Model Green Building Code Provisions for the Five Million Housing Programme in Pakistan

Contents

Disclaimer

This document has been prepared with the technical assistance of the EU SWITCH-Asia Programme (previous Regional Policy Support Component and current SCP Facility) in support to the Ministry of Climate Change. It is been produced in collaboration with NED University of Engineering and Technology. UN-Habitat (Pakistan) has provided detailed technical assistance in development of this document and provisions. Any statement, opinion or advice expressed in these provisions is made in good faith and on the basis that the Government and support institutions, and their employees are not liable for any damage or loss whatsoever, which may occur as a result of action taken in respect of any statement or advice referred to herein. Professional advice should be obtained before applying the information contained in these provisions to particular circumstances.

The sketches and pictures contained herein are for conceptual purposes only, and are to be used as general visual aids in understanding the basic intent of the Guidelines. They are not meant to depict any actual lot or building design.

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Dedication

MODEL GREEN BUILDING CODE PROVISIONS
FOR
THE FIVE MILLION HOUSING PROGRAMME IN PAKISTAN

is dedicated to thousands of innocent people who died due to the heavy rainfalls and disastrous floods that occurred across Pakistan in August 2022

Preface

In 2015, Pakistan being a UN Member State adopted the 2030 Agenda for Sustainable Development. In 2016, the Parliament of Pakistan unanimously approved the Sustainable Development Goals (SDGs) as the National Development Agenda. Accordingly, the Ministry of Planning, Development & Special Initiatives devised seven pillars of Vision-2025, which provided a comprehensive long-term national strategy for achieving inclusive growth and sustainable development in all phases of national planning and development. as mentioned below:

1. Mainstreaming SDGs in Plans, Policies and Resource Allocation aligned to the 2030 Agenda
2. SDGs monitoring, reporting and evaluation capacities strengthened
3. Financing flows increasingly aligned with the 2030 Agenda
4. Innovative approaches applied to accelerate progress on priority SDGs

Pakistan, with its 220 million people, has the fifth largest population in the world, which is increasing as high as 2 per cent annually. Pakistan maintains a 35 per cent urban and 65 per cent rural population distribution. Thirty-five per cent of the people are associated with the construction industry. As per housing estimates, 700,000 new housing units are required to be built annually but the existing capacity is limited to 300,000 units per year. Therefore, in the last twenty years the shortage of housing units accumulated a deficit of 12 million housing units. To address the situation, the then Prime Minister of Pakistan envisioned and initiated Naya Pakistan Housing Programme (NPHP) "to deliver five million housing units with allied amenities to all citizens, especially focusing on the financially underserved and middle-income communities, as a measure of comprehensive socio-economic uplift". Naya Pakistan Housing & Development Authority (NAPHDA) is the national construction organization of the Government of Pakistan. NAPHDA is responsible for planning, development, construction and management of real estate projects.

The national challenge of severely inadequate housing can easily be converted into an opportunity to transform the national construction industry with the new green built-environment interventions by developing a Green Building Code of Pakistan. As part of joint global efforts, in 2016, the Ministry of Climate Change, Pakistan Engineering Council, UN-Habitat Pakistan, EU SWITCH-Asia and UN Environment jointly launched the Sustainable Consumption and Production (SCP) Programme in Pakistan, which focused on:

- SDG 7: Affordable and Clean Energy
- SDG 11: Sustainable Cities and Communities
- SDG 12: Responsible Consumption and Production
- SDG 13: Climate Action
- SDG 17: Partnership & Capacity Building

SDG-12 provided guidelines for the transformation of conventional built practices into a green built environment across Pakistan. The Ministry of Climate Change, along with relevant stakeholders including the key role of Pakistan Engineering Council, started development of the Green Building Provisions for the Five Million Naya Pakistan Housing Programme.

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Acronyms

ACH	Air changes per hour
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials (formerly)
BCP	Building Code of Pakistan
BRI	Building Related Illness (BRI)
CDW	Construction & Demolition Waste
CSA	Canadian Standards Association
CW	Construction Waste
EIA	Environmental Impact Assessment
ERI	Energy Rating Index
EU	European Union
GBC	Green Building Code
GHG	Greenhouse Gases
HEC	Higher Education Commission of Pakistan, Islamabad
IAMPO	International Association of Mechanical and Plumbing Officials
ICC	International Code Council
IES	Illuminating Engineering Society
IgCC	International Green Construction Code
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
MEPS	Minimum Energy Performance Standards
NAPHDA	Naya Pakistan Housing & Development Authority
NPHP	Naya Pakistan Housing Program
NRPU	National Research Program for Universities
PCB	Polychlorinated Biphenyls (PCB)
PEC	Pakistan Engineering Council
PEPA	Pakistan Environmental Protection Act
PV	Photovoltaic
SBS	Sick Building Syndrome
SCP	Sustainable Consumption and Production
SDGs	Sustainable Development Goals
SHGC	Solar Heat Gain Coefficient
SRI	Solar Reflectance Index
SWMS	Storm-Water Management Systems
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
VT	Visible Transmittance
WTO	World Trade Organization

Aim and Scope of the Document

Aim: The GBC Provisions are an integration of all the building codes developed so far to reduce the impact of buildings on climate change by using modernized green products and efficient technologies in Pakistan. The principal aim is sustainable production and consumption of resources. Green building is the practice of creating structures by using a process that is environmentally responsible and resource efficient throughout the life cycle of the building – from design, construction, operation, maintenance, revocation, through to demolition.

Scope: The scope of GBC Provisions is to use environmentally responsible and resource efficient processes throughout the life cycle of the building, namely, (1) Energy efficiency and the use of renewable energy, (2) Water efficiency, (3) Use of environmentally friendly building materials, (4) Waste and toxics reduction, (5) Smart and sustainable growth, and (6) Enhancement of air quality. The code provisions cover two climatic zones, namely;

- Climate Zone 1 – Arid and Hot (ASHRAE Climate Zone 0B) – South and South West of Pakistan
- Climate Zone 2 – Temperate and Humid (ASHRAE Climate Zone 3A) – Northern Pakistan

SWITCH-Asia – EU, in collaboration with the Ministry of Climate Change, Pakistan Engineering Council, UN-Habitat, NED University, Karachi, and a long standing international strategic partnership with the International Code Council (ICC), has successfully developed the Green Building Code Provisions, based on 2018 International Green Construction Code (IgCC-2018), ASHRAE 90.2 2018, and various research projects (Arif 2022/NRPU 9626) conducted in Pakistan. The GBC provisions were developed to meet the Sustainable Development Goals 7, 11, 12 and 13 for developing sustainable green buildings and cities, determined under the National Action Plan for strengthening Pakistan's National Policy Frameworks to Facilitate Resource Efficiency and Sustainable Consumption and Production (RE/SCP). These GBC provisions provide green eco-friendly practices of building's design, construction and operation stages; and ensure the sustainable utilization of construction materials to save energy, conserve water, improve indoor environmental quality and lower greenhouse gas (GHG) emissions. The GBC provisions are based on previous work by the SWITCH-Asia SCP Facility, including the Green Building Guidelines. It provided an introduction to key concepts and practices essential for building and operating green homes, including key elements of design and construction to facilitate the development, construction and operation of green buildings in Pakistan.

The present GBC provisions seek to provide concrete standards and targets enabling green buildings. They are based on the emerging green building approach, which aims to design, construct and operate a building with minimal use of resources. The main idea behind green building is to minimize unfavorable impacts of buildings on the environment through life cycle planning of buildings, efficient use of resources, and environmental waste and pollution reduction. The primary objectives of the approach are to minimize environmental disturbances and waste generation, minimize utilization of energy and other resources, boost renewable energy usage, improve human health and comfort, and reduce the negative effects of buildings on human health and the natural environment. Substantial savings can be achieved through integrated planning and adopting environment friendly design in terms of materials and energy use.

Chapter 1: Site Sustainability

1.1. Introduction

This section of Green Building Code Provisions for the Five Million Housing Programme in Pakistan contains requirements related to the selection, planning and development of sites for residential building and housing projects. First, the following aspects of a site proposed for developing the residential buildings would need to be checked and sorted out to ensure the sustainability of site.

Sustainability criteria for a housing site are that it should be

- Physically accessible
- Financially affordable
- Environmentally suitable
- Socially acceptable
- Economically viable

Legal Provisions/Regulations for the site are

- It should be compliant to land-use plan/Master plan
- Compatible with local byelaws
- Land title should be clear
- There should be no litigation

1.2. Scope

This section addresses requirements for residential building and housing projects that pertain to sustainable site selection, site planning and development, mitigation of the heat island effect, light pollution reduction, and lessening of transportation impacts.

1.3. GBC Provisions

1.3.1. Site selection

The building or housing project shall comply with Sections 1.3.1 and 1.3.2.

Allowable sites

The site development and building project shall take place in or on one of the following:

- **Building project:** A building or group of buildings including houses and flats, and a site that utilizes a single submittal for a construction permit or that are within the boundary of contiguous properties under single ownership or effective control.
- **Brownfield:** A site documented as contaminated by means of an Environmental Site Assessment or a site classified as a brownfield by a local, provincial or federal government agency.
- **Greyfield**: A site of which more than 20 per cent is currently or has been previously developed with impervious surfaces.
- **Greenfield:** A site that is within half a mile (800 metres) of residential land that is developed, or that has one or more residential buildings under construction, with an average density of ten independent or clubbed dwelling units per acre (4 units per hectare), unless that site is agricultural land or forest land.

Proximity

Proximity is determined by drawing a circle with a half-mile (800-metre) radius around the center of the proposed housing project site.

- A Greenfield where the proposed residential building complies with the relevant provision of the concerned Authority Having Jurisdiction (AHJ); unless that site is agricultural land or forest land.
- A Greenfield that is agricultural land, and the purpose of the proposed residential building is related to agricultural use of the land.
- A Greenfield that is forest land, and the purpose of the proposed building is related to forestry use of the land.
- A Greenfield that is designated park land, and the purpose of the proposed building is related to the use of the land as a park.

1.3.2. Prohibited development activity

There shall be no site disturbance or development of the previously undeveloped land having an elevation lower than 5 feet (1.5 metres) above the elevation of the 100-year flood, as determined by the Authority Having Jurisdiction.

