



THE PROPERTIES OF ROOF TILES

This document discusses essential physical properties of roof tiles and other properties including wind and fire resistance, thermal performance, acoustic insulation, and resistance to salt attack. The information is presented in accordance with the Australian standard AS 2049-2002: Roof Tiles and AS 4046-2002: Methods of Testing Roof Tiles.



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ESSENTIAL PHYSICAL PROPERTIES

DIMENSIONAL TOLERANCES AND PERMITTED DISTORTION

The dimensions of the tile shall be the mean of measurements taken at the following locations, rounded to the nearest millimetre:

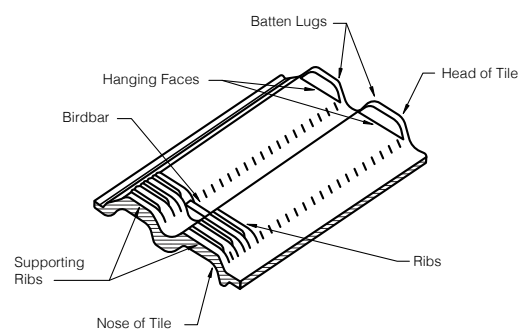
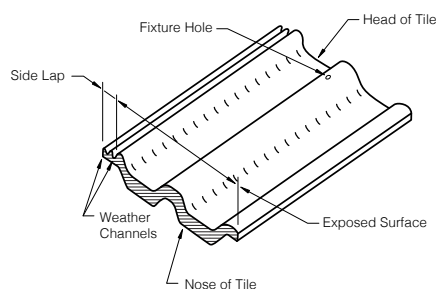
- (a) Exposed width: head, nose and across the mid-point of the tile (Figure 1).
- (b) Length: each side and along the centre of the tile.
- (c) Thickness: the centre of the tile at the mid-point (excluding lugs or brand imprints) and at the head and nose.

Figure 2 shows the general used terms for roof tiles.

Figure 1: Tile Width



Figure 2: General Terms



DIMENSIONAL TOLERANCES

The dimensional tolerances for roof tiles shall be determined in accordance with AS 4046.2-2002. A sample of 12 units shall be selected at random from an identifiable lot and each shall be individually marked. The mean of the individual results shall be as follows:

- (a) Exposed width: manufacturer's nominated width $\pm 2\%$.
- (b) Length: manufacturer's nominated length $\pm 2\%$.

STRENGTH

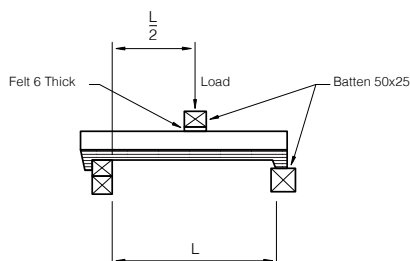
Roof tiles manufactured in accordance with AS 2049-2002 must pass a specified loading test (AS 4046.3-2002) to prove that they have adequate transverse strength. The minimum strength requirements of this test procedure ensure that roof tiles have sufficient strength to withstand normal handling stresses and occasional foot traffic on the roof for maintenance access purposes. The average transverse breaking load for the six test specimens shall be not less than 4 N per millimetre of exposed width for all tiles. Additionally, the transverse breaking load for each of the individual test specimens shall be not less than 3.325 N per millimetre of exposed width for all tiles.

The test tiles, which have been immersed in water at $20 \pm 5^\circ\text{C}$ for not less than 24 h and for not more than 26 h, should be supported in a horizontal position on two battens, each 50 mm wide and not less than 25 mm thick, located at positions that would be applicable when in use on the roof. Apply the load to the tile through a third batten of similar dimensions, placed midway between, and parallel to, the supporting battens, and cushioned on 6 mm thick felt. The load shall be applied at a uniform rate not greater than 100 N/s until fracture occurs. Figure 3 shows typical loading arrangement of this test.

