6 Conclusions

6.1 Questionnaire study

The following bullet points summarise the conclusions from the questionnaire study:

Frequently encountered problems

- There was no consensus of opinion as to whether damp problems have recently become more or less frequent. Most commonly, practitioners thought there had been little change in the frequency of damp problems.
- Damp problems were particularly common where granite walls were ‘plastered on the hard’, and were fairly common where there were solid granite masonry walls with lath and plaster.
- More experienced practitioners felt that prevailing northerly and north-easterly winds, in combination with low levels of sun exposure contributed to dampness problems.
- The most common causes of moisture penetration were failures at roof level or of water shedding details, such as downpipes, gutters, skews, tilted fillets and slates.
- Defects in skews or tilted fillets were commonly encountered.
- The most common cause of condensation problems was lack of ventilation (in rooms and voids) and related problems including condensation from gas fires, blocked off fireplaces and blocked air vents.
- Practitioners often noted problems caused by water vapour produced by Calor gas heaters.

Flues

- Practitioners did not consider change in use from open to gas fires to be a significant problem.
- Excluding commonly encountered physical defects, uncapped, disused chimneys were thought to be the main problem with respect to moisture penetration.
- Inadequate ventilation of capped flues was often cited as a major cause of condensation problems.
- Damage to bedding mortar by acidic flue gases was not thought to be a major problem in relation to dampness.
- Lack of flue liners was thought to be a fairly common cause of condensation problems and in such a case bedding mortar would also be vulnerable to decay.

Pointing and bedding mortar

- Cracked pointing was a commonly encountered defect leading to water ingress
- Many practitioners felt that mortars are often incorrectly specified and too hard - being likely to lead to formation of cracks in pointing.
- Problems related to bedding mortar were less commonly observed, although its decay was mentioned as a contributory factor.
- Water penetration through undamaged pointing was thought to be a negligible problem.
- Repointing was often reported as being a successful treatment, although a significant minority of practitioners suggested that damp problems occasionally occurred following repointing.
- Replacing excessively hard pointing was reported to be a successful remedy for water penetration in only about half the instances where it was tried.
- It is notable that more experienced practitioners reported lesser degrees of success with repointing to cure damp problems. This suggests that there may be a problem related to repointing - perhaps in the mortar mix, methods used or in the raking out process.

Moisture bridging

- Damp problems often arose from moisture bridging across debris build up in voids and cavities. Debris can be dislodged by vibration during raking out of joints, and this was reported to occur more often with mechanical tools than when hand raking was used.
- Moisture bridging across dooks was also commonly reported.

Detailing

- On the external wall surface, removal or loss of harling can cause problems on walls that were not designed to cope with direct rainwater.

- Problems attributable to poor façade detailing were not common, but were occasionally encountered.

Water repellents

- With few exceptions, water repellents were not useful in preventing or reducing damp problems. Most moisture gets in through cracks and other defects, which water repellents cannot seal. Once inside a wall the water repellent may inhibit drying out, exacerbating the problem.

6.2 Survey of granite gables

The following points were the main conclusions of this survey:

- Wind speed was the most important factor controlling wetting of vertical walls
- Higher wind speeds resulted in greater degrees, and more rapid, wetting.
- The duration of rainfall events was also influential with respect to wetting of vertical walls, but of lesser importance than wind speed.
- The direction of wind driven rain had some influence on the degree and pattern of wetting of vertical walls, but even façades at 180° to wind direction could be significantly wetted at higher wind speeds.
- Projecting elements of façades were the first wetted areas - e.g. chimneys that project above roof level.
- Wall top, corners and edges (areas where wind speed changes) were wetted first, other areas of façades being mainly wetted by rainwater run-off, except at higher wind speeds when rain drops could impact directly on the façade.
- The presence of features on gables (e.g. copings, strings and cills) had no obvious impact of the degree of wetting of the wall, although these features could influence the location of wetting.
- Open sub-vertical joints in copings can act as channels, funnelling rainwater run-off down the façade.
- Dry patches on generally wet gables are often located at active fireplaces, flues and, in some cases, room spaces.
- Pointing can sometimes be in a very poor state of repair. In some cases, poor mortar condition may be caused by escape of acidic flue gases.
- Even where pointing is not actually missing or obviously cracked, hairline cracks (within the mortar and at the stone-mortar interface) can retain moisture for substantial periods of time indicating that water could be channelled into the façade by such cracks.
- Ribbon (or tuck) pointing is a deprecated practice as it slows run-off of rainwater over the façade and projecting horizontal surface could channel water into the wall core.

