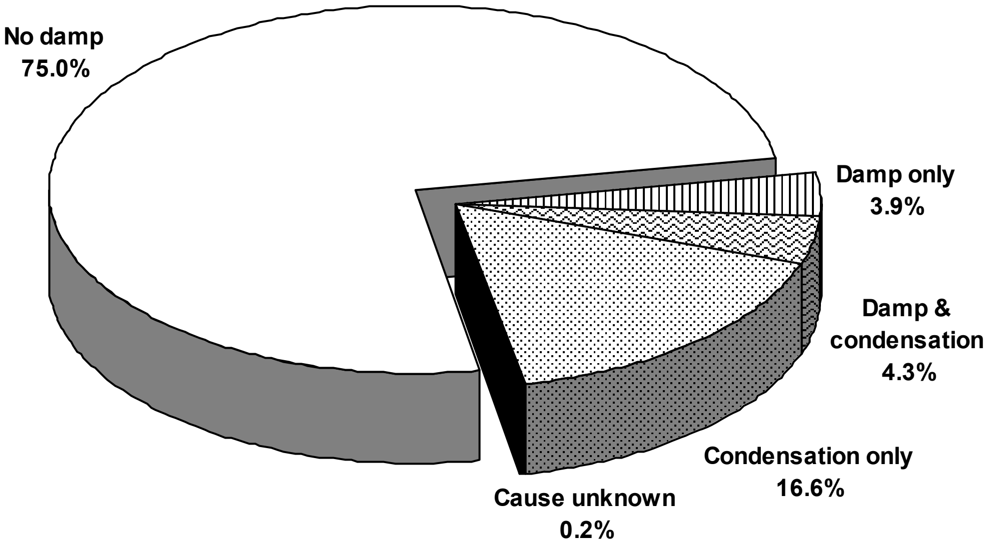
4 Field studies

Twelve varied properties with reported damp problems were examined. This included examination of the exterior from street level for any obvious defects (e.g. roofing, pointing, gutters, downpipe defects, etc) and examination of the interior to determine the areas affected by dampness. Factors that could be contributing to dampness problems were noted. Records of previous refurbishment or remedial treatments to the buildings were examined for evidence of previous interventions and to determine the extent of current and previous damp problems.

Problems with dampness in dwellings are common within Aberdeen, and within the UK housing stock as a whole. The Scottish House Condition Survey of 1996[1] found that 25% of all dwelling in the UK suffered from dampness problems, caused either by condensation or penetrating damp (Figure 4.1). These figures were essentially unchanged since the results of a similar survey in 1991.

Figure 4.1 Proportions of dwellings affected by dampness and/or condensation in the UK in 1996 (data source: Scottish House Condition Survey[1]).



[1] http://www.scot-homes.gov.uk/research/

4.1 Field visits

4.1.1 Case study one

This granite tenement block was constructed around 1874. Damp problems were occurring mainly on the gable wall at first floor level, which is south-east facing (Plates 4.1 & 4.2).

Externally, the granite rubble gable wall has been repointed flush with a small overlap of pointing onto the granite (Plate 2.9). The quality of granite on the gable wall was variable. There were some good quality grey granite blocks but many other blocks were of relatively porous, weathered pink or pale orange coloured granite. On some of the more porous granite blocks decay around the margins adjacent to the cement pointing implies that the mix was too hard for some of the poorer quality granite blocks (Plate 2.10). All chimneys were capped and ventilated (with “elephants feet” or gas fire ventilation).

This three storey property faces onto the street. Damp problems occurred at the south-east end of the tenement adjacent to the gable end. The damp problem was in the sitting room at first floor level. There are two external walls to the room. No damp problems were experienced on the north-east facing wall which faces onto the street. Damp patches were found only on the south-east facing wall which contains flues and has no window (Plates 4.3 & 4.4). Dampness was not restricted to the region around the flue from this room. The location of other flues in the wall is not known. The dampness took the form of patches of various sizes (from about 10cm to 50cm diameter) on the gable end wall, being visible as dark areas on the wallpaper, which was detached in some areas. Damp was also present in a narrow cupboard on the gable end wall to the right. The bathroom and kitchen also have an external wall on the south-east gable. No damp problems were evident in either room. The bathroom has a small extractor fan that vents air from the bathroom, passing through the kitchen and exiting onto the rear garden wall on the south side. The shower normally has a plastic lid on the cubicle. There was no damp in the space above this cubicle (about 1m square) although that wall adjoins the corner of the sitting room where damp was visible in the top right corner. No damp problems were reported or observed elsewhere in the flat and no other flats in this block are known to have problems.

The organising agent was Cattanach & Robertson, Architects (no longer practicing). Grant was approved in May 1998 and paid (including repointing) in March 1989. The current resident has been in the flat for 60 years or more and was never aware of any damp problems until repairs were carried out in 1989. These included repointing and other repairs. At this time there was a switch from using a coal fire to a gas fire.

The source of damp could not be determined by initial visual inspection. On tapping the sitting room wall surface it was evident that many damp patches coincided with solid areas, dry areas sounding hollow. It was reported that five years previously the wall had been opened up and bridging rubble removed from the cavity.

Since initial inspection the internal wall has been taken down and rebuilt. The area affected by damp was inspected during the taking down process. It was observed that there was only few centimetres gap between the external wall and lath & plaster (Plates 4.5 & 4.6). Bedding mortar was badly decayed and this debris formed much of the fill that was bridging the void. The narrow void space was commonly blocked with debris, which filled a number of areas, including those affected by dampness. In the rebuilding process, timber safe lintels over the alcoves (which were badly affected by damp), were replaced with concrete with lead caps. A breathable membrane was installed behind the newly reconstructed internal wall. This should prevent damp from coming through as before although it does not solve the problem of the source of the damp.

Plate 4.1 Case study one.

Plate 4.2 Gable of Case study one.

Plate 4.3 Dampness on internal gable wall.

Plate 4.4 Dampness on internal gable wall.

Plate 4.5 Stripping internal wall.

Plate 4.6 Stripping internal wall. Wall and timber safe lintel above alcove.

4.1.2 Case study two

The block is a four storey tenement facing north-east onto the road, in ashlar granite with no exposed gables. The ground floor is occupied by shops. Flues from fire places in the front flats come up through the front wall to chimneys fronting onto the road. Flues in the front (affected) gable appeared to be uncapped. Most fireplaces were blocked; some had no ventilation of the flues, others had small vents.

Examination of the front of the building shows two areas of rainwater run-off over the face of the building (Plates 4.7 & 4.8) starting from blind ends of guttering at 3rd floor level. The rainwater gutter at 3rd floor level was (at the time of inspection) not properly graded to run towards the outlet. This cannot be the source of damp penetration in the 3rd floor since that dampness begins at roof level, one storey above the external gutters. The run-off over the facade could however be a contributory factor to internal dampness observed at 1st and 2nd storey levels.

Dampness was entering at roof level on the upper storey on the left (north-west) side flats. The plaster on the ceiling of the 3rd floor (top) flat was bossed and dampness was present in the walls of this flat and flats below down to the 1st floor. There was also a small area of damp in the front right corner of the topmost of the right side flats. Water penetration through the roof had been reported previously and this problem had been fixed. There was evidence in the top left flat of an area of dampness at ceiling level which was likely to be caused by water penetration through the roof.

Grant was approved in December 1993 and interim payment (including repointing) made in September 1994.

Most water penetration is believed to be coming from damaged skews in the front chimney. However, poorly maintained guttering may be contributing to dampness at lower levels.

Figure 4.2 Locations of internal dampness at case study two.

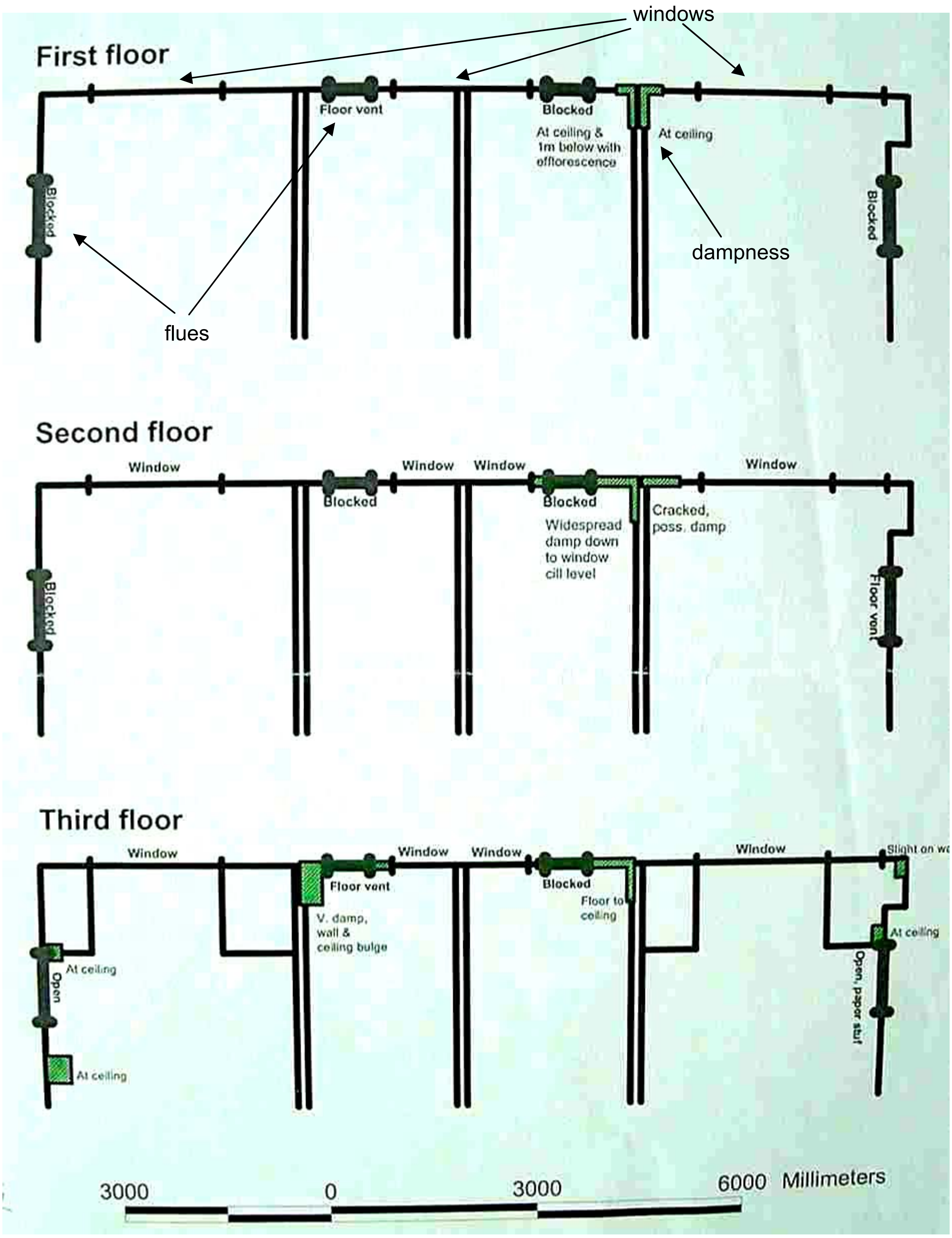


Plate 4.7 Front facade of case study two showing green algal growth on area affected by rainwater run-off.

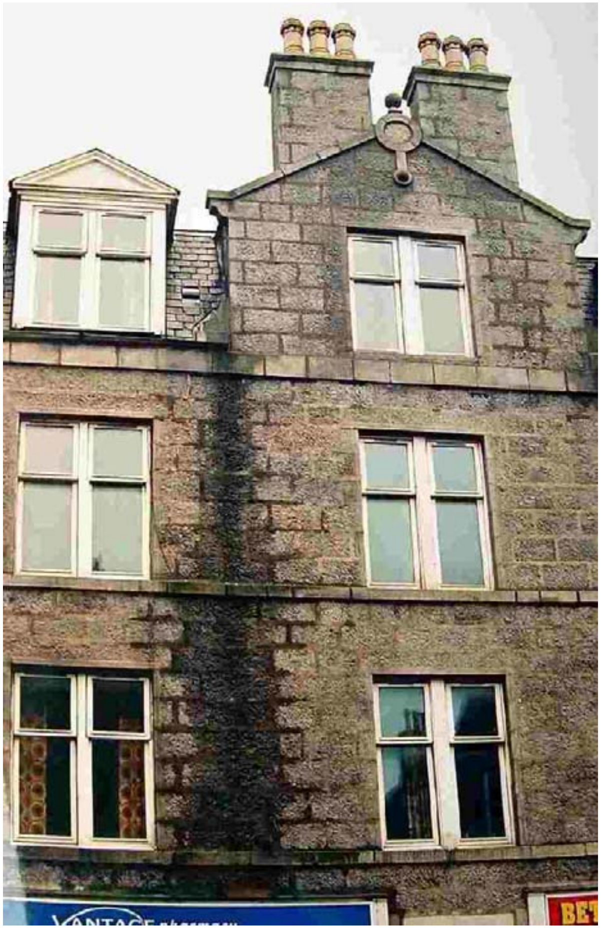


Plate 4.8 Front facade after a period of rain showing degree of wetting around area affected by rainwater run-off.

