Training Manual on application of building insulation

A Step-by-Step Guide to the Practice of Good Insulation techniques for the Energy Efficiency of Buildings

INDIA INSULATION FORUM

Training Manual on Application of Building Insulation

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FOREWORD

The Government of India is on a mission to provide 24X7 power to all by 2019. This means that not only does it have to increase the generation capacity, but also reduce the demand for electricity. Buildings are one of the largest consumers of electricity and hence incorporating energy efficiency features in the design would help in reducing the energy consumption together with improving thermal comfort. .

The building envelope plays a very critical role in the performance of energy efficient buildings as the major heat gain takes place through the roof and walls. Insulation is therefore a key element in achieving the building energy performance parameters as prescribed in building codes. Although the building codes are at the early stages of implementation, BEE is working closely with the urban development departments of the state governments for its wide-scale adoption. It is equally important to sensitize building design professionals and practitioners on the importance of appropriate building insulation usage.

It is heartening to see that the India Insulation Forum (IIF) is working towards creating a skilled workforce for enabling proper application of insulating material. This is equally essential in enhancing the confidence of building developers and the construction industry to the benefits of insulation usage for energy efficient building design. These guidelines developed by the IIF for insulation material applicators will help in adopting standard operating procedures for insulation application in buildings.

I congratulate the India Insulation Forum in their endeavour, and acknowledge the technical support extended under the Indo-Swiss BEEP and the UNDP-GEF projects in developing this manual. I urge the building construction fraternity to make use of these guidelines to arrive at energy efficient building solutions and create a large pool of thermally comfortable buildings.

(Ajay Mathur)
Director General

PREFACE

Anyone building or renovating a property today should be aiming to minimize energy requirements. After all, cooling and lighting costs need to remain affordable. Cooling accounts for by far the largest proportion of the energy used in commercial and private households (an average of 60%). Effective energy-saving practices must therefore always start with the energy required for cooling.

Several way lead to energy savings, the main ones being installing efficient solar protection, add thermal insulation to the building envelope and modernizing the cooling system. If only modernization of the cooling system is done, in any way, you end up with an oversized system that works hard to compensate for cooling losses through the building envelope. Subsequently insulating the building lead then to reduce the heat load and you get an eight-cylinder engine in a small car.

The first step to be taken by a designer/architect/engineer should be to lower heat gains by installing efficient solar protection together with thermal insulation. Only then should you plan how to efficiently cover the remaining cooling energy requirements, for example with renewable energies.

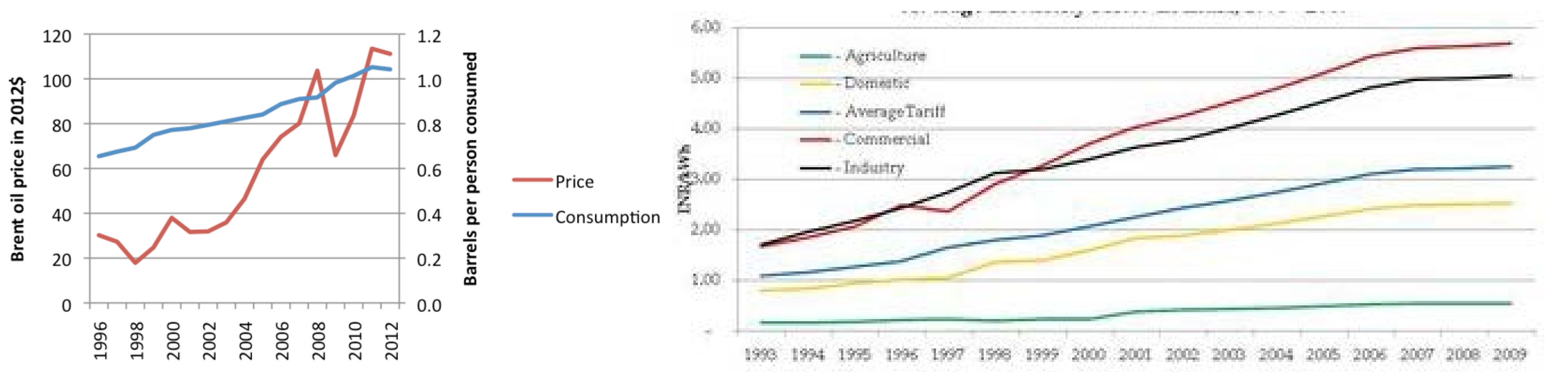
Effective insulation lowers cooling bills and is therefore an important step toward no longer being affected by rising energy prices.

Insulation reduces the amount of energy required and keeps cool in rooms. Interior wall surfaces, ceilings and floors stay in the conditioned temperature and thus prevent the moisture that can allow microbes or mold to flourish. If your building is insulated, it will achieve a better energy certificate rating. In addition to actively helping to protect the climate, insulation pays a key role in significantly reduce the global CO_2 emissions.

If you are planning to renovate, bear in mind that solar protection and insulation are the first and most important step to energy efficiency!

What will energy cost in the future? In the recent past, rising energy costs have put increasing pressure on owner-occupiers and tenants alike (Figure 1). Many are wondering what the future will bring. No one can accurately predict how energy prices will develop in the short term because they depend on the economic situation and a number of other factors.

Figure 1: Oil prices and consumption in India (from http://theenergycollective.com/ and http://www.thealternative.in/



Prices are falling now but we do not know for how long! We are however certain that, in a future today's buildings may live, the energy cost will grow with the depletion of fossil sources. So, the time is ripe to grab the opportunity and invest in making your home/office energy-efficient by installing insulation. India is seeing an aggressive growth which would translate into higher demand of energy and rapid price increases can be expected in the future.

But….crucial to the success of actually benefiting in the multiple ways listed above is the process and skill of technical insulation. This Manual is the first professional attempt by industry experts and government policy implementers who are concerned of the danger of the country losing out on the benefits through poor installation and preparing for the liabilities therefrom, the case as it is beset by its less popular usage. Knowledge shared is half the problem solved.

India Insulation Forum (IIF) was created by IPUA & BEE as a platform to introduce and promote the practice of insulation in buildings and thereby make them energy efficient. Its formal launch took place in Aug 2013 with a seminar participated by key stakeholders like IGBC, TERI, raw material suppliers, applicators and of course, BEE.

A core committee of members from companies such as Lloyd Insulation, Isofoam, Bayer MaterialScience, Supreme Petrochem& Owens Corning and IPUA was formed. Simultaneously, the IIF initiative was keeping in alignment with the Indo-Swiss BEEP project. Three working groups were formed to cover the specific topics of the project: testing, stakeholder awareness and training material.

The year 2014 started off with an ECBC awareness program in Ahmedabad where a cross-section of industry and end users participated and awareness raised, including a lab tour and testing demos.

Further to detailed discussions in the recent past and in order to synergize and formalize the activities of IIF with BEE, the following roadmap is being implemented:

1. **Stakeholder Awareness Campaign**, beginning with Delhi In September 2014 to cover Tier I & II cities (Raipur, Bangalore, Chennai, Vijayawada) in a phased manner. The format to be adopted is that of joint presentations from BEE & IIF with focus on insulation and ECBC.
2. In order to help the users, an **Online Web Tool to familiarize users** with regard to materials, testing, and standards, will be set up.
3. An **Applicator Capacity Building Program** with the goal of offering certified courses will be formulated and deployed at various ITI's and other technical training institutes across the country.

Other alignments include collaboration with Institutes and testing houses like CEPT University's CARBSE, VIMTA, CBRI, Nirma University, Spectro, Isolloyd and other NABL approved ones for incentivized facilities and also creation of an Advisory Board for IIF with the aim of gaining inputs from industry veterans and regulatory authorities.

We consider it a privilege that IIF can work with BEE to help bring about the implementation of the ECBC initiative into normative building & construction. We continue to look to your valuable feedback in playing our role effectively.

ACKNOWLEDGMENTS

The IIF would not have existed if it had not been for the BEE, which fostered the coming together of the insulation industry. Thus, we are indebted to Dr. Ajay Mathur, Director General-BEE and Mr. Sanjay Seth, Energy Economist, BEE for their visionary guidance.

The IIF Core Committee is deeply grateful to the insights and inputs provided by the BEEP team of Professor Claude-Alain Roulet, Dr. Sameer Maithel and Mr. Ravi Kapoor.

The Committee also wishes to thank Parvesh Singla of Owens Corning, Ammar Mahmood & Ajay Singh of Lloyd Insulation and Sunil Bajaj of Isofoam India for the painstaking drafting of and contribution to the document.

Finally the Committee is pleased for the experience itself of working together and enlivening the ‘unity in diversity’ saga once again. We are focussed on the Greater Good of Insulation and are committed to meet all the challenges as we move forward.

We welcome any feedback and suggestions to make our work more effective and seek the participation of all the members of the IIF.

We reiterate here our Vision: People everywhere will use the power of insulation and our Mission: To enhance awareness of using thermal insulation in building envelope and cold chain industry for energy conservation through coordination with Government bodies & nodal agencies.

Core Committee

India Insulation Forum

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Abbreviations used in the Manual

Al.Foil	Aluminium Foil
CPRX	Cold Applied Bituminous Based Adhesive
CFC	Chlorofluorocarbon
C/C	Centre to Centre
ECBC	Energy Conservation Building Code
EPS	Expanded Poly Styrene
G.I	Galvanized Iron
G	Gauge
HCFC	Hydro Chlorofluorocarbon
HVAC	Heating Ventilation & Air Conditioning
M.S.cleats	Mild Steel cleats
PUR	Poly Urethane Foam
PIR	Poly Isocyanurate Foam
R.C.C	Reinforced Cement Concrete
XPS	Extruded Poly Styrene

Chapter 1

Importance of Thermal Insulation in Building Envelopes

Volatile and increasing energy prices, concern over environmental impact, and occupant health and comfort – these are the drivers of green building today. In fact, these trends have become of paramount importance for commercial, institutional and residential building owners.

Thermal insulation in buildings is an important but largely ignored factor to achieving thermal comfort for its occupants. Insulation reduces unwanted and expensive heat gain or loss and can decrease the energy demands of cooling and heating systems. Different types of insulating materials in use today include rigid polyurethane foam, polyurethane spray, expanded and extruded polystyrene foams, glass wool; rock wool etc. Thermal insulation also involves a range of designs and techniques to address the main modes of heat transfer: conduction, radiation, convection and evaporation-condensation.

Heat transfer trough the building Envelope

The thermal envelope defines the conditioned or living space in a house. The attic or basement may or may not be included in this area. How much insulation a house should have depends on building design, climate, energy costs, budget, and personal preference. Regional climates make for different requirements. Building codes specify only the bare minimum; insulating beyond what the code requires is recommended for long-term savings.

The insulation strategy of a building needs to be based on a careful consideration of the mode ofheat transfer and the direction and intensity in which it moves. This may alter throughout the day and from season to season. It is important to choose an appropriate design, the correct combination of materials and building techniques to suit the particular situation.

Insulation primarily takes care of the heat transfer through conduction; however, certain techniques which also address radiation transfer have evolved in the industry and are available. It is appropriate here to have a good understanding of the heat flow types which prevail in buildings.

