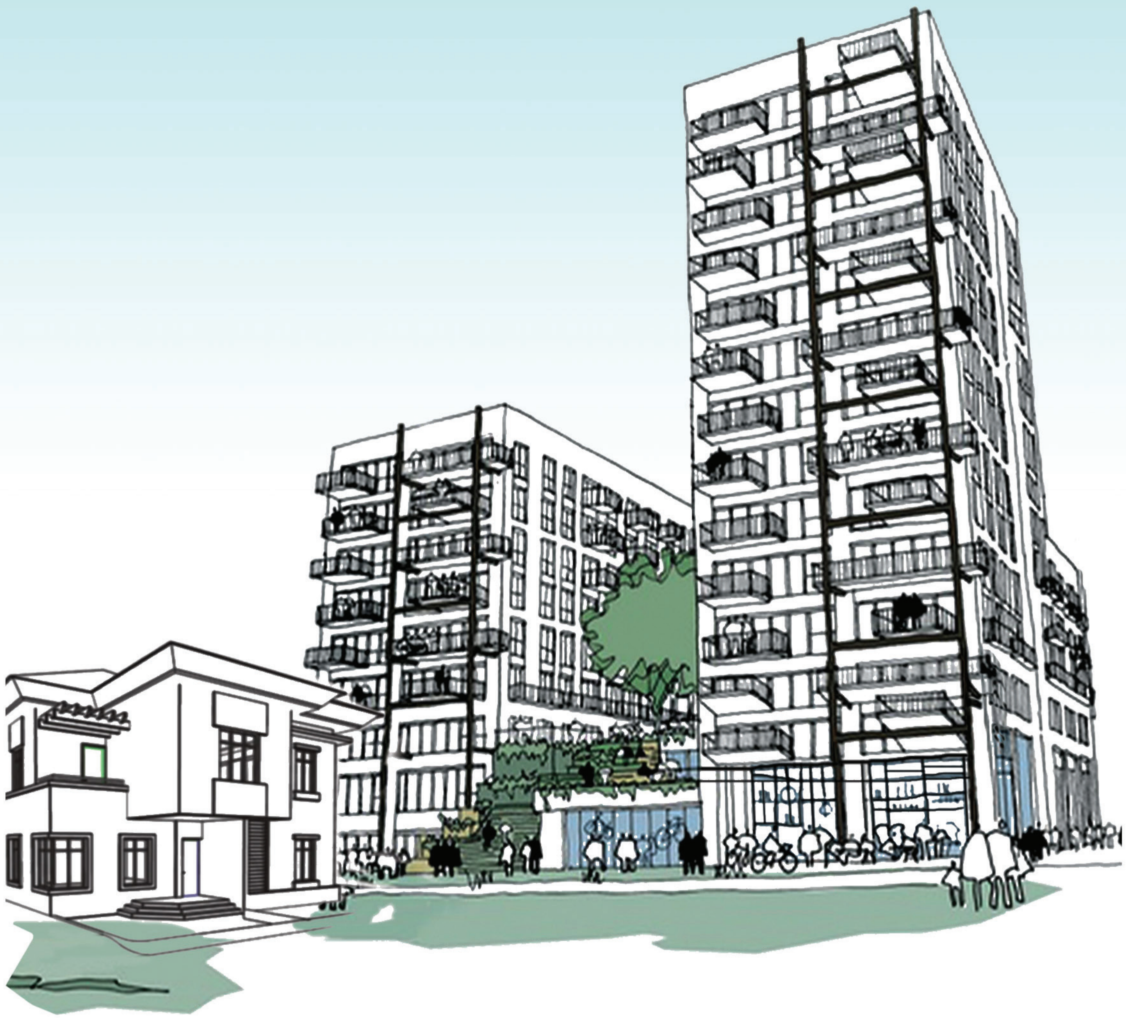
TOWARDS ECO-NIWAS SAMHITA IMPLEMENTATION IN GUJARAT: BUILDING ENVELOPE SOLUTION SETS

FOR EXTERNAL WALLS, ROOF, WINDOW SHADING, AND GLAZING



BEEP
BUILDING ENERGY EFFICIENCY PROJECT

Towards Eco-Niwas Samhita Implementation in Gujarat: Building Envelope Solution Sets

FOR EXTERNAL WALLS, ROOF, AND WINDOW SHADING

GUJARAT

BUREAU OF ENERGY EFFICIENCY (BEE)
(Ministry of Power, Government of India)
Website: www.beeindia.gov.in

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Published by

Bureau of Energy Efficiency

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

1st Printed: 2022

Printed in India by Innovative Designers and Printers Pvt. Ltd, Noida.

Bureau of Energy Efficiency (BEE)

Abhay Bakre

Saurabh Diddi

Swiss Agency for Development and Cooperation (SDC), India

Jonathan Demenge

Anand Shukla

Indo-Swiss Building Energy Efficiency Project (BEEP) Project Management and Technical Unit (PMTU)

Greentech Knowledge Solutions Pvt. Ltd

Sameer Maithel

Saswati Chetia

Vasudha Sunger

ICON Architects and Urban Planners

Jaydatt Vaishnav

Vijal Desai Patel

Ayushi Desai

Effin'art Sarl

Pierre Jaboyedoff

BUREAU OF ENERGY EFFICIENCY (BEE)
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SAURABH DIDDI

Director, Bureau of Energy Efficiency

The Bureau of Energy Efficiency (BEE) has a multi-pronged approach to achieve thermally comfortable and energy efficient buildings in the country. The approach consists of framing regulations in the form of Energy Conservation Building Codes, market transformation through Appliances and Building Labelling Programme, and awareness creation and capacity building.

As far as regulations are concerned, BEE has developed Energy Conservation Building Code (ECBC) for commercial buildings. The recent version of ECBC was issued in 2021. Given the anticipated rapid growth in residential building stock across India and the consequent opportunities as well as the necessity for energy conservation in this sector, BEE had launched the Energy Conservation Building Code for Residential buildings in 2018 called 'Eco-Niwas Samhita (ENS)'.

The code defines provisions for building envelope to reduce heat gain/loss and improve natural ventilation and daylighting potential. To facilitate the implementation of the ENS and provide assistance to concerned stakeholders, a reference booklet titled, 'Building Envelope Solution Sets (v 1.0) for Eco-Niwas Samhita 2018' was developed. This booklet provides ready solutions on the basis of real-life practices to meet building envelope provisions of ENS. Further, to accelerate the work in Gujarat, a state-specific building envelope solution sets have been developed as 'Towards Eco-Niwas Samhita Implementation in Gujarat: Building Envelope Solution Sets'. This was prepared based on a market survey for the state to include local material and construction practice. In other words, the focus of state-specific solution sets is on making the building envelope design energy efficient and thermally comfortable by meeting the ENS provisions for Residential Envelope Transmittance Value (RETV) and roof compliance.

This publication has been developed in close consultation with the local building sector agencies and professionals. I hope this publication will play an important role towards ENS implementation in Gujarat and inspire other states to work in the same direction.

New Delhi
1st September 2022

Saurabh Diddi
Director, Bureau of Energy Efficiency

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

ANAND SHUKLA

Senior Advisor

Swiss Agency for Development and Cooperation

The Indo-Swiss Building Energy Efficiency Project (BEEP) has been a landmark bilateral cooperation project between the governments of Switzerland and India since 2011. Together with Swiss and Indian partners, the Swiss Agency for Development and Cooperation (SDC) has supported BEEP to build on Switzerland's four decades of experience to co-develop knowledge and expertise on energy efficient building design, technologies, and policies in India.

The development of the Eco-Niwas Samhita (ENS) 2018 (Part 1 – Building Envelope) was an important milestone in that direction. To help meet the code requirements, a ready reckoner set of national building envelope solution sets was developed and launched in December 2021 considering the real-life practice and projects implemented in the past. To facilitate the implementation of ENS 2018 in the state of Gujarat and to cater to region-specific requirements, state-specific building envelope solution sets have been developed titled, 'Towards Eco-Niwas Samhita Implementation in Gujarat: Building Envelope Solution Sets'.

The Gujarat Building Envelope Solution Sets (2022) have been prepared after delving into practical and directly implementable solutions drawn through a market survey conducted in the state. The primary objective of this publication is to help building designers in the adoption of ENS 2018 at the state level.

This publication serves as a supplementing document that will help achieve the Residential Envelope Transmittance Value (RETV) and roof provisions for building envelope as per ENS 2018 in the state of Gujarat. It is prepared in such a manner that it will help users to make an informed choice on how best to meet building envelope-related code provisions in Gujarat.

The success of any development cooperation project lies in its effective implementation on the ground. Building practitioners hold the key to the successful implementation and adoption of a code, as they also understand the local climatic conditions and preferences. BEEP has been successfully supporting the Bureau of Energy Efficiency (BEE) in the implementation of ENS in other states such as Rajasthan and Andhra Pradesh. We hope the practitioners in Gujarat will find this document useful to the cause that we are all wedded to, i.e., to reduce energy consumption in the residential building sector in India and achieve thermal comfort.

New Delhi

1st September 2022

Anand Shukla

Senior Advisor

Swiss Agency for Development and Cooperation

CONTEXT

In India, residential buildings consumed about 255 TWh electricity in 2017 and it is expected to increase by more than 3 times to about 850 TWh by 2030. Increased adoption of air-conditioning in residential buildings is one of the key reasons for this growth. Residential buildings will become the largest end-user of electricity in the country accounting for 38% of the total electricity consumption by 2030.[1] The major drivers for the growing residential sector are the increasing new constructions and the rising demand in housing sector, especially in the affordable housing segment.

The Ministry of Power, Government of India, has launched Eco-Niwas Samhita (ENS) 2018 or Energy Conservation Building Code for Residential Buildings (ECBC-R), Part I: Building Envelope on 14 December 2018. The code defines provisions for building envelope to reduce heat gain/loss and improve natural ventilation and daylighting potential. A national building envelope solution set document was developed as a ready reckoner set of solutions to facilitate the implementation of the code as per CPWD's building schedule of rates 2019. To cater to region-specific requirements for implementation of ENS 2018, this document is prepared that contains solution sets specific to the state of Gujarat to help meet the code requirements on reducing heat gains from building envelope. It contains details of external wall construction, roof construction, and window shading to help meet the Residential Envelope Transmittance Value (RETV) and the roof U-value requirements of the code.

Most of Gujarat falls under Hot & Dry climate zone. It lies in the transition zone between the arid region of Rajasthan in the north and the wet Konkan coastal region of Maharashtra in the south. Thus the climatic conditions vary across different regions of Gujarat. The climate in the northern regions like Ahmedabad and Vadodara is similar to that of Rajasthan – hot and arid – due to the high potential of evapotranspiration. At the same time, the climate in the southern parts such as Surat is closer to the Konkan sub-humid climate with heavy rain falls. Climatic conditions form the basis for construction practices and hence are important factors determining the type of construction in the region.

Population Census Data 2011 show that Gujarat has a total population of 6.03 crore. Gujarat is the fastest growing and most urbanized state in India with 42.60% urban population as compared to 31.14% urban population of India. During the decade 2001–2011, Gujarat has seen a growth rate of 36% in urbanization as compared to 31% in India. By 2030, Gujarat is projected to have 66% urbanization. However, the high rate of development and urbanization has not come without the associated problems of increase of burden on the limited urban land, housing, and infrastructure of the state. Gujarat has about 6.5 lakh slum houses in the urban areas. As per the report of Technical Group-12, about 0.99 million houses are required in Gujarat. The report also mentions that 95% of such differences are in the economically weaker section (EWS) and lower income group (LIG).

The affordable housing segment is seeing a boom in construction due to the impetus from the Pradhan Mantri Awaas Yojana (PMAY). This has also led to the introduction of innovative and faster construction technology, where the key focus areas are time-cost economy, adaptability, sustainability, and quality assurance. In this process, alternative construction materials such as expanded polystyrene (EPS)panels, autoclaved aerated concrete (AAC) blocks and fly ash blocks have become potential construction materials. Some of the construction techniques like waffle-crete building system and monolithic concrete constructions are being tried by Ahmedabad Municipal Corporation (AMC), Ahmedabad Urban Development Authority (AUDA), and small towns in north Gujarat.

[1] *https://www.niti.gov.in/sites/default/files/energy/Energy-Efficiency-and-Energy-Mis-in-the-India-Energy-System-by-2030.pdf*

HOW THIS DOCUMENT CAN HELP IN MEETING ENS PROVISIONS?

The Eco-Niwas Samhita ENS 2018 or Energy Conservation Building Code for residential buildings (ECBC-R), Part I: Building Envelope defines the provisions for the following:

1. for natural ventilation potential;[2]
2. for daylight potential;[3]
3. to limit heat gain/loss from the roof;
4. to limit heat gain from the building envelope (excluding roof) in four climatic zones (composite, hot-dry, warm-humid, and temperate); and
5. to limit heat loss from the building envelope (excluding roof) in cold climatic zone.[4]

Out of these provisions, the building envelope solutions sets for ENS 2018 (v 1.0) help in meeting two provisions of the code:

1. Maximum permissible value of thermal transmittance of roof (U_{roof}) for all climate zones to limit heat gain/loss from the roof, a maximum value of thermal transmittance of roof (U_{roof}) for all climate zones is defined as 1.2 W/m^2.K.

   This document gives roof construction solutions to help meet the requirement of U_{roof} given in the code document.

2. Maximum permissible value of residential envelope transmittance value (RETV) for building envelope (except roof) for four climatic zones (composite, hot-dry, warm-humid, and temperate).

   To limit heat gain from the building envelope (excluding roof) in four climatic zones (composite, hot-dry, warm-humid, and temperate), a maximum value of RETV for building envelope (except roof) is defined as 15 W/m^2. RETV depends on multiple parameters, which includes orientation, wall construction (U-value of wall), glazing properties (U-value and solar heat gain coefficient [SHGC]), window-to-wall ratio (WWR), and shading of windows.

   This document gives the solution for wall construction, window shading, and glazing options. A combination of these solutions will most likely help the user to make an informed choice on how best to meet the RETV requirement as per ENS Part 1 for a particular building.

USING THE DOCUMENT

The solutions given in this document are classified into three main categories: Roof Construction, Wall Construction, and Window Shading and Glazing. Each solution contains some standard information, such as general description, detailed drawings, steps of construction, technical specifications, and cost analysis as per Gujarat Specific Market Survey Report 2020.

