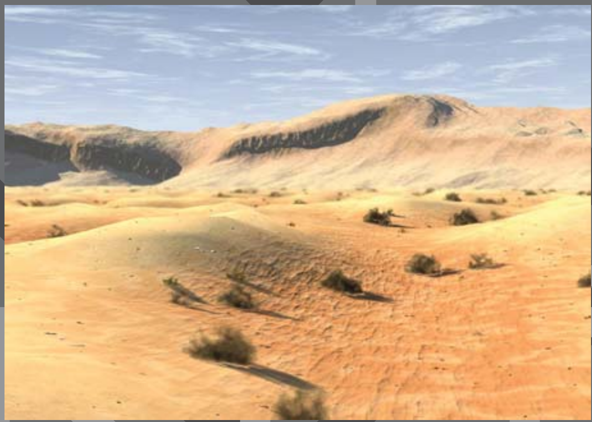
sustainability

thermal insulation



energy efficiency

environment

TIASA

Thermal Insulation Association of Southern Africa

GUIDE FOR THE CONSTRUCTION OF ENVIRONMENTALLY COMFORTABLE HOMES

Endorsed by:

CETA CONSTRUCTION EDUCATION AND TRAINING AUTHORITY

Administered by

AAAMSA Group

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The Thermal Insulation Association of Southern Africa (TIASA), currently under the aegis of AAAMSA, promotes that part of the Industry which specializes in the insulation of ceilings, walls, floors, piping and vessels with thermal insulation.

Membership constitutes manufacturers and suppliers of insulation materials, consultants for thermal insulation as well as contractors who sell and install insulation materials.

TIASA has funded the fast tracking of SANS 283 Energy Efficient Buildings by engaging the University of Pretoria/NOVA.

This Guide is the result of findings/recommendations made by NOVA and we acknowledge their valuable input.

PROJECT TO FAST TRACK THE IMPLEMENTATION OF ENERGY EFFICIENCY STANDARDS IN SOUTH AFRICAN HOUSING FOR IMPROVED COMFORT, HEALTH AND REDUCED CARBON EMISSION

THRIP ID 2689: DESIGNING & CONSTRUCTING FUNCTIONAL HOUSEHOLDS

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INTRODUCTION

South Africa ratified the United Nation Framework Convention on Climate Change in August 1997 and is obliged to develop and submit a National Communication that contains an inventory of greenhouse gas emissions for a base year (1990) and to develop a strategy to address climate change.

When coal is used as energy source, its combustion generates carbon di-oxide and other greenhouse gasses. Coal is the main source of energy in South Africa, and the emission of the combustion products is an environmental concern. Inefficient combustion of coal and wood causes air pollution and emission of greenhouse gases. Globally at the centre of this activity are the window, glass and insulation industries.

Energy consumption in South Africa measured against output (GDP) is very high compared to its global competitors since the use of insulation is very low. Because of the relatively low cost of electricity excessive heat losses or gains are often ignored. The misconception that insulation in the region is not essential and regarded as a luxury item continues. Cheap electrical energy has given rise to excessive use thereof, diminishing the long-term resources and contributing to environmental pollution. Apart from these issues, peak demand for electricity during the winter months is reaching the generating capacity of Eskom.

The vast majority of affordable homes currently being built are not energy efficient, further escalating the problem of energy wastage into the future. Except in the Southern Cape Condensation belt all new low-income housing of low thermal performance.

Currently the electrical energy usage of grid-connected houses has a total electricity consumption of 32000GWh (Giga Watt hours) having a CO_2 pollution of 26,2Mt (Megga tons – 26 200 000 tons).

By 2025, with no intervention to curb energy usage, these figures escalate to 66500GWh and 54,2Mt respectively.

The above must be read in conjunction with Government Gazette #26169 of 14 May 2004 which states that the current installed capacity is approximately 37000MW. Assuming a 10% RESERVE MARGIN South Africa will be short of capacity by 2005-2007 unless demand site management occurs or new plants are built.

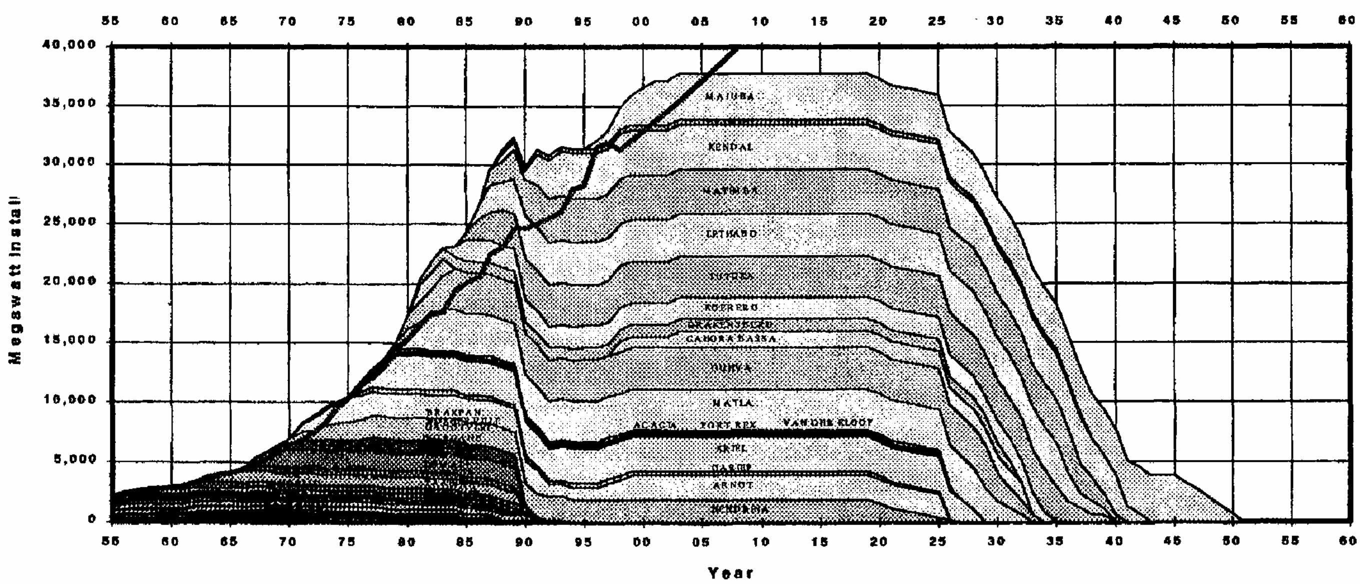


Figure 1: Eskom electricity generation capacity as a function of time – the solid line indicates actual and projected demand (DME, 2003)

This Gazette also publishes the estimated costs to society of health care as follows:

Valuation estimates for the annual mortality and morbidity burden of household coal pollution (Qase et al, 2001) in millions of Rands.						
	2000	**2001**	**2000**	**2001**	**2000**	**2001**
Asthma attack	6.45	6.82	15.15	16.01	63.96	67.61
Acute Bronchitis	120.62	127.50	241.24	254.99	361.00	381.58
Chronic Bronchitis	38.29	40.47	103.65	109.56	19748	208.74
Outpatient/GP visit	0.14	0.15	0.28	0.30	0.56	0.59
Mortality	11.22	11.86	28.61	30.24	63.96	67.61
Respiratory, symptom day	3.37	3.56	10.52	11.12	20.06	21.20
Respiratory hospital adm.	0.14	0.15	0.42	0.44	0.84	0.89
Restricted activity	11.64	12.30	31.00	32.77	60.59	64.04
Total	191.87	202.81	430.86	455.43	769.44	813.30

The Department of Minerals & Energy has requested the SABS to develop a standard for commercial buildings namely SANS 204 – Energy Efficiency and command.

The Department of Housing has requested the SABS to develop a standard for housing namely:

SANS 204 - Energy Efficient Buildings

Both departments are currently negotiation with the Department of Trade and Industry to amend the National Building Regulations and Buildings Act (Act 103 of 1977) to enforce the above standards. It is envisaged that the Act and the SANS Standards are published by June 2007.

GUIDE FOR THE CONSTRUCTION OF ENVIROMENTALLY COMFORTABLE HOMES

1. WHO SHOULD USE THIS MANUAL?

This manual aims to help those persons tasked with erecting and inspecting thermally comfortable homes in South Africa.

It assumes that the building design has been produced by a responsible and knowledgeable person, and that reasonable maintenance is done afterwards.

The manual describes best practice in simplistic terms. It should not be used for e.g. questions of design, structure, safety, health, economics, law, environmental impact, resource efficiency etc.

Finally, while the text has been written in plain English, it is assumed that the reader is familiar with South African building construction and its terminology.

2. WHY IS THE BUILDING PROCESS SO IMPORTANT?

The best thermal design can be ruined if built badly. The builder, and even the owner builder, should understand the intention of the designer. The builder takes co-responsibility for the final product since he is the last authority in the whole process of building procurement who can discover and correct mistakes made in the previous work.

If you notice an obvious design mistake you should report this to the designer or client for correction.

