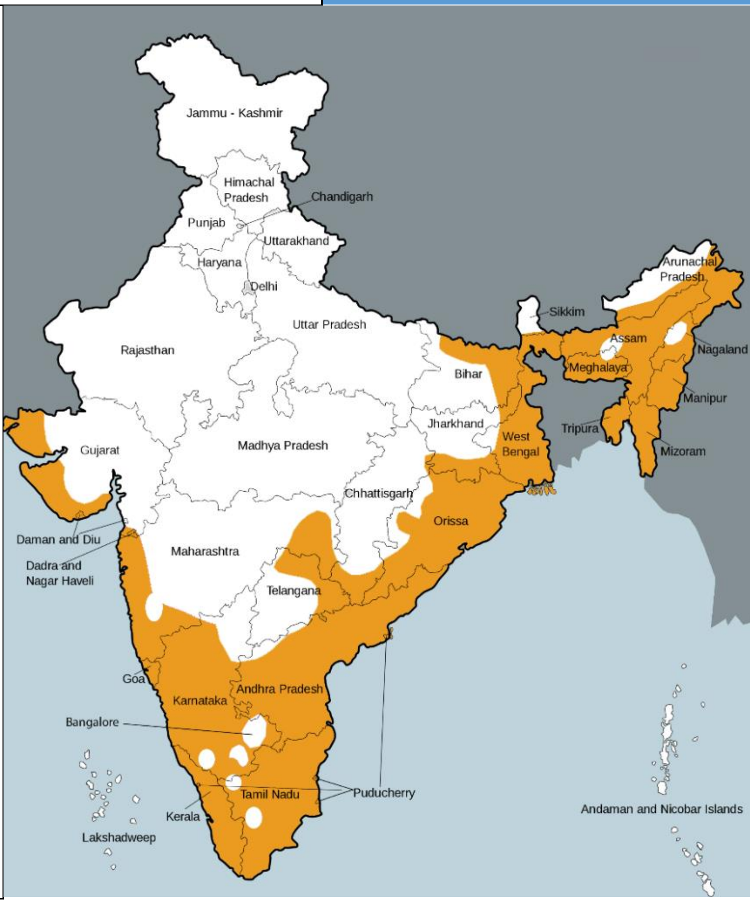
MaS-SHIP

Mainstreaming Sustainable Social Housing in India Project

Guidelines for integrating sustainability in social housing developments in India

October 2018

Warm & humid climate



The purpose of this document is to compliment the guidance provided by the Government and Green Building certification bodies in India.

These guidelines are based on the learning derived from the MaS-SHIP project as well as secondary literature.

Insights are also shared from resident surveys conducted in five social housing developments in India.

Incorporating these guidelines in the design and construction of social housing developments will contribute to enhance the sustainability and quality of life of the residents.

Key principles

- Provide convenient accessibility to basic day to day amenities and proper connectivity to places of work.
- Minimise west façade and glazing to reduce solar exposure by optimum orientation and mutual shading of building blocks.
- Facilitate passive cooling strategies to enhance thermal comfort in social housing, at a low cost. Attention must be paid to not further increase relative humidity, pertaining to the warm & humid nature of the climate.
- Orient the fenestration openings and shading devices, to avoid direct solar gain in summer, but allow for solar radiation to penetrate into the building during winters.
- Maintain quality of construction to developing of cracks, breakage in walls and material joints. Adequate water proofing and good quality plumbing design and installation is imperative to avoid discomfort and damage caused due to occurrence of dampness.

Jakkampudi Housing Society, Vijaywada

Prominent Indian cities within the warm & humid climatic zone (1)
Bhubaneswar, Chennai, Guwahati, Imphal, Jamnagar, Jorhat, Kochi, Kolkata, Kurnool, Mangalore, Mumbai, Panjim, Pune, Tiruchirapalli, Trivandram, Tuticorin, Veraval, Vijaywada, Vishakhapatnam

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Climatic characteristics

- High temperatures in summer and medium-low temperatures in winters.
- Humidity remains medium high throughout the year, except for monsoon season.
- High direct solar radiation in all seasons except monsoons due to high diffused radiation.
- Light or non-existent winds due to minimal diurnal temperature variations.
- Moderately cloudy during summer; heavily overcast sky during monsoon.
- Wind direction varies during monsoon season. (Local climatic data should be referred for establishing wind speed and direction).

