LOWESTOFT TOWN HALL

ROTHOUND INVESTIGATION OF DRY ROT INFECTION AND DECAY

JOB NO. 158-97

LOWESTOFT TOWN COUNCIL

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1 INTRODUCTION

1.1 AUTHORITY AND REFERENCE

Hutton+Rostron Environmental Investigations Limited carried out a preliminary timber decay and damp survey at Lowestoft Town Hall on 26-27 June 2023 in accordance with instructions received from Jorge Moreira of Richard Griffiths Architects by email dated 12 June 2023 (17:39) on behalf of Lowestoft Town Council. Reference was made to drawings supplied by HAT Projects, reference series; 194_HAT_EX for the identification of structures. For the purpose of orientation in this report, the building was taken as facing east onto High Street

1.2 AIM

The aim of this investigation was to determine the probable extent of dry rot (*Serpula lacrymans*) infection and decay and to identify associated defects and latent defects; so that advice can be given suitable for Stage 1 risk management, planning, and QS purposes on cost effective remedial measures to allow the conservation of historically important material, and the refurbishment of a building for sustainable safe use and occupancy, with the minimum risk of damp and decay related problems and maintaining the capital value of the building as discussed in Appendices A, B, C & D

1.3 LIMITATIONS

This survey was confined to the accessible structures. Concealed timbers and cavities have been investigated where necessary by the use of high-powered fibre optics, thermal imaging or Rothounds. The condition of concealed timbers may be deduced from the reactions of the Rothounds or from the general condition and moisture content of the adjacent structure. Only demolition or exposure work can enable the condition of timber to be determined with certainty, and this destroys what it is intended to preserve. Specialist investigative techniques are therefore employed as aids to the surveyor. No such technique can be 100 per cent reliable, but their use allows deductions to be made about the most probable condition of materials at the time of examination. Structures were not examined in detail except as described in this report, and no liability can be accepted for defects that may exist in other parts of the building. We have not inspected any parts of the structure which are covered, unexposed or inaccessible and we are therefore unable to report that any such part of the property is free from defect or, in the event that such part of the property is not free from defect, that it will not contaminate and/or affect any other part of the property. Any design work carried out in conjunction with this report has taken account of available pre-construction or construction phase information to assist in the management of health and safety risks. The sample remedial details and other recommendations in this report are included to advise and inform the design team appointed by the client. The contents of this report do not imply the adoption of the role of Principal Designer by H+R for the purposes of the Construction (Design and Management) (CDM) Regulations 2015. No formal investigation of moisture distribution was made

1.4 H+R STAFF ON SITE
Andrew Ellis
Patrick Hughes
Isabel Mar
'Pip' the Rothound

1.5 PERSONNEL CONTACTED

Sheila Moss King- MossKing Associates Limited
Jorge Moreira - Richard Griffiths Architects
Hana- Lowestoft HAT Projects

2 EXECUTIVE SUMMARY

1 Overview: Dry rot infection (*Serpula lacrymans*) was determined to be affecting approximately 3no. distinct zones to Lowestoft Town Hall Buildings stemming from failures to the external envelope at roof level and allowing decay zones to 'cone' outwards down through the height of the building. All embedded and near proximity timbers within the dry rot infected 'zones' remain highly vulnerable to ongoing decay organisms now and under future occupancy. Severe structural decay is anticipated to concealed timbers within the floor as well as to lintels units

2 Active decay: The greater majority of timbers showed deep moisture contents throughout the Town Hall in the region of 10-12 per cent, which is too low for decay by wet rot infection. However, timbers in close proximity to the designate dry rot infected areas often showed deep moisture contents between 15-22 per cent and surface moisture contents often in excess of 20-22 per cent, which is high enough to re-activate any historic/dormant dry rot infection that exists within the masonry. These high levels of moisture readings were considered of increased significance as the survey was conducted during a particular long spell of dry/warm weather when typically, properties have an opportunity of marginal 'drying down'. It was therefore assumed that the majority of identified dry rot decayed timbers were deemed to be representative of active outbreak further exasperated by poor internal environments to unventilated voids

4 Structural decay by dry rot: Structural decay (25-50 per cent of total section) was determined to have occurred to multiple timber elements throughout the property. These were identified on site via water soluble red spray paint and are shown on Plans to Appendices G. Further extensive decay is anticipated to concealed timber elements. Areas of presumed concealed active and potentially structurally significant dry rot infection to vulnerable timbers have been identified on site via red water-soluble spray paint demarking proposed areas of 'openings' and are indicated on Plans to Appendices G. In the view of H+R, accessible floor structures did not appear to be vulnerable to imminent failure/collapse, although the structural capacity may be compromised beyond reasonable allowance to specific areas subject to further verification/inspection post proposed opening works. Structural Engineer to comment

5 Source of water penetration: They was no access to inspect the external roof envelope at the time of investigation. Therefore, the probable source of historic and/or recent water penetration to the property could not be determined with accuracy. Although, it was noted at the time of investigation that presumed chronic failure to the parapet gutters to the south and east elevations to the roof, as well as to the south-east area to the central lightwell are considered to have been highly vulnerable points of failure/water penetration in the past. It can therefore be surmised that roof, floor, lintel and internal joinery elements adjacent to these perimeter walls have been vulnerable to decay in the past and may contain dry rot infected masonry and timbers

In the view of H+R, the existing timber structures (including roofs, lintels and floor elements) designated to be in contact to damp zones/areas vulnerable to dry rot infected masonry are not suitable for retention in their existing condition/detailing. All embedded timbers to damp affected walls remain highly vulnerable to further/ongoing *decay. In particular, should the existing dry rot issues go unchecked for an additional winter season of 2023-24, then it is highly probable that existing zones of decay will continue to expand, coning outwards down the building with significant further loss to historic fabric. Further to this. Historic and unverified areas of inactive dry rot are therefore also liable to becoming reactivated from any future water penetration issues both from failed external envelope to the property. Additionally, the extent of concealed decay to embedded timbers remains unverified and therefore it remains highly probable that structurally significant decay exists. Structural Engineer to comment*

Allowance should therefore be made for all vulnerable concealed timbers to be exposed and investigated. This will necessitate the careful removal of perimeter floor boards and finishes to investigate floor structures as well as wall plaster/linings to determine the construction and condition to lintels within compromised and dry rot infected masonry. All structurally decayed timbers may then be partner repaired or cut out and replaced in new. All remaining/new timbers should be detailed so as to be separated from vulnerable or potentially vulnerable dry rot infected masonry to a specification agreed to by the H+R and the Structural Engineer. Consideration should also be given to replacement to vulnerable suspended timber ground floor structures in solid variants such as block and beam so as to de-risk latent decay issues and to facilitate ongoing ventilation to the sub-floor voids

3 OBSERVATIONS AND RECOMMENDATIONS

3.1 DRY ROT

The H+R Rothounds are air scenting dogs that are trained to detect dry rot in buildings. The use of specially trained air-scenting dogs can result in a more comprehensive coverage of a building than surveyors would achieve working on their own. Such Rothounds have even been known to find dry rot missed by a building surveyor. The dog is trained to give specific passive indicators when they detect dry rot in a building. A Rothound's ability to detect dry rot before it is detectable by conventional means may allow for the retention of original timbers before their structural integrity is compromised.

The H+R Rothound dry rot search dog gave 6 no. positive 'indications' of active dry rot. The H+R Rothound also showed interest in 2 no. areas suggesting old dry rot decay or wet rot decay. These areas were subject to chronic water penetration and all timber elements in these areas which were built into the brickwork were very vulnerable to decay before and after any future refurbishment. (See drawings at Appendices G for locations)

Dry rot (Serpula lacrymans) is a geophilic fungus that lives in damp masonry subject to chronic water penetration, and decays softwood timber elements built in contact with or in close proximity to the infected masonry. Dry rot mycelium can also grow behind impermeable surfaces, such as polythene or linoleum flooring and into unventilated building voids with high relative humidities. Dry rot infection can persist in infected masonry for many decades or even centuries, and will spread or die back depending on the environmental condition. When stressed, the fungus produces 'fruiting bodies' and many millions of fine light brown spores which spread to new locations through the atmosphere. However, very few spores ever germinate and grow to result in further infection. Dry rot in buildings is therefore almost always found associated with chronic problems of water penetration from defective roof drainage; but may persist or spread locally due to water penetration from other sources; such as defective ground and surface drainage, failure of damp-proofing and plumbing leaks. Problems with dry rot are therefore often found 12 to 24 months after refurbishment of previously infected structures, even when 'chemical remedial or preservative treatments' have been undertaken; as a result of water penetration during works and inadequate provision for ventilation and drying of affected structures

1 *Chemical remedial treatment: No further chemical remedial timber treatments or wall irrigations are required*

2 *Repair and isolation of timbers: Decayed, partially decayed or at-risk timbers should be repaired or replaced as necessary as directed by the Structural Engineer, and reinstated separated from damp or potentially damp or dry rot infected masonry with a damp-proof material or through ventilated air gap using a detail approved by H+R*

3 *Retention of infected and partially decayed timber elements: Existing timber elements that have been infected and partially decayed by dry rot in the past may be retained on refurbishment without any chemical remedial treatment, provided they are structurally adequate, and are separated from damp or potentially damp masonry with a damp-proof material as described at 2 above; and that all practical measures are taken so as to prevent water penetration on future occupancy as described at 3.2 below*

3.2 WATER PENETRATION PROVIDING THE CONDITIONS FOR DRY ROT INFECTION AND DECAY

The structures at Lowestoft Town Hall had been subject to chronic problems of intermittent water penetration since original construction providing conditions for localised infection and decay by dry rot at different times in different areas depending on maintenance and occupancy. In particular there was evidence of chronic problems of water penetration from defects to parapet gutters, and to associated roof drainage, to hoppers and rainwater downpipes to the main building and to the north range; and there was evidence of chronic problems of leaks and overcharging from eaves gutters. This had provided conditions for infection and decay by dry rot down through the structures beneath as described at 3.1 above. There was also a history of water penetration subsequent with intermittent maintenance and occupancy providing the conditions for persistent damp and decay. There was evidence of extensive patch repair to roof surfaces and to roof drainage systems in recent years. However, these remained very vulnerable to leaks and to blockage and overcharging; and only limited provision had been made for safe and convenient access to allow inspection and maintenance. It is therefore highly likely that the structure will continue to be subject to intermittent water penetration issues providing the conditions for dry rot infection and decay before, during and after refurbishment works

The original building had been constructed with 'grilled' horizontal vents around the base of walls and foundations, and with other drainage systems so as to minimise moisture penetration at and below ground floor level. However, these had been poorly maintained, overpainted and damaged on previous occupancy and refurbishments. Further to this, external ground levels had been improperly raised in relation to existing provisions for sub-ground floor ventilation and damp-proof courses, allowing evident chronic problems of water penetration to the base of walls at ground and basement levels as well as to the foundations in many areas. In particular to the north-east area. This will allow dry rot infection to persist within the affected masonry for the foreseeable future, despite any practical remedial measures as described at 3.1 above

Chimneystacks appeared to be largely removed or capped, however it was suspected that enduring stacks remained open/uncapped and in poor condition and likely to allow water penetration during wind driven rain. This will also provide the conditions for decay to timber elements built in contact with chimneystacks down through the structures beneath

1 *Access: Provision should be made for safe and convenient access to all roofs and roof drainage systems before, during and after refurbishment; so as to facilitate inspection and maintenance and minimise the risk of further water penetration. This may be achieved by introducing permanent roof access hatchways onto the main north and south ranges to gain expedient and practical access to the perimeter parapet gutters*

2 *Monitoring: Consideration should be given to installing electronic radio telemetric gutter water level monitoring and alarm systems as an aid to project and facilities managers before, during and after refurbishment. H+R can advise further when required*

3 *Roof surfaces and roof drainage: With immediate effect, all roof surfaces and roof drainage systems should be inspected in detail, and swiftly patch repaired as necessary so as to minimise the risk of further water penetration before and during refurbishment. On future refurbishment allowance should be made for replacing all existing roof surfaces (a proportion of historic slates may be considered suitable for retention/relaying subject to further investigation), gutter linings and roof drainage systems with new detailed so as to be 'fail safe' and so as to facilitate inspection and maintenance on future occupancy. Consideration should be given to temporary roof drainage before and during refurbishment; so as to discharge water clear of the structures beneath before and during refurbishment and promote drying-out of the property during envisaged low occupancy and refurbishment. H+R can advise further when required*

4 *Residual moisture providing conditions for persistent dry rot infection: Consideration should be given to undertaking comprehensive moisture and salt profiling throughout the building to identify areas of significant residual moisture and salt within the masonry masses likely to provide the conditions for persistent dry rot (Serpula lacrymans) infection and decay and damage to vulnerable materials and finishes following the methodology described in BRE Digest 245. H+R can advise further if required. In particular masonry masses beneath parapet gutters and adjacent to rainwater downpipes should be investigated in detail, and existing provision for damp-proofing at and below floor level should be investigated in detail. H+R can advise further when required*

5 *Ground and surface drainage: Existing provision for ground and surface drainage should be inspected in detail using CCTV, mapped and cleared as necessary. consideration should be given to providing effective temporary ground and surface drainage so as to drain water clear of the structures before and during refurbishment as directed by a Structural Engineer. On refurbishment allowance should be made for relaying existing provision for ground and surface drainage with new throughout detailed so as to drain water clear of the base of walls and foundations. This should be inspected using CCTV and 'certified' as clear by the Project Managers at completion and should be detailed so as to facilitate access for inspection and maintenance. In particular improperly raised external raised ground levels to the north and east elevations should be lowered to a minimum 150mm below the existing provision for a damp proof course*

6 *Inspection and maintenance of roof and surface drainage systems: All existing temporary and refurbished roof and surface drainage systems should be inspected and repaired or cleared as necessary daily during planned refurbishment works. After refurbishment all roof and surface drainage systems should be inspected and cleared as necessary at least three times a year as part of routine maintenance*

7 *Accelerated drying: Consideration should be given to accelerated drying of damp affected structures identified as described above before and during refurbishment; so as to meet the programme requirements. H+R can advise further if required*

8 *Long-term drying: consideration should be given to recladding structures identified as having high residual moisture content and/or vulnerable to further water penetration with insulated and vented dry-lining details; so as to allow dissipation of moisture and hygroscopic salts on future occupancy while preventing the conditions for dry rot infection and decay, or damage to vulnerable materials. H+R can advise further on detailing when required after detailed investigation as described above*

9 *Chimneystacks: Any remaining chimneystacks should be inspected in detail and repaired as necessary when full safe access is available prior to re-roofing works; so as to minimise the risk of further water penetration and so as to allow long-term drying. In particular redundant flues should be capped so as to minimise water penetration but allow continued through ventilation by the passive stack effect*

10 *Facades: Facades should be inspected in detail and repaired so as to effectively drain wind-driven rain away from the property and vulnerable structures within. In particular, unleaded cornices and cracking masonry/lintels as well as failed/soiled pointing local to historically problematic downpipes were deemed highly vulnerable to persistent damp penetration and decay issues*

3.3 INTERNAL ENVIRONMENTS PROVIDING CONDITIONS FOR DAMP AND DECAY

Internal environments at Lowestoft Town Hall had generally been controlled since original construction by low level of structural heating to masonry masses and ventilation to interiors by the ‘passive stack effect’ by the use of the open fires and chimneys. This had been supplemented by ‘background ventilation’ and ‘purge ventilation’ via sash windows; and heating had been supplemented in the 20th century by use of hot water central heating systems in particular on the lower floors. This had allowed dissipation of moisture penetrating the structure from the exterior and introduced with occupancy in the past. However, intermittent occupancy and improper maintenance in the 20th and 21st century had provided conditions for condensation, mould growth, damp and decay in unoccupied and poorly heated and ventilated structures. This would have allowed the persistence and spread of dry rot as described above. There did not appear to be any formal provision for structural heating or increased ventilation during the properties existing state of reduced occupancy. During the early winter months this is likely to be providing the conditions for severe localised ‘warm front’ condensation, where warm moisture laden air from the exterior enters the building and condenses on relatively cold masonry masses. Existing central heating systems also appear to be decommissioned. This will limit drying of residual moisture within the fabric as described at 3.2 above. Additionally, there did not appear to be sufficient provision for adventitious ventilation to existing roof structures allowing interstitial condensation issues to form widespread mould spores to the underside of rafters and sarking elements which may lead to both respiratory health issues to due to previous exposure works. However, inadequate provision had been made for long term ventilation

1 *Background ventilation: Provision should be made for through and cross ventilation to all rooms and building voids before, during and after refurbishment; so as to allow drying, minimise the risk of condensation, and prevent the conditions for dry rot mycelial growth*

2 *Windows: All existing windows should be repaired, refurbished or replaced as necessary including provision for ‘trickle ventilation’ and/or window catches to allow them to be securely locked in a partially open position, and allow through and cross ventilation to all areas before, during and after refurbishment*