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[2] *A minimum value of openable window-to-floor area ratio (WFR_{op}) for each climate zone is defined. Hence, based on the climatic zone, minimum WFR_{op} can be taken from Table 1 of the code document. Multiplying this value with the carpet area gives the value of minimum openable area for code compliance. If a project has lesser openable area, then it must be increased to meet the minimum requirement. An example of WFR_{op} calculation is given in the code document.*

[3] *A minimum visible light transmittance (VLT) for different range of window-to-wall ratio (WWR) is defined. An example is given in the code document for the calculation of WWR. Based on the WWR, the minimum VLT value can be taken from Table 2 of the code document. Selection of glazing with a VLT value that meets this requirement ensures compliance to the code.*

[4] *A maximum value of thermal transmittance for building envelope (except roof) ($U_{envelope,cold}$) is defined as 1.8 W/m^2.K. $U_{envelope,cold}$ depends on the U-value of wall, the U-value of window, and WWR. Wall construction and glazing selection with low U-value helps in meeting this requirement. An example is given in the code document for the calculation of $U_{envelope, cold}$.*

EXTERIOR WALL SOLUTIONS

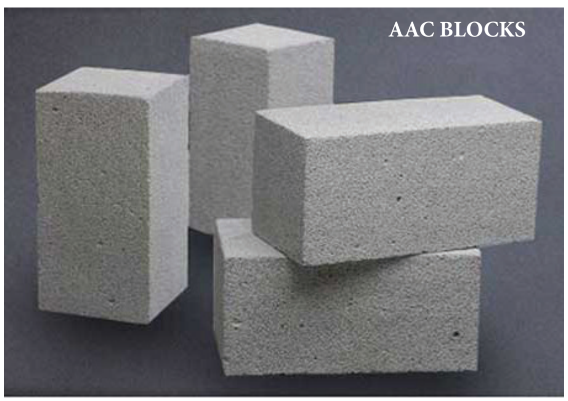
BRIEF DESCRIPTION

An autoclaved aerated concrete (AAC) block is a lightweight, load-bearing, high insulating block that comes in various thickness – 100 mm, 150 mm, and 200 mm.

For the construction of external walls, 200-mm-thick AAC blocks are recommended. For carrying out masonry work, a non-shrink grout should be added to the mortar. This should be used between the blocks as well as at all junctions of mortar and RCC work.

The internal and external surfaces of the 200-mm-thick AAC wall should be provided with a galvanized iron (GI) chicken wire mesh over the entire AAC block masonry, including the overlaps at concrete-masonary junctions. This would help in avoiding shrinkage cracks in the future.

The exposed area of the reinforced cement concrete (RCC) structure to the outside, which can be as much as 15%–20% of the envelope wall area, remains a thermal bridge between the inside and the outside. To further reduce the external exposed RCC surface, one could cast the beams with a small 150-mm projection as shown in Figure C. Now the wall starts from this projection. This protects the outer surfaces of the RCC structure from conductive heat gain.

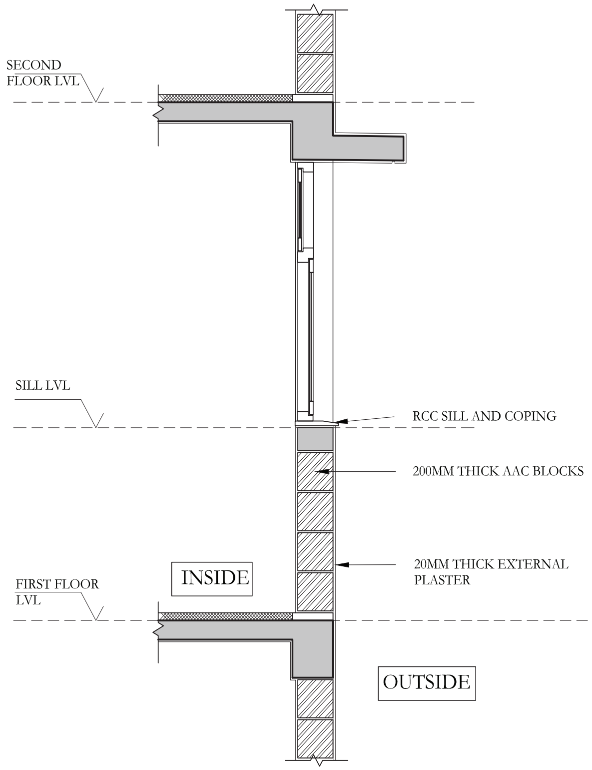


0.77 W/m²K
U-value

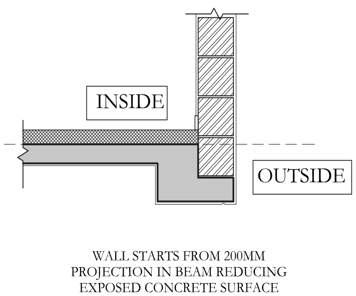
2557 INR#
Cost/m³

Item Description for BOQ

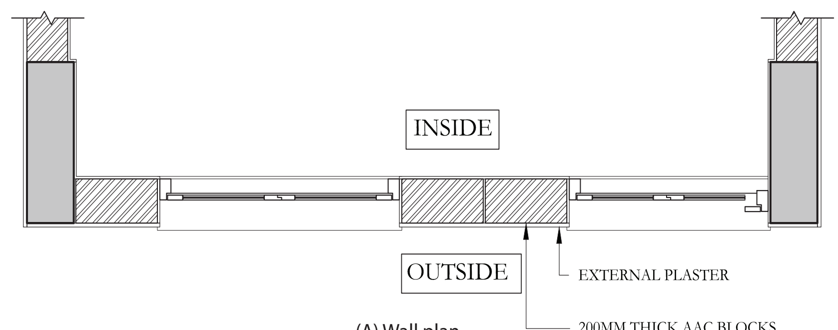
Providing and constructing AAC block masonry conforming to IS 2185 Part 3 with approved quality factory made Grade 1 AAC blocks of dry density of 551–650 kg/m³, compressive strength of 4N/mm², water absorbtion is less than 15%, thermal conductivity less than 0.24 W/m.K and as approved by Engineer-In-Charge (EIC) and approved method statement.



(B) Wall Section



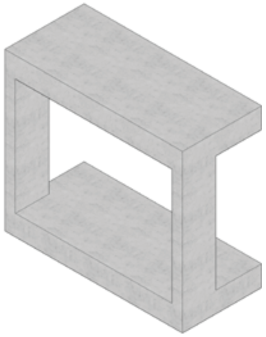
(C) Beam Construction Option



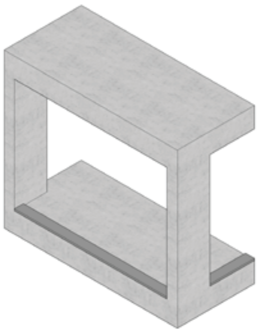
(A) Wall plan

#The cost includes cost of blocks, mortar, plaster, paint and labour. The calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

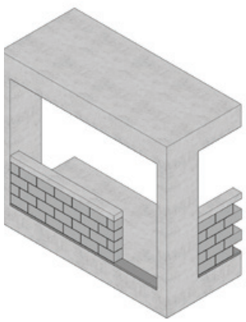
CONSTRUCTION PROCESS



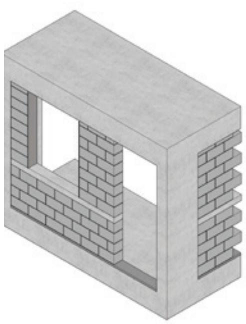
1 Site condition as per actual.



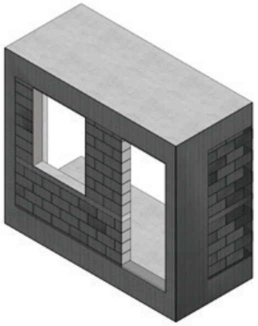
2 Lay the levelling course of 40 mm to begin the masonry work from a flat surface.



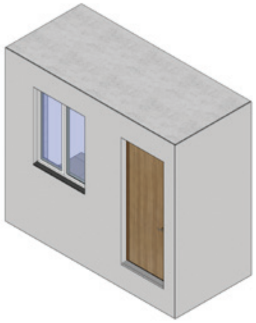
3 Lay AAC blocks of size 200 x 200 x 400 mm up to the sill level. Fill the RCC sill and coping.



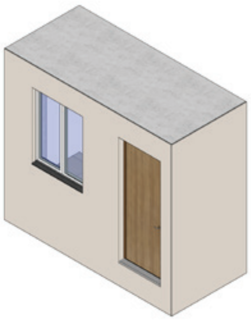
4 Raise the wall and provide openings for doors and windows.



5 Fix GI chicken wire mesh over the entire surface of blocks and structure overlaps, especially at the junctions between the concrete and the blockwork.



6 Plaster the walls and fix the doors and windows.



7 Apply paint.

Precautionary measures for AAC block Construction

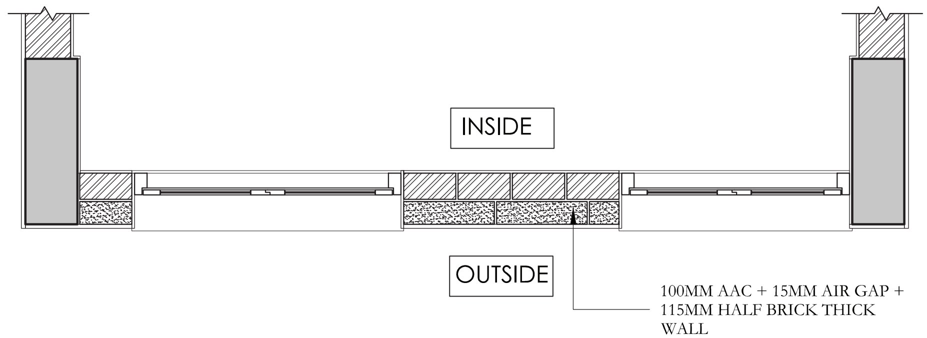
- Water should not be allowed to accumulate anywhere on the wall. Proper drainage of water is required. When used in wet areas fool-proof waterproofing is required.
- Proper wall termination with roof and concrete elements with mortar.
- Nailing and hammering to hang heavy objects should be avoided.

SOLUTION 2: 115-MM-THICK BRICK WALL +100-MM-THICK AAC BLOCK

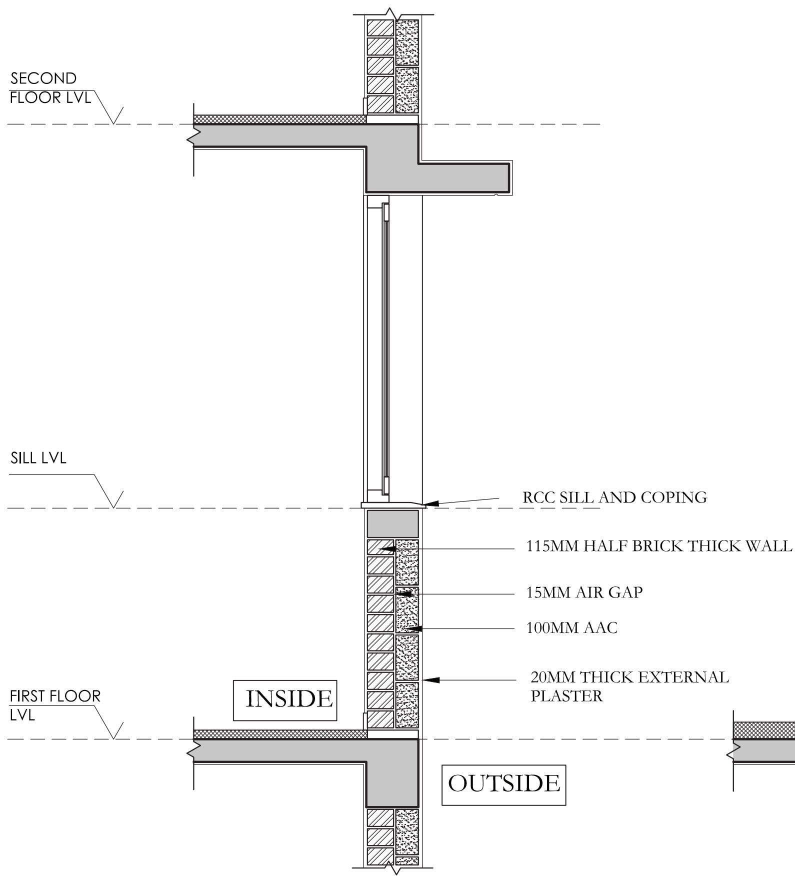
BRIEF DESCRIPTION

This wall assembly comprises a 100-mm-thick AAC blockwork as the outer wall and 115-mm-thick brick wall as the inner wall. The outer face of the brick wall should be painted with a bitumastic paint layer to act as a vapour barrier in warm-humid climates. The total wall assembly will be 230-mm thick. The assembly can be raised a few courses at a time; the AAC wall being raised after painting the outer surface of the brick wall with bitumastic paint. This paint also acts as an adhesive that binds the AAC blockwork to the inner wall.

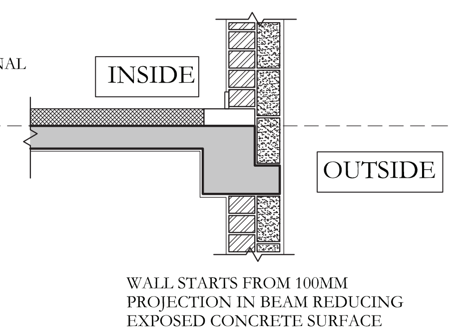
The exposed area of RCC structure to the outside, which can be as much as 15%–20% of the envelope wall area, remains a thermal bridge between the inside and the outside. To further reduce the external exposed RCC surface, one could cast the beams with a small 150-mm projection as shown in Figure C. Now the wall starts from this projection. This protects the outer surfaces of the RCC structure from conductive heat gain.



(A) Wall Plan



(B) Wall Section



(C) Beam Construction Option

Item Description for BOQ

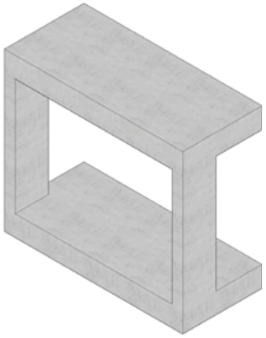
Providing and laying 100-mm-thick AAC wall on the outer face and 115-mm-thick brick wall on the inner face with a 15-mm air gap. The outer face of the 115-mm brick wall is painted with bitumastic paint in warm-humid climate, which acts as a vapour barrier.

