Analysis of the effect of excessive damp and chlorides on the sandstone walls of the Oatlands Gaol (1837)

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SOUTHERN MIDLANDS COUNCIL

Contents

Executive summary

The Oatlands Gaol (1837) is a very significant heritage place, associated with the early penal infrastructure of Tasmania. It was the largest regional colonial gaol in the colony, and operated as a gaol for exactly a century, before being largely demolished in 1937. The Gaoler's residence and much of the perimeter wall remains, as does a wealth of archaeological remains. The site now contains the 53 year old municipal swimming pool.

The sandstone from which the complex is built is of poor durability, having a high content of swelling clay, making it very susceptible to water damage through wet/dry cycles. The pool is leaking, allowing an estimated 1500 litres of chlorinated water to seep through the site, welling up being the sandstone walls, through which it eventually diffuses.

Salts in this chlorinated water accumulate on the face of stone, and through crystallisation mechanisms, which exacerbate the damaging effects of swelling clays, is causing extensive damage to the sandstone.

Unless the source of water and soluble salts is arrested, and remedial works undertaken on the site, this decay will accelerate, and eventually lead to structural damage (and possible collapse) of the gaol walls. It is also unknown what effect the chlorinated water has on the archaeological resource.

This paper examines the effect of chlorinated water on the Oatlands Gaol, and strongly recommends remedial works to arrest this problem before this significant heritage place is damaged beyond feasible repair.

Background to the site

In eighteenth and nineteenth-century Britain stone in building carried a social cachet which no other material did (Clifton-Taylor 1962:62). It was desirable, particularly in regions with ease of stone acquisition, that buildings be stone.

The geology of the Tasmanian Midlands has masses of Triassic/Jurassic sandstone outcrops (Nye 1921:5). While the sandstone of the Oatlands district is of a lesser quality than the Ross sandstones 40km north (Nye 1921:128), its ease of acquisition meant that it was bound to become a favoured building material (Williams 2003:48-51).

The settlement of Oatlands in the mid 1820s saw a quick wave of 'temporary' buildings erected, an early account by Widowson (1829:108-10) described the town as *'a few sod huts mark the site of the place'.* By the end of the 1830s, the town was booming, with over 200 stone buildings erected during that decade (Weeding 1988:9).

Designed by prominent Colonial Engineer John Lee-Archer, under instruction of Governor Arthur, the Oatlands Gaol was convict-built of local sandstone between 1835 and 1837, to replace an earlier timber building. It was central to the Oatlands Military Precinct – the main administrative hub of the southern midlands. The gaol was the largest regional colonial gaol in and operated as a such until 1863, when it was downgraded to a municipal gaol, as which it operated until 1937.

In 1937, all of the gaol buildings (except the Gaoler's residence) were demolished, and the massive sandstone perimeter wall was shortened to less than half its original height. The site lay unused until 1954, when the municipal in-ground swimming pool was installed in the former gaol yard. The Gaoler's residence has been unused for several decades, and is now derelict. The pool is still in use every summer, and lies partially full during other times of the year, slowly leaking.

Figure 1 - The Oatlands Gaol, c1890 (Gaoler's residence at right). Photograph - State Library of Tasmania, Allport Collection.

Figure 2 - A similar view as above, showing the Gaoler's residence and remnant perimeter walls.

The combination of a colonial gaol, and a municipal swimming pool is probably unique in Australia. This is an example of the misguided adaptive reuse ethos of the mid twentieth century, and an attempt to cover the 'convict-stain' upon which Tasmania was founded.

As can be imagined, in this situation, there is a suite of conservation problems manifesting. This paper will specifically look at the effect of excessive dampness and chlorides (salts) on historic sandstone – and where better to do this than in a sandstone-surrounded swimming pool.

Whilst it is acknowledged that the conservation issues of the site extend well beyond sandstone conservation, the scope of this paper is to examine only the sandstone conservation issues associated with dampness and chlorides.