Climate data (1)		
Mean temperature	Summer midday	29 to 34 deg. C
	Summer night	27 to 30 deg. C
	Winter midday	25 to 27 deg. C
	Winter night	18 to 21 deg. C
	Diurnal variations	3 to 7 deg. C
Relative humidity	Min. 10% to 40 % (except during monsoons)	Max. 90% to 95%
Rainfall	Variable - 800 to 2400 mm/year	

Average temperature and relative humidity in five prominent cities (2)

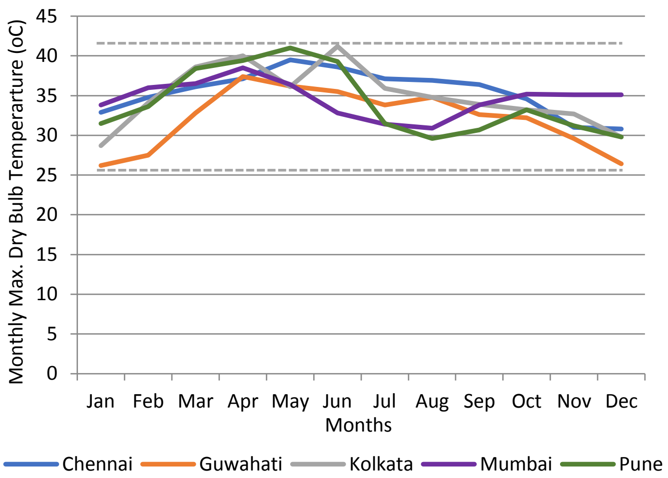

Figure 1: Monthly maximum dry bulb temperature

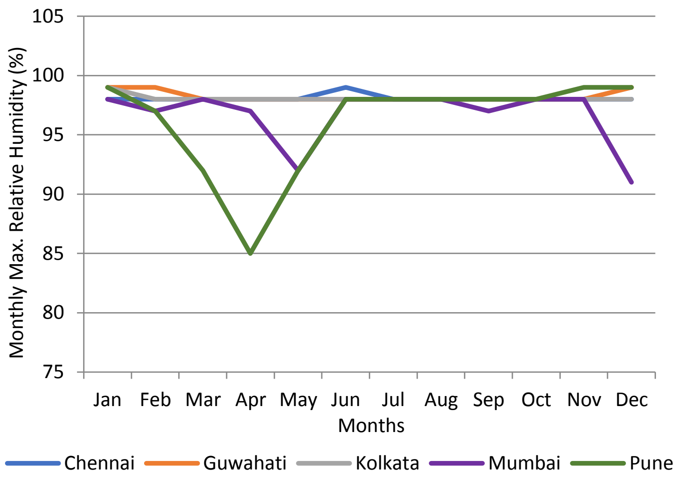

Figure 3: Monthly maximum relative humidity

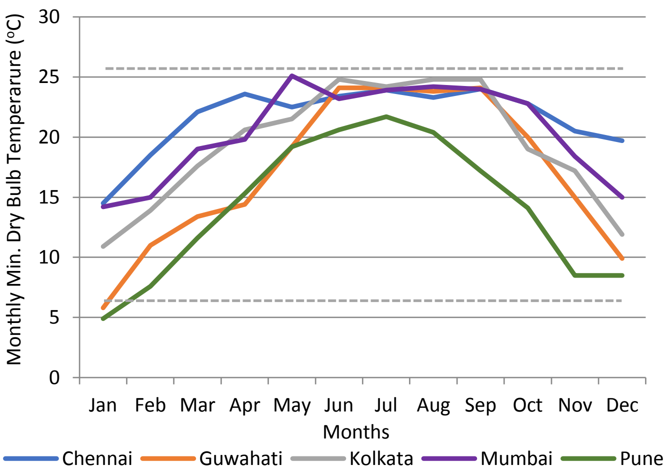

Figure 2: Monthly minimum dry bulb temperature

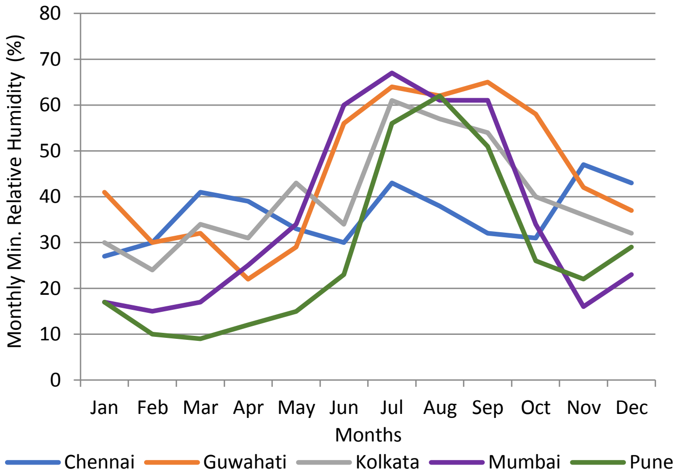

Figure 4: Monthly minimum relative humidity

Site Location

Convenient access to basic day to day amenities around the development has been identified as an important aspect of approach towards sustainability of a housing development. (3, 4).

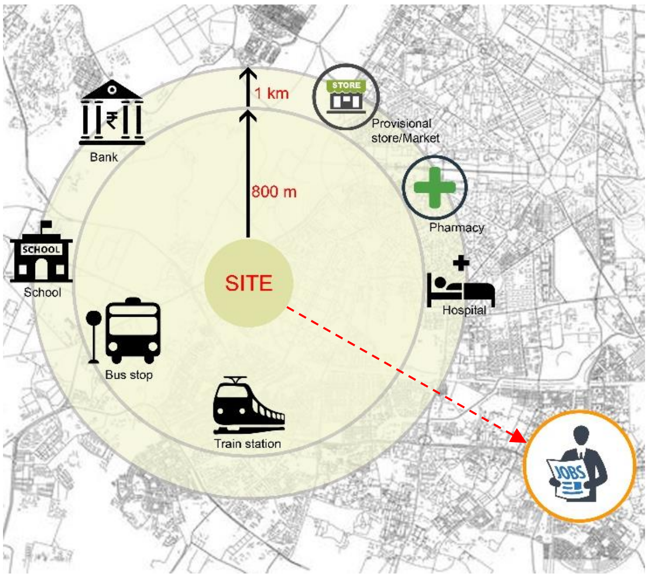

Figure 5: Site location

- Public transport facilities (intra-city station/bus stop/ metro) to be at a maximum distance of 800 meters from the development.
