The Performance of Building Materials in Australia

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The climate in Australia, while by no means unique, is not typical of those countries from where the bulk of new building materials and products emanate, notably Europe, North America, and Japan. In specific terms, the high incidence of solar radiation over most of the Australian mainland and the plethora of construction around coastal Australia places severe demands on organic materials and metal surfaces, respectively. Products marketed satisfactorily overseas have been found wanting in Australia from time to time.

This paper illustrates the impact of the Australian climate and local practices on a range of building materials and coatings by specific example.

INTRODUCTION

The nature of the Australian climate has been well documented in terms of meteorological parameters. However, consistent with data worldwide, the influence of climate on the propensity for building materials to corrode or otherwise deteriorate is less well established. While there has been considerable and effective work on establishing corrosion rates for steel and some other metals in Australia, there has been little work since the early 1980s on correlating the deterioration of organic materials with climatic factors. That such correlations have not been pursued with organic materials is not surprising given that the mechanisms by which such materials deteriorate due to weather are complex and vary from one material to another.

Notwithstanding, a great deal can be said about the performance of building materials in Australia and about some of the parameters, both climatic and local practices, that have caused some striking differences in performance between products in service in Australia and those in more benign situations.

METALS

General Considerations

Compared with the population distribution across other continents, Australia is unique. The bulk of its population is distributed around the coastline. Indeed, apart from Canberra, the national capital, there are no cities larger than 90,000 people located more than 30 km from the coast. Thus, while the concentrations of airborne sea salts around the Australian seaboard are no different from those prevailing over other land masses, Australia has a much greater proportion of its infrastructure close to the coast than other continents. The impact of the marine environment on that infrastructure therefore can be reasonably expected to be greater.

The corrosivity of the Australian atmosphere to steel and a range of other metals has been well researched in Australia by the CSIRO and this information has been exploited in several Australian national standards dealing with protection of metals from corrosion. In particular, the work has quantified the coastal influence on the corrosion of steel, showing that the distance from the coast, the nature of the coastline, and the direction of prevailing winds are the dominating influences on corrosion in Australia.

This work has also shown that industrial pollution plays little influence on the macro climate in terms of corrosion in Australia and is probably limited to a very small fraction of the Australian mainland. This feature is probably attributable to the low density of industrialization and the absence of any close neighboring industrialized countries. Another factor has been the development of environmental protection authorities in Australia since the early 1970s and the virtual elimination of high sulphur fuel oils which were commonplace a few decades ago, and which contributed highly corrosive acidic combustion gases.

Another reason that corrosion is largely confined to the coast is the absence of any salts which are distributed on roads during winter in many colder parts of the world and which are a major factor in the severity of corrosion of steel and reinforced concrete bridges in particular.

Remote from the coastal influence and sustained periods of dampness, the corrosion rates through much of Australia are very low. Galvanized building cladding, wire fencing, and steel fence posts and telegraph poles form the primary infrastructure over most of inland Australia and their service life can be very long. For example, much of the original north-south steel telegraph line built over 120 years ago still stands in sound condition while much of the metal litter of the pioneer farmers and miners will remain a memorial to their endeavours for centuries to come.

Even in coastal places, the rate of corrosion can be quite low. For example, at Darwin, the capital of the Northern Territory, the rate of corrosion of exposed mild steel at the
Scientific Services Laboratory, Darwin exposure station only 0.5 km due south from the beach front confirms the area is quite benign (Figure 1). This low rate of corrosion can be attributed to the dryness of the climate during the winter months and generally off-shore breezes at that time. In the summer, however, when the prevailing wind is shoreward, the drenching monsoonal rains would tend to quickly dilute airborne salts and generally keep metal surfaces clean.

(1) As mentioned previously, aluminum/zinc alloy coated steel has essentially displaced galvanizing for sheet and coil product in Australia. Its durability is significantly superior to galvanizing of the same thickness in both exposed and sheltered situations and is typically threefold better in exposed coastal situations.10

However, two shortcomings of the product were identified after its release to the market:

- Black staining occurred when the product was stored in damp situations. While this did not detract from the durability performance of the product, it was aesthetically unacceptable. The problem was solved after a few months by the manufacturer by modifying the passivation process.

- Unlike galvanized coating, when aluminum zinc alloy coated sheet is overcoated with a high build paint system there is an accelerated tendency for the coating to delaminate at the cut edge in outdoor situations (Figure 2).

Metal Cladding

Galvanizing has been a most significant and forgiving protective coating for steel cladding in Australia for over 100 years.

In 1979 a 55% aluminum/zinc alloy coating alternative to galvanizing for sheet products was introduced to the Australian market and has essentially replaced galvanizing for this purpose. The use of prepainted metal cladding has also developed significantly over the last two decades, with a proliferation of coating types, profiles, colors and embossing and with some imaginative architectural applications.

However, there were a number of problems with some of these new developments in metal roofing and wall cladding in the first few years after their introduction, which in hindsight might have been reasonably anticipated. They serve as a reminder that in extending to new technologies, there is always a potential to discover new problem areas as the following examples highlight.

It is speculated that this is because thick barrier coatings impede oxygen diffusion to the substrate. Consequently, at the cut edge of a sheet, the substrate becomes more anodic at any crevice between the organic coating and zinc/aluminum alloy layer than it otherwise would, and corrosion accelerates due to the oxygen concentration cell established.

This limitation remains and, to maximize the performance of thicker coatings on zinc/aluminum alloy, it is therefore imperative that edges be sealed off from the environment. Sealing usually involves profiling the sheet so that the edge is not subject to wetting or else encapsulating the edge in building sealant.

(2) Embossing of sheet metal products after coating has become a popular innovation which variously enhances product strength, masks any surface variations, and provides decorative effect. However, embossing and other such profiling or bending of sheets imposes additional stressing and may result in serious cracking of the barrier coating (Figure 3).

These defects should not be confused with microcracking which occurs with low build, typically 20 μm thick precoat finishes on metal cladding. Such cracking, only visible at low power magnification, does not detract significantly from sheet performance as their coatings are essentially decorative. The embossing process, notably speed and depth of embossing, can impose stresses on coatings which may impair their performance. There have been instances where the embossing temperature has been carried out below the glass transition temperature and resulted in fine cracking of the coating.

(3) Perhaps the most significant sheet metal problem over the last few decades has been indiscriminate use of low pitch roofs. Because the low pitches encourage water to pond, particularly at the inevitable localized depressions and where sheets and flashing are in contact, the life due to accelerated corrosion is markedly reduced. Corrosion problems are not confined to exposed roof tops but are common within open structures, such as...