DETAILED TIMBER CONDITION SURVEY OF ROOF STRUCTURE

NEW WAREHOUSE, SCIENCE AND INDUSTRY MUSEUM, MANCHESTER

JOB NO. 210-58



SCIENCE MUSEUM GROUP

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1 INTRODUCTION

1.1 AUTHORITY AND REFERENCE

Hutton+Rostron Environmental Investigations Limited carried out a timber condition survey of the roof structure at the New Warehouse, Science and Industry Museum, Manchester on 23 -25 January 2023 in accordance with instructions received from David Brown by email dated 7 December 2022 on behalf of Science Museum Group Order no PO040661. Reference was made to drawings supplied by Buttress Architects, reference 9488 for the identification of structures. For the purpose of orientation in this report, the elevation facing Lower Byrom Street was taken as facing east

1.2 AIM

The aim of this investigation was to identify the extent of timber decay and identify the predominant timber species within the roof structure

1.3 LIMITATIONS

This survey was confined to the accessible structures. 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. 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 woodwork or other 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. The 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

1.4 H+R STAFF ON SITE

Chris Whitfield
Catherine Knowles

1.5 PERSONNEL CONTACTED

David Brown (Capital Project Manager - Science & Industry Museum)

2 EXECUTIVE SUMMARY

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2.1 OBSERVATIONS

Roof structure was a softwood construction, original timbers were Scot's pine group and later timber repairs were initially identified as Norway spruce or Douglas fir. There was evidence of water penetration in multiple areas generally correlating with gutters, wet masonry at the gables and leaks via the rooflights. There was one area that was significantly wet at the east elevation corresponding with a short section gutter. Timbers here were at a heightened risk of decay. The deep moisture content in most locations was below 8 per cent w/w and 'dry' suggesting the decay was historical. However, the survey was carried out during a period of dry weather and the upper floor of the building was excessively heated. The deep moisture contents of timbers may increase following a period of heavy rain the raised internal temperatures encourage evaporation

Structurally significant decay caused by wet rot was detected in the bearing ends of purlins, valley beams, and at the tie beam in a small number of areas identified at Appendix F. Partial decay was also identified in the valley gutter boards and sarking boards in localised areas. Previous phases of repair were identified using both, scarf joints and steels. These repairs were in response to historical damp and timber decay. However, a selection of repaired timbers were water-stained where embedded in the masonry which suggested sustained wetting
or slate shims etc
Inspection of the roof structure to all pitches was limited due to ceiling finishes and plant. The void behind the roof access portal in gridline 'I' was inaccessible, and timbers in these areas could be at risk of decay

2.2 RECOMMENDATIONS

It's recommended that the Estates Department maintain a floor/roof plan indicating the locations of persistent water penetration. These areas can then be revisited prior to re-roofing. Allow for structural repairs to decayed roof timbers as directed by the Structural Engineer. Previous timber repairs and steel reinforcement should be assessed by the Structural Engineer. Gutters should be assessed for their efficiency and gutter timbers investigated for their condition following exposure from above during reroofing. New suitably specified softwood timbers should be separated from direct contact with the masonry using a suitable dpm and/or ventilated air gaps

Roof drainage and high-level masonry e.g. gables and copings should be investigated and appropriate repairs implemented to limit further water penetration

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3 OBSERVATIONS

3.1 ROOF STRUCTURE

See photograph figures 1-57 in the Schedule of Photographs at Appendix E, and annotations on plans at Appendix F

