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TECHNICAL PROJECT #1

Masonry Insulation Solutions
Final Report

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Project Scope

An investigation into sustainable thermal insulation solutions for masonry walling to meet present South African Regulatory requirements and Standards.

Methodology

A survey of RSA & International thermal insulation market offerings for masonry walling was undertaken, and an assessment made as to whether the proposed solutions meet the requirements in terms of the relevant technical criteria.

Introduction

ClayBrick.org (Clay Brick Association) has been closely involved in the development of the walling requirements for SANS 204; Energy Efficiency in Buildings and SANS 10400XA; Energy Usage in Buildings, and was also the sponsor of essential research to develop the thermal requirements for the tables of CR Product values as incorporated in Table 3 of SANS 204. These tables and the CR methodology link Thermal Capacity (C-value) and Thermal Resistance (R-value) into a combined performance requirement for walling.

Designers and builders provide comfortable and energy efficient structures in part by achieving the required level of thermal resistance and thermal capacity in the walls of buildings. This is achieved without compromising structural integrity and without making structures unnecessarily expensive.

ClayBrick.org has initiated this survey of solutions and options available, and an analysis of the efficacy thereof, in order to guide designers and the industry as to how to best to achieve these objectives.

Survey Methodology

An internet search of web sites of various information providers, associations and companies involved in providing insulation solutions for masonry walling, in a limited number of countries where the majority of buildings are constructed with brick.

Members of the Thermal Insulation Association of South Africa were contacted and requested to provide information specific to their masonry insulation solutions.

Categories of Solutions

Thermal Insulation Characteristics

Thermal insulation is typically made from non-metallic and low thermal conductivity materials which are low in density, with high proportions of air volume or gaseous void. This is in order to minimise conductional heat transfer. These are termed resistive insulation materials, and they rely on adequate thicknesses to create the necessary thermal resistance. These materials are often cellular or fibrous structures with a natural or synthetic polymer or ceramic base, and are typically of low compressive strength.

Materials comprising of reflective or low emissivity surfaces are able to minimise radiant heat transfer, if orientated correctly in relation to adjacent air-spaces. Some insulation products are combinations of these reflective insulation materials and resistive insulation.

Insulation Positioning

The cavity between structural wall leaves provides the ideal space and protection for thermal insulation, be it reflective insulation in the form of foil layers adjacent to air-spaces, or resistive insulation of sufficient thickness.

Insulation can also be fixed to internal or external wall leaves. External insulation systems are more effective for temperature management than internal systems as the benefits of the high thermal mass of the walls is then available and can actively absorb or give up heat to the internal occupied space.

The fixing of internal insulation materials to walling is often between wooden studs and noggings, to which a panelling of timber or plasterboard is fixed as protection. This method of fixing walling insulation is not recommended for moderate climates such as those that prevail in South Africa, as the benefit of heat exchanges between the masonry and the internal air is lost. Such systems would need to have a level of thermal insulation commensurate with a low mass wall in order to compensate for the effective absence of thermal mass.

Low density block materials can be considered as in part thermal insulation materials, and may be manufactured from aerated autoclaved cement, perlite or vermiculite blocks, foamed glass, calcium silicate or low density wood fibre (with cement or polymer binder) and may be laid against or bonded to an external masonry wall leaf.

External rigid fibre and foam insulations are applied to older structures as retrofit systems with external rendering and rain-proof coatings.

The thermal efficiency of coating systems may contain phase change materials which are able to absorb a portion of transferring heat as they change into a liquid phase. Coatings which are smooth and white in colour may also temporarily delay radiant heat transfer into high mass elements. Heat adsorbing and reflective paints are not covered in this document as the mechanism by which this material works is not by thermal insulation mechanisms.

Accordingly the various masonry insulation solutions are categorised as:

- Full cavity, partial cavity, external cladding and rendering, and internal systems, which may in turn be split into lightweight block and wall-liner solutions.

Compliance

Regulations and Standards

In terms of the National Building Regulations walls are required to be capable of safely supporting or sustaining any loads which are likely to be applicable, adequately resisting water penetration, and to have combustion and fire resistance appropriate to their positioning.

The application of the National Building Regulations, SANS 10400 Part K, sets out the deemed-to-satisfy for these requirements, SANS 10400 Part T the Fire aspects, and SANS 2001 CM2; 2006 details good practice in masonry wall design and construction.

Environmental Performance Requirements

The requirements of SANS 10400X pertain to the Environmental Sustainability, and Part XA; Energy Usage in buildings. The requirements for the overall efficacy of the building in entirety, is set out in Section 4.2 which details energy consumption and demand performance levels.

