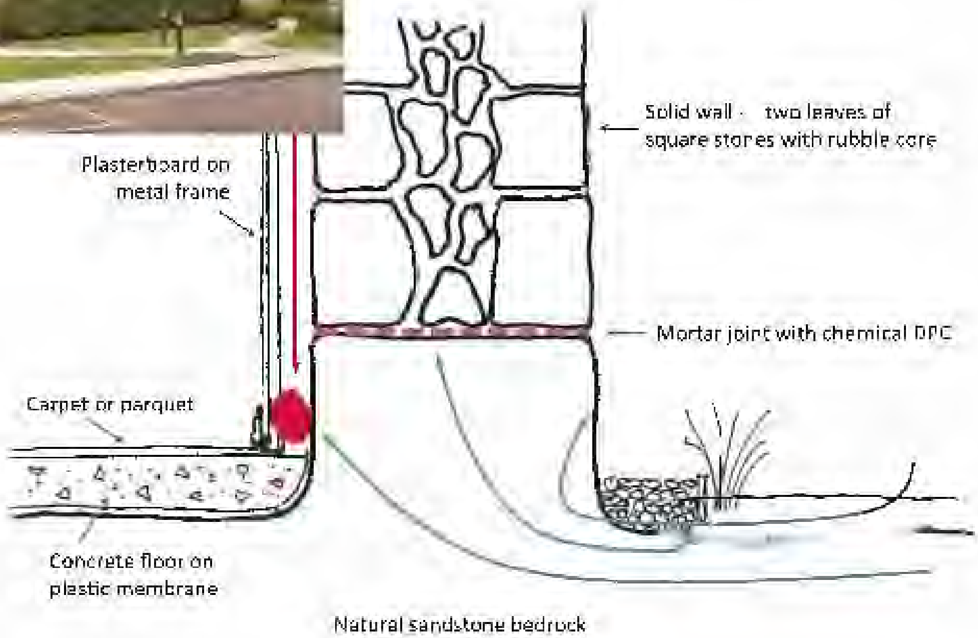
Investigation of dampness

Old Sugar Mill

Canterbury, NSW



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Introduction

Following return of damp problems within four years of the last treatment, the author was engaged by the strata committee of the Old Sugar Mill owners corporation (SP 70958) to:

- make a detailed inspection of the ground floor walls
- document all areas that are presently showing signs of damage or moisture
- make limited openings through the internal wall linings to access the masonry
- review existing documentation and previous works, including
- meeting with the 2013 builder to confirm the nature and extent of works
- meet with the strata committee to explain preliminary findings, and
- provide a detailed report of findings and recommendations.

The site, at 2–4 Sugar House Road Canterbury, was inspected in the period 6–8 March 2017. Detailed moisture meter measurements were taken and close visual and photographic observations made of the walls of the basement units. Sections of plasterboard linings were removed by Mark Clarkstone (Redwoods Building P/L) from six locations in two units. Six samples taken from the walls were chemically analysed for salts.

Background

The former Australian Sugar Company's mill was constructed on the banks of the Cooks River in two stages: the main building in 1840–41 with the east wing following soon after. The thick walls are built of large blocks of white sandstone that was quarried from the site, the quarry floor forming the foundation on which the building was constructed. The mill ceased operating in 1854 and the site remained unused until the 1880s when for a period it was refitted as an engineering works. It was briefly used a butter factory and in 1900 became the Canterbury Bacon Factory. Purchased in 1908 by J.C. Hutton and Co. the former mill's longest use (for seventy five years) was as a ham, bacon and smallgoods factory (Howard, 1995). Internal alterations saw parts of the basement converted to cold storage rooms (Steding, 2000). Gutted by fire in 1996, the building was sold and redeveloped as residential apartments in 2002–3.

The site is listed on the State Heritage Register (Listing number 00290).

Previous work

The 2002–3 conversion into apartments was undertaken by Westbourne Constructions to the specifications and drawings of Woodhouse & Danks Pty Ltd, architects (1999). Although all the drawings and specifications were not made available to the author, it is possible to discern from those sighted that the architects planned to lower the ground level (inside and out) around the building by about three-quarters of a metre, presumably in order provide greater headroom for the apartments.

By 2012, residents concerns about bubbling and blistering of paintwork on plasterboard linings resulted in the owners corporation, through their Strata managers (Bright & Duggan P/L), engaging Core Project Consulting to investigate. Their report, of 24 October 2012, identified that "in this case no damp proof course is present as the architect was relying on the actual thickness of the was (walls) to resist moisture ingress." Photographs in the report show loose sand falling out of a vent in plasterboard linings in Unit 1, and corrosion of an aluminium sliding wardrobe door frame in Unit 3. The report recommended "that 'Chemical Dampproof Course' be installed on all the lower level sandstone walls of apartments 1, 2 and 3", i.e. all the original walls of the main 1841 building. Their subsequent tender documents (dated 3 December 2012, which were not proceeded with) called for chemical damp-proofing on a 150 x 150mm grid of drilled holes from ground level up to 500mm above, cement rendering the sandstone foundation from ground level to the base of the sandstone block wall, and repointing of mortar joints in a strong mortar.