Exceptions

- Development of low-impact trails shall be allowed anywhere within a flood zone or in a wetland provided that such trails are located at least 15 feet (4.5 metres) from the wetland.
- Development of residential buildings or housing structures shall be allowed in designated alluvial flood zones provided that such structures include an approved engineered flood proofing up to an elevation that is at least as high as the minimum lowest floor elevation determined by the AHJ, and provided that the site includes drainage paths constructed to guide floodwaters around and away from the residential building or housing structures.
- Land within 150 feet (50 metres) of any fish and wildlife habitat conservation area.
- Development of low-impact trails shall be allowed, provided that such trails are located at least 15 feet (4.5 metres) from the wetland area.
- Site disturbance or development shall be allowed for natural habitat enhancement measures, or for restoration of the functions of the wetland.
- Land within 100 feet (35 metres) of any wetland, both in urban and rural areas.

1.3.3. Pre-design site inventory and assessment

A predesign inventory and assessment of the natural resources of the residential building or housing project site shall be submitted to the AHJ along with the site design and construction documents. The inventory and assessment shall include all of the following:

- Sustainability prerequisites of the proposed site, with reference to the climatic conditions of the project area, including severe cold areas in the North and extreme hot zones in the South.
- Location of the site and the proposed layout/design of the residential project, in order to minimize the Heat Island Effect.
- Location of any prohibited development areas identified in Section 1.3.2 that are located on or adjacent to the residential building or housing project site.
- Identification of invasive plant species on the site.
- Identification of native plant species on the site.
- Identification of site features designated for preservation of natural habitats, and existing cultural or archeological structures.

1.3.4. Landscaping and plantation

Invasive plants

Invasive plants shall be removed from the building project site and destroyed or disposed of in a landfill. Invasive plants shall not be planted on the building project site.

On greenfield sites

- Where more than 20 per cent of the area of the predevelopment site for the housing project has existing native plants or adapted plants, a minimum of 20 per cent of the area of native plants or adapted plants shall be retained.
- Where 20 per cent or less of the area of the predevelopment site has existing native plants or adapted plants, a minimum of 20 per cent of the site for housing project shall be developed or retained as vegetated area. Such vegetated areas could include bio-retention facilities, rainwater gardens, filter strips, grass swales, vegetated level spreaders, constructed wetlands, planters and open space with plantings.

Exceptions

The following areas shall not be included in the calculation:

- dedicated sports fields
- driving ranges/roads
- burial grounds or graveyards
- vegetated pavers
- the minimum fire vehicles' lane(s), as required by the AHJ under the local and/or the Building Code of Pakistan (BCP) Fire Safety Provisions 2016.

1.3.5. Storm-water management systems

Storm-water management systems (SWMS) shall be provided on the building site. Except to the extent that other storm-water management approaches are required by a local AHJ, these systems shall be limited to one or more of the following management methods:

- Infiltration
- Evapotranspiration
- Rainwater harvesting, storage and use
- Storm-water collection and use

Projects on greenfield sites

Projects on greenfield sites shall comply with at least one of the following:

- Storm-water management system shall be retained on site as per the hydrologic analysis of the residential buildings project site to determine the water balance of the site prior to its development, clearing and filling, and to demonstrate that the SWMS will not cause ecological impairment by starving receiving waters downstream of the site.
- The storm-water management system design shall maintain site water balance (the combined runoff, infiltration, and evapotranspiration) based on an AHJ-certified hydrologic analysis of the site's conditions prior to development, clearing and filling. Post-construction runoff rate, volume and duration shall not exceed rates preceding development, clearing or filling of the residential project site.

Projects on greyfield sites

Residential projects on greyfield shall retain on site no less than the volume of precipitation during a single 24-hour period equal to or greater than the percentile precipitation as laid down by the local AHJ. Where any fraction of the AHJ-prescribed percentile precipitation event cannot be retained, that fraction shall be treated to limit total suspended solids to 25 milligrams per litre in the remaining discharge.

Discharge rate

Residential building project sites shall be designed and constructed to comply with one of the following requirements:

- The discharge of the designed storm-water management system shall occur over a period of not less than 48 hours.
- The discharge flow duration curve at any point in time shall be plus or minus 10 per cent of the flow duration curve for channel-forming discharges for the selected site prior to its development, clearing or filling.

Adjoining lots

The storm water management system shall direct or concentrate off-site discharge to avoid increased erosion or other drainage-related damage to adjoining lots or public property.

Discharges from contaminated soils

Storm-water management systems on brownfield sites where contaminated soils are left in place shall not use infiltration practices that will result in pollutant discharges to groundwater. Storm-water discharge from brownfields shall be treated to limit total suspended solids to 25 milligram per litre. Storm-water management systems shall not penetrate, damage or otherwise compromise remediation actions at the residential building site.

1.3.6. Mitigation of the heat island effect

Site hardscape

At least 50 per cent of the residential project site hardscape that is not covered by solar energy systems shall be provided with one or any combination of the following:

- Existing trees and vegetation or new biodiverse plantings of native and adapted plants, which shall be planted either prior to the final approval by the local AHJ or in accordance with a contract established to require planting no later than 12 months after the final approval by the local AHJ so as to provide the required shade no later than ten years after the final approval.
- Paving materials to be used with a minimum initial solar reflectance index (SRI) as indicated by the local AHJ.
- Open-graded (uniform-sized) aggregate, permeable pavement and permeable pavers used on the site shall have a percolation rate of not less than 2 gallons per minute per square foot area (100 litres per minute per square metre).
- Shading provided through the use of structures shall ensure that the top surface of the shading structure complies with the relevant provisions as applicable in the site area.
- Parking under a building will be allowed provided that the roof of the building complies with the provisions as applicable in the site area.

Walls

Above-grade residential building walls and retaining walls shall be shaded through the use of shade-providing plants, man-made structures, existing buildings, hillsides, permanent building projections, on-site renewable energy systems, or a combination of these, using the following criteria:

- Shade shall be provided on at least 30 per cent of the South and West above-grade walls and retaining walls from grade level to a height of 20 feet (6 metres) above grade, or the top of the exterior wall, whichever is less. Shade coverage shall be calculated at the site area at 10 a.m. for the South walls and 3 p.m. for the West walls on the summer solstice.
- Where shading is provided by vegetation, such vegetation shall be existing trees and vegetation or new biodiverse plantings of native (local), naturally renewable tree, shrubs and creepers requiring minimum water consumption. Such plants should be planted prior to the final approval by the AHJ or in accordance with a contract established to require planting no later than 12 months after the final approval by the AHJ so as to provide the required shade no later than 10 years after the final approval.
- Vegetation shall be appropriately sized, and shall be selected, planted and maintained so that it does not interfere with overhead or underground utilities.
- Trees shall be placed a minimum of 5 feet (1.5 metres) from and within 50 feet (15 metres) of the building or retaining wall.

Exceptions

The requirements of this Section are satisfied if 75 per cent or more of the opaque wall surfaces on the South and West have a minimum solar reflectance index as indicated by the local AHJ.

Solar reflectance index

The SRI shall be calculated for medium-speed wind conditions using a convection coefficient, as specified by the relevant local AHJ, subject to the condition that the values for solar reflectance and thermal emittance are determined and certified by independent third-party energy auditors.

Vegetated terrace and roofing systems

Where provided, vegetated terrace and roofing systems shall comply with the following provisions.

- All plantings shall be capable of withstanding the microclimatic conditions of the vegetated area, including but not limited to wind, precipitation and temperature. Construction documents shall be submitted that show the planting location and anticipated two-year foliage coverage of the plantings. Invasive plants shall not be planted.
- The growing medium shall be designed for the physical conditions and local climate to support the plants selected. The planting design shall include measures to protect the growing medium until the plants are established. The maximum wet weight and water-holding capacity of a growing medium shall be approved by the local AHJ.
- Irrigation of the vegetated roofs and terraces shall comply with the approvals of the local AHJ.

1.3.7. Reduction of light pollution

The provisions for reducing light pollution are as follows:

Backlight, uplight and glare (BUG) ratings

Exterior luminaire backlight, uplight, and glare (BUG) ratings shall be as approved by the local AHJ.

Glare

Building-mounted exterior lighting with forward light oriented towards the building is not required to have a maximum glare rating. All other building-mounted lighting shall have a glare rating that is no greater than the maximum glare rating value permitted by the local AHJ.

Exceptions

- Specialized signal, directional and marker lighting associated with transportation
- Lighting integral to equipment or instrumentation and installed by its manufacturer
- Lighting for playing areas
- Roadway lighting required by governmental authorities
- Lighting classified for and used in hazardous locations
- Lighting for swimming pools and water features

1.3.8. Mitigation of transportation impacts

1.3.9. Pedestrian and bicycle connectivity

Pedestrian walkways

Each site development project shall provide the primary building entrance along with a pedestrian walkway that extends to either a public road/way or a transit stop. Walkways shall not be less than 5 feet (1.5 metres) in width and shall be clearly delineated.

A public-use walkway shall be provided along the length of the adjoining public-way frontage of the building project site, and such walkways shall connect to adjacent public-use walkways.

Bicycle and motorcycle paths

On-site bicycle and motorcycle paths shall be designed to connect bicycle and motorcycle parking areas to existing and planned off-site bicycle/motorcycle paths adjacent to the building project.

1.3.10. Bicycle and motorcycle parking

Minimum number of spaces

Bicycle and motorcycle parking spaces shall be provided for at least 5 per cent of the occupant load of each residential building but not less than two parking spaces.

Residential building projects with dwelling units/flats that provide each unit with a private garage or private, shall also provide a locked storage space of sufficient size to store a bicycle and a motorcycle.

Location

All other bicycle and motorcycle parking spaces shall be located inside or adjacent to the building, or the nearest point of these parking areas shall be within 50 feet (15.2 metres) of the building entrance being served. Bicycle and motorcycle parking shall not obstruct pedestrian access to the building.

Security and visibility

All bicycle and motorcycle parking spaces shall be: visible from the entrance being served; secured in a locker, cage, or room; or provided with security cameras. Signage shall be provided to identify parking that is not visible from the building entrance.

