NZSTB - 2

Sustainability Technical Bulletin

June 2026 - revision 1

New Zealand Steel

Urban Heat Islands and their mitigation

Introduction

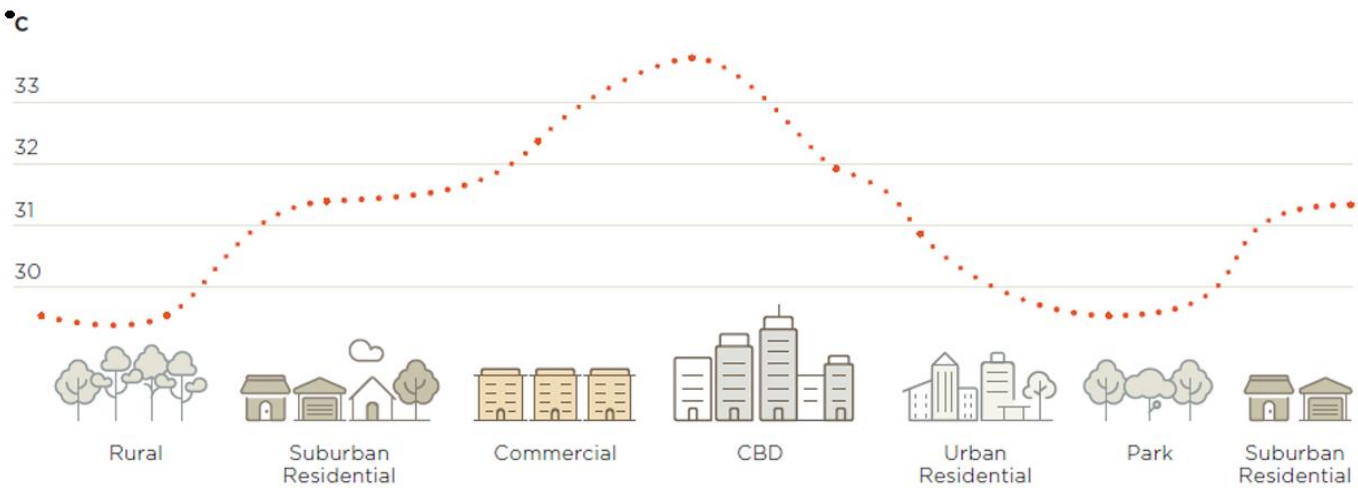
New Zealand Steel has a long-standing commitment to developing innovative, responsible products and services that can help to address environmental issues such as Urban Heat Islands.

The term *Urban Heat Island* (UHI) is used to refer to the fact that cities and urban areas are often significantly warmer than the rural or undeveloped areas that surround them. This technical bulletin details why UHIs form; the consequences of UHI formation; and what can be done to mitigate these. Urban forestry and cool roofs are two of the most effective ways to reduce the intensity of UHIs: light coloured COLORSTEEL® can be used to create cool roofs because it has high solar reflectance and high thermal emittance.

Formation of Urban Heat Islands

Urban Heat Islands are not a new phenomenon. In 1833 Luke Howard – a chemist and amateur meteorologist – presented evidence that the air and surface temperatures in London were often higher than in the surrounding countryside: this is now considered to be the first documented case of an UHI.[1] Today, many cities and suburbs record air temperatures warmer than the surrounding natural land cover (Figure 1.).

Figure 1. Urban Heat Island Profile (adapted from Reference 2)



Urban Heat Islands form when vegetation is replaced with non-reflective, high mass, water resistant, impervious surfaces that absorb a high percentage of incoming solar radiation. There are three main drivers of heat island formation: increased absorption and retention of heat due to decreased surface reflectance; reduced evapotranspiration due to decreased vegetation cover; and heating as a result of human activities.

- **Surface Reflectance and Increased Absorption of Heat:** All surfaces reflect a proportion of the energy that arrives from the sun (solar or shortwave radiation). The more reflective a surface is, the less solar energy it absorbs and the cooler it is. Conversely, the less reflective a surface is, the more solar energy it absorbs and the higher its surface temperature will be. Compared to natural land cover, urban environments have lower surface reflectance and absorb more of the available incoming solar radiation, and are consequently warmer, contributing to the formation of UHIs.
- **Reduced Evapotranspiration:** Vegetation helps reduce air temperatures through a process called evapotranspiration, in which plants release water to the surrounding air, dissipating ambient heat. Evapotranspiration is generally decreased when vegetation is replaced with an urbanscape which evaporates less water and has fewer transpiring plants. Decreased evapotranspiration can contribute to elevated surface and air temperatures.
- **Anthropogenic Heating (Heating as a Result of Human Activities):** The third factor that contributes to UHIs is the increase in near-surface temperatures that is a result of human activities, for example, the heat produced from industrial processes, electricity generation, building and traffic heat loss.