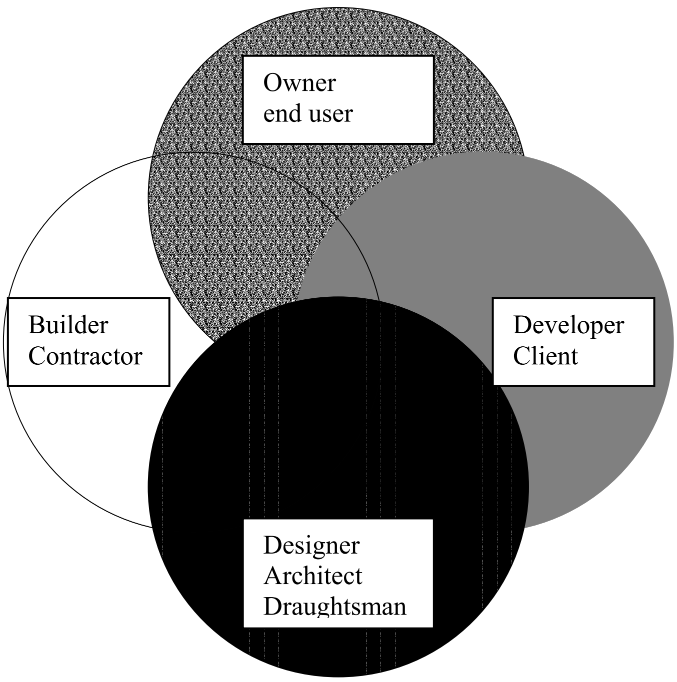


Fig 2.1 - Interaction of role players in residential building

3. WHAT MAKES A COMFORTABLE HOME?

A thermally comfortable home is neither too hot nor to cold for most of the people most of the time. This can be achieved by a clever combination in the design, north orientation, windows, building shell insulation, indoor mass and draught proofing.

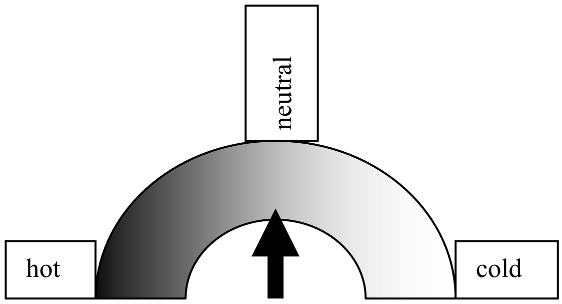


Fig 3.1- Neutrality is neither too hot nor too cold

4. HOW DOES THIS WORK?

Basically, north windows provide winter heating. The combination of indoor mass (concrete floor, heavy walls and roofs) with shell insulation stabilizes the indoor air warmth in winter and coolness in summer.

Heat flows from a higher to a lower temperature level by conduction, radiation and convection. Conduction occurs through solid materials, radiation through the air and convection through free air movement, such as air leakages.

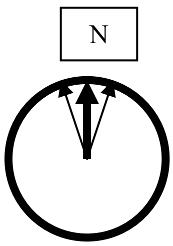


Fig 4.1 – Major windows to face true north ±15°

North window = winter heating
Indoor mass x shell insulation = reduced indoor temperature swing

5. WHAT IS DRAUGHT PROOFING?

It is also called weatherization, which means reducing the uncontrolled and unwanted leakage of outside air into (“infiltration”) or out of (“exfiltration”) the house. *Fig5.1*

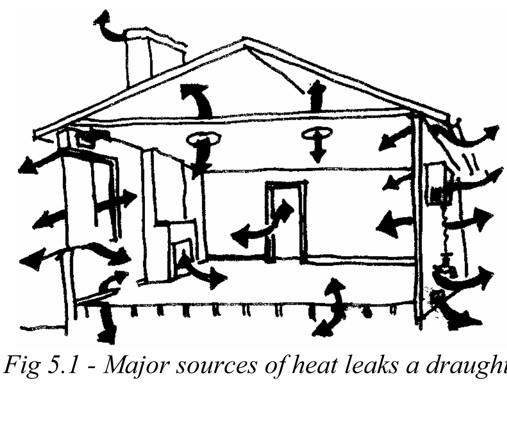


Fig 5.1 - Major sources of heat leaks a draughts

The outside air should not leak into the house because it is too warm in summer and too cold in winter (cold draught). This would defeat the objective of insulation, thermal mass and heating.

6. CAN A HOUSE BE TOO AIRTIGHT?

South African homes are very far from being too airtight. One person requires only as much oxygen as one burning candle. However, a coal burning mbaula is very dangerous, even in a leaky house.

Therefore the aim should be to reduce unwanted air leakage and apply controlled ventilation when needed.

7. HOW IS AIR LEAKAGE (CONVECTION) CONTROLLED?

Air leakage can occur through gaps around exterior doors and windows, airbricks, ceilings and other small holes in the building shell. It is caused by vertical pressure differences between hot and cold air and/or by wind speed. Wherever there is air leakage there is also acoustic noise penetration.

- **DESIGN**

  If for example, the designer orientated the building wrongly, placed the front door facing cold winter winds, or specified glass louvres or steel frames with very high tolerances, this should be pointed out.

  - **The major windows should face true north ±15° and should have site specific overhangs.**

- **OUTSIDE WALLS**

  Cavity walls have weep holes to drain off water. Outside air is allowed to enter the cavity via the holes, but should not be permitted to enter the indoor space from there. The inner brick skin should be airtight.

  - **Seal all gaps where conduits, electrical boxes, pipes and ducts penetrate, using an elastic sealer like foamed polyurethane. The contact surfaces should be moistened before application of the sealant.** *Fig7.1*
  -

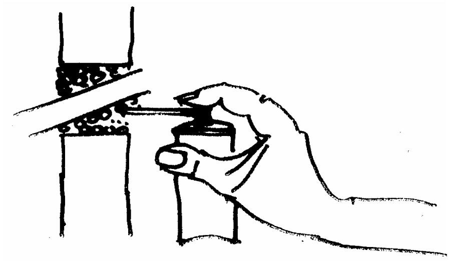


Figure 7.1 Seal penetration through outside wall

Beam filling is the brickwork between the roof and the top of the outside walls. This is an area difficult to work in and not routinely inspected. If not properly closed off, this area will not only permit the ceiling insulation to be blown away, but also invite bats, spiders, snakes, vermin, bees and other assorted lodgers.
Where the wall touches the roof, heat will be transmitted. This is a design weakness.

- **Seal the gap between the roof and the outside wall with mortar, taking care that the roof movement does not break away the filling.** *Fig7.2*

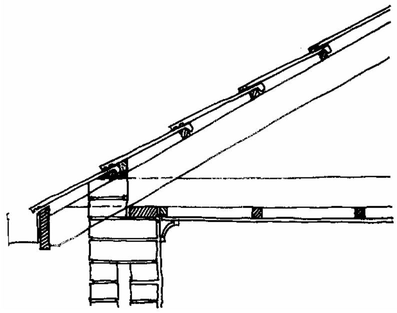


Figure 7.2 Seal beam filling

Structural cracks in the outside walls are cracks that are deeper than the surface plaster and are not a good sign. They are normally not life endangering, but are unsightly and allow air to infiltrate. As rainwater enters, further structural damage is caused.

The cause of cracks may be inappropriate design on moving soil or lacking design for thermal expansion of walls. Cracks can also be caused by poor workmanship such as insufficient foundations, and cement blocks that were not properly cured. Finally, cracks can be caused by outside forces like earthquakes and air blasts.

❖ **Remove the cause of cracking as far as possible, moisten the contact surfaces and apply foamed polyurethane according to the manufacturer's instructions into both inside and outside of cracks inserting the nozzle into the crack. Cut the dried foam back to the wall surface and make good with the surface treatment of the adjacent wall finish.** *Fig7.3*

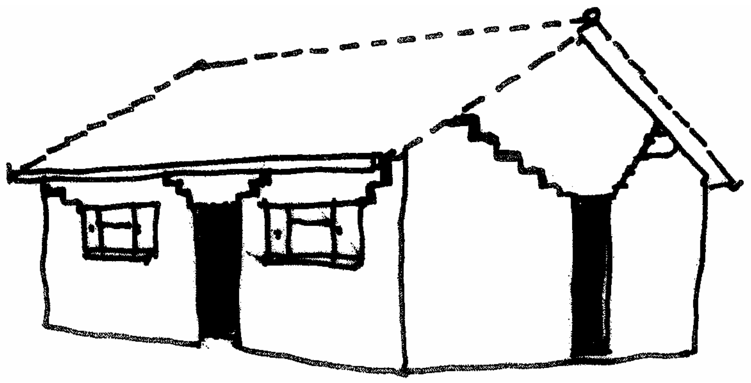


Figure 7.3 – Seal cracks in exterior walls

- **WINDOWS**

Movable glass louvres cannot be made airtight. **Standard opening sections** (top, bottom and side hung) **of steel windows (cottage CF6)** are not designed to be draught proof, and certainly are not.

❖ **In retrofit situations: clean the contact area of the frame (not the opening section) and apply a sealer strip, taking care not to shear the strip at the hinge. Adjust the window handle to exert sufficient even pressure over the strip without breaking the glass – a difficult job.** *Fig7.4*

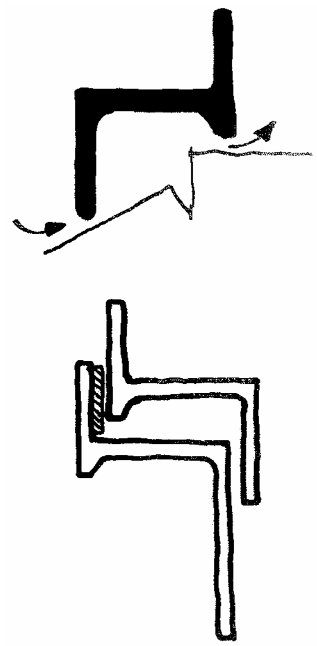


Figure 7.4 – Seal draughty window

Sliding-projecting opening sections and pivot (reversible) steel frame windows of standard cottage steel sections are as air leaky as the standard casement windows, but somewhat easier to retrofit with compressible sealers, because of the closing movement.

❖ **See above.**

Hardwood frame windows have larger contact areas and should have a draught-reducing profile, with a cavity that also serves as a secondary drip. The draught proofing of such opening sections is by design much superior to steel sections, with both hinging and sliding-projecting designs.