6.3 Porosity of pointing and bedding mortars

The porosity and pore size distribution of pointing mortars can vary significantly depending in the composition of the mix. Higher porosity and permeability are desirable features of pointing and bedding mortars as they allow evaporation of moisture that has entered the wall core. However, harder mortar mixes are prone to cracking and have poor adhesion to the stone. Permeability of walls caused by cracking of mortar and poor bonding will channel rainwater run-off into the wall core leading to damp problems. Pointing mortars can also be too permeable, allowing more water to get into the wall than can easily be lost by evaporation processes.

6.4 Previous studies

Previous studies demonstrated that Type S hydrated lime mixes significantly reduced the penetration of dampness and the potential for water leakage through masonry walls. In comparison to masonry cements, lime-cements performed as follows:

- **Time to first dampness was longer**: Walls constructed with cement-lime mortars took 35% to 250% longer to show signs of dampness.
- **First visible water took longer to appear through walls**: It took approximately 350% to 575% longer for cement-lime mortars to show signs of visible water.

- **Percent dampness on rear of walls was reduced**: Cement-lime walls showed 5% to 40% less area of dampness than seen with masonry cement mortars.
- **Leakage through walls was reduced:** The total amount of water leakage collected per wall panel during the test for masonry cement assemblages was 3.5 to 15.3 times the amount for cement-lime mortars.

(National Lime Association Building Lime Group, October 2000)

Leakage can be caused by:

- poor workmanship,
- inadequate design details, or,
- inadequate/incompatible materials.

In the above studies, workmanship and design details were all controlled, leaving problems with the materials as the likely cause of water leakage. In the studies authors' opinion, low bond strength between mortar and masonry was the cause of poor performance by non-lime mortars. The authors (National Lime Association Building Lime Group, 2000) attributed the superior performance of Type S hydrated lime mixes to the following:

1. High water retention due to the high surface area and micro-fineness of Type S hydrated lime. This results in increased water holding capacity. Water is the lubricant of mortars. The more water a mortar can hold, and still be workable, the greater its plasticity, board life, and bond strength.
2. Type S hydrated lime increases the extent of bonding because of its micro-fineness (50% less than one micron in size). These small lime particles will penetrate deeply into brick pores.
3. Lime can reconstitute itself through recarbonation (referred to as autogenous healing). Carbon dioxide from the atmosphere combines with lime to form new calcium carbonate. The minute crystals formed tend to plug the voids or any hairline cracks that may have been developed. Two studies have demonstrated that walls containing lime tend to resist moisture penetration better after six months of outdoor curing.
4. Type S hydrated lime in mortar creates fewer air voids. This makes the mortar less permeable to wind driven rain.

However, although lime-based mortars perform well with respect to rainwater penetration, other workers in this field have recommended cement : sand mixes (e.g. 1:9). Such mixes are recommended as being low in free lime. Lime will react with sulphates to form gypsum which can cause decay of granite. There is however some question as to whether the vapour permeability of such mixes is suitable for use on granite structures where all moisture movement must be accommodated by the mortar.

Appendix 1: Dampness in buildings questionnaire

1. Are you, or have you been, involved in assessing or treating damp problems in buildings?[1]

Yes ☐ No ☐

2. How many properties with damp problems have you been involved with in the previous five years?[2]

None ☐ 1-5 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ 21-25 ☐ >25 ☐

3. Do you think that damp problems in housing have become more or less frequent in recent years?[3]

No/little change ☐ Less frequent ☐ More frequent ☐ Don't know ☐

4. In what % of damp affected properties would you estimate that problems are due to the following? (circle most appropriate answer for each)

Problem	*Estimated percentage*										
Both condensation & moisture penetration[4]	0	10	20	30	40	50	60	70	80	90	100
Condensation[5]	0	10	20	30	40	50	60	70	80	90	100
Moisture penetration[6]	0	10	20	30	40	50	60	70	80	90	100
Unknown cause[7]	0	10	20	30	40	50	60	70	80	90	100

5. Are buildings of a particular type more susceptible to damp problems?
(circle most appropriate answer for each)

Building type	*Never occurs*						*Very common*	*Don't know*
Solid masonry wall with lath & plaster[8]	1	2	3	4	5	6	7	☐
Solid masonry wall plastered on the hard[9]	1	2	3	4	5	6	7	☐
Traditional cavity wall[10]	1	2	3	4	5	6	7	☐
Cavity timber frame with external cladding[11]	1	2	3	4	5	6	7	☐