In Section 4.2.2 it is stipulated that the R-values derived from SANS204 for building shell may be used to comply with the regulations, however the building envelope's minimum requirements are set out in Section 4.4 and External Walls are covered by Section 4.4.3. In this section the deemed-to-satisfy requirements for masonry walls are set out and a minimum performance of R-Value (thermal resistance) of 0.35m^2/WK is prescribed, subject to the allowance for single skin masonry greater than 140mm thickness being deemed to satisfy.

Masonry Thermal Insulation Aspects

The structural and fire requirements of masonry wall insulation are generally met by virtue of the design and use of clay bricks and mortar of appropriate strength and durability. The positioning of thermal insulation in the structure is thereafter designed to provide compliance to the Energy Usage requirements.

The requirement of 2.5 wall-ties per square meter for cavity walls of less that 75mm and 5 wall-ties per square meter for cavities up to 100mm (the maximum) is clear, and the provision for and requirements for cavity wall construction methods are well documented in the SANS 2001 standards and in definitive literature.

For cavity insulation the presence of the masonry wall provides the necessary fire protection to the thermal insulation. In the case of internal and external wall insulation the protection of combustible insulation materials will require protection as classified in terms of SANS 428 and performance indicated by SANS 10177;2006 Part 2 – Fire Resistance.

There are no RSA regulatory or standards aspects dictated for damp and moisture management in insulated walls or the positioning of vapour barriers. However good practice is to follow international methods and those set out in insurance industry standards, such as The Loss Prevention Council, as highlighted in the column titled 'Requirements for Efficacy & Compliance' below.

In this paper the various methods of insulating masonry walls are reviewed, with the range of solutions from the many technologies detailed. The design R-values and insulation thicknesses have been selected by applying ISO6946; Building Components and Building Elements – Thermal Resistance and Thermal Transmittance – calculation method, and thermal conductivity co-efficient results as published by the various suppliers, in order to meet the requirements of the South African National Building Regulations and Standards.

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Masonry Thermal Insulation Solutions

Insulation Systems	Description and Specification	Thermal Resistance Added M²/WK	Requirements for Efficacy and Compliance	Manufacturers
Full Cavity				
Mineral Wool & Fibreglass Batts	Fibrous insulation with low fibre diameter and long length, spun from various silicate based materials, in density ranges from 24kg/m^3 - 32 kg/m^3. Thickness from 50mm to fill the wall cavity, at design K-value 0.04W/mK for lower density product or un-faced material. For faced materials with vapour retarders a lower design K-value may be achieved.	1.25	Full cavity insulation in cold or damp climates with fibre insulation requires a semi-permeable vapour barrier so as to avoid moisture transfer and interstitial condensation. Batts should be of sufficient density or have adequate binder content to avoid slumping in the cavity. Compliance with SANS 204 will require an R-value of 1.50m^{2}K/W in a double brick masonry wall to achieve a CR Product of 120.	Knauf Rockwool Owens Corning Rockfibre Isover
Polyisocyanate and Phenolic Foam Boards	Closed cell rigid foam expanded between flexible facing materials, in density range 30 - 40 kg/m^3 and conforming to EN13165/6. Thickness from 30mm to fill cavity, at design K-value 0.025W/mK with suitable facing.	1.2	Full cavity insulation with foam board insulation requires the foam to be protected with a semi-permeable vapour barrier so as to avoid moisture transfer and interstitial condensation. Compliance with SANS 204 will require an R-value of 1.50m^{2}K/W in a double brick masonry wall to achieve a CR Product of 120.	Kingspan Rigifoam Celotex Quintherm Ecotherm
Extruded Polystyrene Foam Board (XPS)	Closed cell rigid foam of fine cell extruded with density range 30-40kg/m^3, and in conformance with ISO 4898. Thickness from 40mm for design K-value of 0.030 W/mK.	1.33	Full cavity insulation with XPS insulation does not require the foam to be protected with a semi-permeable vapour barrier as the material has a high water vapour permeability resistance and interstitial condensation is not problematic even in cold climates. Compliance with SANS 204 will require an R-value of 1.50m^{2}K/W in a double brick masonry wall to achieve a CR Product of 120.	IsoBoard Pearlboard BASF Dow
Liquid-injected and Spray Foam Systems	Polyurea (UF), polyurethane (PUR) systems which are site dispensed into masonry wall cavities in a range of densities from 20-40kg/m^3 with minimum thickness of 30mm for PUR and 50mm for UF	1.2	Ureaformadehyde resin is injected into wall cavities and expands to fill the cavity without generating pressure. Polyurethane foam can be sprayed onto the internal wall leaf to form an effective heat barrier. To achieve CR Product of 120 for SANS 204 compliance an R-value of 1.50m^{2}K/W is required.	Polyfoam
Blown Insulation	Mineral fibre, vermiculite and polystyrene bead can be blown into wall cavities. A design K-value of 0.065 m^{2}K/W can be achieved and a thickness of 100mm is recommended.	1.5	Blown mineral fibre insulation, vermiculite and polystyrene bead can be blown into wall cavities if these are of adequate width and are suitably prepared. Moisture migration considerations should be taken cognisance.	