Plate 4.9 Flues are lined internally as can be seen in this view up a chimney.

Plate 4.10 Detail at 3rd floor level shows leadwork and green algae on stone indicating that some run-off comes from roof level.

4.1.3 Case study three

Date of inspections
Initial inspection 3rd October 2000. Revisited 26th February 2003

Description of property
This granite tenement, constructed in 1890, is situated at a corner. The main damp problem affects the stairwell at the rear of the property. The stairwell projects into the garden area. Two sides are of brick construction with a dry dash finish; the third side (north-facing) is constructed of granite. This side is most affected by dampness. The walls in the interior are plastered on the hard - finished with plaster applied directly on the inside face of the granite and brick wall.

Examining the exterior of the stair tower from ground level in the back garden it was apparent that the dry dashed walls were in good condition. Pointing on the granite wall on the north side (where dampness was located internally) appeared to be in sound condition. Green algal and moss growth was apparent on this wall, extending downwards from close to the roof level and in approximate line with the exit of a downpipe and overflow from the parapet gutter at the roof of the stair tower (Plates 4.11 & 4.12).

The owner of the top left flat informed us that during wet weather, water gushed from the overflow above the downpipe at roof level. The overflow and drainpipe could be observed from his kitchen window. It was not raining at the time and it could not be determined whether the downpipe was actually blocked.

The shop at the ground floor appeared to have reported damp problems at some time in the past. The current owner was not aware of any problems (except for a dripping overflow from the second floor left flat) and inspection of the shop revealed no obvious damp problems.

Location and description of damp
Dampness, efflorescence and bossing can be seen on the interior of the granite wall in the stairwell (Plate 4.15). The dampness is worst at roof level and decreases downwards to the first half landing. The dampness described in the previous report (from 1996) was similar to that observed during the current inspection. Additionally, there was a minor amount of dampness on the south side of the stairwell near roof level (this was not noted in the report from 1996 and may have occurred since that time). No dampness was present internally to the third floor flat right and no previous problems were known from this flat. The top left flat (fourth floor) had evidence of a previous damp problem above the kitchen window that faces out onto the external surface of the stair tower.

Duration of damp
Damp problems in the stairwell appear to date from some time after mutual repair works in 1992, but before 1996 when a report on the problem was commissioned. There was no evidence that damp was a current problem at the window lintel in the top left flat.

Information on previous interventions
Grant was approved in June 1991, first instalment in March 1992 and work (including repointing) completed in July 1992.

(Ref. 1840/AC/JB) Letter of 22nd August 1996 from Allan Cumming Architects to Murray Montgomery Partnership.
This letter enclosed a report on the current defects within the property. It notes that mutual repair works including reslating, repointing and leadwork were completed in July 1992. The exterior face of the granite was picked and repointed in “what appears to be” 1:3 sand-cement mix. This report suggests that damp problems in the stairwell are likely to be related to disintegration of the lime mortar bedding, and highlighted by the use of emulsion paint.

(Ref. 1840/AC/SB) Letter of 18th November 1996 from Allan Cumming Architects to Murray Montgomery Partnership.
The roof area of the property was inspected from scaffolding. Slating, leadwork, cement haunchings, skews and pointing were all found to be in good order. Parapet gutters had some build up of debris that required to be cleaned out, but this was not thought to be the source of the damp problem. Flue

caps were removed from chimneys above the top left flat and the adjacent wall to the stair (there are chimney flues internal to the stair tower on the north side) to increase ventilation.

A problem with water penetration at the kitchen window lintel in the top left flat was considered likely to be due to flaws in overlying chimney flue liners and/or deterioration of mortar beds. Recommended remedies included taking down the chimney and blocking flues, refitting ventilator caps and water repellent coating for the external granite wall.

On the stairwell, it was noted that repointing had failed to resolve the problem with water penetration. Suggested remedial action included dry dashing the affected side of the stair tower or applying a water repellent coating.

Interventions or alteration to building prior to appearance of damp

Mutual repair works including reslating, repointing and leadwork were completed in July 1992. The first report of dampness was by the occupant in the top floor right on 9th October 1996, referring to dampness in the staircase. The occupant advised that the stair was damp in 1981 [should this be 1991?] prior to repair works but was of the view that it was much worse in October of 1996.

Factors relating to possible causes of damp problems

It appears likely that the dampness and decay in the stairwell are due to water leaking into the wall from roof level due to a blocked parapet gutter.

Visit during February 2003

Stairwells, which were plastered on the hard have been stripped on the north side back to granite and brick (Plate 4.16). The external wall here is pointed, not harled (as the rest of the external stairwell is). These areas were previously affected by bad blistering due to water penetration. The ceramic tiles have not been removed as there was no evidence of any loosening suggesting water damage behind.

Plaster has been stripped off the roof of the stairwell revealing wet wood (Plate 4.18), especially on a joist at the base of a chimney (see later) which will have to be removed.

The stairwell will be replastered on the hard, but with ‘tanking’ behind. This will be in the form of a water repellent plaster on expert recommendation.

All chimneys have elephants feet caps. The chimney was recently (Feb 2003) repointed. It was previously pointed in 1:3 cement:sand (according to specifications). Now it is 1:1:6. Slates and leadwork are in good condition. Overflow from parapet gutter is open, downpipe from parapet drain was blocked (only about 2 inch diameter) and may be cracked (Plate 4.13 & 4.14). It will be replaced with a 3 inch outlet. Debris build up in parapet included remains of seagull nest. It is not cleat how water was getting in to the stairwell as the parapet leadwork seems to be in good condition. The area around the adjacent chimney (where most water seems to have been getting in) will be opened up for inspection.

Plate 4.11 Rear of case study three. Dampness affects the internal walls of the stairwell on the return to the left of the harled wall.

Plate 4.12 Detail of area shown in Plate 4.11.

Plate 4.13 External detail of parapet gutter overflow after unblocking (Feb 2003).

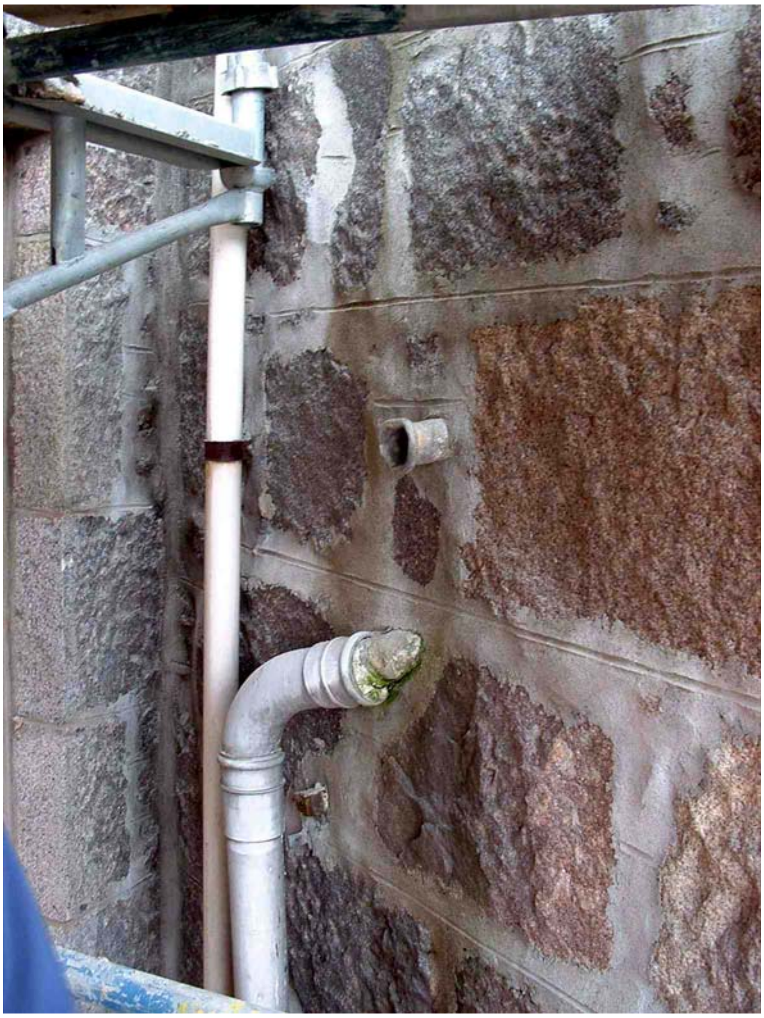
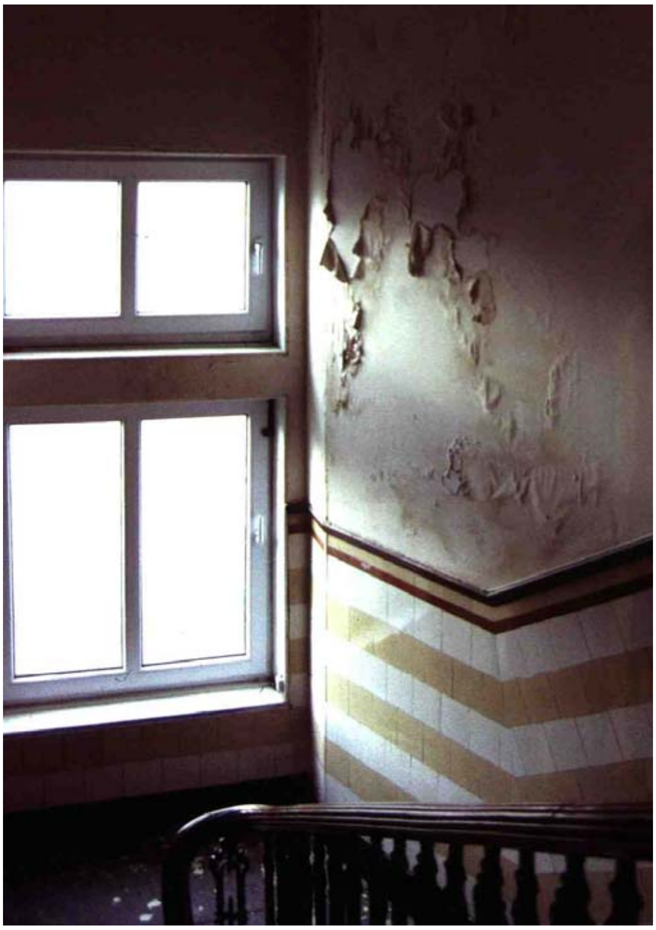


Plate 4.14 Parapet gutter and overflow after unblocking (Feb 2003).

Plate 4.15 Internal walls of stairwell. Plastered on the hard and affected by dampness, with bossing and peeling of surface.



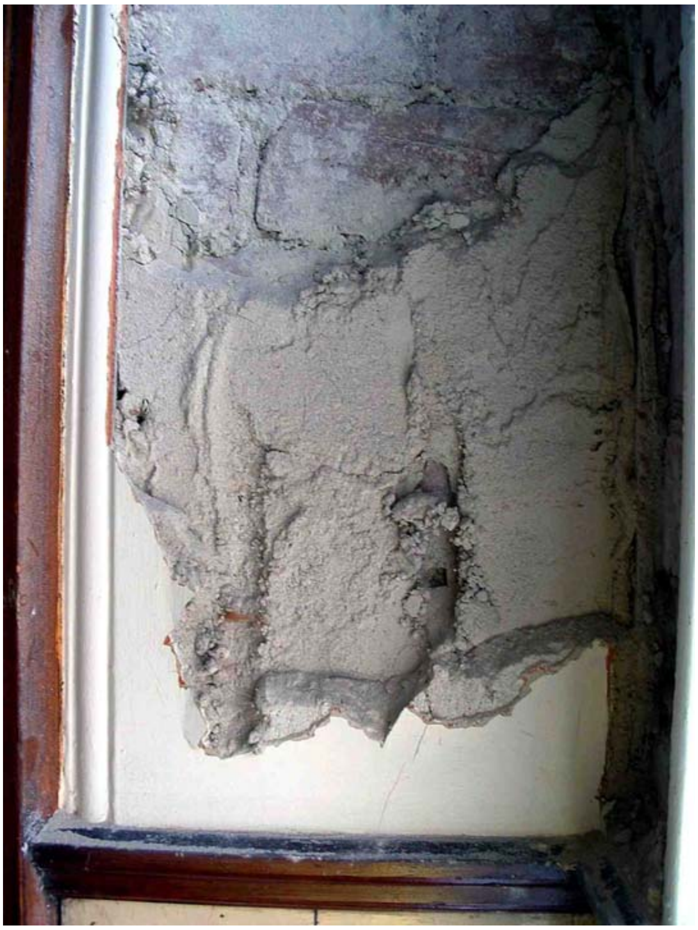


Plate 4.16 Plaster on the hard partially removed (Feb 2003).