1.1 W/m^2.K
U-value

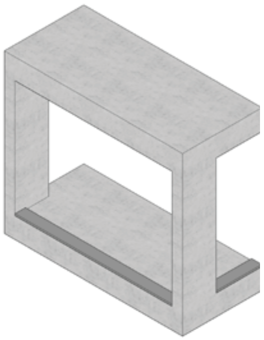
3667 INR#
Cost/m^3

#The cost includes cost of blocks, mortar, plaster, paint and labour. The calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

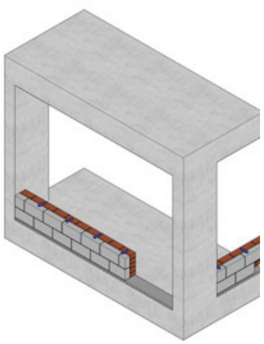
CONSTRUCTION PROCESS



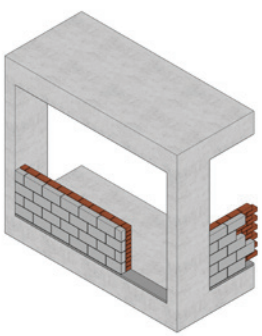
1 Site condition as per actual.



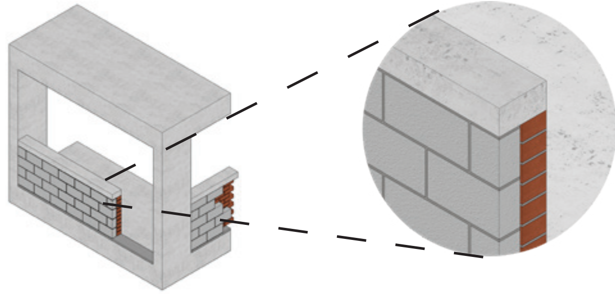
2 Lay a 40-mm levelling course to begin the masonry work from a flat surface.



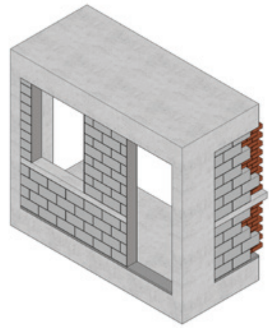
3 Raise the interior wall of 115-mm-thick wall using half bricks. Apply bitumastic paint layer on the outer surface in warm-humid climate. Leave 15-mm air gap. Raise the exterior wall of AAC blocks.



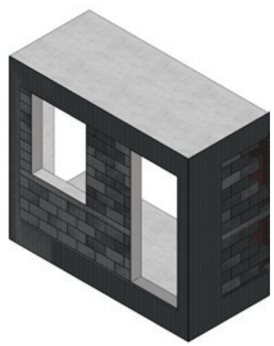
4 Raise the wall up to the sill level.



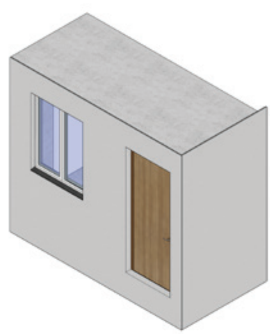
5 Fill 120-mm RCC sill and coping.



6 Raise the wall and provide openings for doors and windows. Cure internal brick wall by sprinkling water.

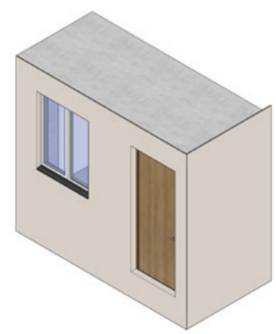


7 Fix GI chicken wire mesh over the entire surface of blocks and structure.



8 Plaster the walls and fix the doors and windows.

9 Apply paint on the wall.



SOLUTION 3: 230-MM-THICK BRICK CAVITY WALL WITH INSULATION

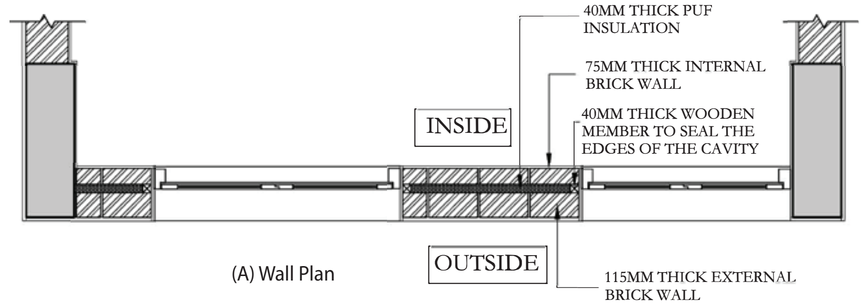
BRIEF DESCRIPTION

This wall assembly comprises of a 115-mm outer brick wall and 75-mm inner brick wall with 40-mm-thick polyurethane foam (PUF) insulation,* which are held together by wall ties. This system ensures uniformity in the thickness of the 230-mm wall as in traditional method and provides better insulation. This wall is generally raised flushed to the outer surface of slab/beam/column.

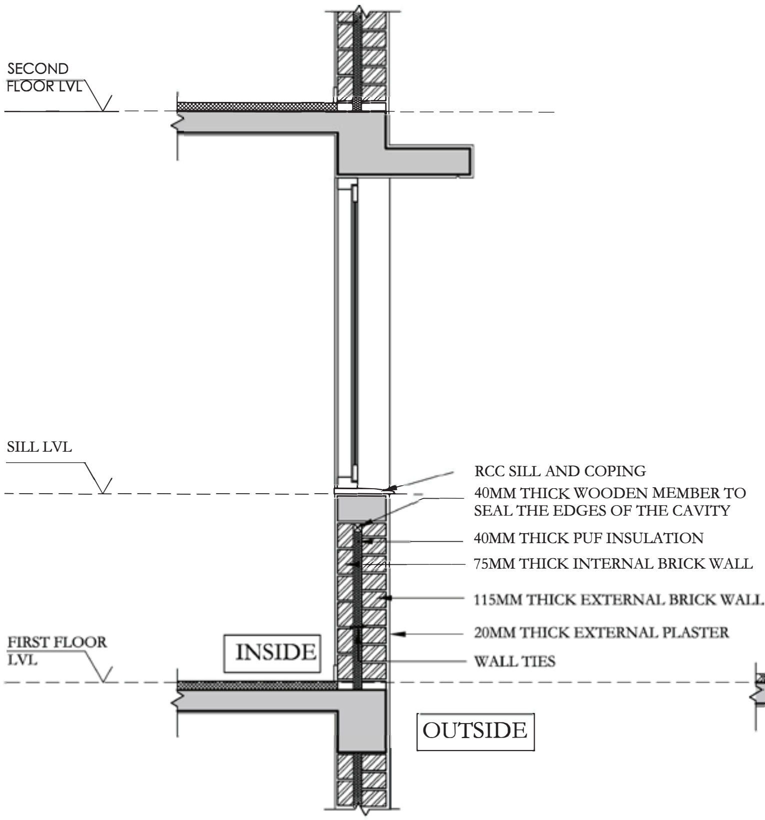
The exposed area of RCC structure to the outside, which can be as much as 15%–20% of the envelope wall area, remains a thermal bridge between the inside and the outside. To further reduce the external exposed RCC surface, one could cast the beams with a small 150-mm projection as shown in Figure C. Now the wall starts from this projection. This protects the outer surfaces of the RCC structure from conductive heat gain.

The ends of the cavity where doors and windows are to be fixed need to be properly closed. This is most conviniently done by plugging these ends with a timber section. Weep holes should be provided at the bottom of each of the outer wall at intervals.

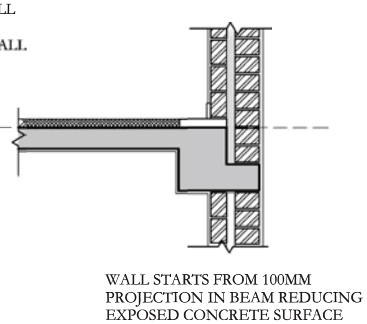
** Alternate non-fibrous insulation materials such as PUF spray, expanded polystyrene (EPS) insulation, and extruded polystyrene (XPS) insulation can also be used. However, the costing, construction steps, and U-value will be different.*



(A) Wall Plan



(B) Wall Section



(C) Beam Construction Option

Item Description for BOQ

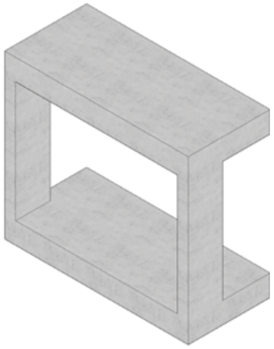
Providing and laying two brick walls simultaneously, with 115-mm-thick brick wall on the exterior face and 75-mm-thick wall on the interior face with 40 -mm thick PUF insulation, thereby making a 230-mm-thick wall assembly. The inner face of the 115-mm wall is painted with bitumastic paint in warm-humid climate, which acts as a vapour barrier.

0.62 W/m^2.K
U-value

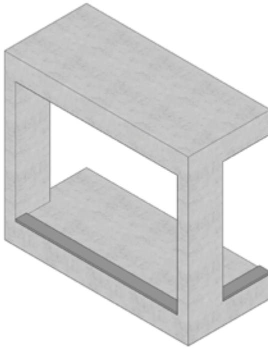
3680 INR#
Cost/m^3

#The cost includes cost of blocks, mortar, plaster, paint and labour. The calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

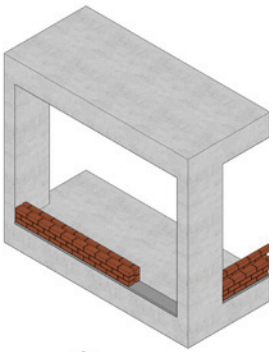
CONSTRUCTION PROCESS



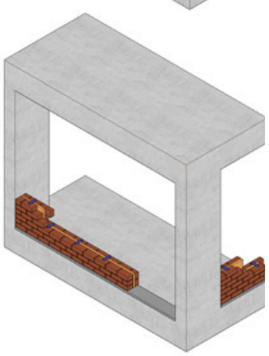
1 Site condition as actual.



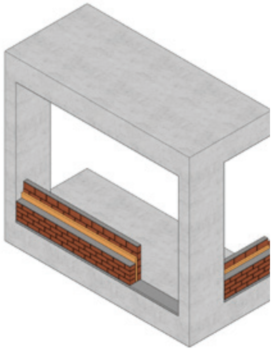
2 Lay the levelling course of 40-mm to begin the masonry work from a flat surface.



3 Lay three courses of exterior wall with 115-mm-thick blocks.

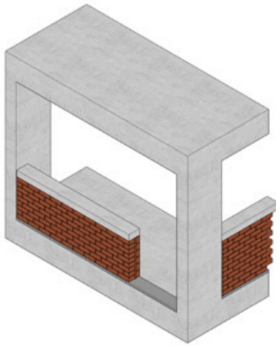


4 Leave air gap of 40-mm and lay two courses of 75-mm thick wall such that the top level matches for both courses.

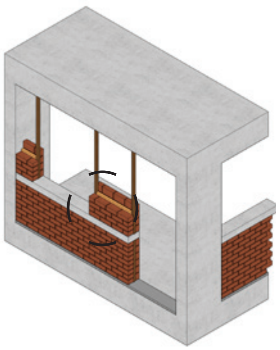


5 Insert 40-mm-thick insulation inside the cavity.

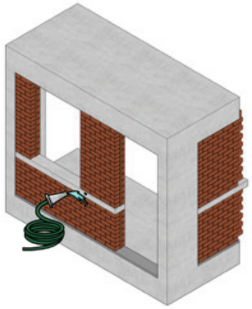
Place wall ties at every 600-mm distance and repeat the next set.



6 Raise the wall and provide 120-mm RCC sill and coping.

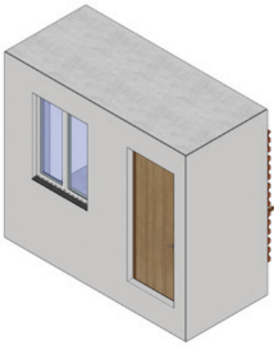


7 Enclose the walls with wooden piece at the masonry openings for door and windows to avoid thermal bridging the cavity between the inside and the outside.

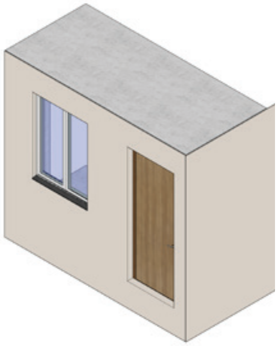


8 Raise the wall and provide openings for doors and windows.

Cure the constructed wall by sprinkling water.



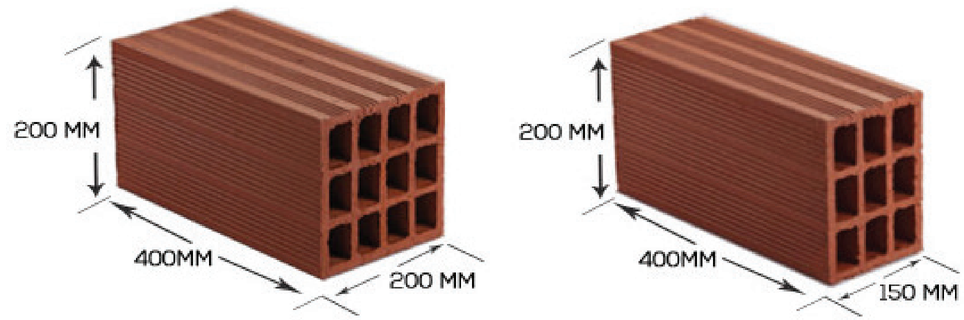
9 Plaster the walls and fix the doors and windows.

