

LOW THERMAL CONDUCTIVITY CONCRETE

SOLUTION GUIDE



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GLOSSARY

Insulating Materials

Those that reduce or prevent the transmission of heat, sound or electricity, in this application those that reduce the transfer of heat energy.

Expanded Polystyrene (EPS)

A rigid cellular plastic that can be formed into a multitude of shapes for a range of applications. It is formed through the expansion of gases within polystyrene beads and is used as an insulation due to its low thermal conductivity (U value)¹.

Thermal Resistance, R (m²/W)

The level of resistance to heat transfer within a specific component, where R increases so does resistance and insulating properties².

Heat Transfer Coefficient, U (W/Km²)

The rate of heat loss through a unit area of an element; as U values reduce so does heat loss. The U value is the reciprocal of the combined R values of a building element

based upon its constituent components.

Density Class

Definition of the density of concrete in the hardened state, as detailed in BS EN 206-1:2000⁵.

Thermal Bridge

A weak point in a buildings envelope where heat energy loss is more abundant than through the rest of the buildings elements and fabric. Thermal bridges can account for up to 50% of all heat loss³.

Linear Thermal Bridge Coefficient (ψ) (W/mK)

The rate at which heat is transmitted through a linear metre of intersection between building elements or components.

Thermal Conductivity, (λ) (W/mK)

A measure of heat flow through a specific material independent of its thickness, the greater the value the lesser the resistance⁴.



Our approach to construction encompasses innovative sustainable products, efficient building systems and practical solutions. We recognise the important role we have in promoting sustainable construction by optimising our products, their use and whole life performance. This document is one of a suite that identifies specific construction solutions that can help deliver a sustainable built environment. They explore the details of each system, its performance benefits, how it can be implemented in a project and then compares its environmental performance against alternative solutions.

This document introduces low thermally conductive concrete which contributes to creating buildings that are long lasting, robust and efficient.

Typical Applications

Residential, Offices, Retail, Commercial, Hospitals and Industrial

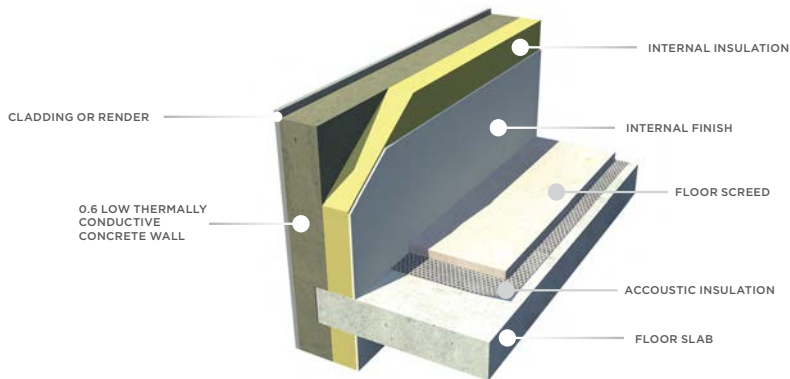


INTRODUCTION

Low thermally conductive concrete is an innovation which, as part of a construction solution, can improve a building's thermal efficiency. It combines improved thermal performance characteristics with the structural and mechanical performance of conventional concretes, requiring no changes to conventional construction methods.

As part of a construction solution significant reductions in heat loss through thermal bridging can be made. Reductions can be as much as 40% and 15% in internally and externally insulated systems respectively and can avoid the need for thermal breakers.

Where internally insulated structures are considered further design and construction benefits can be realised. Low thermally conductive concrete promotes the opportunity to express the structure of the building as part of its aesthetic scheme, without the need to highlight key structural features as part of the cladding system over external insulation. Additional external finishes or cladding typically required for externally insulated structures is not required as low thermally conductive concrete forms a robust and durable external facade.



Low thermally conductive concrete is an ideal concrete to facilitate the construction of low energy buildings. Its thermal properties are derived from its rheology and use of specialist aggregates which deliver its unique thermal performance properties.