Subsequently, the owners corporation engaged Hector Abrahams Architects who opened up the internal linings in four places and reported on 28 March 2013 that "there is no visible evidence of a damp proof course" and noted that "the internal stone walls are seen to be decayed by damp borne salt" and that dampness in the plasterboard linings is because the "surface of the stone is fretting away leaving a pile of sand at the base of the wall." Abrahams recommended the following works:

- removal of plasterboard linings from internal walls, insertion of a chemical DPC at floor level, desalination of the stone to 1m above floor level and reinstating linings
- opening up linings from the inside face of external walls, cleaning out the cavity and reinstating linings
- externally, removing cement pointing from lowest bed joint and repointing in a lime mortar, injecting a DPC at ground floor level, and desalinating the lower 500mm of stonework (using a poultice).

Most of these works were undertaken by Noel T Leach Builders later in 2013, except that, once opened up, the walls were found to already have a DPC and so none was inserted (Hector Abrahams Architects, 2014; John Wallis, Noel T Leach Builders, pers comm. 2017).

Findings

Foundation

The 1840s sandstone walls are founded on sandstone bedrock, which was quarried to provide both stone for the walls and a platform on which to build. The bedrock may slope slightly southwards towards the river, but also steps down across the site. Bedrock is visible at the base of the northern half of the building (including the east wing, Unit 20) but is below present ground level for the southern half of the building. Probing with a long screwdriver in the garden about 2m out from the walls identified impenetrable material (possibly bedrock) between 100–200mm below present ground levels in twelve locations distributed around the building.

As noted above, the Woodhouse & Danks 1999 drawings show ground levels being lowered, implying excavation into the sandstone bedrock. As a result, for the northern half of the main 1841 building (i.e. Units 2 & 3) and for all of the later east wing (Unit 20), what appears to be the lower course of made stonework, is in fact the natural bedrock (Figure 1). A crude attempt to disguise this was made during the 2002 works by the cutting out and filling of fake joints in the sandstone.

Figure 1   North wall showing the bottom 'course' of sandstone, which is actually natural bedrock. An attempt to divide it into 'stones' has been made by cutting narrow slots and filling them with mortar.

Masonry walls

The walls of large blocks of white sandstone range in thickness from 600–800mm, while those of the east wing are around 600mm thick. The lowermost course of stones sit directly on the bedrock: in the case of the east wing this course is made of larger stones that project out from the walls, forming a plinth.

The stones are bedded in earthy mortars that probably contain some lime. Steding (2000) recorded shell lime mortars. Those mortars that are externally visible today are principally a cement-lime composition repointing (Woodhouse & Danks, 1999), dating from 2002 with some possible earlier phases. One section of stonework at the south end of the west wall retains what may be an early mortar and joint profile.

There are substantial areas of new stonework, introduced in 2002 to form openings and to replace missing and decayed stones. The new stones are a pale pinkish or creamy brown colour (Figures 3 and 4). Some stones have been patched with mortar, probably in 2002 though there may be earlier phases. Extensive rendering of the walls was removed in 2002, though traces remain. Some internal walls were rendered and painted during the earlier 'lives' of the building.

Figure 2   Fretting of the sandstone bedrock of the north wall due to salt attack and rising damp, with sand accumulating in the pebble bed below. Note the mortar patching of some stones at the left.

Most of the masonry appears in good condition, particularly given its age — 175 years. There is some decay in the form of fretting of surfaces, of both the cut stonework and the bedrock, the latter proving that some decay has occurred since 2002 (Figure 2). This is also shown by fretting of stones that likely date from the 2002 conversion (Figure 3). Fretting of the stone surfaces results in accumulation of sand in the pebble beds at the base of walls (Figure 2). Mortar patching of stones is failing in places (Figures 2 and 3). Some of the stone decay is being made worse by the impermeable nature of the cement-lime repointing (Figure 4). The 2013 repointing of the 'lowest bed joint' is decaying due to salt attack and probably, poor practice. The garden sprinkler system is spraying water onto the masonry in places, producing patches of green algae on the walls.

Damp-proofing — nature and position of DPC

Detailed drawings that show how the architects intended to damp-proof the walls have not been sighted, but it is known that in 2002 a chemical damp-proof course (DPC) was inserted into the mortar joint between the lowest course of made stonework and the bedrock (photographs attached to, and content of an email message of 5 February 2013, from Derek Pearson of Westbourne Constructions to Dane Maclachlan, Bright & Duggan).

Figures 3 and 4 New stone inserted in 2002 has a pale brown colour compared to the original whiter stone. At left, the new stone is decaying, as is the mortar-patched bedrock below and to its left. On the right, decay of two original stones is made worse by the impermeable nature of the cement-lime repointing, the stones are retreating from the mortar which now stands proud, leaving a shadow line.

Chemical damp-proof courses are produced by drilling a series of holes horizontally into the wall and injecting a water repellent fluid into the holes with the aim of the fluid migrating through the pores of the masonry and linking up to form (once cured) a water repellent zone at the base of the wall. Some of the drill holes from the 2002 work can be seen today in the east wall of Unit 20.

It is likely that the DPC was inserted into the mortar joint at the same level all the way around the building, meaning that for the southern half, the DPC is in joints between stone and stone, rather than stone and bedrock, as it is at the northern end. This should be confirmed during further investigations.