- Basic amenities like hospital/clinic, pharmacy, schools, market/provisional store, ATM/bank to be within a walking distance of 1 km from the development.
- The site location should be such that it either provides the residents easy access to job opportunities or is well connected with the city's main commercial/employment centric areas where the residents work/could find work.

Figure 6: View of market near Jakkampudi colony in Vijayawada (Despite being 11km from the city centre, the residents of Jakkampudi colony had easy access basic amenities)

Massing and space planning

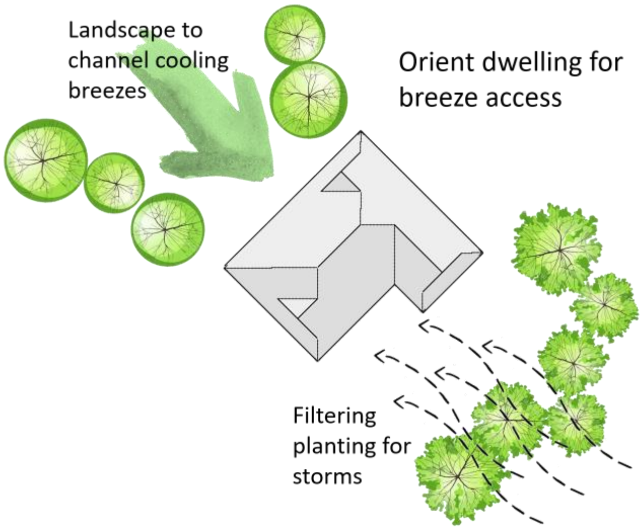

Figure 7: Orienting dwelling for optimum breeze access

- Building axis must be oriented along the east-west direction so that the longer walls face north & south, and only the shorter walls face east-west, to minimise solar exposure of the external walls.
- Habitable spaces should be placed along the north and centre of the building, while buffer spaces like store rooms, staircases and toilets should be located on eastern and western facades, to maximize indoor comfort of the occupants.

