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EVALUATION OF LECTROS DAMPCOURSING SYSTEM - Old Adelaide Gaol

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AMDEL REFERENCE Report 2AM1620

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INTRODUCTION and SCOPE

Amdel Limited was requested by the client to carry out an evaluation of the Lectros Damp Proofing System. The system had been installed in a damp affected wall of the *4 Yard Recreation Room* at the Old Adelaide Gaol, South Australia.

The aim of the investigation was to evaluate the effectiveness of the system to remove excess moisture from the wall using the active electro-osmotic damp proofing system.

2. THEORY and BACKGROUND

Electro-osmosis is defined as “the motion of liquid under an applied electric field through a porous medium”. The mechanism of electro osmosis was first discovered in the 18th Century, but it has only relatively recently been used for practical applications such as soil and slurry dewatering. The phenomena is associated with the variation in charge present at the interface of two phases – in this case, water present within a porous wall. The application of a voltage to the interface causes movement of the phases in relation to each other.

The use of electro osmosis for damp proofing first became practically available in the 1970's. At this stage the majority of systems installed for damp proofing relied on the *passive electro-osmosis* system. Passive electro-osmosis relies on the potential difference (galvanic potential) produced by different metals in an electrolyte to create a small electrical field. In practice, the system is based on earthing an electrical conductor, usually copper, by drilling holes into the wall at approximately 50cm intervals and extending two thirds into the wall. Electrodes formed from the copper strip are inserted into the holes to form the anodes. The electrical conductor is then connected to the ground via an earthing rod (the cathode) formed from a dissimilar metal (e.g. magnesium). This system relies on the depletion of metallic ions from the anodes to travel towards the cathode to produce a current. This “ion depletion”, by definition results in the corrosion of the copper strip and at some stage the resultant failure of the system.

The system under investigation uses *active electro-osmosis* that employs an imposed DC voltage to produce the electrical field. In this case the anodes are made from platinum coated titanium that are similarly inserted into the wall and connected to a low voltage power supply (typically < 9 volts). The circuit is completed by a copper earth rod driven into the ground at a lower level than the anodes and at some distance from them. The earth rod is connected to the negative side of the DC power supply and becomes the cathode. The resultant electric field produced by the system opposes the capillary rise of moisture into the wall resulting in a moisture flow towards the cathode. If the current and voltage are kept at low levels then no significant depletion of the anodes should occur, potentially giving the system a much longer life than the passive system.

3. LECTROS SYSTEM EVALUATION

To evaluate the effectiveness of the system a test wall that exhibited signs of rising damp was chosen and the Lectros system installed.

3.1 The Lectros System

The Lectros system uses 2mm diameter titanium wire as the conductor with platinum coated anodes constructed at regular intervals along the wire. The strip was installed 40 cm above ground level with the anodes located 85cm apart. The cathode was formed from a 1.2m long x 13mm diameter copper rod with the initial metre of the rod electrically insulated to ensure any moisture flows deep into the ground. The rod was inserted into the ground 3m away from the wall approximately midway along the panel. The system was powered by a unit connected to a 10amp / 240 volt power point. The power unit allowed the recording of the system voltage and current throughout the investigation.

The Lectros system was evaluated by the setting up of test panels within the Lectros system and on a representative section of the same wall that was not covered by the system (see Plates 1 to 4). The test panels were identified as:

Untreated – NT

Lectros – LE

To allow moisture levels to be measured regularly at the same location over a long period of time, a conductivity method using a Protimeter moisture meter¹ was established. Pairs of stainless steel pins were inserted into the mortar joint of the wall to a total depth of 175mm, with the initial 150mm electrically isolated from the mortar – this allowed the measurement of the conductivity (relative moisture content) at the centre of the wall. The pins were inserted 1, 3, 6, 9 and 12 mortar courses above floor level. The height of the pins above floor level were as follows:

Mortar Course Designation	Height Above Ground Level
1	10 cm
3	23 cm
6	46 cm
9	69 cm
12	91 cm

Each pair of pins was identified according to its panel type (NT or LE) and location (course 1, 3, 6, 9 or 12) to give a unique identification (e.g. NT-1 or LE-3). To determine variability in moisture content within each course two sets of pins were inserted at each course level to either side of the test panels and labelled set A and B (see Plate 5).