The height of the DPC above external ground level ranges from 350mm at the northeast corner of the east wing to 670mm at the southwest corner of the building. Ideally, DPCs should be about 200mm above ground level (Young, 2008 p26) though many older buildings have been constructed with DPCs up to 1.5m above ground, particularly on sloping sites.

Floors

As part of the 2002–3 conversion new concrete floors were laid within the stone walls on black plastic damp-proof membranes (DPM). The junction of the floor and the walls is visible in four of the openings cut through the plasterboard linings and in each case the DPM is visible and (just) projects above the concrete floor. There is little or no space between the sandstone wall and the DPM and concrete floor. Where readily seen, the floor level is slightly higher than the external ground level. Floors are finished in parquetry or carpet, with ceramic tiles in bathrooms.

Internal inspection

Internally all 1841 walls are lined with plasterboard, which is either glued directly to 2002 brickwork, or more commonly is supported on galvanised steel furrings — a metal frame that support the plasterboard away from the walls (Figure 10). The base of all readily accessible walls was closely inspected for signs of bubbling and blistering of the paintwork (Figure 5) that indicates moisture penetration from behind. The attached plan (Figure 15) shows 'hotspots' marked in red, which are either where there is obvious damage to the paintwork, or where high readings were recorded on the moisture meter (see below), or both.

Figure 5 Corrosion of aluminium sliding wardrobe door frame due to salts and to dissimilar metals (Unit 3). Early stages of corrosion of the same aluminium detail can be seen in Units 1 and 2. Also note typical bubbling and blistering of paintwork due to moisture and salts. See also Figure 11.

Other observations include ongoing corrosion of the aluminium wardrobe door frame seen in Core Project Consulting's report of 2012 (Unit 3, Figure 5) and early stages of corrosion in similar frames in Units 1 and 2. There are rusting steel door frames to bathrooms in Units 1 and 3 (Figure 6) and salt damaged grout between bathroom tiles in Unit 1 (Figure 7). Water staining of the parquet flooring is apparent in several units. The staining occurs near the edges of the floor close to skirtings and the old walls behind. Unexplained puddles of water have been found by the owners on parquet flooring in Units 1 and 3. These may have been related to now-resolved plumbing and drainage issues.

Figure 6 Corrosion (rusting) of steel bathroom door frame due to moisture from behind, Unit 3. Similar corrosion is apparent in Unit 1.

Figure 7 Decay of grout between bathroom tiles in Unit 1, due to salt attack.

Moisture meter survey

The base of readily accessible walls were surveyed with a TRAMEX ME moisture meter, with the aim of identifying areas of dampness in the plasterboard linings. It is important to be clear that moisture meters don't actually measure moisture — they measure one or other electrical properties (such as conductivity) and convert that to a theoretical moisture percentage. There are many reasons why this may not work, including the (unseen) presence of the galvanised steel furrings behind the plasterboard, which are highly conductive and will distort the readings. Another factor is that salty water is much more conductive than fresh water, and so a damp wall containing significant salt can give readings of more than 100% — a physical impossibility. See Young, 2008 p31 for more information about moisture meters.

Because of the uncertainties as to what was being measured, the results are presented as simple 'hotspots' shown as red lines on the attached plan (Figure 15) — it important to be clear that not all surfaces were surveyed (due to furniture and other obstructions), and that the absence of a red line does not mean there is no problem in that area. It is apparent from the plan that the hotspots include a large proportion of the internal walls and some areas of the interior surfaces of external walls. Some current hotspots were treated in 2013, and some weren't. The hotspots shown in Figure 15 are similar to the "areas of high moisture reading" recorded by Core Project Consulting in 2012/3.

Importantly, because of the limitations identified above, Figure 15 should be used only as an indication of the extent of the problem and not as a basis for documenting repairs.

Opening of plasterboard linings

Plasterboard linings were removed from six areas — four in Unit 1 and two in Unit 3, as shown on the attached plan (Figure 15). The exposures reveal:

- damp and fretting stones raining sand into the void behind the plasterboard
- substantial salts crystallising on the surfaces of the stones
- deterioration of 'water-resistant' plasterboard
- corroding galvanised steel furrings that support the plasterboard
- mortar droppings bridging from stone to plasterboard
- significant loss of mortar and sandstone from salty internal walls
- bridged metal DPCs in 2002 brickwork allowing penetrating dampness
- ineffective separation of new from old, due to inadequate or torn membranes
- corrosion of 2002 galvanised steel wall ties, tying new brick to old stone
- deterioration of new brickwork due to salts nearly 2m above floor level.

Figures 8 to 10 illustrate some of these findings. They show similar problems to those found in 2013.

Figure 8 Opening 2 in Unit 1, showing a cross section of about two thirds of the width of an internal sandstone wall. Note salts on surfaces of all stones, particularly the lower ones, and the decay of the mortar from between the stones.

Although this section had been treated in 2013, there was a new layer of damp sand bridging across from stone to plasterboard at floor level. Compare with Figure 11.

Figure 9 Opening 1a in Unit 1, which is on a short return at right angles to opening 1. This 2002 brick is decaying due to salt attack, the salt and dampness coming from the adjacent sandstone. Bubbling of the plasterboard extends almost to the ceiling, indicating that salts may be found in the next level above.

