Calculation of RETV for Residential Project

A Comparative Study for Different Walling Materials for Various Climate zones

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INTRODUCTION

RETV (Residential Envelop Transmittance Values) measured in W/m2, is considered as a methodical approach to evaluate and ascertain thermal comfort in residential buildings and houses. It evaluates thermal efficiency of building envelope, in terms of External walls, windows / Glass and Shading over the non-opaque surfaces in building envelopes. It is more effective in reducing indoor heat ingress and provides continuous comfortable living along with attractive payback in terms of substantial savings in energy utilization for cooling of a residential building. This norm is well established and adopted with a certain amount of customization in several countries globally.

The Government of India too, in association with BEE (Bureau of Energy Efficiency), has drafted a building energy code for residential buildings based on RETV, “Eco Niwas Samhita” released in the year 2018.

Wienerberger India along with Greentech Knowledge Solutions Pvt Ltd (GKSPL), who has contributed in the developing draft of the Code, has recently conducted a study to analyze and compare the impact of walling materials on indoor thermal comfort by evaluating the RETV values and its implications. This paper titled, **Calculation of RETV for Residential Projects: A Comparative Study of Different Walling Materials for Various Climate Zones**, discusses the key findings of this study and the importance of choosing the right walling material for a house that creates a thermally conducive indoor living environment. The RETV calculations only involve the external surfaces / envelope of the building, including doors and windows, shading due to projections etc.

SUMMARY

The report, intended to cater to all related stakeholders including LEAD consultants, construction companies, architects and residential home buyers, aims to increase the awareness of using green and sustainable walling materials and its benefits.

The study was conducted across four cities situated in different climate zones across Southern India, in accordance to the methodology provided in the Eco-Niwas Samhita, 2018. The four cities chosen were Bangalore (temperate), Hyderabad (composite), Chennai (warm and humid) and Cochin (warm and humid). It analysed and compared Residential Envelope Transmittance Value (RETV) for different walling materials, including:

- 200mm Porotherm Thermobrick
- 200mm Porotherm HP
- 200mm Solid Concrete blocks
- 160mm RCC shear walls

The *'U values'*, which measure the heat transmission of any material, were considered for the four products. Porotherm Thermobrick had the lowest (the lower the value, the better) *U Value* of 0.585 W/m^2K as compared to RCC Shear Walls which had the highest value of 3.69 W/m^2K. This indicates that Porotherm Thermobrick delivers highest thermal comfort amongst all other walling materials tested.

The actual indoor to outdoor temperature was recorded and compared throughout the day. There was a marked difference in the outdoor and indoor temperatures (3° C to 7° C) during the period it was measured and compared.

RETV Values - For Different Climate Zones

	RETV (W/m²)			
Walling options and U-Value	Bangalore (Temperate climate)	Hyderabad (Composite climate)	Chennai (Warm - Humid climate)	Cochin (Warm - Humid climate)
200mm Porotherm Thermobrick, 0.53 W/m^2. K	6.9	10.0	8.8	8.8
200mm Porotherm HP, 0.96 W/m^2. K	8.1	12.0	10.5	10.5
200mm Solid Concrete blocks, 2.83 W/m^2. K	13.5	21.7	18.7	18.7
160mm RCC shear walls, 3.69 W/m^2. K	16.0	26.2	22.5	22.5

RETV compliant, RETV≤15 W/m^2 Not RETV compliant, RETV>15 W/m^2

Table 1: RETV results for four building materials and four climate zones

Table 1 clearly shows that Porotherm clay blocks are fully RETV compliant across different climate zones. On the other hand, solid concrete blocks and RCC shear walls are not compliant with RETV requirements in all climate zones in South India. This leads to the three main advantages of using Porotherm blocks, as compared to other walling materials:

1. **Influence on Air Conditioning Cooling Loads, Leading to Cost Savings:** RETV has a high correlation with sensible cooling loads required for air conditioning. Simply put, lower the RETV of a material, the lower will be the load on the air conditioning. This means that for a typical 100 m^2 (appx. 1080 Sq. Ft.) of air-conditioned built-up area, the sensible cooling load using RCC would be 18,700 kWh_{th} as compared to just 10,200 kWh_{th} if you are using Porotherm bricks. Using a Coefficient of Performance of 3.0 for the air conditioner, for the same built-up area, RCC shear walls would consume 6,233 kWh units annually, while Porotherm Thermobricks would consume just 2,833 kWh units. This leads to a direct annual cost saving of ₹ 18,698. (Electricity unit rate in Tamil Nadu is ₹ 6.60 / unit)

2. **High Living Comfort:** Porotherm blocks are made from clay, a 100% naturally occurring material, which is free from any chemical additives. Clay being a breathable material, helps to keep the indoor environment habitable, cool and comfortable (with minimal artificial conditioning). The uniqueness of clay ensures natural, effective cooling in hot weather and better thermal insulation in cold weather, thereby reducing the need for artificial air conditioning. Furthermore, it provides better air quality and air circulation in the house.

3. **Complying with Government Green Initiatives:** Concrete and cement are a major 'sink' in terms of sustainability, due to the sheer volume that is being used. It is estimated that the per capita consumption of concrete in India is approximately 1.5 tonnes annually. The Government is planning to introduce new green initiatives in the building and construction industry to reduce global warming damages and improve sustainability. One of the key initiatives is revisiting the codes and requirements, ECO NIWAS SAMHITA guidelines insist on having RETV of 15 or less for residential building envelopes. Porotherm bricks meet these requirements upfront.

The study was conducted by evaluating the above mentioned different walling materials for a residential building project across 3 climate zones:

- Bengaluru: Temperate Climate
- Hyderabad: Composite Climate
- Chennai and Cochin: Warm and Humid Climate

The following information is recorded and tabulated for the given residential project:

- Architectural drawings (plans, sections and elevations)

  a) Dimensions and orientation of the building envelope components (walls, fenestration, shading and roof)

  b) Door-Window schedules with sill and lintel levels

  c) Shading dimensions, distance from glass edges

- Construction details: Material and its thickness for external wall and fenestration.
  E.g. external wall: 20 mm outer plaster + 200 mm thick external walls + 10 mm internal plaster

CONTENTS

Methodology

2.1 Steps for RETV calculation as per Eco Niwas Samhita 2018

a. Calculating envelope lengths and envelope area for each floor:

- What is included and what is not included in calculating envelope lengths-
    - Exposed envelope lengths of different dwelling units are included and;
    - Exposed areas of common spaces such as stairwells, lobbies etc. and unexposed walls of the dwelling units (facing corridors etc.) are not included in calculating envelope lengths.
- Calculating wall lengths:

    Wall lengths for each orientation are calculated considering the outer perimeter line of the wall (Figure 1).

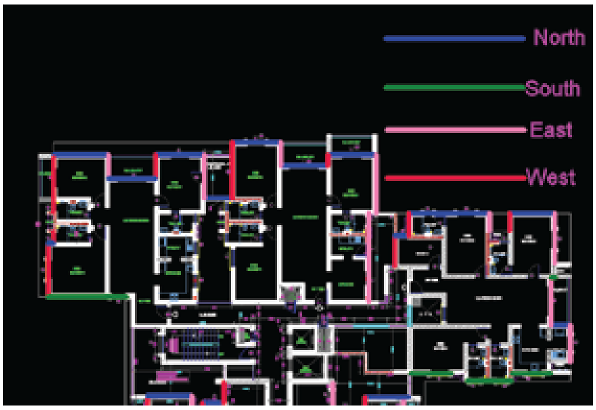

Figure 1: Calculation of orientation wise envelope lengths

- Envelope area: Envelope areas are calculated by multiplying the envelope lengths (W) with the total height (H) of the building (Figure 2).