The conductivity readings were supplemented by determination of the actual moisture content of mortar collected from the same depth as the pins (150-175mm depth). The mortar was collected by drilling with a masonry bit; the collected mortar was dried at 60°C for 24 hours to determine the weight loss. The moisture content of the mortar was also determined using a Speedy Moisture Meter. All samples were taken at locations between the duplicate sets of pins.

Prior to installation of the damp course the initial moisture content of the test panels was established using both methods described above. Upon installation and activation of the Lectros system the moisture content of the test panels was monitored approximately every 14 days using the conductivity method and augmented by drying of drillings.

¹ Protimeter *SurveyMaster* Serial No. 7095-066 with spot-calibration performed prior to use.

3.2 The Test Wall

The test system was installed into the western wall of the *4 Yard Recreation Room* at the Old Adelaide Gaol (see Figure 1). The wall was found to be approximately 350mm thick and composed of clay bricks bonded with a lime mortar of variable strength. The wall exhibited varying concentrations of efflorescence. A representative sample of the efflorescence was analysed by X-Ray Diffraction – the semi-quantitative mineralogy of the sample follows.

Mineral Name	Composition	Relative abundance
Epsomite	MgSO ₄ .7H ₂ O	D
Gypsum	CaSO ₄ .2H ₂ O	A
Hexahydrate	MgSO ₄ .6H ₂ O	Tr-A
Calcite	CaCO ₃	Tr

Semi-quantitative Abbreviations

- D = Dominant. Used for the component apparently most abundant, regardless of its probable percentage level.
- SD = Sub-dominant. The next most abundant component(s) providing its percentage level is judged above about 20.
- A = Accessory. Components judged to be present between the levels of roughly 5 and 20%.
- Tr = Trace. Components judged to be below about 5%.

The analysis shows that the efflorescence is composed of considerable levels of aggressive magnesium salts as well as a significant amount of gypsum.

Drillings were taken at the mid-thickness of the wall to determine the proportion of salt present; the results of the analyses are given below.

Soluble Salts Content (at mid-thickness of wall)

Course Number	Panel LE (%)	Panel NT (%)
1	0.08	0.16
3	0.13	0.07
6	0.85	0.08
9	1.45	0.12
12	0.20	0.49

The results show a maximum salt concentration at *Course 9* on the *LE* panel which is at a height of 69 cm above ground level; this is considered typical for a wall affected by salt damp. The *NT* panel shows a lower concentration of salt, that generally increases with height to the highest test site (*NT-12*).

RESULTS

Introduction

To achieve consistent and reliable results the Protimeter survey results were used to provide a "Comparative Moisture Value", which gives a moisture content that can be used to compare the moisture at different locations. This method of measurement relies on a linear relationship between moisture content and conductivity. As well as being affected by the degree of moisture present, the conductivity reading may also be affected by the presence of soluble ions (dissolved salts), which will increase the conductivity giving the equivalent of an exaggerated moisture reading. This exaggerated comparative moisture value was viewed as a realistic weighting of the more aggressive salt-laden moisture. As the moisture level decreases the concentration of the dissolved salt increases – this will result in an increased weighting commensurate with its aggressive nature. When the moisture has been removed from the wall the salt will be immobilised within the wall and conductivity will decrease to near zero, which equates to a near zero moisture content.

Change in Moisture Content

By drying drillings collected from the mid-thickness of the test walls, the "Initial" (at 10 October 2002) and "Final" (at 6 March 2003) moisture content within the panels can be compared; these results are given below.

Test (Mortar Course) Level	Panel NT (wt%)		Panel LE (wt %)	
	Initial	Final	Initial	Final
1	9.2	8.9	5.8	0.9
3	8.4	8.2	4.9	0.5
6	8.2	7.9	4.2	0.6
9	7.2	5.6	2.5	0.7
12	3.6	2.9	0.1	0.3

Change in Moisture Content Over Time

To evaluate the drying rate and behaviour of the test panels throughout the test period, the absolute Comparative Moisture Values are presented graphically in the table below and Figures 2 and 3 attached; these figures display the Comparative Moisture Value (CMV) over the period of the investigation.