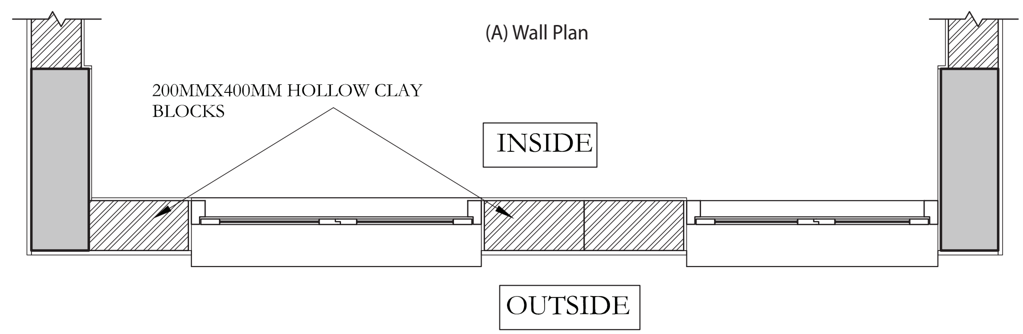


10 Apply paint on walls.

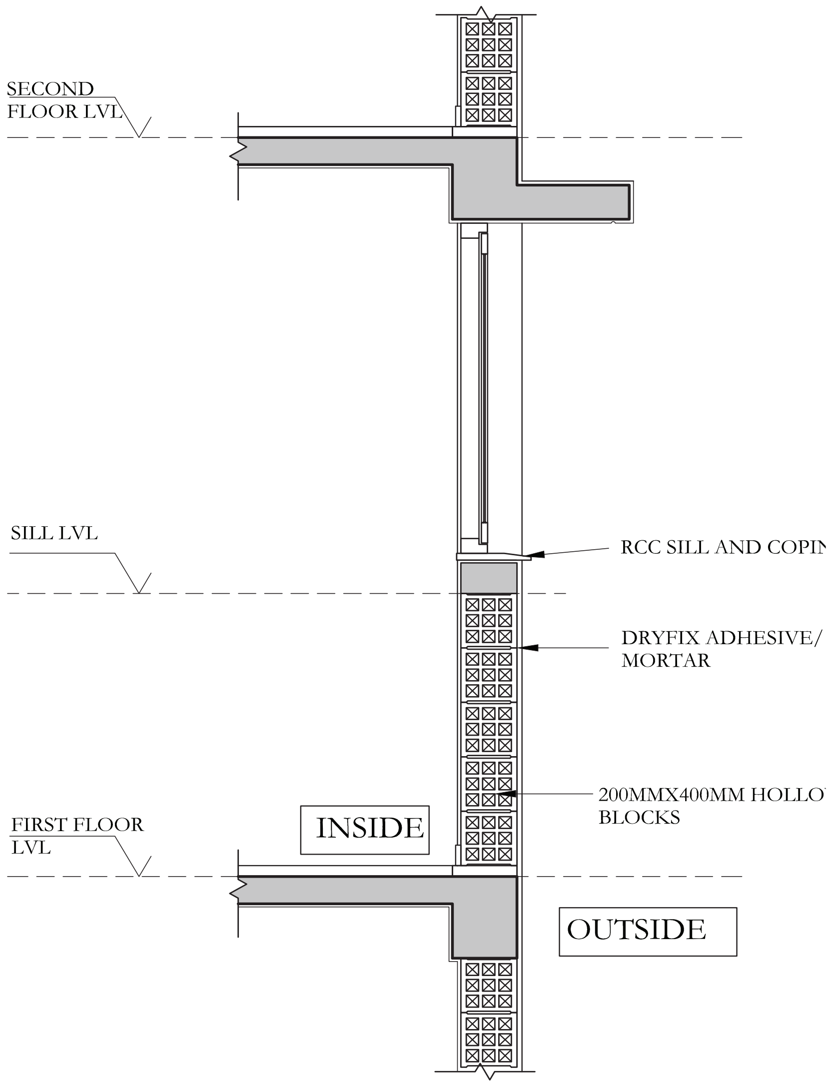
BRIEF DESCRIPTION

The hollow clay bricks generally come in 150-mm and 200-mm thickness. For the construction of the external wall, a 200-mm-thick block is recommended. These blocks have horizontal cavity that improve the thermal performance of the wall. These blocks are joined with a dry-fix adhesive or cement mortar between the blocks.





(A) Wall Plan



(B) Wall Section

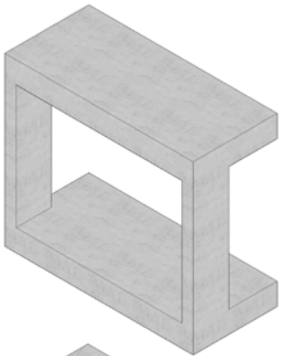
1.0 W/m^2.K
U-value

3200 INR#
Cost/m^3

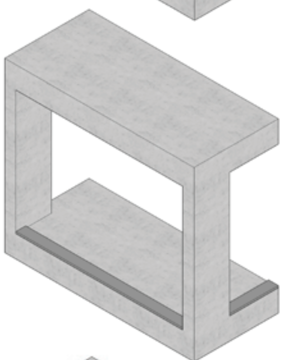
Item Description for BOQ
Providing and laying 200-mm-thick hollow core clay bricks with a dry-fix adhesive/cement mortar between the blocks.

#The cost includes cost of blocks, mortar, plaster, paint and labour. The calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

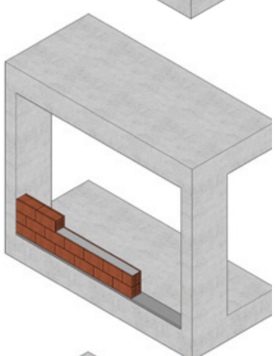
CONSTRUCTION PROCESS



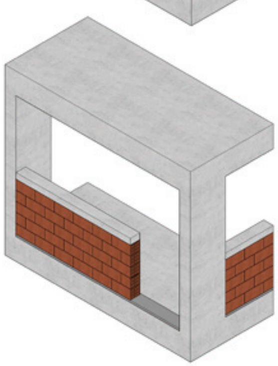
1 Site condition as per actual.



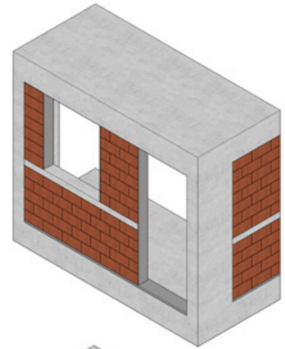
2 Lay the levelling course of 40-mm to begin the masonry work from a flat surface.



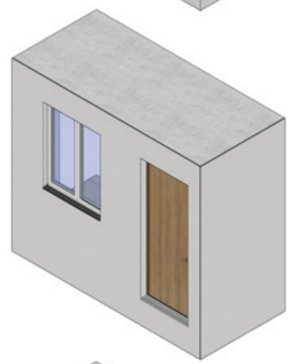
3 Lay hollow blocks of size 400 x 200 x 200 mm.



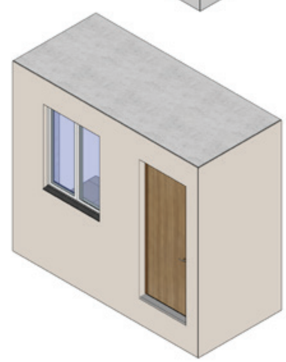
4 Provide 120-mm RCC sill and coping.



5 Raise the wall and provide openings for doors and windows.



6 Plaster the walls and fix the doors and windows. The walls can also be kept exposed for aesthetic purposes.



7 Apply paint on the walls.

ROOFING SOLUTIONS

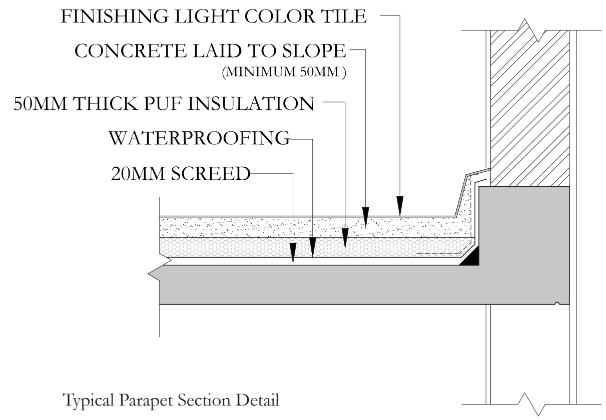
BRIEF DESCRIPTION

This roof assembly comprises a 50-mm-thick rigid polyurethane foam (PUF) insulation* to reduce the conductive heat loads from the roof. First the roof surface is flattened with screed to achieve a smooth finish. Then a waterproofing membrane is applied over the entire surface. Next, the PUF insulation is put on the waterproofing layer. There should be no gap at the joints between adjacent PUF boards. This is to ensure continuity of the insulation layer. Some PUF vendors provide boards with interlocking profiles to ensure that there are no gaps between adjacent boards.

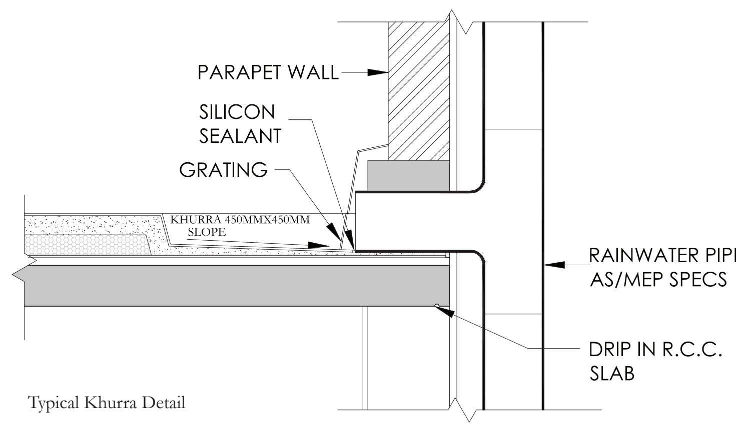
As the waterproofing layer is below the insulation layer, the insulation material should be of a closed cell structure, which does not absorb water. Fibrous insulation material, which absorbs water, cannot be used above the waterproofing layer.

To achieve slope in the terracing, lay concrete 50-mm minimum over the insulation that slopes towards the Khurra of the rain water pipes. This concrete layer is then further finished with a china mosaic/light-colour tile. The light colour helps reflect the incident solar radiation. The joints between these tiles act as a breathable network, which help in the evaporation of absorbed moisture.

** Alternate insulation material such as PUF spray and extruded polystyrene (XPS) can also be used in place of PUF insulation. However, the costing, construction steps, and U-value will be different.*



Typical Parapet Section Detail



Typical Khurra Detail

0.46 $W/m^2.K$
U-value

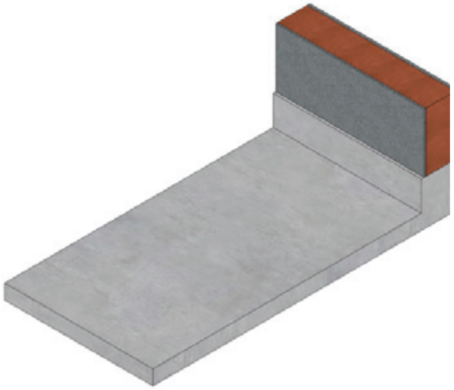
4196 INR#
Cost/m^3

Item Description for BOQ

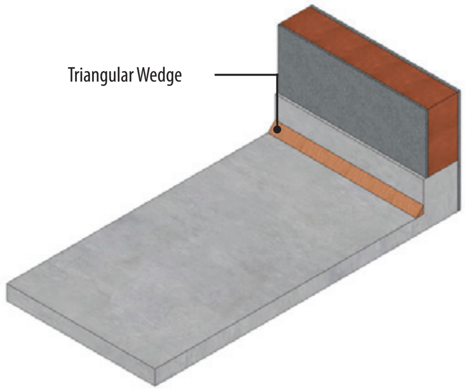
Providing and laying roof insulation with 50-mm-thick rigid polyurethane (PU) sheet over deck insulation (density of the sheet being 36 kg/m^3) and compressive strength of 172 KN/m^2, over a coat of PU primer applied at the rate of 6-8 m^2 per litre, laying 400 G (guage polythene sheet over PUF sheet and providing a wearing course of 40-mm-thick cement screed 1:2:4 (1 cement: 2 coarse sand: 4 stone aggregate of 20-mm nominal size) in chequered rough finish, in panels of 2.5 x 2.5 m and embedding with 24 G wire-netting and sealing the joints with polymerized mastic, all complete as per the direction of the Engineer- in-Charge.

#The cost calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

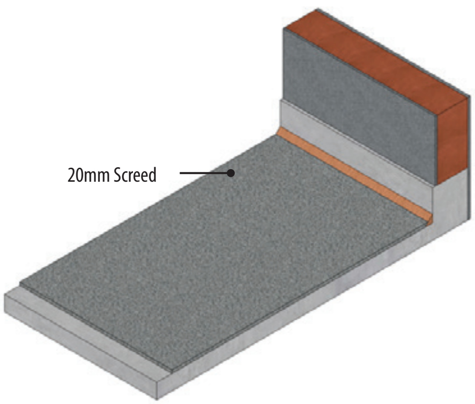
CONSTRUCTION PROCESS



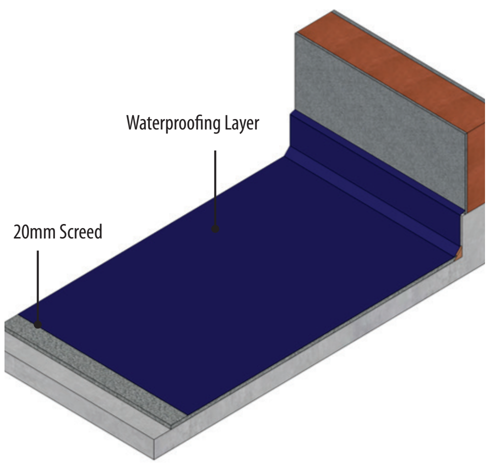
1 Site condition as per actual.



2 Use triangular wedge to enable turning of the waterproofing layer.

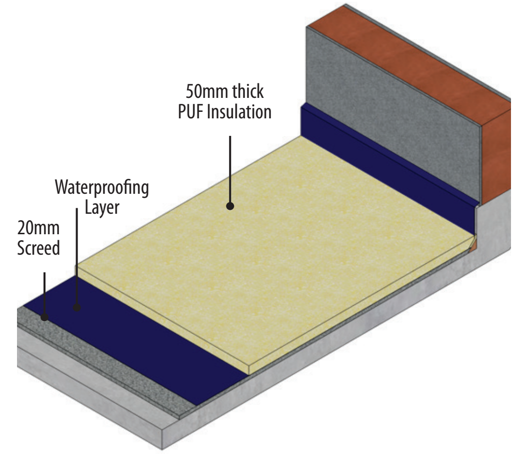


3 Level the top of the terrace slab using 20-mm-thick screed.

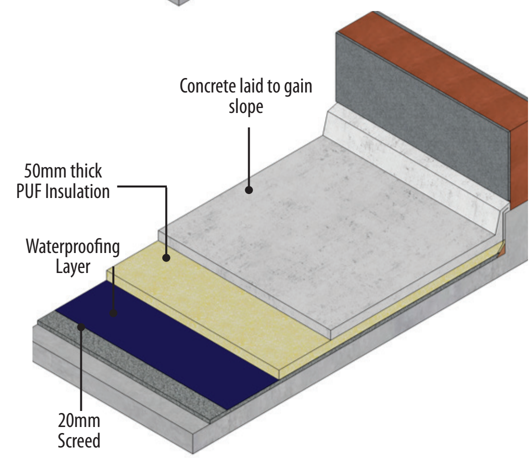


4 Use the waterproofing layer to turn and fold over the terrace parapet base.

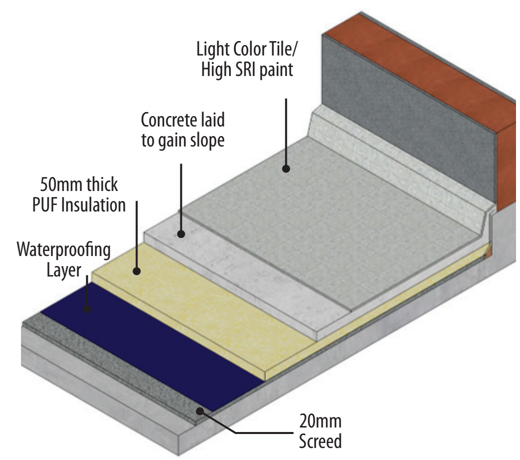
5 Place 50-mm-thick insulation boards over the waterproofing layer.