Documentation

Construction documents shall include all plans and details of bicycle and motorcycle parking spaces showing compliance with all requirements as listed in Section 5.3.7.2.

1.4. Master Planning & Design

1.4.1. Orientation

In the master planning of green housing projects, it is necessary to minimize direct sun-heat exposure. Building orientation influences the streetscape and directly affects the residential amenity within the development and for neighboring properties. The layout of housing units should preferably be oriented in the North-South direction. Row housing protects the two sides of the building from direct solar heat gain from the East and West sides. Also, locating the green pockets or water bodies around the housing will cool down the oncoming hot winds during summers. The master plan should demonstrate how the green building's orientation seeks to balance and optimize the following considerations:

- Desired streetscape: character and relationship to the public realm
- Climatic conditions; such as daylight and solar access, and prevailing winds
- Building orientation and height influence: for solar access to apartments and common open space

1.4.2. Building orientation

Building orientation refers to the solar orientation, whereas green housing is planned with respect to the sun-path. The orientation can refer to a particular room or, most important, the building facade. Basically, the positioning of a building should be planned with respect to the sun, to maximize solar gain at the appropriate time of the year when required in cold climate; and to minimize solar gain in a hot climate. The best housing orientation can increase the energy efficiency of residential space by making it more comfortable to live in and cheaper to run from the energy consumption point of view.

As the sun is lower in the sky in winter than in summer, buildings should be planned and constructed to capture the sun's free heat in the winter and reject it in the summer. The layout design of housing units should be such that all rooms get the maximum benefit of sunlight. Windows should be oriented keeping in view the prevalent wind direction or wind direction in summers, and also the solar axis. For windows and doors of housing unit openings on the South facade, a small overhang or curtains can cut off direct solar penetration during summer and allow it during winter. East and West facades receive maximum solar radiation during summer; therefore, deep patio (verandas) or sunshades in the South and West facades can exclude the strong evening rays. Also, trees and tall shrubs should be planted on the South and West of the housing units/blocks to protect the inmates from the afternoon heat and to provide them with oxygen.

1.4.3. Fire safety

Two aspects to be considered for fire safety are: (1) fire spread between properties through "unprotected areas", and (2) means of escape in case of fire.

External doors and windows need to be fire resistant, the doors should be self-closing and the windows should be fixed shut to limit the risk of fire spread between adjacent habitable areas and properties. The "unprotected areas", that is, walls, doors and windows, need to be fire resistant dependent on how close these elements are to the boundary of living premises.

Firefighting and access to services such as power and water meters require careful consideration in the design of the front façade. Early consultation with relevant authorities would resolve functional requirements in an integrated design solution.

Chapter 2: Water Use Efficiency

2.1. Introduction

This section specifies requirements for potable and non-potable water use efficiency, for the site, residential buildings and houses, and for water management.

2.2. Scope

The GBC provisions for water use efficiency in houses include

- Water use reduction
- Water consumption measurement
- Roof-top rainwater harvesting systems
- Surface water harvesting

2.3. Water Use reduction

Following are the GBC provisions with regard to water use reduction in alignment with the Green Building Guidelines (GBG 2021).

- In Green Housing projects, efforts should be made to reduce water consumption by 20 per cent below the baseline building consumption.
- Use WaterSense labeled fixtures and fittings in bathrooms and kitchens.
- Individual dwelling's and apartment's metering of water shall be used to assist occupants in reducing potable-water use.
- Green housing should consider the use of technology to enable remote reading of meters.
- Reduce the use of potable water for landscaping and irrigation, around green housing by applying the following strategies:
    1. Use recycled water to provide for at least 50 per cent of outdoor irrigation requirements.
    2. Use recycled grey water from bathrooms to flush the toilets.
    3. Plant native or adaptive species that require little or no water for irrigation, and/or plan landscaping utilizing efficient irrigation systems that reduce irrigation requirements by 40 per cent from the baseline for the total planted area.
- The water use efficiency criteria need to be as per water availability and rainfall patterns in different climatic zones of Pakistan. Climate Zone 1 (as defined/proposed in these code provisions) has lesser rainfall expectation than Zone 2.
- In the climatic zones facing water scarcity during most part of the year, provision should be made for roof-top rainwater harvesting on all residential buildings and houses. The water harvesting should include rainwater collection, conduction, treatment for domestic use and storage.

The following are the subsections of GBC provisions for water use reduction in alignment with IgCC 2018.

2.3.1. Plumbing fixtures and fittings

Plumbing fixtures (water closets and urinals) and fittings (faucets and showerheads) shall comply with the following requirements, as shown in Table 2.1.

Table 2.1: Plumbing fixtures and water use requirements

Plumbing fixture	Water volume and flow rate
Water closets (toilets)—flushometer single-flush valve type	Single-flush volume of 1.28 gallons (4.8 litres)
Water closets (toilets)—flushometer dual-flush valve type	Full-flush volume of 1.28 gallons (4.8 litres)
Water closets (toilets)—single-flush tank-type	Single-flush volume of 1.28 gallons (4.8 litres)
Water closets (toilets)—dual-flush tank-type	Full-flush volume of 1.28 gallons (4.8 litres)
Urinals	Flush volume 0.5 gallons (1.9 litres)
Public lavatory faucets	Flow rate—0.5 gpm (1.9 L/min) [a]
Residential bathroom lavatory faucets	Flow rate—1.5 gpm (5.7 L/min)
Residential kitchen-sink faucets	Flow rate—1.8 gpm (6.8 L/min)
Residential showerheads	Flow rate—2.0 gpm (7.6 L/min)

[a] gallons per minute/litres per minute
Reference: IgCC 2018.

Note: Abbreviations used hereunder are "gal" for "gallon"; "gpm" for "gallon per minute"; "L" for a "Litre"; "L/min" for "Litre per minute"; "ft" for "foot" or "feet"; "in" for "inch" and "m" for "metre".

a. **Water closets (Western toilets) flushometer valve type:** For single-flush, maximum flush volume shall be determined in accordance with ASME A112.19.2/CSA B45.1 and shall not exceed 1.28 gal (4.8 L). For dual-flush, the full-flush volume shall not exceed 1.28 gal (4.8 L) per flush. Dual-flush fixtures shall also comply with the provisions of ASME A112.19.14/ PEPA or be AHJ approved.

b. **Water closets (toilets) tank-type:** Tank-type water closets shall be certified to the performance criteria of the Provincial EPAs of Pakistan WaterSense Tank-Type High-Efficiency Toilet Specification and shall have a maximum full-flush volume of 1.28 gal (4.8 L). Dual-flush fixtures shall also comply with the provisions of ASME A112.19.14/ PEPA or be AHJ approved.

c. **Urinals.** Maximum flush volume, determined in accordance with ASME A112.19.2/CSA B45.1, shall not exceed 0.5 gal (1.9 L). Flushing urinals shall comply with the performance criteria of the USEPA WaterSense Specification for Flushing Urinals. Non-water urinals shall comply with ASME A112.19.19 (vitreous china) or IAPMO Z124.9 (plastic) as appropriate.

d. **Residential bathroom/lavatory sink faucets.** Maximum flow rate shall not exceed 1.5 gpm (5.7 L/min) when tested in accordance with ASME A112.18.1/CSA B125.1. Residential bathroom and lavatory sink faucets shall comply with the performance criteria of the PEPA or AHJ-approved WaterSense High-Efficiency Lavatory Faucet Specification.

e. **Residential kitchen faucets.** Maximum flow rate shall not exceed 1.8 gpm (6.8 L/min) when tested in accordance with ASME A112.18.1/CSA B125.1. Kitchen faucets shall be permitted to temporarily increase the flow to more than 1.8 gpm (6.8 L/min) but shall not exceed 2.2 gpm (8.3 L/min), and must automatically revert to the established maximum flow rate of 1.8 gpm (6.8 L/min) upon physical release of the activation mechanism or closure of the faucet valve.

f. **Residential showerheads.** Maximum flow rate shall not exceed 2.0 gpm (7.6 L/min) when tested in accordance with ASME A112.18.1/CSA B125.1. Residential showerheads shall comply with the performance requirements of PEPA or AHJ-approved WaterSense specification for showerheads.

   Exception: Where the area of a shower compartment exceeds 2600 in^2 (1.7 m^2), an additional flow of 2.0 gpm (7.6 L/min) shall be permitted for each multiple of 2600 in^2 (1.7 m^2) of floor area or fraction thereof.

g. **Water-bottle filling stations.** Water-bottle filling stations shall be an integral part of, or shall be installed adjacent to, not less than 50 per cent of all drinking fountains installed indoors on the premises.

2.3.2. Appliances

Clothes washers and dishwashers installed within dwelling units shall comply with the MEPS or ENERGY STAR® Program Requirements for Clothes Washers and ENERGY STAR Program Requirements for Dishwashers as approved by AHJ. Maximum water use shall be as follows:

- Clothes washers (residential)—Maximum water factor (WF) of 5.4 gal/ft^3 of drum capacity (0.72 L/m^3 of drum capacity).
- Dishwashers—Standard-size dishwashers shall have a maximum WF of 3.8 gal/full operating cycle (14.3 L/full operating cycle). Compact sizes shall have a maximum WF of 3.5 gal/full operating cycle (13.2 L/full operating cycle). Standard and compact size shall be defined by MEPS or ENERGY STAR criteria.

2.3.3. Roofs

a. The use of potable water or reclaimed water for roof spray systems to thermally condition the roof shall be prohibited.

   Exception: Where approved, on-site treated reclaimed water or rainwater may be used for roof spray systems.

b. In-ground irrigation systems on vegetated roofs using potable water or off-site treated reclaimed water shall be prohibited.

c. The use of potable water or reclaimed water for irrigation of vegetated (green) roofs is prohibited after the vegetation establishment period or 18 months after the initial installation, whichever is less. After the landscape plants are established, the irrigation system using potable water or reclaimed water shall be removed from site.

   Exception: Where approved, on-site treated reclaimed water or rainwater may be used for vegetated roof irrigation systems during and after the vegetation establishment period.