3 *Ventilation to roof structures: After consultation with the conservation officer, consideration should be given to carefully recording and removing vulnerable ceilings and soffits beneath existing roofs at an early stage during enabling works; so as to allow access to the structures above for decontamination, ventilation, inspection, conservation and repair as necessary; and so as to facilitate the installation of insulation and surfaces on refurbishment as well as permanent access pathways to roofs structures and drainage areas above*

4 *Ventilation to roof structures: On refurbishment all existing roofs should be refurbished as ‘Insulated and Through Ventilated Cold Roof Structures’ fully in accordance with the requirements of current Building Regulations. ‘Warm roof structures’ should be avoided*

5 *Fireplaces and flues: All original fireplaces and flues should be identified, opened, cleared as necessary and provided with through ventilation before, during and after planned refurbishment. Flues intended for continued use should be fitted with wind and weatherproof cowls. Redundant flues should be capped so as to minimise water penetration but including provision for through ventilation to the interior or into roof voids. Consideration should be given to utilising redundant flues as passive stack vents and/or risers from basement to roof level so as to facilitate refurbishment and sustainable occupancy*

6 *Structural heating: Consideration should be given to installation of cost effective and sustainable heating to the structure of the building during and after future refurbishment. In particular consideration should be given to providing a low level of*

continuous structural heating to the lower floors as necessary using radiant heating systems. Intermittent air heating should be avoided. H+R can advise further after computer modelling if required

3.4 DECAYED TIMBERS AND PREVIOUS REMEDIAL TREATMENTS

There was evidence of extensive structural decay to existing timbers in many areas on preliminary inspection at the time of survey. There was also evidence of repeated remedial treatments and repairs many of which may not be structurally adequate to carry the loads to be expected before, during and after refurbishment. In particular, there was evidence for the localised replacement to the bearing ends of trusses, purlins, underlying wall plate and lintels in areas subject to chronic problems of water penetration and dry rot infection and decay in the past as described at 3.1 and 3.2 above and as shown on drawings at Appendices G are highly likely to have been decayed or partially decayed or remain vulnerable to decay. This may allow structurally significant movement as timbers settle and/or shrink with heating and drying on occupancy, and with the change in distribution of loads to be expected with refurbishment. Roof spaces and other building voids appear to be heavily contaminated with dust and debris from previous refurbishments. This was likely to contain residues from previous chemical remedial timber treatments, insecticidal treatments, lead oxides, mould spores and fragments, and other potentially irritant or hazard particulate matter. There may also be residual asbestos containing materials within the dust. This will represent a potential health hazard to those working on or occupying the building before, during or after future refurbishment

1 *Roof timbers: Bearing ends of roof trusses and underlying plates should be inspected in detail by deep drilling and probing when safe and convenient access is available so as to determine their current decay state and deep moisture content. Consideration should be given to carrying out these preliminary inspections as soon as practical, and undertaking detailed inspection in conjunction with the Structural Engineer after exposure by removing ceilings and soffits beneath as described above. H+R can undertake this task if instructed*

2 *Lintels and lintel wall plates: The structure and condition of all lintels and lintel wall plates should be determined as by deep drilling and probing. In particular, lintels and lintel wall plates on the upper floors beneath parapet and valley gutters as well as basement lintels should be inspected as soon as possible so as to determine their decay state and structural adequacy to carry the loads to be expected before, during and after refurbishment. H+R can undertake this task if instructed*

3 *Floor timbers: The structure and condition of all floor timbers including provision for principal beams, joists, ceiling joists, secondary beams and wall plates should be determined by deep drilling and probing as soon as possible so as to determine their decay state and structural adequacy to carry the loads to be expected before, during and after refurbishment. In particular to areas within the designated dry rot 'zones' identified on the Plans to Appendices G*

4 *Contaminated dust and debris: In conjunction to further proposed opening works, allowance should be made for tandem R&D asbestos surveys to newly opened voids in accordance with the Control of Asbestos regulations. Consideration should be given to removing all potentially contaminated dust and debris from roofs and other building voids as soon as practical. Those undertaking this task should be provided with appropriate respiratory protection, gloves and protective clothing; and all practical measures should be taken so as to prevent potentially contaminated dust entering occupied air spaces before, during or after works*

5 *Conservation enabling works: Consideration should be given to removing all ceilings and soffits beneath existing roof structures so as to allow for effective decontamination works;*

and to facilitate access for inspection, conservation, repair, and for installation of insulation and services, so as to allow sustainable occupancy. Works should only be undertaken after consultation with the Conservation Officer

6 *Vulnerable secondary timbers: Provision should be made for all vulnerable secondary timbers remaining within designated dry rot 'zones' to be documented and carefully removed, recorded and safely stored in conjunction to dry rot remedial actions as stated at 3.1 and 3.3 above. These should eventually be re-instated so as to be separated from the potentially harmful masonry structures via a damp proof membrane and/or a ventilated air gap. Secondary timbers include panelling, windows, skirting, architraves, doors and floorboards adjacent to dry rot affected walls. Works should only be undertaken after consultation with the Conservation Officer*

5 GENERAL RECOMMENDATIONS

All new and refurbishment detailing should be assessed for its effect on environmental and structural health. General principles are set out below. Special care is required when introducing new materials, moisture sources or heating and ventilation systems, for example air conditioning

5.1 ROOF AND SURFACE DRAINAGE

5.1.1 Maintenance

All guttering, hopperheads and outlets should be regularly checked and cleared to keep them free of debris, especially during the autumn months

5.1.2 Protection

Hopperheads, gutter outlets and ground gullies should be protected with metal mesh cages so as to prevent blockage and overflow. These should extend higher than the expected water level to reduce the tendency to block and should be easily removable to allow cleaning and maintenance

5.1.3 Overflows

Hopperheads, parapet gutter outlets and valley gutter outlets should be fitted with overflow pipes to drain water clear of the structure in case of blockage. These should be at a level below that at which water would overflow the roof flashings

5.1.4 Roof drainage calculations

Roof drainage calculations should be made to check the adequacy of gutters, drains and downpipes so that their capacities may be increased if necessary during refurbishment. H+R can carry out these calculations if required

5.1.5 Monitoring

The installation of an automatic monitoring and alarm system should be considered to give warning of blockage or overflow in the roof drainage system

5.1.6 Access

Safe and convenient access ladders, safety points and walkboards should be installed to all roof areas to allow proper inspection and maintenance

5.1.7 Pigeons

Feral pigeons should be controlled. H+R can give advice on this if necessary

5.2 VENTILATION

5.2.1 Structural voids

All structural voids within the building should be provided with adequate through ventilation so as to prevent moisture build-up. This must be done with regard to the applicable fire regulations

5.2.2 Chimneys

All chimneys not in use should be capped so as to minimise water ingress but so as to allow maximum ventilation of the flues. Flues should be cleared and cleaned to remove blockages. Fireplaces and chimney breasts should be opened or vented to allow through-ventilation of the flues. This prevents moisture build-up in the flues and helps interior ventilation by the stack effect

5.2.3 Bathrooms and kitchens

All bathrooms and kitchens should be fitted with adequate extractor fan systems. These should run for at least fifteen minutes after occupancy to prevent condensation. The installation of floor drains should be considered in these rooms in case of overflow

5.2.4 Roof spaces

All roof spaces, including flat roof areas and gutter soles, should be provided with adequate through-ventilation. This may occur via the gaps between slates in unsarked pitched roofs. However, flat roofs and pitched roofs with sarking or insulation will require the installation of vents through the roof surfaces or at the eaves and ridges. Insulation material in roof spaces should be kept clear of external walls, gutter soles or timbers in contact with damp or potentially damp masonry

5.2.5 Windows

Windows should be refurbished so as to allow easy and convenient opening and closing by occupants in order to encourage proper ventilation of the building. This is important both for environmental and structural health. Windows should be fitted with security locks so as to allow secure locking in a partially opened position

5.3 STRUCTURAL DETAILING

5.3.1 New timbers

New timbers should be isolated from any damp or potentially damp masonry with a damp-proof material or ventilated air gap

5.3.2 Timber repairs

Structurally decayed timbers should be removed or cut back to sound timber unless required for aesthetic reasons. Timbers should then be partnered or spliced as in section 5.3.1 above. If steel plates or hangers are used, they should be detailed so as to allow sufficient ventilated air gaps and drainage to prevent moisture build-up due to condensation. No timber preservation or remedial treatments should be required

5.3.3 Paint finishes

Moisture vapour permeable or 'microporous' paint finishes should be preferred for internal and external surfaces and woodwork. This is especially important on window timbers. To take advantage of the properties of such paints, the complete removal of old alkyd paint systems is recommended. Health and Safety: Special precautions should be taken during surface preparation of pre 1960's paint surfaces as they may contain harmful lead or other toxic materials

Appendix A

COMMON DECAY ORGANISMS

1 DRY ROT

Dry rot (*Serpula lacrymans*) belongs to the same group of fungi as most of the common mushrooms and toadstools. Reproduction is by means of spores which are produced in enormous numbers by the fleshy pancake-shaped fruiting body. These fruiting bodies generally only appear when the fungus is stressed or dying off. A well established infestation may produce fruiting bodies more than one metre across and be accompanied by thick layers of rust-coloured spore dust. Each minute spore has an outer coat which affords it some protection against heat and desiccation, and germination has been achieved after a twenty-year latent period. Dry rot spores are ubiquitous and there is no domestic or natural environment entirely free of them. They can be found throughout the environment from high up in the jet stream to the middle of the countryside

Spores will germinate and grow in timber with a moisture content of between 20 and 30 per cent. The fine fungal thread (hypha) digests the cellulose and hemi cellulose fractions of the wood, but is unable to attack the structural linings. These remain as a brittle matrix which cracks into cubes under differential stresses. Cuboidal cracking is also a characteristic of many wet rots and does not automatically indicate the presence of dry rot

Fungal hyphae may clump together into a variety of structures known as mycelia which take various forms depending on the surrounding conditions. They may fill a humid cavity as a cotton wool-like mass, or grow across the surface of the timber, as a grey-white skin. Active dry rot has a fresh white or greyish appearance and smells strongly of mushrooms. Distinctive patches of lilac or canary yellow pigmentation are usually present

Some hyphae group together to form conducting strands. These have a fairly impervious outer layer rich in chitin, the major constituent of insect cuticle. The strands, which may reach a centimetre in thickness, are flexible when moist, becoming progressively more brittle as they dry out. Their main function is the conduction of nutrients, through or across inert non-nutrient materials (brickwork etc) to other timbers. Their relatively impervious outer layer, together with an unusual alkaline tolerance, allows them to survive in the mortar layers within masonry and walls. An infested area may be full of dry rot strands. The dry rot fungus may tolerate relatively lower moisture contents and, through this, and other quirks in its biology, is potentially capable of considerable destruction. Realisation of this potential, however, requires a narrow range of environmental conditions and, in practice, several factors restrict growth

Dry rot hyphae may attack timber with a moisture content of about 18 per cent; however, spores would not germinate under these conditions. This moisture content is still 5 to 10 per cent wetter than timber should be in a healthy domestic building, and indicates water penetration or, perhaps, faulty plumbing. There is no evidence that dry rot can 'wet up' timber to any appreciable extent under conditions expected in a healthy building, although this is often claimed. The fine attacking hyphae, unlike the coarse conducting strands, are susceptible to desiccation and dry wood may disperse moisture faster than it can be transported. This means they cannot move through dry masonry and wood or across ventilated cavities

The total breakdown of wood by fungus produces considerable quantities of water. It has been suggested that dry rot can sustain itself on this 'metabolic' water alone. However, in practice, external drying factors disperse the moisture so that favourable conditions can be maintained only in exceptional circumstances such as behind impermeable finishes or in sealed cavities

In order to thrive, dry rot requires a moisture content in timber in excess of 20 per cent, and a relative humidity above 95 per cent. Below these levels the fungus will cease to cause current decay problems. Temperature is also a strong regulating factor, and growth ceases at about 25^{o}C, a temperature frequently exceeded in roof spaces, for example. Large radiators can be particularly lethal to dry rot and measurements of 30^{o}C with 20 per cent relative humidity are not unusual in their immediate vicinity

Dry rot is attacked by many other decay organisms which cause particular damage when the fungus is under stress will eventually destroy it. However, under dry conditions, dead dry rot does not disappear. Strands may eventually darken and the fungal mats may lose their fresh appearance, becoming tinged with brown, and leathery or papery in texture. The decayed wood becomes powdery as it dries, shrinks and distorts, which can be the first sign of decay having occurred behind paint finishes

2 WET ROT

Wet rot is caused by a number of basidiomycete fungi of which the most important are *Coniphora puteana* (cellar fungus), *Poria fungi*; *Fibroporia vaillantii*, *Poria placenta*, *Amyloporia xantha*, *Geophyllum trabeum*, *Phellinus contiguus*, *Donkiporia expansa*, *Pleurotus ostreatus*, *Asterostroma* and *Paxillus panuoides*. They attack both softwoods and hardwoods causing a darkening of the timber (brown rot) or bleaching (white rot). Wet rot fungi usually occur in persistently damp conditions, needing an optimum moisture content of 50 to 60 per cent. Unlike dry rot, the conducting strands of wet rot fungi do not extend far from their nutrient wood, hence they cannot travel through masonry and brickwork. The fruiting bodies occur rarely in buildings. Wet rot has been known to hollow out giant beams. Wet rot *Coniphora puteana* is responsible for up to 90 per cent of wood decay within buildings but raises less concern than dry rot, possibly because it is more easily controlled by standard building techniques. Some wet rots are also called soft rots as they destroy both cellulose and lignin, leaving the colour of the wood largely unaltered, but producing a soft felty or spongy texture. Soft rot is caused by *Chaetomium globosum* and a number of other fungi also found growing on wet wood in buildings

3 WOOD-BORING INSECTS

The common furniture beetle (*Anobium punctatum*) has a life cycle consisting of four stages - egg, larva (which causes all the damage), pupa and adult. The eggs are laid in end grain or in existing flight holes and hatch in 4 to 5 weeks and the new larvae bore directly into the wood. The larvae feed and grow within the wood creating a network of tunnels closely packed with frass (small ellipsoidal pellets). The larvae are whitish, curved, approximately 6mm in length and have well defined dark-brown jaws. When fully grown the larva excavates a small chamber and pupates producing a beetle after 6-8 weeks which bores through a thin layer of wood producing the characteristic emergence holes 1-2mm in diameter. Emergence usually occurs between May and August. The life cycle depends on the condition of the wood, the temperature and humidity. The life cycle usually takes a minimum of 3 years within buildings. Attack is usually confined to the sapwood of softwoods and hardwoods but may occur in the heartwood in timbers such as beech, birch, spruce or in timbers modified by fungal decay. As sapwood only makes up a small cross section of the majority of structural timbers in older buildings, attack is often of little or no structural importance. In most instances of suspected attack, the infestation has died out long ago due to unfavourable environmental conditions. Careful checking is therefore required to establish that living woodworm are present

In cases of active infestation the environmental conditions are often marginal allowing the life cycle to continue but at a very slow rate. Small changes in the environmental conditions can tip the balance against insects. Woodworm attack is often very localised to small areas of high humidity or especially 'palatable' timber and further spread is highly unlikely

In the British Isles, death watch beetle (*Xestobium rufovillosum*) infestations occur most commonly in oak, probably because this wood used to be extensively employed in construction, but infestation can also occur in elm, walnut, chestnut, elder and beech. The life cycle is similar to that of the common furniture beetle but can take many years to complete from one year under experimental conditions, to ten years or more in a building (Ref 11). The hatched larvae wander over the surface of the timber before burrowing into it. When it is fully grown it pupates and changes into the adult beetle which does not emerge until the spring of the following year producing a 3mm diameter hole

In old buildings severe damage can be caused under favourable environmental conditions. Softwoods are occasionally infested where they are in close proximity to damp infected hardwood. Infestation is confined to fungal decayed or damp affected timbers. Many existing cases probably arose from the reuse of infected timbers from demolished buildings and from the use of unseasoned timbers used in their construction. Attack is not confined to the sapwood and often the heartwood is entirely consumed causing severe structural damage. Damage is most severe where ventilation is poor and where timbers are in contact with damp masonry

Death watch beetles are not active fliers. A localised attack of death watch will not automatically spread to the whole house and infest every timber in the building. Lowering of moisture contents of the timber in conjunction with careful observation to determine the level and extent of activity should provide control of the insects. Some severe cases may merit the use of local insecticide treatments as a first aid measure. However, the chemical must be targeted properly or large quantities of toxic pesticides will be used to little effect

Woodworm and death watch beetle infestation will not flourish if the moisture content of timber is below about 14 to 15 per cent. The risk of infestation of insect attack is slight, in timbers with a moisture content at or below 14 per cent and the insect larvae will desiccate below about 12 per cent moisture content. The infestation will eventually die out if the timber moisture content is maintained below this. Healthy roof timbers should have a core moisture content of between 14 to 15 percent, while suspended floor timbers should be between about 11 and 14 per cent. Installation of a central heating system may reduce these moisture contents to about 9 per cent particularly in exposed timbers