Figure 10 Opening 6 in Unit 3, looking down the gap between salty stone at left and the galvanised steel frame that supports the plasterboard lining at right. Note how the almost hidden U-section channel at the base is full of sand. Corrosion of the zinc galvanising (white) has lead to brown rusting of the steel beneath. The inner surface of the grey-green plasterboard is speckled with white salts.

Figure 11 Opening 5 in Unit 3, which is against an external wall. Note the damp sand that has accumulated behind the plasterboard. Vacuuming out the debris in the foreground has revealed the substantial depth of sand, and the rusting steel channel at the bottom, which sits on the concrete slab floor. To the left of the rusting channel is the black plastic membrane that is intended to protect the concrete from dampness. This area was not treated in 2013.

Salt analyses

Six samples of salts, salty sandstone and salty mortar were collected from the locations shown on Figure 15. Two (OSM 1 & 2) were analysed by X-Ray Diffraction (XRD) to determine which crystalline salts are present. The other four, OSM 5–8 (the latter two from decaying mortar on the outside of the north wall) were analysed by ICP–AES and titration to identify the soluble ions that make up the various salts.

XRD of OSM 1 & 2 (internal walls of Unit 1) showed Sodium Sulphate as the principal salt, with lesser proportion of a complex Hydrated Sodium Calcium Sulphate in sample OSM 2. Sodium Sulphate is a very aggressive salt (in terms of its expansive action on porous materials) and is used in accelerated weathering tests in laboratories.

Analyses of the other samples, indicate (after 'recombination' of the ions to make likely salts) the probable presence of the following salts, in concentration order:

OSM 5 (Unit 3, inside external wall) Calcium Sulphate, Sodium Sulphate, Sodium Chloride.

OSM 6 (Unit 3, internal wall) Sodium Chloride, Calcium Sulphate.

OSM 7 (Unit 20, mortar on exterior of north wall) Sodium Chloride, Calcium Sulphate.

OSM 8 (Unit 2, mortar on exterior of north wall) Sodium Chloride, Calcium Sulphate.

OSM 5 was very high in Calcium Sulphate and a possible explanation may be contamination of the sample from dust produced by the sawing open of the plasterboard lining. Calcium Sulphate is the mineral gypsum, which is the raw material from which plaster is made.

Mould & humidity

Several owners report high humidity and consequent problems with development of mould on clothing in wardrobes, particularly in Unit 1. There is limited ventilation in the basement apartments, with apparently low rates of ventilation through bathroom ceiling vents. Combined with the dampness in the walls it is not surprising that there are problems with mould.

Faulty plumbing

The downpipe on the southeast corner of the building is blocked or cracked and is allowing water to run down the lower part of the masonry. It also appears to be cracked and corroding at the top and should be investigated.

A tap in the garden bed on the east side between Units 1 and 3 is running and cannot be turned off. As noted above, the garden sprinkler system is spraying water onto the masonry in places, producing patches of green algae on the walls.

Discussion — diagnosis

Rising damp

Figure 12 is a sketch showing the position of 2002 damp-proof course (DPC) relative to the internal floors and the external pebble and garden beds. As can be seen from the sketch, dampness penetrating from the gardens and through the bedrock can reach the internal surface of the sandstone walls. Sandstone that is fretting due to salt attack leaves a pile of sand at the bottom of the void behind the plasterboard linings. This salty sand permits the dampness to reach the plasterboard and cause the observed bubbling and blistering of paint and the high internal humidity leading to the growth of moulds. It also leads to the corrosion of the galvanised steel furrings (or frame) that supports the plasterboard (Figures 10 & 11).