6 Lay concrete over the insulation to achieve the desired slop in terracing.



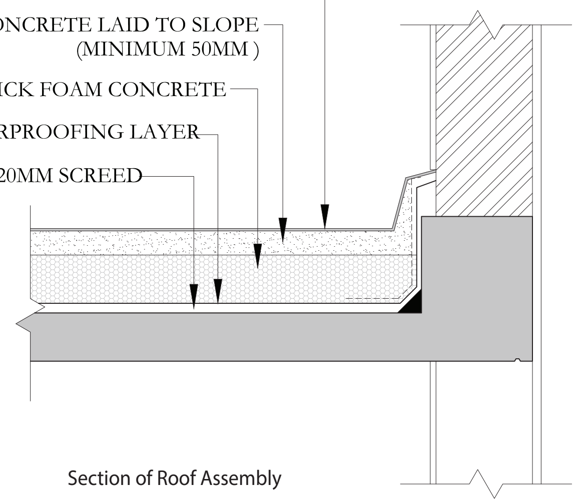
7 Prefer light-coloured tile or high SRI paint as finishing material to reflect solar radiation.



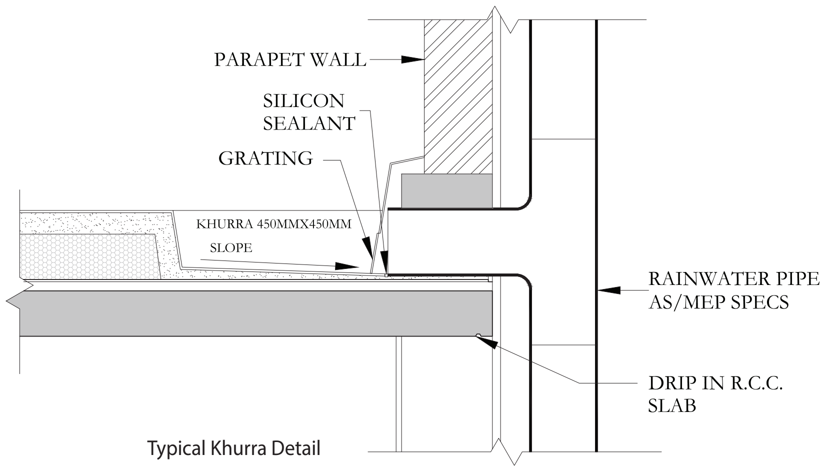
BRIEF DESCRIPTION

This roof assembly comprises a 100-mm-thick foam concrete insulation to reduce the conductive heat loads from the roof. First the roof surface is flattened with screed to achieve a smooth finish. Then a waterproofing membrane is applied over the entire surface. Next, the foam concrete insulation is put on the water-proofing layer. Foam concrete is made of a combination of stable foam, water, sand and cement and has a porous nature.

Then, to achieve slope in the terracing, lay concrete 50-mm minimum over the in-sulation that slopes towards the Khurra of the rain water pipes. This conrete layer is then further finished with a china mosaic/light-coloured tile. The light colour helps reflect the incident solar radiation. The joints between these tiles act as a breathable network, which help in the evaporation of absorbed moisture.



Section of Roof Assembly



Typical Khurra Detail

0.62 W/m^2.K
U-value

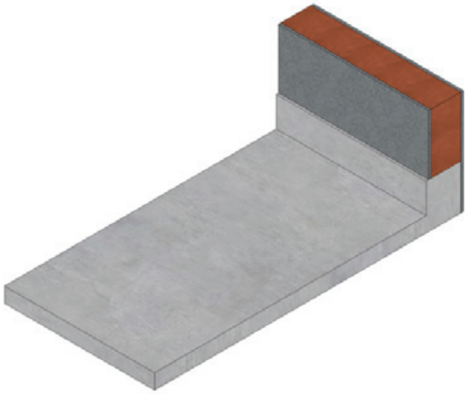
5000 INR#
Cost/m^3

Item Description for BOQ

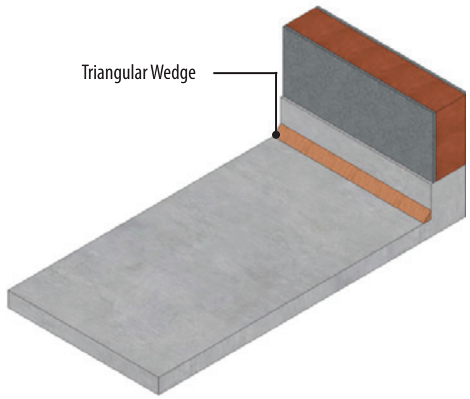
Pouring 100-mm-thick foam concrete insulation over the waterproofing surface having a thermal conductivity of 0.07 W/m.K, density of 320 kg/m^3. The compressive strength is 0.5–1.0 N/mm^2 (Source: British Concrete Association). The laying is done through foam concrete pouring machine. Complete in all respect as per the direction of the Engineer-in-Charge.

#The cost calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

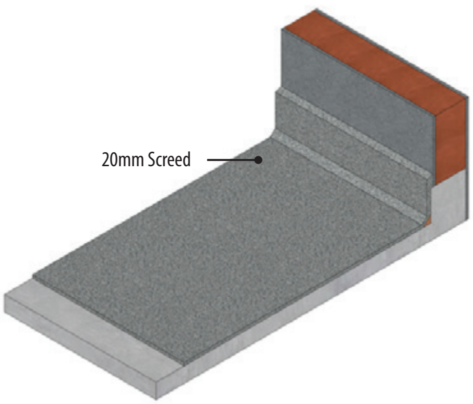
CONSTRUCTION PROCESS



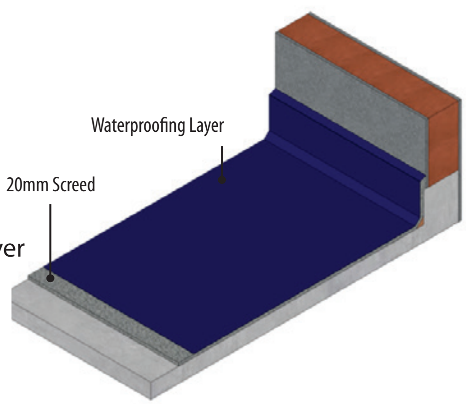
1 Site condition as per actual.



2 Use traingular wedge to enable turning of the waterproofing layer.

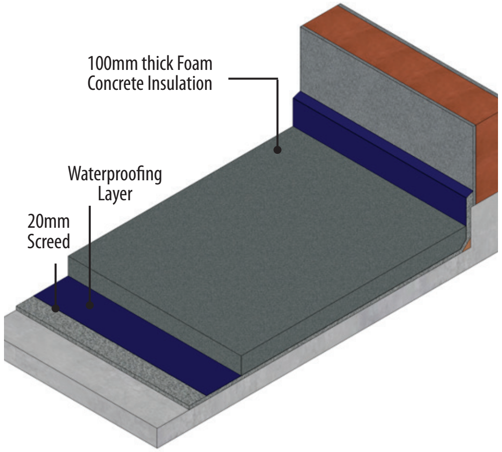


3 Level the top of terrace slab using 20-mm-thick screed.

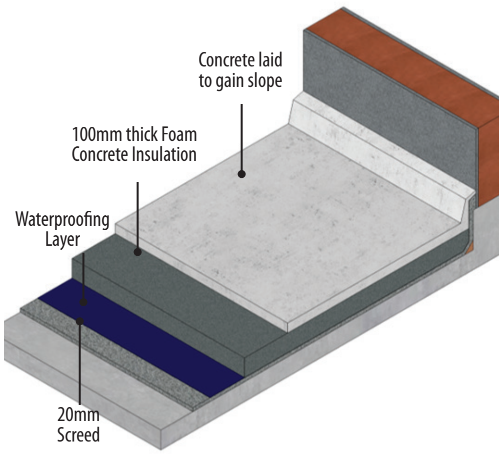


4 Use the waterproofing layer to turn and fold over the terrace parapet base.

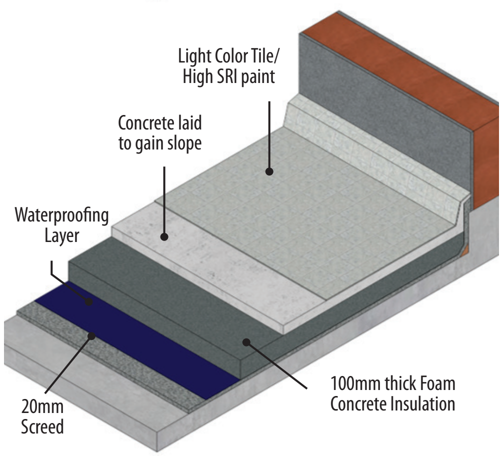
5 Place 100-mm-thick foam concrete over the waterproofing layer.



6 Lay conrete over the insulation to achieve the desired slope in terracing.



7 Prefer light-coloured tile or high SRI paint as finishing material to reflect solar radiation.



WINDOW SOLUTIONS

Windows have three main components that must be taken into consideration while addressing the thermal comfort of the building:

A. Material of sash (frame)

B. Openability of window

C. Specification of glass

A. MATERIAL OF FRAME

1. uPVC Frame

Unplasticized polyvinyl chloride (uPVC) windows offer high energy efficiency and protection from the external elements such as dust and pollution. It also reduces noise transmission and ensures safety and security. The installation of uPVC windows requires special hardware and skills. They are available in 2-, 3-, and 4-track sliding windows. Cost of uPVC frames can vary widely.

2. Aluminium Frame

Aluminium windows come in various sections and qualities in the market. They are durable, low maintenance, and do not require skilled labour for installation. They are available in 2- 3-, and 4-track sliding windows. Cost of aluminium frames can vary widely.

B. OPENABILITY OF WINDOW

1. Sliding Window

Sliding windows comprise two or more horizontal sashes that are fitted with rollers at the base for smooth sideward track movement. A major factor to consider with sliding window is that it does not provide 100% opening.

2. Casement Window

A casement is a window that is attached to its sash (frame) by one or more hinges at the side. It opens outwards or inwards along its entire length in the manner of a door. They are used singly or in pairs within a common frame.

C. SPECIFICATION OF GLASS

There are numerous variations of glass available in the market. They vary in thickness, reflectivity, and colour, which eventually affects the U-value and thermal comfort. In Gujarat, heat gain should be low, with adequate daylight. So, the glass used should have low U-value and low SHGC without lowering the VLT too much.

1. Single Glazed

This is a single glass pane, varying between 5 mm to 12 mm thickness. The most commonly used single clear glass has U value 5.8 W/m^2.K; SHGC: 0.8; and, VLT: 0.85.

Addition of colour, chemical treatments or films change the properties of glass. SHGC can be reduced to 0.45 with VLT 0.5. Doing so, the SHGC may be reduced. U-value may also be reduced.

- U value = 5.0 to 5.8 W/m^2.K as per selection
- SHGC = 0.43 to 0.56 as per selection

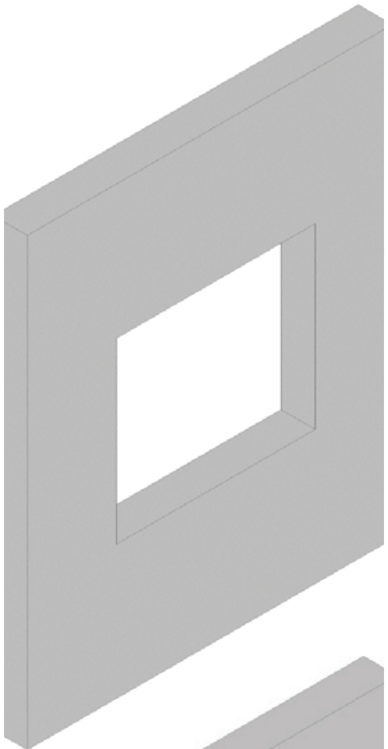
2. Double Glazed

Double-glazed clear glass comprises two or more glass panes separated by an air-filled (or gas-filled) cavity that is completely sealed, forming a transparent insulating barrier. A simple DGU with 2 clear glass panes have U value: 2.7 W/m^2.K; SHGC: 0.7; VLT: 0.75.

High-performance glasses are usually DGUs with treated glass panes with air or argon-filled cavity. Doing so, the U value and SHGC will be reduced.

