimum openable window-to-floor area ratio (WFR_{op}) as per provision number 0
C. Maximum Thermal Transmittance of roof (U_{roof}) as per provision number 0

8.3.8.2 Buildings in Cold Climates, shall comply with the following provisions of the code:

A. Thermal Transmittance value of the building envelope ($U_{Envelope.Cold}$) (except the roof) as per provision number 0
B. Maximum Thermal Transmittance of roof (U_{roof}) as per provision number 0

8.4 INCREMENTAL POINTS PROVISIONS (MAXIMUM 10 POINTS)

8.4.1 CROSS-VENTILATION (MAXIMUM 4 POINTS)

8.4.1.1 Cross-ventilation is ensured in regularly occupied spaces (kitchen, bedrooms, living, dining areas) with openable doors, windows, or ventilators as per Annexure 6. Incremental points are calculated as per the formula below and points as per Table 41.

Percentage of cross ventilation area = (cross ventilation Area / total regularly occupied Area) * 100

Table 41: Cross ventilation requirement for incremental points

Provision	Incremental Points
50% of regularly occupied spaces have cross-ventilation	2
75% of regularly occupied spaces have cross-ventilation	3
90% of regularly occupied spaces have cross-ventilation	4

8.4.2 DAYLIGHT AVAILABILITY (USEFUL DAYLIGHT ILLUMINANCE) (MAXIMUM 4 POINTS)

8.4.2.1 The building shall comply with the useful daylight illuminance requirement as prescribed by the ECBC 2017, clause no 4.2.3. Ensure above-grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 56 for 90% of the potential daylit time in a year. (Refer to **Error! Not a valid bookmark self-reference.**). Incremental points can be achieved as per Table 42.

Table 42: Daylight Requirement

Provision	Incremental Points
40% of the regularly occupied spaces meeting the UDI requirement	2
50% of the regularly occupied spaces meeting the UDI requirement	3
60% of the regularly occupied spaces meeting the UDI requirement	4

8.4.3 AIR QUALITY IN UNDERGROUND PARKING AREA (MAXIMUM POINTS 2)

8.4.3.1 Install a demand control ventilation system to limit CO levels in the underground parking area to ensure safety and air quality. The location of sensors should be followed as prescribed by the NBC 2016, Volume 2, Part 8, section 3, clause no 11.5.4. Incremental points can be achieved as per Table 43.

Table 43: Air Quality in Car Parking

Provision	Incremental Points
CO sensors are installed to control the ventilation system to limit CO level	2

CHAPTER 9: CALCULATIONS AND FORMULA

9.1 CALCULATION OF OPENABLE WINDOW-TO FLOOR AREA RATIO (WFR_{OP})

9.1.1 The openable window-to-floor area ratio (WFR_{op}) indicates the potential of using external air for ventilation. The prescribed minimum WFR_{op} helps in ventilation, improvement in thermal comfort, and reduction in cooling energy.

9.1.2 The openable window-to-floor area ratio (WFR_{op}) is the ratio of openable area to the carpet area of dwelling units.

$$WFR_{op} = \frac{A_{openable}}{A_{carpet}} \quad (1)$$

Where:

WFR_{op} : openable window-to-floor area ratio

$A_{openable}$: openable area (m2); it includes the openable area of all windows and ventilators, opening directly to the external air, an open balcony, 'verandah', corridor, or shaft; and the openable area of the doors opening directly into an open balcony.

Exclusions: All doors opening into corridors. External doors on ground floor, for example, ground floor entrance doors or backyard doors.

A_{carpet}: Carpet Area of dwelling units (m^2); it is the net usable floor area of a dwelling unit, excluding the area covered by the external walls, areas under services shafts, exclusive balcony or verandah areas and exclusive open terrace areas, but includes the area covered by the internal partition walls of the dwelling unit.

9.1.3 The openable area ($A_{openable_{DU}}$)of each dwelling unit (DU) is calculated by adding the openable area of all windows and ventilators, opening directly to the external air, an open balcony, 'veranda', corridor or shaft; and the openable area of the doors opening directly into an open balcony (doors opening into the corridors and ground-floor external doors are not included).

$$A_{openable_{DU}} = A_{openable_{window}} + A_{openable_{ventilator}} + A_{openable_{door}}$$

In case the exact openable area is not known, the default values as per Table 44 can be used:

Table 44: Default openable area to opening area ratio

Type of window/door/ventilator	Percentage openable area
Casement	90%
Sliding (2 panes)	50%
Sliding (3 panes)	67%

9.1.4 Add openable areas of all dwelling units to get the total openable area.

$$A_{openable} = A_{openable_{DU1}} + A_{openable_{DU2}} + A_{openable_{DU3}} + \ldots$$

9.1.5 The total carpet area can be calculated by adding the carpet areas of all the dwelling units (DU). It excludes the areas covered by external walls, areas under service shafts, exclusive balcony or veranda areas and exclusive open terrace areas, but includes the areas covered by the internal partition walls of the dwelling unit.

$$A_{carpet} = A_{carpetDU1} + A_{carpetDU2} + A_{carpetDU3} + \dots$$

9.2 CALCULATION OF WINDOW-TO-WALL RATIO (WWR)

9.2.1 WWR is the ratio of the area of non-opaque building envelope components of dwelling units to the envelope area (excluding roof) of dwelling units.

$$WWR = \frac{A_{non-opaque}}{A_{envelope}}$$

9.2.2 Calculate the total non-opaque (transparent/translucent panels of windows, doors, ventilators, etc.) area of the building envelope for each dwelling unit.

$$A_{non-opaque(DU)} = A_{non-opaque(Window)} + A_{non-opaque(Door)} + A_{non-opaque(Other)}$$

Add non-opaque areas of all dwelling units to get the total non-opaque area of the building block. Non-opaque components facing open corridors and enclosed shafts, as well as walls of common services such as lifts and staircases are to be excluded.

$$A_{non-opaque} = A_{non-opaque(DU1)} + A_{non-opaque(DU2)} + A_{non-opaque(DU3)} + \dots$$

9.2.3 Calculate the total envelope area (excluding roof) of dwelling units of the building block. For each wall of the building envelope, calculate the gross wall area (i.e., overall area of a wall including openings such as windows, ventilators, and doors, with measurement taken horizontally from outside surface to outside surface and measured vertically from the top of the floor to the top of the roof). Add the gross wall area of all walls to get the total envelope area (excluding roof) for the building. Walls facing open corridors and enclosed shafts, as well as walls of common services such as lifts and staircases are to be excluded.

$$A_{envelope} = A_{gross-wall} + A_{gross-wall} + A_{gross-wall} + \dots$$

9.3 CALCULATION OF THERMAL TRANSMITTANCE (U VALUE) OF ROOF AND WALL

Calculate the thermal resistance of each uniform material layer, which constitutes the building component, as follows:

$$R_i = \frac{t_i}{k_i} \quad (2)$$

where,

R_i is the thermal resistance of material layer i, m².K/W

t_i is the thickness of material layer i, m k_i is the thermal conductivity of material layer i, W/(m.K)

Find the total thermal resistance, RT, as follows:

$$R_T = R_{si} + R_{se} + R_1 + R_2 + R_3 + \cdots \quad (14)$$

Where,

R_T is the total thermal resistance, m^2.K/W

R_{si} is the interior surface film thermal resistance, m^2.K/W

R_{se} is the exterior surface film thermal resistance, m^2.K/W

R_1 is the thermal resistance of material layer 1, m^2.K/W

R_2 is the thermal resistance of material layer 2, $m^{2}2$.K/W

R_3 is the thermal resistance of material layer 3, m^2.K/W

Using these default values for calculation, the thermal conductivity of commonly used building materials is given in Table 45, which can be used to calculate the thermal resistance (r- value).

Table 45: Values of surface film thermal resistance for U-value calculation

	Wall	Roof	
	All climatic Zones	**composite climate, hot-dry climate, warm-humid climate, and temperate climate**	**cold climate**
R_{si} (m^2.K/W)	0.13	0.17	0.10
R_{se} (m^2.K/W)	0.04	0.04	0.04

Source: adapted from Bureau of Energy Efficiency (BEE), 2009. Energy Conservation Building Code user guide, New Delhi.

Calculate the thermal transmittance (or the overall heat transfer coefficient or U value) of a wall or roof assembly, as follows:

$$U = \frac{1}{R_T} \quad (15)$$

where,

U is the overall heat transfer coefficient, W/(m^2.K)

Table 46 gives typical thermal properties of commonly used building and insulating materials. This is not an all-inclusive list. In case, thermal conductivity values, measured using the appropriate IS codes, are available; than those can also be used for calculations.

Table 46: Type of material and Thermal Conductivity

S. No.	type of material	Density (kg/m^3)	thermal conductivity (w/m.K)	specific heat capacity (kJ/kg.K)	source
I. Building materials					
1	Solid burnt clay brick	1920	0.980	0.80	(1)
2	Solid burnt clay brick	1760	0.850	NA	(1)
3	Solid burnt clay brick	1600	0.740	NA	(1)
4	Solid burnt clay brick	1440	0.620	NA	(1)
5	Resource efficient (hollow) brick	1520	0.631	0.65	(4)
6	Fly ash brick	1650	0.856	0.93	(2)
7	Solid concrete block 25/50	2427	1.396	0.20	(4)

8	Solid concrete block 30/60	2349	1.411	0.30	(4)
9	Aerated autoclaved concrete (AAC) block	642	0.184	1.24	(4)
10	Cement stabilized soil block (CSEB)	1700	1.026	1.03	(5)
11	Cement stabilized soil block (CSEB)	1800	1.201	1.07	(5)
12	Cement stabilized soil block (CSEB)	1900	1.303	1.07	(5)
13	Dense concrete	2410	1.740	0.88	(3)
14	Reinforced concrete cement (RCC)	2288	1.580	0.88	(3)
15	Brick tile	1892	0.798	0.88	(3)
16	Lime concrete	1646	0.730	0.88	(3)
17	Mud Phuska	1622	0.519	0.88	(3)
18	Cement mortar	1648	0.719	0.92	(3)
19	Cement plaster	1762	0.721	0.84	(3)
20	Gypsum plaster	1120	0.512	0.96	(3)
21	Cellular concrete	704	0.188	1.05	(3)
22	AC sheet	1520	0.245	0.84	(3)
23	GI sheet	7520	61.060	0.50	(3)
24	Timber	480	0.072	1.68	(3)
25	Timber	720	0.144	1.68	(3)
26	Plywood	640	0.174	1.76	(3)
27	Glass	2350	0.814	0.88	(3)
28	Tar felt (2.3 kg/m2)		0.479	0.88	(3)
II. Insulating materials					
1	Expanded polystyrene	16.0	0.038	1.34	(3)
2	Expanded polystyrene	24.0	0.035	1.34	(3)
3	Expanded polystyrene	34.0	0.035	1.34	(3)
4	Foam glass	127.0	0.056	0.75	(3)
5	Foam glass	160.0	0.055	0.75	(3)
6	Foam concrete	320.0	0.070	0.92	(3)
7	Foam concrete	400.0	0.084	0.92	(3)
8	Foam concrete	704.0	0.149	0.92	(3)
9	Cork slab	164.0	0.043	0.96	(3)
10	Cork slab	192.0	0.044	0.96	(3)
11	Cork slab	304.0	0.055	0.96	(3)
12	Rock wool (unbonded)	92.0	0.047	0.84	(3)
13	Rock wool (unbonded)	150.0	0.043	0.84	(3)
14	Mineral wool (unbonded)	73.5	0.030	0.92	(3)
15	Glass wool (unbonded)	69.0	0.043	0.92	(3)
16	Glass wool (unbonded)	189.0	0.040	0.92	(3)
17	Resin bonded mineral wool	48.0	0.042	1.00	(3)
18	Resin bonded mineral wool	64.0	0.038	1.00	(3)

19	Resin bonded mineral wool	99.0	0.036	1.00	(3)
20	Resin bonded mineral wool	16.0	0.040	1.00	(3)
21	Resin bonded mineral wool	24.0	0.036	1.00	(3)
22	Exfoliated vermiculite (loose)	264.0	0.069	0.88	(3)
23	Asbestos mill board	1397.0	0.249	0.84	(3)
24	Hard board	979.0	0.279	1.42	(3)
25	Straw board	310.0	0.057	1.30	(3)
26	Soft board	320.0	0.066	1.30	(3)
27	Soft board	249.0	0.047	1.30	(3)
28	Wall board	262.0	0.047	1.26	(3)
29	Chip board	432.0	0.067	1.26	(3)
30	Chip board (perforated)	352.0	0.066	1.26	(3)
31	Particle board	750.0	0.098	1.30	(3)
32	Coconut pith insulation board	520.0	0.060	1.09	(3)
33	Jute fibre	329.0	0.067	1.09	(3)
34	Wood wool board (bonded with cement)	398.0	0.081	1.13	(3)
35	Wood wool board (bonded with cement)	674.0	0.108	1.13	(3)
36	Coir board	97.0	0.038	1.00	(3)
37	Saw dust	188.0	0.051	1.00	(3)
38	Rice husk	120.0	0.051	1.00	(3)
39	Jute felt	291.0	0.042	0.88	(3)
40	Closed cell flexible elastomeric foam - NBR	40–55	0.043	1.20	(3)

Na: Not available

Sources

(1) American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). 2009. 2009 ASHRAE Handbook (Fundamentals). Atlanta, United States: ASHRAE

(2) Gourav K, et al. 2017. Studies into structural and thermal properties of building envelope mate- rials. Energy Procedia 122: 104–108

(3) Bureau of Indian Standards (BIS). 1987. Handbook on Functional Requirements of Buildings (Other than Industrial Buildings) SP: 41 (S & T) -1987. New Delhi: BIS.

(4) Thermo-Physical-Optical Property Database of Construction Materials, U.S.- India Joint Centre for Building Energy Research and Development (CBERD) and Ministry of New and Renew- able Energy (MNRE). Available at http://www.carbse.org/wp-content/uploads/2017/10/Data- base-of-Construction-Materials_Oct17.pdf (accessed on 1 May 2018).

(5) Balaji N C, et al. 2015. Influence of varying mix proportions on thermal performance of soil-cement blocks. Building Simulation Applications (BSA). 2nd IBPSA Italy Conference, Building Simulation Application - 2015 (BSA 2015). Available at http://www.ibpsa.org/proceedings/ BSA2015/9788860460745_10.pdf (accessed on 1 May 2018).

In case, the construction has air layer, use values of thermal resistance of air layer given in Table 47 for U value calculation.