Masonry Thermal Insulation Solutions

Insulation Systems	Description and Specification	Thermal Resistance Added M²/WK	Requirements for Efficacy and Compliance	Manufacturers
Partial Cavity Fill				
Mineral Wool & Fibreglass Batts	Fibrous insulation with low fibre diameter and long length, spun from various silicate base materials, in density range from 24kg/m$^{3.}$ Thickness from 40mm with reflective foil facer to the wall cavity, at design K-value 0.04W/mK.	1.65	Unless a cavity is maintained between the external wall and the thermal insulation, in cold or damp climates fibre insulation requires a semi-permeable vapour barrier so as to avoid moisture transfer and interstitial condensation. Batts should be of sufficient density or binder content to avoid slumping in the cavity, and occupying the balance of air-space intended to be clear of obstructions for moisture voiding. Compliance with SANS 204 will require an added R-value of 1.50m^{2}K/W in a double brick masonry wall to achieve a CR Product of 120.	Knauf Rockwool Owens Corning Rockfibre Isover
Polyisocyanate and Phenolic Foam Boards	Closed cell rigid foam expanded between flexible facing materials, in density range 30-40kg/m^3 and conforming to EN13165/6 Thickness from 25mm with reflective foil facer to the wall cavity, at design K-value 0.025W/mK.	1.65	Partial cavity insulation with foam board insulation does not require the foam to be protected with a semi-permeable vapour barrier so as to avoid moisture transfer and interstitial condensation, if it can be affixed to the internal wall leaf and as such maintain a clear air-space for moisture condensation and voiding. Compliance with SANS 204 will require an R-value of 1.50m^{2}K/W in a double brick masonry wall to achieve a CR Product of 120.	Kingspan Rigifoam Celotex Quintherm Ecotherm
Extruded Polystyrene Foam Board	Closed cell rigid foam of low cell diameter extruded with density range 30-40kg/m$^{3.}$ Thickness from 40mm at k-value 0.03W/mK.	1.33	Partial cavity insulation with extruded polystyrene foam board insulation does not require to be protected with a semi-permeable vapour barrier. Compliance with SANS 204 will require an R-value of 1.50m^{2}K/W in a double brick masonry wall to achieve a CR Product of 120.	IsoBoard Pearlboard BASF Dow
Expanded Polystyrene foam board	Rigid foam of moulded or cut sheets of expanded and fused PS beads. In density range 15-25 kg/m^3. Thickness from 40mm with reflective foil facer to the wall cavity, at design K-value 0.04W/mK.	1.65	In damp climates partial cavity insulation of expanded polystyrene foam board insulation does not require to be protected with a semi-permeable vapour barrier provided that it is fixed to the internal wall leaf. Compliance with SANS 204 will require an R-value of 1.50m^{2}K/W in a double brick masonry wall to achieve a CR Product of 120.	Isover Technopol Isolite Jablite
Expanded Polyethylene with Reflective Foil	Sheets of closed cell polyethylene foam bonded to flexible reflective foil facing. Thickness of PE foam layer from 40mm with reflective foil facer to the wall cavity, at design K-value 0.04W/mK.	1.65	Brick veneer walls can be insulated internally by creating an airspace immediately inside of the external wall with spacers, and fixing a thermal insulation divider with reflective foil facings inside of plasterboard liners.	Kingspan Thermoflex
Polyethylene Film of Enclosed Air-bubbles	A sheet of polyethylene air bubbles bonded to flexible reflective foil facing to the wall cavity, at design K-value 0.06W/mK.	1.3	Film fixed with 20mm spacers to define and maintain airspaces on both sides of the thermal insulation. Compliance with SANS 204 will require an R-value of 1.50m^{2}K/W in a double brick masonry wall to achieve a CR Product of 120.	Africa Thermal Insulation