With a density of $1,400 \text{ kg/m}^3$ and a compressive strength of 30 N/mm^2 (higher strengths can be achieved in accordance with British Standards⁶), low thermally conductive concrete can be used with traditional construction methods and provide a guaranteed thermal conductivity performance (λ) of 0.6 W/mK .

Additionally, its durability, fire resistance and acoustic properties have been tested and conform to British Standards with its resistance to freeze/thaw attack determined as XF1 exposure⁶. These integral properties enable low thermally conductive concrete to perform in structural applications typically reserved for conventional concretes.

LOW CONDUCTIVITY AND STRUCTURAL CONCRETE

Low thermally conductive concrete is proven to improve energy performance in buildings.

It is a readymixed concrete solution offering improved thermal conductivity performance (actual range $\lambda = 0.45$ to 0.54 W/m.K) with assured structural performance (30 N/mm²). Initial test results have shown that the improvement in thermal performance provided by low thermally conductive concrete can reduce the linear thermal bridge coefficient (ψ) by 15% in externally insulated and 40% in internally insulated construction, whilst maintaining traditional approaches to concrete construction.

PERFORMANCE †	LOW THERMALLY CONDUCTIVE CONCRETE *	CONVENTIONAL CONCRETE (C25/30) †
Thermal conductivity (W/mK)	0.6-0.8	1.75
Density (kg/m ³)	1,400	2,300
Characteristic compressive cube strength of concrete at 28 days (N/mm ²)	30-40	30

† The results described within this table have been taken from laboratory testing and are assured minimum performance characteristics.

* Performance has been shown in the test case to exceed assured minimum performance characteristics, without changes to its original mix design.

STRUCTURAL PERFORMANCE

The unique thermal characteristics of low thermally conductive concrete, in combination with its strength and lightness, ensure that it is a viable option for construction. Through adaptation of its design its characteristic strength can be increased to 40 N/mm², without any detrimental effects on its thermal performance, facilitating its implementation into many forms of construction including structural frame.

SIGNIFICANT REDUCTION OF THERMAL BRIDGES

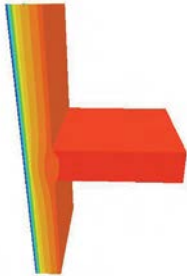
When used in the construction of concrete framed buildings significant reductions in thermal bridging, a source for building envelope losses, can be made.

In internally insulated frame construction it is possible to reduce insulation thickness without significant detriment to the thermal bridging coefficient.

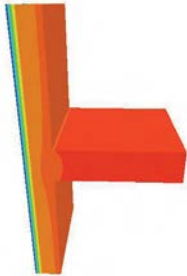
Using low thermally conductive concrete for a wall element, an analysis was undertaken, using computational modelling* to compare thermal bridge effects at the slab/wall interface. The results (shown opposite) illustrate the improvements that can be achieved compared to conventional construction.

* Computational modelling was completed using TRISCO simulation software (<http://www.physibel.be/v0n2tr.htm>)