2.3.4. Hot-water distribution

For climate Zone 2 (as proposed in the GBC provisions) hot-water distribution in pipes shall be in accordance with the applicable IgCC 2018 provisions.

2.3.5. Maximum allowable pipe volume

The maximum volume of water in pipes between the source of hot or tempered water and the fixtures shall be 64 ounce (oz.) or 1.9 Liter (L) where the source of hot or tempered water is a water heater, and 24 oz. (0.71 L) where the source of hot or tempered water is a circulation loop pipe or an electrically heat-traced pipe. The source of hot or tempered water shall be the point of connection to a water heater, heat-traced pipe or a circulation loop. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters, and manifolds between the source of hot or tempered water and the termination of the fixture supply pipe. The volume shall be determined using Table 2.2. The volume contained within fixture shutoff valves, flexible water supply connectors to a fixture fitting, or within a fixture fitting shall not be included in the water volume determination. Where the source of hot or tempered water is a circulation loop pipe, the volume shall include the portion of the fitting on the source pipe that supplies water to the fixture. Where the type of pipe is unknown or not specifically included in the table, the generic pipe column shall be used to determine the volume.

Table 2.2: Internal volume of pipe or tube in I-P (SI)

Ounces (litres) of water per foot (metre) of pipe				
Nominal Size, Inch (Dimension Nominal [DN], mm)	GENERIC PIPE	COPPER TYPE L	CPVC CTS SDR 11	PEX CTS SDR 9
1/4 (8)	0.33 (0.03)	0.52 (0.05)	0.37 (0.04)	0.33 (0.03)
5/16 (9)	0.5 (0.05)	NA (NA)	NA (NA)	0.48 (0.05)
3/8 (10)	0.75 (0.07)	0.97 (0.09)	0.75 (0.07)	0.68 (0.07)
1/2 (15)	1.5 (0.15)	1.55 (0.15)	1.25 (0.12)	1.18 (0.11)
5/8 (18)	2 (0.19)	2.23 (0.22)	NA (NA)	1.78 (0.17)
3/4 (20)	3 (0.29)	3.22 (0.31)	2.67 (0.26)	2.35 (0.23)
1 (25)	5 (0.49)	5.47 (0.53)	4.43 (0.43)	3.91 (0.38)
1 1/4 (32)	8 (0.78)	8.36 (0.81)	6.61 (0.64)	5.81 (0.56)
1 1/2 (40)	11 (1.07)	11.83 (1.15)	9.22 (0.89)	8.09 (0.78)
2 (50)	18 (1.75)	20.58 (2.00)	15.79 (1.53)	13.86 (1.34)

Reference: Table 601.3.3.1 (6.3.3.1) IgCC 2018.

2.3.6. Maximum pipe length

The maximum pipe length from the source of hot or tempered water to the termination of the fixture supply pipe serving any plumbing fixture or appliance shall not exceed 50 feet (15 metres) of developed length (IgCC 2018).

2.4. Water Consumption Measurement

Measurement devices with remote communication capability should be provided to collect water consumption data for the domestic water supply to each house or residential building. Both potable and reclaimed water entering the building project should be monitored or sub-metered. In addition, for individual leased, rented or other tenant or subtenant space within any building in excess of 50,000 ft2 (5000 m2) covered area, separate sub-meters should be provided. Measurement devices with remote capability should be provided to collect water use data for each water supply source to the residential building project that exceeds the thresholds listed in Table 2.3. Local water utility company service entrance/interval meters are allowed to be used.

Table 2.3: Water supply source measurement thresholds

Water Source	Main Measurement Threshold
Potable water	1000 gal/day (3800 L/day)
Municipally reclaimed water	1000 gal/day (3800 L/day)
Alternate sources of water	500 gal/day (1900 L/day)

Reference: Table 601.3.5.1A (6.3.5.1A) of IgCC 2018.

2.5. Rooftop Rainwater Harvesting Systems

Following methods of rooftop rainwater harvesting are proposed as part of these GBC provisions.

2.5.1. Storage for direct use

Rainwater collected from the roof of the building is diverted to a storage tank. Each drainpipe should have a mesh filter at its mouth and a first flush device followed by a filtration system before connecting to the storage tank. Water from the storage tank can be used for secondary purposes such as washing and gardening.

2.5.2. Recharging groundwater aquifers

Groundwater aquifers can be recharged by various kinds of structures to ensure percolation of rainwater in the ground instead of draining away from the surface. Commonly used recharging methods are as follows.

Recharging of borewells

Rainwater collected from the rooftop of a building is diverted through drainpipes to a settlement or filtration tank. After settlement, the filtered water is diverted to borewells to recharge deep aquifers.

Recharging of dug wells

Dug wells can be used as recharge structures. Rainwater from the rooftop is diverted to a dug well after passing it through a filtration bed. Cleaning and desalting of the dug well should be done regularly to enhance the recharge rate. The filtration method suggested for borewell recharging could also be used for dug wells.

Recharge pits

Recharge pits are small pits of any shape, rectangular, square or circular, contracted with brick or stone masonry wall with weep holes at regular intervals. The top of the pit can be covered with perforated covers and its bottom filled with filter media. The capacity of the pit can be designed on the basis of catchment area, rainfall intensity and recharge rate of soil. Usually, the dimensions of the pit may be 1 to 2 metres width and 2 to 3 metres depth, depending on the depth of the pervious strata. These pits are suitable for recharging shallow aquifers, and small houses.

Recharge trenches

Recharge trenches are built where the upper impervious layer of soil is shallow. It is a trench excavated in the ground and refilled with porous media like pebbles, boulders or brickbats. It is usually made for harvesting the surface runoff. Borewells can also be provided inside the trench as recharge shafts to enhance percolation. The length of the trench is decided as per the amount of runoff expected. This method is suitable for small houses, playgrounds, parks and roadside drains. The recharge trench can be 0.50 to 1.0 m wide and 1.0 to 1.5 m deep.

Soakaways or recharge shafts

Soakaways or recharge shafts are provided where the upper layer of soil is alluvial or less pervious. These are bored holes 30 cm in diameter and up to 10 to 15 m deep, depending on the depth of the pervious layer. The shaft should be lined with a slotted/perforated PVC/MS pipe to prevent collapse of the vertical sides. At the top of the soakaway, a sump of the required size is constructed to retain the runoff before it filters through the soakaway. Sumps should be filled with a filter media.

Percolation tanks

Percolation tanks are artificially created surface water-bodies, submerging a land area with adequate permeability to facilitate sufficient percolation to recharge the groundwater. These can be built in big campuses where land is available and topography is suitable.

2.5.3. Technical designs of rainwater harvesting systems

The following rainwater harvesting (RWH) systems' design types 1& 2 are good for low-rise buildings. These designs do not necessarily make water drinkable (that depends on contaminants on the roof). However, they can keep leaves, gravel and other detritus from the roof out of the system, helping to prevent blockages and major contamination. In all designs, some simple rainwater filter systems need to be used to provide basic filtration.

Rainwater harvesting design type 1

Design type 1 RWH tank can be built on a well-constructed, flat-roof building, where the roof can withstand the weight of the tank. See Appendix A for illustration of design type 1.

Rainwater harvesting design types 2 and 3

In case of non-load bearing or structurally-weak roofs of buildings, design type 2 may be used.
When the space is limited around a building, so that storage tanks cannot be fully utilized above-ground, and the roof is unsuitable for a large tank, then design type 3 is used, which is an underground tank (or a combination of rooftop and underground tanks) to store rainwater. This type can also be used for sharing between multiple buildings in densely populated areas. See Appendix A for illustration of design type 2 and 3.

2.6. Surface Water Harvesting and Management

Three types of water harvesting can be undertaken to harvest rainwater in urban areas.

a. Rainwater collected from rooftops, courtyards and similar compacted or treated surfaces for use for domestic purposes, watering garden crops or for groundwater recharge.
b. Micro-catchments water harvesting is a method of collecting surface runoff from a small catchment area and storing it in a zone adjacent to an infiltration basin. The basin is planted with trees, bushes or annual crops.
c. Macro-catchments water harvesting, also called harvesting from external catchments, is where the runoff from hill-slope catchments is conveyed and stored near human settlements located at the foot of the hill on flat terrain.

Chapter 3: Energy Efficiency

3.1. Introduction

This chapter contains requirements related to the effective use of energy in residential buildings, houses and appliances and to on-site renewable energy systems. It references ANSI/ASHRAE/IES Standard 90.2 and contains many provisions that exceed those in Standard 90.2, and in "Standardization of Building Codes, Standards and Specifications for Low-Cost (Affordable) Units" by PEC-2021 and NAPHDA. Moreover, guidelines developed under a research project (NRPU 9626-HEC, Arif, 2022), have been adopted in these GBC provisions keeping in mind its analytical and experimental validations. The coverage of the Code incudes various aspects including building envelope, lighting, renewable energy, and energy monitoring and management.

3.2. Scope

The GBC provisions cover two climatic zones. Prior to applying the requirements specified in this section, not only must the climate zone be known, but the space conditioning category and space classification must also be known.

- Climate Zone 1: Arid and Hot (ASHRAE Climate Zone 0B) – South and South West of Pakistan
- Climate Zone 2: Temperate and Humid (ASHRAE Climate Zone 3A) – Northern Pakistan

The residential space category includes spaces in buildings used primarily for living and sleeping. The scope includes building envelope, lighting, renewable energy, energy monitoring and management.

3.3. Building Envelope

Definition

The building envelope includes all the building components that separate the indoors from the outdoors. Building envelopes include the exterior walls, foundations, roof, windows and doors.

Following aspects are covered in the GBC provisions.

- Conditioned space
- Fenestration
- Insulation and infiltration
- Ventilation

3.3.1. Conditioned space

Definition

Conditioned space is space that has a heating and/or cooling system of sufficient size to maintain temperatures suitable for human comfort. The building envelope requirements do not apply to unconditioned spaces. Note that unconditioned spaces are not automatically exempt from all envelope requirements. For example, the minimum skylight area and automatic daylighting control requirements still apply to certain large open spaces with tall ceilings. Some spaces are considered conditioned even though they may not have a heating or cooling system that directly serves the space. This type of space is called "indirectly conditioned". The residential building envelope requirements apply to indirectly conditioned spaces in the same way that they apply to directly conditioned spaces (IgCC 2018).