FIGURE 2: SCHEMATIC ILLUSTRATION OF HEAT FLOWS IN A BUILDING

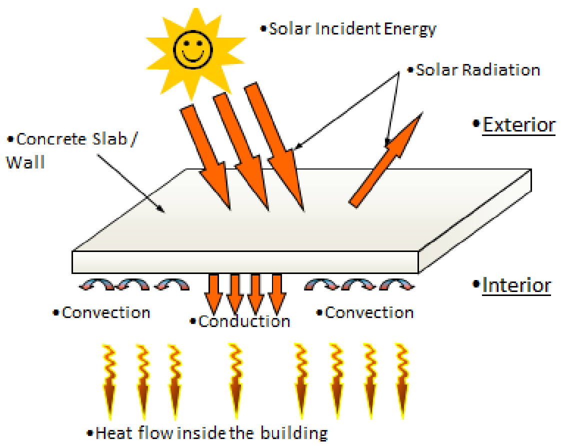

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TABLE 1: FOUR MODES OF HEAT TRANSFER

The fundamental modes of heat transfer, which naturally occurs from high to low temperature locations are:

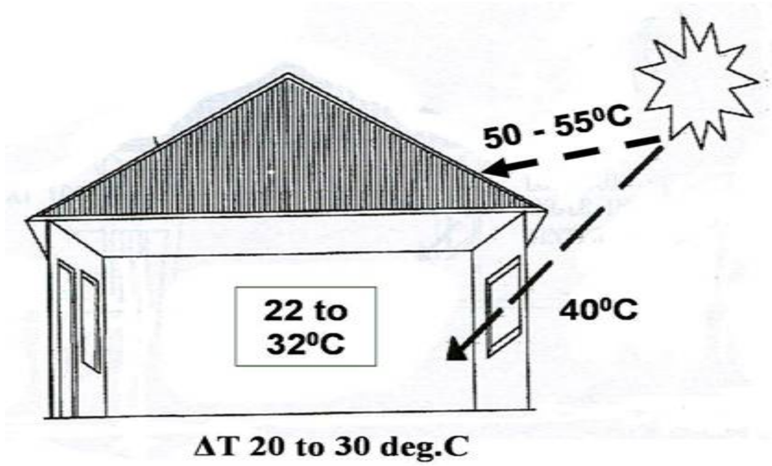
Conduction*:* the direct transfer of the thermal random vibrations from atom to atom or molecule to molecule that are linked together in the matter. Good thermal conductors are dense. To avoid conduction, there should be no matter:the vacuum does not conduct heat. To decrease conduction, low density materials should be used, including air, heavy gases, or non-metallic solids. In thermal insulation materials, conduction is reduced by using mainly air or (another gas) that is a poor conductor.

Convection: the transport of heat in moving warm fluids such as water or air, which give back their heat in contact with a colder surface. Convection is large when a fluid (such as water) with a large heat capacity can easily and quickly move and exchange heat with a hot source at one place and a cold sink a bit further. To avoid convection, the fluids should be either avoided or locked. There is no convection in vacuum or in fluids that cannot move. In thermal insulation materials, the air is locked by the fibres or the foam walls.

Radiation: Electrons, atoms and molecules are electrically charged or polar. When they move, they emit electro-magnetic radiation at a wavelength corresponding to their movement's frequencies. Reciprocally, when an atom or molecule receives some electromagnetic radiation, it becomes agitated, hence heated. Depending on the temperature of the matter, this radiation is in the far infrared (up to about 200 °C) or near infrared range (about 700 °C), or visible (first red at 1200 °C, then white at 5700 °C, then blue when very hot, etc.). Radiation is easily propagated through vacuum or transparent media such as air. Opaque screens or reflecting surfaces are used to stop radiation. In thermal insulation materials, radiation is blocked by opaque fibres or foam walls.

Evaporation-condensation: Much heat is needed to evaporate a heated liquid and, when this water vapour condenses on a cold surface; this heat is recovered and heats that condensing surface. Much heat (about 2.5 MJ or 0.7 kWh for 1 litre) is needed to evaporate water, this condensing water vapour also provides much heat. This very effective transfer process is used in heat pipes. Of course, evaporation-condensation cannot occur in dry places or dry materials, as thermal insulation materials should be!.

FIGURE 3: THERMAL INSULATION IS THE SYSTEM PROVIDED TO RETARD FLOW OF HEAT FROM HOT TO COLD, FROM ENVIRONMENT OR INSIDE OF BUILDING.



THERMAL PROPERTIES OF THERMAL INSULATIONMATERIALS AND COMPONENTS

TABLE2. KEY PROPERTIES OF THERMAL INSULATION

FACTORS	ABBREVIATIONS	UNIT	RELATIONSHIP TO INSULATING VALUE
"K"	Conductivity	W/mK	Lower is better.
"D"	Diffusivity	m^2/sec.	Lower is better.
"U"	Transmittance	W/m^2K	Lower is better.
"R"	Resistance	m^2K/W	Higher is better.

Thermal Conductivity (K) = Time rate of heat flow (Q) through unit area (A) and unit thickness (L) of a homogenous material under steady state conditions when unit temperature difference (ΔT) is maintained in the direction perpendicular to the area - W/mK

$$K = \frac{Q \cdot L}{A \cdot \Delta T}$$

Thermal Diffusivity (D) = Ratio of Thermal Conductivity to the Thermal Capacity per unit volume - m^2/sec and is **a** measure of the rate at which a temperature disturbance at one point in a body travels to another point. It is expressed by the relationship K/(d·Cp), where K is thermal conductivity, d is density and Cp is specific heat.

D = Thermal Conductivity (K)/ThermalVolumeCapacity (C)

$$D = \frac{K}{\rho C_p}$$

K = Thermal Conductivity W/m·K

Cp = Specific. heat in W/m^3K

ρ = density in kg/m^3

Thermal Transmittance (U) = Time rate of heat flow unit area under steady state condition from the fluid on one side of the barrier to the fluid on other side when there is unit temperature difference between the two fluids. Unit = W/m^2K.

U =1 / (R) R= Thermal resistance of material

Thermal Resistance (R) = Thermal Resistance is the property of a layer ofmaterial or a component that opposes the passage of heat through it. Thermal resistance is the temperature difference (ΔT) required to force a constant heat flow rate Q through a layer of material or a component. It is reciprocal to thermal conductance

The thermal resistance of a layer of homogeneous material of thickness L and thermal conductivity K is the ratio:

$R = \frac{\text{Thickness of Homogenous material}}{\text{Thermal Conductivity of the material}}$ or $R = \frac{L}{K}$in (m2K/W)

The effectiveness of a thermal insulation material is commonly evaluated by its Thermal Conductivity that is 'K'-Value. The lower the K-value, the more effective is the insulation material. The main purpose of insulation is to limit the transfer of energy between the outside and inside of a building. Thermal resistance or the 'R-value' of a multi-layered component or a single layer of thermal insulation material is important as it measures the insulation capacity of the materialThe total resistance of a multi-layered component, such a double wall with an insulation layer, is the sum of the thermal resistances of all its layers, plus the surface resistances on both sides of the components. These vary with the wind and the temperature, but, in buildings and at common temperatures and usual winds, conventional values are used. These are: 0.125 m^2K/W indoors and 0.04 m^2K/W outdoors.

Of course, the insulating layer offers the largest resistance, and,in insulated components, the surfaced resistances are often negligible.

The coefficient U of the component is the inverse of the total resistance.

In addition, the properties and density of the insulation material itself arecritical.

Density plays animportant role in thermal conductivity and diffusivity.

At low temperatures below 200°C, a large portion of heat transfer across most insulation materials takes place mostly by conduction. With change in density and temperature, conductivity of this medium changes and as a result the apparent conductivity also changes.

The apparently thermal conductivity of mostinsulation materials increases as the density of material increases. For some materials however (e.g. all fibres), the thermal conductivity increases below a critical density, since radiation and convection then become more important.

Density also plays a very important role in thermal diffusivity, that is related to indoor temperature stability and hence to human comfort.

Other properties or characteristics may be important, depending on the use of the material, as shown in Table 3.

TABLE 3: REQUIRED CHARACTERISTICS FOR THERMAL INSULATION MATERIALS IN RELATION TO THEIR USE.

Characteristics	**Use**
Compression strength	Flat roof and floors, where materials should stand some compression
Traction rupture strength	Materials used in EIFS (External Insulation and Finishing Systems), to resist to wind.
Dimensional stability	Insulation materials used on flat roofs are exposed to large temperature variations, but should not expand too much
Resistance to heat	Insulation materials under bituminous roofing should withstand the heat of soldering roofing rolls.
Water absorption	If materials exposed to water or underground take water, their insulation power is reduced or even disappears
Permeability to water vapour	IN a few cases, it is required that materials should present a resistance to water vapour diffusion
Fire	For internal applications like Underdeck Insulation or Internal partition walls, insulation material should be preferably non-combustible / incombustible.
Thermal Diffusivity	The insulation material should have low thermal diffusivity value to maintain constant temperature for a longer period
Toxicity	For internal applications like Underdeck Insulation or Internal partition walls, insulation material should be preferably non-combustible / incombustible.

Source: Inference from ISHRAE Handbook- All about Insulation and BEEP training manual on Measuring the characteristics of thermal insulation materials

Chapter 2

Definitions of Various Insulation Materials

This manual's scope is limited to insulation material broadly used in the ECBC context. Thus, the insulation materials covered are as under:

TABLE 4: INSULATION MATERIALS COVERED IN THIS MANUAL

Fibrous	Rigid	Flexible*
Rockwool Insulation	Rigid polyurethane foam	Nitrile Rubber
Glass wool Insulation	Rigid Poly Isocyanurate foam	Cross linked polyethylene
	Sprayed rigid polyurethane foam	Expanded polyethylene
	Extruded polystyrene foam	
	Expanded polystyrene foam	
	Phenolic foam	

*Flexible Insulation: They are non-fibrous rubber or thermoplastic material in naturewhich are easily shaped to any design or geometry and predominantly used in HVAC.

For the benefit of the reader, however, the other traditionally used materials are defined in passing:

1. Perlite: Perlite ore (volcanic glass) expanded by exposure to heat to form light-weight angular particles normally between 0.5 and 5.0mm in length.
2. Vermiculite : Vermiculite ore (mica mineral flakes) exfoliated by exposure to heat to form light –weight cubical particles normally between 5 and 10mm in length.
3. Foamed Concrete: Concrete made from a mixture of cement water and chemical foam.
4. Perlite Concrete and Mortar: Concrete and mortar made from a mixture of cement, water and expanded perlite.
5. Vermiculite Concrete and Mortar: Concrete and mortar made from a mixture of cement, water and exfoliated vermiculite.
6. Aerated Sand-lime Block: Masonry units made from a mixture of sand lime and water aerated by inclusion of powdered aluminium to the mix and autoclaved.
7. Foamed Glass: Glass aerated by inclusion of a foaming agent during the process of manufacture.
8. Expanded (Molded) Polystyrene: Rigid light-weight sheet formed by the expansion and partial fusion of polystyrene bead, heated in molds and cut to size.
9. Expanded (Extruded) Polystyrene: Rigid light-weight sheet formed by the direct extrusion of foamed polystyrene into sheet form.
10. Foamed (Rigid) Polyurethane &Polyisocyanurate: Rigid light-weight material made by reacting an isocynurate with a Polyol in the presence of foaming agents. The product may be formed in a molds, slabs and Pipesection, subsequently cut to size, sprayed directly on the surface to be insulated or injected into cavities. However Polyisocyanurate have better fire properties.
11. Fiberglass wool: Fibers formed by the spinning of molten glass, resin bonded to form a flexible mat or rigid Slab usually faced with building paper or metalized foil.
12. Rockwool : Fibres formed by drawing or spinning molten rock, resin bonded to form flexible mat or rigid Slab, sometimes faced with board, paper or metalized foil.