Comparative Moisture Values

Time* (days)	NT1	LE1	NT3	LE3	NT6	LE6	NT9	LE9	NT12	LE12
0	4.3	4.3	4.5	5.8	3.5	4.0	3.3	11.8	10.5	1.0
7	4.3	4.3	4.3	4.5	3.5	2.8	3.3	11.3	9.0	0.0
14	4.3	3.8	4.0	3.3	3.5	2.8	2.8	10.8	8.5	0.0
21	4.3	3.5	4.3	2.8	3.5	2.5	2.8	9.8	8.3	0.0
35	4.5	3.0	4.0	2.3	3.5	1.5	2.5	9.0	7.8	0.0
57	4.3	2.0	4.3	1.6	3.5	0.6	2.5	5.5	7.0	0.0
77	4.3	1.3	4.0	1.3	3.4	0.0	2.3	3.0	6.5	0.0
91	4.3	1.3	4.0	0.6	3.0	0.0	1.8	2.0	5.5	0.0
105	4.3	1.0	4.0	0.1	3.0	0.0	1.5	1.8	5.3	0.0
119	4.3	0.6	4.1	0.0	3.0	0.0	1.5	1.8	4.8	0.0

Notes: * Days since installation of Lectros System

The testing can also be assessed by comparing the change in the current CMV as a proportion of the initial CMV over time. This comparison for the NT and LE panels is presented in the table below and also graphically in Figures 4 and 5 attached.

Change in CMV Over Time Compared to Original Measurement

Time* (days)	NT1 (%)	LE1 (%)	NT3 (%)	LE3 (%)	NT6 (%)	LE6 (%)	NT9 (%)	LE9 (%)	NT12 (%)	LE12 (%)
7	0	0	-6	-22	0	-31	0	-4	-14	0**
14	0	-12	-11	-43	0	-31	-15	-9	-19	0
21	+6	-18	-6	-52	0	-38	-15	-17	-21	0
35	0	-29	-11	-61	0	-63	-23	-23	-26	0
57	0	-53	-11	-72	0	-84	-23	-53	-33	0
77	0	-71	-1	-78	-4	-100	-31	-74	-38	0
91	0	-71	-2	-89	-14	-100	-46	-83	-48	0
105	0	-76	-6	-98	-14	-100	-54	-85	-50	0
119	0	-85	-8	-100	-14	-100	-54	-81	-55	0

Notes: * Days since installation of Lectros System

** This test location was found to be "dry" at the start of the investigation.

6.0 DISCUSSION

6.1 Untreated Panel (NT)

The testing shows that the initial moisture content of most of the NT panel (sites NT-1 to NT-9) was relatively uniform with a Comparative Moisture Value (CMV) range of 3.3 to 5.0. At Course 12 (NT-12), the reading was found to be significantly higher with an initial CMV of 11.8; this higher reading suggests the influence of salt.

Reviewing the data collected throughout the test period shows that the reduction in CMV over time is dependent on its vertical location within the test panel. From Figure 2 it can be seen that NT-1 shows minimal variation (from 5.0 to 4.3), NT-9 showed slightly greater variation (from 4.0 to 1.5), while NT-12 showed significant reduction (from 11.8 to 4.8). This shows that the drying occurred from the "top down" and can be considered as the standard seasonal drying rate. The results also suggest that over a significant dry period, the bottom 50cm or so of the wall maintains at a relatively stable moisture content.

6.2 Lectros Treated Panel (LE)

The testing shows that the initial moisture content of the LE panel varied greatly with a Comparative Moisture Value (CMV) ranging from 1.0 (for LE-12) to 12.0 for (LE-9). The analysis by drying of drillings from LE-9 showed the initial moisture content to be relatively low at 2.4%; the high initial CMV is thought to be due to the relatively high proportion of soluble salts present at this site. The lower courses (LE-1 to LE-6) were considered more uniform and consistent with rising damp with a CMV ranging from 4.5 to 7.0 (approximately 2.5 to 5.0% moisture).

A review of the data collected throughout the test period shows that the reduction in CMV over time was significant for all sites within the test panel. The most dramatic reduction occurring at site LE-9, where the CMV was reduced from 11.3 to 1.8 over the period of the test. Test sites LE-1, LE-3, LE-6 and LE-12 can be considered “dry” while site LE-9 may have equilibrated at 1.8 due to the effect of the higher salt concentration. It is worth noting that the actual moisture content of LE-9 was determined to be 0.7% by the drying of drillings.

7.0 CONCLUSION

Despite the investigation being carried out over a drought period, the *NT* results suggest that the thickness of the wall has allowed the maintenance of a relatively stable moisture content in the untreated section of the wall.