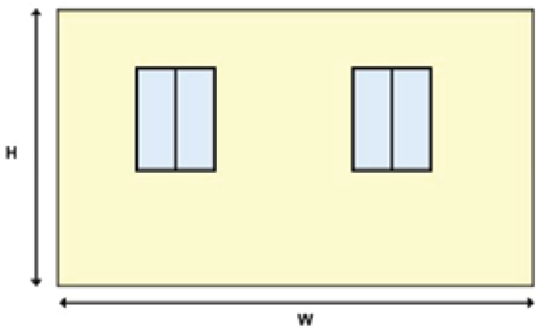

Figure 2: Calculating envelope area from the project drawing

b. Taking note of all openings on the external wall: All windows that face or open directly to the external atmosphere or a balcony have been considered for RETV calculation.

c. Impact of external shading

Impact of external shading such as overhang and side-fin have been accounted. Please refer Annexure 1(b) to understand calculation of H and V values of side-fin and overhang.

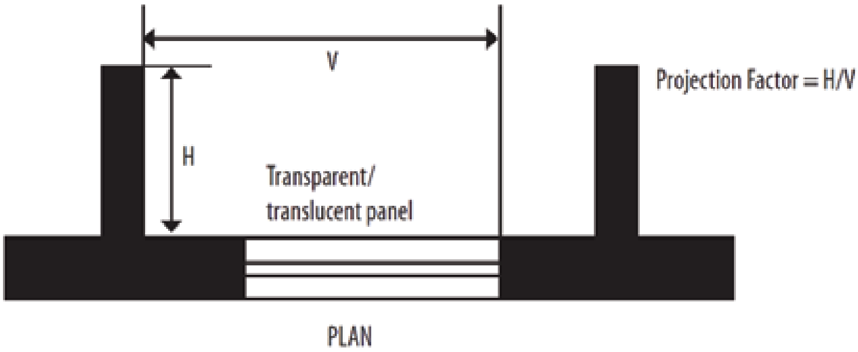

Figure 3: Calculating projection factor for side fin in plan

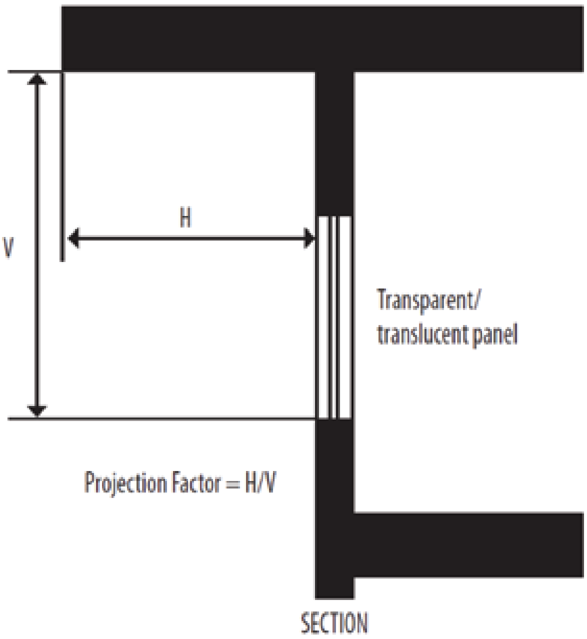

Figure 4: Calculating projection factor for overhang in section

2.2 What all is considered in RETV calculation?

Except basement, ground floor and floors used for commercial purpose on 17th and 18th floors, all other floor areas are considered in the RETV calculation (Figure 5).