It is absolutely necessary to recognise whether an insect infestation is 'active' or 'dead'. The presence of fresh frass (bore dust) in conjunction with damp timbers may be acceptable evidence of active infestation

Appendix B

SPECIALIST SURVEY TECHNIQUES AND THEIR LIMITATIONS

1 PRELIMINARY INSPECTION AND INVESTIGATION

The basis of any investigation is an understanding of building structures and defects and how these may interact to produce the ecological niches in which various decay organisms can thrive. With experience, an initial visual inspection can give a good idea of the areas that will need further study. A check-list for this preliminary investigation includes building defects, significant timber structures and concealed cavities

The condition of concealed timbers may be deduced from the general condition and moisture content of the adjacent structure. Only demolition or exposure work can enable the condition of timber to be determined with certainty and this destroys what it is intended to preserve. A non-destructive approach is therefore required and to help reduce uncertainty, specialist instrumentation and test equipment can be useful. However, it is important to remember that all tests and instruments are only aids to the surveyor, and must be interpreted with experience and care. A slavish reliance on any technique and failure to take into account its limitations is a recipe for disaster. No technique can be 100 per cent accurate or reliable

The techniques that may be used for preliminary investigation include resistance-based timber moisture meters, capacitance masonry moisture detectors, borescopes and Rothounds

2 DETAILED INVESTIGATION

The findings from the initial investigations are followed up by more detailed study. The aim is to determine as far as possible the distribution and extent of all significant decay and organisms in the building, the distribution of micro environments predisposed to timber decay and the building defects that cause them. The extent of significant timber decay should also be determined as far as possible. Active decay organisms may not yet have caused significant timber decay. Conversely, there may be significant decay even when the decay organisms that caused it have been dead for many years. This may seem obvious but many expensive 'treatments' are carried out on insect or fungus damaged timber that has not been infected for tens or even hundreds of years. Key factors that may be noted are species and viability of decay organisms, moisture content of materials, ambient relative humidity, and ventilation. Timber species and previous chemical treatments may also be significant

It is important that the results of the investigation are co-ordinated with the building structure bearing in mind the characteristics of particular periods and methods of building. They should also be carefully recorded and quantified where possible. This allows analysis of the results by other experts, reduces the 'grey' area in which disputes of opinion can arise and forms a basis on which future investigations can build. Photography can be especially valuable and may be used when necessary

3 ROTHOUNDS

Rothounds are specialist search dogs trained to help find dry rot (*Serpula lacrymans*) in buildings. Rothounds may indicate areas of active dry rot even before they are visible to the naked eye. This will occur if the dry rot is just developing, is inside the substance of the timber, between the timber and another surface or within porous masonry. Such indications may be confirmed by comparing them with measurements of the moisture content of the structure or by the use of a drilled sample. Rothounds will not indicate the remains of dead dry rot infestations

In areas indicated by Rothounds the significant timber structures should be checked for structural decay or high moisture levels. Even if these are not found steps should be taken to reduce moisture levels and increase ventilation. This may be all that is required to stop a developing problem and all that is then required is to check the area in 6 months. For this purpose Hutton + Rostron again favour the Rothounds

3.1 Capabilities

a May detect living dry rot (*Serpula lacrymans*) by the scent of the metabolites produced by the fungus

b May detect the scent of dry rot even when hidden behind panelling, under floors, behind plaster or in other concealed cavities

c May detect the scent of dry rot at a distance of several metres depending on scenting conditions

d May detect early dry rot growth before it is detectable by the unaided human eye

e May discriminate between living or dead dry rot and between dry rot and other fungi instantly

f Actively search for dry rot in buildings at high speed, covering 20 to 50 rooms in an hour g May indicate extent and spread of dry rot infestation

g Will search small inaccessible areas and roof spaces i Will work in furnished and inhabited buildings

h Totally non-destructive

i Will work 2-4 hours per day

3.2 Limitations

a Trained only to indicate living dry rot, not wet rot or dead dry rot. Will not indicate fruiting bodies on old dead outbreaks of dry rot

b Indicate the scent of dry rot and the point of maximum scent. This may need interpretation as scent can occasionally be moved by air currents from the point of origin

c Scent will not travel through impermeable surfaces such as neoprene. However, it may be detected at the edge of an impermeable barrier, e.g. around the edge of a room with a rubber-backed carpet covering an infected floor

d Indicate dry rot infection, not decay. Therefore heavily decayed but inactive outbreaks may give a weaker indication than a recent highly active outbreak that has not yet caused significant decay e Maynot work if there is a corrosive or choking dust or vapour. However, Rothounds should not be put off by smells and may detect even small amounts of dry rot in the presence of other strong scents

3.3 Uses

a Survey of properties prior to purchase, renovation, change of occupancy etc, to quickly check for hidden problems

b Preliminary survey of properties with suspected decay problems to determine existence and extent of dry rot infestation

c Survey of properties with known dry rot problems to determine activity and extent of infestation

d Survey of properties undergoing remedial works to check for additional hidden areas of infestation

e Survey of properties after remedial works to check for efficiency of treatment

f Routine survey of properties with past problems thought to be at risk in order to detect recurrence of infestation at an early stage before significant decay can occur

g Periodic survey of properties with known problems awaiting renovation, to detect 'hot spots' of dry rot activity

These can then be dealt with by 'reactive maintenance' allowing outbreaks to be controlled by minor exposure works and environmental controls. This avoids expensive building or remedial works. Further decay is prevented and infection controlled with significant savings on eventual renovation

4 FIBRE-OPTIC BORESCOPE EXAMINATION

A technique we have found routinely useful over the last 15 years is the use of fibre optics. We use long reach, fixed side view, rigid borescopes and high-power light sources.
Although this is comparatively expensive it is essential for getting a clear view across a cavity such as a floor space. It also minimises the time spent and the number of holes drilled. Fibre optic inspection can reveal extensive decay and the consequences of water penetration. However, most wood-destroying fungi will not live on the face of timber which is exposed to air movement because this produces a drying effect. It is always a possibility that a fungus, especially dry rot, is travelling behind a wall plate, for example, and is not detectable from the cavity. Fibre optic inspection may not, therefore, find a minor attack which is developing, but it should indicate where these might be initiated so that faults can be identified and remedied. The siting of inspection holes depends on the points at risk within the room and will usually be located adjacent to balcony floors, flat roofs, cracks in rendering and other points where faults may have resulted in water penetration. Inspection may also be limited in areas of tiled and glued flooring materials and ornate or special wall coverings. Inspection holes are numbered and capped off for future use

5 THE MEASUREMENT AND SIGNIFICANCE OF MOISTURE CONTENT

The moisture contents in timber, mortar and plaster are measured by a variety of methods. Timber moisture content might be ascertained by the use of a standard resistance-type moisture probe which measures the moisture content at the surface of the wood.

However, this moisture content will be subject to considerable fluctuation, depending on current relative humidity and temperature. A rafter in a roof in summer may, for example, have a moisture content at the surface of 16 per cent which might rise to over 20 per cent in winter. This difference would not necessarily reflect increased water content resulting from a fault in the roof, but might simply be a redeposition of water resulting from a considerable drop in temperature

The condition in the core or subsurface of a timber will remain relatively stable which is why the centre of thick timbers may be preferentially decayed. It is this 'deep' moisture content which must be measured if results are to be meaningful. For this reason, a hammer probe with insulated electrodes or deep moisture probe is used to measure the moisture content within the timber. Healthy roof timbers should maintain a stable core moisture content of between about 12 per cent and 16 per cent, whilst suspended floor timbers (excluding ground floors) should be between about 11 per cent and 14 per cent. Central heating will usually reduce this figure to around 9 per cent

Similarly, surface moisture content readings in plaster and mortar are of limited value except for purposes of comparison. A surface capacitance meter may be used on plastered walls. For further investigation absolute measurements of moisture content may be made on site by means of a carbide-type gas pressure meter

Alternatively, samples are taken back to the laboratory in sealed vials, and the moisture contents are measured by the oven and balance method. For this, mortar samples are obtained by drilling holes in the wall and dust from the first inch of each hole is discarded. Dry mortar and plaster should have moisture contents below about 2 per cent. At levels much above this the moisture content of incorporated timbers will exceed 20 per cent and may easily reach levels at which fungal decay is likely

6 OTHER TECHNIQUES

Other techniques that may be used include microscopy, laboratory culture, hot wire anemometry and electronic RH measurement. We have also developed special instruments for measuring 'available' water in materials and for ultrasonic detection of timber-boring insects. More exotic techniques may sometimes be useful such as pheromone insect traps, infra-red thermography, shortwave radar, automatic weather stations and total building monitoring using specialist data loggers

Appendix C

The most critical factors for the environmental control of decay organisms are available moisture and temperature. The former is dependent on such factors as moisture content, relative humidity, micro-ventilation, and salt content. In simplistic terms it is necessary to correct building defects leading to high moisture contents in timber and to increase ventilation around timber at risk

In practice there are two problems; first it is necessary to identify the significant building defects and then the best techniques must be chosen to control the environment at each point. This may be achieved by analysing the building in terms of moisture sources, moisture reservoirs and moisture sinks

It is not possible to prevent moisture entering a building entirely and often attempts to block the movement of moisture through a building structure using impermeable materials are ineffective. They may also be counter-productive as they can prevent moisture being dissipated, resulting in high moisture levels and decay in adjacent materials. The more effective and robust approach is that used in traditional buildings. Here, porous materials are preferred, and every moisture source is balanced by a moisture sink. Thus ground water may penetrate masonry but is evaporated off before it reaches timber structures. Similarly, water vapour is introduced by occupation, but is ventilated out via windows, chimneys and other passive and active forms of ventilation. Failure to balance a moisture source with an appropriate sink may result in moisture moving into vulnerable materials and eventually causing decay and other problems

Moisture reservoirs occur when a moisture 'source' has not been balanced by a 'sink' and water has accumulated in a porous material. Typical examples of this are to be found when thick masonry walls have been soaked by persistent leaks or when chimney breasts have been filled with rain water from uncapped chimneys. Such reservoirs may take years to dry out, even when the source has been dealt with. As a result, they can act as a source of moisture for recurrent timber decay over a long period. A special case of this phenomenon occurs when large quantities of water have been used in fighting a fire

In practice then, each area of decay is associated with a building defect, resulting in an increased moisture source, a blocked or inappropriate moisture sink or a moisture reservoir. The appropriate building measures should then be specified to correct that defect

A common example might be the bridging of a damp proof course by raised ground levels. This will act as a moisture source and may result in decay of timbers in an adjacent floor space. Reducing the ground level will cut off this source and will also provide a sink of moisture by allowing evaporation from the exposed wall. The sub-floor moisture level might also be controlled by increasing the other available moisture sinks. Cleaning pre-existing airbricks or inserting additional sub-floor ventilation would be a common measure. In general, it is important to increase evaporative surfaces and avoid obstructing them during refurbishment

Another common example would be a blocked and overflowing parapet gutter acting as a moisture source. This could wet up gutter soles, joist ends and wall plates as well as any other structure in an expanding cone extending from the leak down through the building. Preventing this moisture source may require a number of measures such as increasing the capacity of down pipes, re-lining the gutters and fitting thermostatically controlled trace heating tape to increase free flow of snow melt water

Any failure in a roof finish, gutter or coping will generally result in significant water penetration into the masonry wall beneath, which will then act as a moisture reservoir. Any timber in contact with this reservoir will be at risk of decay as it will tend to 'wick' moisture from the masonry. Steps must therefore be taken to isolate in-contact timber from the masonry using such measures as DPC membranes or joist hangers producing an air gap. It will also be necessary to ensure the timbers are adequately ventilated so that any moisture that is absorbed can be breathed off. Closed cavities or water-impermeable layers over timbers at risk must therefore be carefully searched out and rectified using knowledge of historic methods of construction. Bricked-in lintels and sealed up emulsion-painted sash windows are typical examples of structures at risk in this way

Having cut off the moisture source to a moisture reservoir and protected the 'at-risk' timbers it is next necessary to provide safe 'sinks' for the moisture. This will ensure that the reservoir is dried out in the long term. In some cases, the reservoir can be removed entirely, for example damp pugging can be dug out and replaced. In most cases it is a matter of promoting ventilation around a wicking surface on the reservoir and ensuring that the moisture-laden air can be vented to the outside. Dry lining systems can be useful for this purpose as can the good old-fashioned chimney. Raising the temperature will promote the process of wicking and evaporation. General house heating can help but care must be taken to ensure that water vapour is not being 'pulsed' into other parts of the building by a sequence of evaporation and condensation down a temperature gradient. Heating can be especially useful if it is possible to heat the reservoir material itself. We have devised special systems for heating large section timbers and masonry for this purpose but again the old-fashioned fire-place and chimney is very useful

In some cases, dehumidifiers can be used in the short to medium term, but care must be taken. They often require special 'tenting' and monitoring so that moisture is removed from the appropriate material and not from the world at large. They also require high air temperatures and high RH's to extract moisture efficiently

In all cases most of the remedial building works that may be required are quite within the capacity of the general contractor. Most are traditional repairs though some may take advantage of new materials or techniques such as dry lining, joist hangers and tanking. New and potentially useful products are coming into the building market all the time, for example, time controlled automatic fans, hollow ventilating plastic skirting boards, plastic masonry drains, roof space ventilating systems and moisture permeable paints. All such products and techniques can be used to help in making the environmental control of timber decay even more efficient and economical. All that is required is careful analysis of each situation and a little scientific understanding

Appendix D

MAINTENANCE AND MONITORING

The investigation and building works described in the previous appendices should put a building back into a state of structural and environmental health. The environmental control approach will also mean that a building is less likely to develop problems in the future. This is because the effect of minor building failures should be 'buffered' by the robustness of the systems established. Fortunately, most traditional systems are robust in this way. This is why older buildings may tolerate a considerable amount of neglect and abuse before developing severe problems. However, the long-term health of the building will always depend on adequate maintenance. This is no less true of buildings treated with timber preservatives

A detailed investigation carried out as part of an environmental control policy provides an excellent basis on which to plan the most cost-effective maintenance program. Indeed, the building works required for environmental control are often best integrated into such a program. Short-term 'emergency' measures can be taken to simply halt further decay and measures to replace damaged structures or prevent future problems can be delayed to fit into a longer term plan of works. This flexibility in scheduling work as a result of the environmental approach allows further saving of costs and inconvenience

A maintenance program must also include provision for the routine inspection of all significant parts of the building at appropriate intervals. This should aim to detect and correct problems developing before they cause significant damage. Again the information gained in the investigation can be used to decide on the most cost effective inspection interval

In many cases remote monitoring systems can be very useful in increasing the efficiency and reducing the cost of maintenance programs. They can be especially useful for checking the moisture content of inaccessible timbers in roof spaces, behind decorative finishes and in walls. H+R have developed the Curator building monitoring systems for this proposal

Sensors can be placed at all critical points after the investigation or after the remedial building works. Areas can then be closed up and finishes re-applied, for example sensors may be placed in lintels, joist ends, valley gutter soles or in damp walls to monitor drying. It is important to use enough sensors and to place them with an understanding of the moisture distribution processes because conditions can vary even in a small area. It is these local variations in conditions that produce the environmental niches which decay organisms exploit

If more than 30 sensors are deployed, taking the readings can become onerous and this may result in human error or negligence. In these situations automatic monitoring systems become desirable. H+R have developed a number of specialised 'Curator' data logging systems to do this. With larger systems, the wiring of sensors can also become a problem. For systems requiring 100 or more sensors we can use a 'Curator A' unit working via a single 4-core main cable connecting up any number of nodes, each supporting 4 sensors. This system can be programmed with logging intervals and alarm limits for each sensor and can be read via the telephone system via its own modem. Data from the system can then be analysed using CAD and programs for statistical interpretation on a remote computer

Appendix E

HEALTH AND SAFETY RISK ASSESSMENT

HAZARD: Irritant dusts

Risk:	disturbance of building material or debris by exposure works, cutting, drilling etc could produce airborne dusts which may be irritant to the skin, eyes, nose and respiratory system, and may be a health hazard if breathed in by workers or others in the area; particular hazards include the disturbance of mineral/glass fibre insulation and/or chemically contaminated dust (resulting from remedial timber treatments) in roof spaces or other voids, the disturbance of materials containing asbestos, especially in boiler rooms, flues and pipework installations and the disturbance or removal of faeces deposited by birds or animals
Reduce risk by:	carrying out a COSHH assessment (the duty of the employer under the COSHH regulations) to determine the health risks and necessary measures to protect employees and others. This may include: correct identification of building materials, if possible before works commence (this may require research into record drawings/specifications for previous building refurbishments/repairs/refits; contacting HSE if the presence of asbestos is suspected; avoiding disturbance of hazardous materials; containment of dust within localised areas of the building by creating dust-proof envelopes; ventilation of working areas (may need to be mechanical and may need filtration for the retention of hazardous particulates); provision by employer and use by the operatives of personal protective clothing, goggles and breathing apparatus/masks suitable for the particular type of dust