Comparison of thermal bridge coefficient of ETI system

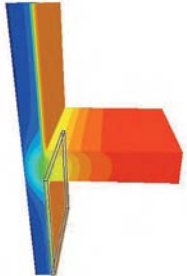


C25/30 concrete wall
 $\Psi=0.007$ W/mK

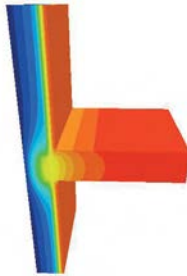


Low thermally conductive concrete wall
 $\Psi=0.006$ W/mK

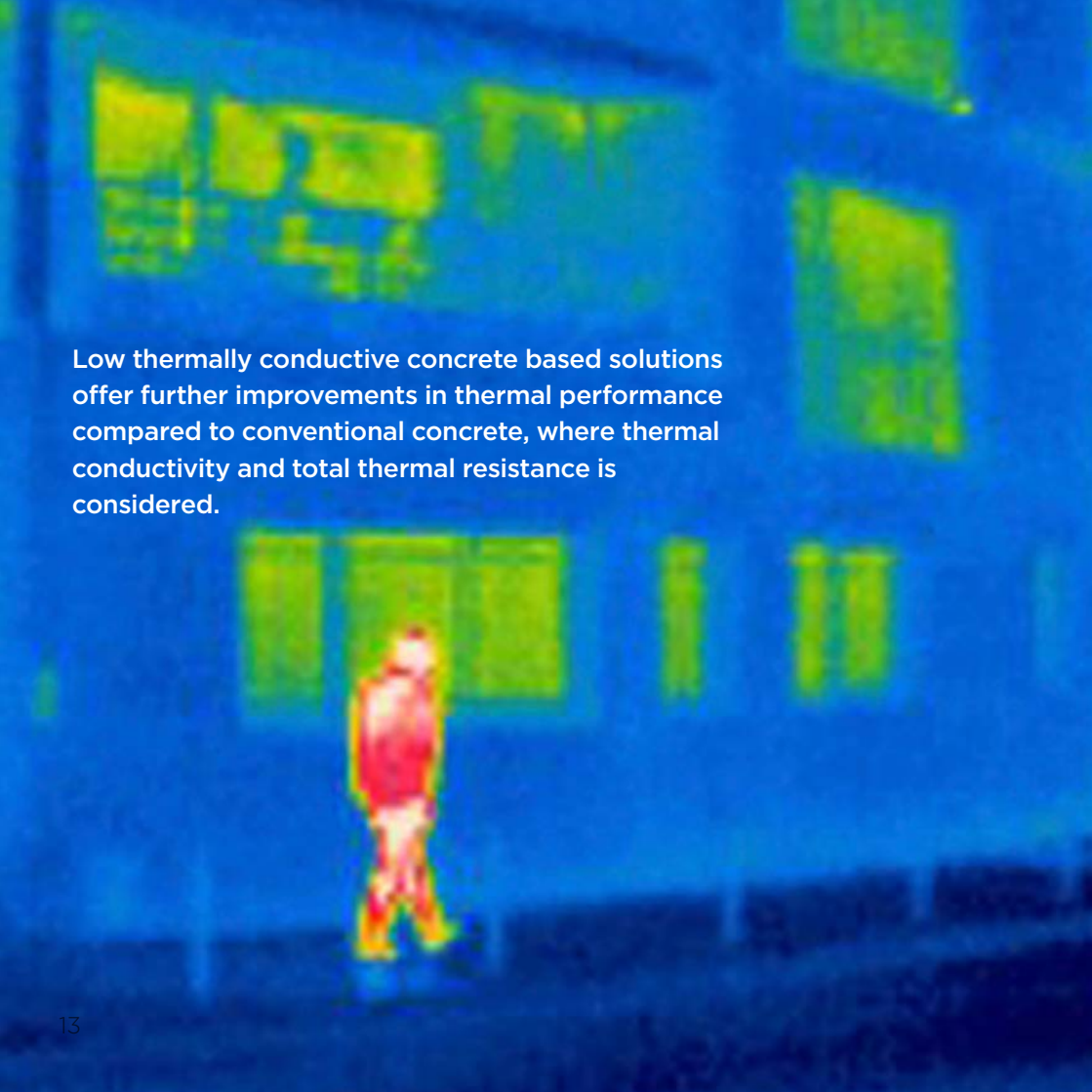
Comparison of thermal bridge coefficient of ITI system



C25/30 concrete wall
 $\Psi=0.99$ W/mK



Low thermally conductive concrete wall
 $\Psi=0.59$ W/mK

A thermal image showing a person standing in a room. The person is the brightest area, indicating they are the warmest object in the scene. The room's walls and ceiling are dark, indicating they are cooler. There are several windows or openings in the walls, which appear as lighter areas, suggesting they are warmer than the surrounding walls. The floor is also dark, indicating it is cooler. The overall scene is a thermal representation of a person in a room.

