

# Building materials, thermal efficiency and reflectivity

## INTRODUCTION

Good building design requires some thought in the selection and use of materials. Reflective building materials can benefit the occupants and the environment. However, in limited instances highly reflective materials or surfaces, if not properly used, can cause some annoyance to immediate neighbours.

Therefore, the challenge is to develop an understanding of the key issues to allow a balanced assessment of material choice in the interests of the occupants, the neighbours and the environment. The purpose of this Technical Bulletin is to provide insight on some of these issues.

## INEFFECTIVE POLICIES

All building materials reflect sunlight. Occasionally policies or guidelines are developed based around a reflectivity limit or with wording such as 'all building materials must be non-reflective'. These policies or guidelines can lack a definition around how to determine reflectivity or quantification to enable compliance.

There are inadequacies in attempting to control the use of building materials based on reflectivity alone. One problem with this approach is that in most Australian climate zones materials with high solar reflectivity can offer better thermal performance than materials with lower reflectivity by way of lower cooling energy costs and/or improved thermal comfort. Placing limits on reflectivity therefore may preclude energy efficient design, to the detriment of the occupants and the environment.

Other problems may be introduced with reflectivity limits. For example, it is inappropriate to have such limits if they are not equally applied to all materials. Materials such as glass may have difficulty in meeting a reflectivity limit if assessed for all lighting angles and not just at normal incidence. While this could mean that some building materials may not comply, they may not pose a problem if they do not cause sunlight to be reflected directly back to the observer.

## CASE-BY-CASE ASSESSMENT

The most effective method of determining which building materials are appropriate is to conduct a case-by-case assessment. A case-by-case assessment can be a reasonably simple process. Important factors to be considered in appraising a building include:

**1. Orientation:** A simple sketch of the house in question, the typical position of the sun and the position of any neighbouring dwellings (see Figure 1) can be a great help in determining whether any neighbours could be affected by directly reflected sunlight. For typical roofing pitches in the southern hemisphere, if a roof is viewed from the north, it is unlikely that it will cause glare. If viewed from the west, it is unlikely that glare would occur other than for a short period in the morning. If viewed from the east, it is unlikely that glare would occur other than for a short period in the afternoon. However, if viewed mainly from the south, roofs may result in glare for extended periods of the day. Furthermore, due to the sun's ever changing path, glare will typically only be present

Figure 1. Direction tendency of mirrored sunlight to the North and to the South.

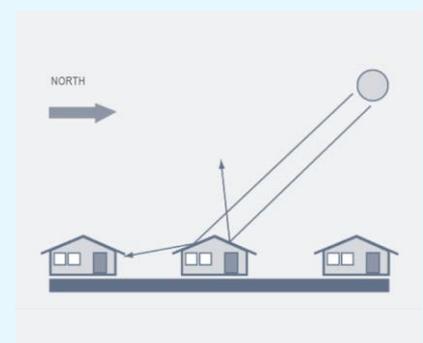
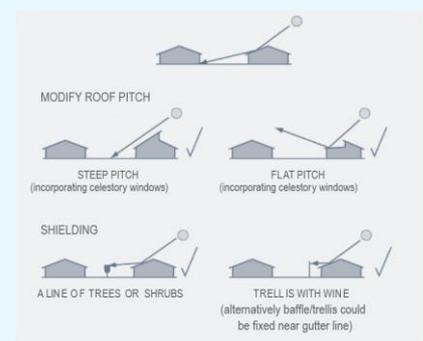


Figure 2. Modifying roof pitch or shielding to avoid directly reflected sunlight.



during particular seasons representing a minority of the year.

**2. Roof Pitch and Topography:** Issues such as roof pitch and the slope of the ground (topography) need to be considered in drawing a sketch such as that in Figure 1. Any vegetation or other screening that is present or could be used to shield the view of the roof should also be considered (see Figure 2).

**3. Seasons and Weathering:** The effects of glare will often be worse in summer when the sun is at its most intense. New roofs built during summer that have not undergone any weathering have the potential to cause the most glare regardless of roofing colours and materials used. As the seasons change, so does the orientation of the sun in the sky and the observer may no longer receive direct reflection. Furthermore, in the case of roofing made from prepainted steel, some weathering will occur over time and the amount of reflected light will be reduced. While this weathering process reduces glare, it occurs in a manner that has minimal effect on the thermal performance of the roofing system.

It is important to consider the effects of weathering, since the tendency for some materials to cause glare will reduce with time (e.g. prepainted steel), while others may continue to cause glare at a consistent level over time (e.g. many types of glazing, solar panels and swimming pools).