Masonry Thermal Insulation Solutions				
Insulation Systems	**Description and Specification**	**Thermal Resistance Added M²/WK**	**Requirements for Efficacy and Compliance**	**Manufacturers**
External Insulation Systems				
Mineral Fibre Batts as part of a ETICS (External Thermal Insulated Cladding System)	Fibrous insulation in density range from 60 -150kg/m^3, and should conform to EN installed in accordance with practices set out in Loss Prevention Council stipulations LPC 1581, to thickness 40mm at a design K-value of 0.04W/mK.	1.0	In cold or damp climates buildings with external fibre insulation require rain protection and a semi-permeable vapour barrier so as to avoid moisture build-up, interstitial condensation and freezing. Batts should be of sufficient density to support the application of proprietary external render coating or will need a protection system. Compliance with SANS 204 will require an R-value of 1.35 m^2K/W in a double brick masonry wall to achieve a CR Product of 100.	Marmorit Permarock Rockwool Weber
Polyisocyanate and Phenolic Foam Boards	Closed cell rigid foam between mineral fibre reinforced facing materials, in density range 40kg/m^3 at thickness from 25mm, at design K-value 0.025W/mK.	1.0	External insulation with foam board insulation requires the foam to be protected with a semi-permeable vapour barrier so as to avoid moisture accumulation, and condensation. Compliance with SANS 204 will require an R-value of 1.35m^2K/W in a double brick masonry wall to achieve a CR of 100.	Kingspan Rigifoam Celotex Quintherm Ecotherm
Extruded Polystyrene Foam Board (XPS)	Closed cell rigid foam extruded with density range 35-45kg/m^3, and in conformance with ISO 4898 and thickness from 30mm at K-value 0.03W/mK.	1.0	External insulation with XPS insulation does not require a semi-permeable vapour barrier. Suitable mechanical and adhesive bonding, and weather and fire-protection system is required. Coating systems should contain reinforcement. Compliance with SANS 204 will require an R-value of 1.35m^2K/W in a double brick masonry wall to achieve a CR of 100.	IsoBoard Pearlboard BASF Dow
Expanded Polystyrene Foam Board (EPS)	Rigid foam of moulded or cut sheets EPS in density range 24-40kg/m^3 and in conformance with ISO4898, thickness from 30mm at K-value 0.03W/mK.	1.0	External insulation with XPS requires a semi-permeable vapour barrier, a suitable mechanical fixing and adhesive bonding, weather and fire-protection system. Coating systems should contain reinforcement. Compliance with SANS 204 levels of R-value of 1.35 m^2K/W in a double brick masonry wall to achieve a CR of 100.	Isover Technopol Isolite Jablite
Expanded Polyethylene or Polyethylene Enclosed Air-bubbles	Sheets of closed cell polyethylene foam or polyethylene air bubbles bonded to flexible reflective foil facing. Thickness of PE foam layer from 20mm with reflective foil facing to the wall cavity, at design K-value 0.04W/mK, fixed inside of rails and weatherboard.	1.0	In warm climates reverse brick veneer walls can be insulated externally by creating an airspace immediately outside of the masonry wall with spacer rails, and fixing a thermal insulation divider, with reflective foil facings inside of external weather-proof cladding. Compliance with SANS 204 will require an R-value of 2.1m^2K/W from a single 150mm brick wall. This can be achieved if an extra 40mm of fibreglass is fixed to the internal wall and concealed by plasterboard.	Kingspan