Plate 4.17 Plaster removed from area affected by dampness at first floor level (Feb 2003).

Plate 4.18 Plaster removed from area affected by dampness at upper level (Feb 2003). This revealed damp wood.

4.1.4 Case study four

Date of inspection
19th October 2000

Description of property
Right side of a two storey, semi-detached granite house constructed in 1925. The roof space (where the damp problem is located in the exterior gable wall) has easy access from the house. There are two skylight windows and a solid wooden floor. The condition of the lime bedding mortar on the affected gable was poor, being soft, friable and damp. Inspection of the exterior of the property revealed that the gable end (Plate 4.19) had been repointed on at least two occasions. The mortar appeared to be relatively hard. Pointing was generally in sound condition although there were some cracks in the pointing, some of which continued through granite blocks - this cracking being associated with settlement, thought to be no longer active (Plate 4.20). Four flues are present in the gable end. The two outer chimneys are capped. The two inner chimneys are uncapped and the fires are in use. Observation of the flue pipes immediately above the fireplaces showed the lime mortar to be in a similarly poor condition to that observed on the interior of the gable wall. Chimney linings immediately above the fireplaces appeared to be in good condition on visual inspection. As far as could be ascertained on inspection from ground level, the slating was in sound condition, as was the mortar adjacent to the coping and around the chimney. The ridge tiles were rather uneven and raised in a few places.

Location and description of damp
The dampness problem was located at the top of the south-east facing granite gable, in the loft space behind the chimney flues. The precise location of each flue has not been determined. Dampness levels (measured with a conductivity probe) were variable across the wall, high in places, especially towards the middle. Dampness in roof timbers was present adjacent to an area where liquid water had been observed on the wall surface. Dampness on the loft flooring timbers was relatively high adjacent to the gable wall and moisture levels were highest where accumulations of mortar had bridged the gap between the flooring and the wall. The damp problem has got worse over the wet winter months (as of February 2001) despite regular use of the two open fires.

Duration of damp
Dampness has only been observed during the past six months since the present owners moved into the property. The previous duration of dampness is not known.

Information on previous interventions
Not known.

Interventions or alteration to building prior to appearance of damp
Not known.

Factors relating to possible causes of damp problems
The highest levels of damp seemed to coincide with the expected location of open flues suggesting that water penetration may be through the open chimneys. Given the poor state of lime mortar on the interior wall surface, there may be significant loss of mortar associated with the flues. Voids in the mortar may provide easy routes for the penetration of water through the wall, resulting in moisture exiting through the interior surfaces. However, it was also reported that during wet weather moisture had been observed glistening on the surface of the wall to the left (north-east) side of the gable. Possibly this moisture is getting in under raised ridge tiles. The dampness may be trapped in the gable by the use of hard cement mortar on the exterior of the property (although the permeability of the external pointing has not been quantified).

Plate 4.19 Gable of case study four.

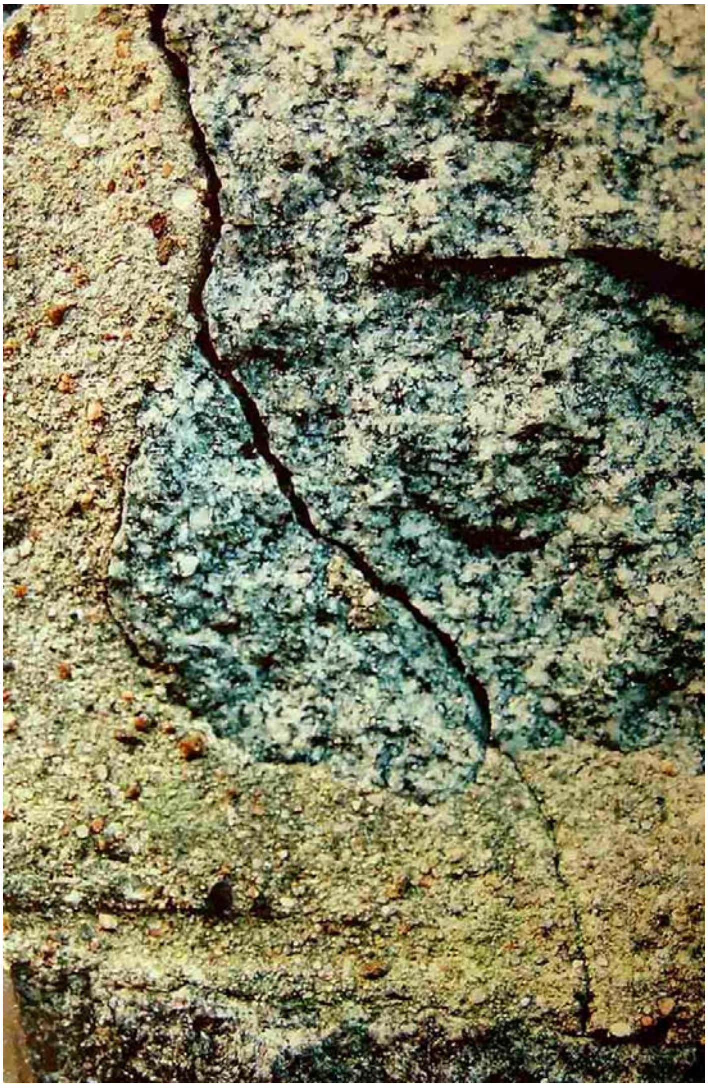


Plate 4.20 Cracked pointing and granite due to settlement.

4.1.5 Case study five

Date of inspection
25th October 2000.

Description of property
The damp problem is located in the top floor of a north-west facing granite tenement. There is a sloping roofed granite faced dormer window at the front of the property. The damp problem is located in this room where the ceiling adjoins the front wall. The dormer is detached to its right, but abuts a newer, flat roofed dormer window on its left. The affected wall contains flues for three chimneys. Which are capped with elephants feet. The granite is good quality ashlar and the pointing appeared (from ground level) to be in sound condition. No problems at roof level were visible from street level although the skews and slates behind the chimney and the mortaring around chimney pots were not visible.

Location and description of damp
On inspection of the roof space above the bedroom it was observed that the bedding mortar was in poor and friable condition and was damp across the wall area above the ceiling. The access point for water could not be determined as the roof could not be accessed. Damp was penetrating into the bedroom by bridging of moisture from the damp mortar across accumulated mortar debris and into the wood and plasterwork at the ceiling level.

Duration of damp
Several months.

Information on previous interventions
Mutual repairs were completed in July 1991. Repairs to the roof included reslating, replacement of zinc ridge, replacement of cement skews (1:3 mix), replacement of chimney pots, fitting of ventilator caps and repointing to the chimney.

The chimney has been recently opened following discovery of the damp problem and was found to be dry inside with no signs of condensation problems. The ventilated cap was replaced after inspection. No problems were found with the slates.

Interventions or alteration to building prior to appearance of damp
None known.

Factors relating to possible causes of damp problems
The source of moisture is not known, but appears to be a problem originating at roof level. It is possible that rainwater accumulating against the wall where it abuts the newer dormer window to the left (when facing the property) is the source of dampness. Condensation in the flues has been ruled out by inspection. The penetration of damp into the interior of the flat was caused by bridging across the wall cavity as a result of collapses of deteriorated bedding mortar.

Plate 4.21 Case study five. Affected central bedroom on top floor with granite faced dormer.

Plate 4.22 Damp patch above window.

4.1.6 Case study six

Date of inspection
26th October 2000

Description of property
This two storey property, constructed in the early 19th Century is located at a corner. Damp problems occur on the south-facing gable - an exposed face looking out over the harbour. Four flues are present in the gable wall and all four chimneys are capped. Three of the four chimneys are ventilated with elephants feet; the second from the left has a gas flue vent (presumed to be the flue for the ground floor flat gas fire).

The gable is constructed of squared granite rubble with occasional blocks of other stone types including sandstone. The pointing on all facades was flush with some overlap onto granite blocks. The pointing on the south gable contains several cement mixes or poor quality. The pointing appears to be very hard with a high proportion of cement. In places the cement appears to have partially separated from the sand and formed greyish surfaces around the contact with granite blocks. There are a large number of cracks in the pointing which are clearly taking up, and acting as conduits for, moisture. Some more weathered, relatively porous granite blocks show deterioration around the margin consistent with use of pointing mortar that is too hard. Elsewhere on the exterior the pointing appears to be of normal hardness.

The slope (tilting fillet) of slates on the lower half of the roof abutting against the south gable appears to be inadequate. At least three different mortars have been used on the skews and around the chimney although there are no obvious flaws on inspection from the street.

Location and description of damp
The damp problem is located on the exposed south facing gable wall overlooking the harbour. This wall contains both a flue and, to its right, a window. Most of the dampness is located around and above the flue in the ground floor flat. Previously an open fireplace, there is now a gas fire, vented through the back of the flue to the south gable wall at about 1m height. The damp problem is severe in the ground floor flat but does not affect the first floor flat where the internal wall is reported to have been rebuilt with a cavity. The interior wall of the ground floor flat is reported to become very wet within hours of heavy rain, sufficiently wet that the wall surface is reported to glisten with water. At the time of inspection the internal wall showed signs of damp (peeling wallpaper) but was not significantly wet to the touch. The damp problem in the chimney was sufficiently severe as to cause corrosion of a gas boiler. The boiler had to be removed to an adjacent wall.

Duration of damp
The damp problem began after refurbishment work on the exterior (in 1990), which included work on the roof, rainwater goods and repointing. Problems with dampness were reported from the first floor flat in 1992 and were resolved (see below). Current problems in the ground floor flat are known to have been reported in October 1998, but may have existed prior to this.

Information on previous interventions
Original organising agents were McGregor Associates, Consulting Engineers, who are no longer in business. Grant was approved in April/May 1990. Payment was made in September 1990 and included repointing of the gable. A further grant was approved in April 1992 in respect of the first floor flat south (directly above the currently affected flat) for removal of an old fireplace and debris in the gable wall to resolve a dampness problem.

Repairs, including repointing external walls and repairs to slates and skews were completed in September of 1990. Following work on the roof, there appears to have been inadequate attention to rainwater run-off from the valley gutter behind the chimney and water appears to have missed the gutter, poring down the wall face and penetrating the interior. This problem is reported to have been remedied.

At the time when the boiler was installed the lintel of the previous chimney place was removed or damaged. A few years later this resulted in a collapse of two granite blocks and substantial debris into the back of the fireplace. This debris has since been removed and the lintel made safe.

Factors relating to possible causes of damp problems

The source of moisture could not be determined by visual inspection. The state of the bedding mortar in the south gable seems likely to be poor given descriptions of debris falls in the cavity and the amount of moisture penetration. Despite the presence of the cracked, hard cement pointing it seems unlikely that these cracks are the sole route of access for water affecting the building interior; however, the impermeable nature of this mortar will prevent drying out of bedding mortar. Bedding mortar, in an already poor state may have been dislodged and weakened by repointing work resulting in development of cavities in the wall and deposits of bridging debris, channelling moisture across the wall cavity. Moisture is likely to be entering the interior wall from bridging debris in the wall cavity, but the source of moisture could not be established by visual inspection. Perhaps the reported rapidity of wetting and the relatively rapid shift from very wet to relatively dry suggests ingress of water at a single source high on the facade rather than condensation problem?

4.1.7 Case study seven

Date of inspection

2nd November 2000

Description of property

A granite tenement facing east onto the street with a good quality ashlar front and squared rubble construction on gables. There is a large basement that has never been used for accommodation and has bricked up windows in the light well. There are flats on three floors, the upper floor having dormer windows at roof level. Cement pointing is mainly in sound condition and does not appear to have been recently replaced. A hidden parapet gutter exists at roof level and may need attention, as there is some evidence of staining around the downpipe and/or below the overflow. A previous minor damp problem may be associated with this defect, but the current problem is not located in this area. Chimney pots are not visible on the north gable and it is assumed that the flues have been blocked at roof level. It could not be determined whether there is any ventilation of the flues.

Location and description of damp

The damp is located in the front bedroom at ground floor level on the north-facing gable wall. There are several damp areas, about 80cm or less in diameter and within about 1 m of the floor. The plaster wall has been opened up in a few areas allowing inspection of the interior cavity. The gable wall contains a bricked up flue. There is some damp in this area but it is not the main area of damp suggesting that condensation or moisture entry through the flue is not likely to be the cause of the problem. The lime pointing behind opened areas of the wall was found to be quite damp and wood in contact with the pointing was also damp. Some mortar debris was removed from the cavity when the wall was opened and moisture seems to have been bridging the cavity through this debris and through dooks.

Externally the gable faces onto a narrow passageway (about 1.5m width) between this and the next door tenement. Above the passageway is a bridging granite structure that is reported to contain a cold water tank for the adjacent flat. This structure has a flat roof that abuts against the affected gable at a level of approximately 2m height within the ground floor flat. During an investigation of the damp problem earlier in the year the flat owner was advised that water penetration from this abutting structure was likely to be the source of the damp. The structure has since been re-roofed; however the ground floor flat continues to be affected by damp some four months later.