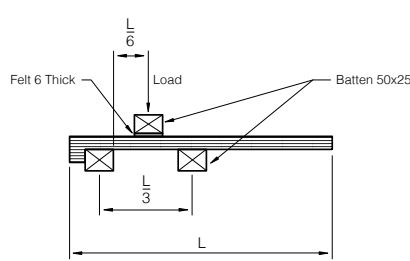
Note: where $L/3$ is less than 150 mm, reduce the width of the loading and support members to permit a minimum span of 100 mm. The minimum width of these members should be 10 mm.

Figure 3: Loading arrangement (dimentions in millimetres)

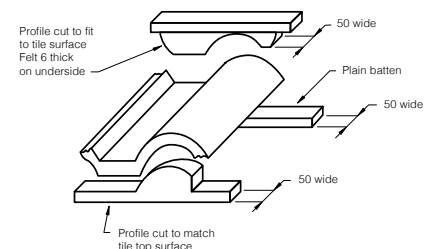
(a) Double-profile/shingle tiles



(b) Single tiles with triple overlap



(c) Single profile tiles



COLOURS

Terracotta tiles are formed from blends of natural clays and shales which are kiln fired to lock in their colour and ensure ultimate durability. They are available either unglazed, in their distinctive, natural red-orange colour, or glazed to provide different finishes and colours. These colours range from the palest ivory to deep reds and blackish hues.

Concrete tiles are available in Australia in a range of at least 18 different colours, including both plain and mottled. Because the colouring of a concrete tile is either integrally bonded with the body of the tile, or it is 'through-colour' with the entire body of the tile being coloured, there is no risk of peeling or delamination of the coloured surface. The exposed surface finish of a concrete tile also suffers far less than painted metal surfaces from industrial pollution and is unaffected by exposure to sea air.

Roofs are the elements of buildings most exposed to high levels of ultra-violet light and solar radiation. Most colour pigments tend to mellow to varying degrees when subject to this exposure. Added to this, the roof

naturally catches the majority of fall-out pollutants and dust from the atmosphere. Often these pollutants or dust particles have the ability to adhere to the roof. It should be recognised, therefore, that all roofing materials will change colour to some extent because of either a mellowing of colour, loss of lustre or a patina of pollution and dirt. To alleviate these conditions, concrete tiles are produced in a range of intensely pigmented colours, selected for their limited reaction to ultra-violet.

Another factor which can affect the colour of roofing materials is the growth of moss or lichens. Moss grows only where there is a sufficient build-up of dirt particles to support the root growth of the plant – thus near-flat roofs and materials with granular surfaces are most prone to this growth. Lichen spores are normally present in the air and can grow on most roofing materials. Concrete tiles display very little of this type of discolouration because concrete is alkaline, making concrete tiles mildly fungicidal in character, thus naturally limiting lichen growth.

TILE PATTERNS AND PROFILES

Concrete roof tiles are produced in distinctly different profiles, ranging from deeply ribbed 'Mediterranean' styles, through the traditional French pattern, to flat 'shingle' patterns.

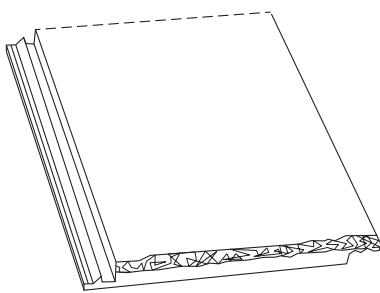
The importance of the 'visual texture' of roofing materials is often overlooked. When designing a roof for a domestic-scale building some account should be taken of the smallest roof planes on a job.

These areas of the roof can appear 'out-of-scale' if course or medium pattern roofing material is selected. If a flat or near-flat pattern is used the overall texture is better suited visually to small roof planes.