Table 47: Values of unventilated air layer thermal resistance for U-value calculation

thickness of air Layer (mm)	thermal resistance (m²·K/w)		
	wall in all climatic Zones	Roof in composite climate, hot-Dry climate, warm-humid climate, and temperate climate	Roof in cold climate
5	0.12	0.10	0.10
7	0.12	0.12	0.12
10	0.14	0.14	0.14
15	0.16	0.16	0.16
25	0.18	0.18	0.17
50	0.18	0.20	0.17
100	0.18	0.20	0.17
300	0.18	0.21	0.17

Source: Adapted from Bureau of Energy Efficiency (BEE), 2009. Energy Conservation Building Code User Guide, New Delhi

9.4 THERMAL TRANSMITTANCE OF ROOF (U_{ROOF})

9.4.1 Thermal transmittance (U_{roof}) characterizes the thermal performance of the roof of a building. Limiting the U_{roof} helps in reducing heat gains or losses from the roof, thereby improving the thermal comfort and reducing the energy required for cooling or heating.

9.4.2 The calculation23 for thermal transmittance of roof shall be carried out, using Equation as shown below

$$U_{roof} = \frac{1}{A_{roof}}\left[\sum_{i=1}^{n}(U_i \, x \, A_i)\right]$$

Where,

U_{roof} : thermal transmittance of roof (W/m²·K)

A_{roof} : total area of the roof (m²)

U_i : thermal transmittance values of different values of different roof construction (W/m²·K)

A_i : areas of different roof constructions (m²)

9.5 RESIDENTIAL ENVELOPE TRANSMITTANCE VALUE (RETV) FOR BUILDING ENVELOPE (EXCEPT ROOF) FOR FOUR CLIMATE ZONES, NAMELY, COMPOSITE CLIMATE, HOT-DRY CLIMATE, WARM-HUMID CLIMATE, AND TEMPERATE CLIMATE

9.5.1 Residential envelope heat transmittance (RETV) is the net heat gain rate (over the cooling period) through the building envelope (excluding roof) of the dwelling units divided by the area of the building envelope (excluding roof) of the dwelling units. Its unit is W/m².

23 To comply with the Code, U value shall be rounded off to one decimal places in accordance with IS 2: 1960 'Rules for rounding off numerical values'.
BEE plans to improve the RETV norm to 12 W/m2 in the near future and the building industry and regulating agencies are encouraged to aim for it.

RETV characterizes the thermal performance of the building envelope (except roof). Limiting the RETV value helps in reducing heat gains from the building envelope, thereby improving the thermal comfort and reducing the electricity required for cooling.

RETV formula takes into account the following:

a) Heat conduction through opaque building envelope components (wall, opaque panels in doors, windows, ventilators, etc.),
b) Heat conduction through non-opaque building envelope components (transparent/translucent panels of windows, doors, ventilators, etc.),
c) Solar radiation through non-opaque building envelope components (transparent/translucent panels of windows, doors, ventilators, etc.)

9.5.2 The RETV for the building envelope (except roof) for four climate zones, namely, Composite Climate, hot-Dry Climate, Warm-humid Climate, and temperate Climate, shall comply with the maximum RETV of 15 W/m2.

9.5.3 The RETV calculation of the building envelope (except roof) shall be carried out, using Equation 4 as shown below. [24]

$$RETV = \frac{1}{A_{envelope}} \times \left[\left\{ a \times \sum_{i=1}^{n} \left(A_{opaque_i} \times U_{opaque_i} \times \omega_i \right) \right\} + \left\{ b \times \sum_{i=1}^{n} \left(A_{non-opaque_i} \times U_{non-opaque_i} \times \omega_i \right) \right\} + \left\{ c \times \sum_{i=1}^{n} \left(A_{non-opaque_i} \times SHGC_{eq_i} \times \omega_i \right) \right\} \right] \quad (3)$$

where,

$A_{envelope}$: envelope area (excluding roof) of dwelling units (m2). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors).

A_{opaque_i}: areas of different opaque building envelope components (m2)

U_{opaque_i}: thermal transmittance values of different opaque building envelope components (W/m2.K)

$A_{non-opaque_i}$: areas of different non-opaque building envelope components (m2)

$U_{non-opaque_i}$: thermal transmittance values of different non-opaque building envelope components (W/m2.K)

$SHGC_{eq_i}$: equivalent solar heat gain coefficient values of different non-opaque building envelope components (values are given in section 9.9)

ω_i: orientation factor of respective opaque and non-opaque building envelope components; it is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation

The coefficients of RETV formula, for different climate zones are given in Table 48

24 To comply with the Code, RETV value shall be rounded off to nearest integar value in accordance with IS 2: 1960 'Rules for rounding off numerical values'.

Table 48: Coefficients (a, b, and c) for RETV formula

Climate zone	a	b	c
Composite	6.06	1.85	68.99
Hot-Dry	6.06	1.85	68.99
Warm-Humid	5.15	1.31	65.21
Temperate	3.38	0.37	63.69
Cold	Not applicable (Refer clause 5.2.1.4)		

9.5.4 If a proposed building development comprises two or more residential building blocks having different RETV. The weighted average RETV of the total residential project shall be computed (using method mentioned in Chapter 9).

9.6 CALCULATION OF THE WEIGHTED AVERAGE RETV OF THE TOTAL RESIDENTIAL PROJECT

9.6.1 The weighted average RETV of the total residential project shall be computed using following equation

$$RETV_{Weighted\ average} = \sum \left(RETV_{bldg.} \times EA_{bldg.}\right) \Big/ EA_{total}$$

$$= \frac{\left(RETV_{bldg1.} \times EA_{bldg1}\right) + \left(RETV_{bldg2} \times EA_{bldg}\ \right) + \left(RETV_{bldg3} \times EA_{bldg}\ \right)}{\left(EA_{total}\right)}$$

Where,

$RETV_{Weighted\ average}$ is the combined RETV of the overall residential development project.

$RETV_{bldg.\ i}$: is the individual RETV of each residential block.

$EA_{bldg\ i}$: is the total envelope area of the individual building or the total residential project.

EA_{total}: is the total envelope area of the individual building or the total residential project.

$A_{envelope}$: envelope area (excluding roof) of dwelling units (m^2). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors)

9.7 THERMAL TRANSMITTANCE OF BUILDING ENVELOPE (EXCEPT ROOF) FOR COLD CLIMATE ($U_{ENVELOPE,COLD}$)

9.7.1 Thermal transmittance ($U_{envelope,cold}$) characterizes the thermal performance of the building envelope (except roof). Limiting the $U_{envelope,cold}$ helps in reducing heat losses from the building envelope, thereby improving the thermal comfort and reducing the energy required for heating.

$U_{envelope,cold}$ takes into account the following:

- Heat conduction through opaque building envelope components (wall, opaque panels in door, window, ventilators, etc.)

- Heat conduction through non-opaque building envelope components (transparent/translucent panels in windows, doors, ventilators, etc.).

9.7.2 The thermal transmittance of the building envelope (except roof) for cold climate shall comply with the maximum of 1.8 $W/m^2.K$.

9.7.3 The calculation of the building envelope (except roof) shall be carried out, using the following equation

$$U_{envelope,cold} = \frac{1}{A_{envelope}} \sum_{i=1}^{n} (U_i \times A_i)$$

Where,

$U_{envelope,cold}$: Thermal transmittance of building envelope (except roof) for cold climate ($W/m^2.K$)

$A_{envelope}$: envelope area (excluding roof) of dwelling units (m^2). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors)

U_i : thermal; transmittance of different opaque and non-opaque building envelope components ($W/m^2.K$)

A_i : area of different opaque and non-opaque building envelope components (m^2)

9.8 CALCULATION OF ORIENTATION FACTOR

9.8.1 The orientation factor (ω) is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation. This factor accounts for and gives weightage to the fact that the solar radiation falling on different orientations of walls is not same. It has been defined for the latitudes ≥23.5˚N and latitudes <23.5˚N (Table 49). Table 49 should be read in conjunction with Figure 1.

Table 49: Orientation factor (ω) for different orientations

Orientation	Orientation factor (ω)	
	Latitudes ≥23.5˚N	Latitudes <23.5˚N
North (337.6˚–22.5˚)	0.550	0.659
North-east (22.6˚–67.5˚)	0.829	0.906
East (67.6˚–112.5˚)	1.155	1.155
South-east (112.6˚–157.5˚)	1.211	1.125
South (157.6˚–202.5˚)	1.089	0.966
South-west (202.6˚–247.5˚)	1.202	1.124
West (247.6˚–292.5˚)	1.143	1.156
North-west (292.6˚–337.5˚)	0.821	0.908

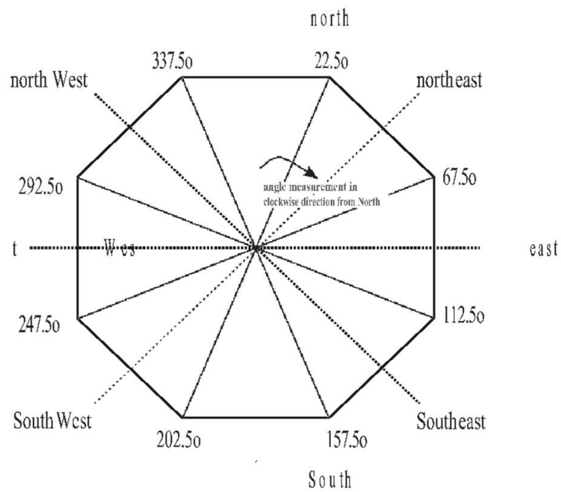


Figure 1: Primary orientations for determining the orientation factor ω

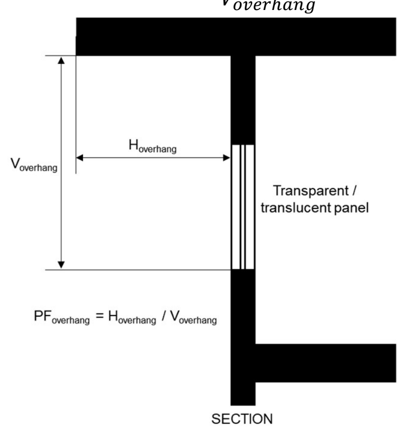
9.9 CALCULATION OF EQUIVALENT SHGC

9.9.1 SHGC Equivalent is the SHGC for a non-opaque component with a permanent external shading projection (overhang and side fins). It is calculated by multiplying the External Shading Factor (ESF) with the SHGC of unshaded non-opaque component. ESF values are defined based on the projection factor (PF). the procedure for calculation is given below:

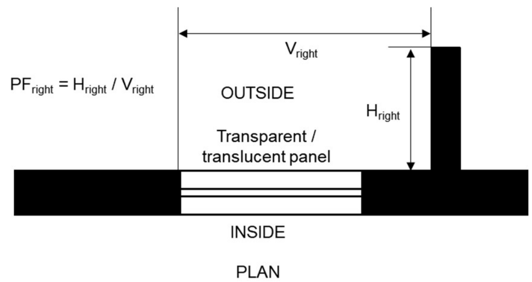
A. Calculate the projection factor (PF) for permanent external projection, including but not limited to overhangs, side fins, box frame, verandah, balcony, and fixed canopies, using the formula:

i. Projection factor, overhang: the ratio of the horizontal depth of the external shading projection ($H_{overhang}$) to the sum of the height of a non-opaque component and the distance from the top of the same component to the bottom of the farthest point of the external shading projection ($V_{overhang}$), in consistent units.

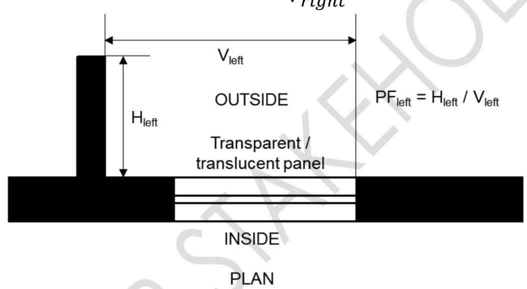
$$PF_{overhang} = \frac{H_{overhang}}{V_{overhang}} \quad (16)$$



ii. Projection factor, side/vertical fin: the ratio of the horizontal depth of the external shading projection to the distance from a non-opaque component to the farthest point of the external shading projection, in consistent units. In case of single side/ vertical fin, it could be on the 'Right' or 'Left' or there could be side/vertical fins on both the sides. A 'Right' side/vertical fin would be located on the right side of the window while looking out from the building and similarly, a 'Left' side/ vertical fin would be located on the left side of the window while looking out from the building.



$$PF_{right} = \frac{H_{rig}}{V_{right}} \quad (17)$$



$$PF_{left} = \frac{H_{left}}{V_{left}} \quad (18)$$

B. Select the ESF value for each shading element as:

I. Overhang ($ESF_{overhang}$): Refer Table 50 and
II.
III. Table 51
IV. Side fin-right (ESF_{right}): Refer Table 52 and Table 53
V. Side fin-left (ESF_{left}): Refer Table 54 and Table 55

Table 50: External Shading Factor for Overhang ($ESF_{overhang}$) for LAT ≥ 23.5°N

External Shading Factor for Overhang ($ESF_{overhang}$) for LAT ≥ 23.5°N								
Orientation	North	North-east	East	South-east	South	South-west	West	North-west
$PF_{overhang}$	(337.6°–22.5°)	(22.6°–67.5°)	(67.6°–112.5°)	(112.6°–157.5°)	(157.6°–202.5°)	(202.6°–247.5°)	(247.6°–292.5°)	(292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.955	0.930	0.922	0.906	0.881	0.905	0.922	0.930
0.20-0.29	0.922	0.876	0.855	0.824	0.789	0.823	0.853	0.875
0.30-0.39	0.897	0.834	0.796	0.755	0.719	0.753	0.794	0.834
0.40-0.49	0.877	0.803	0.745	0.697	0.665	0.695	0.743	0.802
0.50-0.59	0.860	0.779	0.702	0.652	0.626	0.650	0.700	0.778
0.60-0.69	0.846	0.761	0.666	0.617	0.598	0.614	0.663	0.760
0.70-0.79	0.834	0.747	0.635	0.590	0.580	0.587	0.632	0.746
0.80-0.89	0.825	0.737	0.609	0.569	0.569	0.566	0.606	0.736
0.90-0.99	0.817	0.729	0.587	0.554	0.563	0.551	0.585	0.728
≥1	0.810	0.722	0.569	0.542	0.559	0.539	0.566	0.721