HAZARD: Working in confined spaces

Risk:	there may be a build-up of toxic gases (e.g. from chemical remedial treatments or from site contamination) or a depletion of oxygen in the atmosphere of a confined space; restricted working space may be awkward and lead to injuries; escape may be difficult, causing overexposure to adverse conditions or delay to medical treatment; communication with persons outside the confined space may be difficult

Reduce risk by:	testing the atmosphere for toxic gases and if present, carrying out a COSHH assessment; providing a supply of fresh air into a confined space, if necessary; ensuring that work only proceeds with at least two persons - at no time should a person work alone in a confined space; ensuring that there are emergency procedures in place before work commences, for rescue from confined spaces

HAZARD: Collapse: renewal of lintels and beams

Risk:	improperly sequenced works during the renewal of decayed roof trusses, rafters, joists or lintels could lead to collapse of structure causing injury to workers or others
Reduce risk by:	specifying a correct sequence of propping, removal and replacement of structural members to maintain stability during refurbishment

HAZARD: Collapse: dangerous structures

Risk:	unstable structures which are the result of decay, fire damage, impact damage or partial demolition, could collapse causing injury to workers or others
Reduce risk by:	shoring up the structure to ensure its overall stability and prevent loose parts falling off; demolition of parts of an unstable structure which are not to be retained, but only if they are not of historical value and only with instruction from the Supervising Officer. Unstable structures should be made inaccessible to workers and others by means of barricades and warning notices until they have been stabilised/demolished. Barriers to comply with BS 6180:1995 Code of Practice for barriers in and about buildings

HAZARD: Electricity

Risk:	of electrocution by cutting through electric cables
Reduce risk by:	locating cables before excavation work or cutting into or drilling the existing building fabric, using a cable locator and cable plans, marking their position and taking precautions to avoid contact with them; supplying all portable tools and equipment with 110v transformers, not 240v; ensuring proper connections to equipment. All temporary electricity installations for construction sites should comply with BS 7375:1996

HAZARD: Falls from height (over 2 metres): scaffolding

Risk:	undertaking inspections or carrying out work from inadequately designed or erected scaffolding could cause persons to fall or injure themselves or others below
Reduce risk by:	use of properly designed and erected scaffold with adequate access; baseplates to uprights; adequate ledgers, braces, struts, ties; fully boarded platforms; guard rails and toe boards to prevent falls of more than 2 metres; frequent inspections of scaffold. Also personal protection such as safety harness and safety line. Scaffolding to comply with BS 5973:1993 Code of Practice for access and working scaffolds etc

HAZARD: Falls from height (over 2 metres): ladders

Risk:	undertaking inspections or carrying out work from improperly positioned or inadequately secured ladders could cause persons to fall or injure themselves or others below
Reduce risk by:	use of properly positioned ladders secured at the top, and which project at least 1.07 metres above any landing

HAZARD: Falls from height (over 2 metres): flat roof

Risk:	inadequate edge protection can allow persons to fall off the edge of a flat roof or through openings or fragile roof coverings
Reduce risk by:	installation of edge protection such as guard rails around the perimeter of flat roofs, and around openings or areas of fragile roof coverings within flat roofs; providing safe walkways, platforms, travelling gantries across fragile roofs. Barriers to comply with BS 6180:1995 Code of Practice for barriers in and about buildings

HAZARD: General

Risk:	general accidents in the course of work such as cuts, impacts, muscular strains etc
Reduce risk by:	providing first aid facilities; providing welfare facilities; providing personal protective equipment and ensuring that the workers use it; ensuring adequate lighting of all access areas and work areas; ensuring that emergency procedures are in place prior to site work commencing

Appendix F

Fig 1:

External, south elevation; photo showing a general view of the condition and structural arrangement of the south elevation. Note the presence of boarding over windows indicated that the property had not been inhabited for a significant period which would have likely led to the degradation of building materials over this time, in the absence of a regular maintenance schedule

Fig 2:

External, south elevation; photo showing a focused view of the west end of the south elevation. Note the widespread presence of spalling and localised cracking the brickwork forming this elevation, this had likely occurred due to prolonged exposure to inclement weather leading to the saturation of masonry materials and structural movement leading to the failure of subsequent structural elements, causing partial separation of brickwork at the mortar joints

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Fig 3:

External,
south elevation; showing a focused view of the lower section of the south elevation and the interface with the pavement. Note the up stand/external tanking was deemed to likely be of a cementitious material which would prevent saturated moisture due to wind driven rain from evaporating from within the brickwork. This would likely direct it internally and possibly lead to the saturation of vulnerable timber elements and subsequent materials in close proximity

Fig 4:

External,
south elevation; showing a further image of the up stand/external tanking and the localised damage that was visible along the top edge. Note that mortar washout had occurred from the mortar beds connecting the course of brick directly above the top edge of the cementitious tanking. This confirms the suspicion that moisture was being excessively harboured within the brickwork at this location

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Fig 5:

External,
south elevation; showing a focused view of the condition of brickwork and mortar beds. Note that's lightly cementitious mortar had been used to re -point brickwork across the entire elevation, localised failure revealed the original lime mortar beneath that was softer and more permeable. The widespread use of cementitious mortar likely contributed to the spalling of brickwork due to the impermeable characteristics of cementitious mortar causing moisture to be forced inward and preventing it from evaporating at an adequate rate, leading to continual freeze/thaw action during low temperatures leading to damage to brickwork

Fig 6:

External,
south elevation; showing a focused view of and external sandstone windows the type and condition of which were typical throughout the entire elevation. Note that significant spalling had occurred, again likely due to the saturation of moisture during periods of inclement weather leading to excessive spalling, due to the level of saturation and the characteristics and properties of the masonry type

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Fig 7:

External,
south elevation; showing a general view of the central section and east end of the elevation. Note that similar conditions seen over the west end were also observed at this location. Further note the presence of plant growth beneath the upper moulded course, this suggested that significant moisture ingress had occurred in close proximity to this location. In addition to the detrimental effects of excess moisture within a structure, continual plant growth could independently lead to the damage of building materials as roots and root balls increased in diameter, this would lead to the separation of crucial elements such as brickwork

Fig 8:

External, south elevation; showing a general view of the condition of the upper section of the east end of the elevation. Note that widespread staining of masonry was observed due to continue exposure to airborne pollutants. Also note the replacement of historic downpipes with contemporary square sections, these had been connected to historic elements at the interface of the wall, historic rainwater drainage elements and their connection to contemporary elements may be deemed inadequate

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Fig 9:

External, east elevation; know your general view of the structural arrangement and condition of the east elevation

Fig 10:

External, east elevation; showing a focused view of the south side of the east elevation, note the presence of cracking to the flat gauge brick arch above the lower right-hand window and further cracking to the brickwork and what appeared to be slight separation of the masonry moulded course above, which suggested that movement had occurred in this location, possibly due to the failure of internal structural elements

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Fig 11:

External, east elevation; showing a focused view of the interface between the foot of the elevation and the pavement. Note that external vents serving the internal sub-floor void had been partially blocked due to excessive debris and raised ground levels, this would inevitably lead to significant moisture ingress during periods of inclement weather

Fig 12:

External, east elevation; showing a focused view of the damp proof course that was identified at the foot of the elevation, note that the material was deemed to be slate. Further note that ground levels at the north end of the elevation were raised to approximately 25 mm below the slate damp proof course which is significantly less than the required amount. This could allow the saturation of brickwork above the damp proof course during periods of rainfall

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Fig 13:

External, north elevation; showing a general view of the condition and structural arrangement of the east end of the elevation. Note that similar characteristics noted on previous elevations were seen at this location including spalling and localised cracking particularly at the west side of the elevation, including multiple areas of plant growth along the top edges of the parapet wall, and ground levels raised above the slate damp proof course, rendering it completely ineffective. Additionally, widespread moderate levels of degradation to window and door units was also noted again due to prolonged exposure to inclement weather and being finished with inappropriate paint systems

Fig 14:

External, north elevation; showing a general view of the interface between the foot of the elevation and the pavement, note that ground levels at this position were seen to be above the slate damp proof course as mentioned previously. The presence of plant growth at the interface indicated that there were high levels of moisture at this location, which was likely tracking inwards and possibly affecting structural timber elements on the opposing side

Fig 15:

External, north elevation; showing a general view of the west section of the north elevation, from within the enclosed yard. Note that certain building structures at this location had been confirmed for demolition therefore these were not included in the survey

Fig 16:

External, north elevation; showing a general view of the central section of the elevation. Note that significant plant growth was identified which was an indicator of excessive moisture in that location. Moderate levels of spalled brickwork were identified, as well as general levels of wear and tear however, a number of structures at this location were to be demolished. Widespread staining was also noted to the eaves soffits likely due to the corrosion of mechanical fixings over time. Paint delamination was also noted along the soffits, likely due to exposure to UV rays and inclement weather

Fig 17:

External, north elevation; showing a general view of the west end of the elevation. Note that all windows displayed wear and tear to external elements and the brickwork again showed widespread spalling. Additionally, the window sills beneath the pitched gable section were again found to be spalled and the visible pipework and other metal elements were significantly corroded, which could lead to damage of the surrounding materials due to the associated expansion of the corroding metal

Fig 18:

External, north elevation; showing a focused view of the interface between the foot of the wall and the ground at this location. Note that widespread mortar washout had occurred, and the cementitious ground material had been laid to a height that was close to the damp proof course. Also note further plant growth which suggested moisture ingress internally, as well as blocked vents

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Fig 19:

External, west elevation; showing a general view of the structural arrangement and condition of the elevation at this location

Fig 20:

External, west elevation; showing a partial view of an additional section of the elevation, located at the very west end of the building. Full view was obscured by the positioning of fencing, which prevented full access

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Fig 21:

External, west elevation; showing general spalling to brickwork, and a large section of cementitious render to the lower section. In this, were external vents which were considered to be inadequate due to their likely blockage and significant corrosion. Also note the presence of multiple cracks to the cementitious render, which would inevitably enable moisture ingress into the brick substrate beneath

Fig 22:

External, west elevation; showing general view towards gabled end subject to presumed failed coping elements leading to damp ingress to internal structures

Fig 23:

External, central lightwell/courtyard; showing a general view of the internal west elevation. Note that plant growth was identified as well as minor spalling of brickwork

Fig 24:

External, central lightwell/courtyard; showing a general view of the internal east elevation. Note that plant growth was identified at ground level, likely due to inadequate provisions for drainage and the use of improper materials

Fig 25:

External, central lightwell/courtyard; showing a general view of the internal north elevation. Note that no significant degradation was noted to the brickwork, largely due to this building section being of later construction, as well as the sheltered positioning

Fig 26:

External, central lightwell/courtyard; showing a general view of the internal south elevation. Note that an increased level of degradation to brickwork and render seen to the lower section, however the upper section was of later construction and therefore in an improved condition. Rainwater drainage systems in this location appeared to be of recent installation, however provisions for ground drainage were deemed to likely be blocked and therefore of inadequate capacity

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Fig 27:

Internal, second floor; showing a general view of the room south-west to the west range. Note the area of the floor marked for advised exposure to allow for further investigation of the encapsulated floor structure, which may be vulnerable to moisture ingress and biological decay organisms

Fig 28:

Internal, second floor; showing a general view of the west range landing area looking north. Note the 2 no. areas of the floor marked for advised exposure to allow for further investigation of the encapsulated floor structure (at the discretion of future demolition plans), which may be vulnerable to moisture ingress and biological decay organisms

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Fig 29:

Internal, second floor; showing a general view looking east of the entrance to the central rooms to the west range. Note the area of the floor marked for advised exposure to allow for further investigation of the encapsulated floor structure, which may be vulnerable to moisture ingress and biological decay organisms

Fig 30:

Internal, second floor; showing a general view looking south of the south-east room to the west range. Note the 2 no. areas of the floor marked for advised exposure to allow for further investigation of the encapsulated floor structure (at the discretion of future demolition plans), which may be vulnerable to moisture ingress and biological decay organisms

Fig 31:

Clocktower, fourth floor; showing a general view of the floor structure at this floor level. Note that the presence of floorboards and ceiling cladding on the underside restricted full investigations of the structural timber elements. Evidence of moisture saturation of the external brickwork was noted on both the east and west sides. This indicated that there was an increased possibility of moisture saturation of internal structural timbers, that could lead to the onset of biological decay organisms

Fig 32:

Clocktower, fourth floor; showing view towards boarded ceiling soffit beneath bell chamber floor

Fig 33:

Clocktower, third floor; showing a general view of the exposed joists and their east embedded ends. Note that 1 no. joist end had previously been identified as decayed and therefore it had been docked and a trimmer joist/ nogging had been installed as a remedial measure. Also note that all joists ends forming this floor level had been embedded into the external masonry of the tower, increasing their likelihood of moisture saturation and decay

Fig 34:

Clocktower, third floor; showing a general view of the exposed joists and their west embedded ends. Again, the same support method had been employed on this side, increasing the likelihood of moisture saturation and decay to the joist ends

Fig 35:

Clocktower, second floor; showing a general view of the clocktower room at this level. Note the presence of spalling of internal brickwork which suggested that significant moisture saturation had occurred. This would certainly increase the risk of moisture saturation of structural floor timbers that were considered likely to have been embedded into external masonry, as was seen to the floor structure above

Fig 36:

Clocktower, second floor; showing a localised area of recommended exposure of the floor structure, in the south-east corner. To allow for further investigations of the condition and decay state of vulnerable timber floor members

Fig 37:

Clocktower, second floor; showing a focused view of a representative exposed area, allowing for investigations into the structural floor elements. Note that due to the small level of exposure investigations were limited and no decay was detected. Also note the high levels of debris within the floor void, this could contain hazardous materials and should be removed and disposed of in an environmentally friendly and safe manner

Fig 38:

Roof 1; showing a general view to the roof void looking towards the south gable

Fig 39:

Roof 1; showing significant structural fracture to east pitched roof purlin

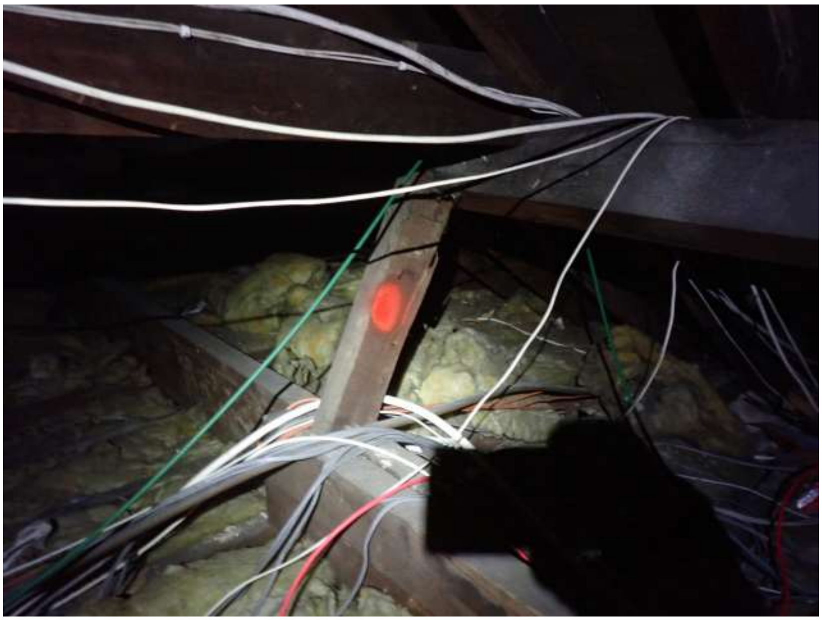

Fig 40:

Roof 1; showing structural fracture to west pitched roof raking strut

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Fig 41:

Roof 1; showing representative view towards the east pitch roof detailing beneath the valley juncture. Note common rafters supported onto a perpendicular plate which is itself supported onto ceiling joists embedded into the historically vulnerable masonry wall. Allow for decay detection drilling and probing to all masonry embedded timbers when safe and convenient access is arranged

Fig 42:

Roof 1; showing view to the 6-10no. historically decayed embedded ceilings joists and common rafter ends to the north area to the west pitch. Concealed rafter plate also presumed decayed

Fig 43:

Roof 1; showing thermal image to decayed structures shown at fig.42. Note no evidence of significant active moisture penetration at the time of investigation

Fig 44:

Roof 2; showing a general view of the roof void looking west

Fig 45:

Roof 2; showing significant build-up of historic debris and insulative material within roof void which may contain hazardous materials and should be removed and disposed of in an environmentally friendly and safe manner

Fig 46:

Roof 2; showing representative area of roof felt formed of a non-breathable bitumen type membrane likely to create the conditions for interstitial condensation issues during periods of high humidity and temperature fluctuations. Also note multiple areas of damaged/compromised roofing felt membrane identified

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Fig 47:

Roof 2; showing significant evidence for surface mould growth to the underside of roof timber elements likely as a result of improper roofing felt membranes combined with inadeqaute ventilation. See also fig.46. NB. Airborne surface mould spores can cause serious respiratory health hazards to those occupying the same air-space

Fig 48:

Roof 2; showing area of ongoing structural decay issues to the central south area beneath failed parapet gutter linings

Fig 49:

Roof 2; showing general view of south pitch roof looking west. Note no safe/ convenient access to deep drill and moisture probe vulnerable timbers beneath the south perimeter parapet gutter. Further investigation warranted

Fig 50:

Roof 2; showing general view of north pitch roof looking west. Note good access to the eaves rafter plate for ventilation, drying and inspection. No significant decay detected

Fig 51:

Roof 2; showing area of ongoing structural decay issues to the central south area beneath failed parapet gutter linings. Decayed items include for ~10no. Common rafters and ceiling joist ends, as well as up to ~4m of rafter plate

Fig 52:

Roof 2; showing thermal image to decayed structures shown at fig.51. Note no evidence of active damp penetration issues to general area from presumed failed parapet gutter linings above. Timbers remain highly vulnerable to further structural decay

Fig 53:

Roof 2; showing north-east corner adjacent to the tower with multiple timbers subject to active moisture penetration issues and decay from failed external roof finishes and faulty guttering. Decayed items include for hip rafter end, ~2-4no. Common rafters and up to ~500mm of rafter plate. Allow for further inspection

Fig 54:

Roof 2; showing external view towards faulty exterior lightwell area roof drainage goods symptomatic of decay issues shown at fig,53

Fig 55:

Roof 2; showing area of apparently recent water penetration issues/ damage to ceiling structures over the principal south-east stairs. Rafter plate and common rafters ends beneath parapet gutter to this area presumed subject to decay issues. Further investigation warranted

Fig 56:

Roof 2; showing thermal image to water damaged ceiling structures shown at fig.55. Note no significant evidence of chronic/active damp penetration issues to general area from presumed failed parapet gutter linings above. However, this may be accredited to the recent warm/dry spell preceding the investigation. Timbers remain highly vulnerable to further damp and decay

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Fig 57:

Roof 2; showing area of apparently recent water penetration issues and subsequent patch repair from water damage to the north-east corner. Rafter plate and common rafters ends beneath parapet gutter to this area presumed subject to decay issues. Further investigation warranted

Fig 58:

Roof 2; showing thermal image to repaired lath and plaster ceiling structures shown at fig.57. Note no evidence of active damp penetration issues to general area from presumed failed parapet gutter linings above. However, further investigation warranted to determine condition to vulnerable timbers beneath the historically failed parapet gutter

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Fig 59:

Roof 3; showing improper detailing to the south area to the roof void indicative of recent remedial efforts to prevent water damage issues to historic lath and plaster ceilings. Roof envelope presumed compromised to this area

Fig 60:

Roof 3; showing general view towards upper rafter plate to lean-to roof structure. Note rafter plate eaves improperly packed with fabric, denying eaves ventilation and restricting drying

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Fig 61:

Roof 3; showing north-east corner apparently subject to low-level recent damp penetration issues with visible early onset of decay issues to roof structural elements. Note embedded collars/ceiling joists deemed highly vulnerable to decay from potentially damp masonry

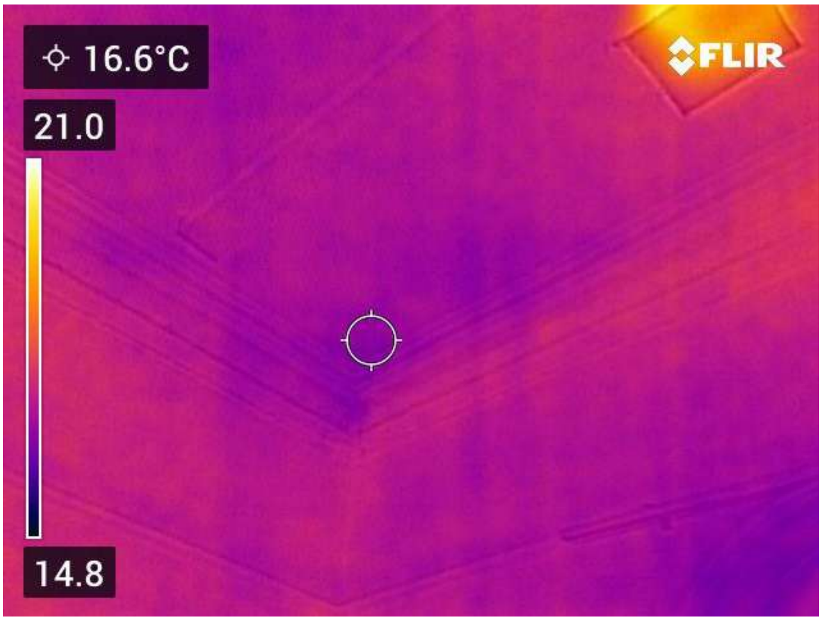

Fig 62:

Roof 3; showing thermal image to vulnerable structures shown at fig.61. Note some evidence of active damp penetration issues to general area from presumed failed parapet gutter linings above. Timbers remain highly vulnerable to ongoing decay issues

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Fig 63:

Tower roof; showing general view of timber structures forming apex joinery. No decay or defects identified

Fig 64:

Tower roof; showing representative view of roof structures forming the eaves hipped end juncture. Note no access to rafter plate for inspection. However, no decay anticipated

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Fig 65:

Tower roof access; showing the small roof structures over the tower roof stairwell subject to active damp penetration issues causing ongoing decay to the rafter plate and rafter ends

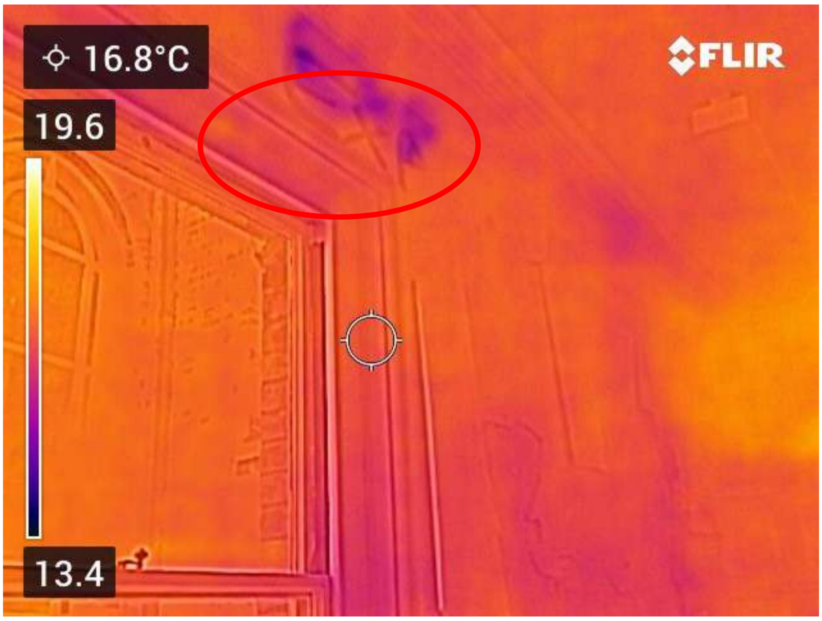

Fig 66:

Roof 2; showing thermal image to general area forming access to the Tower roof. Note masonry mass apparently subject to high moisture contents likely creating the conditions for damp and decay to the embedded adjacent north (lightwell elevation) timber lintels

Fig 67:

Roof 6; showing general view of roof void looking towards the north gable

Fig 68:

Roof 6; showing partially decayed embedded rafter plate/parapet valley beam to the south-east corner

Fig 69:

Roof 6; showing partially decayed embedded plate/parapet valley beam to the north-east corner. Allow for cutting back and separating structural timber from damp masonry via a suitable steel bracket under the direction of the Structural Engineer

Fig 70:

Roof 7; showing general view of upper roof void looking west. No apparent decay detected although access was limited. All lower roof voids form first floor attic rooms

Fig 71:

Roof 6, west eaves area; showing view towards significant blockage to the west pitch eaves gutter. Rafter plate and rafter feet deemed highly vulnerable to decay to this area

Fig 72:

Roof 7; showing view towards the first floor attic east room dormer. Note general area subject to severe damp penetration issues. Widescale decay issues suspected to concealed roof structures to this area. Further investigation required

Fig 73:

Roof 7; showing view towards the first floor attic west room. Note north elevation wall subject to severe damp issues, presumably from failed roof finishes and drainage goods above. Widescale decay issues suspected to concealed roof structures to this area. Further investigation required

Fig 74:

Roof 3; showing general view towards main hall roof structures inaccessible for inspection at the time of investigation. However, no significant damp penetration issues identified

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Fig 75:

Roof 3, main hall; showing very localised opening to the north-east corner. No decay suspected to principal roof structure

Fig 76:

First floor, west range; showing a representative floor joist subject to wood-boring beetle infestation to its vulnerable remaining sapwood band. Note the distinct ~1-2mm diameter flight holes indicative of Common furniture beetle *(Anobium punctatum)*

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Fig 77:

First floor, west range; showing representative view of floor void between joist centres. Note no provision for insulation/pugging material however, joists apparently laterally strengthened via herringbone struts

Fig 78:

First floor, west range; showing representative view to embedded wall plate location providing support to the suspended timber floor structures. All vulnerable embedded timbers require deep drilling and probing to determine decay state and deep moisture content/vulnerability to active decay organisms

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Fig 79:

First floor, south range; showing general view towards the central rooms south elevation subject to severe dry rot decay infection from failed parapet gutters above. Note areas recommended for exposure/further investigation works indicated on-site via water soluble red spray paint

Fig 80:

First floor, south range; showing an active blanket of mycelial growth spreading within unventilated floor void indicative of dry rot decay *(Serpula lacrymans)*

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Fig 81:

First floor, south range; showing further extensive evidence for an active blanket of mycelial growth spreading through unventilated floor void indicative of dry rot decay *(Serpula lacrymans)*

Fig 82:

First floor, south range; showing view towards the central roofs south perimeter wall subject to active decay organisms. All window joinery and secondary timbers local to dry rot outbreak presumed decayed beyond retention as indicated via red lines

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Fig 83:

First floor, south range; showing view towards the east rooms south perimeter wall subject to active damp penetration issues and early onset dry rot infection. Note floor areas recommended for exposure/further investigation works indicated on-site via water soluble red spray paint

Fig 84:

First floor, south range; showing view to adjacent floor void to the east rooms south perimeter wall. Note evidence for prolonged damp penetration issues to the area creating the conditions for fungal growth

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Fig 85:

First floor, west range; showing view towards the east rooms south perimeter wall. Note damp issues visible to masonry walls potentially indicative of decay issues to concealed timber elements including floor and lintel structures. All vulnerable inaccessible items identified for exposure/further investigations on site via water soluble red spray paint

Fig 86:

First floor, main hall; showing view towards the south perimeter wall. Note damp issues visible to masonry wall potentially indicative of decay issues to concealed timber floor structures as well as to the decorative panelling. Further investigation warranted

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Fig 87:

First floor, main hall; showing view towards the south perimeter wall. Note damp issues visible to masonry wall potentially indicative of decay issues to concealed timber floor structures as well as to the decorative panelling. Further investigation warranted

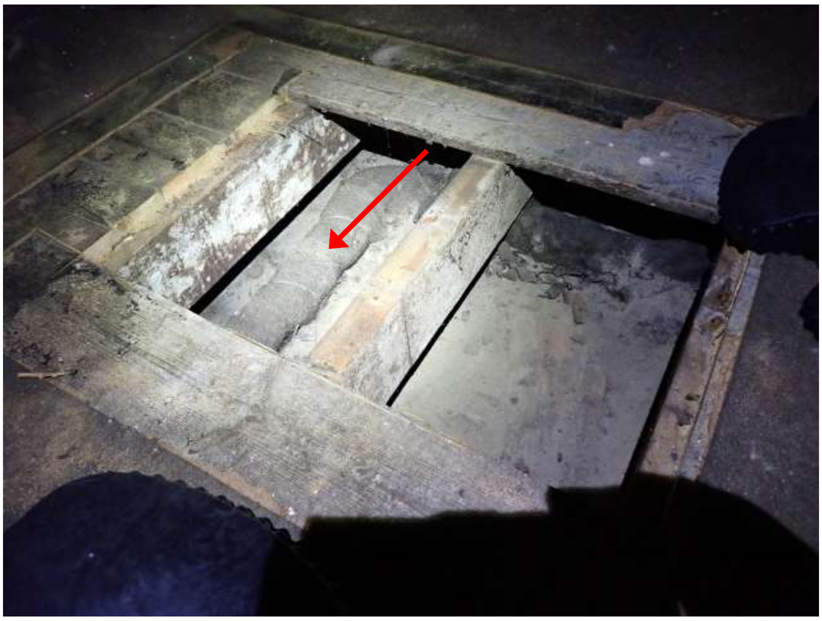

Fig 88:

Ground floor, west range; showing representative view to floor opening. Note fibrous lagging to historic underfloor services presumed to contain ACMs. Timbers inaccessible for deep drilling and moisture probing at the time of investigation

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Fig 89:

Ground floor, west range; showing representative view to floor void. Note floor joist build-up supported onto floor plate supported onto a single brick dwarf wall. Note no apparent provision for damp proofing between dwarf wall and horizontal floor plate

Fig 90:

Ground floor, west range; showing view towards the central room south perimeter wall. Note significant evidence for dry rot infection to south perimeter masonry. All timber elements within dry rot zone require separation from the infected masonry. Note floor exposure parameters indicated on site via water soluble red spray paint. ACMs presumed within floor void

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Fig 91:

Ground floor, central range; showing further evidence of historic dry rot fungus and mycelium growth visible to the underside soffit to the first floor adjacent to the south perimeter wall

Fig 92:

Ground floor, south range; showing representative view to floor void. Note good detailing to plate dwarf wall incorporating vented openings at 1 in 3 bricks

Fig 93:

Ground floor, south range; showing view to the internal north corridor masonry wall subject to severe damp penetration issues due to failed rainwater drainage goods above (see fig 54). However, no embedded bonding timbers visible within wall. Historic skirting boards requiring removal and separation from damp masonry

Fig 94:

Ground floor, south range; showing detailed view to the internal north corridor masonry wall subject to severe damp penetration issues causing significant salt efflorescence which is likely to damage any future finishes in contact to this wall upon refurbishment

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Fig 95:

Ground floor, north range; showing view towards the central corridor east perimeter wall. Note significant decay issues identified to the east perimeter timber floor structures due to apparent inadeqaute/blocked floor void ventilation and raised external ground levels. Decay indicated via red line. Allow for further exposure

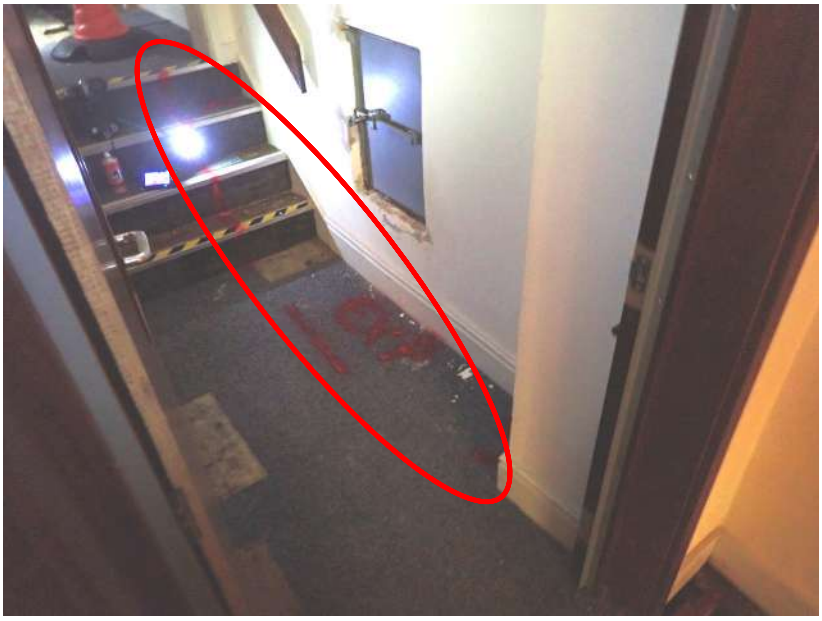

Fig 96:

Ground floor, north range; showing view towards the north-east corridor/ stair access adjacent to the east perimeter wall. Note no access at time of investigation although decay issues presumed. Allow for further exposure to determine extent of decay

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Fig 97:

Ground floor, north range; showing representative view of severe structural decay to the north-east rooms timber suspended floor. Floor structures deemed unsuitable for retention

Fig 98:

Ground floor, north range; showing representative view of severe structural decay to the north-east rooms timber suspended floor as seen from within floor void. Floor structures deemed unsuitable for retention

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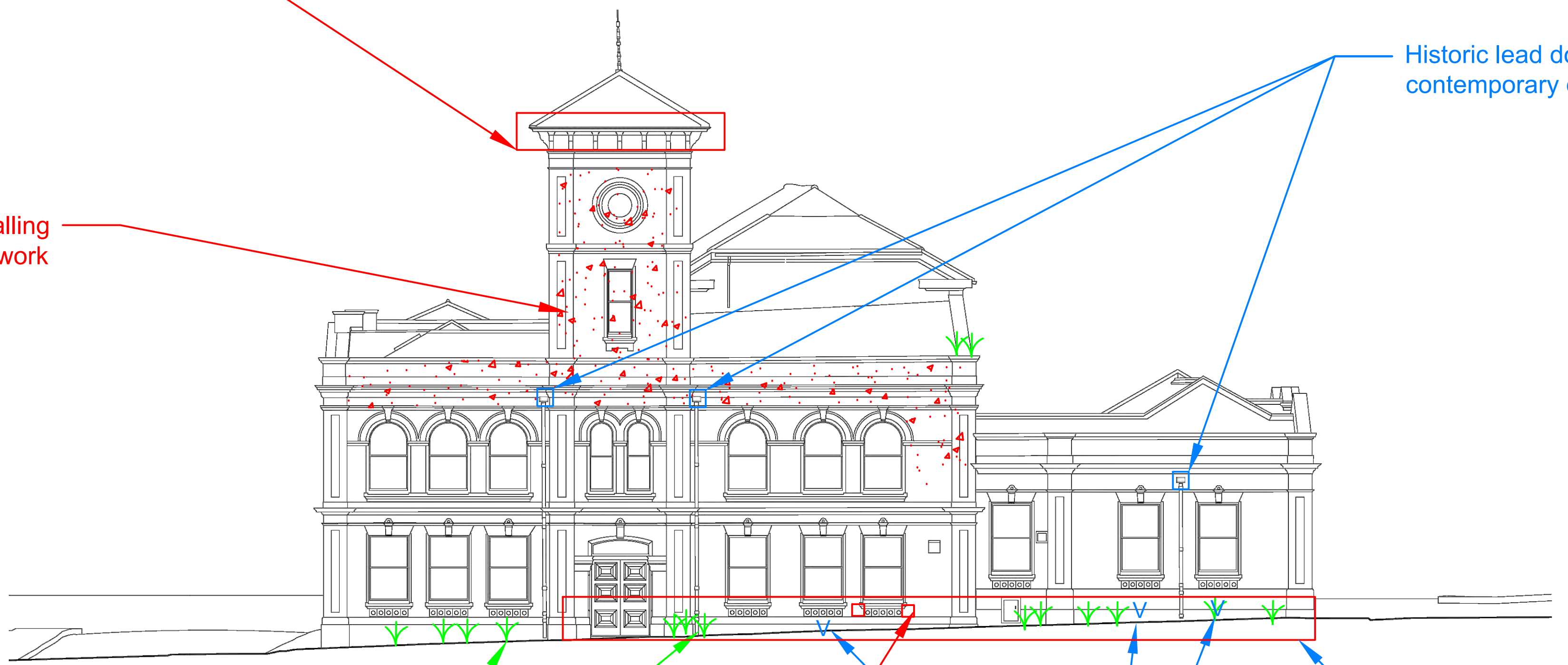
Fig 99:

Ground floor, north range; showing view towards the south rooms south lightwell perimeter wall. Note damp issues visible to masonry walls potentially indicative of decay issues to concealed timber elements including floor and lintel structures. All vulnerable inaccessible items identified for exposure/further investigations on site via water soluble red spray paint

Fig 100:

Ground floor; showing indicative raised moisture content readings to historic high status skirting boards deemed vulnerable to decay issues due to improperly raised external ground levels and ground penetrating damp

Appendix G



Key: Approximate location of plant growth
Approximate location of vent
Approximate location of crack
e Structural engineer to comment

Lowestoft Town Hall - East Elevation
Preliminary Damp and Decay Investigation
June 2023

Hutton + Rostron Environmental Investigations Ltd
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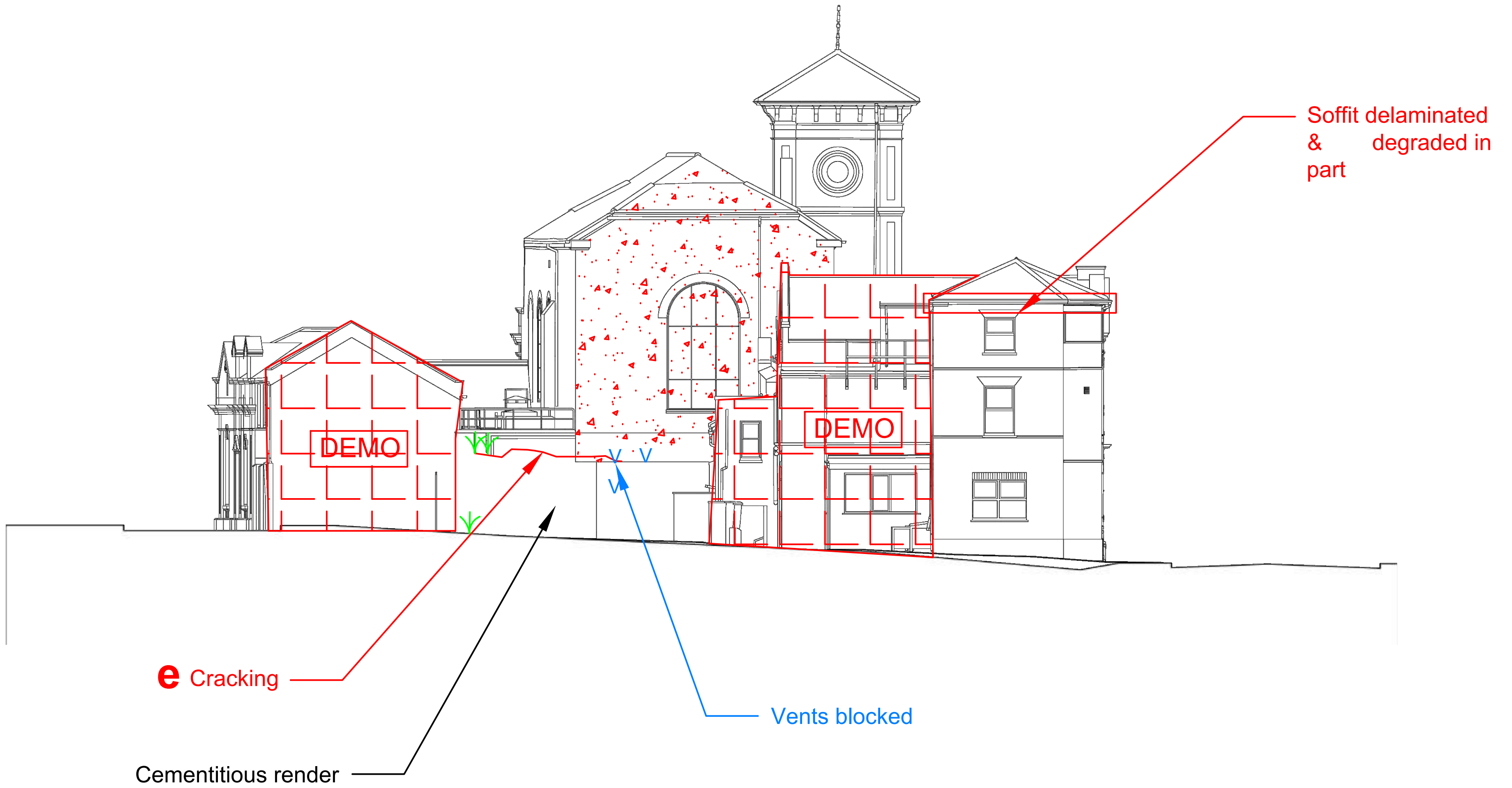
158-97 Report -Not to scale-



Key:
- Approximate location of plant growth
- Approximate location of vent
- Approximate location of crack
- e Structural engineer to comment

H+R

Lowestoft Town Hall - West Elevation

Preliminary Damp and Decay Investigation

June 2023

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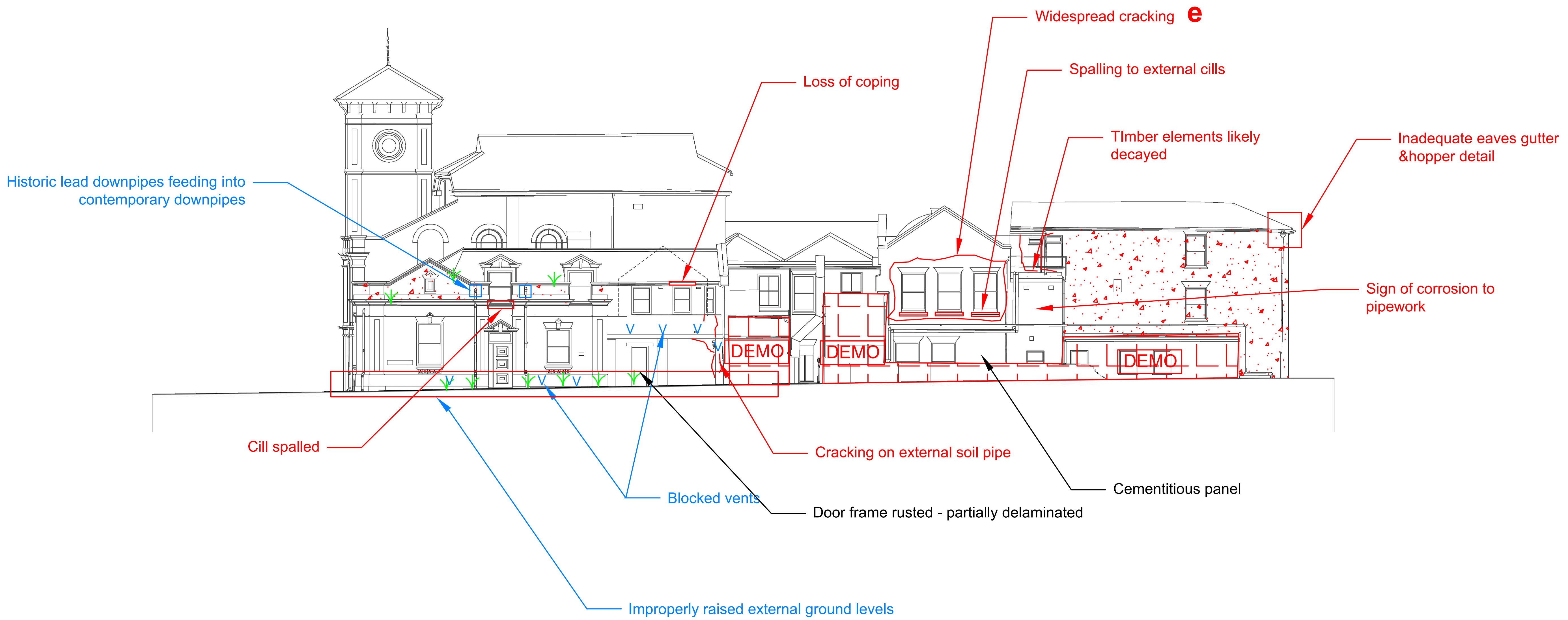
158-97 Report -Not to scale-



Lowestoft Town Hall - North Elevation

Preliminary Damp and Decay Investigation
June 2023

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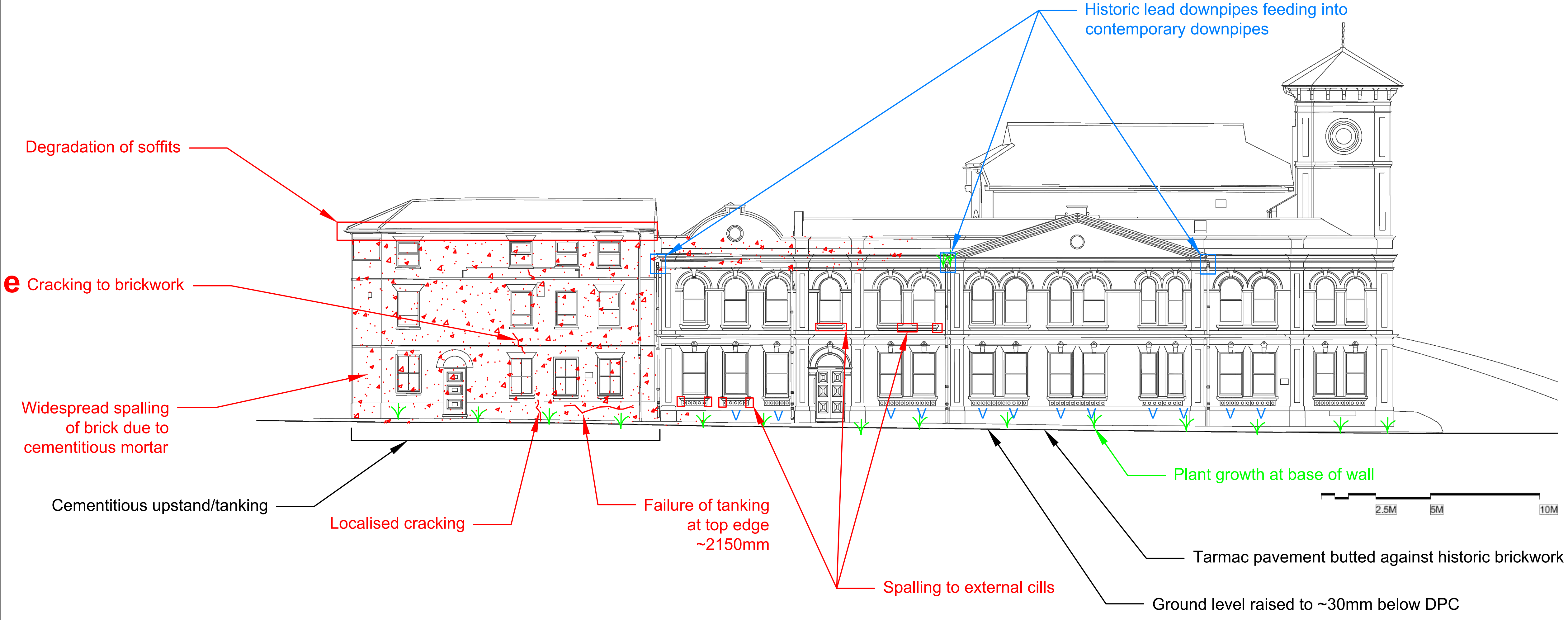
Key:
- Approximate location of plant growth
- Approximate location of vent
- Approximate location of crack
- e Structural engineer to comment



Key:
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- Approximate location of vent
- Approximate location of crack
- Structural engineer to comment