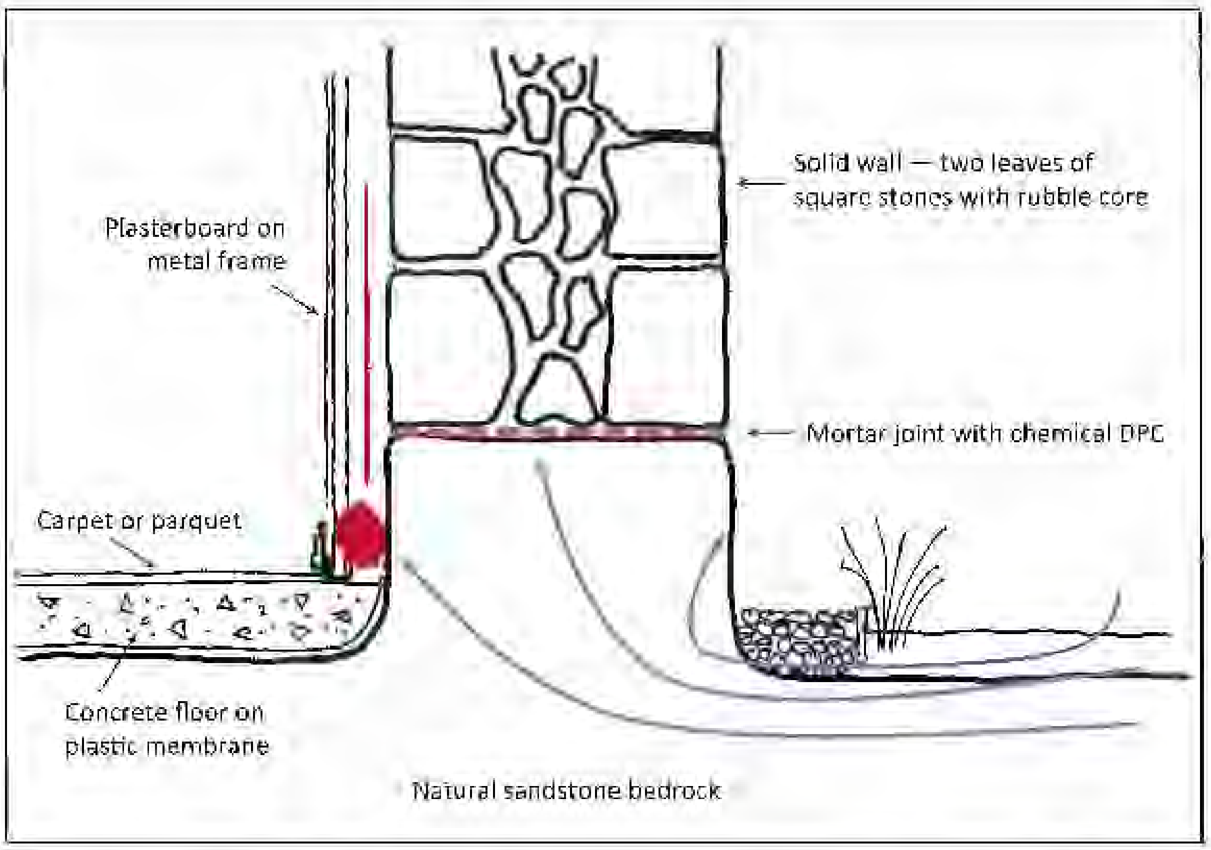

Figure 12 Schematic section through the external wall in the northern part of the main building. Dampness (blue arrows) penetrating from the gardens and percolating through the bedrock can reach the inside face of the wall, because the damp-proof course (DPC) is positioned too high in the wall. Sand (red arrow) from fretting sandstone falls down the void behind the plasterboard linings and accumulates at the base of the void, producing a damp bridge across to the plasterboard (for example see Figure 11). The DPC should have been installed at the level shown in Figure 13.

The DPC should have been installed at and just below the intended floor level as shown in Figure 13. Had that been done, and had the injection process produced a complete water-repellent zone across the full width and length of the walls, then the present problem would be much less severe than it is now. That there would still be a problem is explained below under Salt attack.