The swimming pool and general site observations

An archaeological survey of the site (Williams 2003) and a recent historically georeferenced survey of the site (Taylor 2006) has determined that the swimming pool is positioned in what was formerly the men's division and women's division yards, and that there are likely to be a significant extent of archaeological remains throughout the site. Figure 4 demonstrates the current layout of the site, with historic (likely archaeological) features outlined (as depicted on Figure 3).

Figure 3 – Layout of the Oatlands Gaol during its peak, c1955-1937. Length of outer walls is approximately 45 metres. Adapted from Taylor 2006.

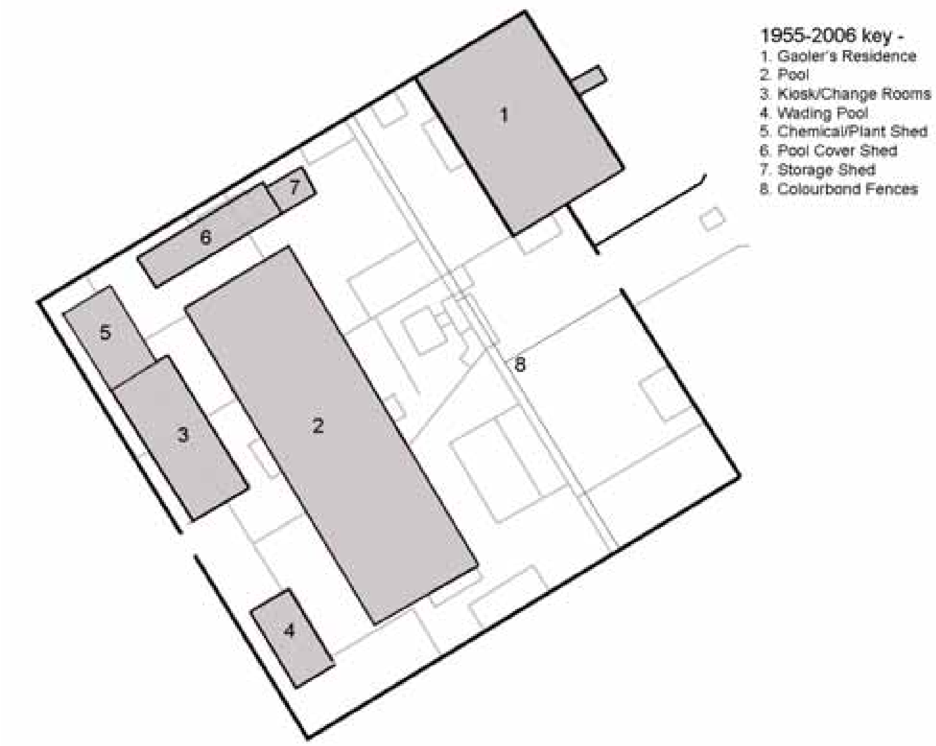

Figure 4 – Overlay of 1955-present site features, georeferenced with historically known features. Adapted from Taylor 2006.

The 53 year old swimming pool is beyond its feasible working life and attempts are being made to develop a pool elsewhere, allowing demolition of the current pool and redevelopment of the gaol as a historic site (Hepper 2006). Southern Midlands Council, the owners, are committed to the restoration of the site. Although a works program is about to commence on the Gaoler's residence, funding for restoration of the site is beyond current means.

It is known that the pool is leaking. Calculations as to the rate of leakage were made in April 2007, with a loss of 240mm of depth measured during that month. Considering the size of the pool, coupled with average evaporation and rainfall figures for Oatlands during April, it is estimated that the pool is leaking 1500 litres per day – this chlorinated (solute sodium chloride) water seeping straight into the site. Coupled with water used for irrigation of the lawns surrounding the pool, the historic elements of the site are subject to a significant amount of dampness.