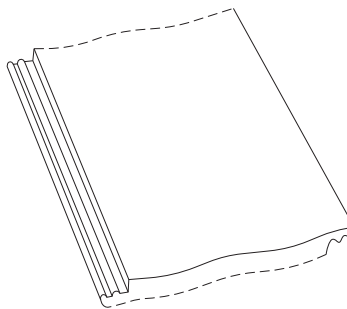
Tile shapes are typically classified into three categories: flat, low profile (i.e. Spanish or interlocking S tile) and high profile (i.e. Mediterranean or barrel tile).

Figure 4: Roof tile types

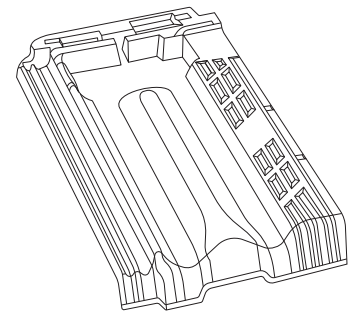
(a) Flat tile



(b) Low profiled tile



(c) High profiled tile



WATER ABSORPTION AND PERMEABILITY

All roof tiles must comply with the requirements of AS 2049-2002 and are tested in accordance with AS 4046.4 for determination of water absorption and AS 4046.5-2002 for determination of permeability.

The percentage of water absorption of roof tiles shall be not more than 10% for tiles graded as 'general purpose'. For terracotta roof tiles that are not kiln fresh and which have been dipped or sealed with a water repellent, they shall be tested after being brought to 500°C, held there for a minimum 2 h, soaked and then cooled.

AS 4046.5 requires three test specimens for roof tile permeability testing. No drop of water shall have formed on the underside of each specimen at the end of 2 h.

DURABILITY

Concrete and terracotta roof tiles, categorized as 'exposure' grade by testing in accordance with AS 4046.7, have an excellent record of durability under all exposure conditions, including severe marine environments, and require very little maintenance.

Based on experience to date in the Australian climate, roof tiles can be expected to perform satisfactorily for periods in excess of 50 years.

With their proven record of resistance to corrosive atmospheres, concrete tiles are the most suitable form of roofing for houses in close proximity to the sea coast. Tests conducted by the WA Institute of Technology, in which samples of 10-year-old concrete tiles from seaside suburbs of Perth were compared with new tiles from the same factory, showed that the physical properties of the tiles were not affected by prolonged exposure to the coastal environment.

ADDITIONAL PROPERTIES



CYCLONE AND HIGH-WIND RESISTANCE

Tiled roofs can be designed and built for all wind exposure conditions right up to cyclonic situation. The weight of the tiled roof will enhance its performance in high wind areas. Terracotta and concrete roof tiles offer more resistance to wind suction than lighter weight materials such as steel sheeting. Research shows that concrete roof tiles can sustain winds in excess of 125 miles per hour that would strip off most other roofing materials.

Investigations revealed that most storm damage was due to poor installation. To ensure high-quality installation, licensed contractors should be retained. This will help ensure proper permits are filed and building code requirements are met. The use of a flexible pointing material to fix ridge capping can enhance security in high winds.

Regardless of the roof surface used, the most important aspect of the roof in its structural frame and sheathing. Wind driven uplift is the roof's biggest threat. Much can be detailed here, but addressing the following is essential:

- Structural walls need to be sufficiently strong enough to secure roof supports (tie or bond beam is best)
- Roof trusses need to be adequately built and attached to walls (double strapping is best)
- Roof deck needs to be strong & properly fastened
- Hip roofs are safer than gabled (if gabled, need to reinforce with bracing and cover vents during storms)
- All openings need adequate protection to impede uplift (doors, garage doors, windows, soffit vents)



FIRE RESISTANCE

Concrete and terracotta roof tiles are completely non-combustible, which provide excellent protection against radiant heat from bushfires. Tiled roofs have been tested and pass the requirement of AS 3959-2009 for fire zone construction. Concrete and terracotta tile roofing are Class A fire rated, the highest fire-resistant rating available. In areas assessed as BAL-13 to BAL-40, sarking with a flammability index of not more than 5 must be installed under the tiles and cover the whole roof. In BAL-FZ areas, sarking must cover complete roof and extend over hips and ridges. It must also protrude over the fascia by at least 50mm.