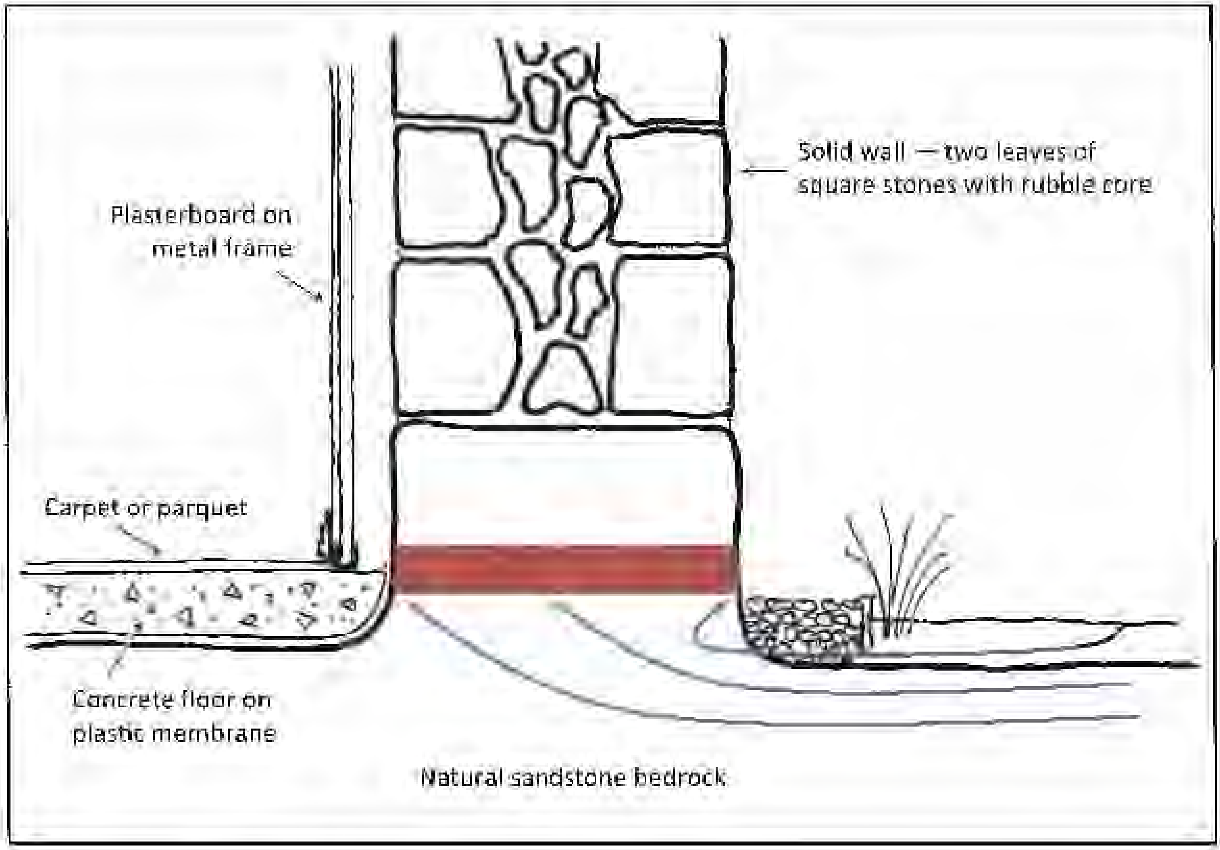

Figure 13 The same section as in Figure 12 but showing the correct position of the DPC (red-brown). Good practice would also have seen the new concrete floors kept back from the sandstone walls by at least 150mm, and the bottom third of the channel so created, filled with coarse sand to provide an evaporation zone (and drain) against the walls.

Another factor to consider is the question of the effectiveness of the present DPC. While reducing the amount of dampness rising in the walls, it may not be eliminating it entirely, and could thus be contributing to the overall problem by allowing dampness to activate soluble salts in the walls above. Given that the sandstone continues to deteriorate and rain sand into the voids behind the plasterboard, it is likely that the DPC is either not fully effective, or was not installed throughout the building. Figure 14 is a thermal image of the exposed stonework on the inside of the north wall of Unit 20. It shows the lower 'course' of stone (actually the bedrock) to be much cooler (i.e. damper) than the made stonework above it. The reasonably crisp distinction between the bedrock and the made stonework suggests that the DPC is moderately effective, though the apparent 'leakage' of colder temperatures into the stones above, does suggest that the DPC may not be fully effective.

Figure 14 Thermal image of the exposed stonework on the inside of the north wall of Unit 20. Yellow colours are warm (TV at top right, stairs and mat at bottom left), deep purple is cool. Note how the bedrock is coolest and how there is a reasonably crisp distinction in temperature between the bedrock and the made stonework above. Part of the reason that the bedrock is cooler is because of evaporation of moisture into the room.

Salt attack

The mechanism of the decay of the sandstone is salt attack, which is the cyclic wetting and drying of porous masonry in the presence of soluble salts. During wet periods the salts dissolve into the moisture in damp masonry, and then during dry spells, as the moisture evaporates, the salts crystallise within the pores of the masonry material (in this case sandstone and earthy mortars). When sufficient salt has accumulated in the pores, the growing salt crystals exert an outward pressure and force the grains of sandstone apart, leading to grain by grain fretting of the surface. This is what is happening externally to some parts of the walls, but is particularly a problem on the internal walls, because of the high concentrations of salts that are apparent there (Figure 8). See Young, 2008 p11, for more information about salt attack.

That there is so much salt in the internal walls may be related to the previous uses of the building, particularly the eighty or so years it was used as a bacon and smallgoods factory. Historically, salts have been used in curing meats and also in refrigeration systems as the chilled brine that was piped around cool rooms. We know that part of the basement of the mill was used as cool rooms and it is conceivable that salts leaked into floors and walls over many years. If these were the case we would expect to find nitrates (preservatives) and sodium chloride (refrigeration). However, although the analysis of the salts has shown the presence of sodium chloride, the nitrate levels are not high, and are highest on the exterior of the north walls, rather than the internal walls. The salt analyses for the two samples from the exterior of the north walls are typical of rising damp with associated salt attack. The presence of the sodium sulphate is not readily explained, though as noted earlier, it is an aggressive salt which must be removed to prevent further damage.

One unresolved question is how extensive is the salt contamination of the internal walls? Where were salts stored in the building, and could the walls of level 2 units also contain worrying amounts of salt?

Summary diagnosis

The basement walls, inside and out, are affected by salt attack and rising damp (salt damp). There is considerable variation across the building, with only minor issues in Unit 20, more substantial problems in Unit 2, and major problems in Unit 3, and particularly in Unit 1, which has the most internal walls remaining from the original mill building. Internal walls are more severely affected than external walls, but the latter are also decaying in places and need attention.

All of the damage within Units 1, 2 and 3 identified in this report (and illustrated in the photographs) can be attributed to the combination of rising (and penetrating) dampness and the action of soluble salts.

Recommendations

Following are a series of recommended actions intended to assist the owners corporation to deal with the intractable problems of salt damp in the Old Sugar Mill. It is important to be clear that there are two phenomena, ***salt attack*** and ***rising damp***, and that both must be dealt with. It is not sufficient to attempt to solve the problem solely by cutting off the damp — the salt must also be extracted. This is because salts are hygroscopic — they attract water and can go in and out of solution just with changes in humidity. Though reducing the rising damp 'stress' on the walls will slow the rate of salt attack, it will not stop it entirely.

These recommendations are set out in approximate order of priority with the aim of reducing the dampness in the walls as much as possible (and as soon as possible) without inserting a new DPC, so that the effect can be monitored and the more difficult and more expensive works planned in a measured and systematic way.

1. Engage a local architect

Engage a local architect to assist the author with further investigations and to manage the various phases of the works.