The only drainage from the site is from showers/toilets and stormwater from the roof of the change rooms. All other water must find its way from the site via natural seepage. Bedrock appears to be less than a metre below natural ground level (evident by an outcrop 3 metres from the western wall), and it is assumed that the foundations of the buildings and perimeter wall are built directly on bedrock (supported by the apparent lack of foundation movement – Spratt 2005). All seepage will either run through the 700mm thick sandstone perimeter walls, or well-up behind the walls. As the site is on a gentle slope (natural ground level on the western side is approximately 1000mm less than on the eastern side (a gentle 1 in 40 grade), seepage naturally flows westward – as apparent by the excessive damp on the western wall.

Figure 5 – The western wall of the gaol (the Gaoler's residence at left). The perimeter wall shows signs of damp (dark patches) and efflorescence of salt (white patches) even at this distance.

As a general statement, the sandstone of the Oatlands Gaol does not suffer a broad spectrum of the problems often associated with sandstone buildings. Structural failure is minimal, and generally limited to the problems associated with roof-spread of the Gaoler's Residence. Generally, foundations are sound (Spratt 2005). A lack of maintenance has meant that there is almost no incidence of inappropriate repair (through cement based products). Falling damp facilitated by loss of pointing, a leaking roof, and removal of capstones, is causing some problems with loss of the mortar core of double-skinned ashlar walls, which will contribute to eventual voids within walls and possible collapse. However, the most urgent and obvious conservation problem with the sandstone of the Oatlands Gaol is that of rising damp and the consequent salt attack – which will form the basis of this paper.

Evidence of rising damp and salt attack on the sandstone of the Oatlands Gaol

The source of damp resulting in degradation of the Oatlands Gaol is unmistakable, as discussed above. All year round, there are parts of the walls (particularly on the western side), which are damp to the touch (see Table 1). Some days the walls appear drier, other days water can be seeping through the stone and mortar joints. With all damp problems come chloride (or salt) problems. Naturally occurring salts in the ground, in water, and in building products (particularly cement) all contribute to sandstone degradation when damp is involved. The Oatlands Gaol scenario takes this one step more extreme – with the stone and mortar exposed to heavily chlorinated pool water.

The mechanism of rising damp involves moisture in the ground rising through a porous substrate, via capillary action, to a point where evaporative action prevents further rise. The area between the ground and the upper extent of damp is the area that is subject to the damp, and the location at which evaporation from the surface of the wall occurs. The extent of this area is very variable according to the amount of water, rate of evaporation, porosity of substrate, presence of barriers (dampcourse) etc. As the damp evaporates, it leaves behind soluble salts, which crystallise on the face and result in salt damage, the mechanism of which will be discussed later (see Lewin 1982, Spennemann 1987).

Figure 6 – The dark areas on the gaol walls are distinct patches of moisture. The ground level inside the walls is at the fourth course shown here.

Sandstone is a porous material – the extent of porosity depends primarily on the geological nature of the stone, which can vary vastly between regions and even within the same quarry. Sharples (*et. al.* 1985, 1990a, 1990b) have analysed architectural sandstones of Tasmania from a geological perspective, to assess their suitability for such use – a knowledge of which can be applied to understanding the potential inherent failure mechanism of the stone. Sharples (1990a) has analysed Oatlands sandstones, and found them to be high in what are known as 'swelling clays' – namely *vermiculite* and *smectite* – when compared to other architectural sandstones used in Tasmania in the nineteenth century. The consequence of these clays is that the sandstone is more susceptible to expansion and contraction through cycles of wet and dry – which can break the microscopic silica bonds present in the stone, and result in 'fretting' (loss of sand granules) – erosion of the stone. This also has ramifications for the diffusion of soluble salts (and consequent damage from such) – discussed below.

These swelling clays, reacting to wet/dry cycles, may not be such an issue where stone is constantly wet, or constantly dry – as the frequency of change is not as regular and there is less pressure on the microscopic bonds within the stone. This is a particular issue at the Oatlands gaol, as there is no regularity as to the amount of moisture. It may be wetter in summer, due to watering of grass, or peak use of the pool. It may be wetter in winter, due to rain. Different parts of the site are subject to different moisture levels at different times. Evaporation from different parts of the site vary. There is no regularity to moisture levels, which presents a danger to sandstone with high swelling capabilities. This has certainly manifested in the gaol.