TABLE 5:TYPICAL THERMAL PROPERTIES OF COMMONBUILDING &INSULATING MATERIALS FOR BUILDINGS- DESIGN VALUES

Discriptions	DensityIB/ft 3	Conductivity (K) Btu-in/h-ft2-ºF	Conductanc (C) Btu	Resistance c (R) Per inch thickness(1/k), ºf-ft2.h/But-in	Resistance c (R) for Thickness listed (1/C) ºF-ft2.h	Specific Heat Btu/lb-ºF
Building Board						
Asbestos -Cement board …………….	120	4.00		0.25		0.24
Asbestos -Cement board …………….0.125 in	120		33.00		0.03	
Asbestos -Cement board …………….0.25 in	120		16.50		0.06	
Gypsum or Plaster board……………..0.375 in	50		3.10		0.32	0.26
Gypsum or Plaster board………………..0.5 in	50		2.22		0.45	
Gypsum or Plaster board…………………0.625 in	50		1.78		0.56	
Plywood (Douglas Fir)…………………….	34	0.80		1.25		0.29
Plywood (Douglas Fir)……………………0.25 in	34		3.20		0.31	
Plywood (Douglas Fir)……………………0.375 in	34		2.13		0.47	
Plywood (Douglas Fir)…………………..0.5 in	34		1.60		0.62	
Plywood (Douglas Fir)…………………..0.625 in	34		1.29		0.77	
Plywood or wood panel vegetable fiber board……….. 0.75 in	34		1.07		0.93	0.29
Sheathing regular density…………0.5 in	18		0.76		1.32	0.31
…………… 0.78125 in	18		0.49		2.06	
Sheathing intermediate density ………0.5 in	22		0.92		1.09	0.31
Nail base sheathing…………..0.5 in	25		0.94		1.06	0.31

shingle backer…………0.375 in	18		1.06		0.94	0.31
shingle backer…………0.3125 in	18		1.28		0.78	
sound deadening board …………0.5 in	15		0.74		1.35	0.30
Tile and lay-in panels , pain or acoustic ……….	18	0.40		2.50		0.14
…………0.5 in	18		0.80		1.25	
…………0.75 in	18		0.53		1.89	
laminated paper boaed …………..	30	0.50		2.00		0.33
Homogeneous board from repulped paper………	30	0.50		2.00		0.28
hard board						
Medium density …………….	50	0.73		1.37		0.31
High density service -tempered grade and service grade………………………	55	0.82		1.22		0.32
high densitystandard -tempered grade and service grade………	63	1.00		1.00		0.32
Particle board						
Low density……….	37	0.71		1.41		0.31
Medium density …………….	50	0.94		1.06		0.31
High density……………	62.5	1.18		0.85		0.31
Underlayment………………0.625 in	40		1.22		0.82	0.29
waferboard……………………	37	0.63		1.59		
wood subfloor………………0.75 in			1.06		0.94	0.33
BUILDING MEMBRANE						
Vapour -permeanle felt ………………..				16.70		0.06
vapour -seal,2 layers of mopped 15-Ib felt………….				8.35		0.12
vapour - seal plastic film………….						Negl

FINISH FLOORING METERIALS						
Carpet and fibrous pad…………			0.48		2.08	0.34
Carpet and rubber pad…………			0.81		1.23	0.33
cork tils………………………….. 0.625 in			3.60		0.28	0.48
Terrazzo …………………………1 in			12.50		0.08	0.19
Tils -asphalt linoleum , vinyl rubber ………………			20.00		0.05	0.30
vinyl asbestos………………….						0.24
ceramic …………………………						0.19
wood hardwood finish ……………………0.75 in			1.47		0.68	

INSULATING METERIALS						
Blaket and Batt						
mineral fiber fibrous processed						
from rock slag, or glass						
approx . 3.4 in………………..	0.4-2.0		0.091		11.00	
approx . 3.5 in………………..	0.4-2.0		0.077		13.00	
approx . 3.5 in………………..	1.2-1.6		0.067		15.00	
approx . 5.5-6.5 in………………..	0.4-2.0		0.053		19.00	
approx . 5.5 in………………..	0.6-1.0		0.048		21.00	
approx . 3.4 in………………..	0.4-2.0		0.045		22.00	
approx . 6-7.5 in………………..	0.4-2.0		0.033		30.00	
approx . 8.25-10 in………………..	0.4-2.0		0.026		38.00	
approx . 10-13 in………………..						
Board And Slabs						
Cellular glass………………	8	0.33		3.03		0.18

Glass fiber organic bonded………………….	4.0-9.0	0.25		4.00		0.23
Expanded perlite organic bonded………….	1	0.36		2.78		0.30
Expanded rubber (rigid)	4.5	0.22		4.55		0.40
Expanded polystyrene extruded						
(smooth skin surface) (CFC-12 exp)…………..	1.8-3.5	0.20		5.00		0.29
Expanded polystyreneextruded (smooth skin surface)						
(HDFC014 exp)…………………….	1.8-3.5	0.20		5.00		0.29
Cellular Polyurethane / Polyisocyanurate (CFC-11 exp.) (unfaced)	1.5	0.16-0.18	-	6.25-5.56	-	0.38
Cellular Polyisocyanurate (CFC-11 exp.) (gas-permeable facers)	1.5-2.5	0.16-0.18	-	6.25-5.56	-	0.22
Cellular Polyisocyanurate (CFC-11 exp.) (gas-impermeable facers)	2.0	0.14	-	7.04	-	0.22
Mineral Fiber with resin binder	15.0	0.29	-	3.45	-	0.17
Mineral Fiber (Rock, Slag or Glass)						
Approx. 3.75 – 5 in	0.6-2.0	-	-	-	11.0	0.17
Approx.6.5 -8.75 in	0.6-2.0	-	-	-	19.0	-
Approx. 7.5-10 in	0.6-2.0	-	-	-	22.0	-
Approx. 10.25-13.75 in	0.6-2.0	-	-	-	30.0	-
Mineral Fiber (Rock, Slag or Glass)						
Approx. 3.5 in (closed side wall applications)	2.0-3.5	-	-	-	12.0-14.0	-
Vermiculite, exfoliated	7.0-8.2	0.47	-	2.13	-	0.32
	4.0-6.0	0.44	-	2.27	-	-
Spray Applied						
Polyurethane Foam	1.5-2.5	0.16-0.18	-	6.26-5.56	-	-
Glass Fiber	3.5-4.5	0.26-0.27	-	3.85-3.70	-	-

Source: Adapted from ECBC 2007 Published by BEE

TABLE 6: ADVANTAGES & DISADVANTAGES OF VARIOUS THERMAL INSULATION MATERIALS

<table>
<tr><th>MATERIAL</th><th>ADVANTAGES</th><th>DISADVANTAGES</th></tr>
<tr><td>Expanded (Molded) Polystyrene</td><td>Can be supplied in any required thickness.
Easy to cut, fix and lay
High thermal resistance
Fair mechanical strength
.</td><td>Degrades on prolonged exposure to ultraviolet light, surface must be protected soon after application.
Will absorb water on prolonged exposure
Combustible –Melt and Drip</td></tr>
<tr><td>Extruded Polystyrene</td><td>Can be shaped and placed quickly and easily
Good mechanical strength
Very High thermal resistance
Highly Water-resistant</td><td>Degrades on prolonged exposure to ultraviolet light, surface must be protected soon after laying.
Combustible –Melt and Drip
Available in limited range of sizes</td></tr>
<tr><td>Foamed Polyurethane & Poly Isocyanurate</td><td>Available both in solid board form and as a liquid suitable for injection or spray.
Liquid forms adhere well to most surfaces.
Very high thermal resistance.
Available in a variety of densities
Can be supplied in any required thickness.
Its skin is highly water-resistant.
Can be easily cut, fix, lay, has good mechanical strength</td><td>Degrades on prolonged exposure to ultraviolet light, surface must be protected soon after laying.
Combustible However, thermoset in nature prevents melting.
Thermal resistance can degrade with time, especially on exposed locations.
Liquid varieties need special skills to apply.</td></tr>
<tr><td>Fiberglass wool</td><td rowspan="2">Can be layered quickly and easily
Available in both flexible and rigid forms for different applications
Good thermal resistance
Incombustible
Can be supplied in any required thickness
Can be made available with a variety of surface treatments for special purposes
Have good sound-absorbing properties.</td><td>No water resistance, but dries quickly
Somewhat irritant or itching for the applicators.
. Low-density products have no resistance to compression or traction</td></tr>
<tr><td>Rockwool</td><td>Water-repellent, but soaks when immersed. Dries quickly.
Low-density products have no resistance to compression or traction</td></tr>
</table>

Note: This table is valid as long as the material are adequately applied and used.

Source: Ministry of Energy- Energy conservation programme Appendix-1 Properties and Application of insulating material from building in Kuwait second edition 2004

EVALUATION OF INSULATION:

All Insulation materials shall be accompanied by a certificate prepared by the manufacturing unit/independent testing laboratories giving the relevant properties of materials as per IS Codes.

TABLE 7: THE SCOPE OF TESTING WILL DEPEND ON THE NATURE OF MATERIAL AND ITS INTENDED USE BUT SHALL NORMALLY INCLUDE THE FOLLOWING:

Type	Density	Grading	Water/ Moisture Absorption	Compressive Strength	Thermal Conductivity	Fire Properties	Smoke Density	Bacterial & Mold Growth
Loose Fill	✓	✓	✓					
Rigid Foam (EPS, XPS, PUR, PIR)	✓		✓	✓	✓	✓	✓	
Fibrous Mineral Fiber (Glasswool, Rockwool)	✓		✓	✓	✓	✓	✓	✓

Source: Ministry of Energy- Energy conservation program Appendix-1 Properties and Application of insulating material from building in Kuwait second edition 2004

Note: For internal applications preferably non-combustible & non health hazardous insulation materials should be used