Comparison of the drying characteristics of the *Lectros* test panel with the *Untreated* (NT) panel shows that the *Lectros* system has had a dramatic effect in reducing the moisture content of the wall (this can be seen clearly in Figure 3). By the end of the investigation the *Lectros* panel was considered to be in a “dry” state; this conclusion was confirmed by analysis of drillings from the mid-thickness of the wall. In comparison, the *Untreated* panel was found to still have a moisture content of 8% at a height of 46cm above ground level.



Plate 1: General view of Untreated (NT) panel. Note Lectros control unit below distribution board.

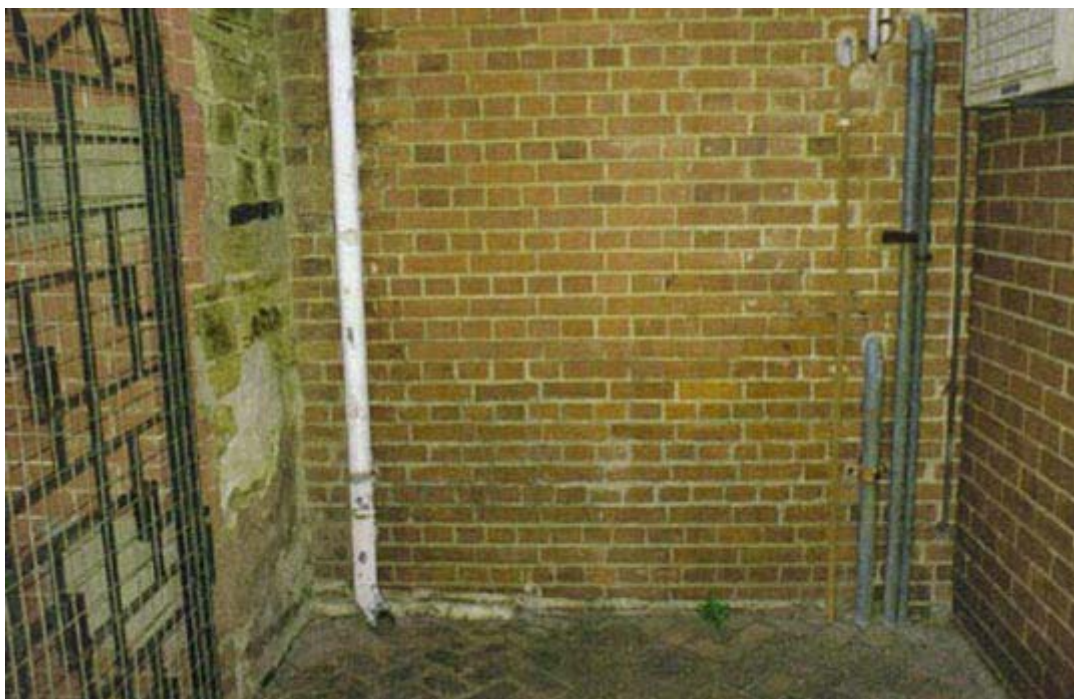


Plate 2: General view of Untreated (NT) panel, exterior face. Note salt attack to lower courses.