1 Construction A-P: All timbers were of softwood species. The roof structure comprised 7 no. adjacent pitched roofs divided by parapet and valley gutters. Each pitched roof comprised 6 no. queen-post trusses spanning east to west that were supported in the masonry and atop cast-iron columns at their bearing end. All trusses included original metal queen-rods and king-rods bolted through the timber elements and connections included cast-iron shoes/sockets. A proportion of the trusses also included original timber cross-bracing, supplementary queen posts and lower struts. Principal rafters supported 2 no. purlins to each pitch, both notched over the principal rafters but the lower restrained by timber cleats and the upper by metal plates with bolted connections. Purlins were supported in masonry pockets at the north and south gables and supported common rafters. Common rafters spanned from the ridge to the wall plate/valley beam and passed through notches in the purlins. Common rafters supported square edge sarking boards. The valley gutters spanned from north to south and comprised of two timber valley beams. Valley beams were supported from notches at the truss tie beams and in masonry pockets at the north and south gables. Gutter boards were supported from bearers that spanned the valley beams supported on battens. The majority of timbers were supported over padstones or corbels where embedded in masonry pockets

Dimensions (approximately)		
Truss		
Tie beam		310 x 170mm
Principal rafters	Lower	270 x 170mm
	Upper	170 x 120mm
Strut		170 x 120mm
Collar		270 x 170mm
Cross-brace		150 x 170mm
Queen-post		150 x 120mm
Purlin		250 x 125mm
Wall plate		275 x 95mm
Common rafter		125 x 60 @ 730 – 770mm
Sarking board		220 x 20mm
Ridge board	Lower	150 x 50mm
	Upper	110 x 50mm
Lower strut (below tie beam)		250 x 170mm
Gutter bearer		75 x 40 @ 400mm
Gutter batten		45 x 20mm

2 Construction P-Q: All timbers were of softwood species. The pitched roof structure comprised 2 no. king-post trusses spanning east to west that were supported in the masonry and atop cast-iron columns at their bearing end. Both trusses included original metal king-rods bolted through the timber elements and

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connections included cast-iron sockets. Principal rafters supported 1 no. purlin to each pitch, notched over the principal rafters and restrained by timber cleats. Purlins were supported in masonry pockets at the north and south gables and supported common rafters. Common rafters spanned from the ridge to the wall plate/valley beam and passed through notches in the purlins. Common rafters supported square-edge sarking boards. Valley and parapet gutter construction was the same as at gridlines A-P

Dimensions (approx.)	
Truss	
Tie beam	320 x 170mm
Principal rafter	195 x 145mm
Strut	95 x 145mm
Purlin	250 x 120mm
Common rafter	75 x 120 @ 770mm

3 Roof finishes: Roof finishes were not inspected by H+R. However, information gained from photographs supplied by Buttress Architects is provided beneath. Rooflights extend the span of the roof at gridline 3-4 to all pitches except at I-K and N-Q. In addition, there are a total of 10 no. Velux style skylights and 5 no. roof access portals. Pitches are sealed with stepped lead flashing at gable abutments

Dimensions (approx.)	
Natural slate	350 x 600mm
Battens	25 x 50mm
Counter battens	25 x 50mm
2x Bituminous felt	
PIR insulation	30mm
Bituminous felt	

4 Rainwater drainage: Valley and parapet gutters were not inspected by H+R. However, photographs and the 3D photogrammetric model supplied by the Architect show the stepped gutters are of GRP fibreglass. The gutters fall to the south into hoppers, suspected to be of asbestos cement, and uPVC downpipes

5 Previous timber repairs: Timbers had been repaired using formally designed steel repairs, scarf joint, and partner repairs. Frequently, purlins were repaired with timber scarf joints reinforced with wedge and bolts, where timber was in contact with the masonry. Valley beams had splice repairs with additional steel plates at their bearing ends, occasionally reinforced with steel angle brackets. Sarking boards had been replaced in localised areas. Partner repairs of common rafters were observed in localised areas as well as replacement of rafters. Repairs were typically concentrated around gutters and where timbers were in contact with the masonry. Note that ~20mm drillholes at the bearing end of structural timbers are associated with a historical timber condition survey presumably undertaken during the 1987-8 refurbishment (*see Fig 23*)