Chapter 3

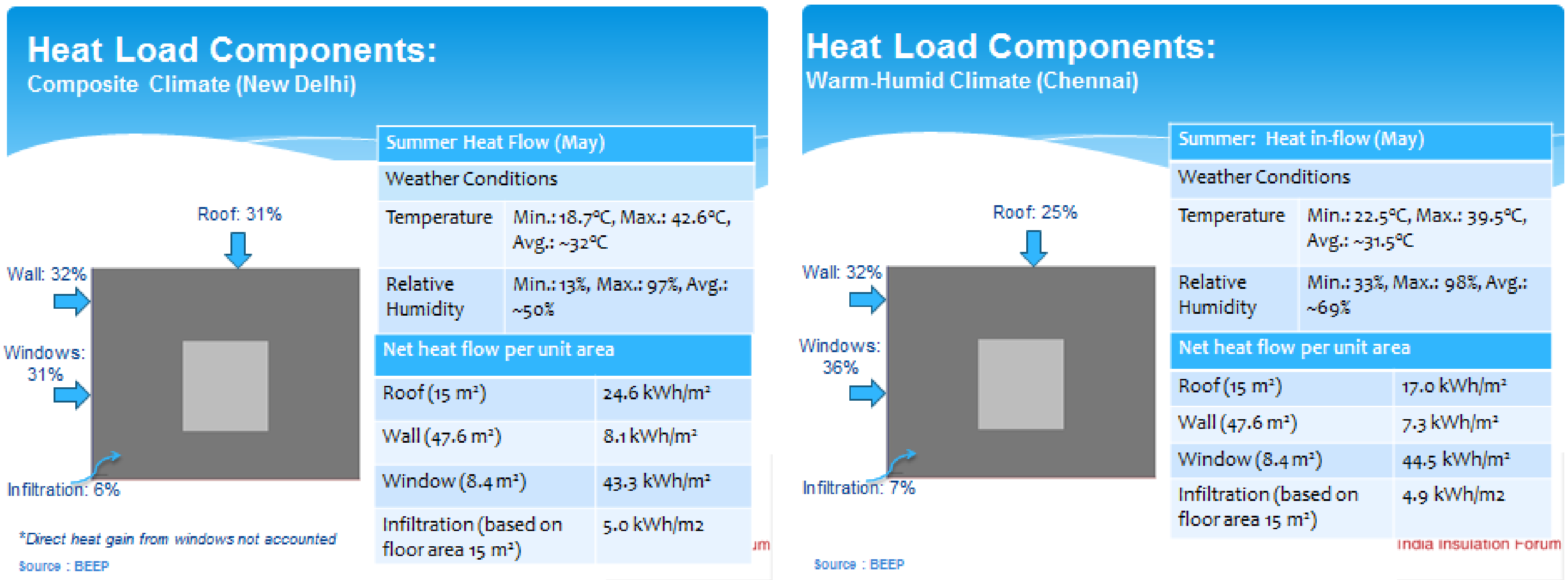
Scope of Insulation in Buildings

Up to 30 % energy saving can be achieved by thermal insulation of buildings, if you decide for thermal insulation focus on building structures which allow the highest heat losses, which is fundamental for highest efficiency. This applies mainly to thermal insulation of the external cladding, exchange of windows or insulation of non-heated rooms. At the same time right regulation of the heating system and solar protection areimportant: up to 50 % of energy savings can be obtained when thermal insulation is associated with efficient solar protection.

TABLE 8. SHARE OF HEAT TRANSFER THROUGH STRUCTURAL ELEMENTS. THE RANGE IS VALID ON AN ANNUAL BASIS FOR INDIAN CLIMATES

Places of heat transfer	Family houses	Apartment houses
Windows and outside doors	30 – 40 %	40 – 50 %
External walls	20 – 30 %	30 – 40 %
Ceilings and roofs	15 – 20 %	5 – 8 %
Floors	5 – 10 %	4 – 6 %

FIGURE 4 :EXAMPLES OF HEAT LOAD COMPONENTS IN DELHI AND CHENNAI IN SUMMER



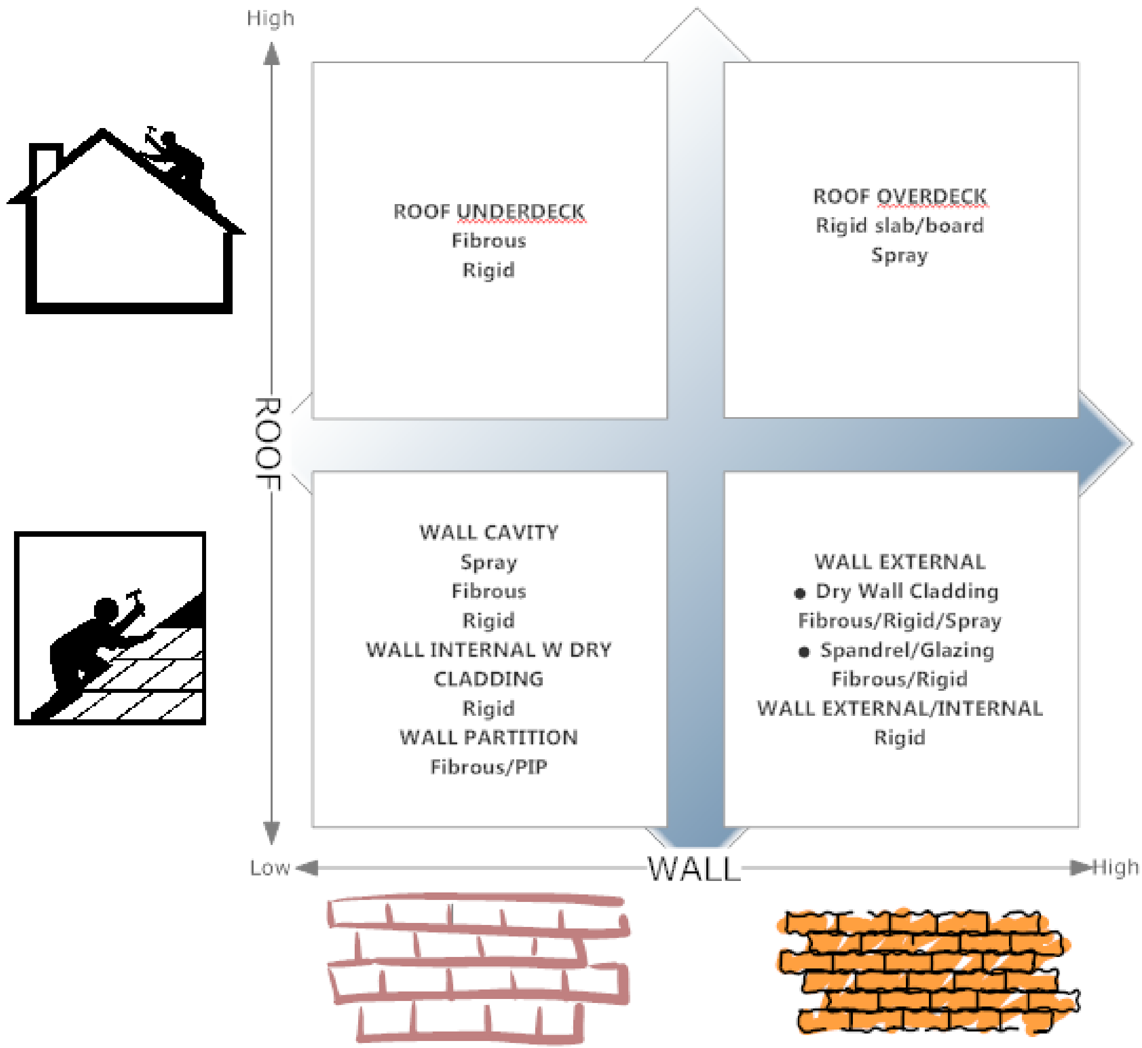
Advantages of thermal insulation

- Reduction of energy consumption for heating and cooling, depending on the indoor conditioning system and on the climate (by 30 % at least),
- Improving thermal comfort by stabilising the surface temperature of the inside walls,
- If the thermal insulation is external, reduction of thermal stress of the framework, by stabilizing its temperature
- Building lifetime prolongation, by reduction of the thermal stresses, and above other by reduction of the energy cost.
- Enhancing the market value of the building
- Improvement of the long term architectural look of the building.

The schematic representation below describes the common methods of application pretaining to the areas of application, based on the efficiency and ease of the process. As can be seen there are various options available to the choice of the consumer and a decision needs to be taken keeping the factor of cost-benefit ratio in mind.

FIGURE 5 :. COMMON METHODS OF APPLICATION PRETAINING TO THE AREAS OF APPLICATION

Source: Inference from ECBC User guide



Chapter 4

Relationship of Insulation to Climate Conditions

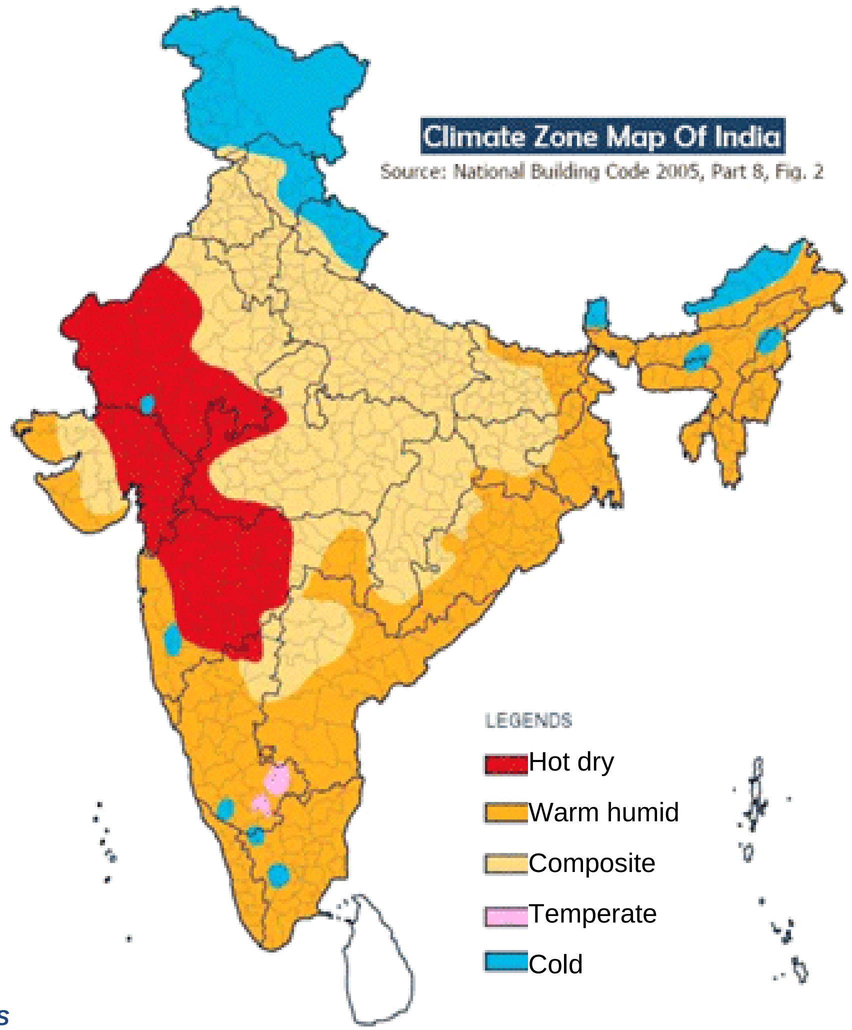


FIGURE 6: INDIA CLIMATIC ZONES

Source : ECBC User guide

Broadly, the principle of "Heat always flows from high temperature to low temperature" must be kept in mind.