Table 51: External Shading Factor for Overhang ($ESF_{overhang}$) for LAT<23.5°N

orientation	External shading Factor for overhang ($EsF_{overhang}$) for Lat < 23.5°N							
$PF_{overhang}$	North (337.6°–22.5°)	North-east (22.6°–67.5°)	East (67.6°–112.5°)	south-east (112.6°–157.5°)	south (157.6°–202.5°)	south-west (202.6°–247.5°)	west (247.6°–292.5°)	North-west (292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.931	0.924	0.922	0.910	0.896	0.910	0.922	0.924
0.20-0.29	0.888	0.864	0.855	0.834	0.816	0.834	0.854	0.864
0.30-0.39	0.860	0.818	0.797	0.771	0.754	0.771	0.796	0.818
0.40-0.49	0.838	0.782	0.747	0.721	0.708	0.720	0.746	0.782
0.50-0.59	0.820	0.755	0.705	0.682	0.675	0.681	0.705	0.755
0.60-0.69	0.806	0.734	0.670	0.651	0.653	0.651	0.670	0.734
0.70-0.79	0.793	0.718	0.641	0.628	0.638	0.627	0.640	0.717
0.80-0.89	0.783	0.706	0.616	0.610	0.628	0.609	0.615	0.705
0.90-0.99	0.775	0.696	0.596	0.596	0.621	0.596	0.595	0.695
≥1	0.768	0.688	0.579	0.585	0.616	0.585	0.578	0.688

Table 52: External Shading Factor for Side Fin-Right (ESF_{right}) for LAT ≥ 23.5°N

orientation / PF_{right}	External shading Factor for side Fin-Right (EsF_{right}) for Lat ≥ 23.5°N							
	North (337.6° –22.5°)	North-east (22.6° – 67.5°)	East (67.6° – 112.5°)	south-east (112.6° – 157.5°)	south (157.6° – 202.5°)	south-west (202.6° – 247.5°)	west (247.6° – 292.5°)	North-west (292.6° – 337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.968	0.942	0.972	0.982	0.961	0.965	0.988	0.985
0.20-0.29	0.943	0.894	0.949	0.968	0.933	0.934	0.977	0.972
0.30-0.39	0.924	0.855	0.931	0.957	0.912	0.907	0.968	0.961
0.40-0.49	0.911	0.824	0.917	0.950	0.898	0.884	0.960	0.953
0.50-0.59	0.899	0.798	0.905	0.944	0.887	0.865	0.954	0.945
0.60-0.69	0.890	0.777	0.895	0.939	0.880	0.849	0.948	0.939
0.70-0.79	0.883	0.762	0.887	0.936	0.875	0.837	0.943	0.934
0.80-0.89	0.877	0.750	0.881	0.933	0.872	0.827	0.939	0.930
0.90-0.99	0.871	0.739	0.875	0.930	0.868	0.819	0.935	0.926
≥1	0.865	0.731	0.870	0.927	0.865	0.812	0.932	0.922

Table 53: External Shading Factor for Side Fin-Right (ESF_{right}) for LAT<23.5°N

orientation / PF_{right}	External shading Factor for side Fin-Right (EsF_{right}) for Lat < 23.5°N							
	North (337.6° –22.5°)	North-east (22.6° – 67.5°)	East (67.6° – 112.5°)	south-east (112.6° – 157.5°)	south (157.6° – 202.5°)	south-west (202.6° – 247.5°)	west (247.6° – 292.5°)	North-west (292.6° – 337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.962	0.948	0.975	0.982	0.962	0.959	0.984	0.984
0.20-0.29	0.934	0.904	0.954	0.968	0.932	0.924	0.970	0.970
0.30-0.39	0.913	0.868	0.937	0.957	0.911	0.894	0.958	0.959
0.40-0.49	0.900	0.840	0.924	0.949	0.896	0.870	0.949	0.950
0.50-0.59	0.888	0.816	0.912	0.942	0.885	0.849	0.940	0.942
0.60-0.69	0.879	0.797	0.903	0.936	0.877	0.832	0.933	0.936
0.70-0.79	0.872	0.782	0.896	0.932	0.872	0.820	0.927	0.931
0.80-0.89	0.866	0.770	0.889	0.929	0.867	0.810	0.922	0.927
0.90-0.99	0.860	0.760	0.884	0.925	0.863	0.801	0.917	0.923
≥1	0.855	0.752	0.878	0.922	0.859	0.794	0.913	0.919

Table 54: External Shading Factor for Side Fin-Left (ESF_{left}) for LAT ≥ 23.5°N

orientation / PF_{left}	External shading Factor for side Fin-Left (EsF_{left}) for Lat ≥ 23.5°N							
	North (337.6°–22.5°)	North-east (22.6°–67.5°)	East (67.6°–112.5°)	south-east (112.6°–157.5°)	south (157.6°–202.5°)	south-west (202.6°–247.5°)	west (247.6°–292.5°)	North-west (292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.968	0.985	0.988	0.965	0.961	0.982	0.972	0.942
0.20-0.29	0.943	0.972	0.977	0.933	0.932	0.967	0.949	0.895
0.30-0.39	0.925	0.961	0.968	0.906	0.911	0.957	0.931	0.857
0.40-0.49	0.912	0.953	0.961	0.883	0.897	0.949	0.916	0.826
0.50-0.59	0.900	0.946	0.954	0.863	0.886	0.943	0.904	0.801
0.60-0.69	0.890	0.939	0.948	0.846	0.879	0.938	0.895	0.781
0.70-0.79	0.884	0.935	0.944	0.834	0.874	0.935	0.887	0.766
0.80-0.89	0.877	0.931	0.940	0.824	0.871	0.932	0.881	0.754
0.90-0.99	0.871	0.927	0.936	0.815	0.867	0.929	0.875	0.744
≥1	0.866	0.923	0.932	0.808	0.864	0.927	0.870	0.736

Table 55: External Shading Factor for Side Fin-Left (ESF_{left}) for LAT<23.5°N

orientation / PF_{left}	External shading Factor for side Fin-Left (EsF_{left}) for Lat < 23.5°N							
	North (337.6°–22.5°)	North-east (22.6°–67.5°)	East (67.6°–112.5°)	south-east (112.6°–157.5°)	south (157.6°–202.5°)	south-west (202.6°–247.5°)	west (247.6°–292.5°)	North-west (292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.962	0.984	0.984	0.959	0.962	0.982	0.975	0.948
0.20-0.29	0.933	0.970	0.970	0.924	0.932	0.968	0.954	0.904
0.30-0.39	0.912	0.959	0.958	0.895	0.911	0.956	0.937	0.868
0.40-0.49	0.899	0.950	0.949	0.870	0.896	0.948	0.924	0.840
0.50-0.59	0.887	0.942	0.941	0.849	0.885	0.942	0.913	0.816
0.60-0.69	0.878	0.935	0.933	0.833	0.877	0.936	0.903	0.797
0.70-0.79	0.871	0.931	0.928	0.820	0.871	0.932	0.896	0.783
0.80-0.89	0.865	0.926	0.923	0.810	0.867	0.928	0.890	0.771
0.90-0.99	0.859	0.922	0.918	0.801	0.863	0.925	0.884	0.761
≥1	0.854	0.919	0.913	0.794	0.859	0.922	0.879	0.752

A. Calculate the total external shading factor (ESF_{total}) using the formula:

$$ESF_{total} = ESF_{overhang} \times ESF_{sidefin} \quad (19)$$

Where,

$$ESF_{sidefin} = 1 - [(1 - ESF_{right}) + (1 - ESF_{left})] \quad (20)$$

B. Calculate the equivalent SHGC of the fenestration ($SHGC_{eq}$) by multiplying the SHGC of the unshaded fenestration product ($SHGC_{Unshaded}$) with the total external shading factor (ESF_{total}), using the formula:

$$SHGC_{eq} = SHGC_{Unshade} \times ESF_{total} \quad (21)$$

9.10 LUX LEVEL CALCULATION

The following formula shall be used to calculate the lux levels:

Formula:
Total luminous flux = number of light fixtures * lumens per fixture
Average lux level = Total luminous flux / Total floor area

9.11 DAY LIGHT AVAILABILITY CALCULATION

This method can be used for demonstrating compliance with daylighting requirements without simulation. Daylight extent factors (DEF) mentioned in Table 56 shall be used for manually calculating percentage of above grade floor area meeting the UDI requirement for 90% of the potential daylit time in a year.

Table 56: Daylight Extent Factors (DEF) for Manually Calculating Daylight Area

Shading	Latitude	Window Type	VLT < 0.3				VLT ≥ 0.3			
			North	South	East	West	North	South	East	West
No shading or PF < 0.4	≥ 15°N	All window types	2.5	2.0	0.7	0.5	2.8	2.2	1.1	0.7
	< 15°N		2.4	2.0	1.3	0.6	1.7	2.2	1.5	0.8
Shading with PF ≥ 0.4	All latitudes	All window types without light shelf	2.8	2.3	1.5	1.1	3.0	2.5	1.8	1.5
		Window with light shelf	3.0	2.5	1.8	1.6	3.5	3.0	2.1	1.8

A. To calculate the daylit area:

I. In a direction perpendicular to the fenestration, multiply daylight extent factor (DEF) by the head height of the fenestration or till an opaque partition higher than head height of the fenestration, whichever is less.

II. In the direction parallel to the fenestration, daylit area extends a horizontal dimension equal to the width of the fenestration plus either 1 meter on each side of the aperture, or the distance to an opaque partition, or one-half the distance to an adjacent fenestration, whichever is least.

III. For skylights, calculate the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, or H or 2H for the sawtooth configuration, or the distance to the nearest 1 meter or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least.

B. A separate architectural plan shall be prepared with all daylit areas marked on the floor plans. A summary shall be provided showing compliance as per Table 58.

C. Glazed façades, with non-cardinal orientation, shall be categorized under a particular cardinal direction if its orientation is within ± 45 degrees of that cardinal direction.

D. Any surrounding natural or man-made daylight obstructions shall not be considered in this method.

9.12 EXAMPLE FOR POST OCCUPANCY WASTE GENERATION

A residential housing complex having area 500 sq.m, consisting of 10 dwelling units, considering 4 occupants each housing. According to the National Building Code (NBC) guidelines, the recommended range of waste generation is between 0.3 to 0.6 kilograms per capita per day, comprises 40% organic waste and 60% inorganic waste.

Calculation for estimation of waste generation:

Step 1: Calculate the total number of occupants in the residential complex:

Total number of occupants = Number of dwelling units x occupants/unit

=10 x 4 = 40

Step 2: Calculate the total waste generation per day Considering the upper range [25] of the NBC guidelines:

Total waste generation = Total number of occupants x waste generation per capita

= 40 occupants x 0.6 kg/person/day

=24 kilograms per day

Step 3: Calculate the organic and inorganic waste generation:

Organic waste generation = Total waste generation x Organic waste percentage

=24 kg/day x 40% = 9.6 kilograms per day (say 10 Kg)

Inorganic waste generation = Total waste generation x Inorganic waste percentage

=24 kg/day x 60% = 7.2 kilograms per day

9.13 CALCULATION OF AREA REQUIREMENT FOR STORING ORGANIC WASTE

The volume required to store **10 kg** (from 9.12) of organic waste depends on the density of the waste and how compacted it is. Organic waste's density can vary based on its composition, moisture content, and packing method.

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25 Considering the upper range of waste generation, the range is given in NBC 2016 edition. According to Mohua (Ministry of Housing and Urban Affairs), there is an annual increase in per capita waste generation of about 1.3%.

Let's consider an example where the organic waste has a density of 0.5 kg/L. Remember that this is an approximate value, as organic waste density typically ranges from 0.2 kg/L to 0.8 kg/L, depending on the specific waste composition.

To calculate the volume required:

Volume = Mass / Density
Volume = 10 kg / 0.5 kg/L = 20 L
As a rule of thumb, 1000 liters require 1 cubic meter of volume
Then 20 L waste required = **0.020 m^3**
(For a thumb rule, it is calculated that 10 kg waste required 0.02 $m^{3)}$

So, if the organic waste has a density of 0.5 kg/L, you would need approximately 20 liters of volume to store 10 kg of organic waste.

9.14 CALCULATION FOR AREA REQUIRED IN VERMICOMPOSTING

Considerations:

Daily organic waste generation: 10 kg (from 9.12)
Retention time: 8 weeks (Source: CPCB) = 56 days = 60 days (round off)
Worm density: Assuming a worm density of 0.5 kg/m^2.
Vermi bed depth: 0.6 m (Should not be more than 600mm for better efficiency)
Vermi bed width: 1.5 m (Should not be more than 1500mm for easy turning and rotation)
Storage density: 10 kg per 0.02 m^3

Calculation:

Calculate the total waste produced during the retention time:
Total waste generated in 60 days = Daily waste generation x Retention time
Total waste = 10 kg/day x 60 days = 600 kg

Calculate the volume of vermi beds required to handle this waste:
Total vermi bed volume required = Total waste / Storage density
= (600 kg / 10) * 0.02 m^3 = 1.2 m^3

Calculate the total area of vermi beds required:
Vermi bed area = Vermi bed volume / Vermi bed depth
= 1.2 m^3 / 0.6 m = 2 m^2

Determine the length of vermi beds required:
Length of vermi beds = Vermi bed area / Vermi bed width
= 2 m^2 / 1.5 m = 1.33

Hence, size of required pit/bed per cycle: 0.6 m X 1.5 m X 1.33 m
Number of beds: 2
Total area required for 10 kg per day organic waste = 2 m^2 * 2 = 4 m^2

Please note that storage and segregation areas are not considered in this calculation.

9.15 EXAMPLE FOR CONSTRUCTION WASTE DIVERSION ESTIMATION:

Table 57: Calculation example for construction waste management

S. No.	Classification of waste	Construction Waste	Total Waste Generated (Kg)	Total Waste Diverted (Kg)	% Diverted from landfills	Method of Diversion
		Total waste generated on site	**10000**			
1	Non Hazaradous	Concrete Waste	1200.0	1200.0	100%	Reused on site
2		Steel Scrap	2400.0	2400.0	100%	Sold to recycler
3		Glass Waste	300.0	300.0	100%	Handover To municipal authority
4		Aluminium Framing Waste	500.0	500.0	100%	Sold to recycler
5		Gypsum Board	400.0	400.0	100%	Sold to recycler
6		Brick Waste	1300.0	1300.0	100%	Reused on site
7		Tile Waste	750.0	750.0	100%	Reused on site
8		Wooden Ply Waste	700.0	700.0	100%	Sent to Recycler
9		AAC Blockwork	1300.0	1300.0	100%	Reused on site
10	Packaging	Cardboard Packaging Waste	700.0	700.0	100%	Sold to recycler
11		Plastic Packaging Waste	150.0	150.0	100%	Sold to recycler
12	Hazaradous	Hazaradous Waste	300.0	300.0	100%	Handover To municipal authority
		Total waste diverted from landfills (Kg)			10000.0	

CHAPTER 10: TERMINOLOGY & DEFINITIONS

A

Above Grade area: It is the carpet area plus the thickness of outer walls and the area covered by balcony, expressed in meters, and subtracting the basement area.