ACOUSTIC PERFORMANCE

The acoustic performance of a roof is the measure of its ability to reduce the amount of sound that is transmitted from the external environment through the roofing material and into internal living areas. In most cases roof is the least important path of noise admission. However, in locations subject to air craft noise or where there is a busy road or railway nearby, the roof becomes an important element to consider.

Tiled roofs offer better performance due to their density and thickness, and are particularly effective in blocking out sounds of low to medium frequency, which is the relative frequency level of most sources of noise pollution affecting homes. High density terracotta roof tiles and concrete roof tiles are found to achieve levels of sound insulation performance far exceeding the minimum required by the Building Code of Australia. In fact, roof tiles could reduce external noise by as much as 30 decibels, compared with a reduction of 12 decibels for sheet metal. A tiled roof also helps minimise "creaking" and "popping" sounds which occur with some types of roofing as a result of temperature variations.



THERMAL PERFORMANCE

Colour of roofing should be considered again in relation to thermal performance. Most of Australia has a climate which requires the roof to limit heat gain rather than heat loss. The colour of an exposed surface determines the amount of solar radiation which will be absorbed. Concrete tile offers a range of mottled white colours which have excellent performance in limiting solar radiation heat gain. The RTAA (Roofing Tile Association of Australia) research conducted by University of Newcastle has shown that light coloured tiles yield energy savings between 25-36% compared to dark coloured tiles. Comparing two cream tiles, with similar solar absorption coefficients, an additional 11% cooling energy is required by the flat profiles. So tile profile is also important.

The uninsulated concrete tiles have a low thermal resistance ($R_{1.3}$) and a thermal lag of less than one hour. Nevertheless this offers a slight thermal advantage over thin, highly conductive metal roofing materials. When sarking is installed in compliance with the AS 2050-2002 Installation of Roof Tiles, it should be of a type which will perform as a reflective insulation under the tiles. Reflective foil with ventilated spaces above and below has the advantage of offering excellent insulation against heat gain in the day time while allowing a rapid loss of heat in the evening. For the warm Australian climate then, this is an excellent performance regime.



RESISTANCE TO SALT ATTACK

Salt can cause damage to roof tiles, by chemical attack or by the expansive effect of salt crystals forming in the pores of a tile, or a combination of both. To assess how resistant a tile is to this, small pieces are alternately soaked in a salt solution, dried in an oven, soaked again etc., for 40 cycles. The amount of material that is crumbled or flaked off the surface during this process determines whether the tile can be classed as exposure grade. When a subsection of a tile is tested in accordance with AS 4046.7-2002, it shall have a minimum dimension of 50 mm × 25 mm × the nominal thickness. Roof tiles manufactured in accordance with AS 2049-2002, categorized as 'exposure' grade shall be deemed suitable for use in all exposure environments, including severe marine environments.

For general purpose, tile products are not expected to meet the mass loss criterion for 'exposure' grade when tested in accordance with AS 4046.7-2002. Supplier's experience should be followed when purchasing roof tiles in this case.

Natural salts within a concrete tile may migrate to the surface as a whitish grey discolouration called efflorescence. This has no effect on the performance of the tile. Although common to many concrete products, efflorescence is relatively rare in concrete tiles. If it does occur it will usually weather off naturally over time.



CONCLUSION

All roof tiles should be designed and tested to conform to the Australian Standards AS 2049-2002 and AS 4046-2002. Tiled roofs combine superior durability, colourfastness and strength with a long life. They also help reduce the intrusion of external noises, provide protection against radiant heat in a bushfire, have high levels of thermal insulation, and offer more resistance to wind suction than lightweight sheets.



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