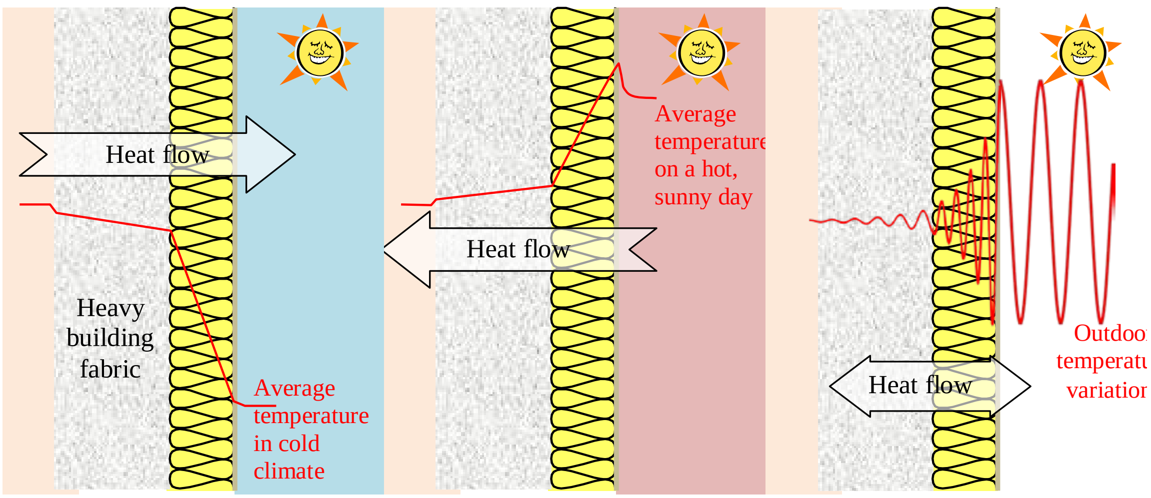
If a wall is submitted to a temperature difference between both sides, the largest temperature fall will take place in the insulating layer. Thus, the part of the wall inside the insulating layer will be practically at the internal temperature and the part on the outside of the insulation layer will be close to the external temperature. The insulating layer may be installed outside or inside the bearing structure, or be distributed, the carrier material being the only thermal insulation.

Both external and internal thermal insulation reduce the heat flow through the building envelope in any case and in both directions. Therefore it reduces the needs for heating in cold climates and for cooling in hot climates.

However, the position of the insulation in the building element, i.e. on the internal or external side of the building envelope component or even inside the components has an important influence on the dynamic behaviour of the component and, in some climates, on possible condensation problems.

For composite and hot-dry climates, it is recommended to use insulation on the outside surface of the wall or inside the cavity, in a cavity wall configuration. As far as possible, insulation should not be applied on the internal surface of the walls, as this does not allow the thermal inertia of the masonry wall to contribute in stabilising the indoor temperature. The detailed reasons are given below.

External insulation



Steady, cold outdoor temperature | *Steady, warm outdoor temperature and solar radiation* | *Variable outdoor temperature and solar radiation*

Figure 7: Typical temperature profiles with external insulation

In external insulation systems, the insulating layer is placed outside the bearing structure. It is protected from the weather and shocks by a protective layer, which can be a finishing, a cladding or even a relatively thin wall.

Advantages

- increases the time constant of the building, (i.e. the time it needs to change its internal temperature after a change of the external temperature), hence protects the indoor environment from external temperature variations;
- stabilizes the temperature of the structure and hence its dilatations and deformations;
- allows using the thermal mass of the building to store excess heat or recover stored heat;
- suppresses most thermal bridges;
- in cold climates, completely suppress the risk of water vapour condensation inside the building element.

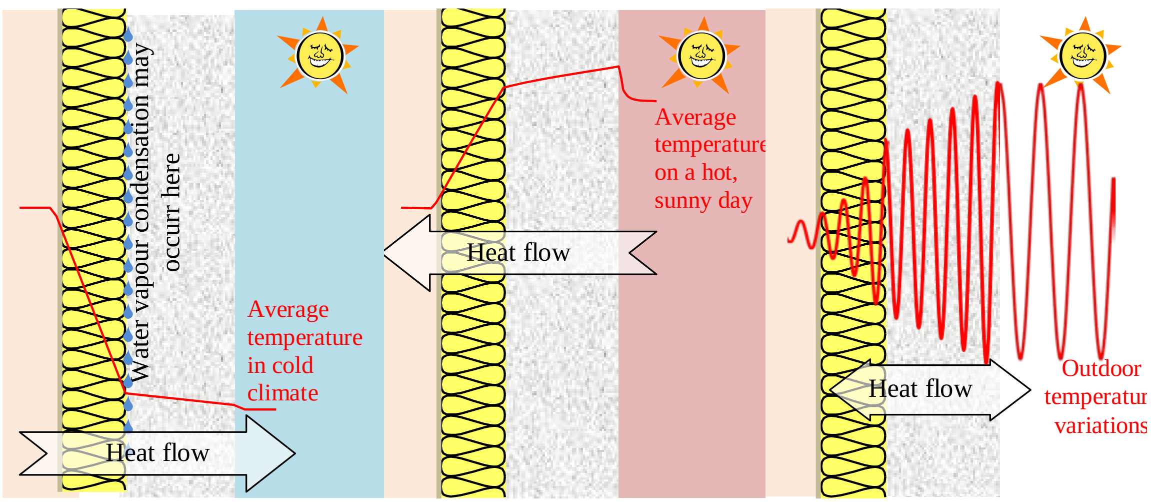
Inconveniences

- needs an application form outside, hence a scaffolding;
- increases the time required to change the internal temperature. In air-conditioned buildings located in warm and humid climate, may increase the risk of water vapour condensation inside the building element.

Internal insulation

In most cases, the advantages of the external insulation overpass its disadvantages. One can however be obliged to isolate indoors, for example when retrofitting historical buildings of which the external aspect must be kept. In these cases, it is essential to check that the risk of water vapour condensation is acceptable and to pay special attention to the residual thermal bridges.

In internal insulation systems, the insulating layer is placed inside the bearing structure. It is protected by a thin internal wall by plaster or wood plates. Unless special measures are taken, the decks and partition walls are therefore not insulated.



Steady, cold outdoor temperature | *Steady, warm outdoor temperature and solar radiation* | *Variable outdoor temperature and solar radiation*

Figure 8: Typical temperature profiles with internal insulation

Advantages

- It is applied inside, at low cost.
- decreases the time required to change the internal temperature, and that could be useful in rooms used part time;
- in air-conditioned buildings located in hot, humid climates, completely suppress the risk of water vapour condensation inside the building element.

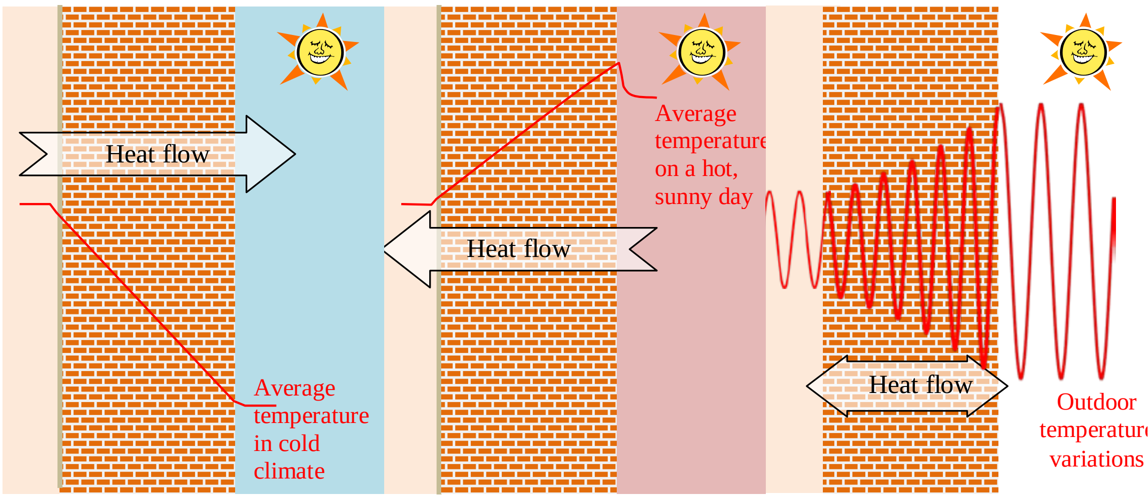
Inconveniences

- in heated buildings located in cold climate, may increase the risk of water vapour condensation inside the building element;
- decreases the time constant of the building. the indoor temperature tends to follow the external temperature variations;
- leaves the building structure outside, exposed to external variations;
- leaves thermal bridges, i.e. location on the building envelope, such as decks and partition walls, that are not insulated.

Distributed insulation

We have seen that homogeneous walls, common almost everywhere even in the last century, cannot in fact be used in cold climates, because stiff enough materials have a limited insulating power, and the required thickness in cold climates becomes prohibitive. However, it has several advantages that allow recommending its use wherever possible:

- Simple construction; ● single material is used; ● regulardistribution of the temperature in the wall; ● relatively high internal thermal inertia.



Steady, cold outdoor temperature *Steady, warm outdoor temperature and solar radiation* *Variable outdoor temperature and solar radiation*

FIGURE 9: TYPICAL TEMPERATURE PROFILES WITH DISTRIBUTED INSULATION

Materials for this type of wall include solid wood; hollow, porous clay brick; mud, mud brick or adobe; aerated concrete and compressed straw. The latter as a pretty good insulating performance and is used in cold climates.

Water vapour diffusion through the wall could condense against the colder surface (e.g. the outer face in winter). It is important that the finishing of this face be permeable to water vapour, to avoid condensation problems.

Table 8 will provide a good understanding of what comprises the different climate zones in India while Table 9 below it classifies the major cities therein.

TABLE 8: CHARACTERISTICS OF THE INDIAN CLIMATIC ZONES

Climate Zone	Description	Mean Temperature (°C)					Mean Relative Humidity	Annual Precipitation	Sky Conditions	Places
		Summer Midday (High)	Summer Night (Low)	Winter Midday (High)	Winter Night (Low)	Diurnal Variation				
Hot and Dry	High Temperature, Low Humidity and rainfall, Intense solar radiation and a generally clear sky, Hot winds during the day and cool winds at night, Sandy or rocky ground with little vegetation, Low underground water table and few sources of surface water	40 to 45	20 to 30	5 to 25	0 to 10	15 to 20	Very Low 25-40%	Low < 500mm	Cloudless skies with high solar radiation, causing glare.	Rajasthan, Gujarat, Western Madhya Pradesh, Central Maharashtra etc.
Warm and Humid	Temperature is moderately high during day and night, Very high humidity and rainfall, diffused solar radiation if cloud cover is high and intense if sky is clear, clam to very high winds from prevailing wind directions, abundant vegetation, provision for drainage of water is required.	30 to 35	25 to 30	25 to 30	20 to 25	5 to 8	High 70 - 90%	High > 1200 mmr	Overcast (cloud cover ranging between 40 and 80%) causing unpleasant glare.	Kerala, Tamil Nadu, Coastal Parts of Orissa and Andhra Pradesh.