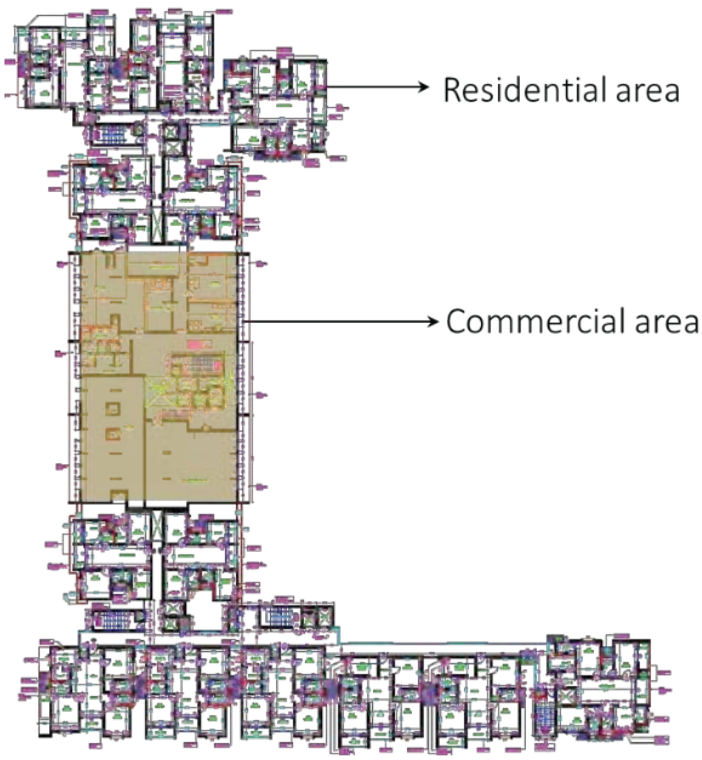

Figure 5: 17th Floor Plan
On 17 and 18th floor, only residential units have been considered for RETV calculation

All inputs considered for RETV calculations are given in Annexure 1(c).

Results and interpretation

Wall material	Thickness (mm)	U-Value (W/m². K)	Remarks
POROTHERM HP with 20mm plaster outside and 10mm plaster inside	200	0.96	U-Value is referred from Wienerberger online brochure.
POROTHERM Thermobrick with 20mm plaster outside and 10mm plaster inside	200	0.585	
Solid Concrete Blocks with 20mm plaster outside and 10mm plaster inside	200	2.83	Source from reputed supplier
RCC Shear Walls	160	3.69	In the projects studied and observed, the thickness of the RCC shear wall considered ranges from 150-170mm, therefore, 160mm thick walls have been considered. Plaster has not been considered.

Table 2: Walling materials considered for analysis

Table 2 gives the walling material thickness and U-value details that has been taken as an input in RETV calculation of this building. The Window wall ratio is 13.8% and the weighted average of effective SHGC is 0.53. The location wise RETV results achieved are given below (Table 2).

3.1 RETV results

	RETV (W/m²)			
Walling options and U-Value	Bangalore (Temperate climate)	Hyderabad (Composite climate)	Chennai (Warm - Humid climate)	Cochin (Warm - Humid climate)
200mm Porotherm Thermobrick, 0.53 W/m². K	6.9	10.0	8.8	8.8
200mm Porotherm HP, 0.96 W/m². K	8.1	12.0	10.5	10.5
200mm Solid Concrete blocks, 2.83 W/m². K	13.5	21.7	18.7	18.7
160mm RCC shear walls, 3.69 W/m². K	16.0	26.2	22.5	22.5

RETV compliant, RETV≤15 W/m²   Not RETV compliant, RETV>15 W/m²

Table 3: RETV results for four building materials and four climate zones

As per Eco Niwas Samhita, to meet the RETV compliance requirement, the project should achieve an RETV ≤ 15 W/m². RETV is the net heat gain rate (over the cooling period) through the building envelope (excluding roof) of the dwelling units divided by the area of the building envelope (excluding roof) of the dwelling units (BEE, 2018).

For e.g. If 730 kWh is the heat gain through the building envelope during cooling period (February -November or 7272 hours) and the envelope area of the space is 10 m² The RETV of this space will be:

$$= \frac{730\ kWh}{10\ m^2 \times 7272\ h}$$

Hence, **RETV= 10.03 W/m²**

In Table 3,

1. In all the cases, 200mm Porotherm Thermobrick has the lowest RETV while 160mm RCC shear walls has the highest RETV.
2. Bangalore comes under the Temperate climate. For the given building, Porotherm Thermobrick & Porotherm HP are best suited to achieve higher living comfort
3. Hyderabad comes under the Composite climate. For the given building, the RETV values are highest amongst all selected cities. Except for concrete blocks and RCC shear walls, all other walling materials (Porotherm Thermobrick, and Porotherm HP) could meet the RETV criteria.
4. Chennai and Cochin comes under the Warm and Humid climate. For the given building, except for concrete blocks and RCC shear walls, all other walling materials (Porotherm Thermobrick and Porotherm HP) could meet the RETV criteria.