Duration of damp

The problem was first noted in the spring of 2000. Repairs were carried out on the abutting flat roof in the summer of 2000. Damp problems have persisted until current inspection (November 2000).

Information on previous interventions

No information with the exception of re-roofing of adjacent flat roof some four months prior to this investigation.

Interventions or alteration to building prior to appearance of damp

None known.

Factors relating to possible causes of damp problems

It is likely that the abutting flat roof was the point of ingress of dampness and that the wall has not yet had sufficient time to dry out (especially since the flat is intermittently occupied).

4.1.8 Case study eight

Date of inspection
7th November 2000

Description of property
Semi-detached granite property built in 1887. The (previous) damp problem was in a gable of squared granite rubble. Pointing appeared to be in sound condition and did not appear to be of too hard a mix. Some granite blocks were of poorer quality and showed signs of superficial flaking. The gable contains capped flues.

Location and description of damp
There are no current damp problems in this property. It is reported that dampness was present in a side gable (south) around and over a doorway at ground floor level.

Duration of damp
There are no current damp problems.

Information on previous interventions
Grant was approved in August 1991 and work (including repointing) completed in August 1992. Dampness was first reported in July of 1998 above the flat entrance door in the southmost gable wall.

Interventions or alteration to building prior to appearance of damp
There were no interventions immediately prior to the occurrence of dampness.

4.1.9 Case study nine

Date of inspection
7th November 2000

Description of property
A four storey granite tenement facing onto the street, built in 1903. The front façade is in ashlar granite of good quality. Gables are in squared rubble of variable, but sound, quality. The east gable is fully exposed above ground level. The west side of the block is continuous with another tenement block but there is a passageway through the tenements at ground level (Plate 4.23). Flues (capped) are present in the east gable and in the internal (west) wall.

Location and description of damp
Although there are currently no internal damp problems, it is reported that dampness was previously present in the exposed east gable and in the ground floor flat in an alcove at the rear, west corner (adjacent to the passageway). Although no dampness was currently present internally, there has been dampness in the east side of the passageway towards both the front and rear. These areas are sheltered from rainfall but do contain internal flues.

Duration of damp
There are no current internal damp problems in this property.

Information on previous interventions
Grant was approved in late November 1996 and the first instalment made in March 1997. Work was completed in September 1997. Re-pointing was carried out some time between November 1996 and September 1997.

It is reported that dampness in the east gable was sorted by taking off the internal plaster and removing substantial amounts of bridging debris from the wall cavity. Gas vents on the chimneys were removed to improve ventilation. Since this was done there have been no further problems.

Interventions or alteration to building prior to appearance of damp
Repointing was completed by September 1997. The first report of dampness was in the gable wall of the east 2nd floor flat around December 1997, shortly after completion of the contract.

Factors relating to possible causes of damp problems
The small area of damp in the rear of the ground floor, west flat appears to have been solved by improving drainage. Dampness in the east gable was first reported after repointing. The source of moisture has not been established but internal problems were solved by removing bridging debris and reinstating the wall cavity.

Plate 4.23 Rear of case study nine.

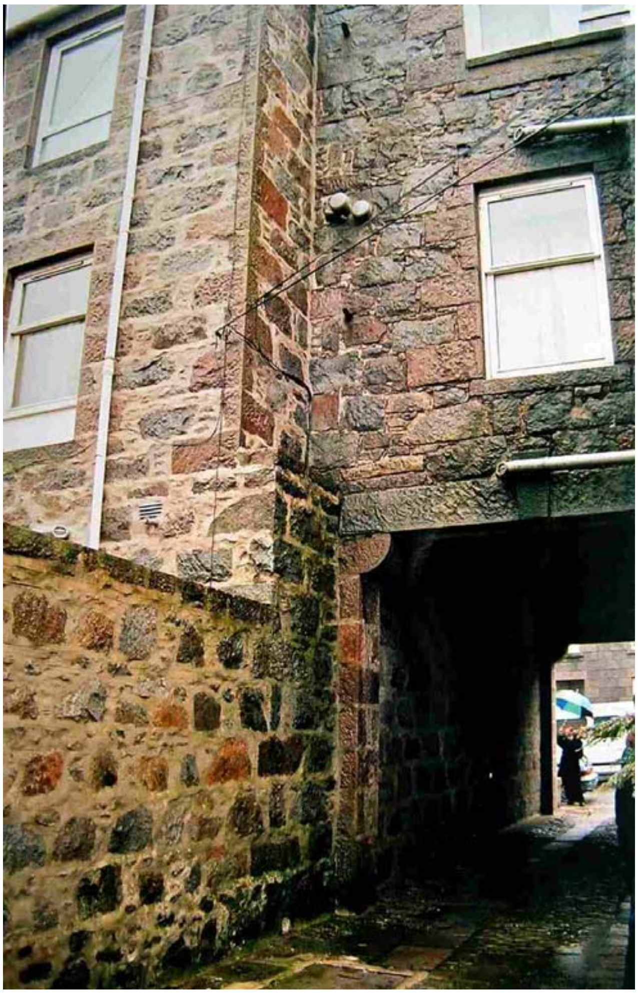


Plate 4.24 Passageway through to rear of case study nine.

4.1.10 Case study ten

Date of inspection
30th November 2000

Description of property
An east facing detached house, built in 1902 with squared granite rubble and ashlar granite walls.

Location and description of damp
Dampness problems exist in a number of areas. The south facing gable wall has damp patches on the internal wall in two rooms. Damp penetration and dry rot outbreaks have occurred around badly fitted window details in the kitchen. Dry rot in the roof has recurred following apparent incomplete removal and treatment of a previous outbreak. The cause of the dry rot outbreak in the roof space appears to have been moisture penetration through poorly repaired skews.

Duration of damp
The first known notification of dampness problems was in December 1997.

Information on previous interventions
Grant was approved in November 1994 and all works completed in April 1995. Interventions included repointing of walls, chimney stack and skews. Pointing was removed mechanically. The chimney stack was repointed in 1998. The pointing is dark grey in colour with hairline cracks, indicating a high cement content. Internally, debris has been removed from behind lathe and plaster walls. Water sealant was applied to the south facing gable wall in the autumn of 1998.

Interventions or alteration to building prior to appearance of damp
Damp problems date from after the interventions completed in 1995.

Factors relating to possible causes of damp problems
Some damp problems have clear causes. This includes water penetration at window details and at skews. In some areas, including the south facing gable wall, the source of dampness is more problematic to determine. The damp areas on the interior of the south facing gable wall appear to be caused by damp bridging by debris in the cavity. There are flues present in this wall whose location in relation to damp patches has not been determined. This may be dislodged debris from mechanical raking out of pointing. An external string course may contribute to direction of rainwater run-off into the wall. The hard, impermeable pointing is unlikely to allow adequate drying out of any moisture present in the interior of this wall.

4.1.11 Case study eleven

4.1.11.1 Observations in January 2003

Background information

The façade on the street and its adjacent gable were reported to have been re-pointed about 3 years ago. The specification was for 1:1:6 mortar. There were some minor damp problems reported before this time, which were diagnosed as being due to:

- Deterioration of skews. There was damp in the roof space. This problem was fixed, though skews did have to be redone after the first attempt at repair.
- Damp penetration around corners at front and rear. This problem was diagnosed as being caused by localised deterioration of pointing and bedding mortar. This was repaired.

More recent, serious damp problems began after the repointing and other works. The flats have been converted to be on two floors with an internal stairwell centrally placed adjacent to the gable wall. The gable wall in the stairwell may be thinner than in adjacent rooms as the wall here is set further back. This is the area currently affected by damp penetration. It is reported that damp comes through very soon after rain events. Dampness manifests itself as wetness on the floor of the half landing on the stairs adjacent to the gable wall. In the lower flat (which was the only one to which I had access), the plasterboard adjacent to the gable wall on the half landing had recently been replaced. When it was removed debris was reportedly found in the void space which was causing moisture bridging across to the inner wall.

Polythene linings have been installed behind the plasterboard walls of rooms adjacent to the gable and no dampness is reported in these locations.

Recently (just before Christmas 2002) the chimney has been repointed and had 6 (of 9) pots replaced. The chimney pots were, and are, capped.

Analysis of the composition on pointing on the gable by Sandberg Consulting Engineers in August 2003 indicated that it was light grey and hard with a cement : lime : sand ratio of 1 : 0.3 : 4.4. This is a cement-rich mix compared to that specified. It is unclear why its permeability was as high as it was found to be (see below).

Observations

The gable wall faces south-east and is highly exposed to driving rain from that direction since there are no adjacent buildings.

Two colours of pointing were observed. Most pointing was light coloured, but some areas had patches of a 'darker' mortar (Plates 4.25, 4.26 & 4.29). This colour difference was not caused solely by dampness although the 'darker' mortar was in some instances found to be wet when surrounding 'lighter' mortar was dry (see Section 4.1.11.2). The 'darker' mortar was often enclosed by the 'lighter' mortar. This suggests that the 'lighter' coloured mortar was applied earlier than the 'darker'. The contiguous appearance of the mortars suggests that the two mortars were applied at approximately the same time. Their composition is unknown.

The gable wall was initially examined in January 2003 after recent rain. It had an unevenly distributed wetting pattern, with most dampness (identified by the darker colour of pointing) to the left central area of the gable (Plate 4.27). The façade was re-examined in March 2003 after a period of 1-2 weeks without rain. Areas of the gable were still visibly damp (Plate 4.28).

Some areas of pointing were cracked and affected areas appeared to retain a lot of moisture, having relatively abundant green algal growth when observed in January 2003 (Plate 4.30). Algal growth requires relatively long periods of dampness and would not normally be expected on a southerly facing gable wall. Green algal growth was no longer visible on the gable during an inspection in March 2003, but was still visible on the front façade (Plate 4.31).

Plate 4.25 Two colours of mortar were visible on some areas of the gable (at its left end, as shown here) and on the front façade. The 'darker' coloured mortar was normally surrounded by 'lighter' coloured mortar.

Plate 4.26 Close-up showing the 'darker' and 'lighter' coloured mortars at the left end of the gable. The darker colour is not caused solely by differences in degree of dampness although the 'darker' mortar here is damp and the 'lighter' mortar is dry (tested by electrical conductivity).

Plate 4.27 Gable photographed in January 2003 showing distribution of dampness (darker coloured areas on pointing).

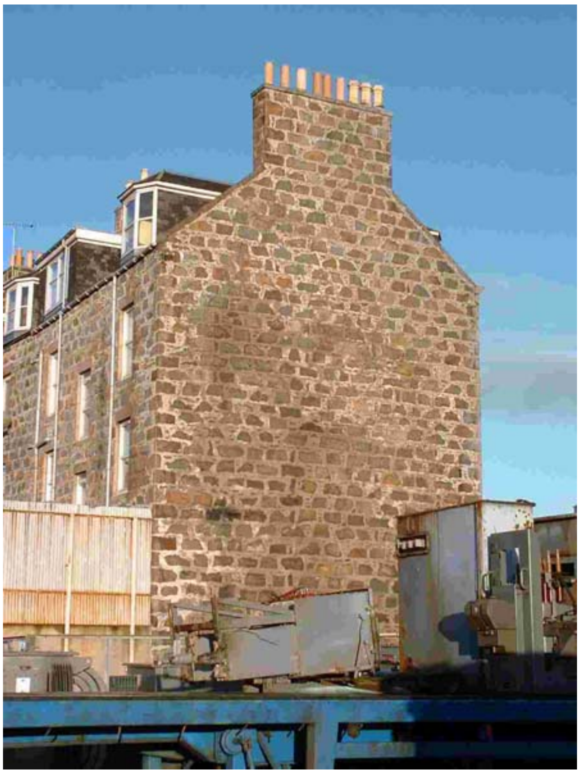


Plate 4.28 Gable photographed in March 2003 showing distribution of dampness after a period of 1-2 weeks without rain.

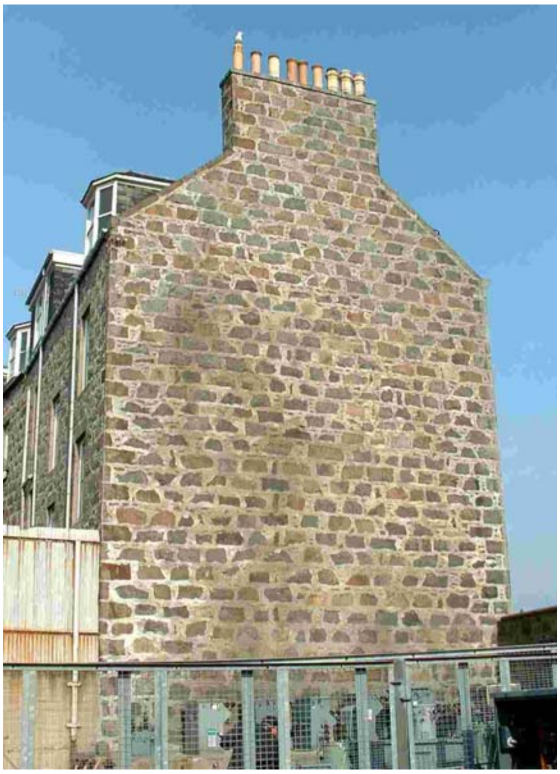


Plate 4.29 This close-up of the area to the upper left of Plate 4.28 (March 2003) shows darker, damp areas of pointing on the left and lower centre. There is an area with two differently coloured mortars (darker and lighter) in the upper right of the picture.