Addition: An extension or increase in the carpet area or height of a building or structure.

Affordable Housing Projects: Affordable houses are Dwelling Units (DUs) with Carpet Area less than 60 sqm. It also includes Economically Weaker Section (EWS) category and Lower Income Group (LIG) category (LIG-A: 28-40 sq. m. and LIG-B 41- 60 Sq.m). Projects using at least 60 percent of the FAR/ FSI for dwelling units of Carpet Area not more than 60 sqm. will be considered as Affordable housing projects. This definition could be changed time to time by Ministry of Housing & Urban Affairs and respective states and latest definition for the respective state shall be considered.

Affordable housing scheme: The Pradhan Mantri Awas Yojana (PMAY), also known as, Affordable housing scheme, including any notification of change in name of the aforesaid scheme, is an initiative provided by the Government of India which aims at providing affordable housing to the urban poor.

Air Changes per Hour (ACH): Air Changes per Hour (ACH) is a measurement that quantifies the number of times the air within a space is completely replaced with fresh air within a one-hour time period. It indicates the effectiveness of ventilation or air exchange in a given space.

Alteration: A change from one type of occupancy to another or the removal of part of a building, or any change to the structure, such as the construction of, cutting into or removal of any wall, partition, column, beam, joist, floor or other support, or a change to or closing of any required means of ingress or egress or a change to the fixtures or equipment.

Authority Having Jurisdiction: The Authority which has been created by a statute and which, for the purpose of administering the Code, may authorize a committee or an official or an agency to act on its behalf.

B

Building Envelope: The elements of a building that separate the habitable spaces of dwelling units from the exterior and are exposed to the ambient (i.e., exposed directly to external air and opening into balconies). It does not include walls facing open corridors and enclosed shafts, as well as walls of common services such as lifts and staircase. (See Figure 2: Walls included in the definition of building envelope. Dotted lines show the walls included in the definition of building envelope in this code.)

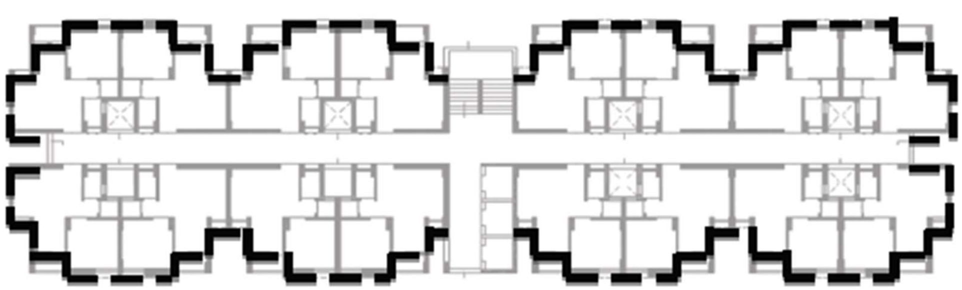

Figure 2: Walls included in the definition of building envelope

Building services: Basic MEP services such as firefighting systems, elevators and escalators, HVAC systems, gas supply systems, building management systems, power backup, water supply, water recycling etc. that are provided for the comfort and available to all dwelling units/apartments of the building or building complex.

Built-up area: It is the carpet area plus the thickness of outer walls and the area covered by balcony, expressed in meters.

C

Carpet Area[26]: Carpet area is the net usable floor area of a dwelling unit, excluding the area covered by the external walls, areas under services shafts, exclusive balcony or verandah area and exclusive open terrace area, but includes the area covered by the internal partition walls of the dwelling unit.

Color Rendering Index (CRI): Color Rendering Index (CRI) is a quantitative measure of the ability of a light source to accurately reveal the true colors of objects compared to a reference light source. It is a scale ranging from 0 to 100, with higher values indicating better color rendering.

Common Area: Amenities such as corridors, hallways, lobby, staircases, lifts, pool, parking areas etc. provided for the comfort and available for use to all occupants, owners, tenants, or users of the building or building complex expressed in m2.

Construction Waste: Construction waste is any substance, matter, or thing that is produced as a result of construction work.

Cool roof: The 'coolness' of a roof is influenced by its solar reflectance and thermal emittance.

D

Dwelling unit: An Independent housing unit with separate facilities for Living, Cooking and sanitary requirement.

E

ENS 2024 building: Any building in which all covered spaces comply with the requirements of §3 of the Eco- Niwas Samhita 2021

ENS 2024 point: It is the algebraic sum of the points that are obtained by meeting the requirements of Eco- Niwas Samhita 2021

Energy Efficiency Ratio (EER): the ratio of net cooling capacity in kW to total rate of electric input in watts under design operating conditions

Envelope Area: Envelope area (excluding roof) of dwelling units is the overall area of the building envelope (see definition 'Building Envelope'). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors), with measurement taken horizontally from outside surface to outside surface and measured vertically from the top of the floor to the top of the roof.

F

Floor area: The net enclosed area expressed in m2 of a floor in the building including circulation spaces like lobby or corridors, service areas and semi-open spaces such as verandah or balcony.

H

High Rise Buildings: A building above 4 stories, and/or a building exceeding 15 meters or more in height (without stilt) and 17.5 meters (including stilt).

I

Integrated Energy Efficiency Ratio (IEER): It is a single-number cooling part load efficiency figure of merit calculated as specified by the method described in ANSI/AHRI Standard 340/360/1230.

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[26] Source: The Real Estate (Regulation and Development) Bill, 2016 as passed by the Rajya Sabha on the 10 March 2016. Available at http://164.100.47.4/BillsTexts/RSBillTexts/PassedRajyaSabha/realest-238-RSP-E.pdf (accessed on 1 May 2018)

Indian Seasonal Energy Efficiency Ratio (ISEER): It is the ratio of the total annual amount of heat that the equipment can remove from the indoor air when operated for cooling in active mode to the total annual amount of energy consumed by the equipment during the same period.

L

Lighting Power Density (LPD): It is the total of the maximum power rating of the lamps (in Watts) in a space, other than those that are plugged into socket outlets for intermittent use such as floor standing lamps, desk lamps, divided by the area of the space (in meters).

Low Rise Buildings: A building equal or below 4 stories, and/or a building up to 15 meters in height (without stilt) and up to 17.5 meters (including stilt).

Low energy comfort systems: Space conditioning or ventilation systems that are less energy intensive then vapor compression-based systems.

Luminous Efficacy (LE): Total luminous flux emitted from a luminaire upon input power, expressed in lumens per Watt.

M

Mechanical Efficiency: It is a dimensionless number that measures the effectiveness of a machine in transforming the power input to the device to power output.

Mixed land-use building projects: A single building or a group of buildings used for a combination of residential, commercial, business, educational, hospitality and assembly purposes

Mixed-mode ventilated: The building in which natural ventilation is employed as the primary mode of ventilating the building, and air conditioning is deployed as and when required.

N

Non-opaque Building Envelope Components: Non-opaque building envelope components include transparent/translucent panels in windows, doors, ventilators, etc.

O

Openable area of dwelling unit: The total openable area expressed in m2 of a dwelling unit is the sum of openable area of all windows and ventilators opening directly to the external ambience, open balcony, verandah, corridor and or shaft.

Exclusions: Doors opening into corridors and external doors on ground floor (for e.g., ground floor entrance doors or back-yard doors).

Opaque Building Envelope Components: Opaque building envelope components include walls, opaque panels in doors, windows, ventilators, etc.

Openable Window-to-Floor Ratio (WFRop): The openable window-to-floor ratio (WFrop) is the ratio of the total openable area to the total carpet area of dwelling units. the total openable area of a dwelling unit is the addition of openable area of all windows and ventilators, opening directly to the external air, an open balcony, 'verandah', corridor or shaft; and the openable area of the doors opening directly into an open balcony.

Exclusions: Doors opening into corridors and external doors on ground floor (for e.g., ground floor entrance doors or back-yard doors).

Organic waste: Including but not limited to, kitchen waste (food scraps, fruit and vegetable peels, tea leaves, and coffee grounds etc.), garden waste (pruning/ cutting waste, shredded leaves, mulches, flowers etc.).

Orientation Factor (ω): It is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation. This factor accounts for and gives weightage to the fact that the solar radiation falling on different orientations of walls is not same.

P

Packaging construction waste: Including but not limited to cement bags, Wooden crates and pallets, Cardboard boxes, Plastic wrapping and shrink wrap, Foam and bubble wrap, Strapping bands and steel wires, PE film or plastic sheeting, Plastic or metal drums/buckets/containers, Corrugated plastic sheets, specialized packaging etc.

Plot Area: A parcel (piece) of land enclosed by definite boundaries expressed in m2. Projection Distance: It is the horizontal depth, expressed in meters, of the external shading projection

Projection Factor, Overhang: Projection factor (overhang) is the ratio of the horizontal depth of the external shading projection to the sum of the height of a non-opaque component and the distance from the top of the same component to the bottom of the farthest point of the external shading projection, in consistent units (Figure 3).

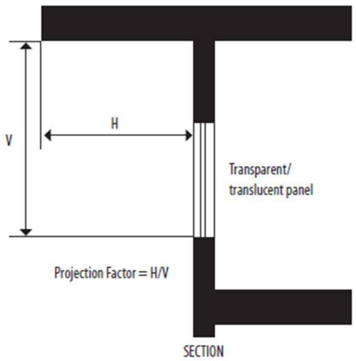

Figure 3: Projection factor, overhang

Projection Factor, Side Fin: Project factor (side fin) is the ratio of the horizontal depth of the external shading projection to the distance from a non-opaque component to the farthest point of the external shading projection, in consistent units (Figure 4).

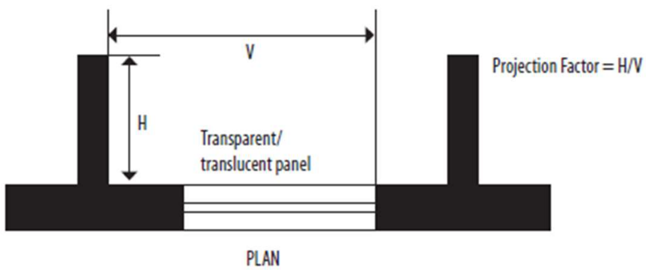

Figure 4: Projection factor, side fin

Residential Envelope Heat Transmittance (RETV): RETV is the net heat gain rate (over the cooling period) through the building envelope of dwelling units (excluding roof) divided by the area of the building envelope (excluding roof) of dwelling units. Its unit is W/m2.

Solar Heat Gain Coefficient (SHGC)[27]: SHGC is the fraction of incident solar radiation admitted through non-opaque components, both directly transmitted, and absorbed and subsequently released inward through conduction, convection, and radiation (Figure 5).

27 Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

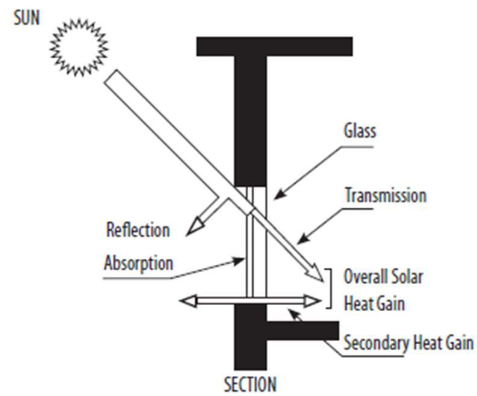

Figure 5: Solar heat gain through a non-opaque component

R

Regularly Occupied Spaces: Regularly occupied spaces include living room, bed rooms, dining room, kitchen, etc.,

Renewable Energy Systems: Energy from renewable non-fossil energy sources, e.g., solar energy (thermal and photovoltaic), wind, hydropower, biomass, geothermal, wave, tidal, landfill gas, sewage treatment plant gas and biogases. A resource that is available naturally, harnessed, and can be replenished.

Residential Building(s): Residential building(s) (including affordable housing) include any building in which sleeping accommodation is provided for normal residential purposes with or without cooking or dining or both facilities. This includes:

i. One- or two-family private dwellings: These shall include any private dwelling, which is occupied by members of one or two families and has a total sleeping accommodation for not more than 20 persons.

ii. Apartment houses: These shall include any building or structure in which living quarters are provided for three or more families, living independently of each other and with independent cooking facilities. This also includes group housing.

However, following buildings are excluded for the purpose of this code.

Lodging and rooming houses: these shall include any building or group of buildings under the same management in which separate sleeping accommodation on transient or permanent basis, with or without dining facilities but without cooking facilities for individuals, is provided. This includes inns, clubs, motels, and guest houses.

Dormitories: these shall include any building in which group sleeping accommodation is provided, with or without dining facilities for persons who are not members of the same family, in one room or a series of closely associated rooms under joint occupancy and single management. For example, school and college dormitories, students, and other hostels and military barracks.

Hotels: these shall include any building or group of buildings under single management, in which sleeping accommodation is provided, with or without dining facilities.

Retrofit: providing or adding something with a building component or feature not fitted when the building or building complex was first constructed.

Roof Gardens: In the case of roofs with roof gardens on earth fill for plantation or lawn, the thermal resistance of the earth fill can be taken into the calculation of the thermal transmittance (U value) of the roof. Some of the heat absorbed by the earth fill is also released into the atmosphere due to evapotranspiration of irrigation water from the roof garden, thus giving additional benefit.

R – Value: The measurement of the thermal resistance of a material which is the effectiveness of the material to resist the flow of heat, i.e., the thermal resistance (m2·K/W) of a component calculated by dividing its thickness by its thermal conductivity.

S

Service Value: The Service value is the ratio of air delivery to power input.

SHGC Equivalent: SHGC Equivalent is the SHGC for a non-opaque component with a permanent external shading projection. It is calculated by multiplying the External Shading Factor (ESF) with the SHGC of unshaded non-opaque component.

Solar reflectance: Solar reflectance is the ratio of solar radiation reflected by a surface to the solar radiation incident upon it. Solar reflectance is measured on a scale of 0 to 1. A reflectance value of 0 indicates that the surface absorbs all incident solar radiation, and a value of 1 denotes a surface that reflects all incident solar radiation. The term 'albedo' is often used inter-changeably with solar reflectance.

Solar reflectance Index (SRI): That incorporates both solar reflectance and emittance in a single value and quantifies how hot a surface would get relative to standard black and standard white surfaces. It is the ability of a material to reject solar radiation, as shown by a small temperature rise.28 The SRI's of a standard black surface (having reflectance of 0.05 and emittance of 0.9) and a standard white surface (of reflectance 0.8 and emittance 0.9) are taken as 0 and 100, respectively.