3.2 Impact of RETV on sensible cooling load/ electricity required for air conditioning

RETV has a very strong correlation with the sensible cooling loads (Qsensible in kWhth/m² of built-up area) of the building (Table 4), this is explained through the example provided for Chennai.

Sensible cooling load (kWh_{th}/m^2 of built-up area)							
Climatic Zone	RETV (W/m2 of envelope area)						
	5	10	15	20	25	30	35
Composite / Hot-Dry	66	93	120	146	173	200	226
Warm-Humid	78	109	140	171	202	233	264
Temperate	28	45	62	80	97		

Table 4: RETV & Sensible Cooling Load Co-Relation

The range covers minimum and maximum RETV values for respective climatic zone, intermediate values can be derived by interpolation.

3.2.1 Sample calculation for this building in Chennai comparing Porotherm Thermobrick blocks and RCC shear walls

1. From the above graph, the $Q_{sensible}$ for Chennai for this building, with RCC shear walls (RETV: 22.5 W/m^2) is ~187 kWhth/m^2 of built-up area and the same with the Porotherm Thermobrick wall (RETV: 8.8 W/m^2) is ~102 kWh_{th}/m^2 of built-up area.
2. This means for a typical 100 m^2 of air-conditioned built-up area, the sensible cooling load with RCC shear walls will be 100 x 187 = 18700 kWh_{th} and the same with the Porotherm Thermobrick wall will be 100 x 102 =10,200 kWh_{th}.
3. If we consider a typical Coefficient of Performance (COP) of 3.0 for the air-conditioner, the 100 m^2 of air-conditioned built-up area with RCC shear walls would consume 18700/3 = 6,226 kWh of electrical units in a year while with the Porotherm Thermobrick wall will consume 10200/3 i.e. 3396 kWh of electrical units. This means 2,830 kWh of electrical units saved in a year or 28.3 kWh/m^2.y of saving with Porotherm Thermobrick wall as compared to solid concrete wall.
4. As per TNERC (The Tamil Nadu Electricity and Regulatory Commission), the unit rate for consumption above 500 units bi-monthly is Rs. 6.60. Therefore, the savings achieved for this residential project will be-
   = 2830 kWh x Rs.6.60
   = Rs. 18680

This implies that this residential unit with 100 m2 of air-conditioned area can achieve annual savings of **Rs. 18680** when Porotherm Thermobrick blocks are used as compared to solid concrete wall material.

Annual Saving in Cooling Electricity Bills (INR/y) for 100 m^2 of air-conditioned space				
Walling options	Bangalore (Electricity* @ ₹7.8/kWh[1])	Hyderabad (Electricity* @ ₹9.5/kWh[2])	Chennai (Electricity* @ ₹6.6/kWh[3])	Cochin (Electricity* @ ₹7.9/kWh[4])
200mm Porotherm Thermobrick, 0.6 W/m^2. K	**8,208**	**27,350**	**18,680**	**22,359**
200mm Porotherm HP, 1 W/m^2. K	**7,126**	**23,974**	**16,362**	**19,585**
200mm Concrete blocks, 2.83 W/m^2. K	**2,255**	**7,597**	**5,181**	**6,202**
160mm RCC shear walls, 3.69 W/m^2. K	**Base**	**Base**	**Base**	**Base**

Table 5: Annual Saving in Cooling Electricity Bills (INR/y) for 100 m2 of air-conditioned space

Conclusions

With continuous shift in climatic conditions and our lifestyle, demand for air-conditioned thermal comfort is growing exponentially. This is estimated to become the biggest contributor to GHG (Green House Gas) emissions nation-wide. The building envelope is responsible for heat gain, which in turn determines the indoor temperature, thermal comfort, and sensible cooling demand. The Indian Government, as part of its green initiative in building and construction industry, is preparing to introduce tough measures, especially in the area of building materials.