❖ **Clean the contact surface and apply compressible sealer strips to the vertical surface of the frame if so specified or in retrofit applications.** *Fig7.5*

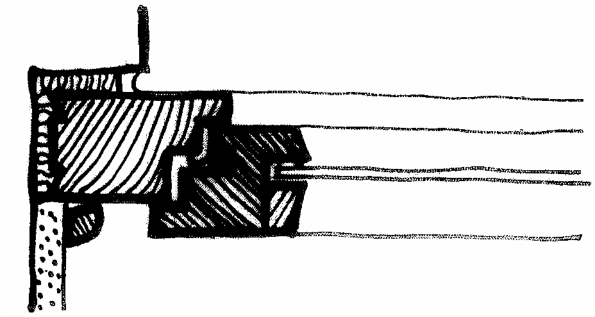


Figure 7.5 – Seal doorframe

Horizontally sliding hardwood windows normally have brush type draught proofing strips that also prevent rattling.

❖ **Carefully protect the sealer strip during construction and inspect functionality upon completion.**

Vertically sliding counter-weighted or spring-loaded hardwood sash windows are exceptional today.

❖ **See above.**

Hollow sections of steel, aluminium or plastic material normally have sophisticated profiles designed for enhanced rigidity, water proofing, tighter manufacturing tolerances and air tightness. These sections are often designed to avoid thermal bridges and to accommodate multiple glazing.

❖ **Follow the manufacturer's instructions and avoid creating thermal bridges with the installation.** *Fig7.6*

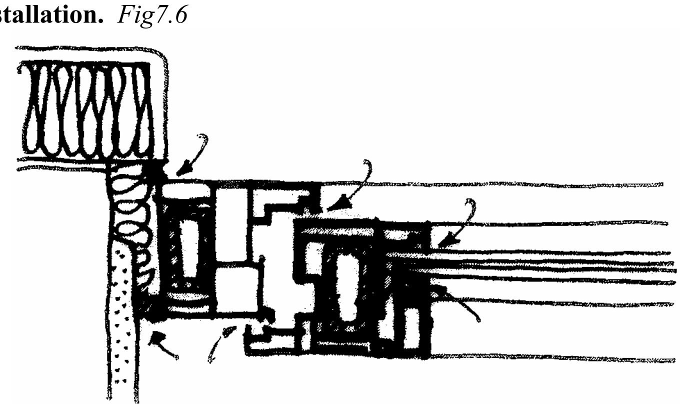


Figure 7.6 – Avoid thermal bridges

- **EXTERIOR DOORS**

Front entrance doors usually swing inwards, which implies that they cannot be lower than the threshold. A normal door has a 5,7metre perimeter of potential air infiltration.

❖ **Ensure that the doorframe as well as the door is straight, plumb and not warped.**
❖ **Ensure that there is an effective drip and threshold.**
❖ **Ensure that the finished floor surface within the door swing is horizontal and smooth.**

For draught-proofing:

- ❖ **Consider using three hinges.**
- ❖ **Provide door sweep to bottom, and sealer strips to top and sides of doorframe.**
- ❖ **Adjust striking plate for door to close snugly.** *Fig7.7*

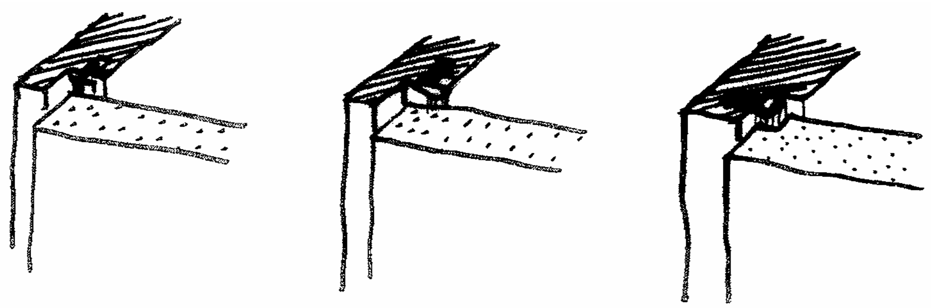


Figure 7.7 – Door sweeps and sealer strips to exterior doors

Back doors opening outward are easier to weatherproof because the door bottom strikes against the threshold.

- ❖ **See "Front entrance doors".** *Fig7.8*

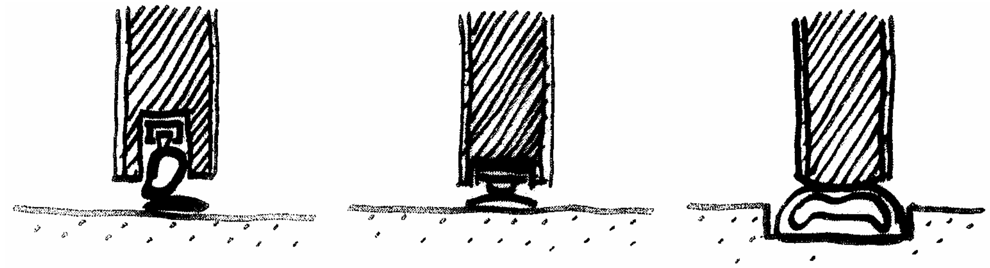


Figure 7.8 – Draught-proofing at door swinging out

Exterior sliding doors normally come with brush-type sealer strips, except steel units and some sliding-folding designs.

- ❖ **Ensure that the sealer strips are in tact and seal properly.**
- ❖ **Remove all dirt and mechanical obstructions.**

- STOVES AND FIREPLACES

Fireplaces are connected to the outside air via chimneys. The hot air escaping from the chimney has to be replaced by fresh, cold air coming from outside.

In addition, a hot chimney continues to withdraw hot inside air, even after the fire has died down.

- ❖ **Provide an air supply from the outside that does not cool the inside air.**
- ❖ **Provide a damper to the chimney that can be closed when the fireplace is not in use.**

- ROOF

South Africa lies relatively near the equator, with considerable areas at elevated altitudes. This means that roofs are exposed to both high solar radiant heat gains in summer and high heat losses during clean winter nights. The roof-ceiling combination therefore warrants special attention from a thermal point of view. In South Africa water heaters are often placed in the attic space where they have standing losses of up to 25% in winter.

Tiled roofs require under tile foils laid over the rafters.

- ❖ **Use reflective foils for higher durability and better thermal performance.**
- ❖ **Tape foil overlaps for draught proofing.**

Ventilated attic spaces do not provide better thermal performance in summer than unventilated ones. This has been verified by CSIR experiments. In fact, ventilated attic spaces lead to higher dust accumulation.

❖ **Seal outside openings in attic space.**

Ceilings are the last line of defence against air leakage, and should withstand upward as well as downward air pressures. Porous acoustic and knotty pine ceilings are not airtight.

❖ **Provide a continuous air barrier over the entire ceiling in the form of a foil, if ceiling is not airtight.**
❖ **Seal ceiling penetrations of electric conduits and water pipes.**

Breathing ceilings admit controlled fresh air through the ceiling insulation that doubles up as heat exchanger, recuperating the heat moving upwards from the room in winter.

❖ **Ensure that ceiling insulation is placed without any interruption, and seal all wall penetrations.** *Fig7.9*

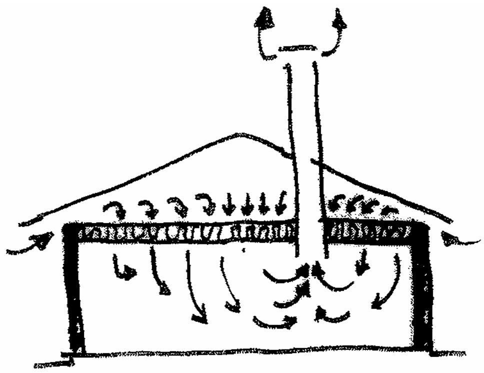


Figure 7.9 – Breathing ceiling

- **FLOORS**

Suspended wooden floors require under-floor ventilation against dry rot. It is difficult to stop air infiltration through cracks, trap doors and around floor skirting.

❖ **Extract under floor air via a chimney pipe, permitting room air to escape at a controlled rate through floor cracks etc.** *Fig7.10*

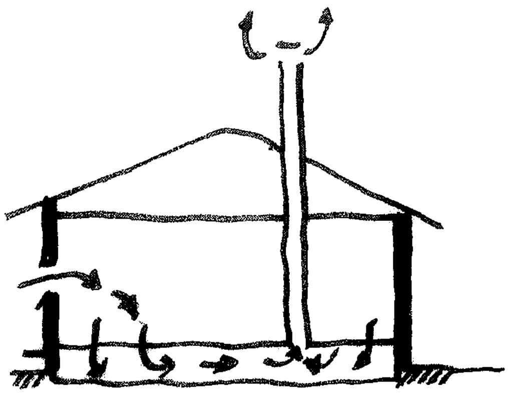


Figure 7.10 – Ventilation under suspended timber floor

8. WHAT IS THERMAL INSULATION?

In the previous section we learned that air leakage (conduction) can largely reduce the benefits of good thermal insulation. This section deals with reflective and resistive thermal insulation.

Reflective insulation consists of shiny surfaces that reflect solar and infrared radiation travelling through the air. Therefore reflective insulation will be effective as long as the surface remains shiny and as long as there is an air space.