Conditioned-space provisions for climate zone 1

Following are the key provisions to ensure energy efficiency in a conditioned space.

- Ceiling area of a flat ceiling shall be equal to the footprint area of the conditioned space in alignment with the Energy Rating Index (ERI) input variables for use with ASHRAE Standard 90.2 for purposes of new construction compliance (Table B-1, ASHRAE 90.2).
- Control of infiltration shall require air changes per hour (ACH) to be maintained at 0.17 ACH, which makes the building tight so that it loses very little energy (Arif, 2022).
- Air conditioning temperature shall be kept between 26 and 28oC, based on local weather requirements, specifically with inverter air conditioners (ibid.).
- Air conditioner condensers shall be kept under shaded area to reduce energy consumption (ibid.).

Conditioned space provisions for climate zone 2

- Designating a space as conditioned, semi-heated or unconditioned affects whether the envelope requirements apply and how much insulation must be installed. A space on the exterior of a building or house, such as an enclosed exit stairway, can be made indirectly conditioned by placing the insulation on the exterior wall.. This is the common approach as in such cases usually less insulation is required. Likewise, by providing ventilation vents or fans, a space can be made indirectly conditioned.
- Certain boundaries of the unconditioned space may be considered as semi-exterior envelope components and must meet the requirements for semi-heated spaces. Rooms should be designed to be properly ventilated and naturally lighted to reduce energy cost.

3.3.2. Fenestration

Definition

Fenestration refers to the openings in the building envelope, including the windows, doors and skylights. The inclusion of windows and other openings in a building or home are necessary as they improve the overall environment inside it, however they do work to break the seal of the building, providing possible spaces for air, water and cold air to enter. Thus, the number of openings included in a building or house must be taken into account, along with their placement and the quality of the materials used to create the openings.

Vertical fenestration

Windows, opaque doors, glazed doors, combination opaque/glazed doors, glazed block, and transparent or translucent glazing materials installed at a slope of at least 60 degrees (1.05 radius) from the horizontal.

Skylight

Windows, glass or other transparent or translucent glazing systems installed at a slope of less than 60 degrees (1.05 radius) from the horizontal.

Fenestration area

Total area of the fenestration includes the glazing, sash and frame. For doors where the glazed vision area is less than 50 per cent of the door area, the fenestration area is the glazed vision area. For all other doors, the fenestration area is the door area.

Fenestration criteria

Fenestration must comply with all relevant requirements in Standard 90.2-2018, Section 7, except as modified or added to the IgCC. The fenestration design criteria apply to windows, glass doors, glass blocks, plastic panels and skylights. For both windows and skylights, there are three performance requirements: a maximum U-factor, a maximum solar heat gain coefficient (SHGC), and a minimum

ratio of visible transmission (VT) divided by SHGC.

- Building thermal envelope, where present, its components shall have SHGC values and U-factors no greater than the values shown in Table 3.1 (adopted from ANSI/ASHRAE/IES Standard 90.2-2018).

Table 3.1: Building envelope component maximum SHGC and U-Factors

	Maximum SHGC	Maximum U-Factor				
Climate Zone	Glazed Fenestration	Fenestration	Skylights	Ceilings	Mass Walls	Floors
1	0.30	6.82	4.26	0.20	1.12	0.36
2	0.30	2.84	3.69	0.20	0.80	0.27

Reference: Adopted from ASHRAE 90.2-2018, Table 7-1

- On-site power utilization, where present, the building envelope components shall have solar heat gain coefficient values and U-factors no greater than the values shown in Table 3.2 (adopted from ANSI/ASHRAE/IES Standard 90.2-2018).

Table 3.2: Maximum SHGC and U-Factors when on-site power is used

	Maximum SHGC		Maximum U-Factor				
Climate Zone	Glazed Fenestration	Skylights	Fenestration	Skylights	Ceilings	Mass Walls	Floors
1	0.25	0.30	2.84	4.26	0.20	1.12	0.36
2	0.25	0.30	1.99	3.12	0.17	0.56	0.27

Reference: Adopted from ASHRAE 90.2-2018, Table 6-2

- It is recommended to use Trp LoE glass for maximum lighting and low heating based on local requirements in Climate Zone 1 (Arif, 2022).
- Sun projection should be made at 2/3rd of window height to reduce cooling loads (Arif, 2022).
- The prescriptive building envelope option limits the window-to-wall ratio (WWR) to 50 per cent of the gross exterior wall (ibid.) and limits the skylight-to-roof ratio (SRR) to 3 per cent of the roof area (or 6 per cent), if the total daylight area under the skylights is a minimum of half the floor area of the space and certain daylighting requirements are met as specified in Standard 90.1-2016 (IgCC 2018).

Fenestration verification

The U-factor of each fenestration product shall be determined by the AHJ. U-factor, SHGC and air leakage values used in the performance analysis shall be verified by inspection of the label on each fenestration product by an independent, third-party auditor.

3.3.3. Insulation and infiltration

Following are the provisions for insulation and infiltration criteria for a building envelope.

- Insulate roof by expanded or extruded fiberglass or thermal properties close to R10 and R38 material, exterior reflective paints, and roof waterproof asphalt sealant in climate zone 1 (Arif, 2022).
- It is recommended that infiltration rate air change per hour should be maintained at 0.17 ACH through caulking and striping in climate zone 1 (ibid.).
- For opaque doors, the U-factor is the only compliance option. Standard 90.1-2016, Appendix A, includes tables of default U-factors for all classes of construction (IgCC 2018).
- For walls, R-values provided in Standard 90.1-2016, Appendix A of IgCC 2018, shall be used as reference. Furthermore, insulation of walls should be done using extruded polystyrene sheets or material with similar thermal properties to ICF in climate zone 1 (Arif, 2022).
- R38 fiberglass batts should be used to insulate the walls in climate zone 1 (ibid.).
- 12.25" structurally insulated panels (SIP) should be used in climate zone 1 (ibid.).
- The eastern side of green buildings and houses should be provided with a 13½"-thick brick wall. On the southern and northern sides, 9"-thick brick walls should be constructed. The western side should have brick cavity walls (GBG, 2021).

3.3.4. Ventilation

Natural ventilation can be achieved by (1) cross ventilation, which occurs when dwellings have openings in different orientations so that breeze can flow through the room or building to flush out hot or stale air, and (2) passive ventilation, which relies on the effect of rising hot air, and requires high and low openings so that warm air is flushed from higher openings and cooler air is drawn in through lower openings. Provision for ventilation are,

- Place the windows in walls facing wind direction prevalent in the summer season.
- Install windows towards open spaces on the rear and front sides of buildings.
- Provide patios or small open-to-sky spaces in the building plans.
- Install ventilation duct and exhaust fan over the stove to improve internal area thermal comfort in climate zone 1 (Arif, 2022). The threshold of exhaust systems whose total exhaust exceeds 5000 cubic feet per minute, or cfm, (i.e., 2400 litres/second) is 2000 cfm (950 L/s). A 10-foot- (3-m-) long wall-mounted canopy hood serving medium-duty appliances must exhaust no more than 2,100 cfm (990 L/s) (IgCC 2018).

3.4. Lighting

Following are the provisions for efficient lighting arrangements.

- All permanently installed luminaires shall have an efficacy or a luminaire efficiency rating (LER) of at least 45 lumens per Watt (lm/W), or contain lamps with efficacies of at least 65 lm/W and controlled with either dimmers or automatic shut-off controls (ASHRAE 90.2 2018, Section 7.5.2).
- All interior and exterior lighting shall be compliant with the requirements of ASHRAE Standard 90.1-2016, with addition of lower lighting power densities (LPDs) (IgCC 2018). LPD shall be calculated using (1) Building Area Method ASHRAE Standard 90.1-2016, Table 9.5.1, or (2) Space-by-Space Method ASHRAE Standard 90.1-2016, Table 9.6.1 (IgCC 2018).
- Lighting efficiency shall be improved by replacing fluorescent tubes with energy efficient LEDs. It is recommended that the consumption of lighting wattages be reduced to 3.23 watts/m2 or the minimum possible by using energy efficient lights (Arif, 2022).
- In common spaces of multi-family residential buildings, such as parking lots and stairwells, the lighting shall meet the requirements of ASHRAE/IES Standard 90.1, Table 9.6.1.

- Daylighting and occupancy control system shall be installed.
- The consumption schedule of 24 hours for 7days equivalent shall be set to12 hours consumption by reducing the energy usage in non-used spaces of the house.
- The plug load shall be reduced to 6.46 watts/m2 or minimum by replacing current equipment with ENERGY STAR equipment.

3.5. Renewable Energy

A common example of on-site renewable electrical energy is PV solar energy, which directly converts solar energy to electricity. Other less common forms of on-site renewable energy are wind power, hydroelectric power and naturally occurring geothermal heat (used for electricity production).

- A site with 1.2 kBtu/ft^2·day (4.0 kWh/m^2·day) of annual daily average solar radiation would need a PV panel area equal to approximately 13 to 25 per cent of the gross roof area (for all buildings except single storey) to satisfy the mandatory energy output requirement.
- Solar PV panel efficiency is 20-21per cent under renewable electrical energy when the sun shaded area for solar is taken as 100 square feet/KWP.
- Use solar panels that consume 18 to 20 per cent panel efficiency and provide 78 to 80 per cent efficiency (Arif, 2022).
- Maximum surface coverage area (90%) which produces greater solar potential should be used (ibid.). Longer the payback duration, greater the potential savings. Thirty years provide the maximum savings (ibid.).
- Solar PV system for single-storey houses shall be designed in alignment with Section 21 Guidelines for Solar PV System of Standardization of Building Codes, Standards and Specifications for Low-Cost (Affordable) Units (NAPHDA/PEC 2021).

3.6. Energy Consumption Monitoring and Management

Following are the provisions for energy monitoring and management.