With a clear focus on sustainable and easy to produce walling materials, Porotherm proves to be the clear leader. These clay-based bricks provide natural comfort for temperature extremes in the house. For builders or consumers, overall structural costs come down because of the lighter Porotherm blocks, along with a reduction in electricity bills (where there is air conditioning) and improvement in thermal comfort due to lower thermal conductivities.

Below are some of the key takeaways:

- POROTHERM is the only walling material among the studied materials, which can be used across all types of climate zones in South India
- Walls built with POROTHERM not only keep the house cool but help save substantial money throughout the utility life of the house
- They need zero maintenance
- They come with zero shrinkage cracks and low water absorption

Annexure 1

a. Terminology and definitions (BEE, 2018)

Building Envelope: The elements of a building that separate the habitable spaces of dwelling units from the exterior and are exposed to the ambient (i.e., exposed directly to external air and opening into balconies). It does not include walls facing open corridors and enclosed shafts, as well as walls of common services such as lifts and staircase.

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

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

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

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

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

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

U Value: Thermal transmittance (U value) is the heat transmission in unit time through unit area of a material or construction and the boundary air films, induced by unit temperature difference between the environments on either side. Unit of U value is $W/m^2.K$. The U value for a wall/roof/glazing indicates its ability to transfer heat through conduction.

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

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

b. Link of Eco Niwas Samhita 2018 (ECBC-R):

https://www.beeindia.gov.in/content/ecbc-residential
https://www.beepindia.org/wp-content/uploads/2013/12/Eco-Niwas-Samhita- 2018_1.pdf

1. For external shading H and V values input, refer Annexure 7, Page no. 28 of the Eco Niwas Samhita code 2018.

2. For RETV formula, refer section 3.4.3 on Page no. 9 of the Eco Niwas Samhita code 2018

About Wienerberger India

Wienerberger, started its operation in India since 2009. In its decade long story in the country, the organization has remained market leader in delivering high-quality clay building materials for modern living. Its sustainable, future-ready solutions are setting trends in new-age constructions while improving people's quality of life.

Wienerberger has its own state-of-the-art production facility in Karnataka which is also its first Asian plant. The facility is highly automated and engages robots for material handling, while adopting efficient use of locally available raw materials and energy to produce green and sustainable bricks for the Indian market. In continuation with its rich legacy of 200 years, the goal of Wienerberger India is to meet the design requirements of architects, developers and builders while creating natural and healthy living spaces for the Indian consumers.

About Greentech Knowledge Solutions Pvt.

GKSPL is a Research and Advisory firm which offer services and solutions for improving energy efficiency in buildings, improving resource efficiency in the production of building materials and deployment of decentralized renewable energy systems. Our spectrum of services ranges from assessment of technologies, development of design concepts and design advice, policy research and advocacy, & training and knowledge dissemination. (https://www.gkspl.in/)

GKSPL is the Indian Project Management and Technical Unit (PMTU) for the Indo Swiss Building Energy Efficiency Project (BEEP) which is a bilateral cooperation project between the Ministry of Power, Government of India, and the Federal Department of Foreign Affairs (FDFA) of the Swiss Confederation. Started in 2011, the project's central focus is to help India mainstream energy-efficient and thermally comfortable (EETC) building design for both commercial and residential buildings. BEEP works with building industry, policy makers, and building owners to catalyze adoption of EETC building design and technologies. (https://www.beepindia.org/)

BEEP has provided all the required technical support for the development of the energy conservation building code for residential building or Eco-Niwas Samhita (ENS) 2018. (https://beeindia.gov.in/content/ecbc-residential)

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