Reflective insulation is better at reducing summer heat gain than slowing heat losses in winter. *Fig8.1*

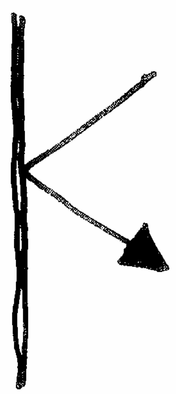


Figure 8.1 – Reflective insulation

Resistive insulation materials have a high proportion of small voids containing air or gas. *Fig8.2*

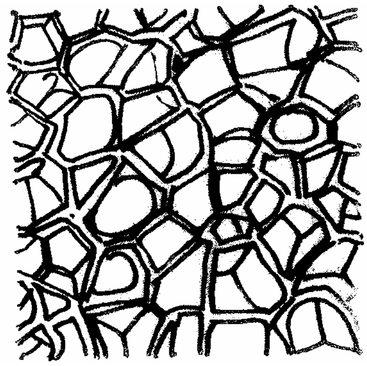


Figure 8.2 – Closed-cell resistive insulation

These voids are too small to transmit heat by radiation or convection, thus providing high thermal resistance. Such materials typically have a low density. Resistive materials may have closed cells like extruded polystyrene or open cells for example rock wool, glass wool, crumpled paper and loose fill materials like cellulose fibre or expanded vermiculite. *Fig8.3*

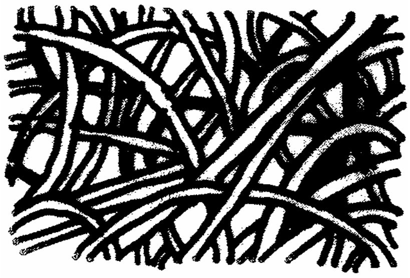


Figure 8.3 – Open-cell resistive insulation

Resistive insulation relies on the integrity of its voids. Therefore resistive insulation will be effective as long as the voids are not filled with moisture or dust particles. Insulation cannot stop the flow of energy, but it can retard it significantly. *Fig8.4*

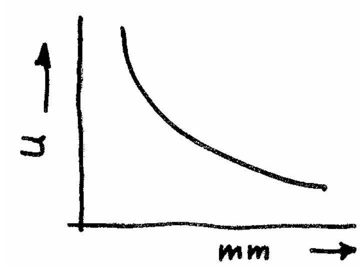


Figure 8.4 – Insulation retards heat flow but does not stop it

Insulation is designed to retard the flow of heat into or out of a house. So, the same insulation is a bonus in summer and in winter. *Fig8.5*

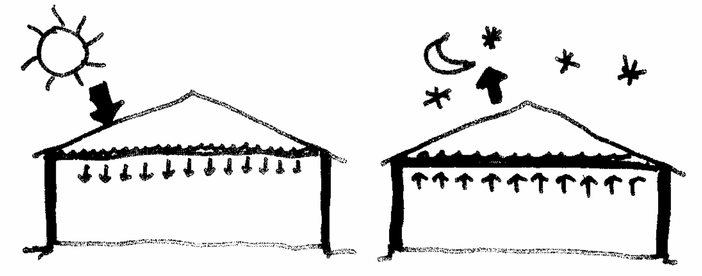


Figure 8.5 – Insulation benefit in summer and winter

Residential buildings are designed for ambient temperatures, and conventional insulation materials are intended for that temperature range.

9. WHAT IS A THERMAL BRIDGE?

A thermal bridge is much like a puncture in a tyre: a small leak makes the rest of the tyre almost useless. Thermal bridges occur where the integrity of an insulation barrier is broken by a structural element like a steel doorjamb, an aluminium frame, a reinforcement bar, wall tie, concrete floor slab or brick window reveal. For example, a thermal bridge of a small 12x12x25mm long copper rod will neutralize the insulation of more than 1,6m² of 25mm thick fibreglass insulation. Great care has to be exercised by the builder and inspector to avoid thermal bridges, and to mitigate their effect, if unavoidable. *Fig9.1*

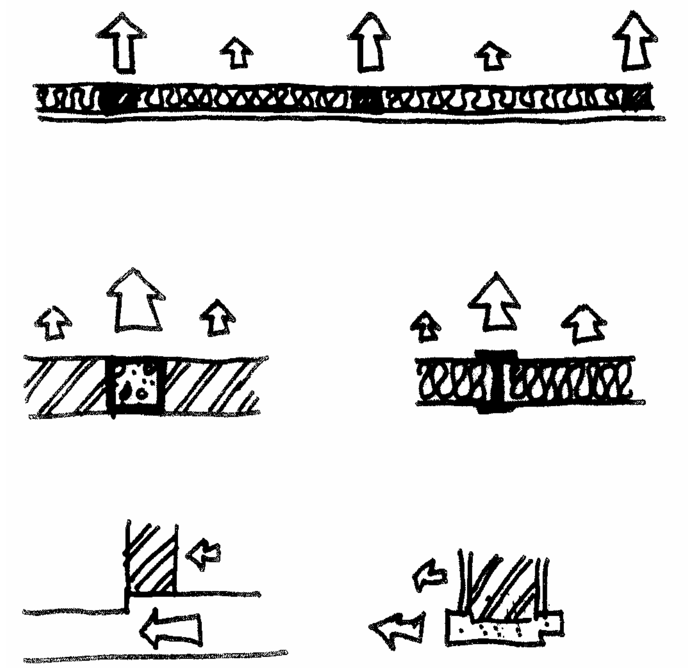


Figure 9.1 – Thermal bridges in conventional construction

10. HOW IS THERMAL INSULATION INSTALLED?

- **DESIGN**

  If the thermal design of the construction-work you have to erect leaves room for improvement in your opinion, feel free to discuss this with the designer and client.

- **OUTSIDE WALLS**

  In principle, the best position for insulation is on the outside face of the exterior walls. In this way the thermal mass of these walls contributes to the thermal flywheel effect, which dampens the indoor temperature swing. *Fig10.1*

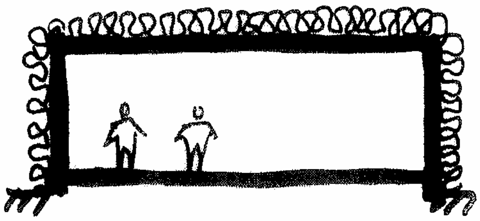


Figure 10.1 – The best position for thermal insulation is outside

In practice, insulation is normally soft and needs protection against physical damage, fire and the elements.

Water or moisture penetrating the outside wall will reduce the thermal resistance very badly, leading to mould growth in the Cape Coastal Condensation Risk area, and to paint and plaster blistering off in all other geographic areas.

❖ **Protect the outside wall with roof overhangs or exterior insulation with damp proofing**. *Fig 10.2*

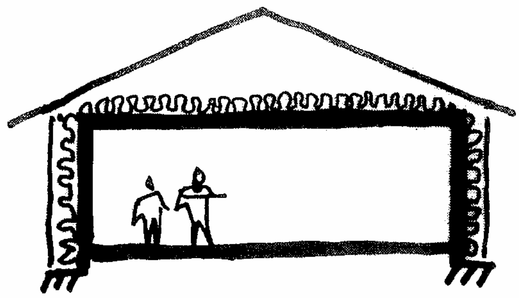


Figure 10.2 – Insulation has to be protected

Parapet walls extending above the roof surface are notorious for leakages and moisture penetrations. *Fig10.3*

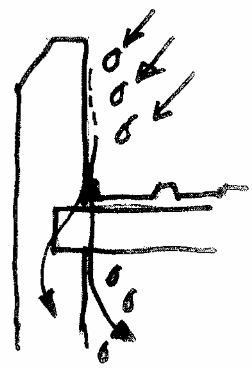


Figure 10.3 – Parapet walls are prone to leak

Less well known is their poor thermal performance, if the ceiling is close to the roof, since they are exposed to the intense midday sunshine *Fig10.4* and cooling effect of the night sky. *Fig10.5*

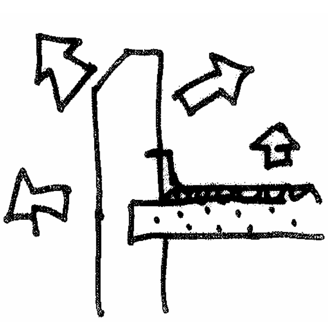


Figure 10.4 –Parapet walls are exposed to the sun

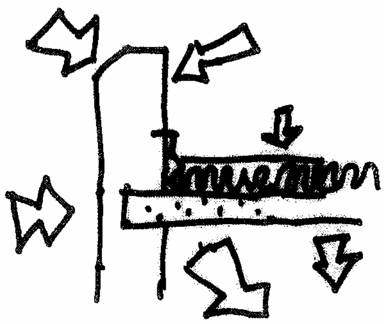


Figure 10.5 – Parapet walls are exposed to the night sky

❖ **If possible, cover both faces with exterior insulation. Apply waterproofing from the roof surface right over the top of the parapet and 500mm down on the other side.** *Fig10.6*

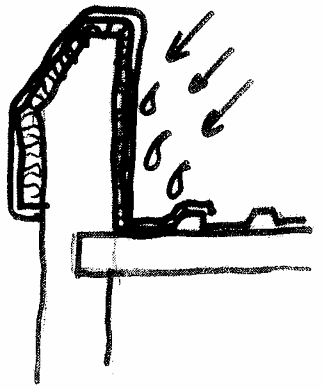


Figure 10.6 – Protect the parapet wall

❖ **Alternatively, remove the parapet and cover the wall with the roof, if this fits in with the total design.** *Fig10.7*

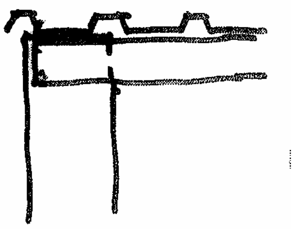


Figure 10.7 – Remove the problem

Mould growth on outside walls occurs where condensate water forms on wall surfaces because the temperature is below dew point for prolonged times. *Fig10.8*

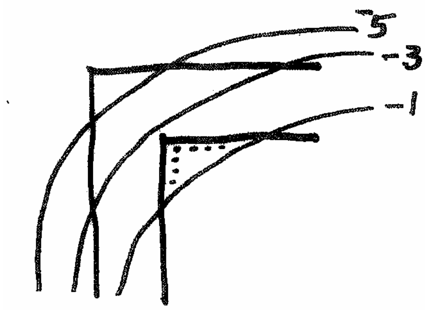


Figure 10.8 – Mould growth in inside corners

❖ **Release less indoor water vapour.**
❖ **Increase ventilation.**
❖ **Apply exterior insulation and moisture barrier on outside walls.** *Fig10.9*

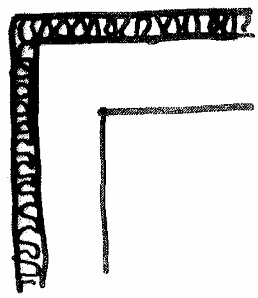


Figure 10.9 – Apply exterior insulation

New **cavity walls** provide protection to the typical extruded or expanded polystyrene boards attached to the inner brick skin, leaving an air cavity for extra insulation and moisture protection. *Fig10.10*

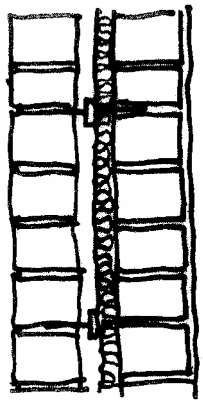


Figure 10.10 – Polystyrene in cavity wall

Walls ties are a necessary evil in cavity wall construction because the two brick (or block) skins have to be tied together for structural reasons. However, metal wall ties form unwanted thermal bridges.