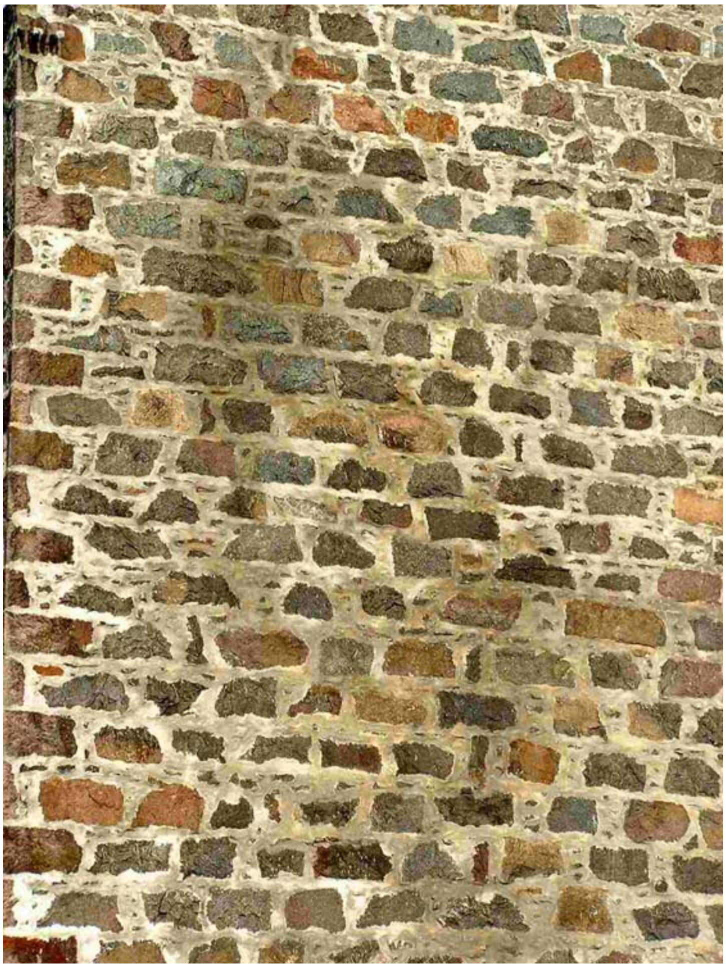
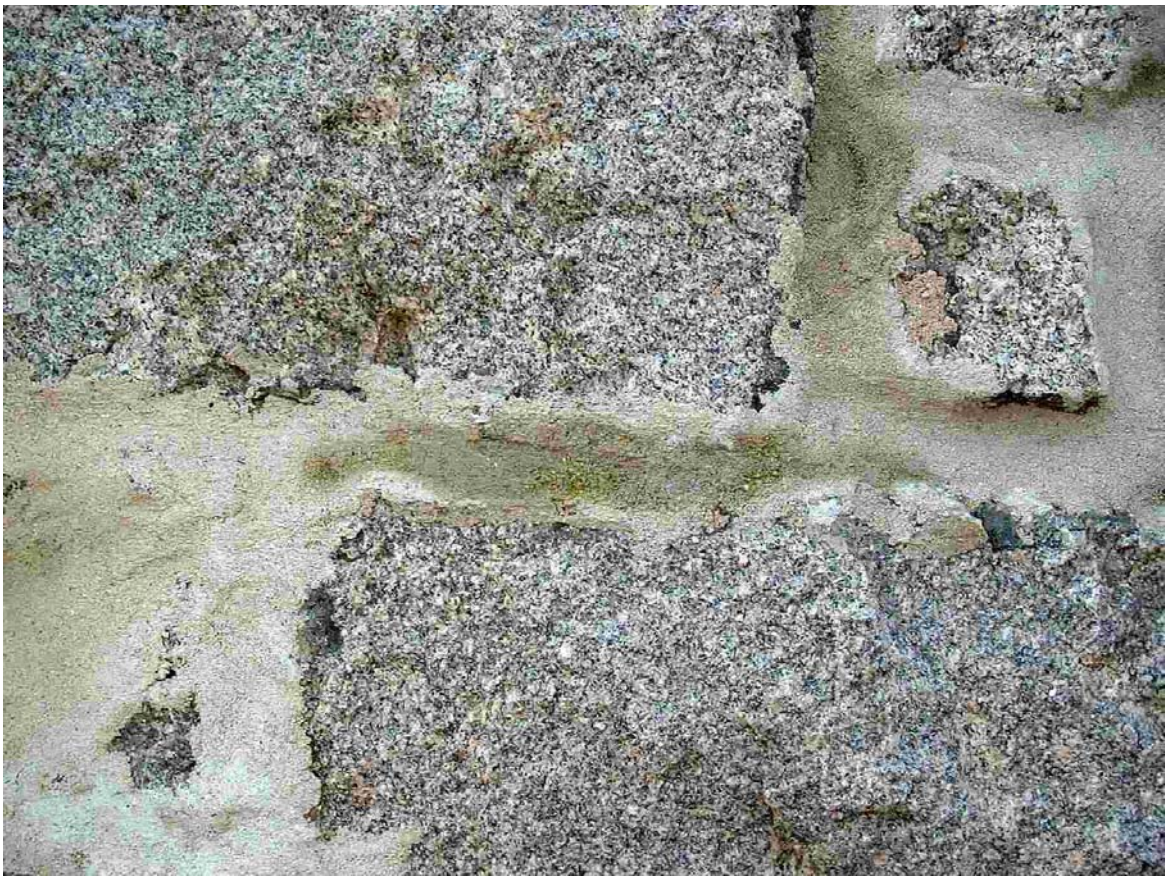


Plate 4.30 Damp pointing on the gable with green algal growth apparently colonising the area around cracks (photographed in January 2003).

Plate 4.31 Damp pointing (darker area) on the front façade with green algal growth (photographed in March 2003).



4.1.11.2 Electrical conductivity data (moisture levels in mortar)

The electrical conductivity of the pointing surface was used as an indication of wetness. Dry mortar (or stone) surfaces do not conduct electricity. Measurable electrical conductivity is only present when the surface is damp. There is a positive correlation between the degree of conductivity and the degree of dampness although no absolute quantification of saturation is possible. Nevertheless, higher electrical conductivity values can be taken to indicate higher levels of saturation in surfaces of similar composition (such as the pointing measured here). The instrument used to measure electrical conductivity was a Protimeter Surveymaster (Model D578S).

Measurements of electrical conductivity were made on three separate occasions during a five day period. There had been no rain for at least a week prior to the first measurement and there was no rain during that period of five days. Measurements were taken at 0.5m intervals at heights of approximately 0.8, 1.3 and 1.8m above the concrete platform at the base of the gable (which is at a height of 0.8m above ground level). The gable was approximately 10m in width. The last metre was inaccessible due to electrical equipment stored in front of the gable at that position.

Electrical conductivity data are shown graphically in Figure 4.3 and diagrammatically in Figure 4.4. These figures show zero, or low levels, of conductivity at the left end of the gable over a distance of about 1 to 2.5m in from the corner. This indicates that the left end of the gable (on 'lighter' coloured mortar only) was dry on the surface. Further along the gable, high conductivity levels indicate that the surface was damp. At 0.80 above the platform, levels of dampness were fairly consistent across the gable. Readings at 1.30m and especially at 1.80m indicate a slightly drier area in the centre of the gable (i.e. slightly lower electrical conductivity). This is consistent with the appearance of the gable in Plate 4.28.

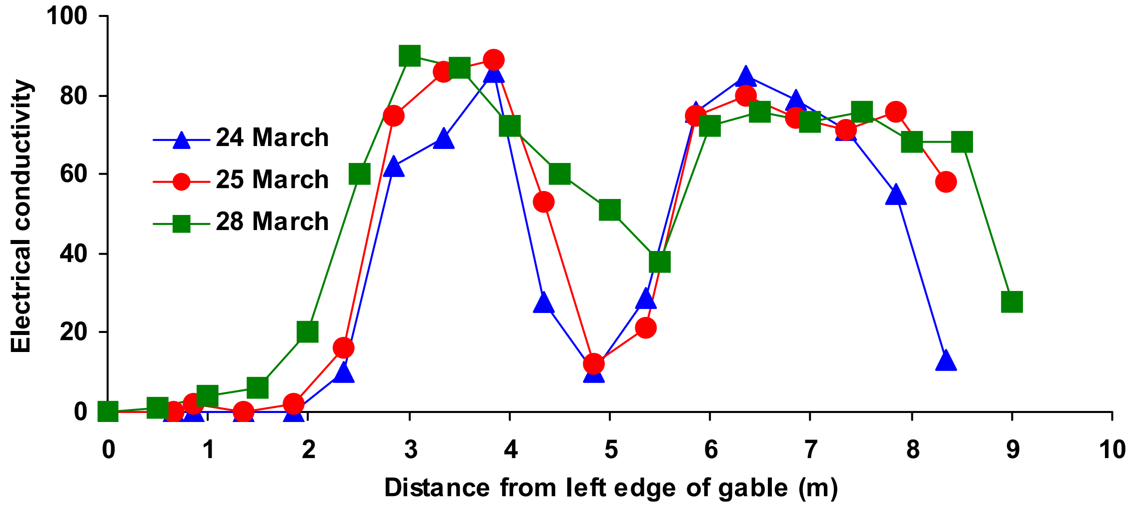
Although the 'lighter' coloured mortar at the left side was dry, there were within it some patches of 'darker' mortar. These were found to have measurable electrical conductivity (Figure 4.5) and were therefore damp. The 'darker' mortar is very impermeable (see Section 4.1.11.3) and hence slower to dry. The remaining wetness in the 'darker' mortar patches may indicate that the subsurface at the left side of the gable is damp, although its surface is dry.

There was no clear evidence of any significant drying of the gable during this period of five days. Drying would have been visible as a fall in electrical conductivity.

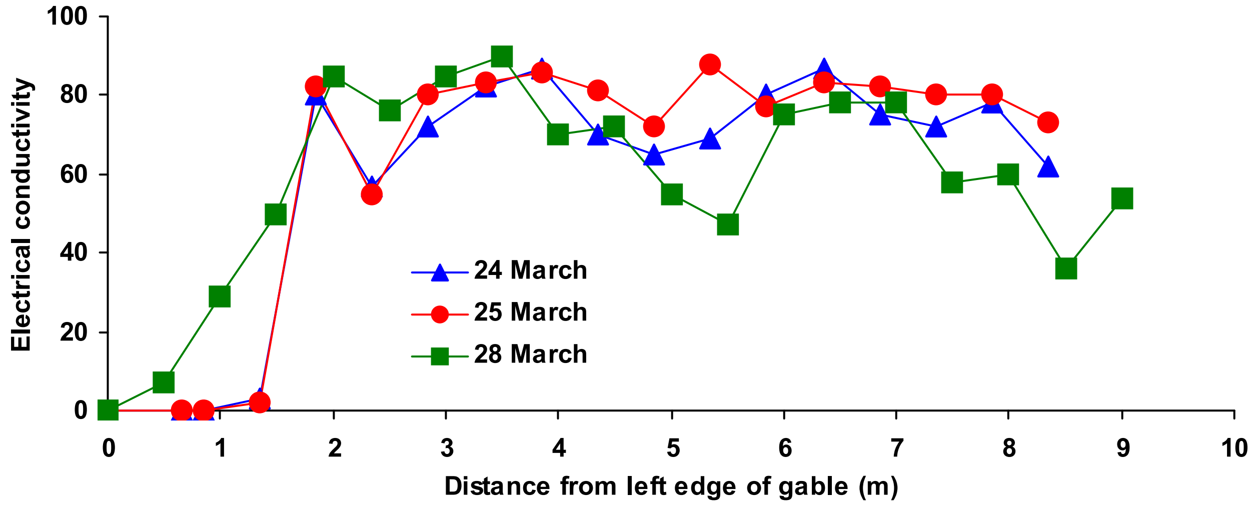
On the 24th March 2003 a series of readings of electrical conductivity were made across the front façade (Plate 4.32). Many areas on the façade were found to have measurable electrical conductivity (Figure 4.6) indicating that the pointing was damp (again, patches of 'darker' mortar had higher levels of dampness). Relatively lower readings on the façade than on the gable implied that the pointing mortar on the façade was not generally so wet as that on the gable. The highest readings (i.e. highest levels of dampness) were found at the left end of the façade, adjacent to the gable and around the leftmost window. Dampness was lower, but still detectable over the remainder of the façade. However, conductivity readings taken on the adjacent façade were all zero, indicating no significant dampness in its pointing mortar. The adjacent façade had a visually different, greyer pointing mortar.