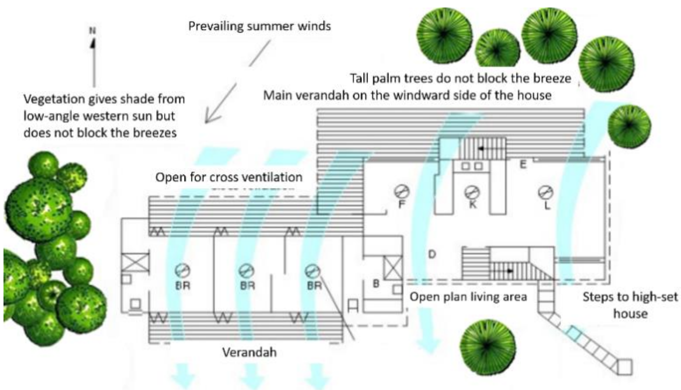

Figure 8: Design for a house in warm & humid climate

- To optimally utilise the wind flow, the building needs to be oriented at an angle (usually +/- 45 degrees) to the prevailing wind direction. Building forms with shorter depths can facilitate cross ventilation throughout the building.
- Neighbouring building blocks or other features like trees should be planned to achieve mutual shading, to avoid direct solar heat gain especially during summer.

Building envelope

Thermal performance

The thermal performance of a building envelope refers to its capacity to regulate heat exchange and it serves to be one of the most important criterions especially in case of buildings in warm & humid climate zone. The design of building envelope in this climate should be done keeping in mind the following considerations:

1. Reduce heat gain, by minimising the solar exposure of the building components (external walls, windows and roof).
2. Improve natural ventilation and utilise air flow to remove indoor heat and enhance thermal comfort for the occupants (5).

- The baseline thermal conductivity (U-value) value for different building components as defined in IGBC Green Affordable housing are provided below (4).

Building component	**U-value (W/m^2K)**
Wall	≤2.5
Roof	≤1.8
Glazing	≤5.7
Glazing (SHGC)	
WWR <20%	0.5
WWR >20%	0.42

- Use of materials with low thermal mass is preferable, since the diurnal temperature difference is low. While in composite and hot & dry climates, this could lead to reduction in cooling energy, but in warm & humid climates, they are not so effective.

- Heat gain from the external walls can be minimised by using light colours on the exterior surfaces (absorptivity < 0.4).

- Heat gain from roof surface can be reduced by using roofing materials with high Solar Reflective Index (SRI), like white broken china mosaic, high SRI paints etc. on the roof surfaces.

- In the particular case of social housing developments where affordability is of prime concern, insulating the walls may not be economically conducive. Hence, ensuring good quality construction practices to avoid or minimise air leakage through cracks and joints can contribute in improving the overall indoor comfort.

Window openings and shading

- In warm & humid climatic zone, where cool interior spaces are preferred for most of the year, large glazed windows should be avoided to reduce excessive heat gains and loss from the glazing.

- Windows area should be 15 to 20 percent of floor area. The sill height of windows should be low. Fixed windows should be avoided.

- Ensure adequate shading on the west and south side windows to cut-off direct solar radiation during the latter half of the day, especially in hot summer months but permit winter sun. Fenestrations on the northern façade of the building needs better shading especially in case of southern India.

- Minimum projection factor for external shading should be 0.5 (3).

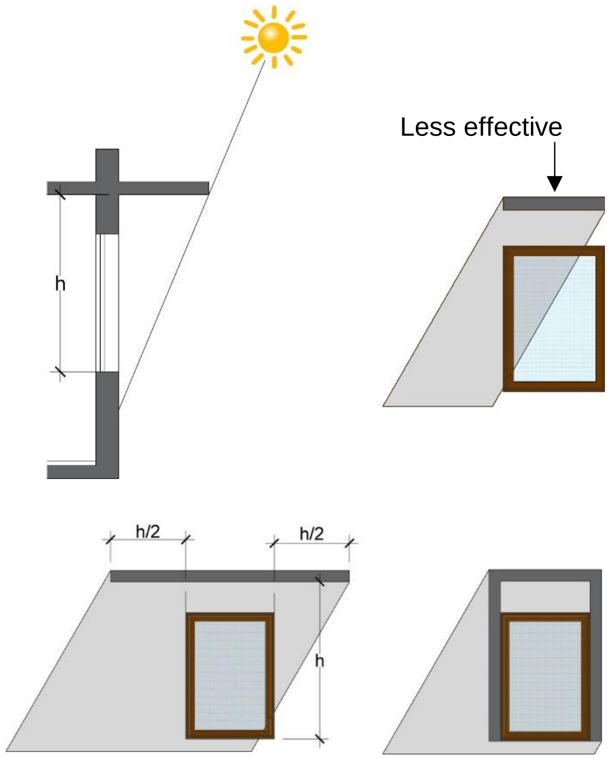

Figure 8: Guideline for designing effective horizontal shading for windows on south façade. Image adapted from: The Carbon Neutral Design Project (6)