- ❖ **Keep the cavity meticulously clean.**
- ❖ **Use the minimum prescribed wall ties.**
- ❖ **Use wall ties with low conductivity.**

Cavity walls with bulk insulation faced with a reflective sheet towards the cavity are designed to reduce the radiant transmission across the cavity.

- ❖ **Avoid soiling the shiny surface with cement or lime material.** *Fig10.11*

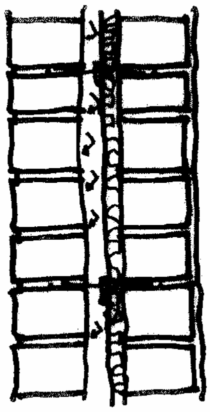


Figure 10.11 – Avoid cement on shiny surface

Cavity walls filled with loose blown or poured granular insulation is attractive in retrofit situations. In practice, a percentage of sagging has been observed at the top of the filling. This leaves an un-insulated area at the top of the wall near the ceiling where most of the hot air accumulates in winter. *Fig10.12*

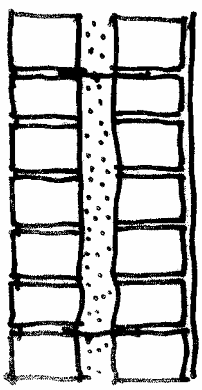


Figure 10.12 – Loose fill in cavity wall

- ❖ **Carefully calculate the amount of insulation that has to fill the cavity to ensure that there are no unfilled spots.**
- ❖ **Form a surplus heap of insulation at the top of the cavity to compensate for sagging.** *Fig10.13*

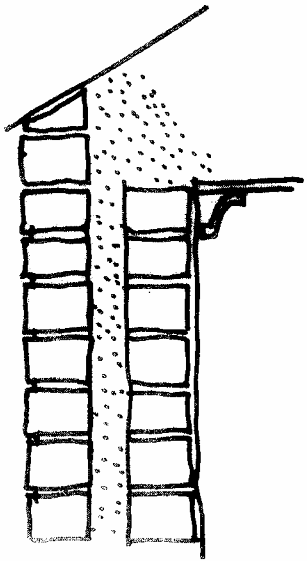


Figure 10.13 – Surplus heap to compensate sagging

Cavities filled with foamed insulation is standard practice in many industrial applications, but rare in retrofit buildings.

- ❖ **Avoid restraining the insulation while foaming, since this can damage the walls.** *Fig10.14*

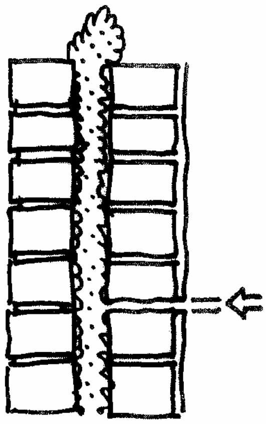


Figure 10.14 – Foamed insulation in cavity wall

An interior brick or solid concrete block skin of sufficient stability with attached bulk insulation faced with a reflective foil towards a cavity, which is covered on the outside with a dry wall construction avoids most problems of the above mentioned cavity wall construction, but is unconventional in South Africa. *Fig10.15 &Fig10.16*

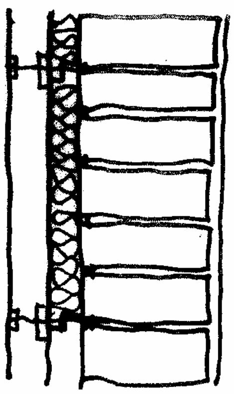


Figure 10.15 – Exterior insulation on solid wall

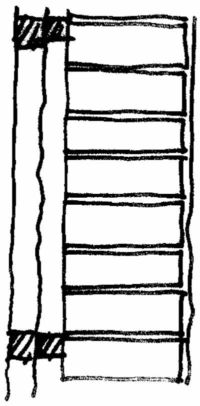


Figure 10.16 – Dry construction protects insulation on heavy wall

- ❖ **Meticulously avoid spilling cement on the aluminium surface as this destroys the shiny surface.**

Solid brick, concrete, adobe walls with applied exterior insulation and protected by plaster is a standard procedure in new and retrofit buildings abroad. The method has been approved by Agrément in South Africa, with fire precautions specified. The construction is hail resistant to stones of up to 60mm diameter. *Fig10.17*

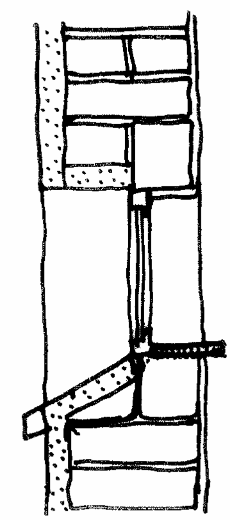


Figure 10.17 – Exterior insulation plastered

- ❖ **Carefully follow manufacturer's specifications, especially with respect to the application of the exterior plaster at external corners, lintels and window sills.** *Fig10.18*
- ❖ **Mix small batches for best results.**

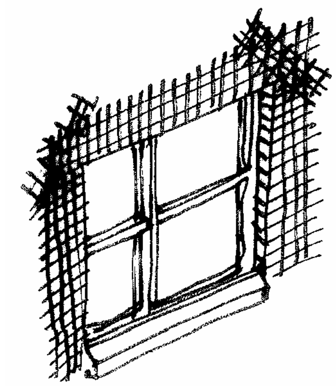


Figure 10.18 – Net reinforcement of exterior plaster

Straw bales and adobe walls provide excellent insulation and can be used structurally. Several buildings exist in South Africa. *Fig10.19*

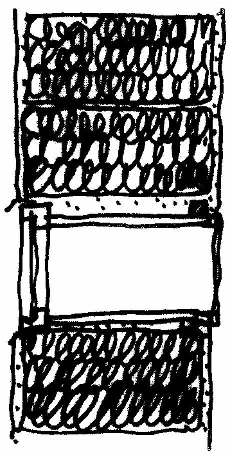


Figure 10.19 – Straw bale construction provides excellent insulation

- **WINDOWS**

Normal glass transmits about 73%; absorbs 20% and reflects 7% of average incident solar radiation sunlight. During the night, its thermal conductance is comparable to a brick wall of 3mm thickness – not much. *Fig10.20* Various designs produce barriers to radiant and convective transmittance. Windows are therefore to be considered as efficient transmitters of solar radiation but a poor insulator that can be improved if double glazed.

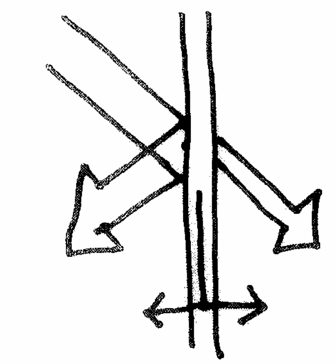


Figure 10.20 – Properties of clear glass

Low E glass has a coating on one inside face of sealed double glazing to either stop the entry or exit of long wave radiation, depending on the design intent. *Fig10.21*

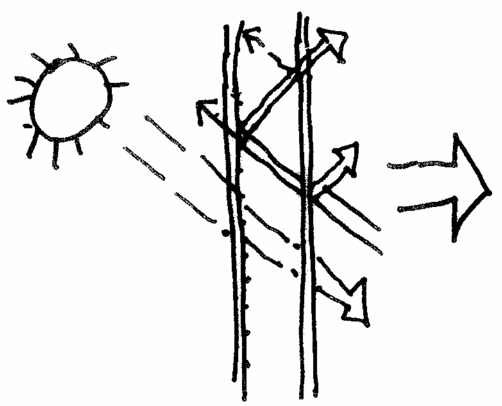


Figure 10.21 – Low E glass retains infrared radiation inside

❖ **Ensure that the glazing is installed the right way round.** *Fig10.22*

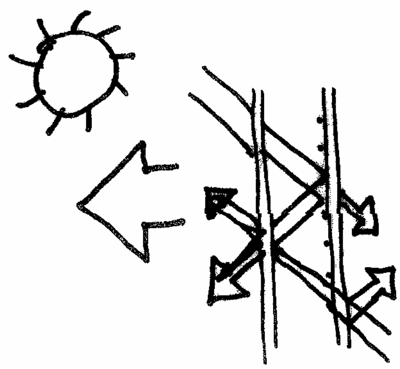


Figure 10.22 – Low E glass stops entry of infrared light

Absorbing/tinted glass absorbs a higher proportion of solar radiation within the glass itself. It is heated in the process, emitting part of the heat on either side. *Fig10.23*

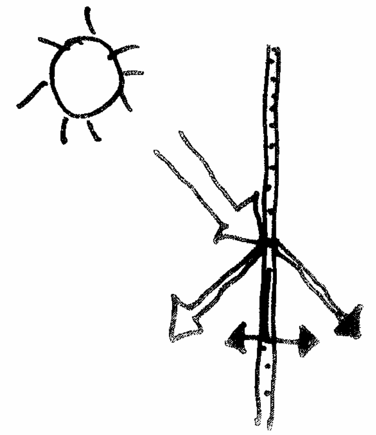


Figure 10.23 – Grey tinted glass absorbs heat (64%)

- ❖ **Heated glass expands. Allow liberal provision for expansion.** *Fig10.24*
- ❖ **Absorbing/tinted glass is more effective if placed as a screen outside the normal clear glass.**

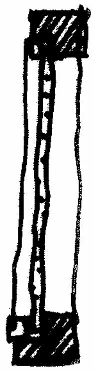


Figure 10.24 – Tinted glass expands

Reflective glass acts like a partial mirror. The glass material itself is not heated as significantly as a tinted glass of the same performance.