**4. Choice of Colour and Finish:** Choosing a darker colour over a lighter colour can reduce the brightness of a material, however may not have the desired effect of reducing glare. Problem glare is commonly associated with directly reflected sunlight. Colour has a much smaller secondary impact on direct reflection. COLORBOND® steel colours all have a standard finish while the COLORBOND® steel Matt colours have a matt finish which provides for a more diffuse reflection.

### THERMAL EFFICIENCY

Many building materials are designed to be highly reflective. The main benefits being that highly solar reflective materials do not absorb as much heat as less reflective materials and therefore stay cooler. Generally, the use of highly solar reflective materials will result in a building with greater thermal efficiency (which can improve occupant comfort and improve effectiveness of cooling systems).

The most exposed element of a building is its roof. Therefore, it is an important element in designing an energy efficient building. During hot sunny weather, the temperature of a light-coloured roof can be up to 35°C cooler than a dark coloured roof. This results in a significantly lower cooling load from the roof. In warm and temperate climates, this can translate into

energy savings and improved thermal comfort for no additional cost. The benefit of light colours in warm climates has been well established through research and through monitoring of real buildings. Numerous experiments in several residential and commercial buildings in California and Florida in the USA show that white roofs can reduce air-conditioning energy use by between 10% and 50%<sup>1</sup>. The energy efficiency benefits of high solar reflectance roofs are recognised in both the National Construction Code and BASIX (NSW), and concessions are provided where appropriate to encourage their use.

Whilst the potential for reflective visual problems reduces with weathering, outdoor exposure testing has shown that the heat reflective properties of COLORBOND® steel and COLORBOND® steel Matt, both with Thermatech® solar reflectance technology<sup>†</sup>, are maintained. In addition, on hot summer nights a steel roof will radiate less heat into your home. This is due to steel's low thermal mass, which enables it to cool down fast once the sun has set.

### ENVIRONMENTAL BENEFITS

The thermal efficiency features of a light-coloured roof may offer benefits to the environment by reducing energy use and greenhouse gas emissions through improved efficiency of building air-conditioning systems. This may also help moderate our cities' increasing peak electrical summer loads, due largely to the increased residential air-conditioner use. Further benefits to the environment result from light coloured roofs because they are cooler helping to mitigate Urban Heat Islands (UHI). The use of dark building materials (particularly high mass materials) in built-up areas contributes to increased local temperatures causing UHI. Elevated temperature from UHI, particularly during summer, can affect a community's environment and quality of life.

According to the US Environment Protection Agency, impacts of UHI include increased energy consumption, elevated emissions of air pollutants and greenhouse gases, as well as impaired water quality. For more information on UHI and their effects visit <http://www.epa.gov/heatisland/about/index.htm>

### COMMERCIAL/INDUSTRIAL BUILDINGS

Whilst most of the preceding comments are equally applicable to commercial/industrial buildings, these types of buildings are less prone to cause glare disturbance as commercial/industrial roofs are usually of low pitch, high set, in flat terrain and typically elevated above pedestrian and neighbourhood line of sight. As many commercial and industrial roofs are not easily seen, roof colour is usually of less importance and higher solar reflectance materials are often preferred on the basis of their thermal performance. Consequently, BlueScope developed COLORBOND® Coolmax® steel for roofing having the highest solar reflectance of the COLORBOND® steel range.

Higher solar reflectance may raise concern that roofing made from COLORBOND® Coolmax® steel has increased potential for creating glare. It should be noted that the mirrored reflection of the sun from COLORBOND® Coolmax® steel in the colour Whitehaven® is similar to COLORBOND® steel in the colour Surfsmist®. Therefore, the performance of COLORBOND® Coolmax® steel with respect to potential glare arising from mirrored reflection of the sun is also expected to be similar to COLORBOND® steel in Surfsmist®. Commercial/industrial walls do not typically cause glare problems, as direct reflection often goes straight to the ground and is not received by people around the building. The main instance where reflection from walls may cause glare issues is multi-storey buildings. In this case, if the observer can see direct reflection from a wall, glare from windows would also be a significant problem as the sun would hit the windows at a low angle and most of the sunlight will be reflected.

### CONCLUSION

Key Points to Remember:

1. All materials are reflective.
2. A case-by-case assessment is the most effective means of managing reflectivity and thermal efficiency concerns with appropriate choice of building materials.
3. Reference to reflectivity limits alone can restrict the opportunity to use thermally efficient light colours, which can have inherent environmental benefits including reduced energy use, reduced greenhouse gas emissions, and mitigation of UHI.

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Given the benefits of choosing solar reflective building material and the effective ways to manage glare issues, it is suggested that building owners should be encouraged in their use, rather than discouraged.

## REFERENCES

1. Akbari H, Konopacki S and Parker D, Updates on revision to ASHRAE Standard 90.2: Including roof reflectivity for residential buildings, Proceedings of the ACEEE summer study on energy efficiency in buildings, 2000.

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