The formation of heat islands is not necessarily uniform across cities, nor over time: heat islands can evolve around a single building, across a small section of the city or over the entire urban region. Some researchers have also reported that local and regional climate, and the topographic features of cities affects the strength and persistence of heat islands.[2]

Consequences of Urban Heat Islands

In cities, increased local temperatures often lead to increases in energy demand for air-conditioning, particularly in the summer.

This in turn places a strain on power delivery systems and may result in the need for additional power generation sources. If power is generated using fossil fuels, then Greenhouse Gases (GHGs) and particulate emissions are also increased contributing to air pollution. Water temperature can also rise which may affect aquatic ecosystems, especially the metabolism and reproduction of many aquatic species.[3] Higher daytime temperatures, reduced night-time cooling and higher pollution levels may also contribute to heat related health conditions ranging from general discomfort to respiratory difficulties, heat cramps, heat exhaustion, and non-fatal heat stroke.[3]

Mitigation of Urban Heat Islands

Two of the key strategies for reducing the intensity and longevity of UHIs are: increasing surface reflectance to reduce the amount of solar energy absorbed and converted into heat (e.g., via cool roofs); and evapotranspiration to cool the surface through latent heat loss (e.g., through urban forestry).

Urban forestry has been found to produce the greatest reduction in surface temperature per unit area, because of the increase in evapotranspiration and the additional shading of buildings and pavements.[4]

Cool roofs help reduce the intensity of UHIs, as well as help maintain thermal comfort which can minimise energy demand in buildings. Cool roofs have high solar reflectance and high thermal emittance. High solar reflectance means that less energy is absorbed into the roof initially, thereby reducing the amount of energy that can be converted to heat and re-radiated as longwave radiation (Figure 2).

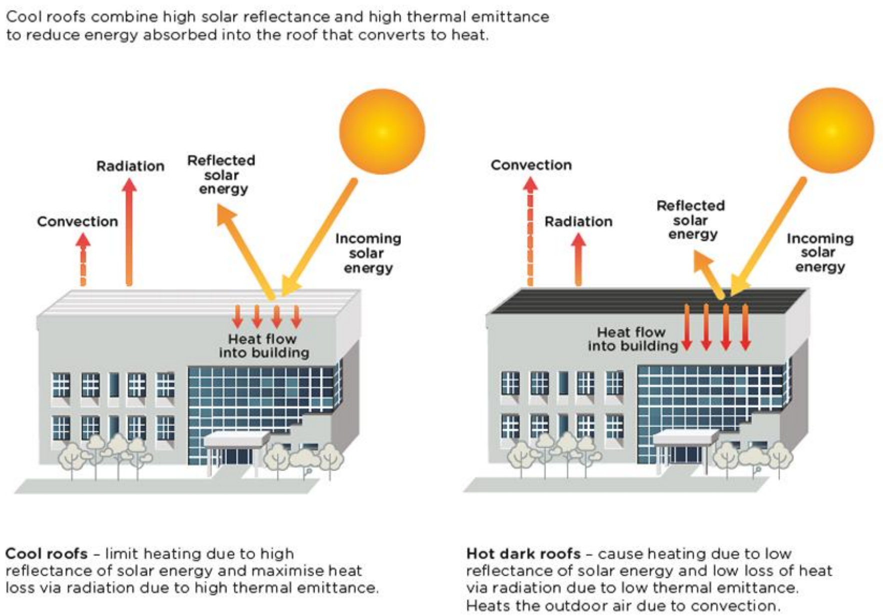
High thermal emittance means that any energy that is absorbed into the roof is re-radiated from the building quickly (again helping to increase thermal comfort and potentially minimising energy demand).

Therefore, high thermal emittance helps reduce the heat that can move from the roof to the atmosphere by convection and conduction – the surface temperature of a light-coloured roof can be up to 35°C cooler than a dark coloured roof – and this can limit the amount of longwave radiation that can interact with GHGs and heat the atmosphere.[5]

There are also financial benefits for building owners. Cool roofs can generally help reduce the annual cooling energy costs of a building.* Therefore a cool roof, such as one made from light coloured COLORSTEEL®, has the potential to help reduce the upfront capital cost or ongoing operational cost of air-conditioning equipment. Cool roofs may also help reduce stresses on the roof and its materials by limiting the quantity of absorbed solar energy and reducing daily temperature fluctuations, which can cause repeated contraction and expansion.

A light coloured COLORSTEEL® roof not only reduces the amount of solar radiation absorbed but can also be very effective at re-radiating heat.