For more detailed information on cool roof, please refer Cool roofs for Cool Delhi: Design Manual.[29]

T

Thermal Insulation: A material used to reduce heat loss or gain through thermal envelope component.

Thermal emittance: Thermal emittance is the relative ability of a material to reradiate absorbed heat as invisible infrared radiation. Emittance, measured from 0 to 1, is defined as the ratio of the radiant flux emitted by a body to that emitted by a black body at the same temperature and under the same conditions.

According to ECBC 2017 cool roof requirement, roofs with slopes less than 20 degrees shall have an initial solar reflectance of at least 0.6 and an initial emittance of 0.9.

The Solar reflectance Index (SRI) is a term that incorporates both solar reflectance and emittance in a single value and quantifies how hot a surface would get relative to standard black and standard white surfaces. It is the ability of a material to reject solar radiation, as shown by a small temperature rise.32 the SRI's of a standard black surface (having According to ECBC 2017 cool roof requirement, roofs with slopes less than 20 degrees shall have an initial solar reflectance of at least 0.6 and an initial emittance of 0.9.

Thermal Transmittance (U-Value): Also known as U-Factor, thermal transmittance (U-value) is the heat transmission in a unit of time through a unit of area of an envelope component or insulating material, induced by a unit of temperature difference between conditioned and unconditioned spaces. The U-value for an envelope component indicates its ability to reduce heat transfer through conduction. U-value is expressed as W/m2·K.

U

U Value: Thermal transmittance (U value) is the heat transmission in unit time through unit area of a material or construction and the boundary air films, induced by unit temperature

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28 Bureau of India Standards (BIS). 2016. National Building Code 2016. Part 11. New Delhi: BIS

29 Shakti Foundation. 2017. Cool Roofs for Cool Delhi: Design Manual. Available at http://shaktifoundation.in/ wp-content/uploads/2017/06/cool-roofs-manual.pdf (accessed on 01 May 2018)

difference between the environments on either side. Unit of U value is W/m^2 K. The U value for a wall/roof/glazing indicates its ability to transfer heat through conduction.

V

Visible Light Transmittance (VLT): VLT is the ratio of the total transmitted light to the total incident light. It is a measure of the transmitted light in the visible portion of the spectrum through a material.

Volatile Organic Compounds (VOC): Volatile Organic Compounds (VOCs) are a group of organic chemicals that easily evaporate at room temperature. They are commonly found in various products such as paints, solvents, cleaning agents, adhesives, and building materials.

W

Window-to-Wall Ratio (WWR): WWR is the ratio of the non-opaque building envelope components area to the envelope area (excluding roof) of dwelling units.

Waste Management: Waste management refers to the activities and actions required to manage waste from its start till its disposal. This includes collection, transport, treatment and disposal of waste together with monitoring and regulation.

ANNEXURES

Annexure 1: Compliance Documents

The building project can demonstrate compliance using the software/toolkit that has been approved by the BEE or authority having jurisdiction and submit the following list of documents to show compliance with the code.

S.No.	Compliance Document	
1.	**Sustainable Site Management**	
1a.	Site Plan highlighting contours, topsoil preservation area, mature trees and their preservation along with existing features of the site like existing water bodies, power or communication lines, sewerage lines.	☐
1b.	Accessibility Plan highlighting measures to ensure universal accessibility including features for differently abled, children and elderly.	☐
1c.	Landscape Plan highlighting the following: • planting beds, species being planted along with measures taken to preserve local biodiversity and ecology; • Total paved area on the site along with the kind of paving used.	☐
2.	**Envelope and Electro-Mechanical and Renewable Energy System**	
2a.	Construction drawings and specifications shall show all pertinent data and features of the building, equipment, and systems in sufficient detail to permit the authority having jurisdiction to verify that the building complies with the requirements of this code.	☐
2b.	Details shall include, but are not limited to: • Building envelope: opaque construction materials and their thermal properties including thermal conductivity, specific heat, density along with thickness; fenestration U-factors, solar heat gain coefficients (SHGC), visible light transmittance (VLT); overhangs and side fins and operable window area; • Building services: Common area lighting (lamp efficacy for lamps and their controls); pump efficiencies; elevator technologies and their controls; transformer losses; power distribution losses; power factor correction devices; basement ventilation controls; efficiency of EV charging infrastructure and electric check metering and monitoring system. • Indoor electrical end-use: Indoor lighting (type, number, and wattage of lamps and ballasts; automatic lighting shutoff, occupancy sensors, and other lighting controls); ceiling fans star labelling; service hot water type and their efficiency; air- conditioners (system and equipment types, sizes, efficiencies, and controls);	☐

	• Renewable energy systems: system peak generation capacity, solar water heating system; technical specifications, renewable energy zone area.	
	3. Water Conservation	
3a.	Landscaping Plan highlighting planting beds, turf grass and irrigation layout.	☐
3b.	Good for construction plan and sections of the building highlighting the plumbing layout along with the dual pipes system, water recycling & reuse provisions.	☐
3c.	Good for construction site plan and building plans highlighting the rainwater harvesting system, storage tanks and recharge provisions.	☐
3d.	Specifications of various sanitary fitting and sanitary ware used along with copy of purchase invoice/ BoQ/ tender documents.	☐
	4. Waste Management	
4a.	Declaration for safe handling and disposing C&D waste as per CPCB guidelines/ (C & D Waste Management Rules, 2016).	☐
4b.	An inventory of the waste generated during construction by either weight or volume, but not both shall be developed. The inventory shall classify the quantities of waste generated as per clause 7.2.1.	☐
4c.	**During Construction** A waste management plan shall be developed which include: i. Estimate the quantum of waste generated daily ii. Designate an area for collection of daily waste iii. Site Logistics plan including; designated collection, segregation and storage areas for construction waste as per categories as mentioned in Chapter 7: clause 7.2.1.2. iv. Detailed implementation plan for reuse of waste on site as per clause, Chapter 7: clause 7.2.1.3. a) Detailed implementation plan for resale of recyclable waste to recyclers or municipal authorities as per Chapter 7: clause 7.2.1.4.	☐
4d.	**Post Occupancy:** Site and Building floor plans including; highlighted area for floor wise waste collection, with different color bins, organic waste composting location with catering capacity.	☐

5. **Indoor Environmental Quality**		
5a.	Good for construction' plan showing openings (doors, windows and ventilators), and enclosed parking highlighting ventilation and exhaust systems.	☐
5b.	Calculation of lux levels for common areas, exterior lighting and interior lighting (if applicable).	☐
5c.	Calculation of RETV and WFR_{op} for each typical block.	☐
5d.	Specifications of VOC content in paints, coatings, adhesives, and sealants. (With copy of purchase invoice/ BoQ/ tender documents).	☐
5e.	Specifications of glass provided by the manufacturer. (With copy of purchase invoice/ BoQ/ tender documents).	☐
5f.	Specifications of various lighting fixtures used. (With copy of purchase invoice/ BoQ/ tender documents)	☐
5g.	Description of ventilation and exhaust system installed in the enclosed parking with showing ACH calculation.	☐
5h.	'Good for construction' floor plan of enclosed parking showing the placement of sensors should be submitted.	☐

ANNEXURE 2: EMBODIED ENERGY

RATIONALE

Embodied energy in construction in India (especially in "formal' residential buildings of the sort that are covered by the ENS 2024 code) can sometimes be of the order of magnitude of many decades of operating energy use[30] and therefore is very significant to consider when such a code is being developed.

However, this was true for non-air-conditioned housing stock, and it seems likely that, like in the developed economies, increasing consumption of operating energy (e.g., for appliances, common area services, air-conditioning etc.) may cause the embodied energy to become less significant compared to operating energy. Still, this is an important area to include in the code.

Embodied energy is also important because much of it is consumed in the form of primary energy (coal, oil, fuels) causing direct pollution and carbon emissions.
Embodied energy is the sum of all energy used in the construction process, i.e., in the product, transport and installation: from the extraction of raw materials, manufacture of materials and fabrication of products, to their transportation and installation in buildings. It is often measured in megajoules per square meter. But its units can also be kWh(th) (Thermal Kilowatt hours, with 1kWh(th) being equivalent of 3600 kJ) per sqm of built-up-area, making it more easily comparable with EPI of the ENS 2024 code.

Cement and steel are the major contributors of embodied energy in residential building construction in India. According to the study conducted by Jadavpur University[31], 98% of the embodied energy is attributed to the embodied energy of the materials used and 2% is the contribution of actual erection of the building. Unfortunately, embodied energy is often "hidden" in industry for the manufacture and transport of materials, and the transportation of workers.

Institutes of technological research need to be tasked with creating standards for embodied energy benchmarks based on average and best practice. If necessary, this research needs to attract funds from the building industry and foundations.

Embodied Energy measured in kWh(th)/sqm and Operating Energy measured in kWh(th)/sqm. year can be combined. In order to combine the (capital) embodied energy with the operating energy, it is necessary to merge the two to units equivalent of kWh(th)/sqm. year so that a single number can represent the energy performance of a project.

In a recent piece of research for Technology Information Forecasting and Assessment Council of India[32], it was found that the best way to translate from kWh(th)/sqm (Embodied Energy) to kWh(th)/sqm. year (equivalent Operating Energy) would be to set up a notional or actual discount/ replacement rate of construction taking its nominal life, say, as:

30 The Mud Village project, sponsored by HUDCO, entry by Studio Plus, 1987
31 Embodied Energy Analysis of Multi-storied Residential Buildings in Urban India, S Bardhan - WIT Transactions on Ecology and the Environment, 2011
32 Technology Vision 2035, Technology Information Forecasting and Assessment Council (TIFAC) 2014

- 50 years life leading to a 2% replacement rate of stock for mainstream buildings
- 20 years life leading to a 5% replacement rate of stock for temporary industrial materials (steel) buildings.
- And so, on

According to a study by HUDCO[33], affordable housing uses 4257 MJ/sqm of embodied energy and so at a rated life of 50 years (or 2% replacement rate), this is equivalent of 85 MJ/sqm.year or 23.6 kWh(th)/sqm.year which is substantial for a building without air-conditioning but low for a building with various mechanical systems using up substantial operating energy.

This can be codified along with other benchmarks in the ENS 2024 code after suitable characterisation, study, analysis of best practices, and benchmarking.

NOTES

- Embodied energy is given less importance in the affluent regions of the world since their operating energy is high. There are two methods to evaluate this energy: by process or by input-output.
- Researchers in the Indian Institute of Science[34] identified process analysis as appropriate for embodied energy assessment in the Indian context.
- One of the earliest researchers using process-based analysis of embodied energy, Dr. Mohan Rai, carried out studies at CBRI Roorkee in the early 1960s and made the first listing of embodied energy, sorted in descending order, as follows in Table 58: Materials and Embodied energy consumption:

Table 58: Materials and Embodied energy consumption

Materials	Unit	kWh(th)	MJ
Sheet Glass	sqm	74.199	267.1
Linoleum	sqm	46.287	166.6
Aluminium	kg	39.891	143.6
PVC	kg	32.273	116.2
Sanitaryware	kg	9.071	32.7
Mild Steel	kg	7.327	26.4
L.D. Polyethylene	kg	6.048	21.8
Stoneware Pipes	kg	5.896	21.2
Cement	kg	2.245	8.1
Quick Lime	kg	1.756	6.3
Bloated Clay Aggregate	kg	1.477	5.3
Burnt Clay Roofing Tiles	each	1.233	4.4
Burnt Clay Bricks	each	1.187	4.3
Wood Particle Board	kg	0.861	3.1
Sand Lime Bricks	each	0.773	2.8
Clay Fly-Ash Bricks	each	0.643	2.3

33 Accessed in December 2019 at https://www.slideshare.net/sslele456/embodied-energy-in-residential-cost-effective-units.

34 K.I. Praseeda, B.V. Venkatarama Reddy, Monto Mani, 2015. Embodied energy assessment of building materials in India using process and input–output analysis, Energy and Buildings, 86 (677-686), ISSN 0378-7788

Gypsum (Calcined)	kg	0.420	1.5
Brick Dust (Surkhi)	kg	0.384	1.4
Crushed Aggregate	kg	0.060	0.216

The table above shows (as is well-known) that the embodied energy of processed industrial materials like aluminium, steel and cement is much higher than relatively unprocessed and mined materials extracted from nature (like crushed aggregates). Natural and renewable materials such as timber may be deemed to have zero renewable energy. Therefore, all other things being equal, a concrete framed structure with cement and steel is worse than a load bearing structure with hardly any cement and steel and masonry (preferably non-fired) and funicular forms holding up the roof.

ANNEXURE 3: BEST CONSTRUCTION PRACTICE

Energy can be consumed in bad practices that may be observed on building sites. This needs to be stopped but is currently outside the scope of the ENS 2024 code. Typical practices include excessive requirement of movement of fluids (like mixed concrete) or solids (like steel) on site due to bad layout, improper sizing of pipes to save initial costs but causing greater pumping power due to friction losses, an over- or under-reliance on assisted manual labour (which may be seen as a form of renewable energy), and industry having got used to fuel-based services or energy-on-tap (firm energy) and so unable to convert to renewable energy such as solar photovoltaic systems (due to their being infirm, not available on-tap). Often machinery is also often designed so as to have very high starting surge loads, thereby making it impractical to invest in capital-intensive technologies (renewable) instead of fuel-based technologies, causing emissions and/or pollution. These areas need to be improved and then can be codified.

Although according to the study conducted by Jadavpur University[35] 98% of the embodied energy is attributed to the embodied energy of the materials used and 2% is the contribution of actual erection of the building, it is important to look at this seemingly trivial 2% for the main reason that there can be a lot of energy wasted and emissions and pollution created by bad site practices, and also because better site practices lead to better buildings and saves cost for the builder, thereby (ultimately) resulting in more affordable construction.

To achieve this:

- Layout planning of sites should be made a course in civil engineering and project managers need to, by mandate, graduate in at least a one-semester course in this subject.
- Civil engineers need to be able to engage with concepts of renewable energy through manual labour and solar and wind energy systems and they, along with project managers, need to, by mandate, graduate in at least a one-semester course in this subject.
- Total energy losses due to waste and friction on site (per unit area of building being made) need to be analysed, benchmarked, and codified.
- All these point to research directions that need to be undertaken (again by Civil Engineering departments in our Engineering Institutes).
- Best industry standards for ratios of running energy: starting surge, need to be analysed, benchmarked, and codified, so that infirm energy sources such as solar photovoltaics may be able to be considered to meet the demand of energy on site. It may be noted that infirm energy sources such as solar photovoltaics could be seen to be a form of production of energy, and if managed well and with sufficient open area, with a good rental market created for solar photovoltaics or wind turbines, sites can in the future become energy-neutral for construction of buildings.