6. Are damp problems more frequent on external walls with a particular facing direction?[12]

Yes ☐ No ☐ Don't know ☐

If YES, which facing direction/s are most commonly associated with damp?[13]
(tick as many boxes as necessary)

North-west ☐ North ☐ North-east ☐

West ☐ East ☐

South-west ☐ South ☐ South-east ☐

and, why do you think this occurs : ______________________________

______________________________ [14]

7. To what extent are the following factors responsible for MOISTURE PENETRATION problems in buildings? (circle most appropriate answer for each)

Factor	*Never occurs*						*Very common*	*Don't know*
Cracked or lost external pointing [15]	1	2	3	4	5	6	7	☐
Moisture permeating through undamaged pointing [16]	1	2	3	4	5	6	7	☐
Moisture permeating through stone [17]	1	2	3	4	5	6	7	☐
Moisture penetration due to decay of bedding mortar [18]	1	2	3	4	5	6	7	☐
Rain water penetration down uncapped chimneys [19]	1	2	3	4	5	6	7	☐
Improper grading of runs on gutters [20]	1	2	3	4	5	6	7	☐
Overflows from blocked/damaged downpipes or gutters [21]	1	2	3	4	5	6	7	☐
Failed skews or tilted fillets [22]	1	2	3	4	5	6	7	☐
Lost or damaged slates/tiles [23]	1	2	3	4	5	6	7	☐
Removal/loss of harling [24]	1	2	3	4	5	6	7	☐
Other [25] (please specify)... [26]	1	2	3	4	5	6	7	

Comments: ____

____ [27]

8. To what extent are the following factors responsible for CONDENSATION problems in buildings? (circle most appropriate answer for each)

Factor	*Never occurs*						*Very common*	*Don't know*
Inadequate ventilation of rooms [28]	1	2	3	4	5	6	7	☐
Excessively hard or impermeable pointing [29]	1	2	3	4	5	6	7	☐
Lack of air circulation in void space or cavity wall [30]	1	2	3	4	5	6	7	☐
Inadequate ventilation of capped flues [31]	1	2	3	4	5	6	7	☐
Inadequate ventilation of blocked off fireplaces [32]	1	2	3	4	5	6	7	☐
Lack of flue liners [33]	1	2	3	4	5	6	7	☐
Condensation from gas fire [34]	1	2	3	4	5	6	7	☐
Application of water repellent to external walls [35]	1	2	3	4	5	6	7	☐
Harling external walls [36]	1	2	3	4	5	6	7	☐
Painting external walls [37]	1	2	3	4	5	6	7	☐
Other [38] (please specify)... [39]	1	2	3	4	5	6	7	

Comments: ____

____ [40]

9. How often have you found the following to be involved in damp problems?
(circle most appropriate answer for each)

Cause	*Never observed*						*Very common*
Lack of damp-proof course [41]	1	2	3	4	5	6	7
External soil level higher than damp-proof course [42]	1	2	3	4	5	6	7
Occupants blocking air vents [43]	1	2	3	4	5	6	7
Bridging debris in wall voids or cavity [44]	1	2	3	4	5	6	7
Moisture bridging across wall dooks [45]	1	2	3	4	5	6	7
Flue liners not properly installed [46]	1	2	3	4	5	6	7
Change in use from open fire to gas fire [47]	1	2	3	4	5	6	7
Poorly fitted windows/doors [48]	1	2	3	4	5	6	7
Poor façade detailing to control rainwater run-off [49]	1	2	3	4	5	6	7

- which detailing?.. [50]

Other [51] (please specify).. [52]	1	2	3	4	5	6	7

Comments: ____

____ [53]

10. In GRANITE buildings, do you think that some damp problems may be related to the following characteristics of mortar or pointing? (circle most appropriate answer for each)

Cause	*Definitely not*						*Certainly occurs*
Does much moisture penetration occur through damaged pointing? [54]	1	2	3	4	5	6	7
Are many damp problems solved by repointing? [55]	1	2	3	4	5	6	7
or, have you found that damp problems begin after repointing? [56]	1	2	3	4	5	6	7
Does mechanical raking out cause debris build-up in voids/cavities? [57]	1	2	3	4	5	6	7
Does raking out by hand cause debris build-up in voids/cavities? [58]	1	2	3	4	5	6	7
Do you think mortar mixes are often incorrectly specified? [59]	1	2	3	4	5	6	7
Do you think repointing mortar mixes are often too hard? [60]	1	2	3	4	5	6	7
Does decay of bedding mortar lead to moisture penetration? [61]	1	2	3	4	5	6	7
Have you noticed that bedding mortar is damaged by flue gases? [62]	1	2	3	4	5	6	7

Comments: ____

____ [63]

11. Which of the following methods have you experience of in treating damp problems, and how successful was the treatment?