- ❖ **Reflecting glass can cause glare to adjacent buildings and may lead to complaints, if not litigation.**

Applied films to absorb or reflect solar light can be applied in various shades for retrofit situations. These are also applied to motorcar windows.

- ❖ **Remember that films are more easily scratched than glass.**
- ❖ **The application of tinted films is inclined to heat the glass surface. Glass may crack, and as a consequence of the increased performance will invalidate the glass manufacturers warranty.**

Double-glazing is readily available in South Africa. It can serve to reduce heat losses in winter and to reduce noise transmittance, in which case the air gap between the panes has to be larger than for thermal needs.

- ❖ **Normal clear double-glazing is not suitable for reducing solar radiant heat gains. Direct exposure to solar radiation will result in significant heat gains which will not be allowed out due to the insulating effect of the double glazing.**
- ❖ **Double-glazing cannot be cut on site.**
- ❖ **Do not scratch the surface as this may lead to glass breakage.**
- ❖ **Allow for glass expansion.**

- **EXTERNAL DOORS**

Front doors conventionally occupy an area of 1,65m² and are normally made of 45mm thick wood of medium thermal resistance.

Backdoors are of the same size as front doors but of less substantial construction.

Pressed steel doorframes are common in middle to low-income houses, while pressed steel doors are found in low-income housing. Their thermal performance is extremely poor.

❖ **Consider better thermal alternatives to steel doors.**

- **FIREPLACES**

Conventional fireplaces burn very inefficiently because fireplaces and chimneys are encased in heavy brickwork and cold incoming air prevents the burning of secondary gases.

❖ **Consider insulation of fireplace and chimney and use of air convection (Jet master principle).** *Fig10.25*

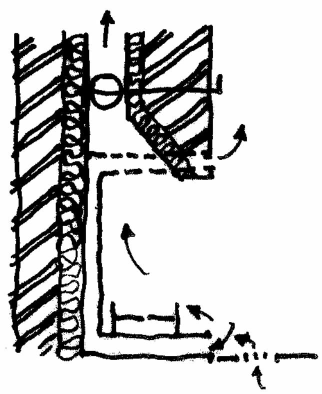


Figure 10.25 – Insulate fireplace and chimney – Use air convection

Standard mbaulas (coal burning braziers or konkas) emit inordinate amounts of pollution. *Fig10.26*

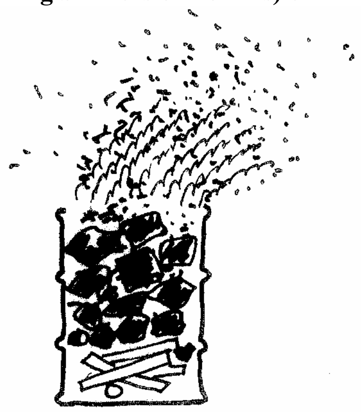


Figure 10.26 – Conventional mbaula emits excessive smoke

❖ **Encourage scotch fires ("basa magogo"), i.e. lighting coal bucket from top, burning downwards. This halves smoke emissions for the same heat release.** *Fig10.27*

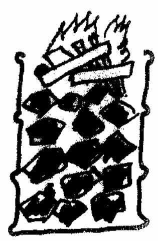


Figure 10.27 – Top-lit scotch fire (basa mogogo) burns much cleaner

Water heaters, electric geysers

Electric water heaters consume about 42% of the domestic energy and contribute 22% to the domestic sector peak demand. One quarter of the energy is wasted in standing losses.

❖ **Consider the use of solar water heaters.** *Fig10.28*

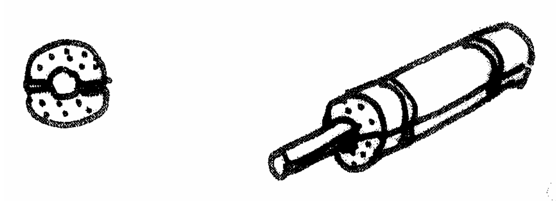


Figure 10.28 – Integrated solar water heater

❖ **Consider gas water heaters.**

❖ **Install pipe lagging (insulation) on all hot water pipes and 2m on all cold water pipes connected to geyser.** *Fig10.29*

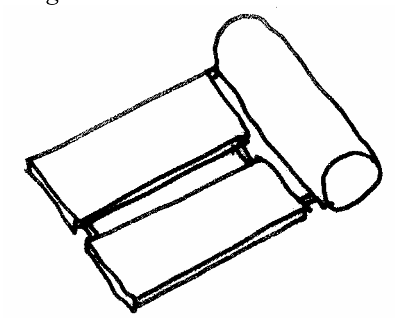


Figure 10.29 – Prefabricated pipe lagging installed on existing pipe

❖ **Consider retrofitting Solar Water Collector to existing geyser.** *Fig10.30*

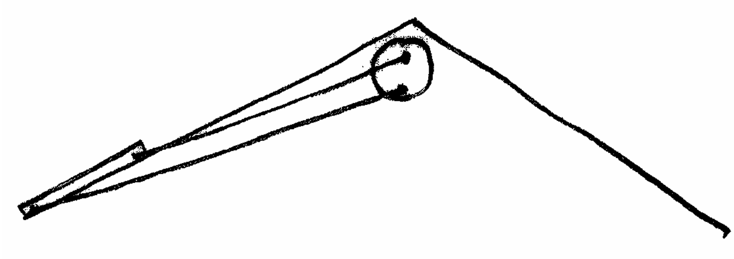


Figure 10.30 – Solar water collector connected to existing geyser

❖ **Geyser mantles greatly improve the efficiency of standard SABS approved geysers.** *Fig10.31*

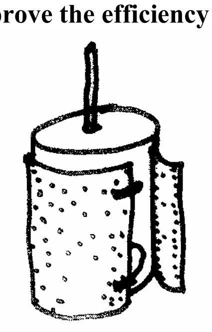


Figure 10.31 – Retrofit geyser mantles on existing geyser

- **ROOFS AND CEILINGS**

Roofs without ceiling are currently being built in South Africa with government subsidies. Since there is little awareness and no legislation it is also common to have ceilings without thermal insulation, even in high-income homes. Homes in cold winter areas (see map) will save more by installing roof/ceiling insulation, but houses in hot summer areas will be substantially (4K) cooler with insulation. Homes with ceiling heights above 3m, and homes with air conditioning should have higher than minimum insulation values.

Flat ceilings with pitched roofs are the easiest to insulate.

- **Use reflective foil laminate ("sarking") over the rafters but below the battens of the roof tiles with a minimum overlap of 150mm starting from the bottom where the foil should end in the gutter.** *Fig10.32*

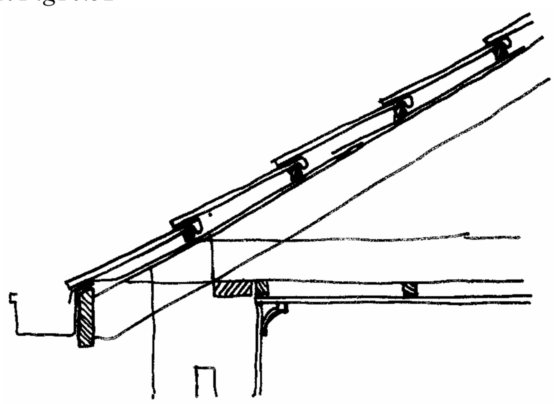


Figure 10.32 – Double-sided reflective sarking over rafters

- **If single-sided, the reflective surface should face down to prevent the effect of dust accumulation. This insulation is a more permanent and better solution than foils. It provides a less dusty roof space and reduces temperature extremes, which are bad for the roof construction. However, bulk insulation is still needed.** *Fig10.33*

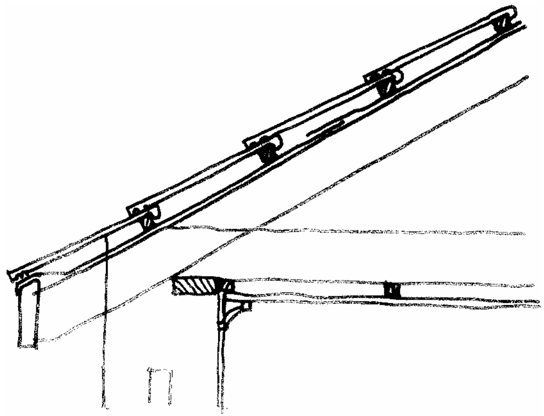


Figure 10.33 – Single sided reflective foil facing down

Flat ceilings with pitched roof, with reflective sarking and bulk insulation boards to underside of rafters require more insulation material but provides an insulated roof space.

