Feature

Beyond bright

A new study sheds light on zircon's sustainability credentials. **Dr Keven Harlow**, Executive Director of the Zircon Industry Association, says the findings could enhance roof tiles.

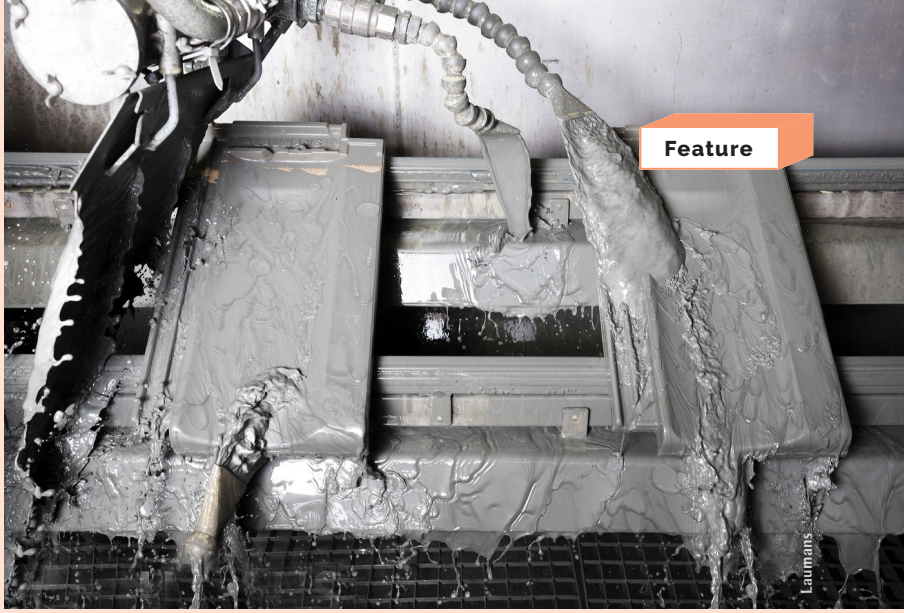
Above: Coloured roof tiles containing zircon.

As our world faces increasing challenges from industrialisation, urbanisation and a rising global population, sustainable development has become the goal of our times.

Architects and specifiers the world over strive to create buildings that are as visually stunning as they are sustainable, combining the smallest possible environmental footprint with the highest possible standard of living. Roof and façade tiles play a crucial role – not just aesthetically – in delivering this goal. While not immediately obvious, zircon – a naturally-occurring mineral – can significantly enhance glazed roof and façade clay tile performance.

Zircon's unique properties are renowned in the ceramics industry. Widely used as an opacifier to increase the whiteness, brightness and glossiness of tiles, its hardness and chemical resistance ensures ceramic surfaces are resistant to scratching and chemical damage. Walls and floors across the globe have been adorned with zircon-containing tiles for decades.

Now recent research demonstrates that zircon can also help architects and construction specifiers to lower the environmental footprint of the buildings they design and build, enabling compliance to green building standards and supporting bids to achieve LEED (Leadership in Energy and Environmental Design) accreditation. The study, *Thermal Performances of Ceramic Glazes Containing Zircon*, conducted by the Zircon Industry Association and Centro Ceramico in Bologna, Italy, reveals that glazed, zircon-containing tiles, when used as part of a building's outer envelope, can reduce its environmental footprint by reflecting solar energy and lowering demand for internal cooling.



Right: Application of the colour glaze.

Urban hotspot

Over the past few decades, architects have battled to combat the urban heat island phenomenon in many cities. The materials on which these metropolises are built, such as concrete, steel and asphalt, absorb the sun's heat and store it in large thermal masses. This, as well as the waste heat generated by energy usage, ensures the temperature in cities can be significantly higher than nearby rural areas. The result is that many cities across the globe are uncomfortably warm in the summer months and, as everyone reaches for the air conditioning buttons, energy consumption rises and so too do carbon emissions into the atmosphere.

Architects, specifiers and their clients strive to mitigate this heating effect through design and the materials they employ. Over the years, one of the solutions to address urban heating is to design building envelopes that use cool materials with high reflective properties – the so-called 'cool roof' concept. It is widely proven that using roofing materials with high solar reflectance and high thermal emissivity can decrease the indoor temperature of buildings by about 2.5°C, thus reducing summer cooling energy requirements, for example, by as much as 43% in Florida and 30% in Rome. This offers significant energy cost savings, but also a considerable reduction in carbon emissions.

A cool façade

Spray paints and sheaths, waterproof membranes, poly bitumens, corrugated sheets and ceramic tiles are all high-reflectance materials used by building designers for cooling roof structures. The most effective paints are white, with high solar reflectance and excellent thermal emissivity.

However, in recent years, the focus has turned to the long-term performance of these materials. Tests in the outdoor environment show that, due to exposure to atmospheric agents and fouling, the solar reflectance of roofs using bituminous membrane coated with cool acrylic paint is almost halved within two years. Therefore, cool coatings have required periodic washing, maintenance, or restoration treatments, which are all costly and time-consuming.