6 Previous steel reinforcement: During the 1987-88 refurbishment the building was subject to several steel reinforcement measures which appear to be focused around ensuring the structural integrity or the roof structure. These interventions did not appear to be in response to specific contemporary timber condition issues. Locations of steel reinforcement can be found at Appendix F. Hollow steel tension ties have been added below the ridge board between trusses and between the outer trusses and gables to most pitches. Square section steels have been added below the wall plate at the east and west wall. Steel fish plates also connect abutting tie-beams beneath valley gutters

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7 Finishes: Timbers appear to have been decorated with a wood stain or varnish, presumably to help disguise previous timber repairs. However, there was a notable sheen to the timbers which is probably a clear intumescent coating. Cast-iron and steel elements have been painted in a maroon-coloured paint. The steel reinforcement was powder coated in a similar shade

8 Access limitations: The survey was limited to areas where the roof structures could be accessed from beneath. The building mostly consisted of an open roof structure; however, some areas could not be inspected due to the presence of suspended ceilings, plant, and locked rooms

9 Water penetration: The 2nd floor is well heated (possibly overheated) and well ventilated, so identifying ongoing water penetration was particularly challenging given the dry conditions. There has been an ongoing issue of water penetration, indicated by the staining of roof timbers, wall, and floor finishes. Historically, timbers most affected have been the bearing end of purlins, and valley gutter timbers but leaks through the rooflights and where services passed through the roof was also prevalent. Many leaks were managed with buckets. Many timber repairs had staining, showing repeated water penetration where these timbers were in contact with previously damp or wet masonry. Areas of known water ingress are identified on the plans at Appendix F

10 Timber condition: All accessible roof timbers were visually inspected and vulnerable bearing ends were tested by micro-bore decay detection drilling and deep moisture probing. Areas of significant decay are identified on the plans at Appendix F. Structurally significant decay was identified in the bearing end of a purlin at the South gable wall (*see Figures 25-26*) and valley beams at the Conference Room I-K (*see Figures 32-33*) and Administration Office E-G (*see Figures 19-20*); both of which corresponded with areas of recent water penetration. The most significant area of decay was in a tie beam at Conference Room I-K (*see Figures 29-31*). However, the decay in the tie beam was historical and pre-dated the redevelopment of the building in 1988. Sarking boards, gutter boards and bearers and common rafters were partially decayed in localised areas where water penetration has occurred historically. This included rooflights, roof access points and gutters. Where tested, the deep moisture contents of timbers were generally below 10 per cent w/w which is too low for decay to occur. However, elevated deep moisture contents were identified in areas subject to water penetration. Timbers here were at a heightened risk of fungal decay and insect infestation in these areas

3.2 TIMBER SPECIES

1 Methodology: Small, matchbox size, samples were obtained from representative original softwood roof timbers in 7 no. locations for timber species identification. See Appendix F for sample locations. Previous repairs are likely to have been undertaken in a range of species, including Norway spruce/European Whitewood *(Picea abies)* and Douglas fir *(Pseudotsuga menziesii)*. Each sample was visually inspected under 3 no. planes of orientation: transversal, radial, and tangential to observe anatomical features

Sample No.	Timber member	Common name	Botanical name
1	Tie beam	Scot's pine/ European Redwood	*Pinus sylvestris*
2	Principal rafter		
3	Strut	Scot's pine group/ European Redwood	*Pinus uncinata*
4	Common Rafter		*Pinus sylvestris*
5	Sarking board		

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6	Principal rafter	Scot's pine/ European Redwood	
7	Valley beam		

2 Achievable Strength Classes: *BS EN 1912 2012 'Structural Timber – Strength Classes – Assignment of visual grades and species'* is the UK's standard for achievable Strength Class for common and commercially available softwood timber, based on source/timber origin and following Visual Strength Grading to either Special Structural (SS) or General Structural (GS)

Botanical name	**BS EN 1912 identification number**	**SS**	**GS**
Pinus sylvestris	47	C24	C16