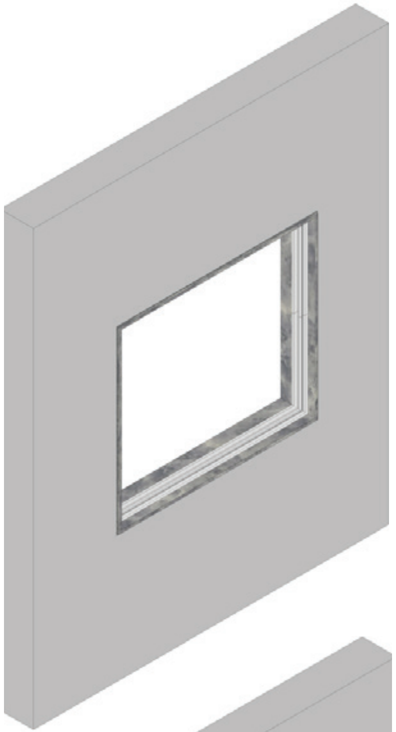
- U value = 1.8 to 2.7 W/m^2.K as per selection
- SHGC = 0.35 to 0.47 as per selection

CONSTRUCTION PROCESS – GENERIC

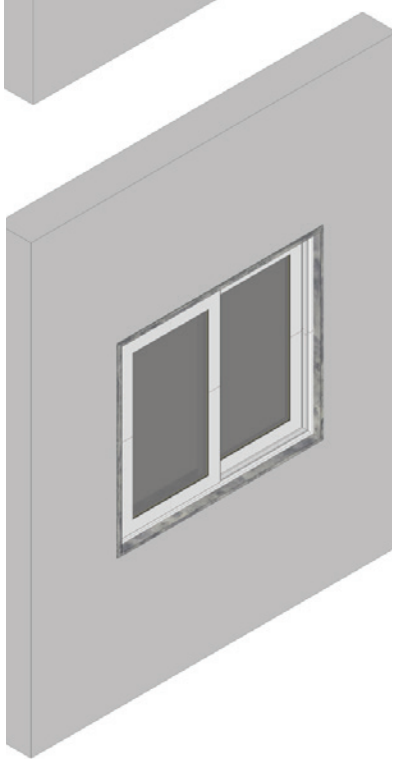


1 Do the opening as per actual site condition.

2 Level the opening by fitting a stone/tile frame as per selection.

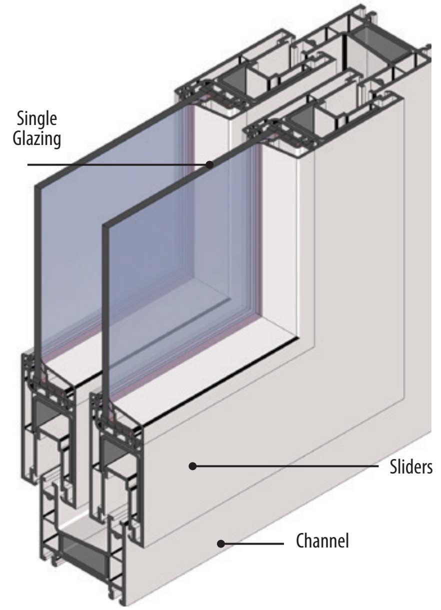


3 Fit the sliding window section as per selection. Casement window can be directly fitted after levelling.

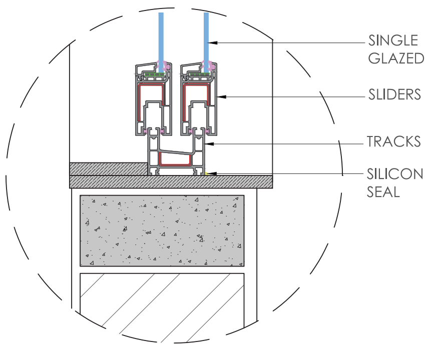


4 Fit the window on site with appropriate accessories.

uPVC FRAME + 6-MM-THICK GLASS SLIDING WINDOW



Window Sectional View



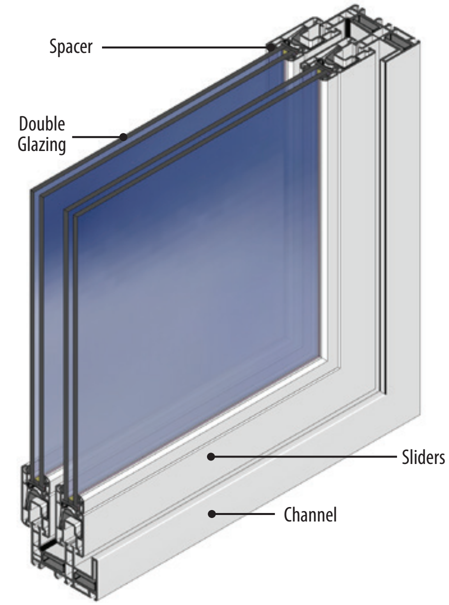
Typical Section Detail

Item Description for BOQ

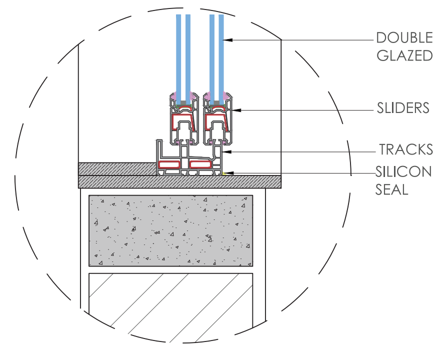
Providing and installing sliding window as per design with uPVC sash of U-value 2.6, conforming to IS 4021:1995 and 6-mm single clear glass, with similar or equivalent properties like SHGC = 0.56, VLT = 0.64, and U-value 5.6 as per IS 14900 (2000).

3500–18000 INR# Cost/m^3	**2.6** W/m^2.K Frame U-value	**5.0–5.8** W/m^2.K Glass U-value

uPVC FRAME + 24-MM-THICK GLASS SLIDING WINDOW



Window Sectional View



Typical Section Detail

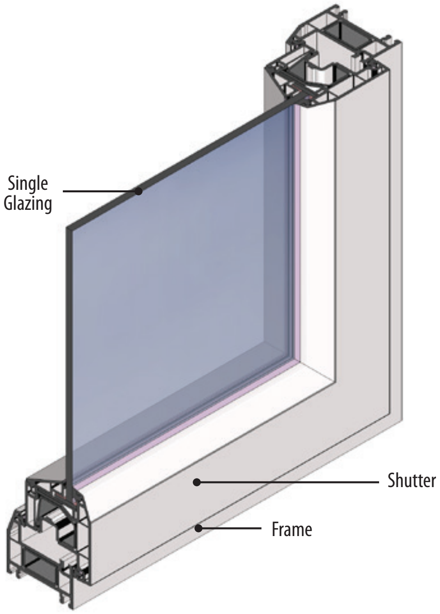
Item Description for BOQ

Providing and installing sliding window as per design with uPVC sash of U-value 2.6, conforming to IS 4021:1995 and 24-mm-thick (two 6-mm-thick glass panes with an air gap of 12 mm) double-glazed glass, with similar or equivalent properties like SHGC = 0.47, VLT = 0.57, and U-value 2.8 as per IS 14900 (2000).

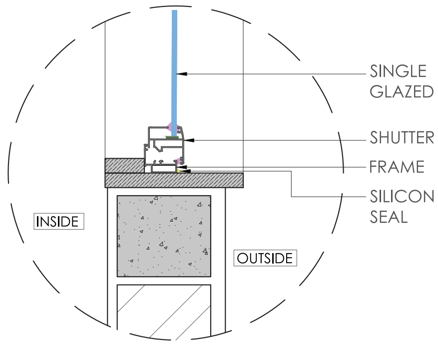
5000–18000 INR# Cost/m^3	**2.6** W/m^2.K Frame U-value	**1.8–2.7** W/m^2.K Glass U-value

#The cost calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

uPVC FRAME + 6-MM-THICK GLASS CASEMENT WINDOW



Window Sectional View



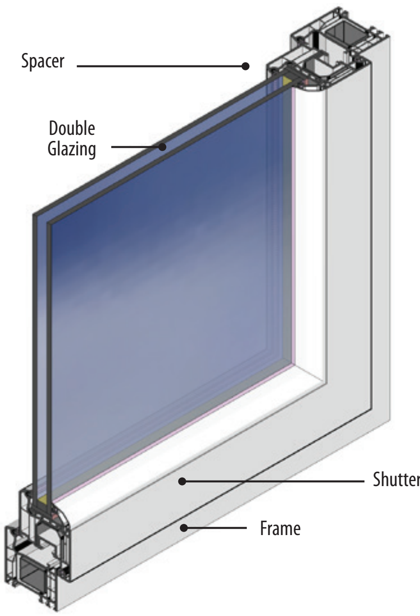
Typical Section Detail

Item Description for BOQ

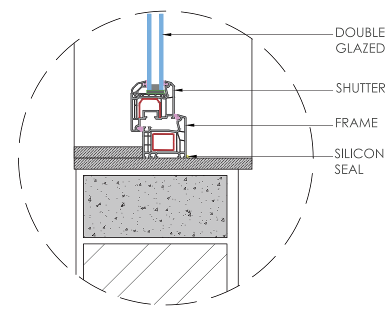
Providing and installing casement window as per design with uPVC sash of U-value 2.6, conforming to IS 4021:1995 and 6-mm single clear glass, with similar or equivalent properties like SHGC = 0.56, VLT = 0.64, and U-value 5.6 as per IS 14900 (2000).

4000–22000 INR# Cost/m^3	**2.6** W/m^2.K Frame U-value	**5.0–5.8** W/m^2.K Glass U-value

uPVC FRAME + 24-MM-THICK GLASS CASEMENT WINDOW



Window Sectional View



Typical Section Detail

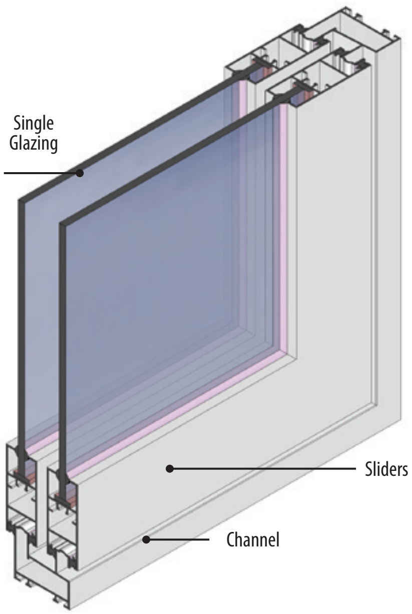
Item Description for BOQ

Providing and installing casement window as per design with uPVC sash of U-value 2.6, conforming to IS 4021:1995 and 24-mm-thick (two 6-mm-thick glass panes with an air gap of 12 mm) double-glazed glass, with similar or equivalent properties like SHGC = 0.47, VLT = 0.57, and U-value 2.8 as per IS 14900 (2000).

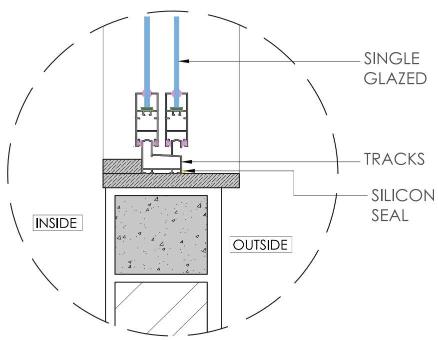
5700–22000 INR# Cost/m^3	**2.6** W/m^2.K Frame U-value	**1.8–2.7** W/m^2.K Glass U-value

#The cost calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

ALUMINIUM FRAME + 6-MM-THICK GLASS SLIDING WINDOW



Window Sectional View



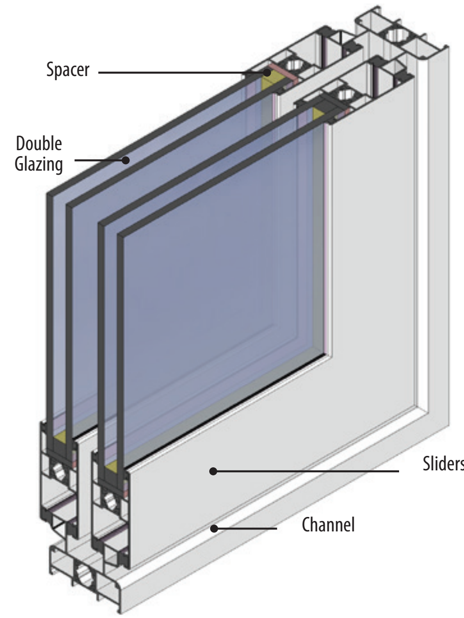
Typical Section Detail

Item Description for BOQ

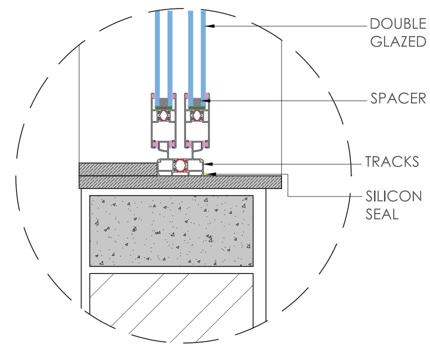
Providing and installing sliding window as per design with aluminium sash of U-value 4.92, conforming to IS 4021:1995 and 6-mm single clear glass, with similar or equivalent properties like SHGC = 0.56, VLT = 0.64, and U-value 5.6 as per IS 14900 (2000).

2200–12000 INR# Cost/m^3	**4.92** W/m^2.K Frame U-value	**5.0–5.8** W/m^2.K Glass U-value

ALUMINIUM FRAME + 24-MM-THICK GLASS SLIDING WINDOW



Window Sectional View



Typical Section Detail

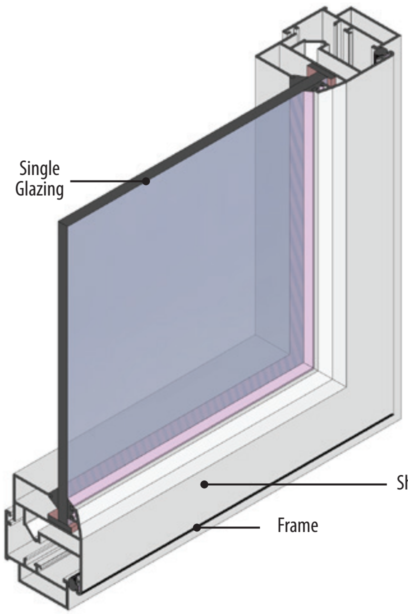
Item Description for BOQ

Providing and installing sliding window as per design with aluminium sash of U-value 4.92, conforming to IS 4021:1995 and 24-mm-thick (two 6-mm-thick glass panes with an air gap of 12 mm) double-glazed glass, with similar or equivalent properties like SHGC = 0.47, VLT = 0.57, and U-value 2.8 as per IS 14900 (2000).