Figure 2. Cool Roofs



COLORSTEEL® Roofs

Thermal performance of roofing materials is commonly understood based on the following values:

Total Solar Reflectance (TSR) relates to the temperature an object will reach on a hot summer's day and measures the amount of solar energy reflected from that object. A high TSR rating will mean a structure does not absorb as much energy from the sun, which will in turn keep the building cooler in summer and could help to save on energy costs in the long run.

Light Reflectance Value (LRV) measures the total amount of visible light reflected by a surface when illuminated by any light source and runs on a scale of 0% (pitch black) to 100% (perfectly reflective white). A low LRV rating can help a building to sit more comfortably in its environment and with its neighbours, as it won't reflect light so readily under the harsh New Zealand sun.

Solar Reflectance Index (SRI) provides a metric to compare the roof surfaces. It's calculated using both the solar reflectance and thermal emittance values described above. The higher the SRI, the cooler the surface temperature of the roof will be in the sun.

A light coloured, low Solar Absorptance COLORSTEEL® roof not only reduces the amount of solar radiation absorbed but can also be very effective at re-radiating heat. This means that the building can be cooler overall and may cool down faster when the sun is not shining, which can potentially help reduce energy demand.

A light-coloured painted steel roof, on a building which is surrounded by trees that provide both adequate shade and evapotranspiration conditions to the atmosphere, has the potential be one of the best design scenarios to help reduce the intensity and overall impact of UHIs.

References

1. Howard,L (1833). The Climate of London, Second Edition. https://www.researchgate.net/publication/292141041_The_Climate_of_London_by_Luke_Howard_1833
2. 2.US Environmental Protection Agency (2021). Learn About Heat Islands, published by EPA. https://www.epa.gov/heatislands/learn-about-heat-islands#heat-islands
3. 3.US Environmental Protection Agency (2021). Heat Island Impacts, published by EPA. https://www.epa.gov/heatislands/heat-island-impacts
4. Rosenzweig, C., Solecki, W., Parshall, L., Gaffin, S., Lynn, B., Goldberg, R., Cox, J. and Hodges, S. (2006). Mitigating New York City's Heat Island with Urban Forestry, Living Roofs, and Light Surfaces. 86th American Meteorological Society Annual Meeting. Atlanta, Georgia, USA. 5pp.
5. Pisello, A.L. (January 2017). State of the art on the development of cool coatings for buildings and cities, p664.

*Compared to conventional roofing materials of lower Solar Reflectance Index (SRI). Any savings and/or the extent to which a building is cooler may vary and depend upon the circumstances of the building, including building location, level of insulation, location of air-conditioning when installed, building shape, building function and environmental factors.

Table 1. COLORSTEEL® products' Solar Absorptance (SA) and Solar Reflectance Index (SRI) values

Colour	TSR[1]	LRV[2]	SRI[3] (as new)	SRI[3] (aged – 1 year)
TuiTuft®	69.0	76.0	84	82
Cloud	69.4	74.2	84	81
Titania	65.3	67.8	79	75
Sandscape®	64.5	65.0	77	74
Gull Grey	55.0	49.9	64	62
Sandstone Grey	40.5	27.2	45	43
SandBar®	46.7	33.7	53	51
Lichen	42.0	27.6	47	45
Mist Green	38.6	24.9	42	41
Permanent Green	24.7	10.1	24	23
Pioneer Red	35.8	12.0	38	37
Scoria	30.6	10.0	31	29
Ironsand	25.7	8.1	25	24
Karaka	24.3	7.9	23	22
New Denim Blue	24.2	10.9	23	22
Grey Friars	26.6	10.3	26	26
Thunder Grey	28.7	12.0	29	28
Windsor Grey	21.6	7.1	20	19
Slate	25.0	8.5	24	23
FlaxPod®	23.5	6.9	22	22
Ebony	4.9	4.9	1	1

Colour	TSR	LRV	SRI (as new)	SRI (aged – 1 year)
StonePeak® Matte	55.7	49.7	65	62
TidalDrift® Matte	29.2	12.6	30	29
FlaxPod® Matte	19.9	6.2	17	17

[1] TSR values were calculated according to ASTM E 903-96, *Standard test method for solar absorptance, reflectance and transmittance of materials using integrating spheres*, Section 8.3.4, Selected Ordinates.

[2] LRV is a weighted average calculation, using 16 evenly spaced wavelengths between 700nm and 400nm. Weights applied to reflectance values are the product of E (direct normal spectral irradiance), provided in ASTM E891-87 and Y (y-chromaticity co-ordinates), provided in ISO/CIE 11664-1:2019 *Colorimetry-Part 1:CIE standard colorimetric observers*.

[3] SRI calculations were undertaken according to ASTM standard E1980-11.

nzsteel.co.nz
0800 100 523

New Zealand Steel