Temperate	Moderate Temperature, Moderate humidity and rainfall, Solar Radiation same throughout the year and sky is generally clear, High winds during summer depending on topography, hilly or high plateau region with abundant vegetation.	30 to 34	17 to 24	27 to 33	16 to 18	8 o 13	High 60 - 85%	High > 1000 mm	Mainly clear,occasionally overcast with dense low clouds insmmer	Bangalore, Goa and parts of the Deccan
Cold(Sunny /Cloudy)	Summer Temperature and very low in winter, Low humidity in cold/sunny high humidity in cold /cloudy , High solar radiation in cold/sunny and low in cold/cloudy, cold winds in winter, very little vegetation in cold/sunny and abundant vegetation in cold/cloudy.	17 to 24/20 to 30	4 to 11/17 to 21	-7 to 8 4 to 8	-14 to 0 -3 to 4	25 to 25 5 to 15	Low: 10-50% High 70-80%	Low: < 200mm Moderate 1000mm	Clear with cloud cover< 50%/ Overcast for most of the year.	Jammu and Kashmir, Ladakh, Himachal Pradesh, Uttranchal, Sikkam , Arunachal Pradesh
Composite	This applies when 6 months or more do not fall within any of the above categories, High temperature in summer and cold in winter, Low humidity in summer and high in monsoon, High direct solar radiation in all seasons except monsoon high diffused radiation, Occasional hazy Hot Winds in summer, cold winds in winter and strong wind in monsoons, variable landscape and seasonal vegetation.	32 to 43	27 to 32	10 to 25	4 to 10	35 to 22	Variable Dry periods = 20-50% Wet Periods = 50 -95%	Variable 500-1300 mm During monson reaching 250mm in the wettest month.	Variable Overcast and dull in the monsoon.	Uttar Pradesh, Haryana, Punjab, Bihar, Jharkhand, Chattisgarh , madhya Pradesh etc,

Source : ECBC User guide

TABLE 9: CLIMATIC ZONES OF THE MAJOR CITIES IN INDIA

City	Climate Zone
Ahmedabad	Hot & Dry
Allahabad	Composite
Amritsar	Composite
Aurangabad	Hot & Dry
Bangalore	Temperate
Barmer	Hot & Dry
Belgaum	Warm & Humid
Bhagalpur	Warm & Humid
Bhopal	Composite
Bhubaneshwar	Warm & Humid
Bikaner	Hot & Dry
Calcutta	Warm & Humid
Chitradurga	Warm & Humid
Dehradun	Composite
Dibrugarh	Warm & Humid
Gauhati	Cold
Gorakhpur	Composite
Gwalior	Composite
Hissar	Composite
Hyderabad	Composite

City	Climate Zone
Imphal	Warm & Humid
Indore	Composite
Jabalpur	Composite
Jagdelpur	Warm & Humid
Jaipur	Composite
Jaisalmer	Hot & Dry
Jamnagar	Warm & Humid
Jodhpur	Hot & Dry
Jorhat	warm& Humid
Kota	Hot & Dry
Kurnool	warm& Humid
Lucknow	Composite
Madras	warm& Humid
Manglore	warm& Humid
Mumbai	warm& Humid
Nagpur	Composite
Nellore	warm& Humid
New Delhi	Composite

City	Climate Zone
Panjim	warm& Humid
Patna	Composite
Pune	warm& Humid
Raipur	Composite
Rajkot	Composite
Ramgundam	warm& Humid
Ranchi	Composite
Ratnagiri	warm& Humid
Raxaul	warm& Humid
Saharanpur	Composite
Shillong	warm& Humid
Sholapur	Hot & Dry
SunderNagar	cold
Surat	Hot & Dry
Tezpur	warm& Humid
Tirucchirapali	warm& Humid
Trivandrum	warm& Humid
Tuticorin	warm& Humid
Veraval	warm& Humid
Vishakhapatnam	warm& Humid

Source: ECBC User guide

TABLE 10: ECBC PRESCRIPTIONS REGARDING MAXIMUM OVERALL THERMAL CONDUCTIVITY U OF ENVELOPE COMPONENTS AND MINIMUM THERMAL RESISTANCE R OF THE INSULATION LAYER

Envelope component	Climate Zone	24-h. use buildings, hospitals, hotels, call centers, etc.		Day-time use buildings & other building types	
		Max U-value of component W/(m²K)	Min. R-value of insulation alone m² K/W	Max U-value of component W/(m²K)	Min. R-value of insulation alone m² K/W
Roofs	Composite	0.261	3.5	0.409	2.1
	Hot & Dry	0.261	3.5	0.409	2.1
	Warm & Humid	0.261	3.5	0.409	2.1
	Moderate	0.409	2.1	0.409	2.1
	Cold	0.261	3.5	0.409	2.1
Opaque walls	Composite	0.440	2.10	0.440	2.10
	Hot & Dry	0.440	2.10	0.440	2.10
	Warm & Humid	0.440	2.10	0.440	2.10
	Moderate	0.440	2.10	0.440	2.10
	Cold	0.369	2.20	0.352	2.35

Chapter 5

Training Modules

The key to an effective thermal barrier is proper installation of quality insulation products. A building should have a continuous layer of insulation around the entire building envelope. Studies show that improper installation can cut performance by 20% or more.

We will now take the reader through a step-by-step process through the different methodologies of application of insulation. Foremost, we recommend that the best safety practices need to be followed, for which we have devoted a chapter later. For its most effective usage, it is advised that the procedures be religiously followed without fail.

We will begin with ROOF INSULATION. Both the OVERDECK and UNDERDECK areas are potential surfaces for application of insulation. We will consider the various methods which are commonly followed for insulating them separately.

Overdeck Roof Insulation

Rigid board slab insulation

1. Roof slab should be totally dried and free from all protrusions and depressions and should have proper sloped for free flow of water (1:100).
2. Providing suitable waterproofing over the Sloping screed
3. Providing and laying specified thickness of RIGID FOAM INSULATION SLAB/BOARD of minimum 32-40±2 kg/m^3 density.(The Rigid foam Insulation slab/board can be fixed with suitable adhesive like Hot Bitumen or CPRX compound as OPTIONAL)
4. Providing and laying min. 150 gms Geo Textile membrane or 400g polythene sheet over the fixed INSULATION Slab/BOARD, for the protection and as separation layer.
5. Providing and laying over the Polythene sheet/Geo-textile membrane in slope gradient min.40mm thick PCC(1:2:4)in chequered 2.5mtr x 2.5mtr panels, reinforced with welded mesh of 75mm x 75mm x1.5mm embedded in between.
6. Sealing all joints between panels with polymerized mastic.
7. Final finish as per specs or engineer in-charge.

FIGURE 10: ROOF OVERDECK THERMAL INSULATION SYSTEM, WATERPROOFING LAYER IS UNDER INSULATION

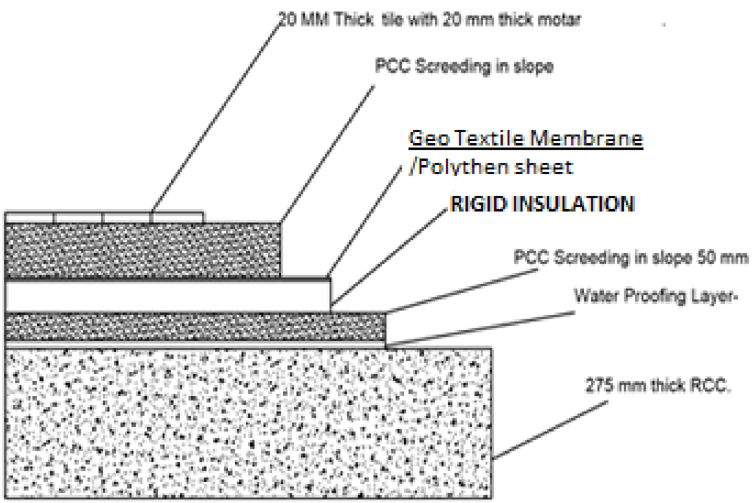
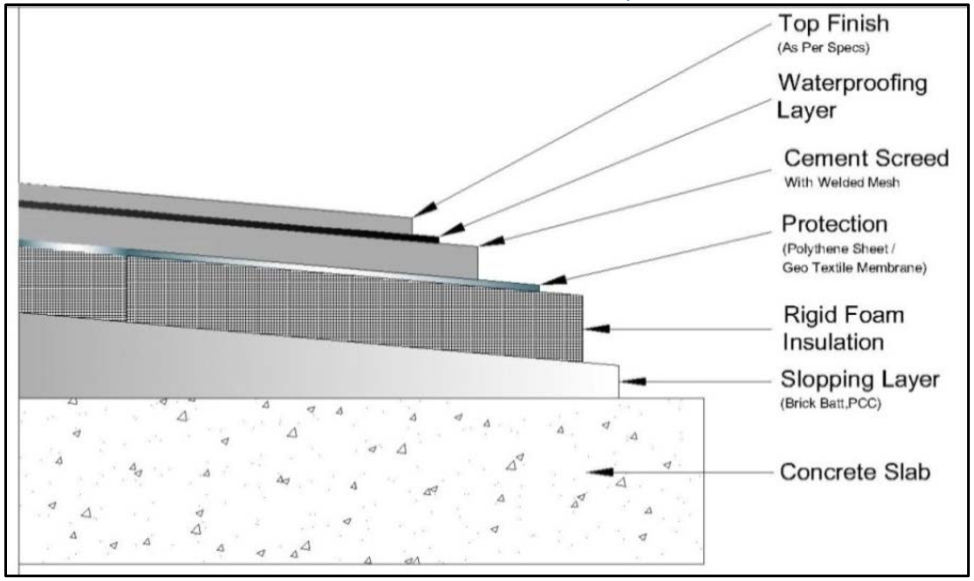


FIGURE 11: ROOF OVER DECK THERMAL INSULATION SYSTEM, WATERPROOFING LAYER ABOVE INSULATION



Sprayed rigid insulation

1. Roof slab should be totally dried and free from all protrusions and depressions and should have proper sloped for free flow of water (1:100).
2. Cleaning the surface properly with wire brushes manually.
3. Providing and applying a coat of Polyurethane primer at entire roof surface @ 6-8 Sqm/Ltr.
4. Providing and applying desired thickness of closed cell sprayed rigid PUF insulation foam of 42±2 kg/m^3 density conforming to IS-12432 Pt.III with Graco/Gusmer machine. – to form a monolithic joint less treatment overdeck insulation of desired density of insulation. The sprayed foam adheres instantly to the roof surface and form a composite system.
5. Providing and laying min.120 gsm Geo Textile membrane or 400g polythene sheet over the layed Sprayed foam insulation, for protection and as separation layer.
6. Providing and laying in slope gradient min.40mm thick PCC(1:2:4)in chequered 2.5mtr x2.5mtr panels, reinforced with welded mesh of 75mm x 75mm x1.5mm embedded in between over the Polythene sheet/Geo-textile membrane.
7. Sealing all joints between panels with polymerized mastic.
8. Providing suitable waterproofing treatment.
9. Final top finish as per specs or Engineer in-charge.