Low thermally conductive concrete based solutions offer further improvements in thermal performance compared to conventional concrete, where thermal conductivity and total thermal resistance is considered.

HIGHER THERMAL RESISTANCE

A low thermal conductivity results in a higher thermal resistance (R) than conventional concretes, which can reduce energy losses through the fabric of a building.

AS-BUILT PERFORMANCE GAP

A Carbon Trust study demonstrated that energy use in buildings can be five times that expected in design and the same study stating that the average performance gap was 16%, with the worst performing case adding operating costs of £10/m² per annum⁸. This gap is defined as the difference in terms of energy consumption

and carbon emissions, between design and as-built performance⁷ due to shortfalls in modelling, poor construction, unexpected energy use or inefficiencies in operation.

Confidence or tolerance design⁷, utilising low thermally conductive concrete, can mitigate poor construction practices. This approach involves thermal performance based design decisions to be made based on the use of conventional concrete but actual construction completed using low thermally conductive concrete.

The improved thermal characteristics can provide confidence that performance requirements will be satisfied by creating a performance buffer.

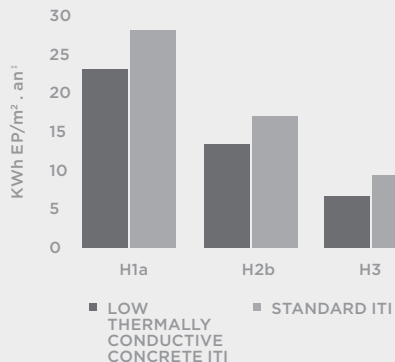
REDUCTION IN HEATING (OR COOLING) DEMAND

Through an independent study carried out by Tribu Energie, low thermally conductive concrete was shown to considerably improve energy performance.

The study illustrated that the use of low thermally conductive concrete could reduce primary energy (heating and hot water) consumption by 7-10%.

The study considered three climate zones - H1a, H2b and H3 - and demonstrated improvements in all.

In the chart shown, zones H1a and H2b can be considered indicative of the UK climate.



The study was carried out by Tribu Energie an independent energy assessment organisation. Climate zones have been taken from Réglementation Thermique 2012⁹.

⁹ Energy Consumption Ratio: is the energy consumption in kilowatt hours for primary energy usage (heating, hot water) per square meter per year. In France this is known as kWhEP/m².an.

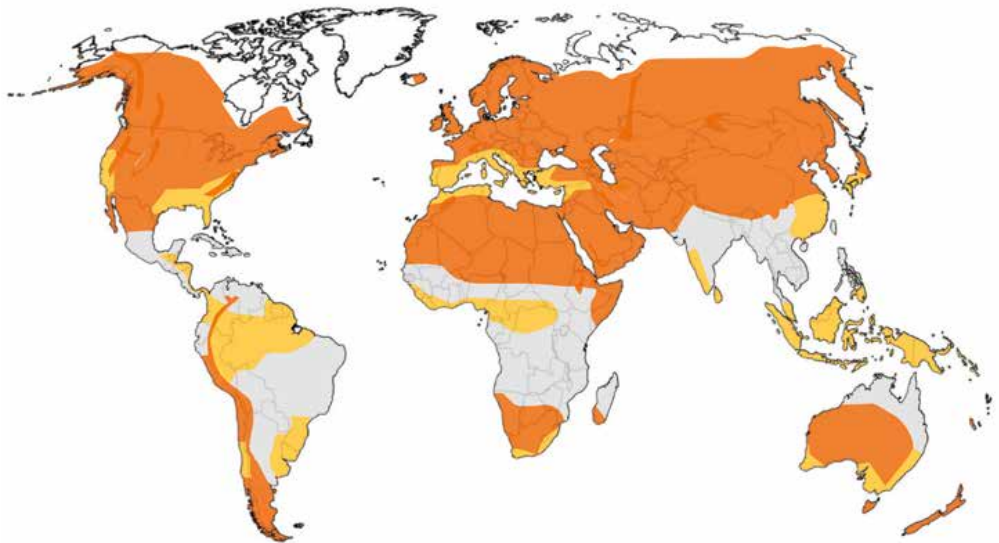


EFFICIENCY OF THE SYSTEM WITHIN CLIMATIC REGIONS

Structural walls constructed with low thermally conductive concrete have the potential to add value when a buildings thermal resistance is considered, however performance is dependent on heating and cooling requirements.