- For any energy supply source to a building project that has a service size exceeding the thresholds prescribed by the local utility company, measurement devices provided must have the capability to record energy consumption at specific intervals. The electrical service threshold of 200 kVA of connected load is relatively low and can be applied to most buildings larger than 15,000 to 20,000 square feet (1400 to 1900 m^2) covered area.
- For energy management, applicable guidelines as per climate zones provided in Section 4 of the Green Building Guidelines for Prime Minister's Five Million Naya Pakistan Housing Programme, in alignment with local AHJ, shall be followed (SWITCH-Asia, 2021).
- Independent energy auditors shall be engaged to conduct energy audits to determine consumption and provide energy efficiency management plans (Arif, 2022).

Chapter 4: Indoor Environment Quality

4.1. Introduction

Indoor air/environment quality depends upon many internal and external factors. It is directly related to ventilation, availability of natural light, and indoor temperature and humidity, all of which contribute to the comfort of the occupants of a building. The quality of the indoor environment is also related to the activities of the occupants and to the outdoor environment as well.

4.2. Scope

Many external factors which affect indoor air quality are not controllable most of the time in our local context, therefore, only limited provisions are made for them in this GBC.

4.3 Provisions

For improving the quality of the indoor environment, the provisions are as follows.

- The indoor space should be naturally ventilated in alignment with section 3.3.5 of this code.
- These naturally ventilated spaces must have minimum air openings and space configuration requirements in accordance with ASHRAE Standard 62.2-2010.
- There should be not be any smoking zone within the building nor within 25 ft from entries and operatable windows or openings.
- Kitchen/s must have an exhaust system installed, with its vent outside to ensure removal of smoke from the building.
- The occupants of the building should have access to the controls of any kind of air conditioning, lighting or heating system in order to ensure their thermal comfort. This should be in alignment with sections 3.3.6 and 3.3.8 of this code.
- Use of paints and coatings having a high content of Volatile Organic Chemicals (VOCs), such as formaldehyde, and other gases including carbon dioxide, carbon monoxide, ozone, nitrogen dioxide and radon, should be prohibited to ensure healthy indoor air. Composite wood and agrifiber products must contain no added urea-formaldehyde resins.

Chapter 5: Material and Resources

5.1. Scope

This chapter specifies provisions related to the environmental and human health impacts of materials, including resource conservation, reduced life-cycle impacts of building materials, impacts on the atmosphere, and product transparency.

5.2. Compliance

The building materials shall comply with "Mandatory Provisions" either as prescriptive and/or performance options.

5.3. Regional Materials

15 per cent of the building materials or products used, based on cost, shall be extracted/harvested/recovered or manufactured within a radius of 500 miles (800 kilometres) of the housing project site (IgCC 2018).

5.4. Bio-based Products

5 per cent of the building materials used, based on cost, shall be biobased products (IgCC 2018).
Biobased products shall:

a. Comply with the minimum biobased contents of threshold(s) as determined by the Environment Protection Authority or the AHJ; and

b. Be composed of solid wood, engineered wood, bamboo, wool, cotton, cork, agricultural fibers, or other biobased materials with at least 50 per cent biobased content.

5.5. Wood Building Components

Wood building components, including but not limited to structural framing, sheathing, flooring, subflooring, wood window sash and frames, doors and architectural millwork in residential buildings and houses, used to comply with this requirement shall contain not less than 60 per cent certified wood content tracked through a chain of custody process, either by physical separation or percentage-based approaches, or wood that qualifies as a salvaged material. Certified wood content documentation shall be provided by sources or vendors certified through a certification system or the local Forest Department (AHJ), with principles, criteria and standards developed using ISO/IEC Guide 59 or the WTO Technical Barriers to Trade.

5.6. Building Materials Sustainability

Material sustainability governs all matters related to resource efficiency and construction material selection, and requires their use with the least impact on the environment. The construction of green buildings must be undertaken by using high quality materials to ensure the wellbeing of building occupants.

5.6.1. Recycled materials

Recycled materials shall be utilized in green housing projects to promote circular economy and divert material from landfills. The recycled material needs to be a specified percentage of the total material, preferably by cost. Following recycled content, satisfying the relevant specifications, can be used in green buildings:

- Steel (reinforcing, structural)
- Cement
- Aggregate
- Composite wood
- Masonry blocks or bricks

5.6.2. Non-toxic materials

- Non-toxic building materials shall be used in green buildings. These refer to building materials without hazardous or toxic chemicals that could cause Sick Building Syndrome (SBS) and eventually lead to Building Related Illness (BRI).
- All other materials containing chemicals used in construction should not compromise and be deleterious to the health and safety of the workers and occupants of the building.
- Use of paint and coats should be in accordance with section 4.3 of this code.
- Use of wood during the construction of the building should also be in alignment with section 4.3 of this code.

5.6.3. Hazardous materials

- The use of hazardous materials must be prohibited to promote the wellbeing of occupants of green buildings. The use of asbestos, formaldehyde, lead-based coatings, mercury and Polychlorinated Biphenyls (PCB) in the construction of green buildings
- The manufacturer's data sheets and invoices confirming that the products used in their building materials do not contain the prohibited hazardous substances must be obtained.

Chapter 6: Waste Management and Recyclability

6.1. Introduction

This section includes provisions related to construction and building waste management and recyclability during different phases of construction and operation.

6.2. Scope

In general, "waste" is defined as "any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, or that is intended or required to be discarded or disposed of, by the holder of that substance". Waste is of many types and may include domestic waste, industrial waste, agriculture waste, food waste etc. Waste is commonly solid or liquid in nature.

Taking guidance from various in-practice byelaws across the globe (e.g., IgCC. European Union CDW Management Protocol), the byelaws for the effective management of construction waste in Pakistan have been framed. Furthermore, there are different definitions and names of construction waste based on the constituents and stages of construction. For example, there is inert waste, non-inert waste, mixed waste and demolition waste. The general term Construction Waste (CW) has been used in this document, except when there has been a need to differentiate the term.

The byelaws discussed below are divided into three sections, as per the three phases of a construction project, namely, Pre-construction phase, Construction phase, and Post-construction phase. Also, it is important to consider "waste management life cycle", which has been discussed in conjunction with the three phases of construction. The process starts with an accurate estimation of the generated waste, followed by its collection and transportation, then its treatment, and in the end its disposal.

6.3. Part 1: Pre-Construction Phase

6.3.1. Definition

This phase covers the activities involved during the pre-construction stage of a construction project. It mainly includes an accurate estimation of quantities, consideration of environmental aspects, a focus on design quality, use of digital technologies for better outputs. minimizing the chances of waste generation, and greener procurement practices.

6.3.2. Estimated quantities

- The bidder should submit the estimated quantities of waste that is likely to be generated during the course of the project, along with its composition.
- For new construction only, the total amount of construction waste generated prior to the issuance of the final certificate of occupancy on the project shall not exceed 20 lbs. per ft2 (100 kg per m2) of the floor area of the new building.

6.3.3. Environmental consideration

The bidder should provide specific calculations of the possible positive impacts of effectively managing the waste, along with the usual EIA Report.

6.3.4. Design quality

The quality of design should be such that it results in low constructability issues and thus generates less waste at the time of execution.

6.3.5. Digitalization

The drawings and other documentation should be converted into digital form, thus reducing paper waste.

6.3.6. Greener procurement

- Procurement of 3Ms (Manpower, Material, Machinery) should be in line with the green public procurement practices.
- Authorities at all levels can provide incentives for promoting the use of green public procurement.

6.3.7. Life cycle analysis

- The life cycle analysis (LCA) should be performed in accordance with ASTM E2921 and ISO Standard 14044, for a minimum of two building alternatives, both of which shall conform to the owner's project requirements (OPR).
- The LCA performance metric: The LCA shall demonstrate that the final building design achieves one of the following minimum improvements over the reference building design assessed in the LCA:
  a. Ten per cent improvement in a minimum of each of two impact categories, one of which must be global warming.
  b. Five per cent improvement in a minimum of each of three impact categories, one of which must be global warming.

Procedure

The LCA shall be performed in accordance with the service lives, life cycle stages, study boundaries, and comparison methodologies of ASTM E2921 with the following modifications:

a. Each building alternative shall comply with this Code.
b. Operating energy consumption shall be included or excluded at the discretion of the project team.
c. The LCA tool (or tools) or software shall include a published third-party impact indicator method.
d. The estimate of structural system material quantities shall be verified by a registered design professional or other approved source.

6.3.8. Clearing and grubbing-up

The sites of all excavations shall be cleared of all shrubs, plants, bushes, large roots and other surface materials. All such materials shall be removed and disposed of in a manner considered satisfactory by the Site Engineer. All trees and shrubbery that are designated by the Site Engineer to remain shall be adequately protected and preserved in an approved manner.

All surplus material excavated by the Contractor shall be disposed of at locations approved by the Site Engineer. The method of disposal shall not interfere with other works, nor shall it damage or spoil other materials. When it is necessary to haul earth material over streets or pavements, the Contractor shall prevent such material from falling on them.

6.3.9. Reporting

A report that includes a description of the building alternatives and their physical differences shall be prepared, and must comply with the reporting requirements stated in ASTM E2921. The name and address of the registered design professional or other approved source verifying structural system material quantities shall be included. A critical review shall be performed by an external expert independent of those performing the LCA.

The report shall be submitted to the AHJ and will include documentation of critical peer review by a third party, results of the review, and the reviewer's name and contact information.

6.4. Part 2: Construction Phase

6.4.1. Definition

This phase covers the activities that happen during the main construction stage, that is, the execution of the construction project. It includes various aspects of different construction sequencing activities starting with the Waste Management Plan, involvement of third-party supervision, improving source separation, on-site operations, stockpiling potential and proper stocks, setting up of material recovery facilities (mrf), improving logistics; packaging waste, waste treatment, hazardous waste removal (decontamination), and the essential documentation.

6.4.2. Waste management plan

- Bidder should submit a comprehensive Waste Management Plan along with the bid documents.
- The plan should contain information about how the different steps in the management of waste will be performed, by whom will they be performed, which materials will be collected selectively at source, where and how will they be transported, what will be the recycling, re-use or final treatment and how will the follow up happen.
- The Waste Management Plan will also cover how to address safety and security issues, as well as how to limit environmental impacts, including leaching and dust.
- The Plan should also state how both the non-hazardous and hazardous wastes will be managed.