Figure 4.3 Graphs showing the levels of electrical conductivity across the gable at various heights above the concrete platform on 24th, 25th and 28th March 2003. NB There was no rain during this period and for at least a week prior to March 24th. (Same data shown diagrammatically on Figure 4.4)

a. 1.80m above platform.



b. 1.30m above platform.



c. 0.80m above platform.

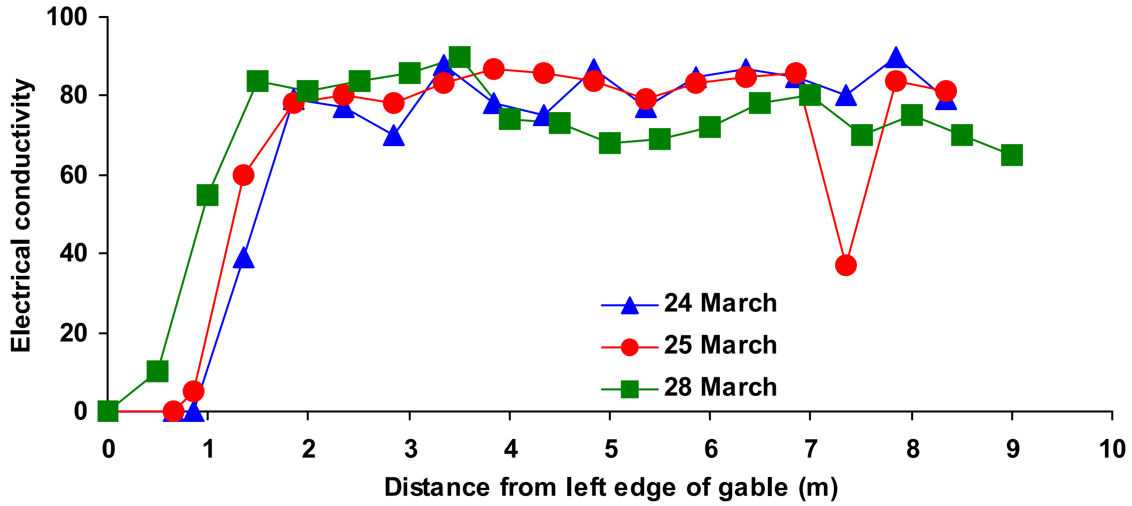
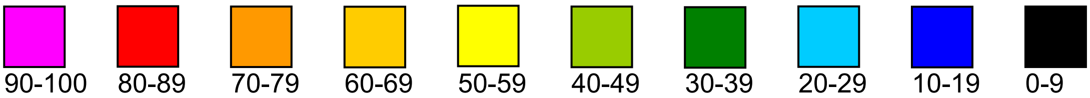
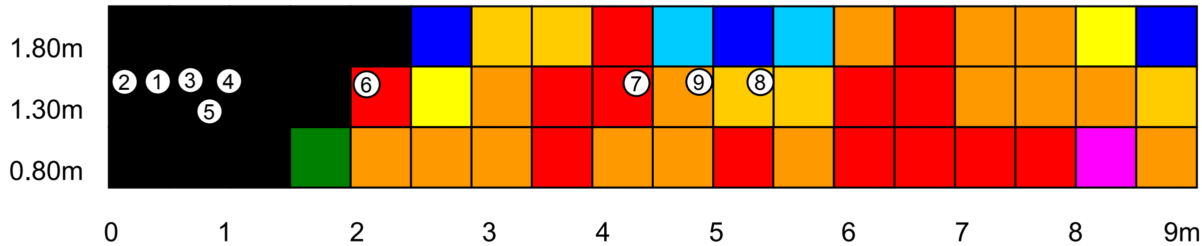


Figure 4.4 (Same data as Figure 4.3) Diagram showing the levels of electrical conductivity across the gable at various heights above the concrete platform on 24th, 25th and 28th March 2003. NB There was no rain during this period and for at least a week prior to March 24th. The numbers in Figure 4.4a. show the positions of water absorption measurement points (see Figure 4.8).

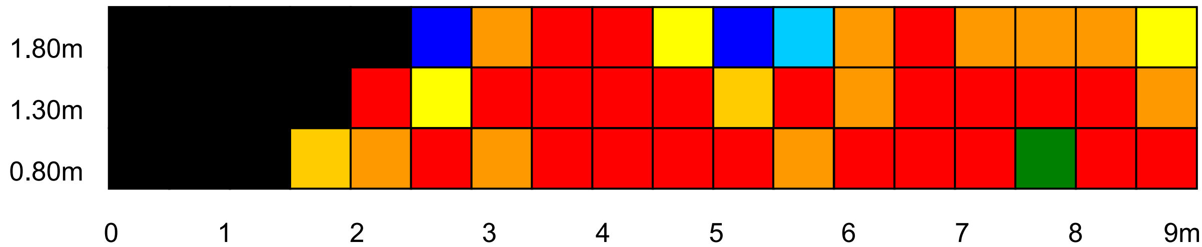
Key to electrical conductivity levels



a. Readings taken on 24th March 2003.



b. Readings taken on 25th March 2003.



c. Readings taken on 28th March 2003.

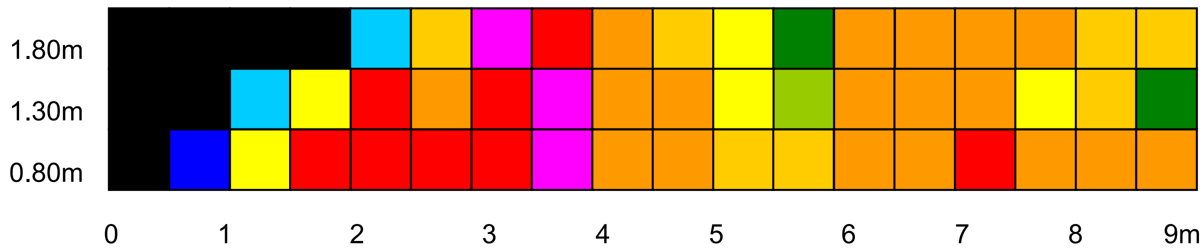


Figure 4.5 Electrical conductivity of patches of 'darker' mortar embedded within the (dry) 'lighter' mortar at the left side of the gable (data in March 2003).

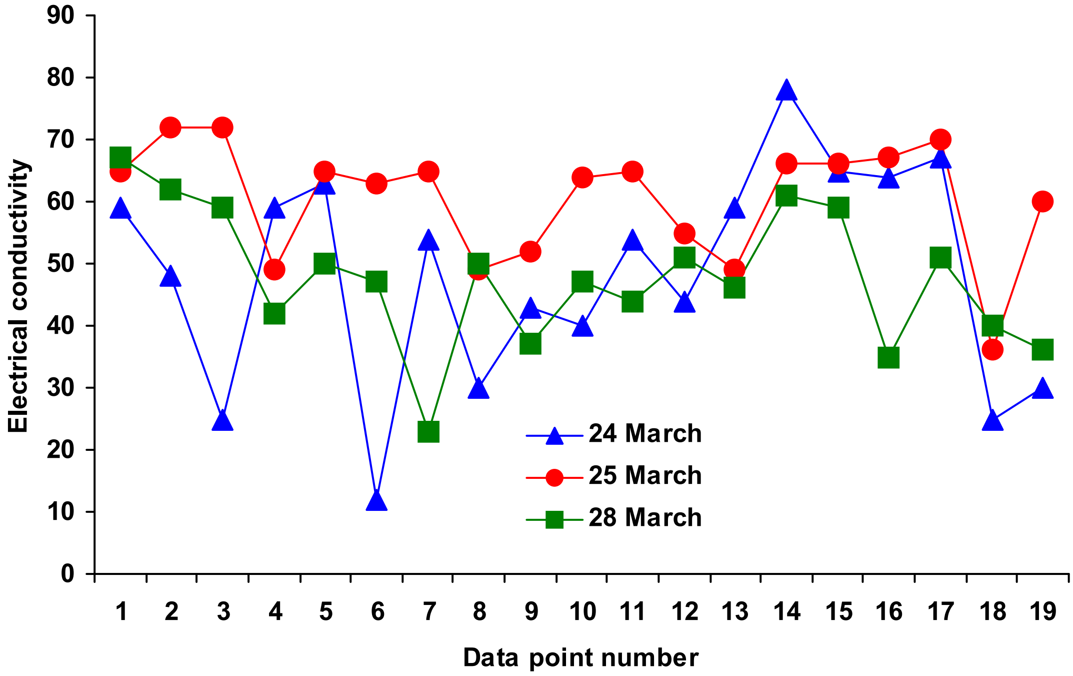
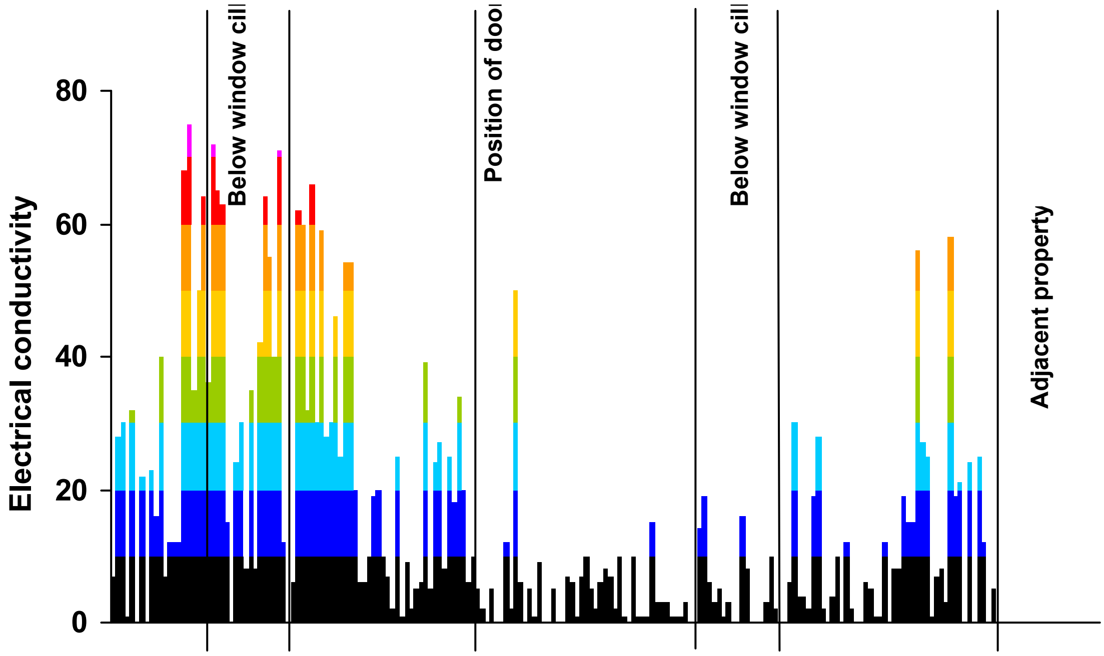


Plate 4.32 Front façade of case study eleven (photographed in January 2003).

Figure 4.6 Electrical conductivity across the front façade. This includes readings on 'lighter' and 'darker' mortar areas. Both types were damp, but 'darker' mortar was generally wetter. Pinks and red indicate high water saturation, blues and blacks low water content. Readings of zero indicate no significant water content. The positions of windows and the doorway is indicated.



4.1.11.3 Water absorption rates

Water absorption was measured using a RILEM (or Karsten) tube. This device is used to measure the rate of water uptake by porous substrates. It is a graduated tube with a bulbous bottom, one side of which is open (Figure 4.7). The open side of the base is sealed against the stone (using a plastic, mouldable adhesive or some other appropriate sealant) and the tube is filled through the open top. Water flows into the substrate and its rate of flow is measured by timing the drop in water level inside the tube against the graduations down its side. The surface area through which the water is absorbed is a circle 26 mm in diameter (the size of the open side at the tube base).