Daylighting

- A window-wall ratio of 10%-15% in bedrooms and 30% in living room are optimum to provide adequate daylight.
- Providing windows at higher lintel levels or use of light shelves can increase the daylight penetration into the building. It is conducive to have lesser glazed facades in warm & humid climates. These openings should be planned at facades that do not face direct sun to utilize the diffused light.
- As a rule of thumb- daylight penetrates a room approx. 2.5 times the height of the top of the window.

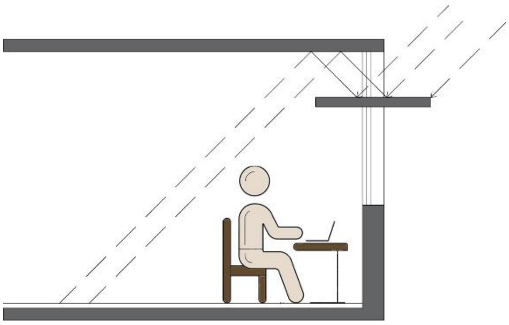

Figure 9: Light shelves (Externa/internal light shelves allow diffused light penetration & shade)

Figure 10: Daylight penetration extent in a space.

Ventilation and passive cooling

- In the warm & humid climatic zone where diurnal temperature variations are low, natural ventilation throughout the day is favourable and economical to achieve comfort levels inside the building.

Funnel effect

- Directing prevailing wind towards the building is one of the best ways to achieve relative 'coolth' in habitable spaces. The process of redirecting the wind flow from a larger catchment area to a smaller will convert high pressure low velocity winds to low pressure high velocity winds, providing more coolth as they pass through.
- Sashes, canopies and louvers help achieve this effect around the fenestration. Strategic placement of dense vegetative cover and wing wall are on-site strategies to channelize the wind.
- This deliberate creation of positive and negative pressure zones can create an increased air flow through the building for cooling effect.

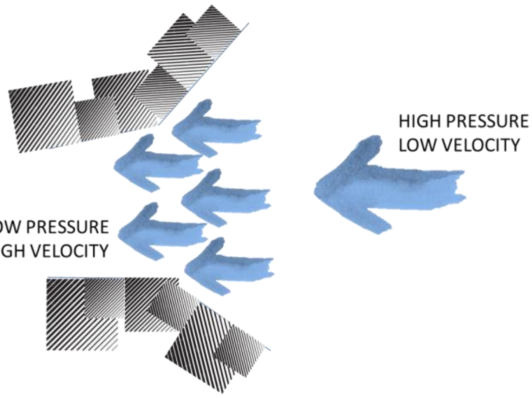

Figure 11: Funnel Effect

Drainage & Waste management

- The site plan should be developed so as to minimize the disturbance caused to the existing natural habitat at the site. Detailed guidelines for providing and developing green areas at site are available in NBC vol. 2, 2016.

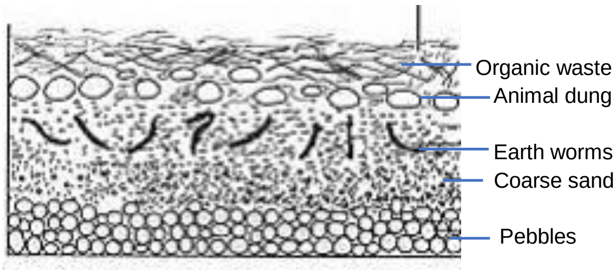

Figure 12: Diagram of vermicomposting pit

- Segregation and disposal of organic waste through natural process like dump-pits, vermi-composting etc. should be incorporated in the design and planning of the project to encourage cleanliness at site. A regulatory body can be formed from among the residents to oversee the regular disposal of garbage. This will help provide them with a sense of responsibility and also assist in job creating.