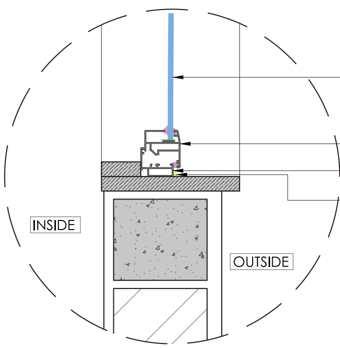
3400–12000 INR# Cost/m^3	**4.92** W/m^2.K Frame U-value	**1.8–2.7** W/m^2.K Glass U-value

#The cost calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

ALUMINIUM FRAME + 6-MM-THICK GLASS CASEMENT WINDOW



Window Sectional View



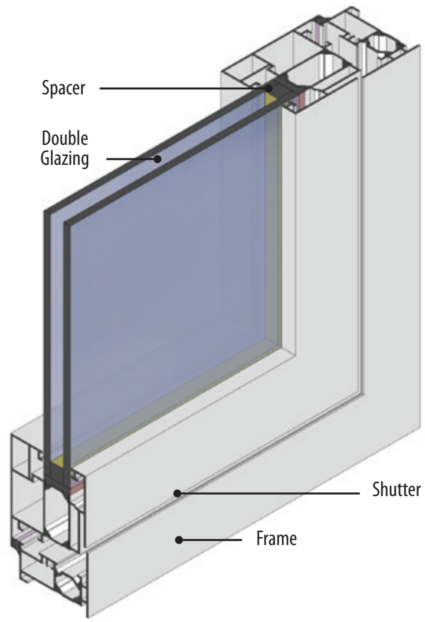
Typical Section Detail

Item Description for BOQ

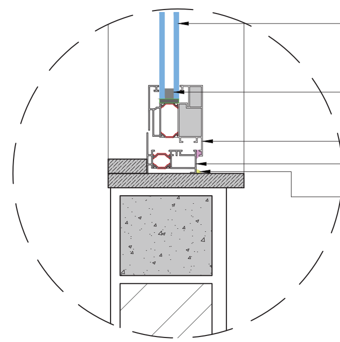
Providing and installing casement window as per design with aluminium sash of U-value 4.92, conforming to IS 4021:1995 and 6-mm single clear glass, with similar or equivalent properties like SHGC = 0.56, VLT = 0.64, and U-value 5.6 as per IS 14900 (2000).

3300–14000 INR# Cost/m^3	**4.92** W/m^2.K Frame U-value	**5.0–5.8** W/m^2.K Glass U-value

ALUMINIUM FRAME + 24-MM-THICK GLASS CASEMENT WINDOW



Window Sectional View



Typical Section Detail

Item Description for BOQ

Providing and installing sliding window as per design with aluminium sash of U-value 4.92, conforming to IS 4021:1995 and 24-mm-thick (two 6-mm-thick glass panes with an air gap of 12 mm) double-glazed glass, with similar or equivalent properties like SHGC = 0.47, VLT = 0.57, and U-value 2.8 as per IS 14900 (2000).

4100–14000 INR# Cost/m^3	**4.92** W/m^2.K Frame U-value	**1.8–2.7** W/m^2.K Glass U-value

#The cost calculations are done as per Gujarat Specific Market Survey Report 2020. It is recommended to calculate the cost based on local rates of material, labour, taxes, etc.

SHADING DEVICES

BRIEF DESCRIPTION

A shading device is designed to cut off solar radiation when it is undesirable. Openings can be shaded with fixed and movable design elements.

In Gujarat, shading elements may be provided in the following broad ways:

- Deep seated / recessed windows
- External shading device system

Deep Seated/Recessed Windows

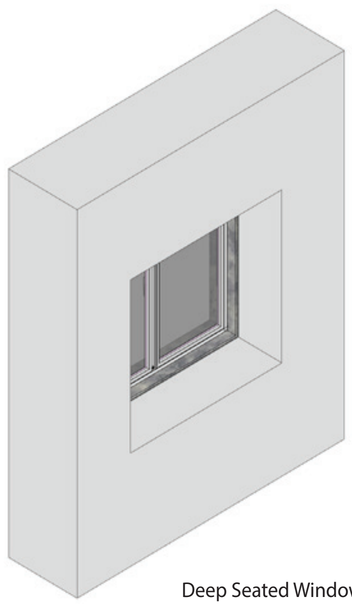
This type of window is common in Gujarat. Here, the window is 'recessed' into the room and the surrounding walls act like chajja and side fins for the window. Opening to views and daylight, the recessed windows help to mitigate thermal heat gain and create accessible spaces along the building façade. The window is fixed on the inside edge of a wall and generally recessed by 450–600-mm distance from building façade.

External Shading Device

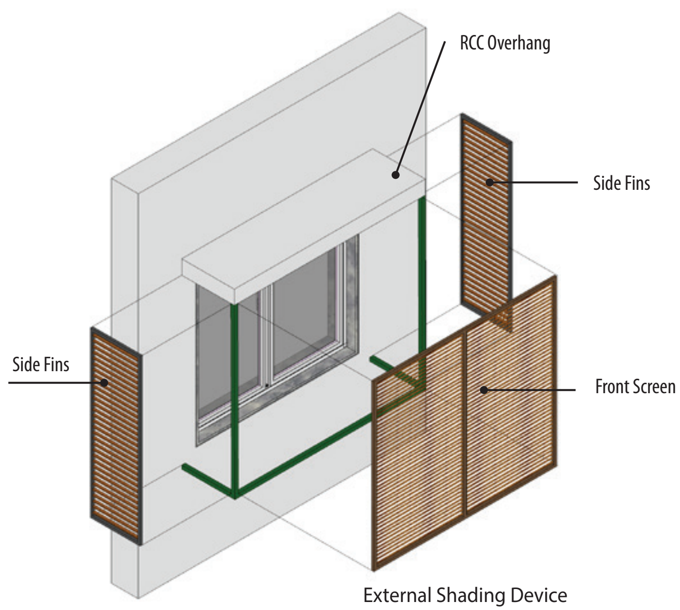
Typically, external shading can be in the form of overhangs or side-fins or front screens.

1. **Overhang:** An overhang is a horizontal projection above the window that shields it from direct solar radiation when the sun is at a high altitude, and also protects from rain. In Gujarat, overhangs are commonly casted in RCC and are thus a fixed element.
2. **Side-fin:** A side-fin restricts direct solar radiation from the sides when the sun is at a lower altitude.
3. **Front screen**: A front screen should be a movable/retractable system that allows some light even while shading. The screen can be drawn across the front of the window when the sun is directly facing the window and it can be retracted or opened when the sun is on the other side.

Overhangs and side-fins are generally fixed shading elements while the front screen is often movable.

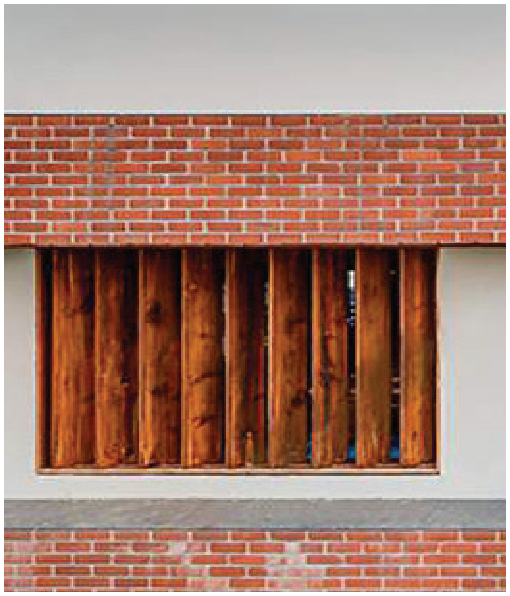


Deep Seated Window

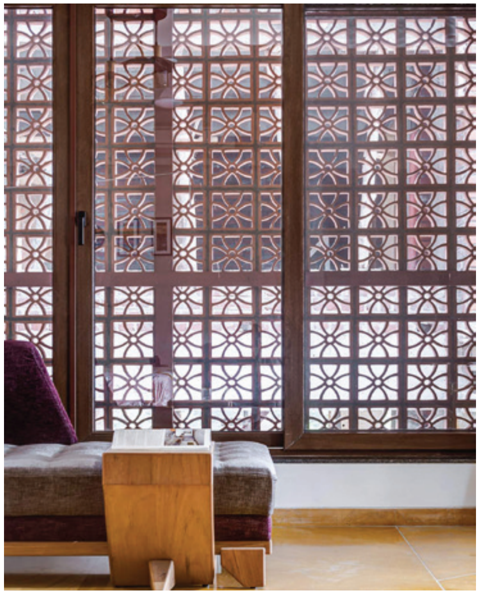


External Shading Device

EXTERIOR SHADING DESIGN AND MATERIAL OPTIONS

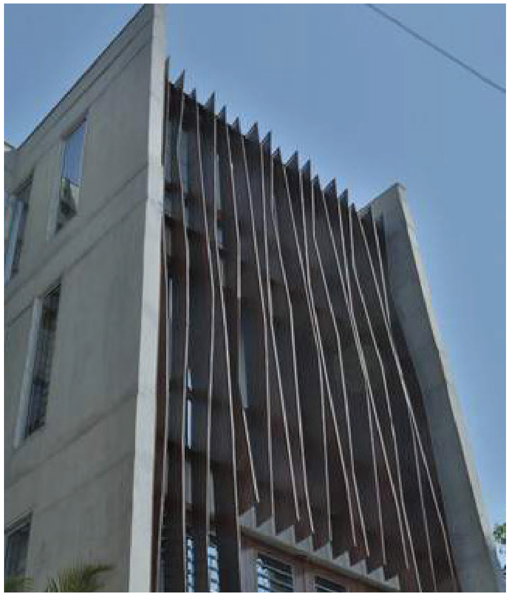


Louvres

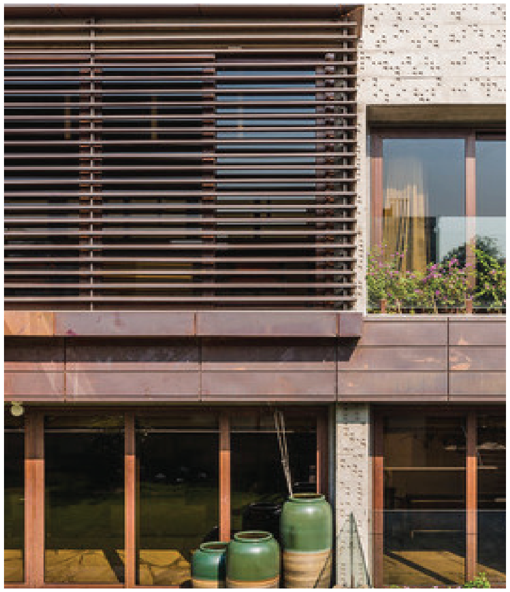


Jali

Recessed Windows



Sun Breakers



Front Screen

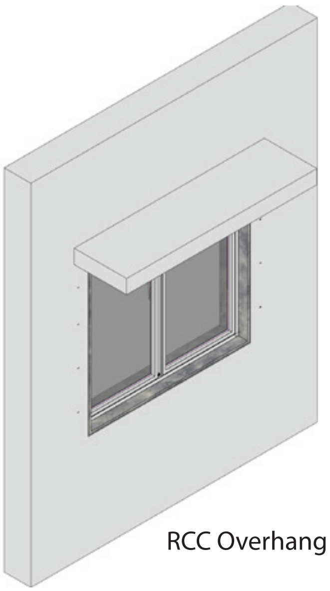
Clay Tiles

EXTERIOR SHADING DEVICES AND MATERIAL OPTIONS

There are a number of materials that can be used to block the solar radiation depending on the functionality, aesthetic form, and ease of use in the form of shading devices.

OVERHANG

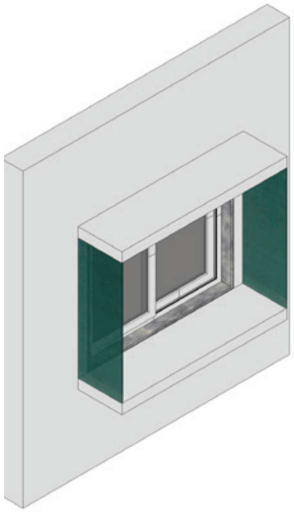
Materials such as ferro cement, precast concrete panel, and chajja made of RCC are used for overhangs. Some of these materials will require a framework to support the overhang.



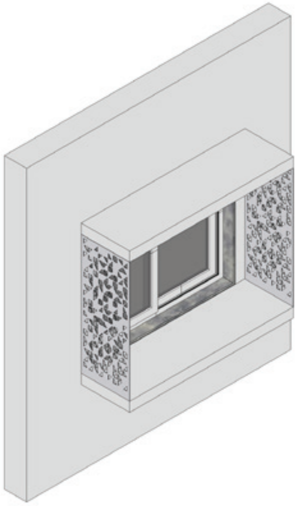
RCC Overhang

SIDE-FIN

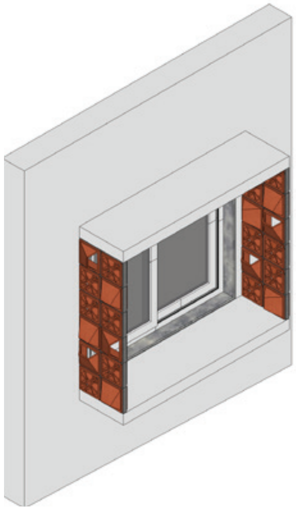
Materials such as ferro cement, precast concrete panel, and chajja made of RCC are used for overhangs. Some of these materials will require a framework to support the overhang.



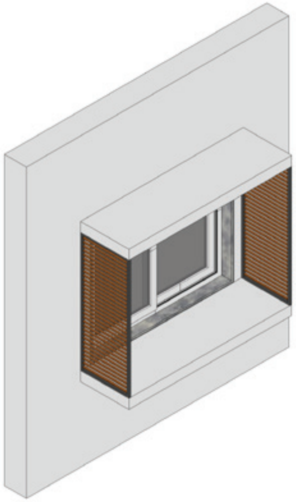
Foldable Fabrics



Perforated Metal Sheet



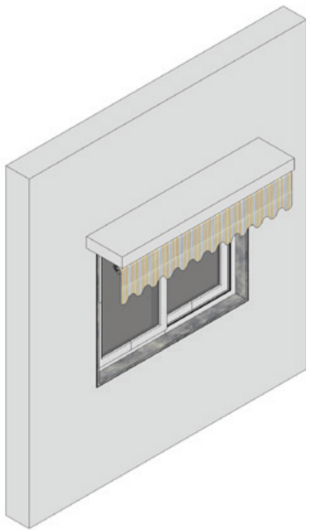
Clay Tiles Jali



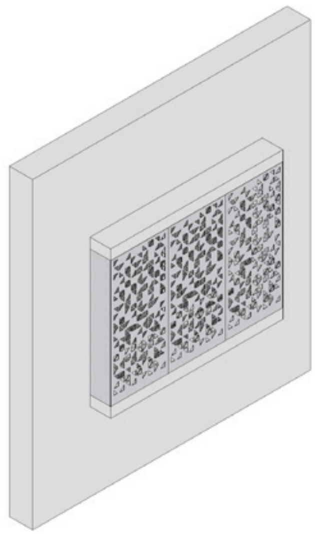
Bamboo Chiks

FRONT SCREEN

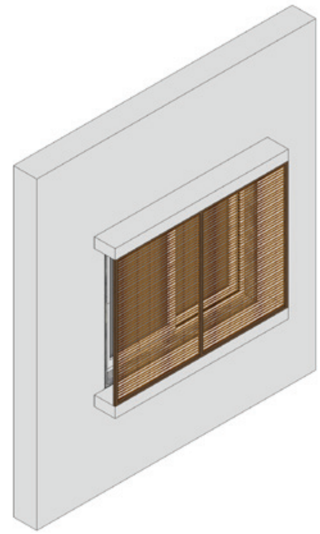
Vertically suspended lightweight materials such as bamboo chiks, foldable fabrics, cloth, and fix metal or clay jaali, aluminium or wooden movable louvers and GRC panels can be used as front screens.