2. Plumbing — short term

Fix the leaking tap on the east side between Units 1 and 3. Turn off the garden watering system, or at least isolate those parts that are closer than one metre to the walls.

3. Roof plumbing — short and medium term

Repair the blocked and corroded downpipe on southeast corner of the building. Check other downpipes and all gutters.

Review the capacity of gutters and downpipes and make adjustments if projected rainfall intensities warrant them.

4. Remove garden beds from base of walls

The aim is to provide for a well-drained dry base to the walls, so as to minimise the rising damp 'stress'. Some rainwater will still soak into the sandstone, but importantly, more will be able to evaporate from the dry zone around the walls.

4.1 Remove all pebble and garden beds down to bedrock and out from walls by one metre. If bedrock is not exposed at the southern (river) end then lower ground by 200–300mm (to be confirmed on inspection, see 5.2).

4.2 Establish a new shallow open drain about 600mm out from base of walls. This may require grading (grinding) the sandstone surface to ensure adequate falls away from the walls.

4.3 Build a garden retaining wall at least 750mm out from the walls, thus allowing 150mm to the base of the shallow open drain.

4.4 Connect the new drain to the existing sumps using the existing ag-pipes, cut down to suit, and set through the retaining wall.

4.5 But first, undertake a hydraulics survey to confirm levels and ensure that the proposed drainage will function with minimal disruption to the existing stormwater system.

4.6 Remove all garden taps from the walls and relocate them (and any other plumbing) to outside the new retaining wall. Water supply pipes to the units may be an issue.

4.7 Install 'bridges' over the new drain to provide access to the doors of the basement units.

5. Hold point — inspection

Closely inspect the lower parts of the walls once the garden beds have been removed.

5.1 Check the position of the existing DPC in the southern half of the building — is it at the same level all the way around the building, or does it step down towards the southern end?

5.2 Determine a suitable depth of excavation around the southern half of the building.

5.3 Determine the condition and conservation needs of the masonry and amend the following if required.

6. Repoint mortar joints to encourage evaporation from base of walls

The aim is to encourage evaporation from the base of the walls via the joints, rather than through the stones, and by so controlling salts to the mortars, limit decay of the sandstone. The new lime mortar should be considered sacrificial — it will decay and require replacement as the salts are drawn out, but that is better than having to patch or replace sandstone.

6.1 Rake and cut out to at least 30mm depth, all mortar joints up to and including the course above the present DPC.

6.2 Thoroughly pre-wet the masonry to control suction.

6.3 Repoint in a lime mortar made from slaked lime putty and washed well-graded sand.

6.4 When leatherhard tamp joints with a stiff bristle to compact mortar and open surface.

6.5 Protect from sun, wind and rain with draped removalists blankets, kept damp.

6.6 Cure for four weeks of wetting, drying, wetting and drying, with covers kept damp.

6.7 Other areas where stone is decaying back from impermeable cement mortars (e.g. on the south wall, Figure 4) may also warrant repointing, and so the lower parts of the walls should be carefully surveyed.

6.8 Expect the new mortar to decay and require periodic replacement — taking some salts with it.

7. Improve ventilation of basement units

Investigate ways of improving ventilation of basement units.

7.1 Review the adequacy of bathroom exhaust systems, and whether there should be a light switch-activated fan added in line to each bathroom exhaust to improve air extraction.

7.2 Also consider the feasibility of incorporating some form of vent within the existing windows so as to enable cross-ventilation of the apartments.

7.3 To minimise the risk of mould growth, unit owners should consider installing tiny fans to promote air circulation within wardrobes. Silent low-wattage fans, such as are used in computers, may be ideal. Such fans not an alternative to overall ventilation improvements, but an additional tool in the anti-mould kit.

8. Hold point — further investigations

This hold point could be about 12–18 months after the first works to reduce dampness in the base of the walls (4, above). Things to investigate and consider are:

8.1 How the shallow open drain is functioning (observe it during heavy rain), and whether the base of the walls are drying out and what impact that is having internally and externally.

8.2 If the walls are still very damp, consideration may need to be given to a deep cut-off drain and trench around the northern end of the building designed to intercept groundwater flowing downhill towards the river.

8.3 The extent of salt contamination in the internal walls, including whether there are any salts in the walls above the basement apartments. The latter should be checked, initially by close visual observation and a moisture meter survey of the interiors of the level 2 units.

8.4 The extent of salt contamination in the basement (level 1) units should be investigated by extending some of the existing openings (up to the ceilings, and out to the full width of the old walls) to enable a thorough look at the wall sections. Of the existing openings, those that should be extended are numbers 1, 2 and 6.

8.5 Additional openings may be warranted:

- to investigate any hotspots discovered in level 2 units
- to check the 2002 dividing walls for dampness and fire-safety compliance
- to check other hotspots, including
- any that are not directly related to old walls, such as the north wall of the northern bathroom in Unit 1.

8.6 Whether there is a need for active salt reduction on the outside of the external walls — in addition to the sacrificial repointing undertaken as part of 6, above. This may require drilling mortar joints to obtain samples at a series of depths for chemical analysis. Active salt reduction might be undertaken by poulticing (as in 2013) or by captive head washing, or a combination of both techniques (see Young, 2008 pp44–45).

