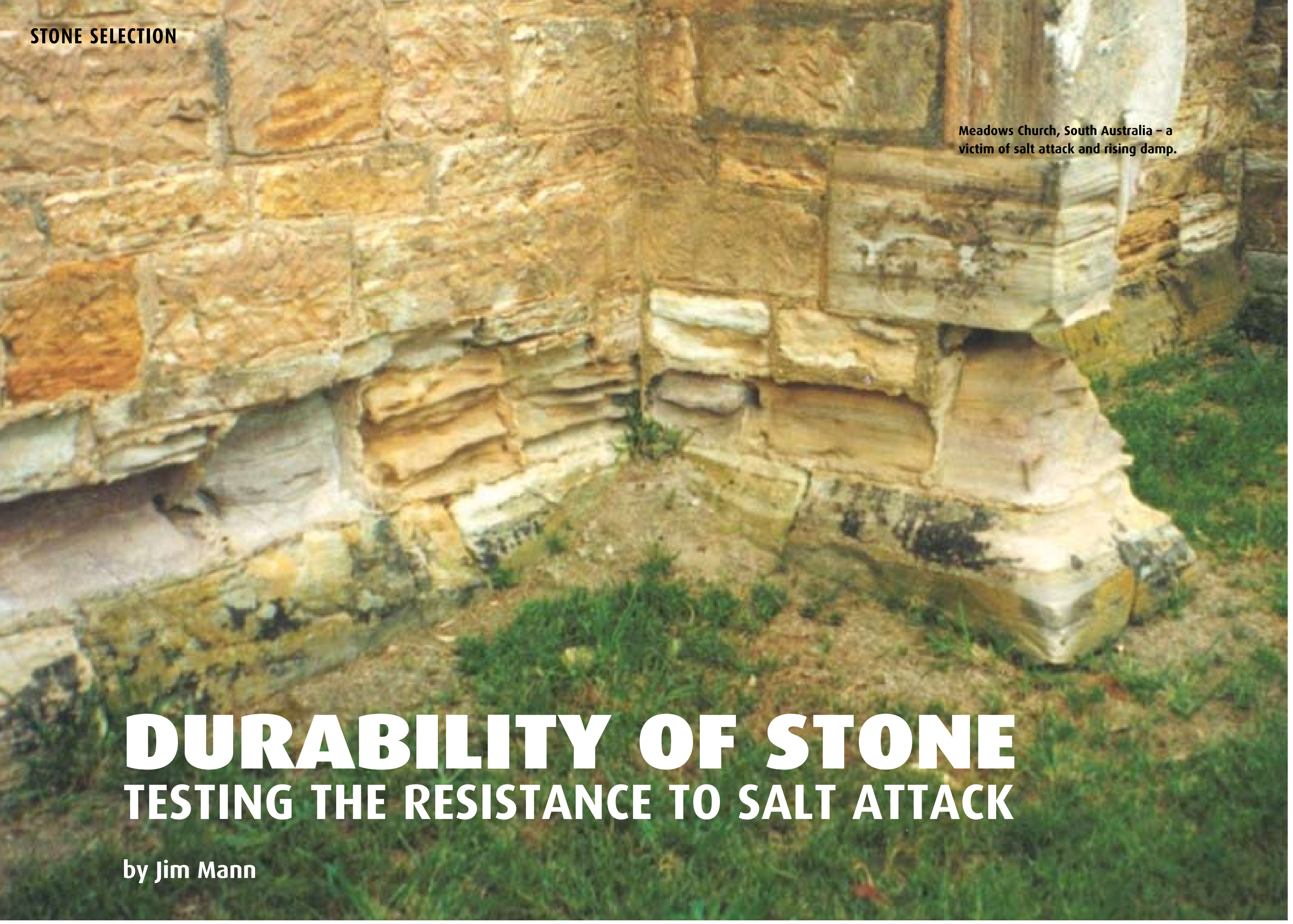

Meadows Church, South Australia – a victim of salt attack and rising damp.

DURABILITY OF STONE
TESTING THE RESISTANCE TO SALT ATTACK

by Jim Mann

Whether stone is being selected for use as cladding for a curtain wall, as coping for a parapet or as pool surround paving, durability needs to be considered as a key factor when determining its fitness for purpose. In Australia, assessing durability of stone has focused mainly on determining its resistance to salt attack. The Australian 'salt attack test' for stone was initially developed for the evaluation of argillaceous (clayey) sandstones from the Sydney and Gosford regions. Versions of this test have been used in Australia for many years; it is now formally documented as Australian/New Zealand standard AS/NZS 4456.10 Method A. Simply put, the test involves the immersion of five cubic (50 mm) specimens in a sodium sulphate (or sodium chloride) solution for a specified period followed by overnight oven drying and cooling to room temperature. On completion of fifteen cycles, the sample is weighed and the collected decay residue is filtered, dried and weighed to determine the actual weight loss of the specimen. The test result is presented as the mean weight loss (percentage) of the five specimens.