An approximate estimation of the systems efficiency in a range of climate zones has been provided with estimates based on the thermal resistance (R) of the system and average climatic data, for example daily and seasonal temperature variance.*

* The system efficiency assessment proposed in the map is based on the comparative analysis of various climatic parameters (temperature variations, solar radiation, etc.) within the different considered climate zones and does not take into consideration factors such as micro-climates, specific building load and occupancy, etc. which may highly influence the efficiency of the building system.



VERY EFFICIENT	EFFICIENT	LESS EFFICIENT
<p>CLIMATE TYPE</p> <ul style="list-style-type: none"> • Desert • Oceanic • Alpine • Humid continental 	<p>CLIMATE TYPE</p> <ul style="list-style-type: none"> • Equatorial • Mediterranean • Humid subtropical 	<p>CLIMATE TYPE</p> <ul style="list-style-type: none"> • Savannah • Monsoon

Building with low thermally conductive concrete does not require any new construction techniques or approaches to achieve its insulating thermal properties.

Existing UK best practice for concrete placement should be adhered to and care taken as with all concrete final quality is dependent on workmanship.

Quality Assurance

The Quality Scheme for Ready Mixed Concrete (QSRMC) provides ISO 9001 and product conformity certification for the design, production and supply of ready mixed concrete. QSRMC sets the highest certification standards for ready mixed concrete and it is the preferred certification scheme of almost all the major UK suppliers and a large number of smaller producers¹⁰.

CONCRETE CONSTRUCTION BEST PRACTICE

Delivery	Attention is needed to ensure that the correct concrete construction product is specified for the application, with any adjustment or addition only undertaken by the supplying company.
Formwork	Required to be fit for purpose to enable construction to be completed safely, with consideration in design to ensure that formwork pressures are not exceeded through placement methods and filling rate. Selection of release agents should also be carefully considered as these can have a direct effect on the quality of final finishes.
Placement	Care and attention is required during the placement process, particularly where placement rates, method of delivery into formwork, material free fall and compaction are concerned. Compaction is fundamental to low thermally conductive concrete achieving its structural and thermal performance properties requiring suitably skilled operatives to carry out this activity.
Finishing	Finishes to concrete elements are dependent on formwork type, release and curing agents and placement methodologies. In order to achieved desired finishes these aspects need to be considered at early project stages and it is recommended that trial panels are constructed to establish benchmarks for what is achievable.
Curing	All concrete is required to be cured to ensure that its designed performance characteristics are realised and should be carried out as soon as practicably possible.

SUSTAINABILITY

Utilising low thermally conductive concrete in frame construction offers further environmental improvements when used in place of conventional concretes.

OPERATIONAL ENERGY

Low thermally conductive concrete as a replacement for conventional concrete in a traditional construction systems can reduce the impact of thermal bridging. By reducing thermal bridging the associated energy loss is reduced enabling operational energy demand to be reduced in order to maintain a comfortable environment for occupants.

RESOURCE DEPLETION

Concrete is an inherently flexible material with regards to its on site placement and also its constituents. It is possible to adapt mix designs to incorporate recycled and secondary aggregates to reduce its impact on virgin and finite materials⁵.

RECYCLING

The concrete industry has taken significant steps to improve its performance in terms of material reuse, reducing the depletion of abiotic resources, increasing energy efficiency and reducing carbon emissions. Significant improvements have already been achieved compared to the industry's 1990 baseline¹.

With respect to material reuse and the depletion of abiotic resources, concrete readily utilises recycled and secondary materials along with cement replacements. This has enabled the industry to be a net user of waste, using 47 times more waste than it generates¹, and concrete itself is also 100% recyclable¹².