Water conservation

Rainwater Harvesting

- Since warm & humid climate zones receive heavy rainfalls, capturing and preserving rain water is an excellent opportunity to reduce portable water consumption and address water crisis.
- Rainwater harvesting can be done either for-

I. Storage (underground or over-ground tanks) and direct use of rain water, or

II. Charge into the ground – Ground water recharge.

- Rainwater harvesting system for a minimum of 20% of run-off volume from impervious surfaces (both site & roof) should be provided.

Or

- If the ground water table is less than 4m, rainwater harvesting storage tanks for a minimum of 7.5% system for a minimum of 20% of run-off volume from impervious surfaces (both site & roof) should be provided (4).

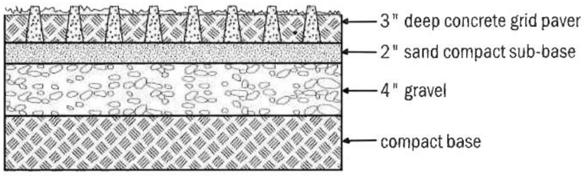

Figure 13: Performed lattice unit grids for storm run-off control, pedestrian pathways and soil conservation. Image adapted from: Sustainable Building Design Manual, Vol.2 (7)

- Providing pervious &/or semi-pervious surfaces on site, in the form of grass pavers, pebble beds etc. can also lead to less run-off and allow for ground water recharge through a larger area.

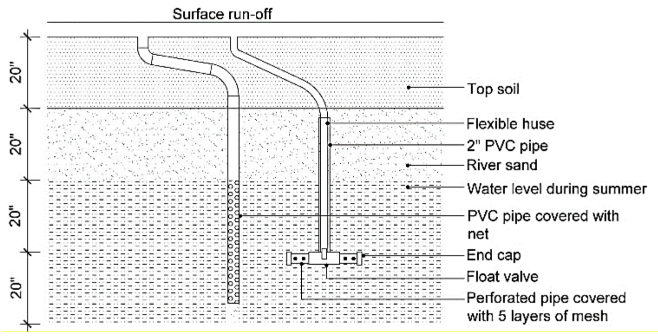

Figure 14: Rainwater harvesting combined with a pavement design at an interval dependent on the run-off. Image adapted from: Sustainable Building Design Manual, Vol.2 (7)

- The type & amount of rainwater harvesting suitable for a development varies and depends on the climatic zone, rainfall intensity, soil conditions, run-off volume and site design. NBC and Local Building Byelaws must be referred for planning and detailing RWH system in a development.

Building materials

Selection of materials in warm and humid climate should be done primarily to :

- Reduced heat gain through increased thermal resistance and buffer spaces
- Promote quick heat loss
- Be local availability to reduce transportation energy.
- Have lower embodied energy (EE).
- Minimise humidity through quick dissipation

Exposed materials with high absorption rate perform well when properly sheltered from rain by absorbing humidity from within the building.

As diurnal variation is low, insulation in the roof does not provide high benefits (3). RCC filler slab helps increase insulation and reduces heat gain from the roof. Reflective/light paint or the use of broken glazed tiles reduces the heat gain further.

Materials with cavities such as hollow concrete blocks and rat-trap bond perform better as they introduce air spaces which act as buffer zones and ventilation points.

Water proofing is an essential step in construction in the warm and humid climate.

Impact on cooling load

- Simulations were carried out to estimate the annual energy consumption per unit area due to cooling, in a 4 storey building using DesignBuilder software. The Bhawana housing case study was used as a reference to model a social housing project in the context of India. The simulations were run for a single dwelling unit of 22.35 Sq. M. area situated on the top floor (4th floor). A split air-conditioning HVAC system (COP-3.26) was modelled and the set-point for the operative room temperature was assigned in accordance with the EN 15251 standards of adaptive thermal comfort.

- Occupancy and activity schedules were assumed from national standards, similar research work and homeowner's survey data collected as part of MaS-SHIP. A total of 16 existing and emerging building construction systems were assessed in comparison to the base-case. Comparative analysis between the annual cooling load per Sq. M. shows the savings potential for each of these systems as enlisted in the table below.