Since research in this area is nascent, it has been kept out of the ENS 2024 code for now.

35 Embodied Energy Analysis of Multi-storied Residential Buildings in Urban India, S Bardhan - WIT Transactions on Ecology and the Environment, 2011

ANNEXURE 4: RETROFITTING OF RESIDENTIAL BUILDINGS

Retrofitting consists of additions and alterations to existing (and, in the context of the ENS 2024 code, residential) building stock and typically this is set into motion by building owners.

For reasons of poor research and difficult practice, this code is currently silent on retrofit provisions and this appendix is created because given the right conditions this situation may change. This code does not mention provisions for retrofit cases because of the principle that laws (and codes) should preferably not be applied retroactively (so we cannot declare a building not meeting standards before the standard was even made), but in doing so we lose out a large potential of building stock (say over 50% of the residential building stock in 2030 if we read the McKenzie report[36] that "nearly 70% of building stock that will be there in 2030 is yet to be built in India" and geometrically extrapolate it from 2010 when it was written to 2019 today).

The following market innovations need to be encouraged to cover a large part of India's existing residential building stock even when they are not being added to or being altered:

- For apartment dwellers, before enforcing this code, there need to be financial (low-interest loan) instruments available or created whereby collective retrofitting may take place through collective action, for example changing of window or wall specifications through RWA action to comply with provisions of the ENS 2024 so that capital cost of such retrofits may be kept low per month.
- For individual house owners, there need to be encouragement of vendors who can audit and retrofit because until that is done the implementation of ENS 2024 code shall be resisted or "loopholed" by homeowners.
- For rental stock, these audits and retrofit companies can undertake audit and retrofit to meet the ENS 2024 code provisions either through RWA or through apartment owners' associations (this is more difficult but can be eased by easy upgrade costs accompanied by strict compliance demands).

It would help a lot if the improvements effected by RWAs or contractors can be documented in a standardized way and the improvements in performance recorded numerically on a plaque or certificate for the owners to take pride in retrofitting their homes. This can be designed like the BEE star labels for various appliances.

It is anticipated that since the primary means of enforcing the ENS 2024 code is at the time of municipal approval and completion, this code could be immediately applied (subject to state-by-state acceptance into law) at the time of application for addition and alterations of buildings.

This would automatically exempt minor addition and alterations (such as raising internal walls, painting, etc.) For reference, these "minor" retrofits in existing buildings that do not need any permission according to Delhi Development Authority (DDA), similar to changes in buildings all over the country, are provided below:

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36 India's Urban Awakening: Building inclusive cities, sustaining economic growth (McKinsey Global Institute, April 2010)

Except from DDA[37]

1. To convert existing barsati into room provided the wall is made of only 115 mm thick.
2. Grills and glazing in verandah with proper fixing arrangement.
3. Raising height of front and rear courtyard wall up to 7' height by putting up jali/ fencing.
4. Providing door in courtyard wherever not provided.
5. Providing sunshades on doors and windows wherever not provided with proper fixing arrangements.
6. Closing the door.
7. If the bathroom or WC are not having roof, these may be treated as open urinals and allowed.
8. Raising the wall of balcony/terrace parapet with grill or glazing up to 5' height.
9. Construction of open staircase (cat ladder) where no staircase has been provided for approach to the terrace.
10. To put provide additional PVC water tank at ground floor area without disturbing the common passage.
11. To provide an additional PVC water tank in the scooter/car garage at the surface level.
12. To provide loft /shelf in the rooms without chase in the walls.
13. To change the flooring with water proofing treatment.
14. To remove half (41/2) brick wall.
15. To make a ramp at front gate without disturbing the common passage /storm water drain.
16. To provide sunshades or the outer windows up to 2'wide projection.
17. To provide false ceiling in rooms.
18. To make an opening of maximum size of 2'6" x1'9" for exhaust fan or air- conditioner in existing walls.
19. Fixing of door in back and front courtyard.
20. Converting of window into Almirah subject to availability of light and ventilation as per building byelaws provided that no structural elements are disturbed and there is no projection extending beyond the external wall.
21. Shifting of water storage tank/raising of parapet wall up to 5' height and putting additional water storage tank. Wherever the existing water storage tank capacity is less than 500 litres in a flat, a 500 litres tank can either replace the existing water storage tank or if possible, the additional tank can be added so as to make the total storage capacity up to 550 litres. However, such replacement/provision of additional tank will be done only on the locations specified for such tanks and the supporting beams will be required to be strengthened suitably. Parapet wall around terrace can be increased to a height of 5'.
22. To shift the front glazing, rooms/windows up to existing chajja.

Not implementing retrofit cases for, say, 5 years, it can then be suggested that the ENS 2024 code could be made applicable to all Addition and Alterations cases that come for approval to ULBs. This will cover at least some 5% of existing building stock (say 10% of 50%) and simultaneously measures (1) through (3) in the last page need to be actively pursued in the market to make alterations proactively possible for existing building stock, even when not undertaking additions and alterations.

37 http://www.dda.org.in/housing/pending_cases/permissible_alteration_housing.htm, accessed December 2019.

Generally, alterations in themselves do not require municipal approval. The key changes that require getting municipal approval is increase of height / FAR / Ground Coverage, all of these are related to increasing the size of the home.

Studying codes from other countries[38], it can be seen that whenever a project comes up for municipal sanction, the codes require the renovated project to comply with the code provisions. This should be recommended in India also.

This will leave out only that part of the existing building stock that has a completion certificate from the ULB and remains unchanged. In time it shall be added to (requiring ULB approval) or demolished and rebuilt (requiring ULB approval). Therefore, by the later part of this century the entire residential building stock shall become ENS 2024 compliant, even if market forces do not already make it so.

38 There are many references. See for instance, the Residential Compliance Manual for the 2019 Building Energy Efficiency Standards, California, at https://ww2.energy.ca.gov/2018publications/CEC-400-2018-017/CEC-400-2018-017-CMF. pdf, or https://www.buildwaikato.co.nz/building-projects/additions-alterations/ from the Waikato Building Consent Group (WBCG) in New Zealand, both accessed in December 2019

Annexure 5: Improved Air Cooling

Residential buildings sector accounts for 24% of the electricity consumption and is the second largest consumer after industries. Within the building sector, the residential electricity consumption amounts to 259 TWh. Within this sector, with increasing affluence in the Indian middle class, there is a tendency (in warm humid, hot dry, composite and even moderate climates which always have some hot days) to create comfort by installing an air-conditioner or two. Capital costs of air conditioning is low compared to capital costs of building (today, cheap – and inefficient – air-conditioning can be as low as 5% of the building cost). EMI-based loans make it easy for even a lower middle-class family to install split air-conditioners at less than the monthly energy costs of running the same.

Use of air-conditioning therefore is a major hurdle in creating energy efficient residential stock in India, since it cannot be denied that it creates superior comfort in all sorts of conditions: warm humid, hot dry, composite, and moderate.

Often the rationale for a lower middle-class family, who realize that the energy bills are not easy to manage, is that they will use it minimally, only in the night and only in extreme weather, or by setting the thermostat up to higher temperatures. However, air-conditioning, with its superior performance in terms of managing humidity, is addictive, and there is a tendency for its use to increase to the limit of the users' paying capacity, and even beyond it.

It is worse that in this economic class, the tendency is to procure cheap, lower rated inefficient equipment, and install it in poorly insulated houses, which uses even more electricity than it could.

This causes residential air-conditioning to become a major barrier in energy efficiency (USAID, 2014)[39]. This issue is a major guzzler of energy in houses and needs to be mitigated by codification. However, since the research on this is ongoing, this has not yet been included in the ENS 2024 code.

On November 15, 2019, the Rocky Mountain Institute (RMI) in collaboration with the Ministry of Housing and Urban Affairs (MoHUA) of the Government of India (GoI) announced the results of a Global Cooling Prize competition, for Incentivizing the development of a residential cooling solution that will have at least five times less climate impact than standard residential/room air conditioners (RAC) units in the market today. This technology could prevent up to 100 gigatons (GT) of CO2-equivalent emissions by 2050, and put the world on a pathway to mitigate up to 0.5°C of global warming by 2100, all while enhancing living standards for people in developing countries around the globe.[40]

Therefore, the following are urgently required to be researched and implemented for Indian residences to become comfortable while remaining energy efficient, at capital costs that are affordable or can be made affordable by fiscal incentives or financial instruments:

39 HVAC Market Assessment and Transformation Approach for India, PACE-D Technical Assistance Program, USAID, August 2014

40 https://globalcoolingprize.org/ accessed in December 2019

Air-conditioning systems that can be used at higher set-point temperatures (say, up to 28 °C) in combination with ceiling fans. These require higher cfm of air to be pushed through (rather than the industry standard of 400 cfm per Ton) and a balance between refrigerant temperature, air flow, and set point since currently air-conditioning industry has optimised all systems for 22°C - 24°C. As the set point temperature is increased, the other parameters need to change. This kind of device will be ideal for bill- conscious lower middle classes even if they can progressively afford air-conditioning capex.

Fiscal incentives or financial instruments to lower capex for improving house thermal performance to ENS 2024 code levels so that optimum (not too much) air-conditioning is installed. Unfortunately, at this point, the ENS 2024 code has been developed assuming that the cooling system is some form of air-conditioning.

Rapid development and deployment of effective an acceptable intermediate technologies including adiabatic technologies, such as passive hybrid and active evaporative coolers, better natural ventilation, indirect evaporative coolers, or chilled coil indirect evaporative coolers, combined with fiscal incentives or financial instruments to lower capex for improving houses to a level so that sufficient passive cooling is managed and the number of days of usage of cooling or conditioning can be brought down.

Alternative desiccant and evaporative systems for cooling (which are not yet well-developed). This may require fundamental research and cannot be expected to be rapidly deployed.

Promotion of all these above alternatives through some cultural or social incentives (such as the BEE star rating system or TV promotions) so that they are not perceived as inferior to “complete” air-conditioning. This requires a major social change in attitude from progress seen as consumption only to progress seen as sufficiency, but is probably the most effective instrument for meeting and even bettering the EPI targets of the ENS 2024 code.

NATURAL AND ENS 2024 POINT VENTILATION

If buildings can achieve comfort by natural or sense Point ventilation, this would entirely avoid the use of energy for mechanical cooling, and needs to be highly encouraged.

Natural ventilation fulfils two primary needs: first, it gives fresh air for satisfactory indoor quality; and, second when the outdoor temperature is comfortable (during night and transition seasons), it expels heat from inside the structure and facilitates cooling.

Natural ventilation is of course not useful for cooling when the outdoor air is at a temperature higher than the set-point or desired indoor temperatures. This leads us to another very important concept of ventilation, ENS Point ventilation, opening the building very much to the outdoor air whenever the temperature outside is more comfortable than the inside, namely summer nights and winter days.

The National Building Code 2016 (Part 8; 1; 5. Ventilation) or ASHRAE 62.1–2016 provide standard ventilation rates for acceptable indoor quality.

To aid cooling a larger volume of airflow is required than the standard ventilation rates. The rate of ventilation by natural means through windows or other openings depends on, direction and velocity of wind outside and sizes and disposition of openings (wind action); and convection effects arising from temperature of vapour pressure difference (or both) between inside and outside the room and the difference of height between the outlet and inlet openings (stack effect).

One of the parameters to quantify the adequacy of natural ventilation is hourly air change rate (ACH), which is a proportion of how frequently the air volume inside a room is supplanted by outside air in 60 minutes. The larger the number, the better is the cooling potential through common ventilation. As a rule, 5 to 20 ACH gives good natural ventilation.

NBC 2016 discusses the design guidelines for natural ventilation in the 5.4.3 of Part 8: Building Services of the code.

Once the promotion of naturally ventilated buildings can be successfully undertaken, it should be possible to eliminate the use of air-conditioning or at least drastically reduce its use in all but the most affluent residences.

Ventilation in residential buildings can be provided by one of the following methods:

a) Natural supply and natural exhaust of air (natural ventilation)
b) Natural supply and mechanical exhaust of air (mechanical ventilation, see below)
c) Mechanical supply and natural exhaust of air (mechanical ventilation, see below)
d) Mechanical supply and mechanical exhaust of air (mechanical ventilation, see below).

MECHANICAL VENTILATION

There are a range of circumstances in which natural ventilation may not be possible or sufficient to attain thermal comfort:

- The building is too deep to ventilate from the perimeter.
- Local air quality is poor, for example if a building is next to a busy road. Local noise levels mean that windows cannot be opened.
- The local urban structure is very dense and shelters the building from the wind. Privacy or security requirements prevent windows from being opened.
- Internal partitions block air paths.
- The density of occupation, equipment, lighting and so on creates very high heat loads or high levels of contaminants.

Some of these issues can be avoided or mitigated by careful design, and mixed mode or assisted ventilation might be possible, where natural ventilation is supplemented by mechanical systems. Naturally it is not desirable to go with mechanical ventilation where natural ventilation could achieve the similar results.

Where mechanical ventilation is necessary it can be:

- A circulation system such as a ceiling fan, which creates internal air movement, but does not introduce fresh air.
- A pressure system, in which fresh outside air is blown into the building by inlet fans, creating a higher internal pressure than the outside air.

- A vacuum system, in which stale internal air is extracted from the building by an exhaust fan, creating lower pressure inside the building than the outside air.
- A balanced system that uses both inlet and extract fans, maintaining the internal air pressure at a similar level to the outside air and so reducing air infiltration and draughts.
- A local exhaust system that extracts local sources of heat or contaminants at their source, such as cooker hoods, fume cupboards and so on.

KITCHEN VENTILATION

Kitchen is always the hottest space in a flat on account of the huge amount of heat produced due to cooking. The arrangement of a decent ventilation framework that can proficiently separate hot air from the kitchen before it blends with the encompassing air can help lessen the heat in the kitchen and adjoining spaces.

For powerful natural ventilation of the kitchen, notwithstanding the window, an extra louvre opening ought to be given to further aid the movement of air.

If the kitchen is ventilated utilizing a fume hood, the distance of the hood from the gas fire and the fume flow rate should be appropriately chosen for best ventilation of the kitchen.

EVAPORATIVE COOLING

Evaporative cooling is a process that uses the effect of evaporation of water as a natural heat sink. The amount of sensible heat absorbed depends on the amount of water that can be evaporated. Currently this is the most promising area of reducing energy for cooling, except that it is largely ineffective in warm and humid seasons or climates. Sensible heat from the air is absorbed to be used as latent heat necessary to evaporate water.