8.7 How to deal with any ongoing rising dampness issues and the considerable challenge of getting the salts out of the interior walls. These works are likely to involve:

- stripping all the internal plasterboard linings and kitchen cabinets from affected walls
- drilling and injection of a chemical DPC at the correct level (Figure 13) from both sides of each wall
- injection of DPCs into the base of brick dividing walls, constructed in 2002
- desalination (by poulticing and captive head washing) of all affected walls, including internal walls and the interior surfaces of some external walls
- testing, by drilling and analysing samples, before and after desalination to confirm effectiveness of treatment, and determine the number of cycles required
- consolidation of weak mortars and stones by multiple applications of limewater

- deep packing of open joints and grouting of voids in walls (to ensure structural integrity)
- repointing of joints in a permeable mortar to flush finish the walls
- allowing a period of time for thorough drying of thick walls
- reviewing the internal walls for any residual salts at the surface
- if present, extracting remaining salts with captive head washing
- relining, reinstating and redecoration of interiors.

These points amount to considerable works which will be very disruptive for an extended period. The owners corporation should consider how best to manage them to ensure a good outcome for the owners and for the building, which is of State significance.

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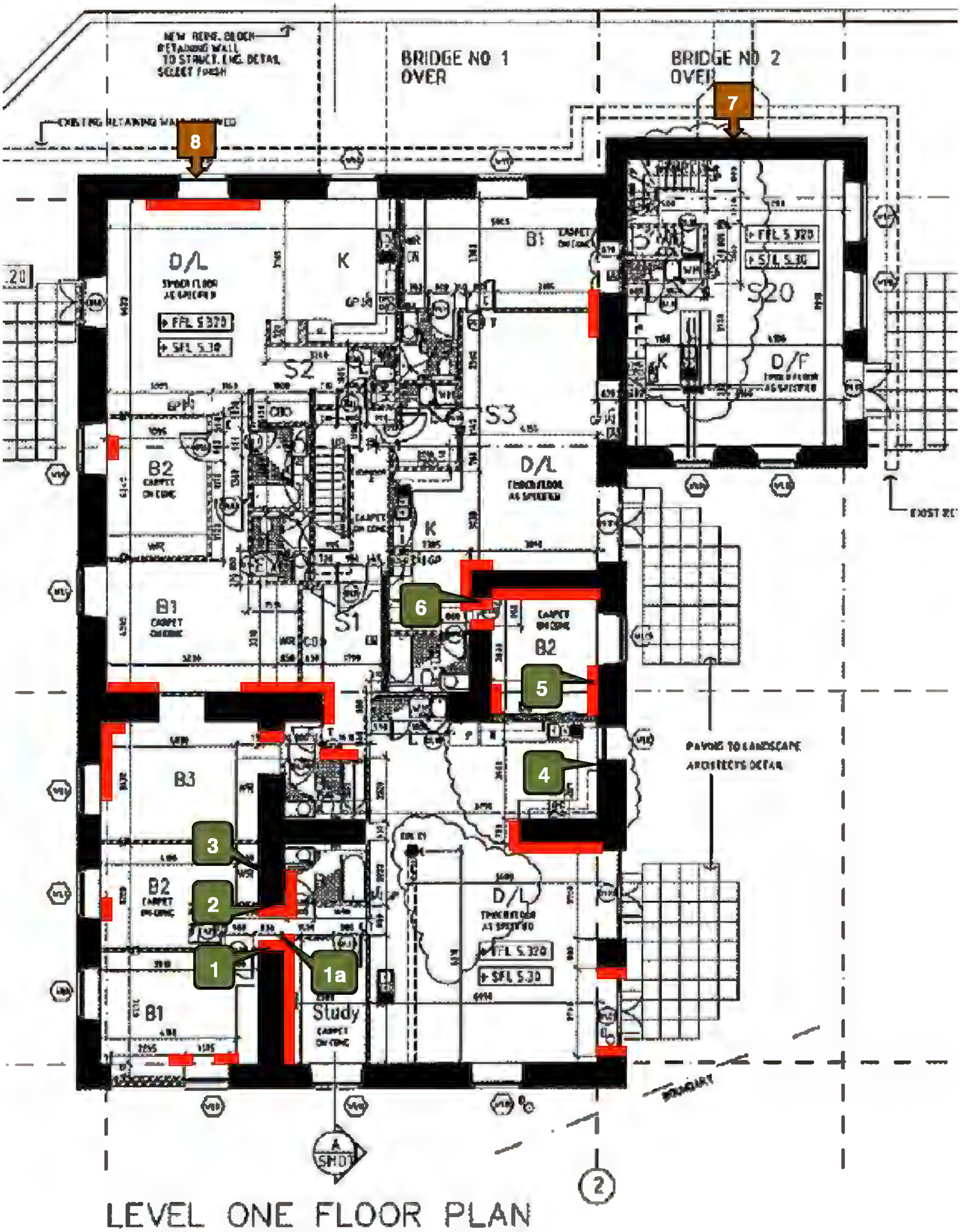

Moisture/decay 'hot spots' shown as

Openings through linings and salt samples shown as 2

Additional salt samples shown as 7

Figure 15 Plan (base extracted from Woodhouse & Danks, Job 0255, Drawing SM02—M)