3 Visual Strength Grading: Identifying whether specific members are likely SS, GS or Reject requires on-site visual inspection following the standards set out in BS 4978: 2007 'Visual Strength Grading of Softwood'. To date, H+R have not been instructed to undertake this service

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4 RECOMMENDATIONS

4.1 ROOF STRUCTURES

4.1.1 Repairs generally

1 Water penetration: Every practicable effort should be made to prevent water penetration prior to re-roofing. The parapet and valley gutters and rainwater drainage goods should be inspected at the earliest opportunity and cleared of any debris. If necessary, temporary repairs should be undertaken ahead of re-roofing so as to stop water penetration and the likelihood of additional timber decay-related repairs. It would be advantageous for the Estates Department to mark-up the existing 2nd floor/roof plans in areas of ongoing leaks prior to re-roofing. These areas can then be revisited by H+R once roof finishes are removed, if instructed. H+R recommend that a temporary roof is installed over the building before re-roofing and that rainwater drainage is effectively managed and diverted towards existing drains

2 Structural timber repairs: No chemical treatments are required. Structurally decayed timbers may require temporary propping, as directed by the Structural Engineer. The decayed tie beam, purlin, and valley beams should be sensitively repaired with suitable softwood timber of appropriate strength class, preferably Scots pine, and/or with steel, as directed by the Structural Engineer. New and repaired timbers should be physically isolated from direct contact with the masonry using damp-proof materials e.g. slate shims etc. and/or ventilated air gaps. H+R can provide further advice to the Design Team on detailing when necessary. Timbers currently identified as wet but not yet structurally decayed may require repair if water penetration is allowed to continue

3 Previous repairs: Structural Engineer to assess the design and performance of all previous repairs and reinforcement identified in the roof structure

4 Parapet and valley gutter timbers: Following removal of roof finishes, allow for detailed inspection and repairs to the gutter timbers above the areas of decayed roof structure. H+R can undertake this service if required. New gutter timbers should be isolated from direct contact with the masonry using dpm materials or slate shims etc. H+R can review proposed gutter details, if required

4.1.2 Further investigations and additional consultancy

1 Roof drainage: Existing rainwater goods should be assessed for their drainage performance and modifications implemented to aid drainage and prevent future blockage, if appropriate. H+ R can provide a full inspection and undertake rainwater drainage calculations to provide an informed approach, if required

2 Roof coverings: Allow for re-roofing as specified by Buttress Architects. Existing slates should be assessed for their condition, service-life and suitability for salvage and reinstatement prior to reroofing. H+R can undertake a slate condition survey, if instructed

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3 High-level masonry: Copingstones, parapets and high-level masonry should be inspected to determine condition and vulnerability to water penetration prior to reroofing. H+R can undertake a high-level masonry condition survey, if instructed

4 Loading doors: The historic loading doors and architrave to the north elevation were partially decayed and require repair. H+R can undertake a condition survey of all historical external joinery, if instructed

5 Timber floorboards: Areas of partial decay were noted in the softwood timber metal tongued millboards at second floor level. H+R can undertake a timber condition survey of the floor to determine the severity of decay and assess whether repairs are required, if instructed

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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

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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 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

5.2.3 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

5.3 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. 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

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Appendix A

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A.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

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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°C, a temperature frequently exceeded in roof spaces, for example. Large radiators can be particularly lethal to dry rot and measurements of 30°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

A.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

A.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

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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

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Appendix B

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B.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

B.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

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B.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

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

h Will search small inaccessible areas and roof spaces

i Will work in furnished and inhabited buildings

j Totally non-destructive

k Will work 2-4 hours per day

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, eg 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

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e May not 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 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

B.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

B.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

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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

B.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

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Appendix C

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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

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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

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Appendix D

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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