Method	*Have you used it? (tick for YES)*	*..... and did it work?* Yes	*No*	*Temporarily*	*Partially*	*Don't know*
Install barrier treatments for rising damp [64]	☐	☐	☐	☐	☐	☐
Electro-osmosis process for rising damp [65]	☐	☐	☐	☐	☐	☐
Improve drainage around wall base [66]	☐	☐	☐	☐	☐	☐
Capping flues [67]	☐	☐	☐	☐	☐	☐
Uncapping flues [68]	☐	☐	☐	☐	☐	☐
Improving ventilation of rooms [69]	☐	☐	☐	☐	☐	☐
Replacing decayed pointing [70]	☐	☐	☐	☐	☐	☐
Replacing impermeable/hard pointing [71]	☐	☐	☐	☐	☐	☐
Replacing permeable/soft pointing [72]	☐	☐	☐	☐	☐	☐
Clearing our debris from void/cavity [73]	☐	☐	☐	☐	☐	☐
Re-grouting bedding mortar in wall [74]	☐	☐	☐	☐	☐	☐
Taking down and rebuilding a wall [75]	☐	☐	☐	☐	☐	☐
Apply water repellent coating [76]	☐	☐	☐	☐	☐	☐
Install/replace flue liners [77]	☐	☐	☐	☐	☐	☐
Correct defects in slates/tiling [78]	☐	☐	☐	☐	☐	☐
Correct defects in tilted fillet/skews [79]	☐	☐	☐	☐	☐	☐
Correct defects in gutters/downpipes [80]	☐	☐	☐	☐	☐	☐
Harling the exterior wall [81]	☐	☐	☐	☐	☐	☐
Other [82] (please specify)... [83]		☐	☐	☐	☐	☐

Comments: ____

____ [84]

12. Any other comments? [85]

____

____

____

____

____

____

____

Would you be willing to take part in a follow-up interview? [86] Yes ☐ No ☐

If yes, then please provide contact details:

Name ....

Address ....

....

....

....

Tel: ....

Fax: ....

E-mail: ....

Appendix 2: Summary of ASTM Test Method E 514
Water penetration and leakage through masonry

(Adapted from: National Lime Association Building Lime Group, October 2000. www.lime.org/)

Scope

ASTM test method E 514 describes a procedure for determining the resistance to water penetration and leakage through masonry subjected to wind driven rain.

Apparatus

Sample panels are constructed in a test chamber. Attached to the chamber is an air line to provide wind pressure, a water line for water spraying the masonry test sample, flashing to collect water penetrating through the masonry specimen, and a drain pipe for overflow water.

Test specimens

Masonry and/or mortar being tested shall be representative of construction and materials under study. Specimen size shall be a minimum of 1.08 m^2 (12 ft^2). After construction, the specimens shall be cured for a minimum of 7 days wrapped in impervious plastic and an additional 7 days minimum in laboratory air. Curing of specimens is to be done in laboratory air temperature maintained at 24 ± 8 ºC (75 ± 15 F). The relative humidity shall be not less than 30% and not more than 80%. Each test shall consist of at least 3 specimens.

Test chamber

The test chamber opening shall be a minimum of 1.08 m^2 (12ft^2). The edges of the chamber shall be lined with a closed-cell type gasket material. An observation port shall be provided on the face of the chamber. A 19 mm. (¾ in.) diameter spray pipe with single 1.0 mm (0.04 in.) diameter holes spaced 25.0 mm (1 in.) apart provide the water spray. The water spray cannot impinge on the specimen more than 75.0 mm (3 in.) below the top of the test chamber. An air line with a manometer is attached to the test chamber.

Procedure

Clamp the pressure chamber firmly to the test specimen so that there is no water or pressure leak through the gasket. Apply a 3/8-in. layer of mortar parging to all exposed surfaces of the test specimen, except the backside of the wall and the area enclosed by the pressure chamber. The water flow rate should be 138 L/m2(3.4 gal/ft^2). Air pressure should be simultaneously adjusted to 500 Pa (10 lb/ft^2). The test conditions are maintained for not less than 4 hours.

Data collection

During the testing period, observations are made at 30 minute intervals of the following:
1. Time of first dampness on back of specimen.
2. Time of first visible water on the back of the specimen.
3. Total water collected and the percentage of damp area.