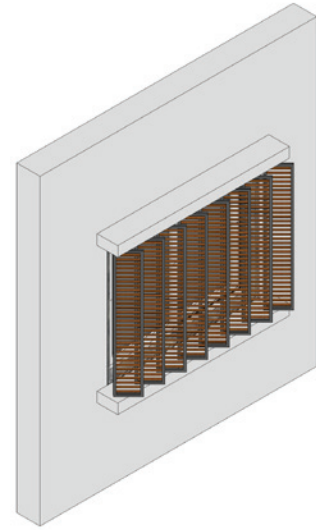
Fabric Awning



Perforated Metal Sheet



Bamboo Chiks/Green Net

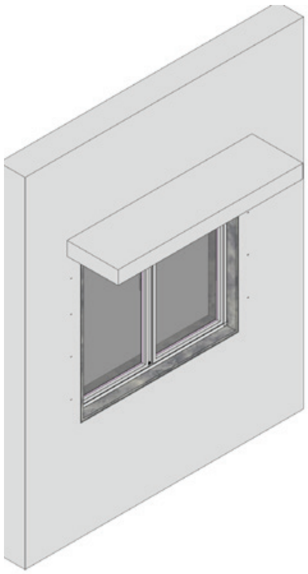


Louvres

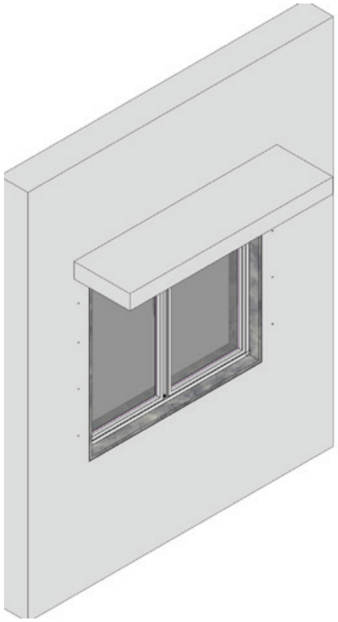
TYPICAL SHADING DEVICE FRAMEWORK

The framework is a support system designed to easily fix shading screens corresponding to the orientation. A typical box frame is made up of MS sections; other alternative options include aluminium, stainless steel, and GI. This frame (Figure A) would allow the user to easily install shading screens/chiks/cloth, etc. The extent of the shading panel would depend on the orientation of the window.

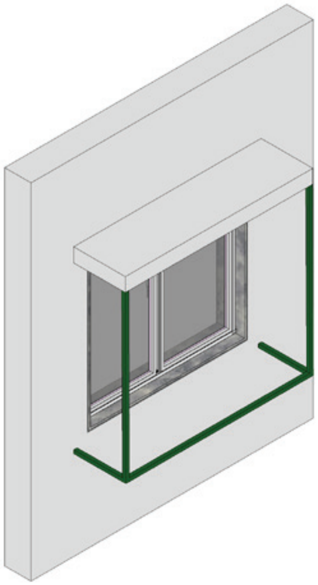
Fixed shading elements may be provided by the builder at the time of making the building, whereas roll-up/pull-down screens may be left to the user to install. The construction steps are shown in Figure A (steps 1 to 3).



1 Taking the case of a typical window



2 Drill holes, fix PVC sleeve that projects out by 15 mm and align them in one plane



3 Fix the MS box frame with bolts, each frame can come separately and bolted

A: Construction steps of a typical shading device

SHADING IN NORTH FAÇADES

The northern façade is exposed to direct solar radiation during the morning and evening hours for a much longer period of the year, as compared to the exposure in northern latitudes. Also, the angle of incidence of the sun's rays on the façade is less oblique and more impactful. Hence, it is necessary to provide vertical fins on the eastern and western sides of the window in addition to the horizontal overhang.

SHADING IN SOUTH FAÇADE

The southern façade faces the sun for the longest period. Here, the overhang above the window plays a major role in cutting the solar radiation. The vertical fins on either side of the window cut off the direct solar radiation of the early morning and late afternoon. These fins could be of a triangular shape for places above the Tropic of Cancer. They can be made out of wooden or bamboo panels, metal screens, or water-resistant fabrics.

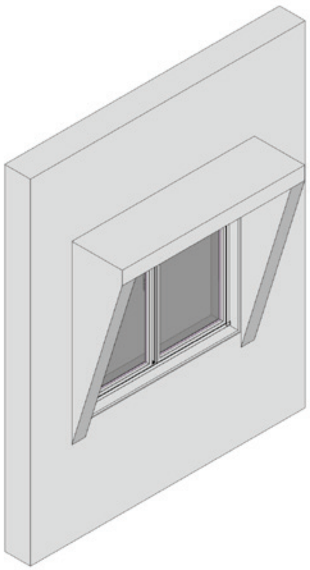


Image showing optimum shading during morning and afternoon in the south/north façade above the Tropic of Cancer

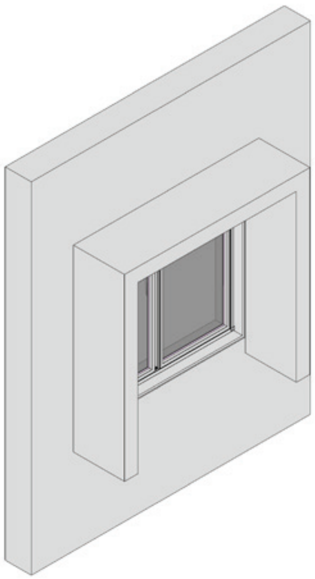
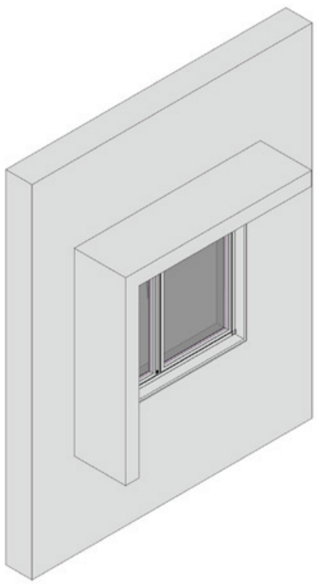


Image showing shading for south/north sun exposure below the Tropic of Cancer

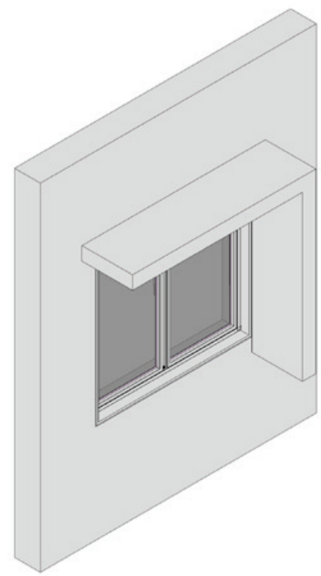
SHADING IN NORTH-EAST/NORTH-WEST FAÇADES

The north-east and north-west façades face the rising and the setting sun, respectively, during the hottest part of the year. The sun angle is low and thus it leads to direct solar radiation into the building. This is most critical for the north-western façade as the ambient temperature is already high in the afternoon.

This can be dealt with by putting fixed screens/shutter across the face of the window as shown in the images below. The screen can have slits or perforations on 15%–20% of the surface area. This would allow for better ventilation, while blocking 80% of direct solar radiation. The perforations and slits also help in dissipating the heat that the screen itself would absorb and re-radiate towards the window.



Shading for north-east windows



Shading for north-west windows

SHADING IN EAST / WEST / SOUTH-EAST / SOUTH-WEST FAÇADES

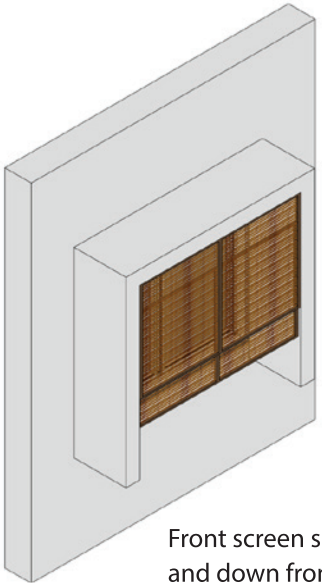
The east-facing window needs protection from the sun during the morning. The west-facing window needs to be protected during the afternoon. Thus, a screen or shutter is necessary across the face of the window to block the direct solar radiation. As this is necessary for only half of the day, a good solution is to have a movable shading system across the face of the window.

The south-east and south-west façades are exposed to both the lower altitude sun and the overhead sun. Thus, it gets solar radiation from both sides and front. So, it is necessary to have a shading provision on sides and front as well. This could be achieved by having fixed side-fins and a movable front screen.

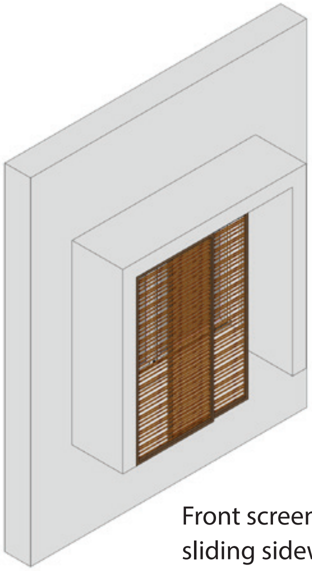
Movable shading screens can operate in the following ways:

1) A hinged or pivoted shutter with optimum size perforations/cut-outs/ openings, etc. can be made of various materials such as the following:
   a) Punched galvanized steel louver panel
   b) Painted louvre wooden panel
   c) Perforated metal/plastic screens
   d) Water-resistant/WPC boards
   e) Treated bamboo chiks

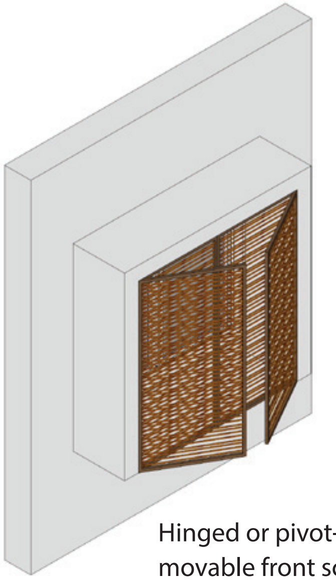
2) A retractable system with a breathable and translucent membrane could be further classified into two categories.
   a) Sliding/Folding (horizontal movement). Here, stretchable, durable, and abrasion-resistant nylon and polyester fabrics/curtains can be slid along two rods fixed on top and bottom of the fabric.
   b) Roll-up/roll-down (vertical movement). Here, materials like bamboo chiks, foldable fabrics and cloth could be used.



Front screen sliding up and down front screen



Front screens sliding sideways



Hinged or pivot-type movable front screen

About Building Envelope Solution Sets

This ready-reckoner set of solutions is made to facilitate the implementation of the *Eco-Niwas Samhita 2018, Part I: Building Envelope* in the state of Gujarat. It contains details of external wall construction, roof construction, and window shading to help meet the Residential Envelope Transmittance Value (RETV) and roof U-value requirements for composite, and hot-dry climatic zones of Gujarat. Each solution set gives a brief description of the construction assembly, its detailed drawings, steps of construction, technical specifications, and cost analysis as per Gujarat Specific Market Survey Report 2020.

About Bureau of Energy Efficiency

Bureau of Energy Efficiency (BEE) is a statutory body under the Ministry of Power, Government of India. It assists in developing policies and strategies with the primary objective of reducing the energy intensity of the Indian economy. BEE coordinates with designated consumers, designated agencies, and other organizations to identify and utilise the existing resources and infrastructure in performing the functions assigned to it under the Energy Conservation Act.

About the Indo-Swiss Building Energy Efficiency Project

The Indo-Swiss Building Energy Efficiency Project (BEEP) is a bilateral cooperation project between the Ministry of Power, Government of India, and the Federal Department of Foreign Affairs of the Swiss Confederation. The overall goal of the project is to reduce energy consumption in new commercial, public, and residential buildings in India through energy-efficient and thermally comfortable design. The project has four key components: building design, building technologies, building policy, and outreach.

For further information

Bureau of Energy Efficiency
Ministry of Power, Government of India
4th Floor, SEWA Bhawan
R. K. Puram, New Delhi - 110 066 (INDIA)
Website: www.beeindia.gov.in

Project Management and Technical Unit
Indo-Swiss Building Energy Efficiency Project
Telefax: +91 11 45535574
Email: pmtu@beepindia.org
Website: www.beepindia.org

The Ministry of Power, Government of India, has launched *Eco-Niwas Samhita (ENS) 2018 or Energy Conservation Building Code for Residential Buildings (ECBC-R), Part I: Building Envelope* on 14 December 2018. The code defines provision for building envelope to reduce heat gain/loss and improve natural ventilation and daylighting potential.

To facilitate the implementation of ENS 2018 in the state of Gujarat and to cater to region-specific requirements, state-specific building envelope solution sets have been developed titled, 'Towards Eco-Niwas Samhita Implementation in Gujarat: Building Envelope Solution Sets'. *The Gujarat Building Envelope Solution Sets (2022)* have been prepared after delving into practical and directly implementable solutions drawn through a market survey conducted in the state. The primary objective of this publication is to help building designers in the adoption of ENS 2018 at the state level.

This publication serves as a supplementing document that will help achieve the Residential Envelope Transmittance Value (RETV) and roof provisions for building envelope as per ENS 2018 in the state of Gujarat. It is prepared in such a manner that it will help users to make an informed choice on how best to meet building envelope-related code provisions in Gujarat.

FOR FURTHER INFORMATION

Bureau of Energy Efficiency
Ministry of Power, Government of India
4th Floor, SEWA Bhawan
R. K. Puram, New Delhi - 110 066 (INDIA)
Website: www.beeindia.gov.in

Project Management and Technical Unit
Indo-Swiss Building Energy Efficiency Project
Telefax: +91 11 4553 5574
pmtu@beepindia.org | www.beepindia.org