6.4.3. Third party supervision

The whole process of managing waste shall be supervised by a local authority or by an independent third party, for example, by an external waste management organization.

6.4.4. Improve source separation

- A key aspect of effective waste management is to keep materials separated. The mixed waste should be separated for more effective recycling and improving the quality of recycled products.
- Identify the construction and demolition waste materials expected to be diverted.
- Identify materials or building elements to be deconstructed.

6.4.5. On-site operations

- Consider on-site operations as they can offer cost advantages and reduce transport needs. However, decisions on such on-site preparation for re-use and recycling need to be taken on a case-by-case basis depending on the site characteristics, such as, size of the site and proximity to green areas, residential areas and businesses.
- Install waste bins on the site at different accessible points, with a clear pathway for the waste trucks, without disturbing the site movements.
- These bins should be properly covered and preferably be moveable so that they can be displaced in case of rain to avoid waste getting wet.

6.4.6. Stockpiling potential and proper stocking

Reuse, recycling and recovery of construction waste materials require proper stocking. Take precautionary measures to minimize harmful emissions and risks of direct or indirect exposure.

6.4.7. Material recovery facilities

- Instances where not much space is available on-site, it is better to transport waste material to a nearby material recovery facility (MRF) for maximum material recovery.

- Preferably, in the residential neighborhood a minimum area for the MRF @ one square metre waste storage space per 2,500 square metres total gross floor area plus 50 per cent circulation space should be provided.

6.4.8. Improve logistics

Try to keep distances short, as proximity of sorting and recycling plants is important for construction waste because bulky materials such as aggregates for construction (asphalt, concrete, etc.) cannot be transported by road over l distances longer than 35 km.

6.4.9. Packaging waste

Packaging materials brought to construction sites should be minimized as much as possible through optimization of the supply chain, for example, through bulk deliveries and the suppliers' take-back agreements.

6.4.10. Documentation

Documentation in a construction project is essential. Throughout the waste management life cycle, monitoring is crucial. All contractors involved in the construction project need to have the necessary documentation, and the real activities need to be recorded in the relevant correspondence and files, both manual and digital. This contributes to transparency and trust in the construction waste management process.

6.4.11. Waste Treatment

- A distinction needs to be made between the types of waste materials for their treatment options. A wide range of waste processing and treatment options exist, and these are commonly known as preparation for reuse, construction material and energy recovery – in that order of priority.
- The actual choice of the waste management option differs from case to case, depending on regulatory requirements, as well as economic, environmental, technical, public health and other considerations.
- Waste hierarchy should be followed to maximize benefits in terms of resource efficiency, sustainability and cost savings.
- If possible, waste materials and products should be sorted depending on their economic value.
- Materials should be processed or treated based on the environmental criteria and regulations in vogue.
- Reuse of construction waste material should be promoted, as it involves use with little or no processing.
- Sound planning of construction activities and related waste management activities on construction sites needs to be a prerequisite for high recycling rates and quality recycled products.
- Materials can either be recycled on-site into new construction resources or off-site at a recycling plant.
- There should be specific areas that serve the entire building and are dedicated to the collection and storage of non-hazardous materials for recycling, including paper, corrugated cardboard, glass, plastics and metals
- Wood building components, including but not limited to structural framing, sheathing, flooring, subflooring, wood window sashes and frames, doors and architectural millwork used shall contain not less than 60 per cent certified wood content tracked through a chain of custody process, either by physical separation or percentage-based approaches, or wood that qualifies as a salvaged material.

- Backfilling[1] is one way to reuse non-hazardous construction waste. However, backfilling should be used as a last resort option as it has drawbacks: it can undermine the incentives to reuse and recycle in higher value applications.
- For large building projects, including residential units, both low and high rise, there shall be an area designed to serve the entire building for the collection and storage of discarded but clean items in good condition. Charitable organizations or others to arrange for periodic pickups should be identified and posted.
- For energy recovery, all possibilities for recovery should be considered using available technologies for substitute fuel, the so-called Refuse Derived Fuels.
- The focus should be on practices resulting in maximum waste recovery and maximum waste diversion from landfills.
- Preferably, a minimum of 50 per cent of non-hazardous construction, demolition or deconstruction waste material shall be diverted from disposal in landfills through reuse, recycling, repurposing and/or composting.
- All diversion calculations shall be based on weight throughout the construction process.

6.4.12. Hazardous waste removal/Decontamination

- Proper decontamination needs to be done for a number of reasons – to protect the environment, to ensure the health of workers at site and of people living in the surroundings of the site, and for general safety reasons.
- Hazardous waste should not be mixed with non-hazardous waste.

6.5. Part 3: Post-Construction Phase

6.5.1. Definition

This phase covers the activities involved during the post-construction stage of the construction project. It mainly includes post-construction site cleaning, scrap valuation, pre-demolition audit, selective demolition and deconstruction, and hazardous waste consideration in demolition.

6.5.2. Post-construction site cleaning

Proper site cleaning should be planned and a waste management action plan prepared based on the nature of the waste material collected and stored after site cleaning.

6.5.3. Scrap valuation

- Identify the condition of scrap material collected during the site cleaning activity, and assess the financial value that can be derived from it.
- The content value of salvaged material should be determined based on the actual cost of the salvaged material or the cost of a comparable alternative component material.

6.5.4. Pre-demolition audit

- In case of building demolition, a detailed pre-demolition audit should be carried out for any materials to be reused or recycled as well as for hazardous wastes. This should be done by a qualified expert with appropriate knowledge of building materials, building techniques and building history.

1 "Backfilling is the process of reusing or replacing the soil that is removed during the excavation of foundations, ground bearing slabs or other groundworks **to support and strengthen a structure**. It protects foundations and forms part of the substructure of slabs, roadways, walkways and other groundwork elements". https://www.designingbuildings.co.uk/wiki/Backfilling

- The qualified expert also needs to be familiar with demolition techniques, waste treatment and processing as well as with (local) markets.

6.5.5. Selective demolition and deconstruction

- Advanced techniques, such as selective demolition or deconstruction techniques, should be used instead of the conventional demolition process, in order to recapture the maximum value out of the target building.
- Main waste streams from buildings or civil infrastructure should be treated separately (e.g., concrete, bricks, masonry, tiles and ceramics). For the use of recycled materials in high grade applications, a more selective demolition can be required (such as separate collection/dismantling of the concrete and masonry).

6.5.6. Hazardous waste consideration in demolition

Hazardous waste material needs to be removed carefully and systematically prior to its demolition, as it can be explosive, oxidizing, toxic, harmful, corrosive, irritating, carcinogenic or infectious.

6.6. Waste Management

Today, the majority of buildings, including housing, are built with concrete and bricks, with an approximate life of 100 years. During this period, a building can consume unimaginable quantities of resources and generate waste. The reduction of nonrenewable resources is an important aspect of green design. The following reduction practices should be encouraged.

- Utilization of environmentally preferable building materials, such as nonvirgin, renewable and recyclable materials as they aid in the reduction of nonrenewable resources.
- Construction of waste recycling programmes.
- On-site recycling and/or donation of scrap materials to local charitable organizations to reduce construction waste.
- Use of low-flow water fixtures as they limit the amount of water used, including at the household level.

The reuse of building materials and waste resulting from construction works must be clearly set out for utilization as recycled building materials. It is necessary to develop site-wise waste management plan(s) regarding the following activities, in advance.

- Recycling goal for the project
- Record all types of waste streams and the waste recycled
- If more than one site, prepare site-wise waste logistics plans
- Types of equipment and manpower that need to be deployed.

6.7. Material Recovery Facility

At green housing project sites, a material recovery facility should be provided for the collection and segregation of solid waste materials. In a residential neighbourhood, a minimum area for MRF @ one square metre waste storage space per 2,500 square metres total gross floor area, plus 50 per cent circulation space should be provided.

The material recovery facility must be fully enclosed and easily accessible from within the building for easy collection of waste, and from the outside for easy sorting and disposal of waste. The solid waste containers should be provided for at least four types of waste:

1. Compostable (biodegradable)
2. Nonrecyclable (to be disposed of in a landfill)
3. Recyclable (paper, cardboard, plastic, metal, wood, etc.)
4. Special waste (e.g., for incineration)

6.8. Utilize Recycled Material for Minimizing Building Cost

Building construction activities consume substantial water, wood, other materials and energy flow. The waste material (bricks, concrete, steel, etc.), if readily available, should be reused in green buildings or recycled, thereby prolonging the supply of natural resources and minimizing construction cost.

6.9. Post-Occupation Waste Management

- Consider the appropriate waste management systems for the scale and nature of green housing developments; for instance, combined bulk receptacles for larger developments with on-site bin management. Consult early with the local governments or waste contractors to determine the right waste collection strategy for a green housing development.
- Design vehicle access and circulation areas for the site to suit the required handling of bins, including the design of pedestrian access and circulation to allow bins to be easily maneuvered between storage and collection points. Consider providing temporary storage for large bulk items such as mattresses, taking into account management of these areas and the control of vermin, odour and dust.
- In larger apartment buildings, incorporating waste chutes increases the convenience of waste management for occupants. Communal recycling rooms/cupboards can also be located throughout the development, coupled with an appropriate management regime to ensure regular removal of recyclables and management of the facility.

6.10. Liquid Waste Management

On-site water recycling

- Water recycling is considered to reduce the urban dwellers' water consumption and relieve the pressure on existing water supply systems. However, water recycling is only one element of the total water cycle in urban settlements and its integrated water resource management.
- Recycling wastewater from residential areas assists in achieving the water reduction objective as well as to reducing sewer overflows, if properly targeted. Recycling the rain and storm water, on the other hand, achieves the water reduction objective as well as potentially relieving the drainage infrastructure, especially in storm events.
- However, it is necessary to ensure that recycled water being supplied to the urban residents is safe, environmentally sustainable and cost-effective. This can best be achieved by matching the quality of recycled water to its intended uses, both safely and cost-effectively.