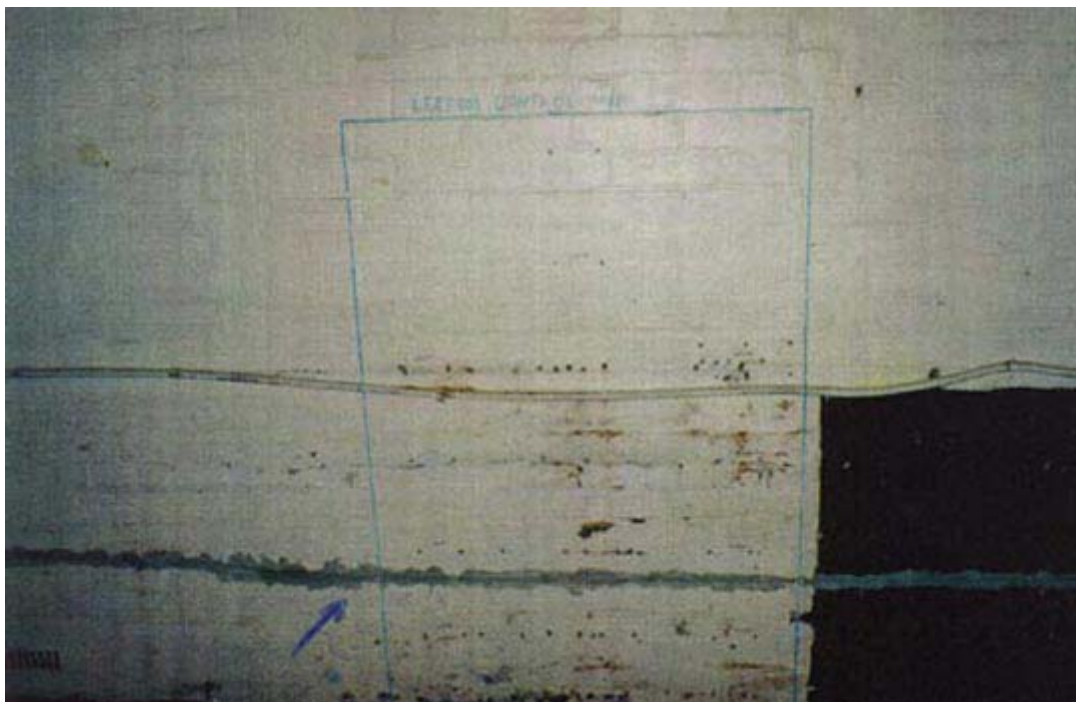


Plate 3: General view of Lectros (LE) panel, interior face. Note grey Lectros strip crossing test panel (arrowed).



Plate 4: General view of Lectros (LE) panel, exterior face. Note salt attack at lower level and location of downpipe.



Plate 5: Close up view of typical pin configuration.