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Appendix E

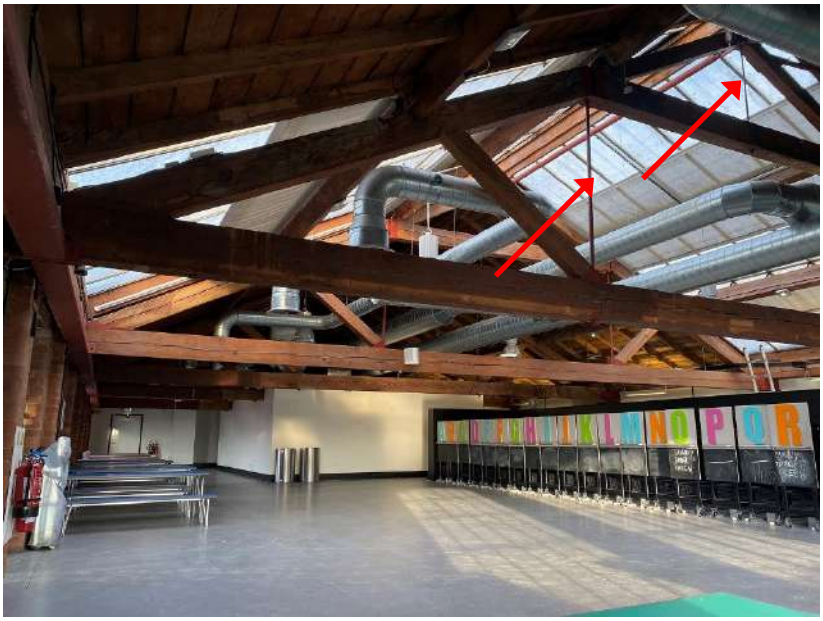


Fig 1:

Education Suite A-C; showing an example of the softwood queen-post roof trusses. Note the metal tie-rods acting as queen and king-posts



Fig 2:

Education Suite A-C, South gable; showing a timber scarf joint and steel repair to the upper purlin. We understand these repairs date from the 1987-88 refurbishment

Note the timber wedges left in situ

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Fig 3:

Education Suite A-C, South gable; showing a timber splice and steel repair to the valley beam

Note steel corbel at the bearing end of the valley beam, we assume this dates from 1987-88



Fig 4:

Education Suite A-C, West wall; showing the square section steels below the wall plate

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Fig 5:

Education Suite A-C, West wall; showing a mortise in the tie beam where a lower strut was located historically (please see Fig 12)



Fig 6:

Education Suite A-C; showing hollow steel tension ties beneath the ridge

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Fig 7:

Education Suite A-C; showing the steel fish plates connecting abutting tie beams beneath the valley beams



Fig 8:

Education Suite A-C, West wall; showing effloresence on the masonry. This indicated a history of water penetration in the area. However, roof timbers were dry when tested for their deep moisture content

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Fig 9:

Education Suite A-C, North gable; showing ongoing water penetration via an external roof vent

Note staining to the sarking boards around the vent opening



Fig 10:

Education Suite A-C, North gable; showing water penetration and staining to the plywood platform beneath the vent. Also note efflorescence on the masonry

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Fig 11:

Education Suite A-C, North gable; access was limited but the lower purlin at this wall was suspected to be damp and vulnerable to decay