There is no widely recognised treatment which prevents the stress to sandstone resulting from swelling clays. Wangler *et. al.* (n.d.) presents brief results of tests using alkane-based surfactant treatments to alter the viscoelastic properties of sandstone – stiffening it to reduce mechanical stress. Whilst this may show promising results on laboratory samples, its application in the architectural conservation industry has not yet been comprehensively trialled, particularly when applied to cases where chemical (not mechanical) stresses are prevalent.

The effects of salt damage manifest primarily at the face of the stone – where soluble salts are left behind by evaporation of water, generally within the outer 10-20mm of the stone (Warke & Smith 2000). Further detailed theory on the capillary diffusion of water within stone is discussed by Lewin (1982). Clay rich sandstone is particularly susceptible to salt attack, as the porosity (through mechanical dilation of swelling cycles) of this stone allows greater mobility of solute salts, and their transfer to the outer surface where they cause their greatest damage (Mohan *et. al.* 1993). According to the source of water, this can accentuated by frequent (or irregular) drying cycles, allowing greater volumes and regularity of salt transfer to the face of the stone – resulting in salt accumulation on exposed surfaces. Dryer, harder or less porous stones do not allow such ease of salt transfer to the surface, hence low concentrations of salt may accumulate as efflorescence (a loose white powder) at the face (Figure 7). This is generally not harmful, but does indicate an underlying problem which can accelerate. In worse cases (i.e. softer, more porous, or wetter), salt may accumulate in sheets on the face of a stone, where it causes a granular disintegration of the face – flaking it away (Figure 8). In even more sever cases, the salt can be so violent that the face of the stone flakes in a 'blister' effect (Figure 9). Eventually this process can wear away successive faces of the stone, and result in structural failure of a building.

The presence of sodium chloride in clay rich sandstone is additionally problematic. As the stone gets wet (whether through soaking or humidity), it expands. It contracts upon drying at a reasonably similar rate. Sodium chloride does the opposite, expanding when drying, but at a much slower rate than it contracts. Lewin (1982) and Lombardo *et. al.* (2004) have studied how excessive salts (namely sodium chloride) affect porosity of stone in wet/dry cycles, and coupling this with the findings of Warke & Smith (2000), a dangerous mix of differential reactions (and rates of reaction) between the stone and salts can accelerate granular disintegration of the stone.

The Oatlands Gaol is a particularly good example of how the above circumstances act together with disastrous consequences. The effect of chlorinated water is obvious, particularly on the western wall of the gaol (see Table 1), where expanses of salts can be seen crystallised on the wall, flaking is common, and a few blocks are severely degraded. Unless addressed, this flaking will continue to erode the outer face of the block, gradually eating its way into the block and resulting in loss of facing and eventual loss of structural integrity.

Figure 7 – Efflorescence of salt on the face of stone. Whilst the exfoliation is probably a result of face bedding, continued salt attack will accelerate this (note also pointing loss).

Figure 8 – Efflorescence of salt forming on the face of the stone of the gaol walls, with some flaking beginning to occur. Note that the pointing was replaced in 2003.

Figure 9 – Severe flaking and blistering of the face of ashlar blocks.

The severity of the problem at the Oatlands Gaol

This paper has briefly discussed the mechanism of salt decay and the evidence of deterioration at the Oatlands Gaol. It has also considered the cause of the problem. The Oatlands Gaol is an almost unique case in Tasmania, as stated earlier the combination of a swimming pool and a significant sandstone structure is unusual. The historic fabric of the building has a direct and constant source of comparatively concentrated salts (when compared to natural levels in groundwater). This has manifested in disastrous consequences for the sandstone. An indication of overall damage is demonstrated in Table 1, which briefly shows the number of blocks visually affected by salt damage. Further damage (and potential for damage) would be evident in actual microscopic or invasive testing of individual blocks, which is beyond the scope of this paper. This table demonstrates that the western wall of the Oatlands Gaol has an alarmingly high incidence of salt damage, with around 64% of blocks showing symptoms.