Lowestoft Town Hall - South Elevation

Preliminary Damp and Decay Investigation
June 2023

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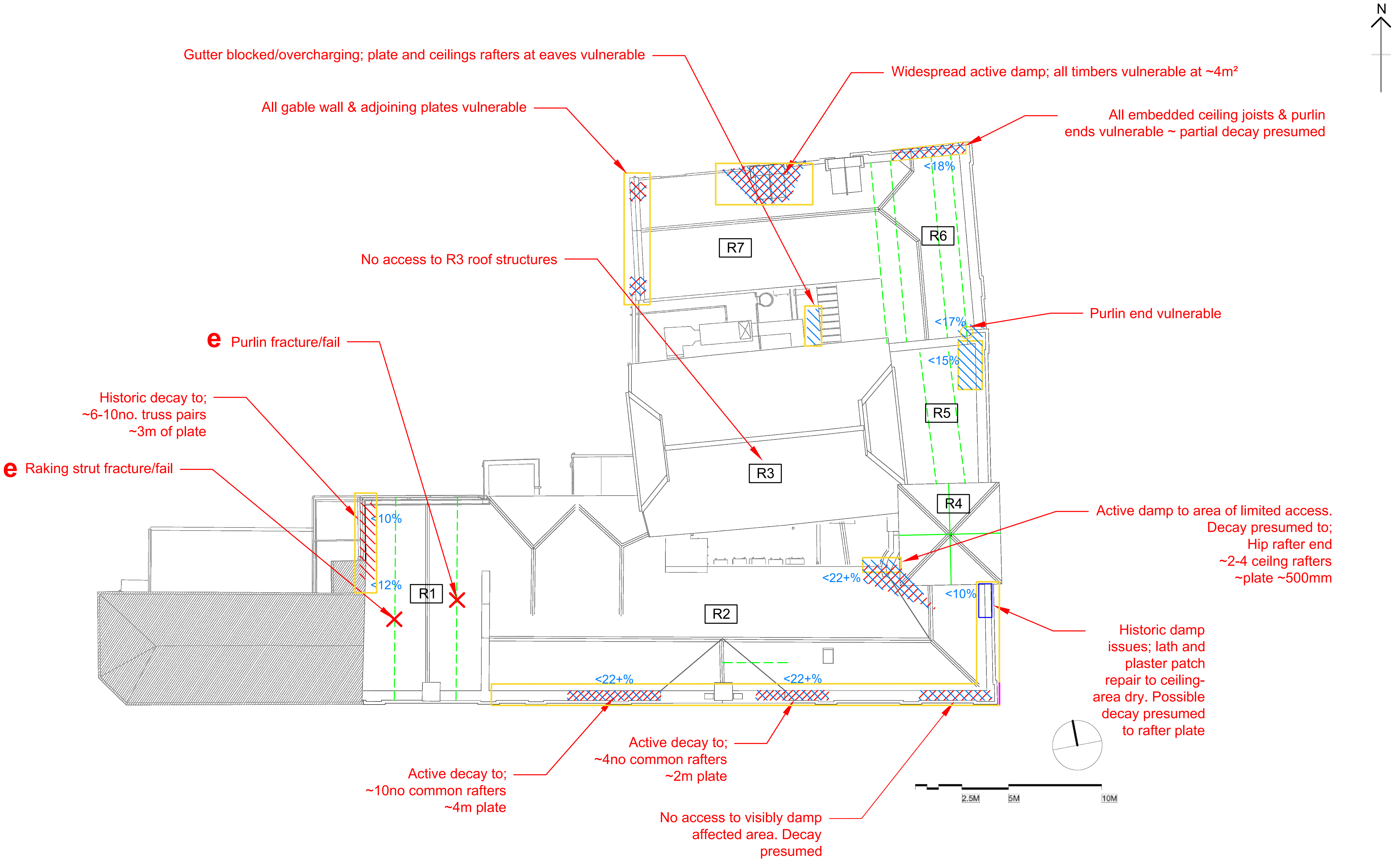
158-97 Report -Not to scale-



Lowestoft Town Hall - Roof Plan

Preliminary Damp and Decay Investigation
June 2023

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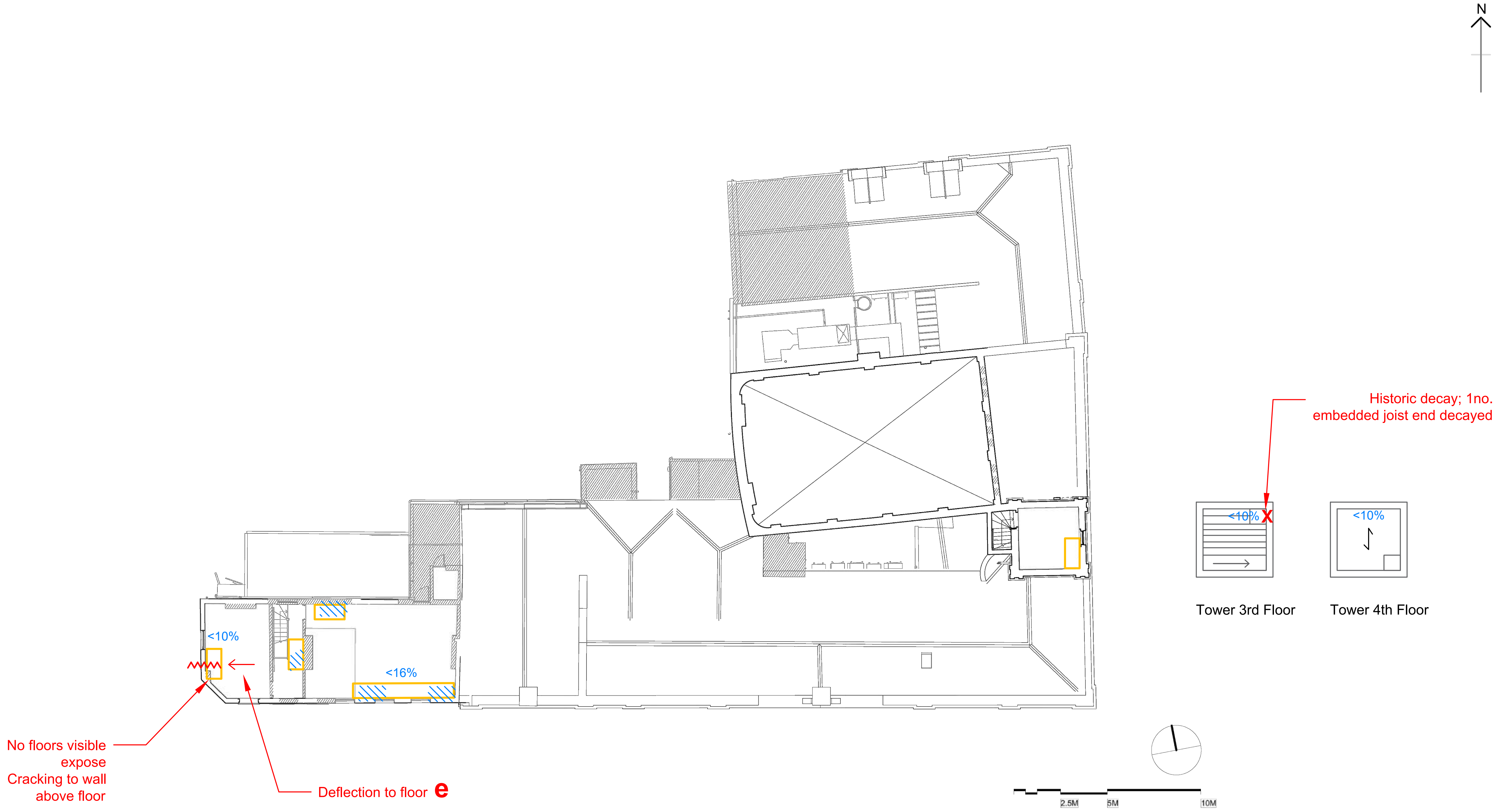
158-97 Report -Not to scale-

Key:

- R1 — Roof Area
- Vulnerable area, requires exposure/further investigation
- Area subject to water penetration providing the conditions for damp and decay
- <10% — Level of moisture content
- X — Defective item
- e — Structural engineer to comment
- Area subject to dry rot infection *(Serpula lacrymans)* / timber decay
- Approximate location of H+R Rothound indication of dry rot *(Serpula lacrymans)* activity



Key:

- Vulnerable area, requires exposure/further investigation
- Area subject to water penetration providing the conditions for damp and decay
- <10% Level of moisture content
- X Defective item
- e Structural engineer to comment
- Area subject to dry rot infection *(Serpula lacrymans)* / timber decay
- Approximate location of H+R Rothound indication of dry rot *(Serpula lacrymans)* activity
- Approximate location of H+R Rothound interest indicating old dry rot or wet rot decay
- Joist direction
- Masonry sample location

Lowestoft Town Hall - Second Floor Plan

Preliminary Damp and Decay Investigation
June 2023

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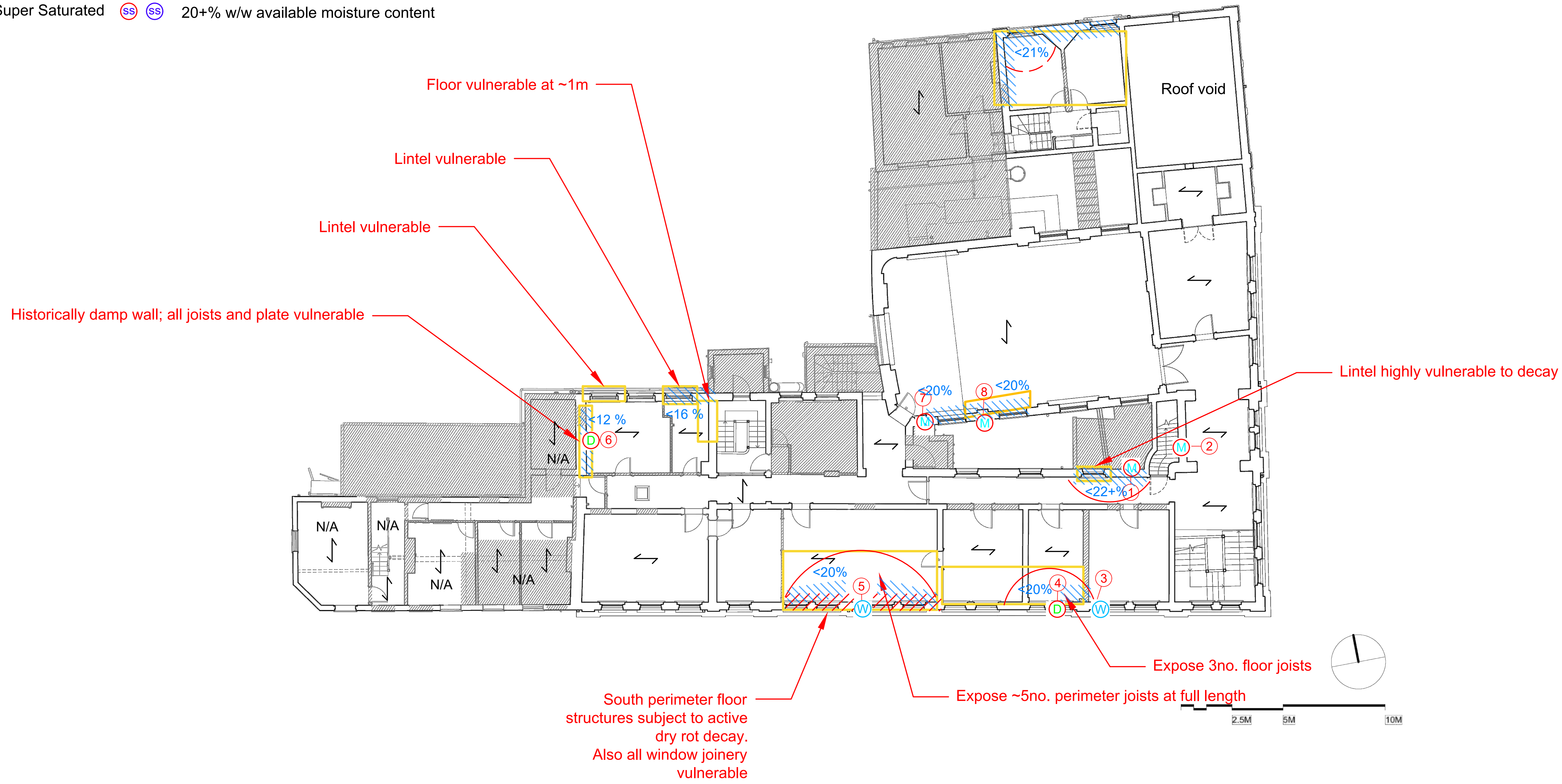
	High salt content	Low salt content	
Dry	D	D	0-2% w/w available moisture content
Moist	M	M	2-5% w/w available moisture content
Wet	W	W	5-8% w/w available moisture content
Saturated	S	S	8+% w/w available moisture content
Super Saturated	SS	SS	20+% w/w available moisture content

N



Lowestoft Town Hall - First Floor Plan

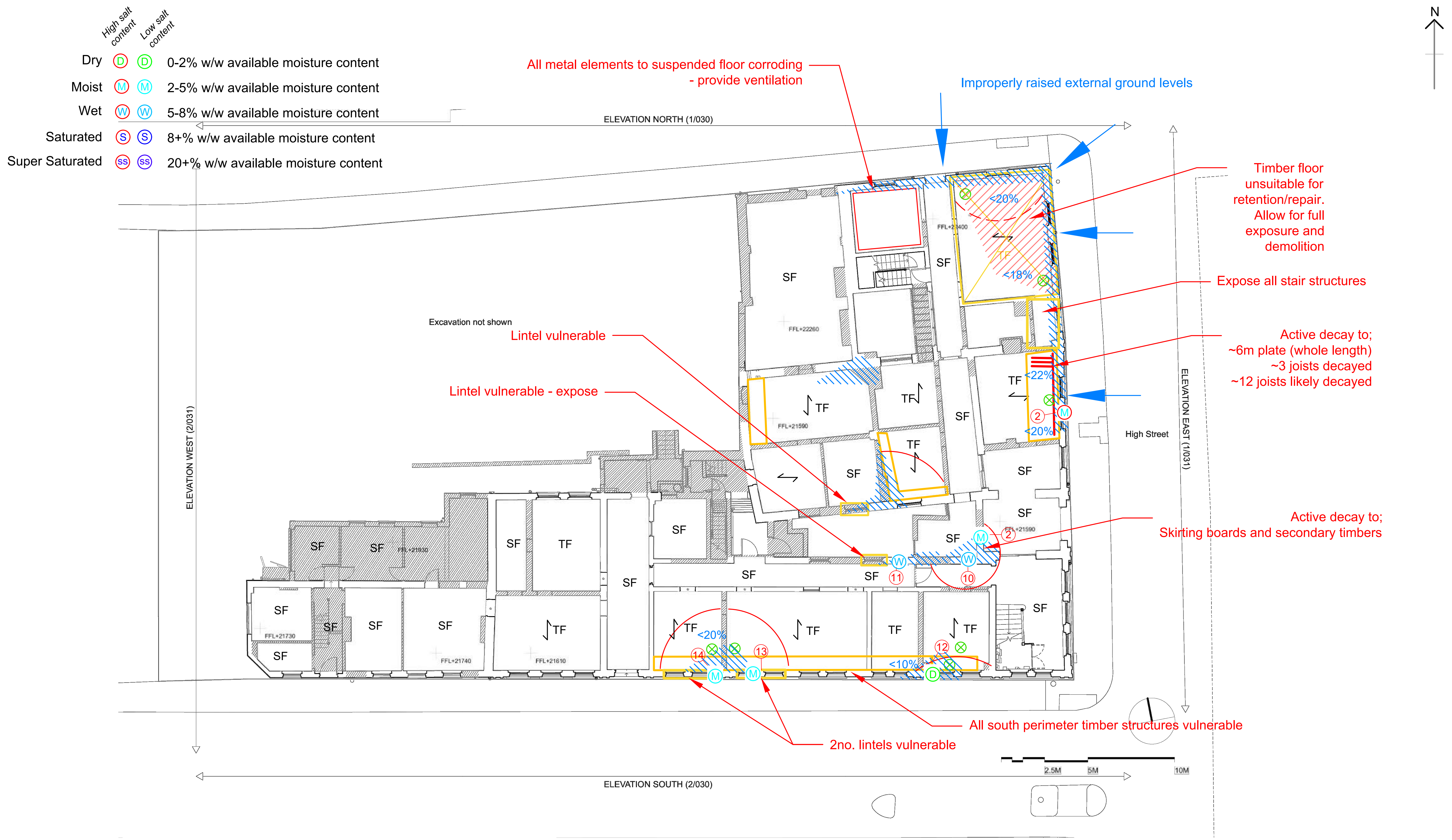
Preliminary Damp and Decay Investigation

June 2023

Hutton + Rostron Environmental Investigations Ltd
Netley House, Gomshall, Surrey, GU5 9QA Tel: 01483 203221
158-97 Report -Not to scale-

Key:

- Vulnerable area, requires exposure/further investigation
- Area subject to water penetration providing the conditions for damp and decay
- <10% Level of moisture content
- X Defective item
- e Structural engineer to comment
- Area subject to dry rot infection *(Serpula lacrymans)* / timber decay
- Approximate location of H+R Rothound indication of dry rot *(Serpula lacrymans)* activity
- Approximate location of H+R Rothound interest indicating old dry rot or wet rot decay
- Joist direction
- 1 Masonry sample location
- N/A Area of no access at time of survey



Lowestoft Town Hall - Ground Floor Plan

Preliminary Damp and Decay Investigation

June 2023

Hutton + Rostron Environmental Investigations Ltd
Netley House, Gomshall, Surrey, GU5 9QA Tel: 01483 203221

158-97 Report -Not to scale-

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- Joist direction
- Masonry sample location
- N/A Area of no access at time of survey
- Approximate location of borescope inspection
- SF Solid / Stone floor
- TF Timber floor

Appendix H

Table of material moisture contents **Appendix H**

Samples of masonry were drilled from walls in areas vulnerable to damp penetration. The samples were placed in sealed containers and tested at the H+R laboratory in accordance with the procedure for gravimetric measurement of moisture content as described in the appendix to BRE Digest 245