- **Rodent proofing is difficult.** *Fig10.34*

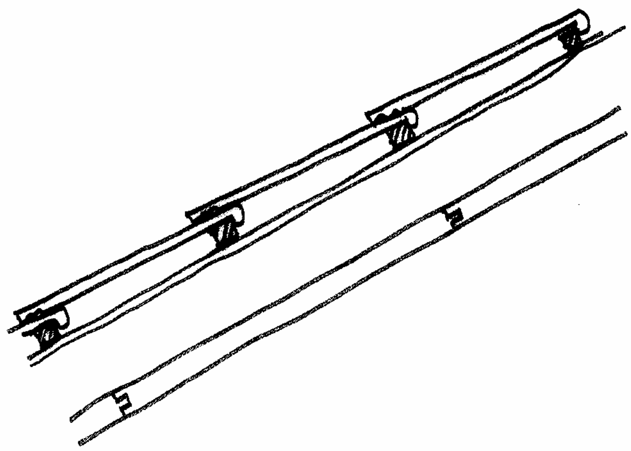


Figure 10.34 – Reflective foil sarking and bulk insulation to underside of rafter

Flat ceilings with pitched roof, with reflective sarking and bulk insulation on top of the ceiling between ceiling joists (tie beams) in the form of batts, boards or loose fill material allow vermin control and good visibility of potential leaks, but has thermal bridges at ceiling joists, and requires a lot of cutting. *Fig10.35*

❖ **Fit tightly between joists.** *Fig10.36*

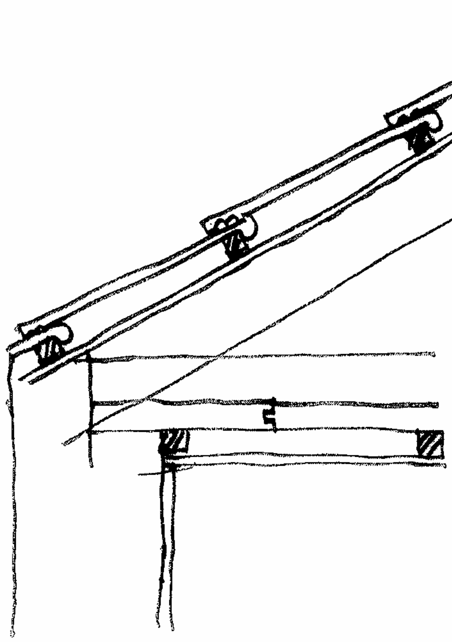


Figure 10.35 – Bulk insulation on top of ceiling batterns

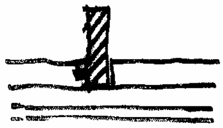


Figure 10.36 – Bulk insulation between tie beams

As above, but with batts or boards over ceiling joists, provides an additional air space and avoids thermal bridges, but the air space is an opportunity for vermin. Workers may step between rafters breaking the insulation and falling through the ceiling. *Fig10.37*

❖ **Provide gang planks.** *Fig10.38*

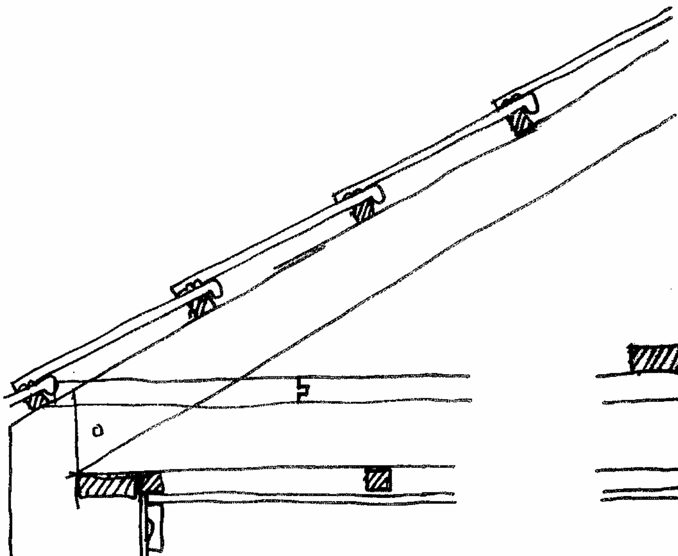


Figure 10.37 – Bulk insulation over tie beams

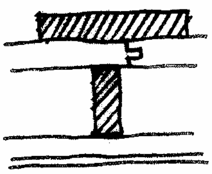
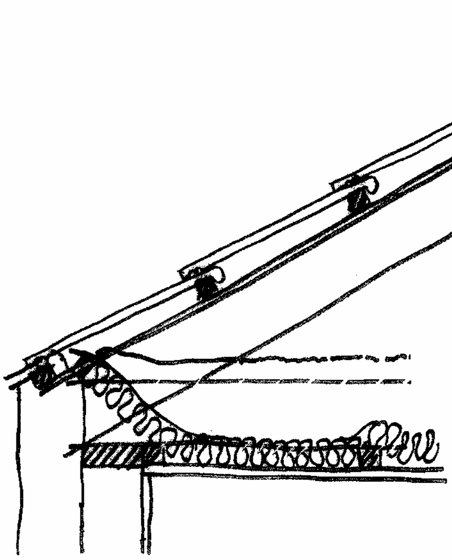


Figure 10.38 – Position gang planks for workmen

As above, but with fibrous bulk insulation draped over ceiling joists Fig10.39, obviates thermal bridges, and workers know where to step. *Fig10.40*



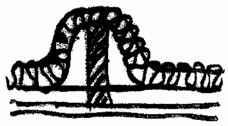


Figure 10.39 – Fibrous insulation drape over tie beams

Figure 10.40 – Continuity of insulation over tie beams

Ceilings with exposed rafters, inclined or flat ceilings have to be insulated during construction. Retrofits are seldom satisfactory.

- ❖ **Rather provide ceiling insulation during construction.**

Metal sheet roofs on purlins with bulk insulation infill provide support to the decking, but the purlins cause frequent thermal bridges. Cannot be retrofitted unless the roof is removed. *Fig10.41*

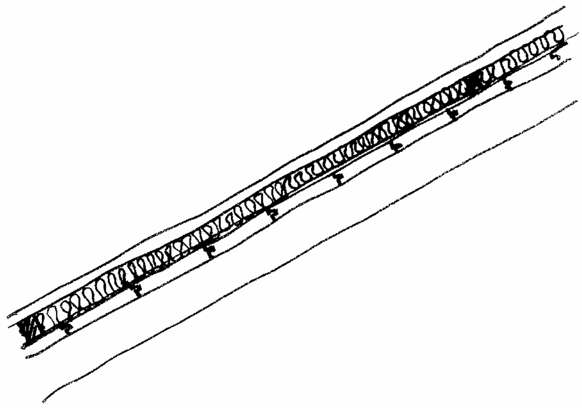


Figure 10.41 – Insulation between purlins

- ❖ **Provide continuous vapour barrier plus sarking in case of low pitch.** *Fig10.42*

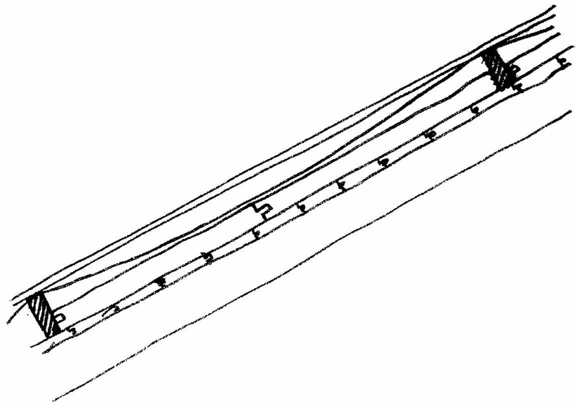


Figure 10.42 – Rigid insulation between purlins

Metal sheet roofs on counter battens on extruded polystyrene with vapour foil and reflective sarking (if required), provide a continuous insulation barrier without thermal breaks.

- ❖ **Nail purlins on every alternate rafter.** *Fig10.43*

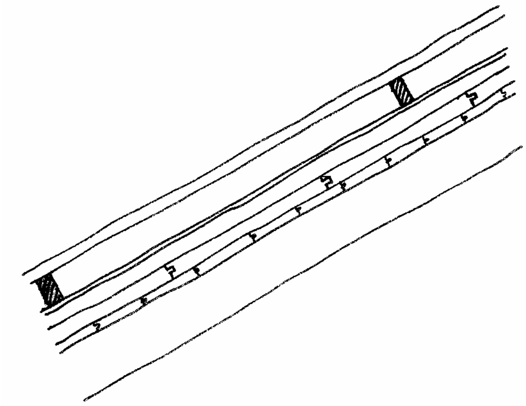


Figure 10.43 – Counter battens ensure continuous insulation

Metal sheet roofs with fibrous insulation draped over purlins and reflective foil backing facing down. The foil acts as vapour barrier, and the insulation dampens noise, but the compressed section is thermally of little value. Draping over purlins prevents sagging of insulation. *Fig10.44*

- ❖ **Carefully seal metal sheeting because dust could accumulate on fibre insulation.**

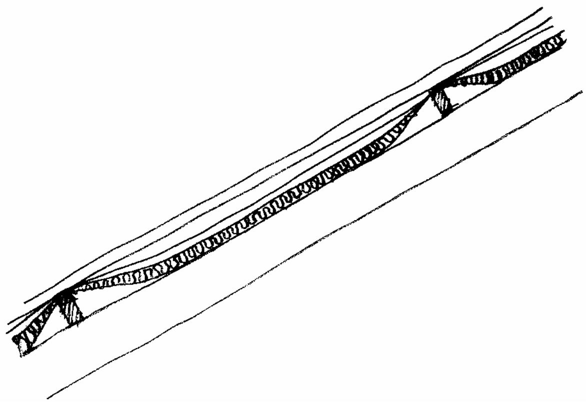


Figure 10.44 – Fibrous insulation over purlins cannot sag but compression reduces effectiveness