Symptom	Example	Number of blocks observed	% of wall (n=420)	Note
Visually damp (i.e. dark colour of wet feel in full sunlight at 15 degrees ambient temp.		64	15	Levels have been observed to fluctuate according to weather, temperature, pool use etc.
Flaking, erosion or salt accumulation (i.e. some visual evidence of active salt accumulation)		270	**64**	Mostly limited to the lower 5 courses of stone, where incidence is practically 100% (consistent with the mechanism of rising damp described here).
Efflorescence (i.e. distinct minor build-up of salts on face – number included in above)		101	24	
Severe blistering (i.e. indicating severe active salt attack)		20	5	
Deep erosion which may result in structural failure (i.e. severe loss of all the stone face – number included in above)		20	5	
Note that the observation methodology employed here is subjective. More accurate measurements could be made by empirical testing for salt and moisture. These observations are therefore indicative only.				

Table 1 - Observed incidence of salt and damp damage, Oatlands Gaol (west gaol wall).

This paper has discussed the severity of the damp and salt problems mainly in the western wall of the Oatlands Gaol. These problems are widespread across the site, and due to modern accretions (soil fill) a full comprehension of the extent of the problem is not yet possible. Buried structure and artifacts are also likely to be subject to sever damage from moisture and chloride attack – a factor which must be considered both as a means of scoping the extent of the problem, as well as the consequences of the eventual exposure of buried structure and artifacts to the air (when the pool is removed). Spennemann (1987:10-1) briefly discusses the effect of damp and salts on archaeological artifacts.

Possible solutions

It is beyond the scope of this paper to provide a full program of rectification works to address the issues identified here, however a brief analysis of broad solutions will be proposed, which may form the basis for conservation planning at the site.

A common means of extracting salt from the surface of stone is by means of poulticing. A pulp and/or clay 'render' is applied to the wall, allowed to dry then naturally fall off – which removes much of the soluble salts from a wall. Similarly, sacrificial render can act to remove salts in more severe cases. A soft lime render is applied to the stone, adding a sacrificial face to the stone, which is targeted and destroyed by the salts, and can be removed and reapplied. This has the disadvantage of covering the original face, and can be unsightly (as it can be designed to last from a few weeks to a few years, depending on the circumstances). Dampcoursing, whereby an impermeable membrane is installed in a lower course of stone, can also control salt damage, by stopping capillary action from drawing water (and soluble salts) up a wall. Any ground moisture stays below the dampcourse (hence below the evaporation region) and minimises salt damage through minimising wet/dry cycles resulting in salt crystallisation.

Damaged stone faces may be readhered by means of consolidant. Ethyl acrylate products such as *Primol B60A* are salt stable, however do not allow a high level of moisture permeability, thereby trapping salt below the surface (cryptoflorescence), which may result in loss of the entire consolidated stone face. Silicate based consolidates, such as ethyl silicate, allow moisture permeability, but are less salt stable and would require poulticing prior to application. It is not recommended that any attempt be made to consolidate the face of the sandstone of the Oatlands Gaol until the actual source of salts is arrested, and only then should detailed core sampling and testing be undertaken to determine whether consolidation is appropriate, and what product to use.

Whilst the solutions above are valid means of minimising salt damage in most cases, the Oatlands Gaol presents a severe case of water ingress into a sandstone structure, and it is considered that unless the source of water is firstly addressed, the solutions outlined above would be futile. Removal of the pool, or the installation of more adequate drainage is considered to be the most sensible (although certainly requiring major works) means of controlling salt damage to the site. Once this is addressed, then solutions such as those outlined above can be considered.

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