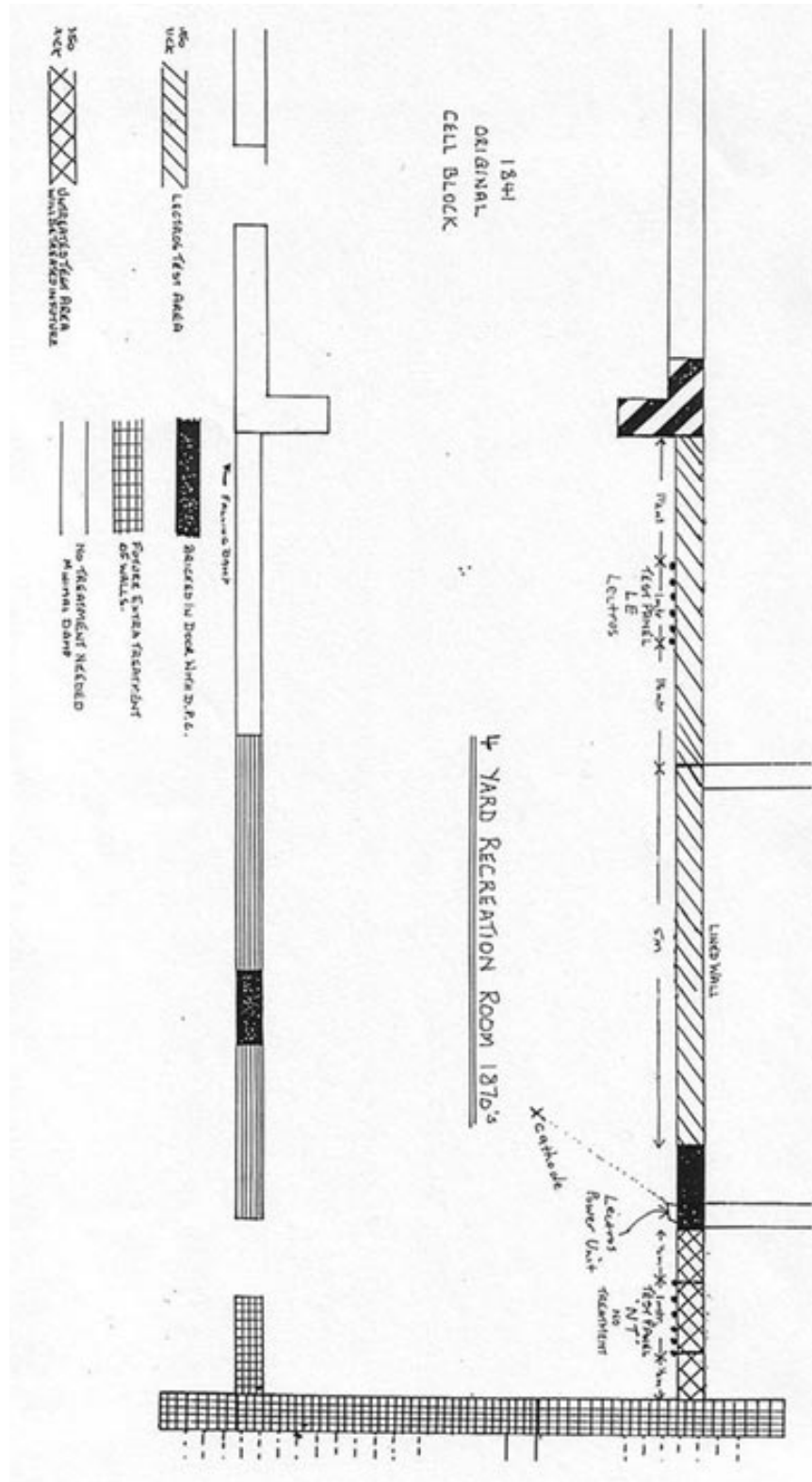


Figure 1: Plan showing location of test panels.

Not Treated (NT) Test Panel - Moisture Survey

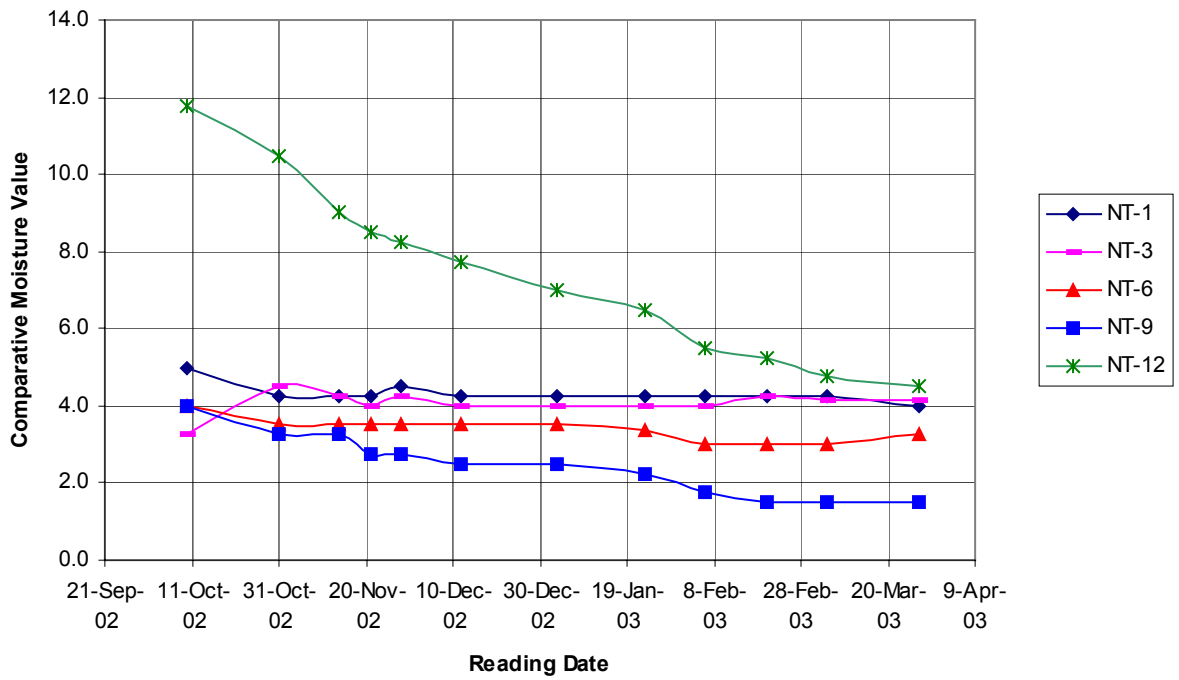


Figure 2: Chart showing Comparative Moisture Value over time for Untreated (NT) panel.