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Ceramic tiles have far greater overall durability and resistance to atmospheric damage and, with increased solar reflectance, could offer a lower maintenance solution. Tiles undergo various quality tests, including freeze thaw cycles (ISO 10545-10), thermal shock (ISO 10545-9) and solidarity of colours to light (DIN 51094), during their certification. These tests reveal that porcelain stoneware tiles do not undergo colorimetric variations or solar reflectance reduction due to UV radiation or hygrothermal shocks. And it has now been shown that the addition of solar reflectance boosting zircon to glazed ceramic tiles substantially improves the potential of ceramics as a low maintenance cool roof and cool façade material, which is more durable in terms of resistance to deterioration and wear. Ceramic surface glazes can also be designed with a finish that increases tiles' cleaning performance, substantially reducing overall maintenance costs.

Zircon's impact

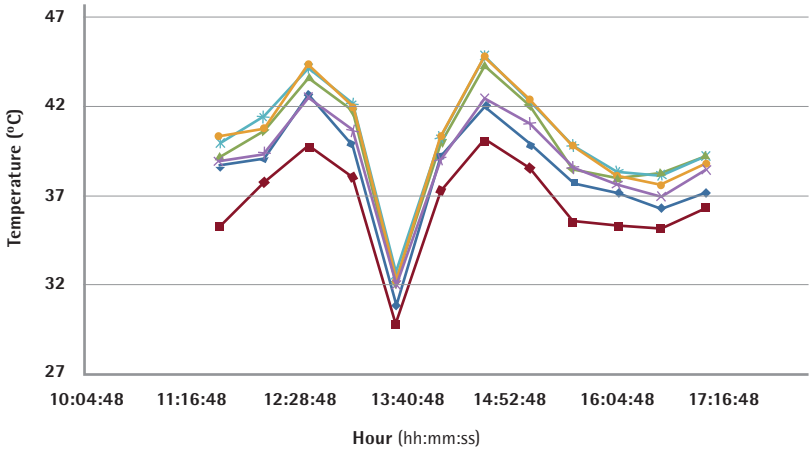
The recent study looks at the effects of adding zircon to ceramic glazes of various colours including black, brown, blue, green, and yellow. Carried out at laboratory scale and in-field trials, the mineral was added to 36 tile samples both as an opacifier directly into the glaze formulation (up to 10wt%) and as a frit component (up to 6.6wt%). A frit is a ceramic material that has been melted, quenched and granulated. The solar reflective index (SRI) was calculated for each sample. The colorimetric coordinates was also determined to evaluate any colour variation due to the presence of zircon. The thermal performance of the samples was automatically monitored every 30 minutes in an outdoor environment during the hot Italian summer months.

Results of tests carried out on the samples of glazed ceramic tiles reveal that, in general, zircon increases SRI of the surface glaze, with the effect being more pronounced when it is added as an opacifier. Also, as the zircon content in the glaze increases, the SRI value rises linearly for all colours in this study. Overall, the increase in SRI is greater in percentage terms when zircon is used as an opacifier, and greater in absolute terms when zircon is used as a frit. Percentage increase is more pronounced for darker colours (black, brown and blue) when zircon is used as an opacifier. The black glaze saw an SRI increase of 90% when 10wt% zircon was added, while brown saw a 43% increase, blue a 45% increase, green a 33% increase, yellow a 23% increase and the white tile saw a 21% improvement in SRI.

Monitoring of each tile's surface temperature when exposed outdoors to solar radiation confirmed that the measured higher values of brightness and solar reflectance parameters are entirely due to zircon. In these field trials, a clear decrease in surface temperatures (i.e. a cooling effect) was observed for glazes where zircon was used as a frit component. The frit composition containing 3.3% zircon was observed to be the most effective in cooling.

The figure on the right shows the monitoring of surface temperature of black glazed samples. The graph shows that the black tile sample with 3.3% zircon in the frit when exposed to solar radiation maintains lower surface temperatures of up to 5°C when compared to the other black glazed samples.

These zircon-containing tiles, if used as a building envelope, could improve thermal comfort in the building by reducing energy demands and, compared to alternatives on the market, such as paints, are able to reduce maintenance costs thanks to their high resistance to wear, dirt and stains.



	SRI (h_c=12)	L*	a*	b*
Black_F	17	31.31	2.28	0.96
Black_3.3_F	23	40.13	2.14	-0.14
Black_6.6_F	25	45.18	1.70	-1.04
Black_Op	11	28.97	1.74	0.78
Black_5_Op	15	34.50	2.09	0.61
Black_10_Op	21	40.77	1.91	-0.03

Centro Ceramico

Black_F
Black_3.3_F
Black_6.6_F
Black_Op
Black_5_Op
Black_10_Op

Above: Solar reflectance index values, colorimetric co-ordinates, and variation curves of the surface temperatures of black glazes containing zircon as opacifier (Op) or as frit (F), during monitoring on a sunny day. For hourly intervals considered in the figure, the ambient temperature varied from 27 to 32°C.

A sustainable solution?

As the drive for sustainable solutions in our modern world intensifies, consumers are more aware than ever before of the impact of their lifestyle choices. While we now know that zircon-containing roof tiles can offer a 'cool material' for building envelopes, their environmental credentials do not end there.

A recent independent peer-reviewed Life Cycle Assessment (LCA) for zircon sand concludes that zircon has an overall low environmental impact which is lower than alumina – an alternative to zircon as an opacifier (or whitener) in ceramic tiles.

Many tile producers already offer beautiful glazed, zircon-containing roof and façade tiles which are used to create visually stunning, memorable buildings that have significantly less energy demands and offer increased thermal comfort to those who use them.

It is clear that by adjusting the composition of their glazes, tile producers can play an important role in the sustainable development of our world.