The standard does not offer any specification or performance guidelines; durability requirements are usually set on a job-specific basis. There are some 'non-standard' industry specifications that have been developed based on the historical performance of sandstone. One of the most commonly used is a requirement for sandstone specified for curtain wall construction to have a weight loss of less than 1.0 per cent. There is also an advisory A to D classification (attributed to AH Spry and DG West) which has been extended by Stone Initiatives to include an AA class. This additional class allows the identification of sandstone types with a very low weight loss (i.e. high durability). The classifications, along with suitability guidelines based on the author's experience, are presented in **Table 1**.

Table 1: Classification guidelines for durability of stone.

Weight Loss (%)	Grade	Environment Suitability Guidelines
< 0.1	AA	Aggressive environments, constant wetting and drying and exposure to salt attack
0.1 – 1	A	Exposed to continual wetting and drying or moderate salt attack
1 – 5	B	Exposed to intermittent wetting and drying or moderate level salt attack
6 – 10	C	Exposed to infrequent wetting and drying or low-level salt attack
> 10	D	Sheltered locations free from exposure to salt attack; additional engineering practices may be required to protect the stone in harsher environments

The usefulness of the salt attack test goes beyond providing a quantitative evaluation of durability; it also provides an indication of the behaviour of the stone in different environments and its typical mode of decay. At this stage, it is worth discussing the two-stage 'mechanics' of the action of repetitive immersion of the stone in the salt solution used during the test.

Firstly, the 'salt load' that permeates the pores of the stone increases with each immersion cycle, gradually increasing the pressure of the salt crystals on the walls of the pores during the drying cycle (due to this salt uptake, some specimens weigh more after the test than they did beforehand). This mechanical pressure tests the tensile strength of the stone, literally trying to tear the stone apart. It has been found that the ability of a stone to resist the crystallisation pressure (i.e. resistance to decay) is related not only to the stone's strength but also to pore size.

A stone's resistance to salt crystallisation has also been found to be directly related to its ability to withstand freeze/thaw cycling. Although this is not a problem in most of Australia, the test does provide a useful initial guide if you are selecting stone for higher altitudes.

The water used in the salt attack test also plays an important role in assessing durability. The wetting and drying cycles cause expansion and/or contraction of unstable minerals (e.g. clay minerals such as smectite or vermiculite) that may be present within the specimens. The notorious Barrabool sandstone from Victoria is a good example of this effect; this stone is packed with a range of unstable minerals, and is likely to decay during cycling even if the salt is omitted!

It can be seen from these mechanisms that the salt attack test provides a qualitative assessment of the 'pore strength' and dimensional stability of the stone and provides useful information on the likely performance of the stone even if salt attack is not a concern.

Although the method was originally designed for the testing of sandstone, the test also provides a good guide to the mode of decay of all stone types. The mode of decay of stone varies greatly depending on its genesis, texture, and mineralogy and can occur as crumbling, cracking, pitting, delamination or exfoliation. Decay of Sydney sandstones is typically through delamination where the skin of the specimen becomes detached. This form of decay is quite often seen on historic buildings where the stone develops a hard casing and delaminates; this often occurs without any relation to bedding (this is referred to as 'contour delamination'). A comparison of natural contour delamination and the similar delamination of test specimens can be seen in **Photos 1** and **2**.

Assessment of decay mode can be very useful when evaluating stone for use, especially where aesthetics is of particular importance. Some stone types can achieve a very low weight loss and therefore receive an AA rating, but the resultant decay may make the stone visually unsuitable due to the resultant pitting, loss of polish or micro-cracking.

A classic example is illustrated in **Photo 3**, which shows the effect of salt attack on polished black granite panels that have been adhered to cement blockwork (direct stick). Even though the black granite is very strong and has a very low water absorption, the salt solution has crystallised within the grain boundaries causing micro-cracking. Had this risk been assessed prior to construction, the suitability of the stone and surface finish could have been checked and the need for repair or replacement may have been avoided.

The salt attack test is also very useful for identifying less durable features such as clay pockets, stylolites or fillers used in materials such as travertine. **Photo 4** shows the appearance of a sandstone sample after a salt attack test. Although overall decay can be considered moderate, the test does identify a less durable (darker) band within the stone which may compromise the integrity of the stone.

In summary, it can be seen there is more to this test than is immediately apparent. Given the large amount of information that can be gained from such a small sample at a relatively low cost, testing the resistance to salt attack should be considered a necessity for evaluation of any stone where durability may be an issue.

Photo 1

Photo 2

Photo 3

Photo 4

Photos 1 & 2: Comparison of natural contour delamination of sandstone and similar delamination on test specimens following salt attack test. Photo 3: The pattern of the adhesive applied to the rear of the panel, which allowed transmission of the salt solution, has been highlighted by the subsequent attack and decay. Photo 4: The salt attack can identify less durable components of stone as seen by the preferential decay of the darker band.