Prevention of Deterioration from Salt Contamination in Heritage Artifacts

Past Techniques and Future Directions

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The following paper will outline different techniques that have been used in the past aimed at reducing deterioration of cultural and heritage artifacts through salt contamination. Salt contamination in/on objects can be naturally occurring but can also be caused by incorrect restoration and conservation techniques/materials, pool building practice/maintenance or even carried into the building on the feet of tourists. Pollution from flooding is also a common cause of salt deposition into building fabric while vehicles and industry contribute greatly to the air borne pollution. The paper will then discuss the most recent technology utilizing a cellulose fibre poulticing technique with illustrations of case studies from Australia and elsewhere in the world.

In Australia, sacrificial renders have been the most accepted and commonly used materials in preventing degradation of buildings suffering from salt contamination. Since the late 70's to the mid 80's when extensive testing was carried out by the CSIRO on sacrificial renders based on sand and slaked lime formulations, many properties have been treated with these materials to minimise the deterioration rate of the building fabric. Most salts are stable in two forms, when they are in solution and when they are in a dry crystal form (Anhydrous). Salt damage is caused when the salts hydrate and convert from a liquid to a solid or vice versa; this is when an expansive force is created just below the surface of stone or brick causing exfoliation of the surface. Sacrificial render is used to alter the point of evaporation where the expansion of the salt takes place, so that the render is eaten away rather than the face of the stone or brick, hence the name sacrificial render. Provided the render is maintained and replaced if the substrate fabric becomes exposed and the sacrificial render does not become "drummy", deterioration to the main fabric can be held off indefinitely.

As we all know, best intentions when the job is started do not always carry through with regards to maintenance, this is especially so when in areas of high salt contamination, the render may be eaten back to the substrate within two or three weeks. This is one of the major drawbacks for the sacrificial render system, the fact that the maintenance can be so high. Other areas of concern are staining of the brick or stone surface with lime. Also, the need to catch all eaten away render to prevent it from laying at the bottom of the damp wall where the moisture converts the salts back into a solution and recycles them into the wall. Sacrificial renders have now been in use in Australia for over 25 years and there are very few applications that have lowered the salt to a safe level where the sacrificial render could be permanently removed to expose the original surface.

Poultices based on various clays or paper pulp have been tried in Europe and Australia, although they appear to be quite beneficial, they tend to dry very quickly then shrink and crack losing contact with the wall in a very short time, well before the transfer of salt activated by the water component is complete.

In 1995 Westox acquired a filter paper making factory and carried out tests using filter paper technology in poultices to remove salt from contaminated masonry.

A pharmaceutical grade insulin filter is made in the normal manner and then passed through the manufacturing process again to reconvert the "high wet strength" material back into a pulp

without stripping the diatomaceous earth from the fibres. The pulp is then used to make a soft, easily dispersible board that is the basis of “Westox Cocoon” as the material is known.

Trials and applications have been carried out since 1997 with an enormous amount of success, in some cases, salt contamination (see Figure 8) has been lowered by more than 90% in just 4 weeks using two applications.

The following case study is one of many projects where work has been successfully carried out using “Westox Cocoon”.

Working closely to the interpretation of the Burra Charter, "Doing as little as possible to achieve as much as possible". It was decided to carry out trials and establish if some longevity and reduction in maintenance could be achieved from sacrificial renders if the treated walls were desalinated prior to the application of the render. This had been trialled previously and quite successfully at Fort Denison. We also needed to establish if the damage caused by salts associated with rising damp could be controlled without the necessity of installing a damp-proof course, thereby minimising the amount of change made to the original building fabric.

Case study

Elizabeth Farm Circa 1794 (Figure 1) Australia’s oldest European style building, where previous unrestrained salt contamination has caused substantial fabric loss and structural deterioration. Elizabeth Farm was the home of John and Elizabeth Macarthur and was operational from 1793.

This early Australian homestead became the design for many houses that were built after it because of the wide verandahs that are particularly suited to hot climate countries. Elizabeth Farm is also considered the birthplace of the Australian wool industry.

The original house was built with bricks, rendered and marked with Ashlar blocking, the servants’ quarters (see Figure 3) and kitchen were built from Sydney sandstone, the sandstone walls were suffering from decay due to high salt contamination caused by rising damp and in some cases previous lateral water problems. Several attempts had been made over the years to try to arrest the problem with limited success. Sacrificial renders have been on the building for some years and have been helpful in holding back the rate of decay, as has the use of traditional type lime washes particularly in the basement area (see Figure 6).

The “Westox Cocoon” material was used on several of the badly affected walls after the removal of the sacrificial render or lime wash with the aim of reducing the salts to a “safe” level so sacrificial renders or traditional lime wash could be used with some longevity. The cocoon was applied in two applications (see Figure 4), each application being left for two weeks before removal (see Figure 5). Analysis was carried out to verify the transfer of salt from the wall to the cocoon. The first set of samples was taken prior to application, the second set of samples taken two weeks after the first application. These samples also included a sample of the cocoon material taken from over the drill site of the previous samples and the third set of samples taken after the removal of the second application, also including a sample of the cocoon from over the drill site.