FIGURE 11 OVERDECK SPRAYED RIGID INSULATION

UnderDeck Roof Insulation

Fibrous Insulation

1. Clean the surface thoroughly with wire brush to free it from dust and chippings.
2. Providing and fixing M.S. cleats of suitable to the ceiling at 1mtr X 1/2mtr.C/C with help of dash fasteners.
3. Providing & fixing DESIRED THICKNESS of FIBROUS INSULATION of minimum 24-48 kg/m^3 density encased in 200g polythene sheet or one side laminated with Alfoil.Caution: This Al foil is a vapor barrier. In Hot-humid or cold climates, it should be placed on the warm side of the thermal insulation.
4. All joints to be sealed with adhesive tape/Aluminium tape and held tightly in position with the help of crisscross GI lacing wire and further installing the same in 24 G x 3/4” hexagonal wire netting.
5. The joints of the wire netting shall be butted and stitched with GI lacing wire.
6. Final finish as per specs or engineer in charge

FIGURE 12UNDER DECK FIBROUS INSULATION

Rigid Insulation

1. Drilling & making holes on R.C.C slab at 1mtr X 0.5mtr C/C size panels.
2. Entire R.C.C surface shall be thoroughly cleaned of all dust, dirt and loose particles by wire brushing.
3. Providing and applying a coat of bituminous primer to the bare R.C.C. ceiling and allow it to dry
4. Providing and Applying cold adhesive to the underside of R.C.C. ceiling as well as to one side of surface & sides of each RIGID INSULATION SLAB/BOARD of density minimum 32-36±2 kg/m³ and press it in position & holding it with the help of screws and washers back to the RIGID INSULATION SLAB/BOARD and press it in position with the help of screws and washers inserted inside the rawl plugs.
5. Butt the joints together symmetrically and joints sealed with 75mm wide aluminium tape.
6. Providing and fixing chicken wire mesh 24G x 3/4” to the GI screw and tightening the same with lacing wire.
7. Final finish as per specification or engineer-in-charge.

FIGURE 13: UNDER DECK RIGID INSULATION

Cavity Wall Insulation

Spray in-situ PUF insulation

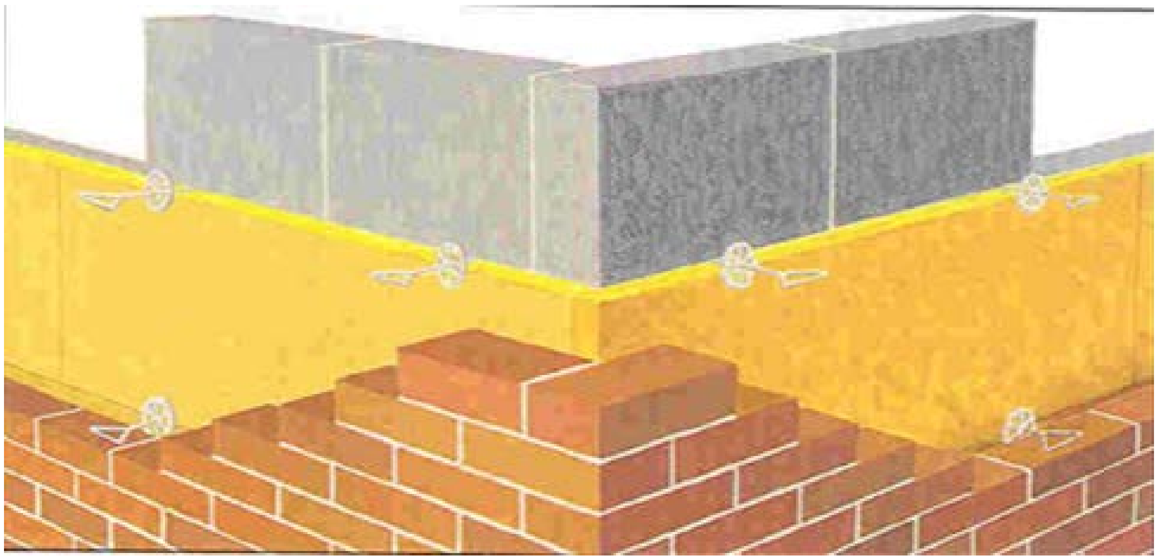
1. Providing hole with drilling machine on the inner wall at 100mm distance from the edges and thereafter at every approx. 600mm c/c in stagger form starting from bottom to top.
2. Providing and filling through these holes with in-situ pouring of closed cell POLYURETHANE FOAM (CFC FREE) IN THE CAVITY WITH GUSMER/GRACO MACHINE CONFORMING TO IS: 13205, DENSITY OF FOAM SHALL BE 36±5 kg/m^3.The foam adheres instantly to the wall surface on both sides and has a free rise filling the gap/cavity.
3. The pouring/ in-situ Lloydfoam polyurethane foam insulation would start from the bottom and proceeding up.
4. Finally the hole will be plugged with cement mortar or as per specs

FIGURE 14:SPRAY IN-SITU INSULATION

Fibrous Insulation

1. Providing and fixing, DESIRED THICKNESS of FIBROUS INSULATION of minimum 32-96kg/m³ density encased/wrapped in polythene sheet/bag of 200 gauge, to the wall in staggered form using fasteners one each at corners 100mm away from edges and one at Centre.
2. Providing and holding the fibrous insulation in position with criss cross lacing wire secured with the earlier fixed fasteners.
3. Finally finishing it with another Brick wall duly plastered and finish smooth.

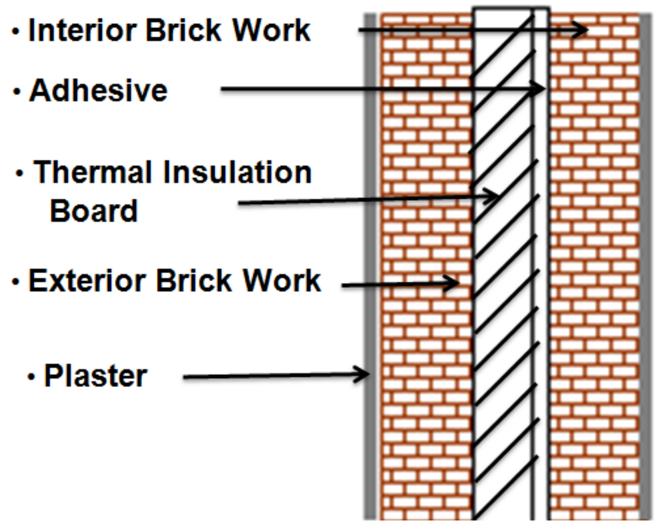
FIGURE 15: CAVITY WALL INSULATION WITH FIBROUS MATERIALS



Rigid Insulation

1. Providing a coat of bitumen or old CPRX compound on inner side of the wall.
2. Providing and fixing, DESIRED THICKNESS of RIGID INSULATION of minimum 32-40kg/m³ density to the wall in staggered form using fasteners one each at corners 100mm away from edges and one at Centre.
3. Finally finishing it with another Brick wall duly plastered and finish smooth.

FIGURE 16: CAVITY WALL INSULATION WITH RIGID FOAM



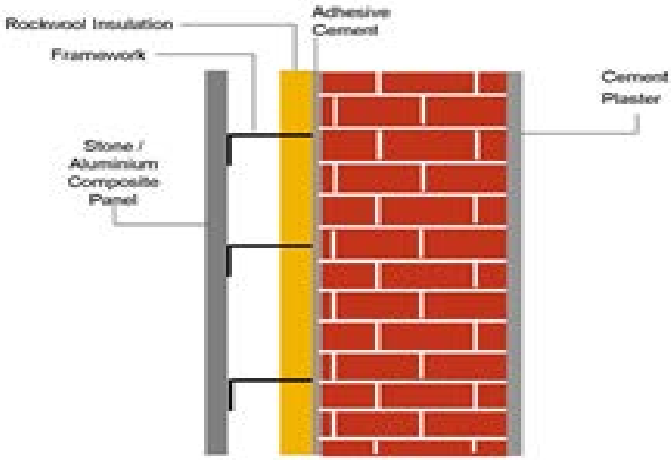
External wall insulation

Fibrous Insulation behind cladding

Dry stone cladding/spandrel

1. Providing and fixing DESIRED THICKNESS of FIBRIOUS INSULATION of minimum 32-96kg/m³ density encased/wrapped in polythene sheet/bag of 200G or one side laminated with Al.foil in the existing wall with the help of fasteners provided at one each at the corner 100mm away from the edge and one at centre.
2. Providing and holding the fibrous insulation in position with criss cross GI lacing wire secured with the earlier fixed fastener.
3. Insulation is can be sandwiched between wall & dry stone cladding or Aluminium cladding etc as per specs or engineer-in-charge. A ventilated air layer should be present between the insulation layer and the cladding to evacuate water vapor. Also useful to evacuate excess heat from sun.

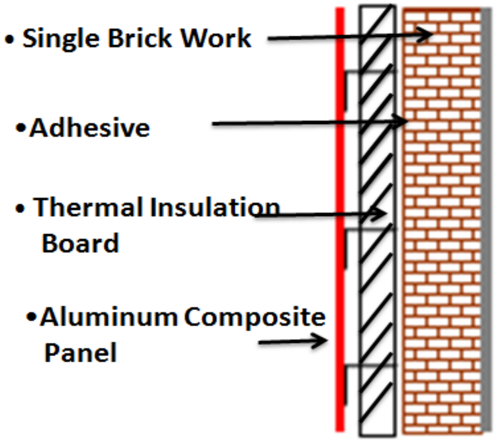
FIGURE 17: EXTERNAL WALL FIBROUS INSULATION BEHIND CLADDING



Rigid Insulation behind cladding

1. Providing a coat of bitumen or old CPRX compound on to the existing smooth wall.
2. Providing and fixing, DESIRED THICKNESS of RIGID INSULATION of minimum 32-36±2kg/m³density to the wall in staggered form using fasteners one each at corners 100mm away from edges and one at Centre.
3. Insulation is can be sandwiched between wall & dry stone cladding or Aluminium cladding etc as per specs or engineer in charge.A ventilated air layer should be present between the insulation layer and the cladding to evacuate water vapor. Also useful to evacuate excess heat from sun.

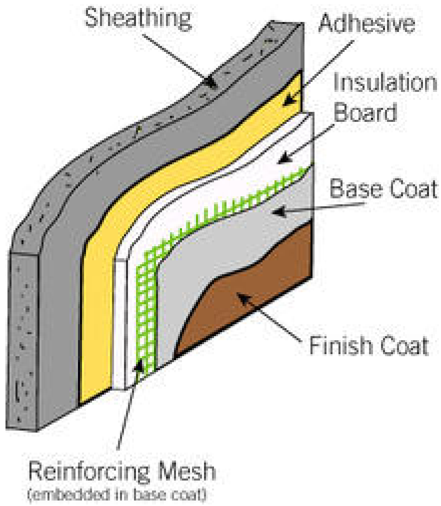
FIGURE 18: EXTERNAL WALL FIBROUS INSULATION BEHIND CLADDING



External rigid Insulation with finishing (EIFS)

1. Providing and patch applying polymerized cementations based adhesive plaster to the back of the RIGID INSULATION of minimum 32-36±2kg/m³ density & sticking the same to the existing plastered /smooth brick walls and holding it with insulation fasteners one each at corner.
2. Providing and applying cementations base coat of 1-2 mm over the RIGID INSULATION
3. Providing & fixing glass fibre mesh as reinforcement over the base coat followed by polymerized cementations based top coat plaster of 1-2 mm.
4. The top coat can be finally finished with any paint of choice (As per specs)

FIGURE 19: EXTERNAL THERMAL INSULATION WITH FINISHING SYSTEM(ETICS)

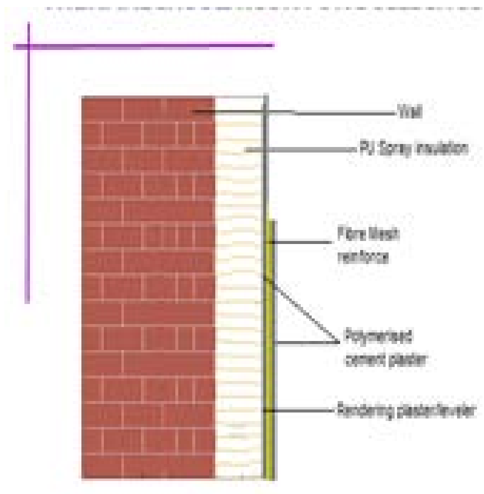


Spray cast in-situ Insulation

1. Providing and applying directly SPRAY INSULATION on the clean wall having minimum 40±2kg/m³ density in multiple passes to achieve the specified thickness.
2. Providing and applying cementations base coat over the sprayed RIGID INSULATION
3. Providing & fixing glass fibre mesh as reinforcement over the base coat followed by polymerized cementations based top coat plaster of 1-2 mm.
4. The top coat can be finally finished with any paint of choice (As per specs)

Caution: The system must be coherent: all products shall be parts of approved system.