Property name **Lowestoft TH**
Job no **158-97**
Survey date **27.06.23**

Sample Number/Location	Moisture content % w/w			Hygroscopic moisture content % w/w	Available moisture content % w/w
	0.00	D		0.00	0.00
1	7.81	M	H	4.34	3.48
2	7.05	M	H	2.41	4.64
3	7.51	W		1.59	5.92
4	2.28	D	H	2.03	0.24
5	5.88	W		0.82	5.06
6	12.53	D	H	12.07	0.46
7	6.26	M	H	3.11	3.15
8	6.27	M	H	2.36	3.91
9	3.78	M		0.76	3.01
10	7.10	W		0.97	6.13
11	8.81	W		1.34	7.47
12	1.08	D		1.03	0.04
13	4.33	M		1.42	2.90
14	5.62	M		1.75	3.87
15	5.36	M	H	2.46	2.91

Hygroscopic moisture is the 'air dry' moisture content of the sample at 75 per cent relative humidity. High levels above, say, 2 per cent are attributable to salt contamination. Hygroscopic salt commonly accumulates in old plaster and masonry that has been subject to dampness penetrating from the ground over many years. High levels above, say, 2 per cent of available moisture (liquid water) in the sample indicate continuing dampness due to liquid water in the sample usually resulting from faulty rainwater and plumbing goods

Appendix I

'MOTHBALLING BUILDINGS' -
PROACTIVE MAINTENANCE AND CONSERVATION
ON A REDUCED BUDGET

Introduction

In these days of financial stringencies and a sluggish property market there are many buildings awaiting renovation or development. In this building equivalent of the 'poverty trap', maintenance programmes are often curtailed at the very time when reduced occupancy puts the building at a higher risk of problems such as water penetration and poor ventilation. These conditions often result in chronic problems of timber decay and especially dry rot *Serpula lacrymans*. In these circumstances, it can be difficult to motivate property owners and managers to carry out remedial works, as they will wish to minimise expenditure which might be made irrelevant by future developments. At the same time, it is important to prevent rampant timber decay developing, as this devalues the property and increases the cost of eventual renovation

Examples of the conundrum discussed above can be found in every sort of property portfolio from Grade 1 listed historic buildings to offices and domestic accommodation. Similarly, the owner may be anyone from a government department to a private individual and from an occupier to an offshore based speculator. This may raise an additional problem of conflict of interest if the owner is tempted to let a listed building decay so that it can be demolished

The result of this situation is that many basically sound buildings are allowed to decay to a stage where it is expensive or even impossible to refurbish them. In the author's opinion, this represents a negligent waste of money and valuable resources. This state of affairs is even more reprehensible because there are a few simple and cheap measures that can be taken to prevent further timber decay in such buildings. These measures should be understood and advocated by any professional involved with building conservation, so that owners can preserve their property by a policy commonly called 'Mothballing' when applied to other situations

Factors in the spiral of decay and neglect

As discussed in a previous article (1), timber decay occurs when environmental conditions in the structure become suitable for the growth of timber decay organisms. These are generally adapted to survive in the damp airless conditions found in the forest floor. This applies to both wet rot and dry rot fungi and to the wood boring insects such as woodworm and death watch beetle. The environmental conditions required for such organisms to flourish are very specific and narrow (9). However, the major factors are moisture levels and ventilation rates (8). These in turn are affected by many factors including building defects, maintenance programs and occupant activities

Maintenance

A major problem for conservation is the difficulty in getting small maintenance tasks done in an unoccupied building or a building under reduced occupancy. This is not just a result of budget constraints but may also be due to organisational and contractual problems

Occupancy

Reduced occupancy often means tenants on short term 'licences to occupy' or even squatters. Such people have no interest in maintaining the building so far as cleaning drains, stopping plumbing leaks or even preventing overflowing baths! Another factor resulting from such styles of occupancy is the reduced levels of structural heating and ventilation that tend to be used. In an attempt to save money, the occupiers will often use intermittent air heating systems and block all chimneys, windows and ventilators. This results in condensation problems and moisture build-up (4)

Malicious damage

Vandals are an important factor in the structural damage that they can cause. This may be a serious problem independent of timber decay. However, damaged windows and doors can also allow water penetration. Arson and its consequences are also, sadly, only too common. Another 'human' factor is that common pest *Plumbus larcenus* or the 'common spotted lead nicker', whose theft of even small amounts of lead from valley gutters, parapet gutters and flat roof areas can result in massive water penetration into very vulnerable areas. The measures taken to try to control vandalism can also be very damaging. Thus, the locking or screwing up of windows and doors restricts ventilation and access for inspection. The restriction of ventilation is especially severe if windows are tightly boarded up

Roof drainage

The most important sources of moisture causing timber decay in buildings are those associated with defective roof drainage (3). This may be as a result of leaks, for example, as caused by the loss of lead guttering described above or as a result of the blockage and overflow of roof drainage systems. Of these, the latter can be the most dangerous, as blocked drainage can result in the pooling of water in the system. This then acts as a long term reservoir of moisture for decay organisms as compared to leaks which may only be intermittent. Common causes of blocked roof drainage are leaves and the activities of feral pigeons. However, it is surprising how often detritus such as tennis balls and plastic bags are found blocking hopperheads, even on the highest of roofs. Similarly, ice and snow can block drainage systems, especially on the roofs of country houses or churches which often have roofs designed for regular cleaning by permanent staff

Pigeons and plants

Feral pigeons are a special problem as they are particularly attracted to unoccupied buildings for nesting. Not only can their carcasses, feathers, faeces and nests block roof drainage systems, but they can also force their way into roof spaces by displacing slates (2). Creepers and other plants are obviously the source of the leaves that commonly block roof drainage if not cleared out regularly. In severely neglected buildings, they can also grow into roof drainage systems, blocking them with their stems and roots. Their roots can also grow down into pre-existing fissures in and open up leaks to masonry. Extensive creeper growth also restricts ventilation around infested structures

Plumbing

Plumbing leaks can be an important source of chronic moisture penetration into the structure of unoccupied and partially occupied buildings. Burst pipes, as a result of freezing, cause the most severe water ingress and may commonly remain undetected long enough for large quantities of water to build up in the structure. Minor leaks also typically occur around lavatory systems and the stop cocks of central heating radiators, and these commonly cause localised timber decay

Moisture reservoirs

Large quantities of water, introduced into the structure of the building at any time, can form a reservoir of moisture in the fabric which will be available to timber decay organisms for many years. Such water penetration is commonly the result of catastrophic roof drainage leaks or gutter overflows or of plumbing problems as described above. The most severe manifestation of this problem is seen after fires. As previously discussed, these are relatively common in unoccupied buildings and when buildings are not properly maintained. Many thousands of litres of water may be introduced into the building in the process of extinguishing such fires, and roofs are commonly destroyed, leaving the building exposed to the elements for some time

Poor ventilation

The major factor in the development of timber decay in unoccupied or partially occupied buildings is poor ventilation. In a well ventilated structure, timber decay may be limited even if it has been left roofless for several years. However, timber decay will quickly set in if such structures are subsequently roofed and boarded up. Factors affecting structural ventilation internally are doors or shutters, furnishings, stored goods, general detritus and floor coverings. The latter are especially important, and fitted rubber backed carpets or linoleum commonly result in the decay of floor timbers because they restrict ventilation of sub-floor spaces. Linoleum, in particular, provides an ideal impermeable surface for the spread of foraging dry rot mycelium at its interface with floorboards

Timber preservation

Previous chemical timber treatments have little effect on the development of timber decay in unoccupied buildings or buildings under reduced occupancy. This is because of the long time scales involved, compared to the very short duration of protection they provide in conditions of chronic water penetration or long term high moisture levels. The only effective way to control timber decay is, therefore, by altering those factors affecting moisture penetration and ventilation

Proactive maintenance and conservation

Having considered the factors leading to timber decay in unoccupied buildings or those under reduced occupancy, it is possible to identify the minimum, cost effective, proactive measures that can be taken in each case to conserve the building. The aim of such measures is to set up the building structure and its management so that the environment is unfavourable to decay organisms. This involves attention to moisture sources, moisture reservoirs, moisture sinks and structural ventilation. If properly set up in this way, the system can be very robust and tolerant of major problems of water ingress and will even control pre-existing decay problems. The optimum combination is a self correcting balance of passive ventilation and moisture control measures. These should put the building environment and structure into a 'virtuous spiral', whatever state it is in. By maintaining the building in such a 'virtuous spiral', the time remaining before refurbishment is usefully used in drying the structure and in eliminating decay organisms. This time then becomes an asset for the building's conservation and a financial advantage to the owner

Moisture sources

The most common factors precipitating the growth of timber decay organisms in buildings are associated with roof drainage problems. Although roof surface defects and leaks can cause local problems, it can be surprising how a well ventilated structure will tolerate these without significant structural decay. Far more important are defects in the roof drainage system because water has been concentrated at these points. Gutter soles and hopperheads are also commonly associated with less well ventilated parts of a structure. Special attention is therefore required to minimise defects, blockage and leaks. This will require regular inspection and maintenance. Measures that will help safe and easy access to the important parts of the roof drainage system are, therefore, well worthwhile, especially when time and money are restricted. Temporary repairs to roof drainage systems need not be difficult or expensive. However, in some cases it is cost effective to by-pass blocked or defective systems. The ultimate measure of this type is the installation of complete temporary roof structures. Less drastic measures are the installation of overflow spouts from gutters and the by-passing of blocked hopperheads or downpipes by spouts draining water clear of the building. Such measures can be especially useful, as the effect of most roof drainage systems is to concentrate water and hence multiply the size of the potential problem when a leak occurs. It should not be forgotten that all such temporary roof and roof drainage measures will require the same attention to inspection and maintenance as the main systems. Similarly, balconies and the roofs over bay windows and porches require the same consideration. Water penetration at ground level should also be minimised. This is made far easier and cheaper if all rubbish and vegetation can be cleared from around the base of the walls and external ground levels can be reduced to below internal floor levels. Ultimately, if drains are inadequate or cannot entirely be kept clear, the digging of temporary surface water drains is worthwhile. It is important that water overflowing from roof drainage is prevented from splashing back onto the walls. This may be done using temporary spouts and gutters as described above. Obviously, the most economical way of minimising moisture sources inside the building is to turn off and drain any plumbing or heating systems that are not required. Those that are still in use will require inspection and maintenance

Moisture reservoirs

A number of the factors that favour timber decay organisms act as moisture reservoirs, providing a long term and continuous supply of moisture for their growth. If such moisture reservoirs are identified, measures can be taken to isolate them from valuable structures and to allow them to be dried out in the long term. This will usually only involve minor exposure work and attention to ventilation, although in some cases more active measures are useful. As a first step, if building rubbish, furnishings, or other movable items have become wet and are acting as a moisture reservoir, they should be removed from the building. Building materials such as insulation material, plaster, pugging or other infill material can be similarly disposed of if they become wet. This is especially useful if they are in sealed cavities as is the case with the masses of building rubbish that can be found in most sub-floor spaces

Moisture sinks

In a building under reduced occupancy and maintenance, it has to be accepted that there will be some moisture sources and even occasional catastrophic water penetration into the structure. Given this situation, it is necessary to arrange adequate moisture sinks for all foreseeable moisture sources or moisture reservoirs. Ideally these should be passive, should require minimal intervention or maintenance and should be self correcting. As water tends to percolate downwards through a structure, the provision of good drainage for the foundations is useful. As described above, the physical removal of wet materials from the building is also cost effective. Mechanical dehumidifiers can sometimes be useful and may be cost effective in some circumstances. However, the most important moisture sink is provided by ventilation

Ventilation

All structures and cavities should be provided with adequate through ventilation, and anything that tends to restrict this should be removed. A through flow of fresh air not only acts as a moisture sink but also has a direct effect in limiting the growth of decay organisms. The dry rot fungus, *Serpula lacrymans* particularly, is unable to grow in these conditions and is the major cause of structural decay in neglected buildings (6). As a first step, all windows can be fixed slightly open and any protective boarding perforated or spaced away from the window frames. Similarly, all internal door hatches or cupboards should be fixed open. It is most important to allow adequate ventilation into the top and bottom floor of the building. This takes advantage of the 'stack effect' to increase through ventilation and also protects the two areas of the building where most water penetrates or gathers. Any fireplaces or chimneys should be opened up to allow through ventilation of the structures involved. This also takes advantage of the stack effect to ventilate the rooms they serve

Any furniture, rubbish or other stored goods can restrict ventilation and are best removed. This is especially important with fitted floor coverings. These should be removed wherever possible or at least rolled back from external walls to allow some ventilation to 'at risk' floor timbers. The next step is to carry out minor exposure work to allow through ventilation of any sealed cavities. Such works need to be carefully carried out and supervised in order to prevent damage and to maximise their effect. Examples of such measure are the raising of floorboards overlying joist ends in external walls and the opening up of window soffits, shutters or reveal boards. Where moisture sources or moisture reservoirs are found, extra ventilation may be introduced. This may be accomplished, for example, by the cutting of vents in lath and plaster to allow a through flow of air behind or by the stripping of plaster overlying built-in timbers. Insulation materials and pugging can also be removed from around 'at risk' structures to allow proper ventilation. It is important that any of these works are carried out carefully so as to preserve any materials removed that may be used on renovation. For example, floorboards and window shutters should be carefully identified and stored. If timbers removed in this way are damp or partially decayed, they should be stored so as to allow adequate ventilation and drying of the individual elements. In this way, considerable savings of historically important materials can be made and the cost of renovation significantly reduced

In some cases, it is cost effective to continue heating an unoccupied building. Ideally, this should employ low level structural heating techniques to increase the movement of moisture from the structure into the air. A similar effect can be achieved by careful use of pre-existing heating systems run continually at a low setting. However, intermittent heating, air heating systems or heating without proper structural ventilation is to be avoided. These tend to promote condensation and may even increase the rate of growth of some decay organisms. They are thus, at best, a waste of money and may be counterproductive

Management

Monitoring and maintenance can be the most important and the most problematic part of conserving a neglected building. This is not just because of financial constraints but is due to the difficulty in organising appropriate small scale inspections and works. For this reason, a specialist consultant and contractor team are required. This ensures that information is not lost, that continuity of policy is maintained and that fixed costs are minimised

The most cost effective interval between inspections will vary with the complexity of the building and its state of decay. Once the environment has been stabilised by appropriate measures, less frequent inspection may be required, but in all cases there should be at least two thorough inspections per year. Inspections should assess all the relevant factors described above and be followed by appropriate maintenance. Any measures that can be taken to help this process can be very cost effective. For example, the provision of ladders and temporary access hatches to facilitate access are especially important

Some techniques have been developed specially for inspection and monitoring work, to make it as cost effective as possible (7). For example, the use of Rothound search dogs is generally useful because of their ability to search a large building quickly and to indicate the extent and degree of dry rot activity. This gives a timely indication of critical areas for maintenance work and picks up any residual 'hot spots' of fungal growth from previous problems which require further measures (5). In some cases, electronic monitoring and alarm systems are useful. These can allow the rapid reassessment of inaccessible structures and can even be connected via the telephone system to allow the remote monitoring and inspection of buildings. Such remote monitoring and alarm systems can save travel expenses and high cost expert time. They also allow the earliest possible detection of problems in unoccupied buildings. The most useful sensors on such systems are timber moisture probes and roof drainage overflow sensors. Standard burglar alarm sensors and systems for the early detection of the activities of anyone trying to steal roof lead can also be installed

Conclusions

The existing stock of buildings should be conserved, not for cultural or historic reasons, but because they represent a major national asset. This is because they are a repository of irreplaceable natural resources, especially high quality timber from the virgin forests that we have now destroyed. Similarly, the craftsmanship and artistry that went into the design and construction of these buildings is no longer available. It is to be hoped that we are moving from a society based on extravagant consumerism to one aiming at sustainable development. These assets are thus becoming increasingly important to our future prosperity and quality of life. The combination of design and material found in traditional buildings has often evolved over many centuries, to give an optimum solution to a particular social and environmental requirement which we discard at our peril. This principle does not just apply to the prevention of damp and decay. It is equally relevant to environmental health, where the importance of ventilation was well understood and far better managed than today. Similarly, those readers who have experience of open fires will appreciate that 'energy efficiency' was a real necessity, not just a slogan, when people had to carry energy into buildings by hand in the form of solid fuel. Because of this, the solutions that were evolved by our predecessors involved structural storage heating and the management of microclimates to a level that we are only now beginning to appreciate

If we accept that buildings should be conserved as discussed in this article, then there are six very simple and cost effective measures that can be taken in unoccupied buildings and those under reduced occupancy, whatever their current state of neglect. They can be summarised as follows:-

1 Inspect and clear roof drainage systems at least twice a year

2 Ensure ventilation through all windows, internal doors and hatches

3 Remove all floor coverings and rubbish

4 Raise floorboards along external walls and in damp areas

5 Turn off and drain all unnecessary plumbing

6 Open all window shutters and reveals and soffits if damp

Even the partial application of these measures, in the absence of advice from expert consultants, will significantly reduce the damage caused by damp and decay. In the opinion of the authors, there are compelling financial, environmental and cultural arguments for all professionals involved with conservation to undertake an urgent campaign to bring these policies to the attention of property owners and the building industry generally

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