Masonry Insulation Solutions

Insulation Systems	Description and Specification	Thermal Resistance Added M²/WK	Requirements for Efficacy and Compliance	Manufacturers
Internal Insulation Systems				
Mineral Fibre Matt as part of internal liner system of plasterboard or wood-fibre	Fibrous insulation in density range from 24kg/m^3, in Batts of 75mm thickness fixed between 76mm timber laths and covered with plasterboard.	1.0	Insulation should not be installed on the inside of masonry or high thermal mass walls, and compliance will not be by via CR method for this mode of construction. Equivalence with SANS 204 will require an R-value of 2.1m^2K/W from a single 150mm brick wall. This can be achieved if fibreglass is fixed to the inside of the internal wall leaf and concealed behind plasterboard.	Knauf Rockwool Owens Corning Rockfibre Isover
Mineral Fibre Matt as part of an internal liner system of plasterboard or wood-fibre	Fibrous insulation in density range from 24kg/m^3, in Batts of 75mm thickness fixed between 76mm timber laths and covered with plasterboard.	1.8	Insulation should not be installed on the inside of masonry or high thermal mass walls, and compliance will not be by via CR method for this mode of construction. Equivalence with SANS 204 will require an R-value of 2.1m^2K/W from a single 150mm brick wall. This can be achieved if the fibreglass is fixed to the inside of the internal wall leaf and concealed behind plasterboard.	Knauf Rockwool Owens Corning Rockfibre Isover
Polyisocyanate (PIR) and Phenolic Foam (PF) boards and plasterboard	Closed cell rigid foam between mineral fibre reinforced facing materials, in density from 30kg/m^3 and 50mm thick, and should conform to ISO/EN 13165 or 13166.	2.0	For internal insulation systems compliance with SANS 204 will not be via the CR method and will require an R-value of 2.1m^2K/W. Equivalence can be achieved if an additional foam board is fixed to the inside of the internal wall leaf and is concealed behind plasterboard. Internal insulation with (PIR) foam board insulation requires a fire-proof liner.	Kingspan Rigifoam Celotex Quintherm Ecotherm
Extruded Polystyrene Foam Board (XPS)	Closed cell rigid foam extruded in density range from 30kg/m^3 and 60mm thick, and in conformance with ISO/EN 4898.	2.0	For internal insulation systems compliance with SANS 204 will not be via the CR method and will require an R-value of 2.1m^2K/W. This can be achieved if an additional foam board is fixed to the inside of the internal wall leaf and is concealed behind plasterboard. Internal insulation with XPS foam board insulation requires a fire-resistant liner.	IsoBoard Pearlboard BASF Dow
Expanded Polystyrene foam board (EPS)	Rigid foam of moulded or cut sheets EPS, in density from 15kg/m3, and in conformance with ISO 4898 and 75mm thick.	2.0	For Internal insulation systems compliance with SANS 204 will not be via CR method and will require an R-value of 2.1m^2K/W. This can be achieved if an additional foam board is fixed to inside of internal wall leaf and concealed behind plasterboard. Internal insulation with EPS foam board insulation requires a fire-resistant liner.	Isover Technopol Isolite Jablite
Expanded Polyethylene or Polyethylene Enclosed Air-bubbles	Sheets of closed cell polyethylene foam or multiple layer polyethylene air bubbles bonded to flexible reflective foil facing. Thickness of PE foam layer from 50mm and air bubble 75mm, with reflective foil facing to create cavity at design K-value 0.04W/mK for PE at 0.065 for air bubble.	1.8	In warm climates brick veneer masonry wall from a single 150mm brick can be insulated internally by creating an air-space immediately inside of the masonry wall with spacer rails and fixing a thermal insulation between rails with thermal breaks. If a reflective foil is applied and facing the cavity inside of plasterboard and the insulation is spaced 20mm away from the wall, compliance with SANS 204 will be achieved as result of satisfying the R-value of 2.1m^2K/W.	Kingspan
Lightweight Internal Blocks	Calcium silicate, autoclaved aerated cement or cement blocks with PUR foam liner		Internal leaf of such walls is a combined brick system and thermal insulator. Internal insulation systems compliance with SANS 204 will not be via CR method and will require a R-value of 2.1m^2K/W. This can be achieved if an additional foam board is fixed to inside the internal wall leaf and concealed behind plasterboard.	
Heat Absorbing Paint	Phase change additive		Wax incorporating beads in formulation.	BASF

Recommendations for Long Term Performance

Thermal bridging via wall ties and brick force will undermine the theoretical values obtained with traditional Thermal Resistance calculations, and allowance for these highly conductive elements should be built into calculations. Estimation methods to be applied that account for these conductive elements are provided for in ISO6946, and via the ASHRAE Zone Method.

If the design does not build in for protection of the systems via moisture barriers, these moisture effects should be allowed for in the Thermal Resistance calculation, particularly in damp climates in accordance with ISO10456; Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design values.

ClayBrick.org has tested a number of insulated masonry systems to ASTM C1363; Thermal Resistance using the Hot Box method and the correlation to calculated Thermal Resistance is good, provided allowance is made for the highly conductive wall reinforcing.

The quality of workmanship will need to be taken into account by building professionals. Discontinuities and gaps of a few millimetres between sheets of insulation can cause significant loss (20-50%) of thermal performance; hence the supervision of workmanship is an aspect which can add to the installed material's performance. It should be clearly stated in drawings and specifications as to where and how thermal insulation is positioned and fixed in masonry walls. Consideration should also be given to discontinuities between insulation systems in between the roofs and walls, and in between walls and floors/perimeter insulation. It is in these areas that heat leaks will take place.

Thermal insulation systems available for use with masonry walling are many and varied. Specifiers should therefore familiarise themselves with the relative advantages and disadvantages of these possible solutions.

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