FIGURE 20: SPRAY CAST IN-SITU INSULATION

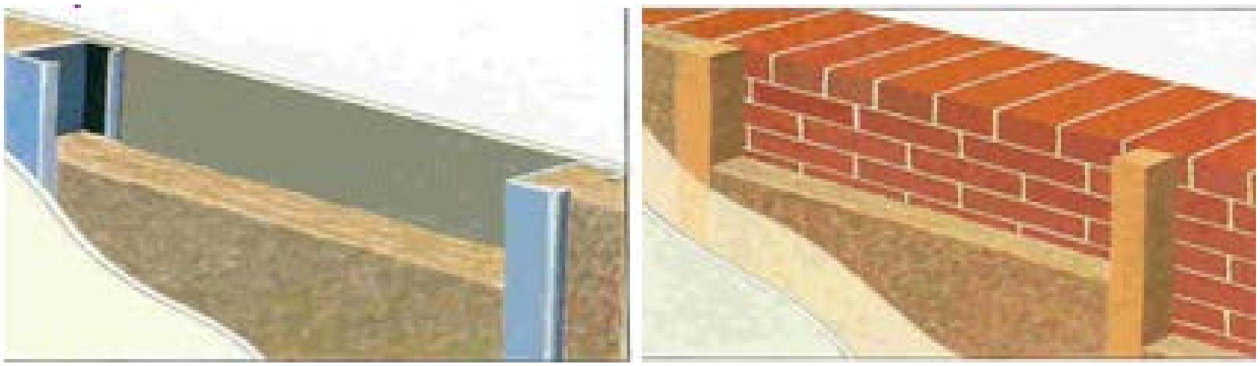


Internal wall insulation:

Fibrous Insulation

1. Providing and fixing suitable wall GI channel of suitable size and thickness to the brick / RCC walls with dash fasteners.
2. Providing and fixing FIBROUS INSULATION of minimum 32-96kg/m^3 between the channels with the help of fasteners and holding it in place with GI lacing wire.
3. Providing and fixing desired thickness Gypsum/Cement fibre/ply board with drywall screws at 300 mm c/c. ensuring proper jointing and finished to have a flush look which includes filling and finishing the tapered or square edges of boards with jointing compound and joint paper tape.
4. Finally providing two coats of top coat as a primer over the entire surface which can be finished with paint or wall papers or any other texture finish.

FIGURE 21: INTERNAL WALL INSULATION WITH FIBROUS MATERIALS

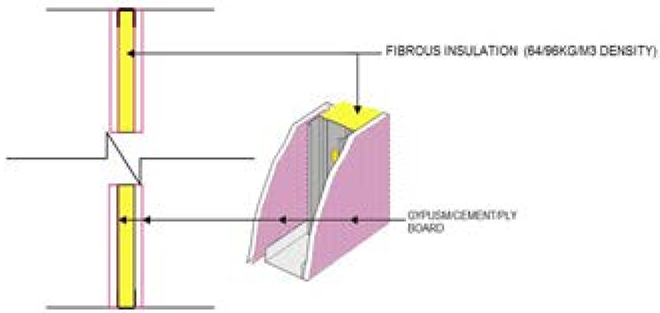


Partition wall insulation:

Fibrous Insulation

1. Providing internal wall partition framework of GI channel of suitable size and thickness.
2. Providing and fixing incombustible FIBROUS INSULATION of minimum 32-96kg/m³ between the partition framework and holding it in place with GI lacing wire.
3. Providing and fixing on both side Gypsum/Cement fiber/ply board in staggered form with drywall screws at 300 mm c/c. ensuring proper jointing and finished to have a flush look which includes filling and finishing the tapered or square edges of boards with jointing compound and joint paper tape.
4. Finally providing two coats of top coat as a primer over the entire surface which can be finished with paint or wall papers or any other texture finish.

FIGURE 22: PARTITION WALL INSULATION


FIBROUS INSULATION (64/96KG/M3 DENSITY)
GYPSUM/CEMENT/PLY
BOARD

Chapter 6

Personal Protective Equipment

Hazards exist in every workplace in many different forms: sharp edges, falling objects, flying sparks, chemicals, noise and a myriad of other potentially dangerous situations. Controlling a hazard at its source is the best way to protect employees.

When engineering, work practice and administrative controls are not feasible or do not provide sufficient protection, personal protective equipment (PPE) is issued to employees and ensure its use.

There must therefore be a procedure whose purpose is to establish minimum personal protective equipment standards for personnel working in potentially hazardous areas, protect all people working at or visiting the site facilities from bodily injury and illness by providing guidance for selection and use of personal protective equipment (PPE).

The Site Management shall ensure that all aspects of this procedure are implemented and followed, and that all potential workplace hazards have been properly assessed.

Site HSE team shall provide advice to the facility on the selection, wearing, and maintenance of PPE, based upon the hazards potentially present; Review and audit PPE for effectiveness. Work with management to define areas/jobs where PPE is required. Provide training resources.

Line Managers shall assure all required training is given; enforce all PPE requirements; Ensure required PPE is available and fit for use.

Employees shall wear proper PPE as required; Inspect all PPE prior to each use to insure proper maintenance and integrity; Remove and replace defective or damaged PPE immediately.

The purpose it to ensure the greatest possible protection for employees in the workplace, the cooperative efforts of both employers and employees will help in establishing and maintaining a safe and healthful work environment.

Hazard assessment and control

A first critical step in developing a comprehensive safety and health program is to identify physical and health hazards in the workplace. This process is known as a "hazard assessment".

Hazards shall be eliminated or reduced so far as practicable in the first instance by substitution or by the use of engineering or administrative controls before PPE is considered; when PPE is used, it must provide protection to a level below applicable exposure limits for known or anticipated hazards;

Work procedures, including signage as appropriate, must clearly specify the use of the PPE identified in the assessments;

Equipment Design

All PPE must meet applicable national/local standards and recommendations.

The design, construction, and material used must give adequate protection for the hazards involved, be they chemical, biological, radiological or physical.

Selection Guidelines

The general procedure for selection of protective equipment is to:

Become familiar with the potential hazards and the type of protective equipment that is available, and what it can do; i.e., splash protection, impact protection, etc.

Compare the hazards associated with the environment; i.e., impact velocities, masses, projectile shape, with the capabilities of the available protective equipment.

Select the protective equipment which ensures a level of protection greater than the minimum required to protect employees from the hazards.

Fit the user with the protective device and give instructions on care and use of the PPE. It is very important that end users be made aware of all warning labels for and limitations of their PPE.

Appendix:

CONVERSION TABLE

Basic Conversion	1 in	=	25.4 mm		
	1 ft	=	0.3048 m		
	1in^2	=	645.2 mm^2		
	1 ft^2	=	0.0929 m^2		
	1 in^3	=	16390 mm^3		
	1 ft^3	=	0.07832 m^3		
Force	1 lb	=	4.448 N	=	0.4536 kg.
	1 lb/ft	=	14.59 N/m	=	14.873 kg/m
	1 ton	=	9.964 kN	=	1016 kg = 1.016
Force per unit area	1 lb/in^2	=	0.006895 N/mm^2	=	0.0703 kg/cm^2
	1 lb/ft^2	=	47.88 N/mm^2	=	488.2 kg/cm^2
	1 ton/in^2	=	15.44 N/mm^2	=	157.5 kg/cm^2
	1 ton/ft^2	=	0.1073 N/mm^2	=	1.094 kg/cm^2
Force per unit volume	1 lb/ft^3	=	157.1 N/m^3	=	16.02 kg/cm^3
	1 lb/in^3	=	271.4 kN/m^3	=	27.68 tonne/m^3
	1 ton/ft^3	=	351.9 kN/m^3	=	35.88 tonne/m3
Temperature	N Fahrenheit	=	0.5556 (N-32) Celsius		
Heat	1 Btu	=	1055 Joule		
	1 Btu	=	1.055 Kilo-joule		
Heat Flow	1 Btu/hr.	=	0.2931 Watt		
	1 Btu/hr.	=	0.0002931 Kilowatt		
Heat Flow per unit area	1 Btu/ft^{2}hr.	=	3.155 W/m		
Intensity of heat flow	1 Btu/ft^{2}h	=	3.155 W/m2		
Thermal Conductivity	1 Btu in/ft^{2}h^{0}F	=	0.1442 W/m^{0}C		
Coefficient of heat transfer	1 Btu/ft^{2}h^{0}F	=	5.678 W/m^2 ^{0}C		
Thermal resistivity	1 Ft^{2}h^{0}F/Btu in	=	6.933 m^{0}C/W		
Thermal Capacity	1 Btu/lb^{0}F	=	4.187 kJ/kg ^{0}C		
Thermal Conductivity	1 Btu in/ft^{2}h^{0}F	=	0.1442278889 W/m^2·K		
Thermal Conductance	1 Btu/ft^{2}h^{0}F	=	5.678 W/m^{2}K		

Source : Ministry of Energy- Energy conservation programme Appendix-1 Properties and Application of insulating material from building in Kuwait second edition 2004

Bibliography & Useful Links

References have been taken from as under:

1. ISHRAE Handbook- All About Insulation
2. Energy Conservation Building Code (ECBC) 2007 Published by BEE
3. ECBC User guide
4. Ministry of Energy- Energy Conservation Program - Appendix-1 Properties and Application of insulating material from building in Kuwait; second edition 2004
5. BEEP training manual : Measuring the characteristics ofthermal insulation materials
6. www.indiainsulationforum.in
7. http://www.carbse.org/resource/tools/
8. http://www.greenbiz.com/news/2013/04/04/there-business-case-building-green
9. http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/energy-efficiency-quiz/?utm_source=Twitter&utm_medium=Social&utm_content=link_tw20140902env-geceff&utm_campaign=Content&sf4457303=1
10. http://www.beepindia.org/content/indo-swiss-beep
11. http://www.iusstf.org/story/53-61-Joint-Clean-Energy-Research-and-Development-Center%28JCERDC%29.html