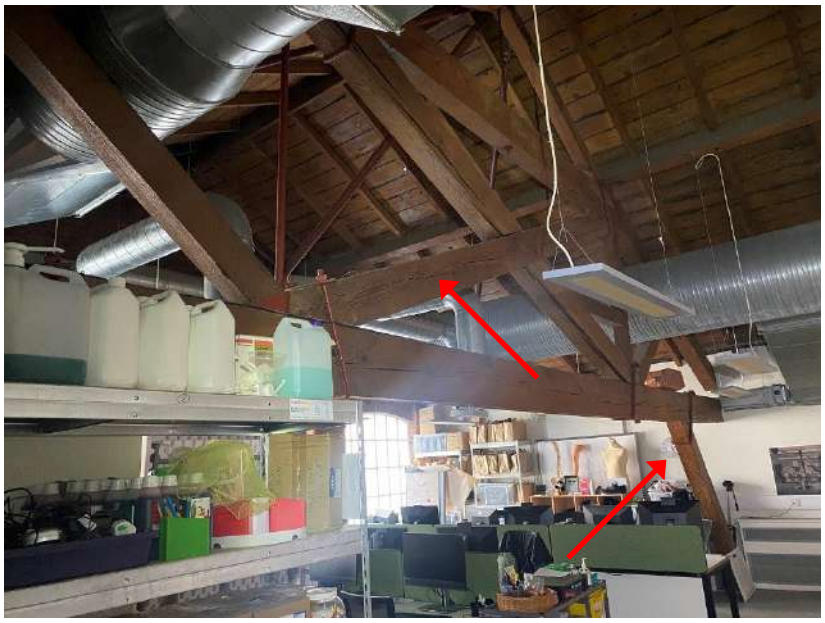


Fig 12:

Education Suite C-E; showing an example of timber cross bracing and lower struts within the truss

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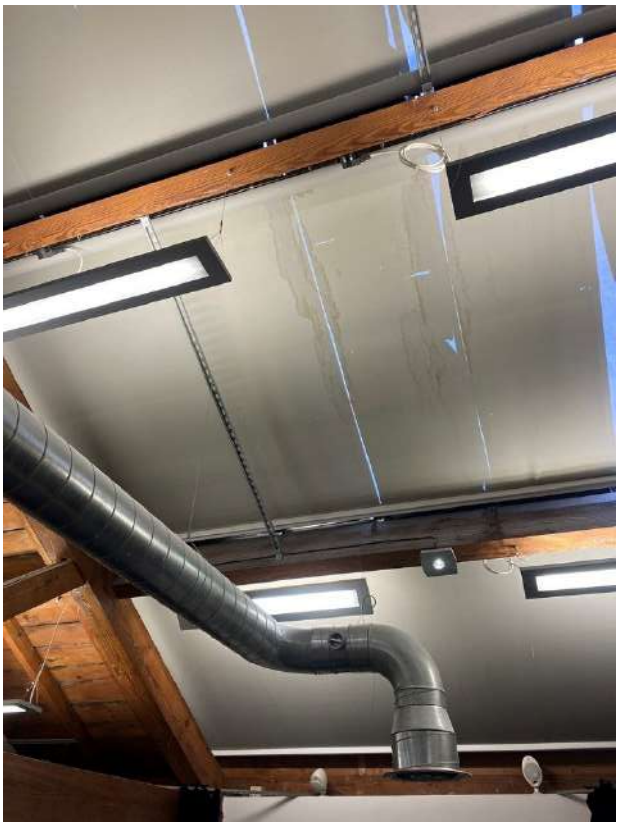


Fig 13:

Education Suite C-E; showing water staining to the blinds beneath a rooflight. No significant damp or decay was identified in the purlins in this area