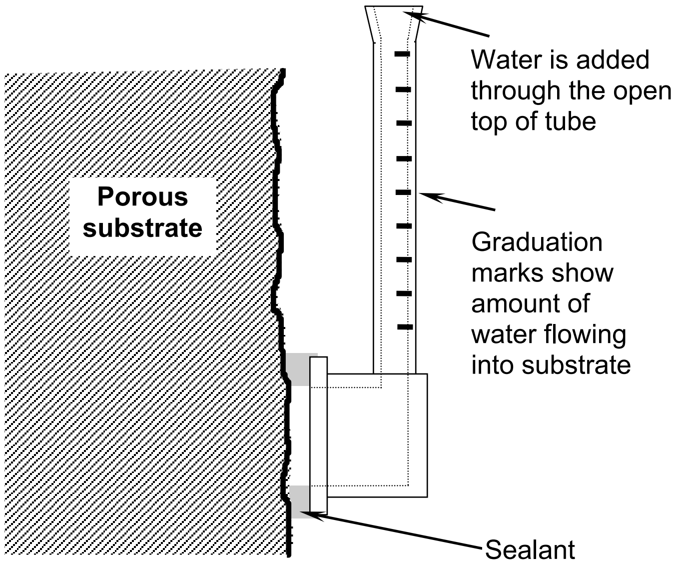


Figure 4.7 Diagram of a RILEM (or Karsten) tube for measuring water flow into porous substrates.

Plate 4.33 RILEM tube attached to a patch of 'lighter' mortar (Run 3).

Plate 4.34 After Run 6 showing spread of water after 5mL absorption. Most water has gone deeper into the mortar; only a small proportion is visible on the surface.

Data on water absorption rates was obtained in March 2003 after a period of at least one week without rain (see Section 4.1.11.4). The results are shown in Figure 4.8 and Table 4.1. Table 4.1 shows a calculation of the 'water absorption coefficient'. This is a common method for comparing water absorption rates of porous materials and is calculated from the data obtained with the RILEM tube. Higher values imply faster rates of water absorption.

Two measurements of water absorption were made on the 'darker' mortar (Runs 1 & 2). Since there was no measurable water absorption after 5-10 minutes, monitoring was stopped. The water absorption rate of the 'darker' mortar was therefore found to be very low and unquantifiable by this technique.

Run 4 was done on 'lighter' mortar adjacent to a granite block. The water absorption rate here was extremely fast - 5 mL being absorbed in 10 seconds. This was by far the fastest rate of absorption measured. Perhaps the mortar here was a thin layer on top of underlying granite? Or this may be an extremely absorbent patch of pointing mortar.

Six other measurements of water absorption were made on the 'lighter' mortar (Runs 3, 5, 6, 7, 8 & 9). Results were variable. Runs 3 & 5 were made on the left end of the gable. The water absorption coefficient in this area was about 9 to 15 $kg/m^2\sqrt{h}$. This area appeared dry and electrical conductivity measurements (Section 4.1.11.2) indicated that it was dry (on the surface at least). Runs 6 to 9 were done on mortar which appeared damp, and electrical conductivity data showed that the mortar was damp in these areas. The water absorption coefficient of these damp areas was found to range from 25 to 33 $kg/m^2\sqrt{h}$.

Faster water absorption rates correspond with areas where the mortar was found still to be damp after one to two weeks without rain. This suggests that mortar permeability varies over the façade and that the more porous areas are indicated by long term residual dampness. The fact that 'darker' mortar patches at the left end of the gable were found to be damp when surrounding 'lighter' coloured mortar was dry suggests that this less permeable mortar retains dampness derived from a wet interior for longer than the more permeable 'lighter' coloured mortar. On the 'lighter' mortar, the rate of evaporation in this area appears sufficient for the surface to have dried out. However, the bedding mortar may still be wet.

The mortar mix was specified as 1:1:6. Water absorption coefficients measured on some of the drier areas of the gable are close to those in the literature for 1:1:6 mortar (Tables 4.1 & 4.2). However, water absorption coefficients on damper areas of the gable are much higher than those expected of 1:1:6 mortar. It has been suggested[2] that pointing which absorbs more than 5mL water in 5 minutes is too permeable. Run 7 achieves this rate of absorption and Runs 6, 8 and 9 are close to it. Run 4 (which may be exceptional) had a much higher rate of water absorption.

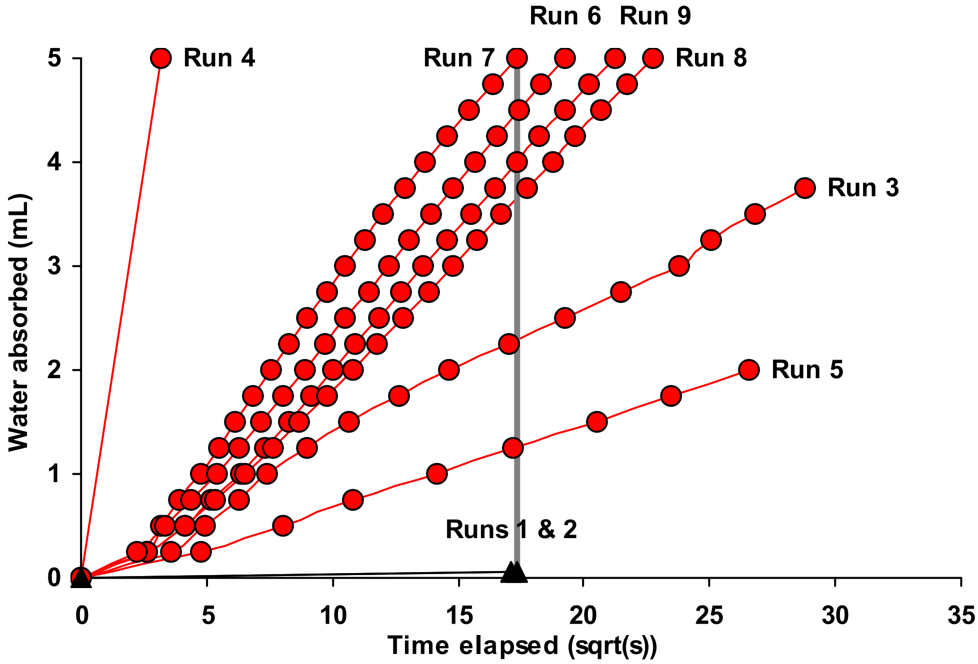


Figure 4.8 Water absorption data from RILEM tube measurements. The vertical line shows 5 minutes duration. Pointing which takes up more than 5mL in 5 minutes can indicates a serious problem with excessive water absorption. Note that the less water absorbent areas (Runs 3 & 5) correspond with drier areas of the gable and the more absorbent, with wetter areas.

[2] John Meredith. *Test methods to determine water penetration in masonry structures* http://homerepair.about.com/

Table 4.1. Details of water absorption data from RILEM tube measurements. See Section 4.1.11.2 for data on dampness of surfaces.

Run number	Mortar type	Water absorption coefficient (kg/m²√h)	Observations (in March 2003)
1	'Darker'	<0.33	No measurable absorption after 5 minutes
2	'Darker'	<0.33	No measurable absorption after 5 minutes
3	'Lighter'	15	Pointing looked dry
4	'Lighter'	179	Pointing looked dry. Perhaps thin mortar cover on underlying granite?
5	'Lighter'	9	Pointing looked dry
6	'Lighter'	29	Pointing looked slightly damp
7	'Lighter'	33	Pointing looked very damp
8	'Lighter'	25	Pointing looked slightly damp
9	'Lighter'	27	Pointing looked damp

Table 4.2. Comparative data on water absorption coefficients available from other sources.
NB. These data are 'capillary' water absorption rates which are derived by placing samples in a few millimetres of water and measuring the rate of uptake.

Substrate	**Proportions of mix**					**Water absorption coefficient (kg/m²√h)**
	Portland cement	**'Masonry cement'**	**Hydraulic lime**	**Lime**	**Sand**	
Lime mortar[2]				1	2	23
Hydraulic lime mortar[2]			1		3	27
Cement:lime:sand[1]	1			½	4½	4
Cement:lime:sand[1]	1			1	6	5
Cement:lime:sand[3]	?			?	?	2
Cement mortar N type[1]		1			3	1
Cement mortar S type[1]		1			3	0.7
Cement mortar[2]	1				3	5
Cement mortar[4]	?				?	0.5

[1] Kumaran, K., Lackey, J., Normandin, N., van Reenen, D. and Tariku, F. 2002. Summary Report from Task 3 of MEWS Project at the Institute for Research in Construction. Hygrothermal properties of several building materials. IRC Research Report 110. National Research Council Canada: Ottawa, Canada.

[2] Moropoulou, A., Avdelidis, N.P. and Koui, M. 2000. Compatibility assessment of building materials using Infrared Thermography. In: Proceedings of the 15th World Conference on Nondestructive Testing, Roma (Italy) 15-21 October 2000.

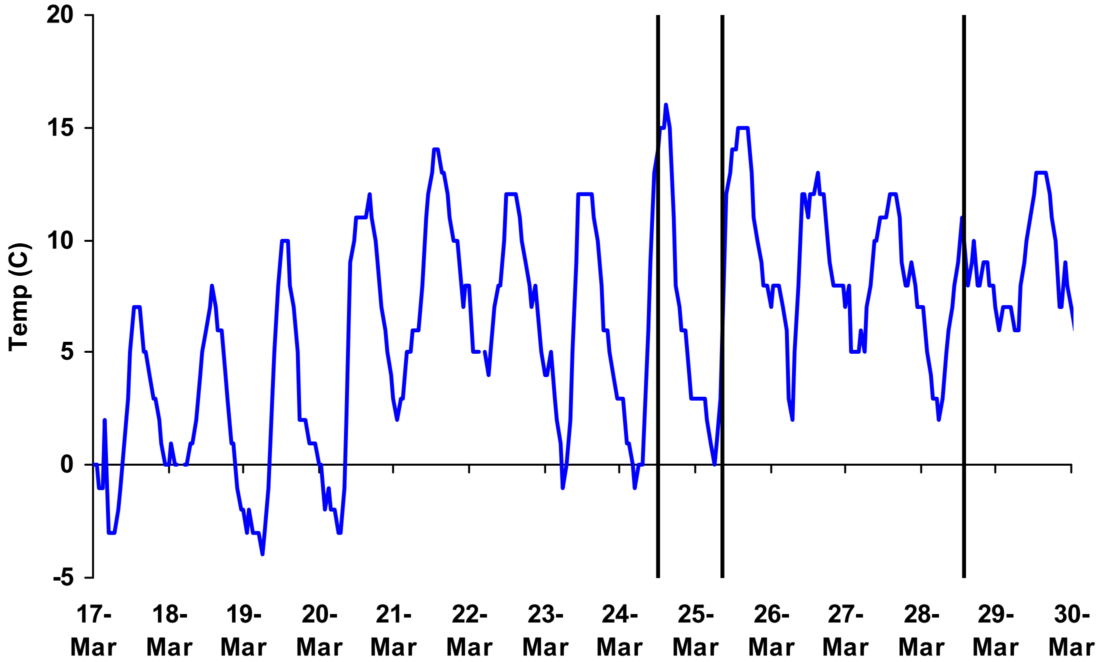
[3] Bednar, T. 2000. Influence of the variation of material properties and uncertainties of the material data model on the results of moisture performance calculations of constructions, Materialsweek, München, September 2000.

[4] Anon. Degussa one component mortar EMACO R305 'Finishing and levelling mortar'.

4.1.11.4 Meteorological Office data

Weather data for Aberdeen was obtained from the Meteorological Office web site which provides data on the previous week's weather (http://www.meto.govt.uk/education/data/index.html). The week prior to 24th March 2003 (when the first measurements of electrical conductivity and water absorption were made) had no rainfall and there was none until after 28th March when the last data was obtained. Figure 4.9 shows air temperature variations per hour from 17th to 30th March 2003.

Figure 4.9 Air temperature for Aberdeen per hour from 17th to 30th March 2003. The vertical lines show times when readings of electrical conductivity and water absorption were taken.There was no rainfall during this period. Data from Met. Office.



4.1.11.5 Conclusions

- Mortar permeability varied over the gable. Permeability in some areas was within normal limits for 1:1:6 mortar, but many areas had higher (or much higher) permeability.

- Most water movement into and out of the gable is likely to be concentrated in areas where the mortar is more permeable. These areas seem to correspond to areas which remain visibly damp for a long time, since measurements of water absorption rates on pointing near ground level suggest that the most porous pointing is located in areas which display dampness for the longest period. These areas can be observed in Plates 4.27 and 4.28. Generally, affected areas are the upper left and lower left and centre of the gable.

- Several areas of cracking of the pointing were also observed. These are likely to provide other routes for penetration of water by capillary action.

- The gable wall and, to a lesser extent, the front façade must be highly saturated with rain water since they remained damp after more than one week without rainfall. This implies that a lot of water is present within the bedding mortar and fill.

- Less porous areas of 'lighter' coloured pointing have water absorption rates consistent with 1:1:6 mortar and within an acceptable range for water absorption. However, some areas are much more permeable and have water absorption rates high enough to lead to problems with water saturation of the interior of the wall.

- The reported rapid penetration of dampness inside the flats after rainfall is consistent with observations of highly porous pointing on some areas of the gable. It has been suggested that the gable wall is thinner in the area where the flats' internal stairway is located, and where most damp problems have occurred. In the lower flat this coincides with an area of apparently porous pointing. The combination of a thinner gable wall with porous pointing is likely to cause more problems in such areas.