Tiles on battens with reflective sarking under purlins with shiny face up, on counter battens overlain with fibrous blankets or between-counter-batten bulk insulation.
This construction requires counter-battens of at least 110mm height, and has thermal bridges. *Fig10.45*

- ❖ **Consider alternatives.**

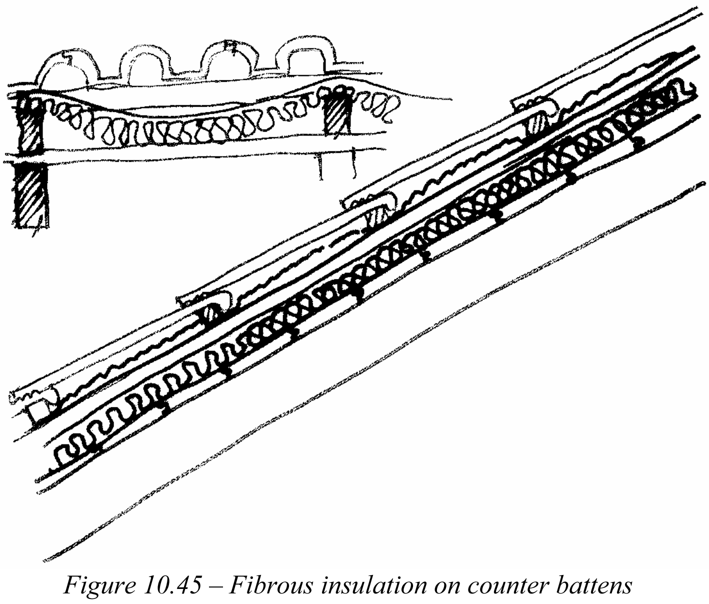


Figure 10.45 – Fibrous insulation on counter battens

Tiles on battens on reflective sarking (two sided or shiny side down) on counter batten on extruded polystyrene on ceiling, providing an additional airspace and unbroken insulation barrier. *Fig10.46*

- ❖ **Ensure that counter battens are fixed according to manufacturer's details.**

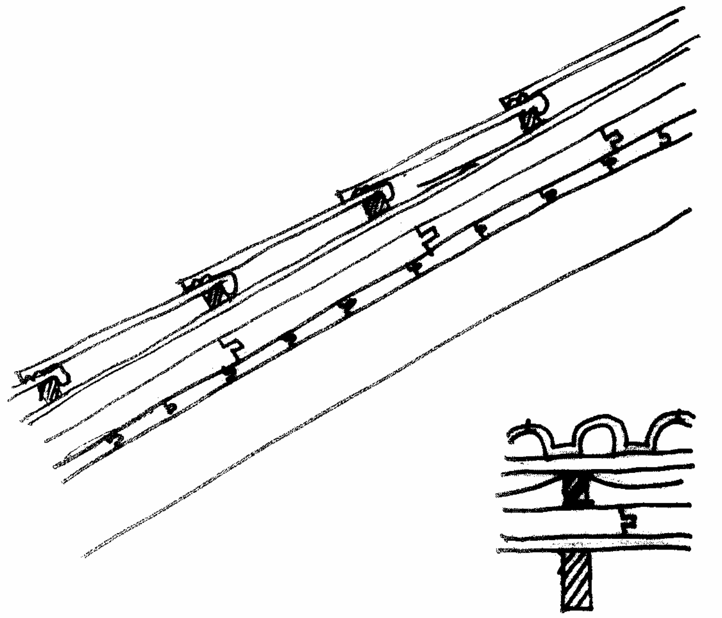


Figure 10.46 - Insulation boards with counter battens and reflective sarking forming air spaces

Inverted or Upside-down roofs consisting of tiles or pebbles covering, interlocking extruded polystyrene boards on top of water proofing, this construction can be used in new and retrofit applications and has the advantage of protecting the water proofing while reducing the thermal movement of the structural members. It can also be used on slightly inclined roofs. *Fig10.47*

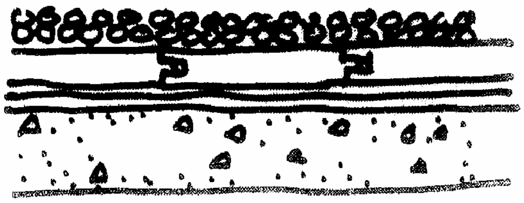


Figure 10.47 – Upside-down/inverted roof has closed cell insulation on top of water proofing

- ❖ **Preferably take insulation up against parapets.** *Fig10.48*
- ❖ **Follow manufacturer's instruction.**
- ❖ **Take precautions against puncturing waterproofing.**

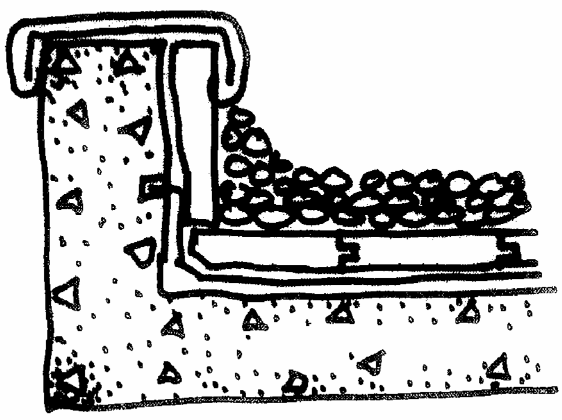


Figure 10.48 – Insulation taken up against parapet

- FLOORS

In South Africa concrete surface beds resting on soil should only have thermal insulation if they are heated by e.g. embedded hot heating systems or heating under carpets. The reason is that under-floor insulation reduces the effective indoor thermal capacity.

❖ **For heated floors place the extruded polystyrene on top of the surface bed, place the heating system, and cover with minimum screed required for structural purposes.** *Fig10.49*

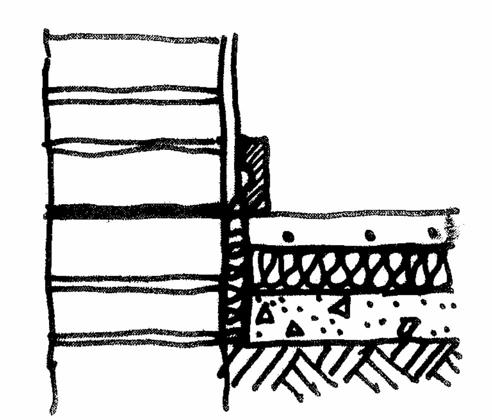


Figure 10.49 – Low-mass screed contains heating elements on top floor insulation – Note perimeter insulation

❖ **Allow for thermal movement.**
❖ **Provide insulation around perimeter of screed.**

Floor perimeter insulation is not in general use in South Africa. Preliminary calculations indicate that buildings with a large perimeter-to-floor area ratio would benefit from floor perimeter insulation. Extruded polystyrene (closed cells) is normally used.

❖ **Provide drainage**
❖ **Protect moisture barrier.**
❖ **Install either in foundation cavity wall** *Fig10.50* **(with concrete filling), exterior to solid foundation wall** *Fig10.51* **or under skirting.** *Fig10.52*

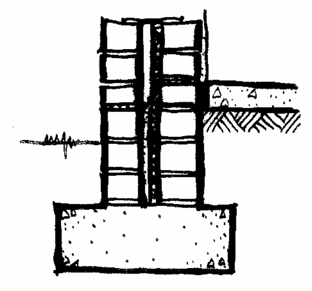


Figure 10.50 – Rigid insulation in foundation cavity wall with concrete filling

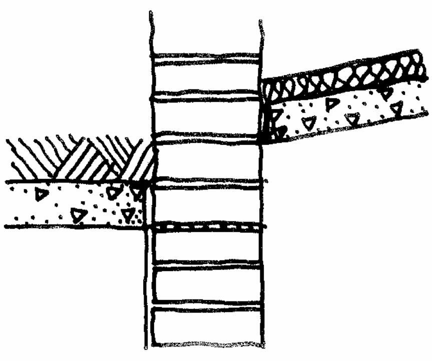


Figure 10.51 – Rigid closed-cell insulation under outside perimeter skirting

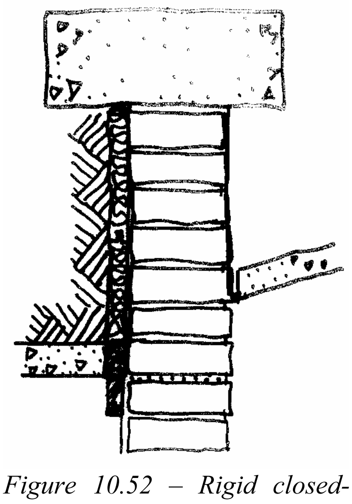


Figure 10.52 – Rigid closed-cell insulation on inside of foundation wall also insulation interior surface bed

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South African Window Energy Registration Council

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thermal insulation association of S.A.

TIASA

Thermal Insulation Association of Southern Africa

TIASA promotes the benefits of insulation. Although providing a service to all industries, it's initial focus is the development of its products & services for the building and construction industry with specific attention being paid to sustainable energy efficient homes. It is the only organisation that embraces the entire thermal insulation marketplace, including Manufacturers, Distributors, Contractors, Specifiers, Designers, Architects, Energy Service Companies, National and Local government, Utilities as well as End Users in the domestic sector.

thermal insulation

- Insulation has proved to be effective and beneficial in the following:
- Reducing energy costs in the home & workplace
- Safety of personnel working in "hot" applications
- Achieving comfort
- Temperature control in processing equipment

energy efficiency

- SAVE MONEY
  through reducing electricity usage
- REDUCE
  the possibility of electricity black-outs
- SECURE
  future peak demand electricity supply

sustainability

- Assisting in the reduction of environmental pollution
- Reducing the consumption of natural resources
- Reducing noise pollution
- Increasing the productivity of workers in factories, commercial buildings etc.

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