- **Direct Evaporative cooling (DEC):** In this system, commonly used in the form of a 'desert' cooler, the outdoor air is brought into direct contact with water, cooling the air by converting sensible heat to latent heat. DEC systems could be divided into: Active DECs which are electrically powered to operate and Passive DECs that are naturally operated systems with zero power consumption. In DEC, the water content of the cooled air increases because air is in contact with the evaporated water. This strategy is useful in dry and hot climates.

- **Indirect Evaporative Cooling:** Indirect evaporative coolers operate by decreasing air sensible heat without changing its humidity, which is a distinct advantage over DEC systems (the final temperature approached can be dew point instead of wet bulb temperatures). In indirect evaporative cooling, evaporation occurs inside a heat exchanger and the absolute humidity of the cooled air remains unchanged. This strategy is even more effective in hot and dry climates that DEC and fairly effective for warm and humid climates, too.

EPI FOR EVAPORATIVE COOLER

The efficiency of the evaporative coolers is measured based on the evaporative efficiency which depends on the outside dry bulb temperature and relative humidity of the airstream. The EPI shall be estimated for Evaporative Coolers as shown below:

EPI = [Total Wattage of fan(s) + Total wattage of pump(s)]
* Hours of operation/ (1000 * Built-up area)

Rationale for EPI calculation for evaporative cooler

Parameters influencing EPI for evaporative cooler are:

Design Parameters	Technology Parameter
● Location (Climate) ● Air delivery rate ● Pump water circulation rate ● Fan and Pump efficiencies	● Direct evaporative cooling ● Fan and pump motor types
Controls	
Dew point based shut-off controller	

The EPI ranges from

User inputs in calculating the EPI shall include:

Power rating of the fan motor (From nameplate) in watts

Power rating of the pump motor (From nameplate) in watts.

If a residence uses DEC or IEC or any of the natural, ENS 2024 point, or mechanical ventilation strategies for cooling and avoids Carnot cycle-based air-conditioning altogether, then it is proposed that it should automatically be able to meet the ENS 2024 code without undergoing the rigorous process of showing complete EPI calculation processes. This part has not been codified but remains in this appendix as a proposal that may be considered.

DISTRICT COOLING

District cooling systems, which typically require about 15% less capacity than conventional distributed cooling systems for the same cooling loads due to load diversity and flexibility in capacity design and installation. District cooling helps in greatly reducing the peak demands and provide new generation capacity to meet cooling demand. District cooling systems are appropriate for densely populated urban areas having mixed uses of buildings with high cooling requirement. It provides enhanced level of reliability and flexibility, as individual building's cooling demand can increase or decrease without the need to change the main plant's capacity.

District cooling indicates central manufacturing and distribution of cooling energy. Chilled water is generated at main plant and then by means of an underground insulated pipeline is provided to the buildings to cool down the interior within a neighbourhood/zone. Specifically, designed devices (HX & pumps, AHUs etc.) in each building utilize this chilled water to decrease the temperature level of air going through the building's cooling system.

THERMAL ENERGY STORAGE

Thermal storage may be used for limiting maximum demand, by controlling peak electricity load through reduction of chiller capacity, and by taking advantage of high system efficiency during low ambient conditions. Thermal storage would also help in reducing operating cost by using differential time-of-the day power tariff, where applicable.

The storage media can be ice or water. Water needs stratified storage tanks and is mostly viable with large storage capacity and has an advantage of plant operation at higher efficiencies but requires larger storage volumes. In case of central plant, designed with thermal energy storage, its location shall be decided in consultation with the air conditioning engineer. For roof top installations, structural provision shall take into account load coming on the building/structure due to the same. For open area surface installation, horizontal or vertical system options shall be considered and approach ladders for manholes provided. Buried installation shall take into account loads due to movement of vehicles above the area.

ANNEXURE 6: SMART HOME

The concept of smart home is in existence for many decades; however, it has gained further importance in present scenario due to increase in demand for comfort and convenience (with growth of disposal income), increased dependence on appliances, increase in per capita electricity consumption and availability of rooftop solar PV and EV for potential onsite generation and storage respectively.

Alongside these drivers at consumer end; technology advancement in the form of availability of high-speed computing devices (smart phones) and affordable internet data, reduction in size of IoT devices / sensors and by shifting sophisticated computing functions to cloud and development of complex algorithms to control systems as per user requirement and preference (using Artificial Intelligence) has provided fresh push to demand of smart home product and services.

The need of utility-based demand response program to match the variable consumer demand (due to use of diverse appliances) with dynamic electricity supply (due to penetration of renewable energy in grid) is gradually making the smart home solutions a must have product/service in every home, to make it demand response ready.

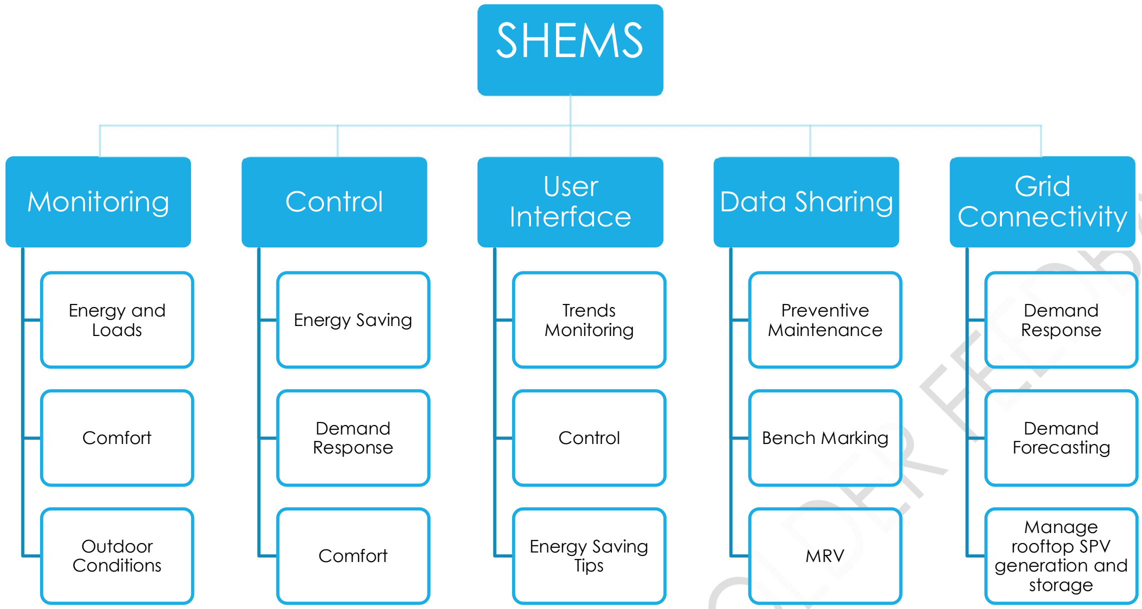
To manage the energy use in a home in order to make optimum use of these opportunities and for minimizing the demand supply gap, there is need of Smart Home Energy Management System (SHEMS). SHEMS can be defined[41] as the combination of a service and devices that are designed to work together to deliver occupancy-based optimization of energy use. SHEMS[42] consist of hardware and software, which are linked and integrated to, monitor energy usage, provide feedback on energy consumption, enhance control and provide remote access and automation provisions over appliances and devices that use energy in the home. SHEMS can deliver a range of services and benefits to households, which includes:

- Energy management (energy efficiency)
- Demand response (contribute to regulating energy demand)
- Electricity generation, storage and delivery to the grid
- Comfort and convenience.

The functionality of SHEMS can be broadly categorized in five areas that include monitoring, control, user interface, data sharing and grid connectivity. Schematics indicating the functionality of SHEMS and purpose of each functionality is given below:

41 Source: ENERGY STAR® Program Requirements, Product Specification for Smart Home Energy Management Systems, https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20SHEMS%20Version%201.0%20Program%20 Requirements_0.pdf

42 Source: Sustainable Now, https://sustainable-now.eu/guide-to-home-energy-management-systems/



The above-mentioned functionalities of SHEMS[43] can be operationalized with the support of:

- Physical sensors and devices
- Communication network for data transfer across smart devices, computation and data storage systems
- Data processing, decision making and relay commands as per defined logic or preference
- Smart appliances, devices and actuators to align the physical parameters to required level
- User interface to enable user to monitor, interact with smart home components and convey preferences
- Smart meter to monitor, record the energy consumption, load variation and to facilitate implementation of demand response program

In smart home, energy and cost savings is achieved by:

- Preventing idle running of energy consuming system
- Optimization of adjustable building envelope elements to minimize energy demand
  Optimization of operating parameters to match user preference
- Shifting the operation of non-essential energy consuming systems to off peak time
- Making use of renewable energy generation source, whenever available to meet the energy demand

43 Source: Based on the analysis conducted as part of BEE-GIZ study on Smart Home: Technology Assessment Study and Pilot Design through technical support of Deloitte Touche Tohmatsu India LLP and Prof. Vishal Garg (IIIT Hyderabad, India)

- Optimization of charging and discharging of storage for cost saving
- Smart home has significant potential for saving energy, however, the net energy savings depends on a range of factors, which include:
- The rationale behind automation (comfort or energy saving)
- Level and type of automation used (i.e., occupancy based on/off control or fine tuning of operating parameters based on user preference and weather conditions)
- User behaviour (whether the user just looks at energy monitoring information or uses this information to change settings or change behaviour)
- Power consumption by monitoring and control devices
- Additional power consumption by appliances in standby mode due to inclusion of smart communication features.

Several studies have been undertaken at international level by various public and private agencies, including manufacturer associations, to estimate the energy savings from smart home solutions (product and services). Based on one of them, conducted by the Connected Device Alliance (CDA)[44], energy savings potential in a dwelling enabled with smart home devices and services could be in the range of 20-30% of the present household energy use, subject to the factors mentioned above.

As technologies are optimised, developed and linked with the implementation of further energy efficiency opportunities in homes, the energy savings potential may increase. Smart Home requirement can be added to code along with other benchmarks in the ENS 2024 code after suitable characterisation, study, analysis of best practices, and benchmarking.

NOTES

MINIMUM FUNCTIONALITY REQUIREMENT FOR SMART HOME

To ensure availability of minimum capabilities (regarding monitoring, control, user-interface, data sharing and grid connectivity) and to successfully deliver basic smart home experience to user, a minimum set of smart home devices should to be installed in a home. Table indicating the minimum device/capability requirement for each functionality of SHEMS is provided below in Table 59:

Table 59: Functionality Requirement for smart Home

Functionality	Smart home device and/or solution
Monitoring	Home level phase-wise energy and load monitoring Two 15A outlets for energy use monitoring of two appliances One temperature and humidity sensor One occupancy sensor
Control*	One AC Controller to control set point, mode of operations, ON/OFF with provision of receiving control signals One Geyser Controller for ON/OFF, with provision of receiving control signals One Controllable light with provision of receiving control signal
User interface	Common user interface (app, voice or gesture based), to connect

44 A case study of barriers and solutions – Smart Home by Connected Device Alliance (CDA), which is a network of more than 350 government and industry participants that have come together to work on the energy efficiency opportunities provided by networked devices. Further information on the CDA is available at: https://cda.iea-4e.org

	smart home devices over single software package for energy use monitoring and control
Grid connectivity	Able to participate in utility demand response program
Data sharing	Typical daily indoor conditions, and device-wise energy consumption, and hours of usage to be reported once a month in anonymous way

*All controllable devices to be able take control signals from hub/cloud

Data privacy, cyber security, interoperability, safety and energy efficiency - minimum requirement for smart home devices and components.

- All components, devices or elements of smart home that connects “directly or indirectly” to the internet must be equipped with “reasonable” security features, designed to prevent unauthorized access, modification, or information disclosure.
- All components, devices or elements of smart home should follow common standards (for hardware and software), as prescribed by the concerned department for connected devices, enabling them to discover and communicate with one another, regardless of manufacturer, operating system, chipset or physical transport.
- All components, devices or elements of smart home should have adequate level of fire, electricity and other user health related safety features to avoid potential accidents, hazards and discomfort.
- All components, devices or elements of smart home should be energy efficient and should meet the minimum energy efficiency criteria set by concerned government department.

Annexure 7: Guidelines for Design for Natural Ventilation

This annexure provides a simple and illustrative interpretation of provisions for the location of windows in a room and its impact on natural ventilation. A detailed design guideline for natural ventilation is available in the NBC 2016[45] (Volume II, Part 8 Building Services, Section 1 Lighting and Natural Ventilation).

The code gives the following provision for minimum WFR_{op} values for natural ventilation Table 60:

Table 60: Minimum requirement of window-to-floor area ratio, WFR_{op}

Climatic Zone	Minimum Wfr_{op} (%)
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperate	12.50
Cold	8.33

SOURCE: Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

Openable window-to-floor area ratio (WFR_{op}) indicates the potential of using external air for ventilation. the openable area allows external air, when the ambient temperature is cooler than the inside air, into the internal spaces, which helps in ventilation, improvement in thermal comfort, and consequent reduction in cooling energy.

This openable area can be distributed on the external wall in a number of ways. rooms may have openings on only one external wall or multiple external walls (usually two external walls). Some guidelines for design of these openings are given below. It is to be noted that internal doors cannot be relied for enhancing ventilation and are assumed to be closed.[46]

1. Distribution of the openable area on the external walls of a dwelling unit must be done to maximize cross-ventilation, i.e., the air inlet and outlet openings should be separate and positioned on different walls in a way that optimizes the air flow path through the space. this can be done by placing openings on adjacent walls or on opposite walls, where possible (Figure 6).

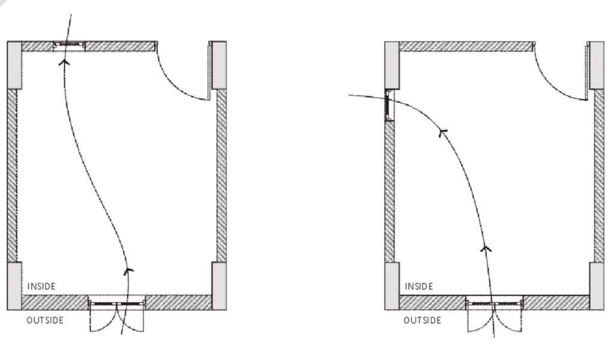


Figure 6: Openings on adjacent or opposite external walls for cross ventilation (Guideline)

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45 Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.
46 Heat exchange during night-time in hot/warm climates has greater value for thermal comfort. At this time, it is generally seen now that people keep the doors of their private rooms, i.e., the internal doors, closed.

In rooms that have openable area on only one external wall, cross ventilation can be achieved by having an opening at a higher level on one of the internal walls (Figure 7). this will enhance cross ventilation through the habitable space. this principle can be extended from room to room, for instance, from a bedroom into a living room which is cross-ventilated, thus enhancing cross ventilation through the entire dwelling unit.