	Warm & Humid		
	Base Case	**Cooling energy ($kWh/m^2/yr$)**	
	Walling (12.5 mm cement plaster + 225 mm brick + 12.5 mm cement plaster)	**44.85**	
	Roofing (100 mm RCC + 100 mm lime concrete)		
		Savings from Base Case	**Savings**
		($kWh/m^2/yr$)	**In %**
	Improvements - Walling		
1	Fly Ash brick	1.48	3
2	AAC Block	13.23	29
3	Rat-trap bond	2.30	5
4	Hollow concrete block masonry	1.52	3
5	Solid concrete block masonry	-2.07	-5
6	Compressed Stabilised Earth Block	-1.57	-3
7	Stonecrete Blocks	-1.85	-4
8	Glass Fibre Reinforced Gypsum (GFRG) panel	-2.24	-5
9	Precast Large Concrete Panel System	0.93	2
10	Reinforced EPS Core Panel System	-1.83	-4
11	Light Gauge Steel Frame (LGSF)	-0.40	-1
12	Monolithic Concrete Construction using Plastic/Aluminium Formwork	-1.31	-3
	Improvements - Roofing		
1	Reinforced Brick Panel Roof	6.16	14
2	RCC Filler Slab	-0.78	-2
3	Plank & Joist Roof (60 mm tile above + 60 RC plank + 75 mm mud phuska)	3.82	9
4	Ferro-cement Roof Channel	10.89	24

Note- Negative sign signifies that the building system impacts to a higher cooling load than the base case.

- While AAC Block has the highest savings potential, Glass Fibre Reinforced Gypsum (GFRG) panel system performs the worst. The simulation has been run for a dwelling unit with exposed roof, hence the most drastic changes in cooling load were observed in cases where the construction of roof changes.

Sustainability Assessment Tool

- The Sustainability Assessment Tool (SAT) is built on a Multi-Criteria Decision support system to provide the targeted beneficiaries with evidence based performance information. This would aid decision making in their choice of building materials and construction systems, both walling and roofing, for social housing projects in India.

- A total of 17 building materials and systems have been evaluated on the basis of 18 attributes categorized under 4 main criteria – Resource Efficiency, Operational Performance, User Experience and Economic Impacts

- The link to the SAT is: https://teriindia-my.sharepoint.com/:x:/g/personal/megha_behal_teri_res_in/EYFFmyuT1sdDjvod8oZqlK4BVw-OKPkVGVlnUn-8Rsro4g?e=sZrveE

- The SAT would enable the user to make an informed choice by providing:
  - Order of preference of 17 walling & roofing building systems across all 18 attributes
  - Order of preference of 17 walling & roofing building systems across selected attributes
  - Customized results based on the location selected

- The SAT outputs are represented in the form of graphs which provide '**scores**' of the building materials and systems with respect to the selected attributes. The scores have been calculated on the basis of absolute data gathered for 17 building materials and systems across 18 weighted attributes.
- Higher score of a building material or system with respect to others is an indicator of its better performance. Precisely, higher the score, better the building material or system.

Insights from resident experiences of living in social housing developments in warm & humid climate

- Dwellings in social housing developments fail to provide comfort indoor environment especially in summer (in the absence of air–conditioning). Interventions like desert coolers which might be implementable in other climatic zones of India, fail to provide any real comfort in warm & humid climatic zone, as they might tend to over-humidify the living space.

- More number of households perceived *indoor air quality as stuffy during summer.* This can be attributed to the inappropriate locations of the window wherein most of the windows and ventilators open on to the central access corridor and/or the staircase. The residents were forced to keep these windows closed due to privacy issues, resulting in inadequate cross-ventilation, making the interiors feel *stuffy.*

- The housing projects aimed to address the needs of people from the economically weaker sections of the society often face cost constrains and therefore focus on using cost-effective affordable building materials and systems. Consequently, the quality of construction and workmanship gets compromised.

- The nail-ability of the walls is an important lifestyle factor for the people belonging to this group. It is one of the few ways they can modify their habitable spaces. Poor quality of workmanship and difficulty in accessing plumbing pipe works for repair and maintenance were the primary concerns expressed by the householders.

- The lack of maintenance and up-keep of the common areas and the site was a common sight in all the surveyed developments. In some developments incomplete or poorly planned drainage system lead to water logging around the dwellings, while absence of cleanliness and proper garbage disposal system resulted in unhygienic streets and surroundings.

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MaS-SHIP

Mainstreaming Sustainable Social Housing Project in India (MaS-SHIP) is a two-year research developed to promote sustainability in terms of environment performance, affordability and social inclusion as an integral part of social housing. Funded by the United Nations Environment Programme (UNEP) 10 Year Framework of Programme on Sustainable Consumption and Production (10YFP).

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