The analysis of the samples was carried out by the CSIRO and included the types of salts present and the percentage of each type. It is important to know the types of salt present because this can vary the application procedure of the cocoon. Experience has shown if a high nitrate contamination is present then the length of time between cocoon application and removal changes.

Nitrates, being very mobile, tend to migrate quickly into the cocoon if the material is left in place; other salts migrate into the cocoon and the nitrates being a deliquescent salt, convert to liquid and soak back into the wall taking the other salt with them. In Australian conditions, we have found that removal of the cocoon after approximately four days removes a high percentage of the nitrates. The cocoon is then applied in the two applications, each being for two weeks, to reduce the remaining salt contamination. On the other hand, high sulphate contamination tends to be more difficult to remove and three applications are sometimes necessary. If chlorides are present with sulphates, the migration tends to be completed in the two applications. We believe that the chlorides tend to be more soluble in water and assist to solubilize the sulphates; temperature also has a bearing on the solubility of the sulphates.

The areas that were treated at Elizabeth Farm included a wall in the basement (see Figure 2), which was below the external ground level, this wall was lime washed along with the other basement walls after the desalination work, the outside wall of the servants' quarters (see Figure 3), which was also lime washed after desalination, and the internal and external of the laundry walls (see Figure 5) which had two types of sacrificial renders applied after the desalination work with a lime wash being applied over the sacrificial render. All existing sacrificial render was removed prior to the application of the cocoon so the original stone surface was exposed for the desalination work, in the areas that were originally lime washed, the stone was mostly exposed by the ongoing exfoliation caused by the salt contamination.

The results from the applications at Elizabeth Farm showed a significant reduction in most areas, there were two particular drill sites where it was difficult to obtain good samples for analysis. On one drill hole, the material was very wet and stuck to the drill making it impossible to take uncontaminated samples for each depth. One other drill hole had a hollow area behind the 20mm depth so the complete set of samples could not be taken. Precise sampling and analysis are essential if verification of the salt transfer is required, recording any difficulties experienced while collecting samples should be included in the report as it will most certainly show in the analysis results. Two different mixes were used for the sacrificial render in an effort to establish if there was any benefit or additional longevity from either mix, although both mixes followed the traditional 3 parts sand to 1 part slaked lime sacrificial renders, in an effort to provide more long term protection and reduce maintenance requirements, one mix was used at the ratio of 12 parts sand to 4 parts slaked lime to 1 part Portland cement whilst the other was 3 parts sand to 1 part slaked lime to which was added trass flour at the ratio of 25% to the lime component by volume. The areas where the different mixes were used were documented as well as being marked on the renders. These areas included both one internal and one external wall of the laundry area that were badly affected by rising damp. The basement walls (see Figure 6) that were below the external ground level, and the outside wall of the servants' quarters (see Figure 3) were the areas that were just lime washed over the desalinated stonework, no render was used in those areas. The work was completed in November 2002 and there is no sign of further deterioration at this time. This is a very positive indication that the salt reduction is at a reasonably "safe" level. As mentioned before, a sacrificial render or a traditional lime wash would start to breakdown within a very short period of time and if enough residual salts were present on the surface of the treated stone, then the deterioration would certainly have been active well before now.

Because Elizabeth Farm was comparatively high in salt contamination, especially nitrates, it should prove as a good indicator for other properties where deterioration from salt contamination needs to be controlled by doing the minimum amount of work. The traditional lime wash used over the desalinated areas should, by their sacrificial nature, provide early warnings of when the salt levels have again reached a stage where there is enough contamination to cause further

deterioration. In theory, if it took 210 years for the salt contamination to reach the stage it was at, if all the salt was removed, it should take another 210 years to reach the same level, of course it would not be allowed to reach the same level when preventing further deterioration is as simple as two more applications of cocoon as and when any areas of exfoliation become visible.

An inspection of the areas of desalination carried out in the November 2002 work was made in February 2010 and the results are quite impressive, only one small area of salt contamination is visible in the laundry area (see Figure 8) where the sacrificial render was used and another on the outside wall of the servants' quarters (see Figure 7) where the lime wash was used. All other areas including the basement had no visible signs of salt action; even the flag stones (see Figure 10) on the verandahs (see Figure 9) which were deteriorating at a very fast rate have no signs of exfoliation after the cocoon treatment. The former curator of Elizabeth farm Mr. Gary Crocket confirmed that the maintenance costs associated with lime washing and sacrificial renders had been reduced dramatically. The last inspection in 2022 showed no change from previous inspection in 2020.

References

https://australia.icomos.org/wp-content/uploads/The-Burra-Charter-2013-Adopted-31.10.2013.pdf