BES 6001*

Tarmac has achieved an 'Excellent' rating for all its production sites and products. The independent third-party scheme assesses responsible sourcing policies and practices throughout the supply chain¹³.



ISO 14001

Tarmac is fully accredited with ISO 14001, having implemented Environmental Management Systems throughout our business, maintaining our commitment to reducing our environmental impact¹⁴.

¹ Tarmac's concrete products offer the ability to conform with a wide-ranging number of assessment criteria in both BREEAM and LEED. For more information contact Tarmac sustainability team.

* Our BES 6001 certificate number for our readymix concrete products is BES 559207.

SUSTAINABILITY ASSESSMENT SCHEMES

Concrete can play an extended role in enabling an efficient building to be created and can contribute in a number of assessment schemes and help achieve a range of credits[†].

	BREEAM [†]	LEED
CREDIT/TARGET	<p>Man 03: Responsible Construction Practices Tarmac's Carbon Calculator has the capability to determine and provide data relating to the CO₂ arising from production and delivery of our products.</p>	<p>EA Credit 1: Optimise energy Performance Low thermally conductive concrete based solutions can reduce energy loss and subsequently energy demand reducing environmental and economic impacts.</p>
	<p>Hea 02: Indoor Air Quality Concrete can help achieve a healthy internal environment; it is an inert material which can be used to create final finishes which can reduce the reliance on materials which are required to be assessed for emissions.</p>	<p>MR Credit 2: Construction waste management Construction and demolition waste is encouraged to be diverted away from landfill or incineration, concrete is an inherently reusable material that is 100% recyclable.</p>
	<p>Ene 01: Reduction of CO₂ emissions Low thermally conductive concrete can improve and reduce the energy demands for heating and cooling by reducing energy losses aiding the reduction of CO₂ emissions.</p>	<p>MR Credit 4: Recycled content Concrete is a versatile material whose design can be readily adapted to enable the use of recycled, secondary or replacement materials.</p>
	<p>Mat 03: Responsible sourcing of materials Concrete is primarily constituted of locally available materials, all concrete products produced by Tarmac are BES 6001 accredited to an 'Excellent' standard.</p>	<p>MR Credit 5: Regional materials Concrete is one of the few materials that is produced locally to where it is used; it can typically be supplied from within 10 miles of any given site.</p>
	<p>Wst 02: Recycled aggregates Concrete is a versatile material whose design can be readily adapted to enable the use of recycled, secondary or replacement materials.</p>	

PEOPLE



Safety and health
Our people
Community involvement

PLANET



Climate change
Environmental stewardship
Resource efficiency

PERFORMANCE



Economic value
Governance and ethics
Communication

SOLUTIONS



Sustainable supply chain
Innovation and quality
Sustainable construction

OUR SUSTAINABILITY STRATEGY

Sustainability is about securing long-term success for our business, customers and communities by improving the environmental, social and economic performance of our products and solutions through their life-cycle. This means considering not only the goods we purchase, our operations and logistics but also the performance of our products in use and their reuse and recycling at the end of their life. By doing this, we can understand and take action to minimise any negative aspects, while maximising the many positive sustainability benefits our business and products bring.

Using this 'whole life' thinking we have engaged with our stakeholders to develop our sustainability strategy. The strategy defines the main sustainability themes and our key priorities, those issues which are most important to our business and our stakeholders. It sets out our commitments to transform our business under four main themes: **People, Planet, Performance and Solutions**.

Building on progress already made, we have set ambitious 2020 milestone targets for each of our key priorities. These ambitious targets have been set to take us beyond incremental improvement programmes to business transforming solutions.

FOUR THEMES

Twelve key priorities

Twelve commitments

Twelve 2020 milestones

Forty four other performance targets

Our 2020 milestones are supported by a range of other performance targets.

This hierarchy helps make it easier to build understanding, drive improvement and enables us to report progress in a meaningful and measurable way.

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