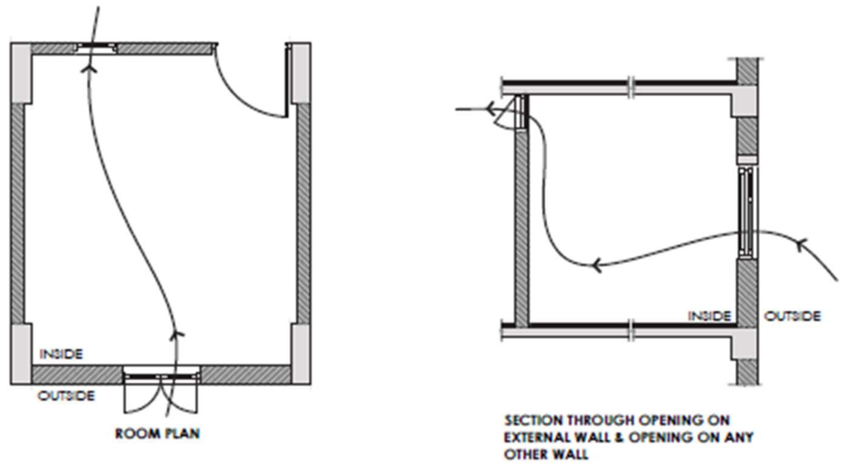

Figure 7: Openings on external wall and internal wall for cross ventilation (Guideline)

3. In rooms with only one external wall, and where cross ventilation is not possible (see point 2, above), provision of multiple windows on the external wall is preferred to that of a single window (Figure 8). the farther apart these windows are placed on the wall, the better is the effect of air movement across the room.

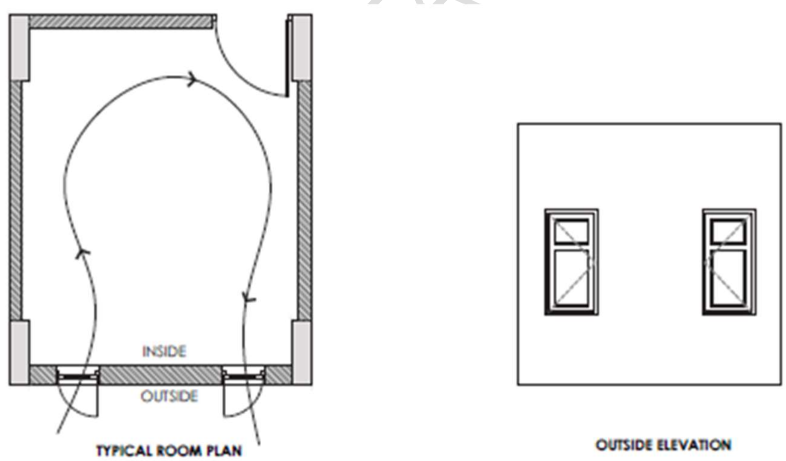

Figure 8: Two windows on single external wall (Guideline)

4. Adding a ventilator above the windows on the external wall helps increase the rate of convective heat exchange (Figure 9). this is especially helpful in cases where windows are available on only one external wall and there is no means of cross ventilation.

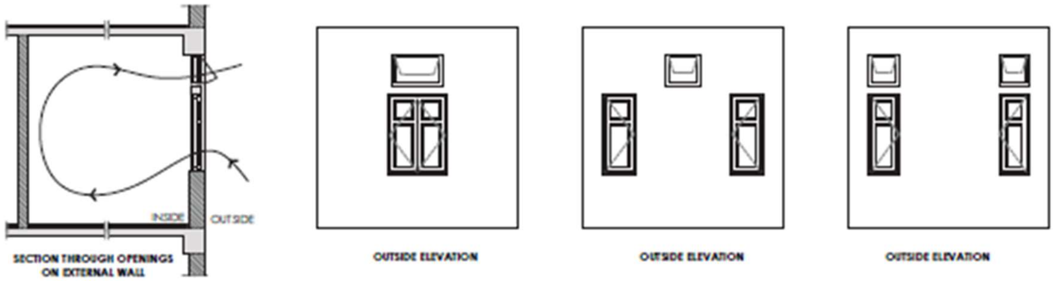

Figure 9: Adding ventilators above windows improves ventilation especially when only single external wall is available for openings (Guideline)

The following illustrative diagrams recommend good design strategies to help achieve better air exchange and increase the rate of heat loss through the buildings.

SINGLE-SIDED VENTILATION

Case 1: Room with only one opening on the external wall (Figure 10 **)**

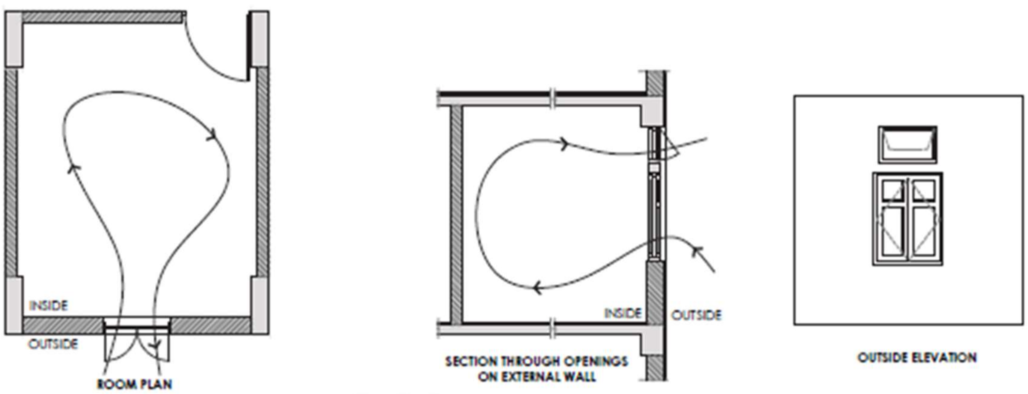

Figure 10: Room with only one opening on the external wall

Addition of ventilator at an upper level increases the rate of convective heat exchange with the outside air.

Case 2: Room with multiple openings on the external wall (Figure 10 **)**

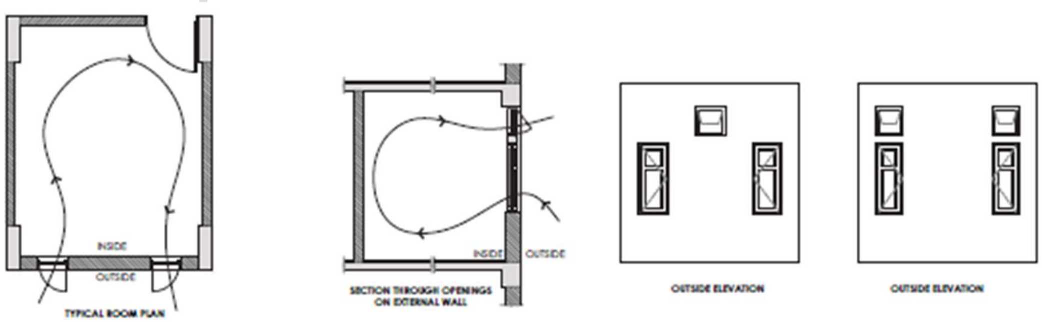

Figure 11: Room with multiple openings on the external wall

Cross ventilation

Case 1: Room with openings on both the external wall and another internal or external wall. (Figure 10 **)**

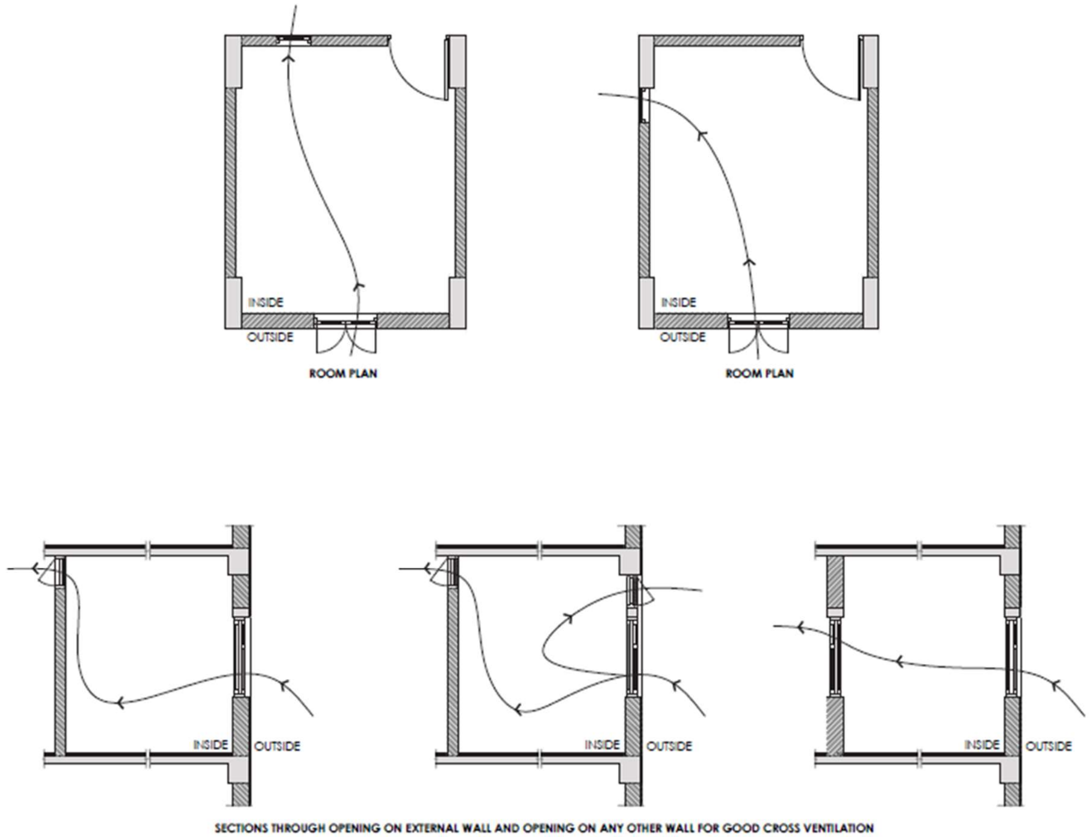

Figure 12: Room with openings on both the external wall and another internal or external wall.

Comparison (Figure 10 **)**

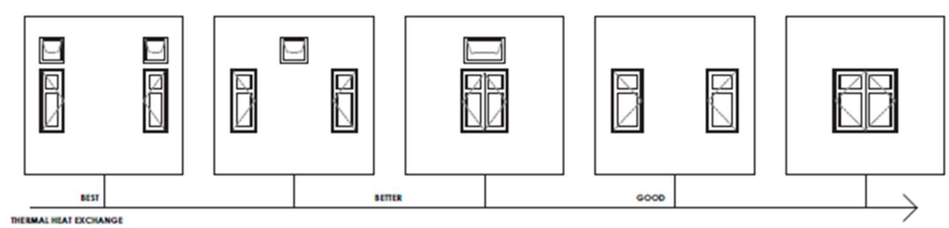

Figure 13: Comparison of different cases

For the same ratio of area of openings to floor area of a room, the thermal heat exchange increases as the number of openings increases on the wall.[47] It is thus recommended to have openable ventilators to aid better ventilation.

47 This conclusion is generally valid for hot-dry, warm-humid climates. For cold regions, this may vary.

ANNEXURE 8: COOL ROOF AND ROOF GARDENS

A cool roof is one that reflects most of the incident solar radiation and efficiently emits some of the absorbed radiation back into the atmosphere, instead of conducting it to the building below.[48] The term specifically refers to the outer layer or exterior surface of the roof, which acts as the key reflective surface.[49] A cool roof minimizes the solar heat gain of a building by first reflecting a considerable amount of incoming radiation and then by quickly re-emitting the absorbed portion. Cool roof encompasses an extensive array of applications including roof coatings, colours, textures, and finishes such as broken China mosaic, tiles, and even metals.

However, cool roofs are not to be seen as an alternative to the thermal transmittance requirement of the roof (U_{roof}) as given in this code. It is encouraged to have any cool roof application over a roof assembly complying with the maximum thermal transmittance value given in the code.

Defining a cool roof

The 'coolness' of a roof is influenced by its solar reflectance and thermal emittance.

- Solar reflectance: Solar reflectance is the ratio of solar radiation reflected by a surface to the solar radiation incident upon it. Solar reflectance is measured on a scale of 0 to 1. A reflectance value of 0 indicates that the surface absorbs all incident solar radiation, and a value of 1 denotes a surface that reflects all incident solar radiation. The term 'albedo' is often used inter-changeably with solar reflectance.
- Thermal emittance: Thermal emittance is the relative ability of a material to reradiate absorbed heat as invisible infrared radiation. Emittance, measured from 0 to 1, is defined as the ratio of the radiant flux emitted by a body to that emitted by a black body at the same temperature and under the same conditions.

According to ECBC 2017 cool roof requirement, roofs with slopes less than 20 degrees shall have an initial solar reflectance of at least 0.6 and an initial emittance of 0.9.

The Solar Reflectance Index (SRI) is a term that incorporates both solar reflectance and emittance in a single value and quantifies how hot a surface would get relative to standard black and standard white surfaces. It is the ability of a material to reject solar radiation, as shown by a small temperature rise.[50] The SRIs of a standard black surface (having reflectance of 0.05 and emittance of 0.9) and a standard white surface (of reflectance 0.8 and emittance 0.9) are taken as 0 and 100, respectively.

IGBC Green Homes requires a minimum SRI value of 78 for roof slopes with gradient $\leq$1:6 and 29 for steeper roof.

48 Shakti Foundation. 2017. Cool Roofs for Cool Delhi: Design Manual. Available at http://shaktifoundation.in/ wp-content/uploads/2017/06/cool-roofs-manual.pdf (accessed on 1 May 2018)

49 ibid

50 Bureau of India Standards (BIS). 2016. National Building Code 2016. Part 11. New Delhi: BIS

For more detailed information on cool roof, please refer Cool Roofs for Cool Delhi: Design Manual.[51]

Roof Gardens

In the case of roofs with roof gardens on earth fill for plantation or lawn, the thermal resistance of the earth fill can be taken into the calculation of the thermal transmittance (U value) of the roof. Some of the heat absorbed by the earth fill is also released into the atmosphere due to evapotranspiration of irrigation water from the roof garden, thus giving additional benefit.

[51] Shakti Foundation. 2017. Cool Roofs for Cool Delhi: Design Manual. Available at http://shaktifoundation.in/wp-content/uploads/2017/06/cool-roofs-manual.pdf (accessed on 01 May 2018)