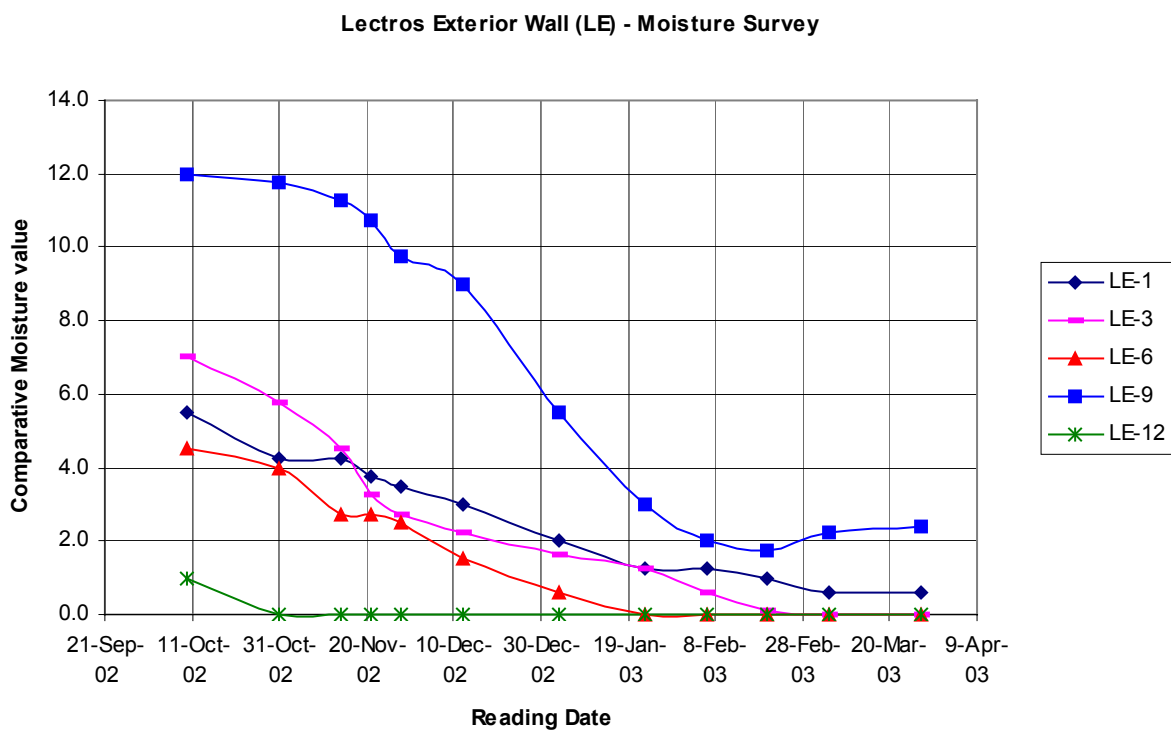


Figure 3: Chart showing Comparative Moisture Value over time for Lectros (LE) panel

