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Building materials, thermal efficiency and reflectivity

INTRODUCTION

Good building design requires some thought in the selection and use of materials. Reflective building materials 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 with wording such as 'all building materials must be non-reflective'. One implication of such a statement would be that nothing could be built, as all materials are reflective to some extent.

There are several inadequacies in attempting to control the use of building materials based on reflectivity alone. One problem with this approach is that it is well known 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 energy costs and/or improved comfort. Placing limits on reflectivity therefore precludes energy efficient design, to the detriment of the occupants and the environment.

Many other problems are 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 any reflectivity limit if assessed for all lighting angles and not just at normal incidence. While this would mean that some materials could not be used in any building application, 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. Arbitrary approaches that do not account for site conditions will always be to the detriment of the applicants, the neighbours or the broader environment. 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 can result in glare for extended periods of the day. Furthermore, due to the sun's ever changing path, glare will typically only be present 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*).

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

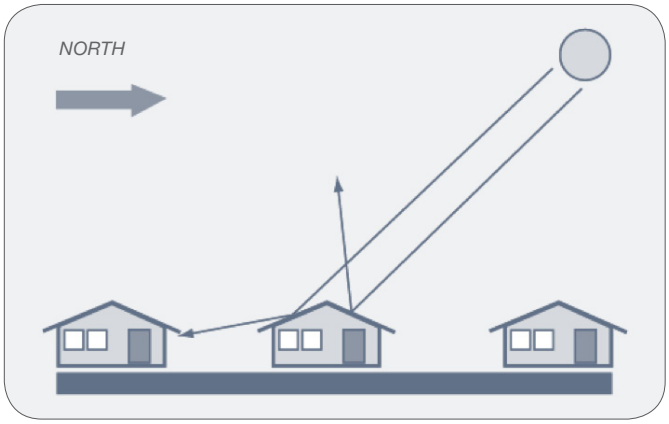
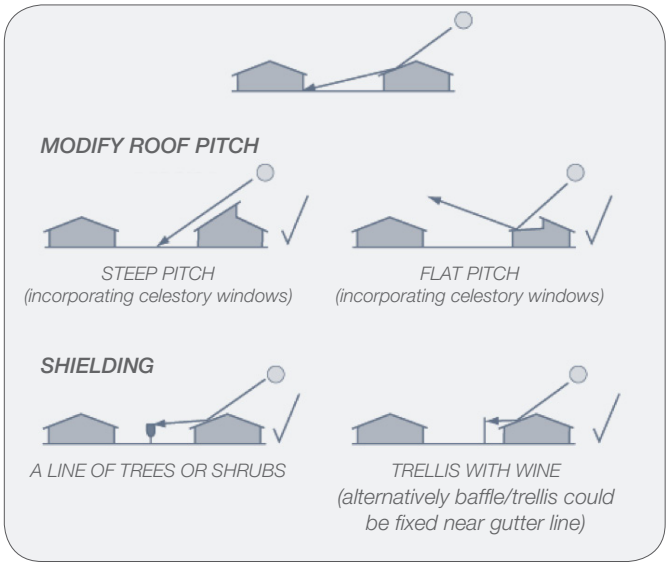


Figure 2. Modifying roof pitch or shielding to avoid directly reflected sunlight.



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 COLORBOND® 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 does not substantially affect 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. COLORBOND® steel), while others may continue to cause glare at a consistent level over time (e.g. terracotta tiles, many types of glazing and swimming pools).
4. **Choice of Colour:** Choosing a darker colour over a lighter colour may not have the desired effect of reducing glare. Problem glare is commonly associated with directly reflected sunlight, which is primarily affected by material gloss level. Colour has a much smaller secondary impact on direct reflection. It is typical for all colours of a standard material range (COLORBOND® steel, tiles etc.) to have similar gloss levels and to reflect similar levels of direct sunlight.

THERMAL EFFICIENCY

Many building materials are designed to be highly reflective. The main benefits being that highly reflective materials do not absorb as much heat as less reflective materials and therefore stay cooler. Generally, the use of highly 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 extremely 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%[1]. The energy efficiency benefits of high solar reflectance roofs are recognised in both the Building Code of Australia and BASIX (NSW), and concessions are provided where appropriate to encourage their use.

COLORBOND® steel with Thermatech® solar reflectance technology is a low maintenance and durable roofing material that can be used to improve building energy efficiency. Whilst the potential for reflective visual problems reduces with weathering, outdoor exposure testing has shown that the heat reflective properties of COLORBOND® steel are maintained.

In addition to this, on hot summer nights a roof made from COLORBOND® steel 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. As with all roofing products, the use of light solar reflective colours is preferable for thermal efficiency.

ENVIRONMENTAL BENEFITS

The thermal efficiency features of a light coloured roof can offer benefits to the environment by reducing energy use and greenhouse gas emissions through improved efficiency of building air-conditioning systems. This also helps to moderate our cities' increasing problems with meeting peak electrical summer loads, due largely to the huge increase of 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 tend not to cause glare disturbance as commercial/industrial roofs are usually of very low pitch and typically elevated beyond line of sight.

COLORBOND® Coolmax® steel has been designed to achieve the maximum solar reflectance for a prepainted steel product whilst maintaining all the quality and durability of COLORBOND® steel. 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 Surfmist®. 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 Surfmist®. On this basis, if it was deemed appropriate to use COLORBOND® steel in Surfmist® for roofing, as would be the case for the large majority of commercial and industrial roofs, then COLORBOND® Coolmax® steel in Whitehaven® should also be suitable.

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 light 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 tend to restrict the opportunity to use thermally efficient light colours, which have inherent environmental benefits including reduced energy use, reduced greenhouse gas emissions, and mitigation of UHI.

Given the benefits of choosing reflective building material and the effective ways to manage glare issues, it is suggested that building owners should be encouraged, rather than discouraged, in the use of products such as COLORBOND® Coolmax® steel and standard COLORBOND® steel with Thermatech® solar reflectance technology.

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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