6.11. Conclusion

The aim of wastewater treatment is to reduce the level of pollutants in the wastewater before its reuse or disposal into the environment, and to meet the standard of treatment required at a location to be use-specific. The choice between centralized (sewer) or decentralized (on-site/neighborhood-level) wastewater management systems depends upon a number of factors, but it is important that full consideration be given to the both options rather than continuing with what has existed in the past, where sewerage was considered to be the only 'proper' form of urban sanitation.

In the case of construction and demolition waste, all generators of the waste must segregate it into four categories – concrete and soil; steel and wood; plastics; bricks and mortar – and then either deposit it at collection centres set-up by the local authority or hand it over to processors/recyclers. Large generators of construction and demolition waste should prepare their respective Environment Management Plan along with a Waste Management Plan, detailing the environmental issues that can stem from the storage, transportation, disposal and reuse of such wastes. They should get local authority approval before starting any construction/demolition/renovation work. They should also pay the relevant charges to service providers and contractors for collection, transport and disposal of construction and demolition waste.

In addition, to promote the reuse of construction and demolition waste, the National Building Departments should be advised to incorporate a clause in their tenders mandating that a certain percentage of recycled products from construction and demolition waste should be used in roads and non-structural works. Also, the making of waste recycling plants should be encouraged on public-private partnership basis.

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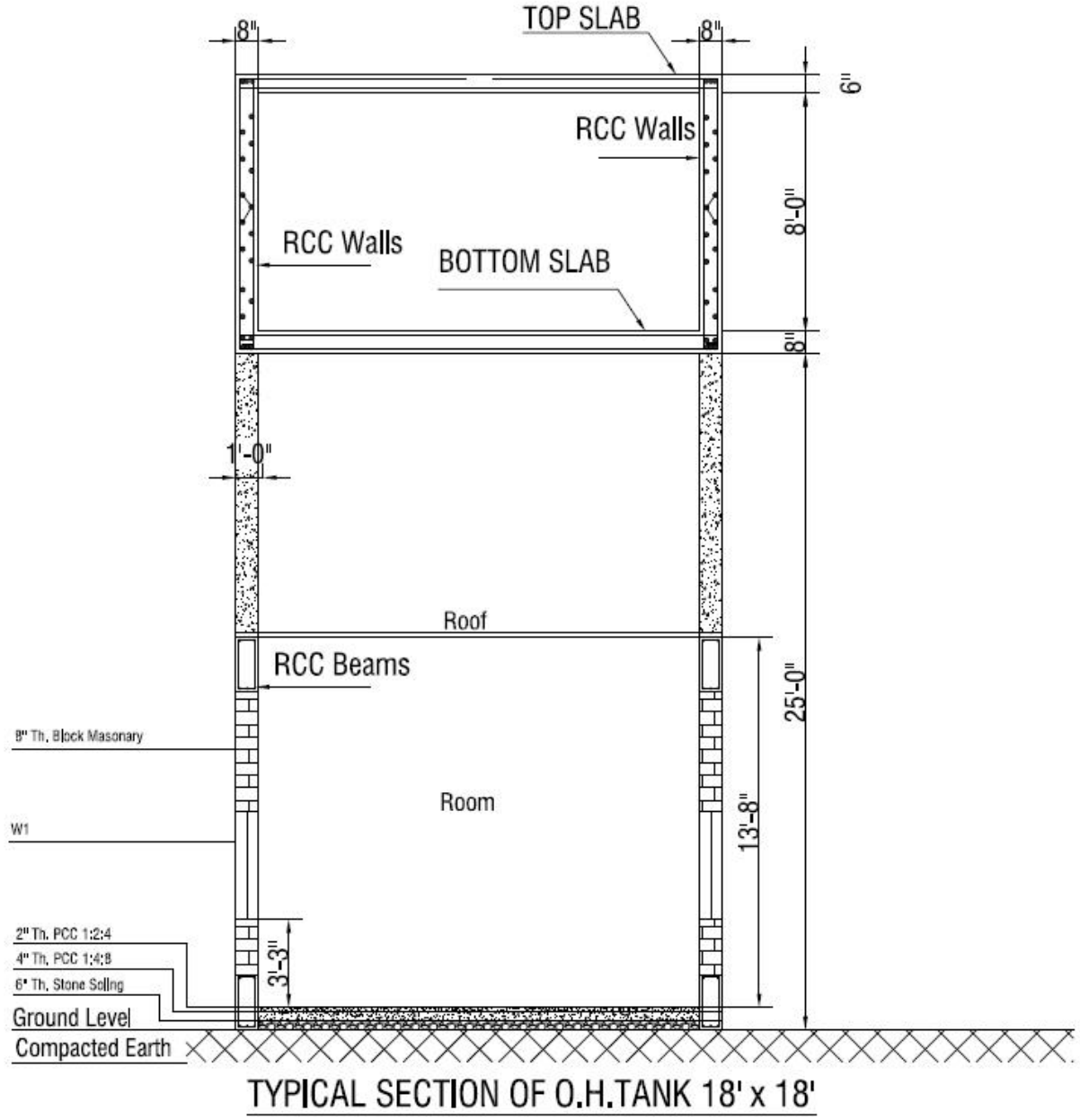
Appendix A



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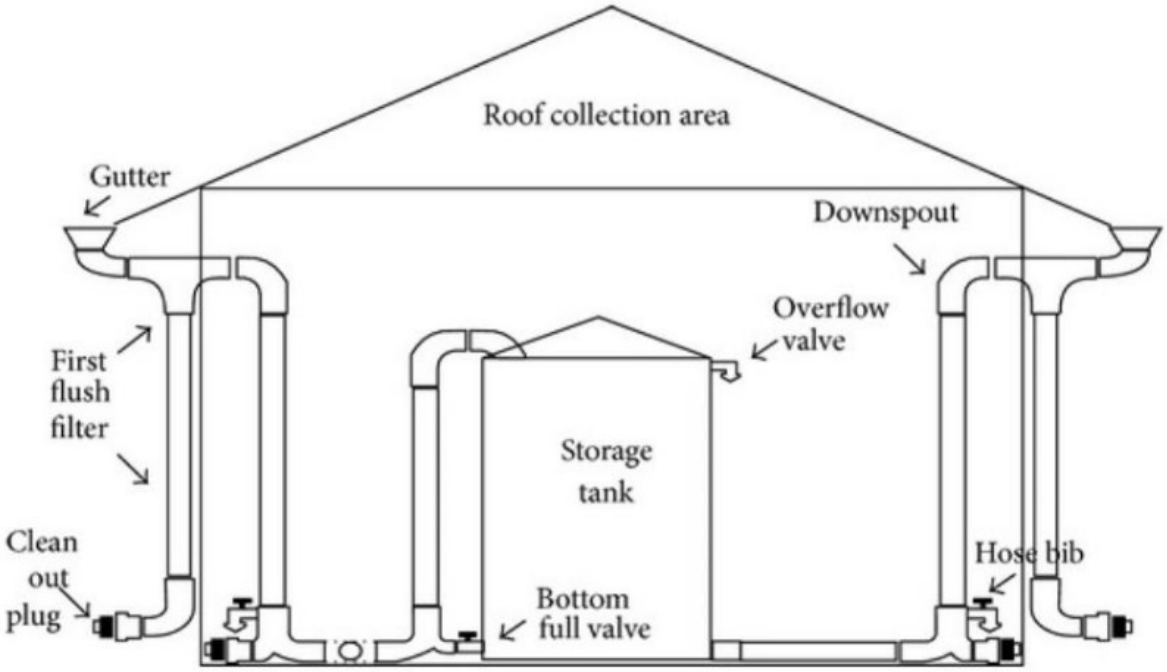

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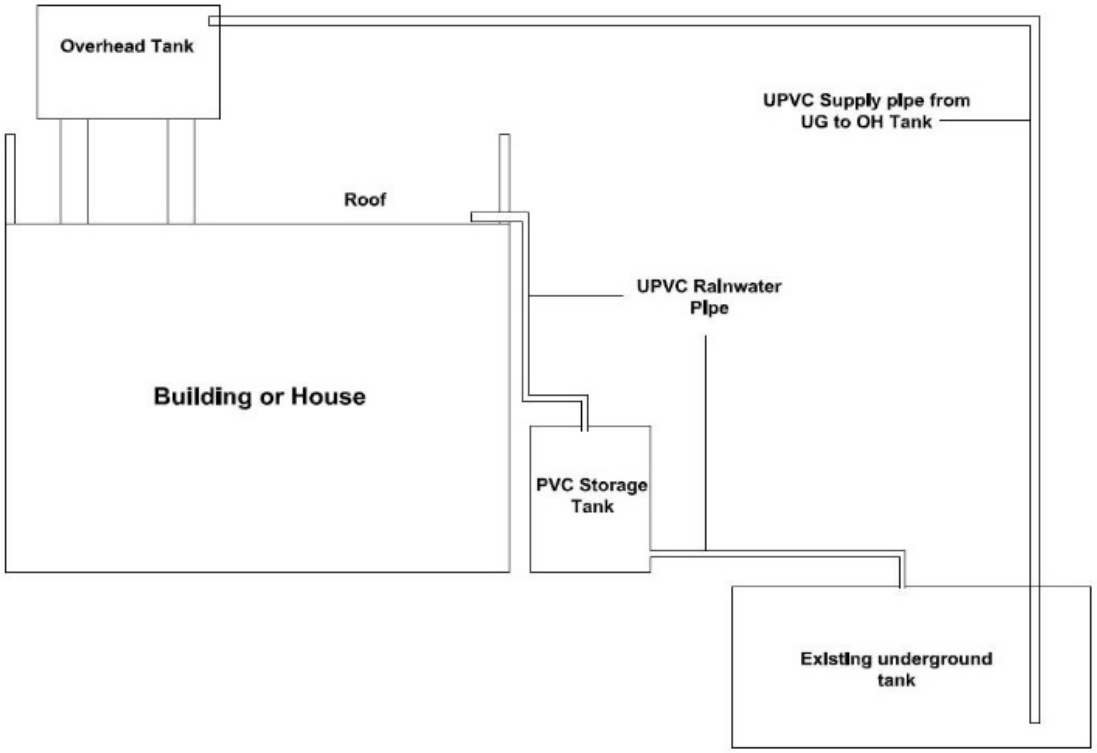

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