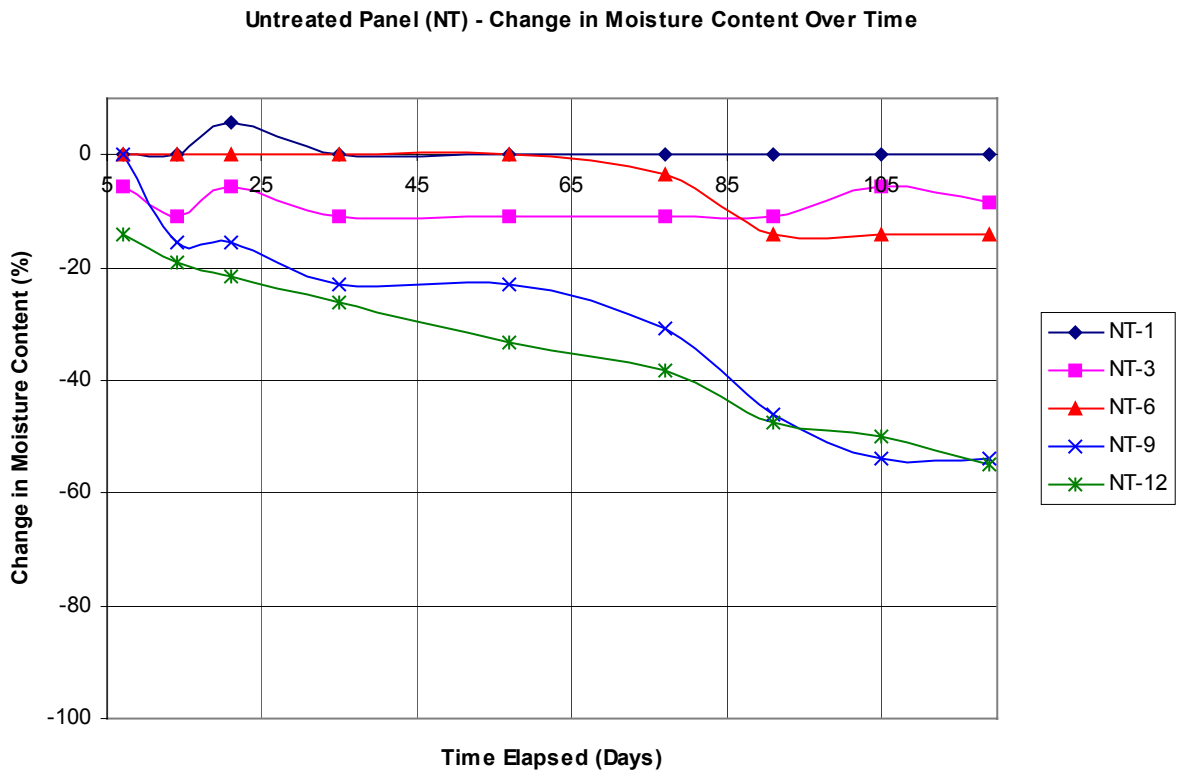


Figure 4: Chart showing change in Comparative Moisture Value over time as a percentage of Initial reading for untreated (NT) panel.

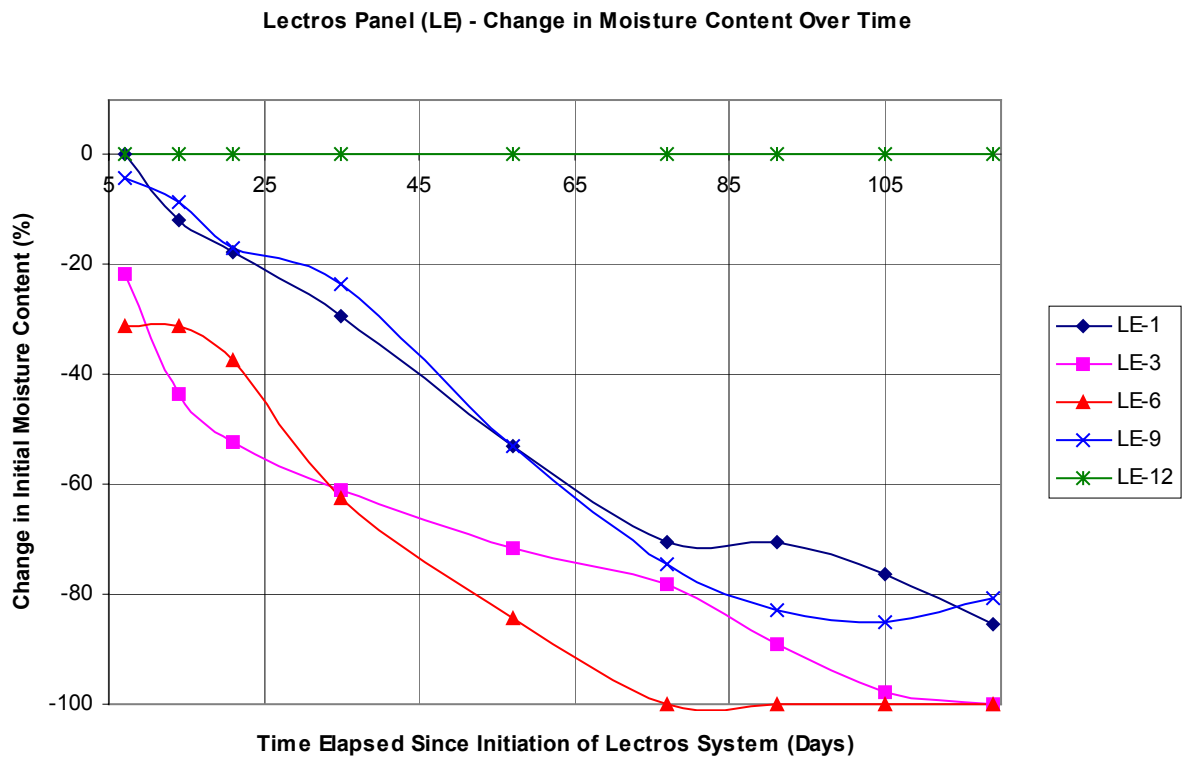


Figure 5: Chart showing change in Comparative Moisture Value over time as a percentage of Initial reading for untreated (NT) panel.