- The far left side of the gable near ground level was found to be dry on readings taken on the 'lighter' coloured mortar. However, detectable dampness on the 'darker' mortar patches in this area may indicate that the subsurface and bedding mortar in this area remains damp.

- Excessive water absorption will lead to a build up of water in the pointing and bedding mortar as the gable will absorb more water than it can easily lose by evaporation. It is clear that the interior of some areas of the gable must have become very wet, probably saturated. The wettest areas are likely to be those which remain damp on the exterior for the longest period. However, water will be able to flow from saturated areas to drier areas and it is possible that serious dampness may occur over much of the gable interior.

4.1.12 Case study twelve

Damp problems in the 13th century keep at this castle were examined. The tower was originally harled and some remnants of the original harling can still be seen. The walls are very thick and it is likely that these have become saturated with moisture which has easy access to the interior since the loss of the original harling. Moisture will move down through the walls, accumulating at lower levels where the internal problems have been observed.

Plate 4.35 East wall of the 13th century keep at case study twelve. The keep was originally harled and some residue of this can be seen on the left.

Plate 4.36 West wall of the keep. Damp patches can be observed on the lower parts of the wall.

Plate 4.37 North wall of the keep.

Plate 4.38 Outer wall of keep.

Plate 4.39 Roof of keep. The roof is well maintained and drainage is provided to minimise rainwater penetration into walls.

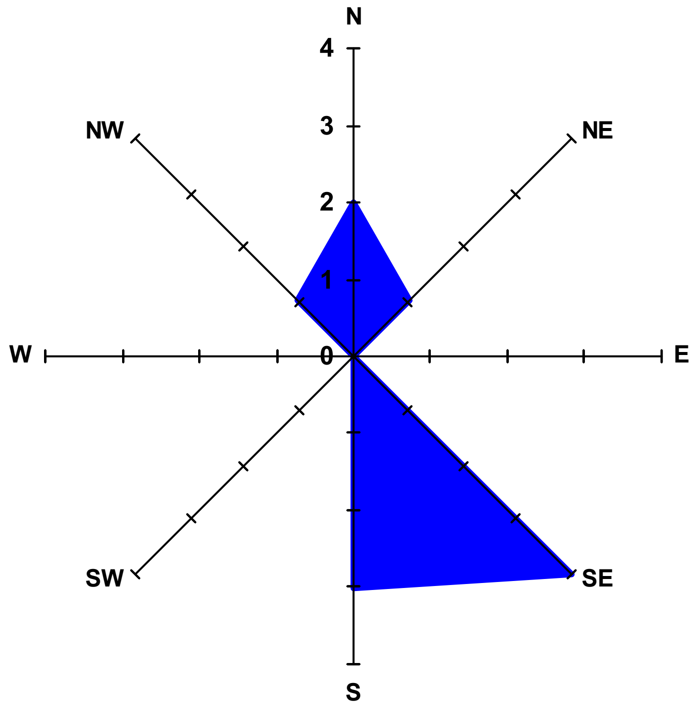
Plate 4.40 The adjoining 17th century mansion house is harled.

4.2 Discussion of case studies

Facing direction

There was no indication that damp problems were related to any particular facing direction, although the number of building studies was rather too small to draw any definitive conclusions. Figure 4.10 shows the facing directions of walls where damp problems were located. There was no indication of any domination by prevailing wind direction.

Figure 4.10 Facing direction of damp problems in case study façades



First occurrence of dampness

With respect to the timing of reports on dampness problems, as far as can be ascertained, most reports of dampness date from within a few months or years of refurbishment or other major interventions on the façade (Figure 4.11). This may imply a link between certain interventions and occurrence of dampness problems; however, although there may be no known reports of prior damp problems, it is not necessarily clear that these did not exist prior to intervention on the façade. Even where dampness problems do occur following interventions, the connection between any one intervention and later dampness cannot be unambiguously determined at this stage.

Association between building features and damp problems

In the case study buildings, the location of damp shows a clear association with end gables and the presence of flues (Figure 4.12). However, given the purpose of this report, there may have been some bias towards selection of buildings displaying dampness associated with gable walls. It is also normal for gable walls to contain flues. Despite the potential bias in the sample, it seems clear that damp problems do often occur in this location. Often the problem becomes apparent when moisture begins to bridge across from the external to the internal wall. In some instances bridging is across dooks; often it occurs across accumulations of debris within the wall cavity. Mortar samples were not analysed; however, visual inspection suggested a number of cases where the hardness and impermeability of repointing mortar may be causing problems for walls; cracking can provide access routes for rainwater, low porosity can restrict moisture evaporation internally, excessive hardness can accelerate decay of the stone.

Figure 4.11 Dates of refurbishment or other major intervention on façades and the first known report of dampness problems.

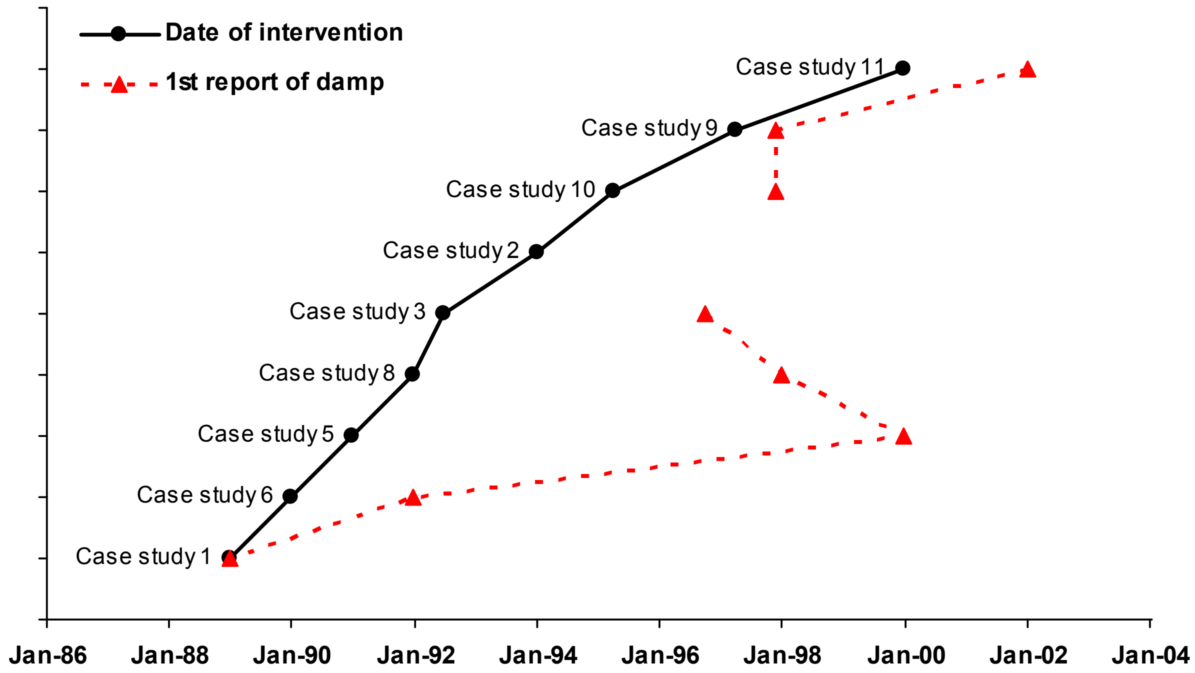
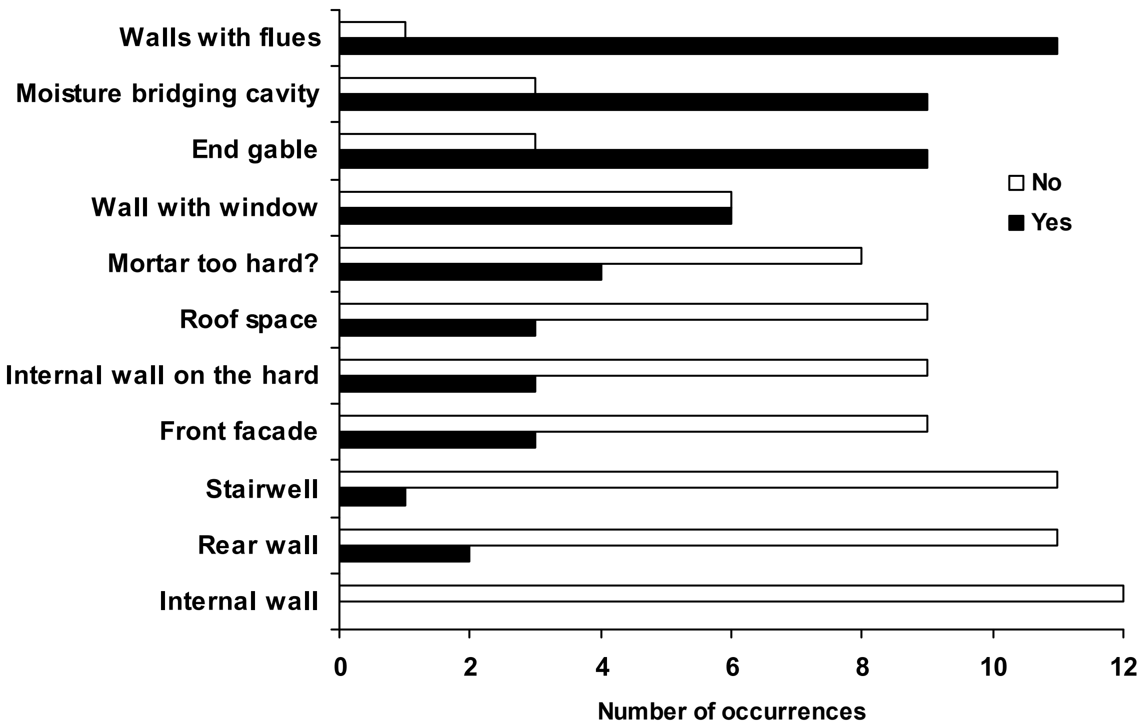


Figure 4.12 Association between building features and occurrence of damp problems.



4.3 Discussion of field studies results

Based on the above case studies, there are some initial observations that can be made:

1. Many of the damp problems in the surveyed buildings date from a short time after refurbishment or other major interventions were carried out.
2. There is an association between dampness and walls containing flues (capped or uncapped).
3. Dampness on internal walls is often transmitted by bridging debris in the wall cavity.
4. The bedding mortar is in poor condition in many properties.
5. Deteriorated bedding mortar can be dislodged by mechanical tools used during raking out prior to repointing. This debris accumulates in wall cavities.
6. The low permeability and excessive hardness of some pointing mortars may make a significant contribution to damp problems by preventing adequate drying of bedding mortar and wall cavities.
7. Some moisture penetration problems can be attributed to building defects including faulty guttering and downpipes, failed skews and the absence of a tilted fillet at coping.
8. Many damp problems have no obvious single cause.

Causes of damp problems

The case studies undertaken during preliminary investigations indicated a number of actual and potential causes of damp problems in granite gable walls. Clearly established problems included:

- blockage of downpipes and/or gutters,
- improper grading of runs on gutters,
- failed skews, tilted fillets or other roofing defects.

More often, the cause or causes of damp problems could not be clearly established by visual inspection. The source of moisture may be external (rainwater penetration) or internal (condensation) and problems may be exacerbated by inadequate provision for evaporation or drainage of moisture from wall cavities and by moisture bridging to internal surfaces.

Potential contributing factors to **moisture penetration** include:

- roofing defects,
- defects in control of rainwater run-off,
- cracks in pointing allowing penetration of rain water,
- deterioration of bedding mortar, especially around flues where acidic flue gases can attack lime mortar, leading to the development of cavities in walls,
- problems with external detailing, e.g. ribbon pointing or string courses which reduce rainwater run-off and may direct water into the wall,
- uncapped chimneys,
- porous stone.

Potential contributing factors to **condensation in wall cavities** include:

- hard, impermeable pointing on façade exterior which reduces drying of wall,
- changes from coal fires to gas fires and effects on water vapour production,
- properties of flue liners (e.g. diameter, deterioration of liners or joints),
- inadequate ventilation of capped flues leading to excessive condensation,
- absence or inadequate ventilation of blocked off fireplaces,
- inadequate ventilation and/or heating of rooms.

Potential contributing factors to moisture penetration on **internal walls** include:

- moisture penetration of solid wall - plaster on hard,
- moisture bridging across wall dooks,
- moisture bridging across debris accumulations in cavity. Significant accumulations of debris in wall cavities appear in some cases to be attributable to decayed bedding mortar, loosened by mechanical raking out of pointing.

In the ten buildings assessed during this survey, no single overriding cause of damp problems could be determined. Where dampness cannot be clearly linked to an obvious building defect, it seems likely that a number of contributing factors come together to cause the problem.

Dampness often comes to the notice of home owners when it penetrates internal walls across dooks or accumulations of bridging debris. While this may be the route of penetration of moisture to internal surfaces, the source of that moisture it is not clear. Root causes may be either penetration of rainwater or build up of condensation. Different buildings may experience either or both of these problems.