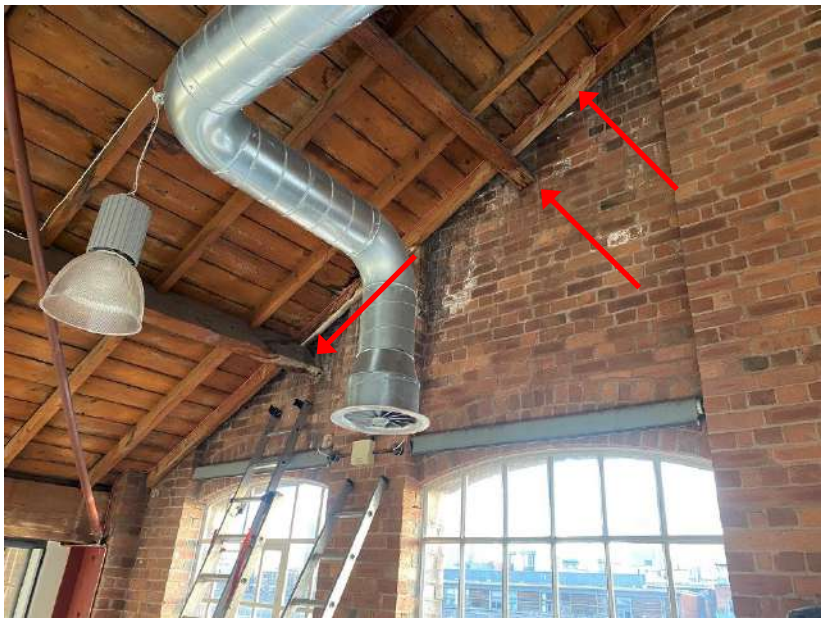


Fig 14:

Education Suite C-E, South gable wall; showing water staining to the upper and lower purlins and common rafters. Timbers were dry with a deep moisture content of below 7 per cent w/w. No significant decay was identified in this area

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Fig 15:

Administration Office E-G, over toilet block; investigation was limited to visual inspection due to limited access. Note the truss tie beams were concealed by suspended ceilings



Fig 16:

Administration Office E-G; showing water staining to roof timbers and deck from a leak via the rooflight

No significant damp or decay was detected where tested. Where accessible for testing , timbers were dry

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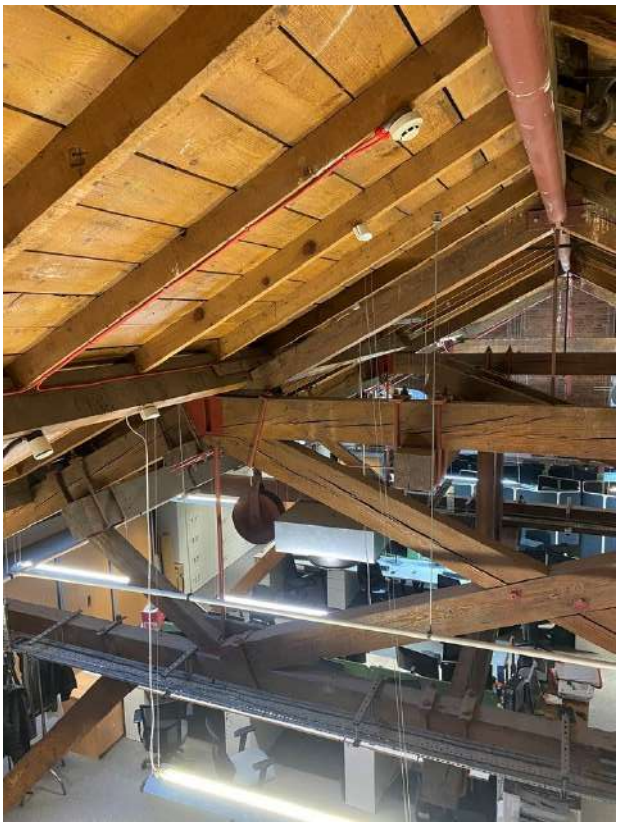


Fig 17:

Administration Office E-G; showing a general view of the roof which comprised 6 no. softwood trusses



Fig 18:

Administration Office E-G; sarking boards were decayed towards the valley gutter

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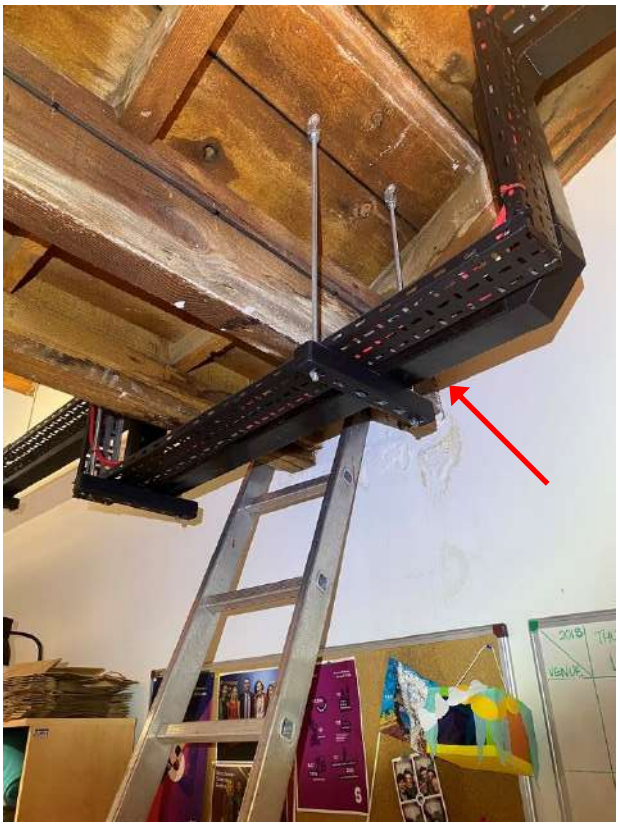


Fig 19:

Administration Office E-G; showing water staining to the valley beam



Fig 20:

Administration Office E-G; showing the bearing end of the valley beam at Fig 19. Partial decay was identified in the valley beam but access was limited due to the stud partition. A deep moisture content of 8% w/w was recorded. Allow for exposure and detailed investigation

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Fig 21:

Administration Office E-G; showing the abutting valley beam to Figures 19-20. The beam produced no significant moisture content reading. However, water staining suggests a recent leak in this corner



Fig 22:

Administration Office E-G; showing water staining close to the rooflight where leaks have occurred

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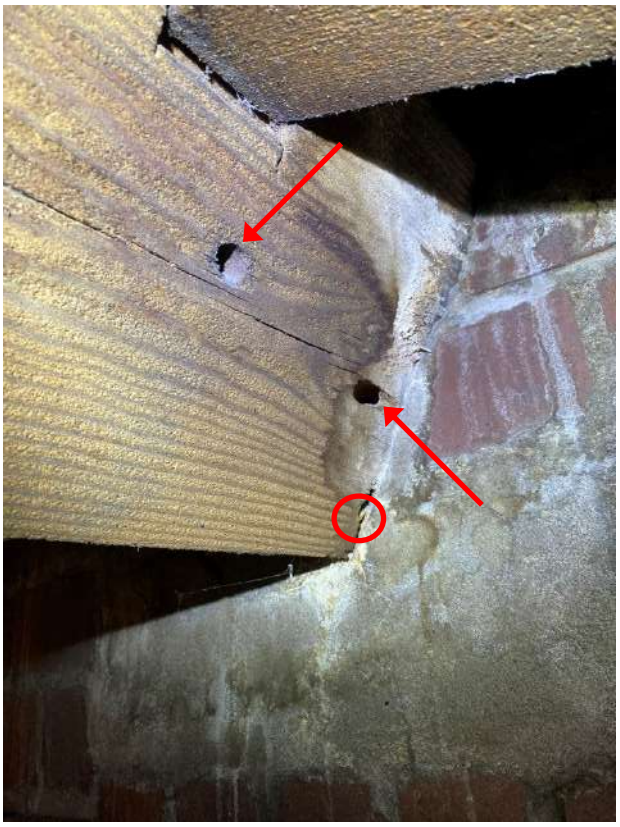


Fig 23:

Administration Office E-G, North gable; showing 12mm diameter holes drilled during a historical timber condition survey. H+R holes were discrete and concentrated at the bearing end (circled)



Fig 24:

Administration Office G-I; showing where decayed sarking boards had been replaced

Note the original sarking boards had received in situ abrasive cleaning prior to their removal and reinstatement. This is evidenced by the dark-coloured sections that were previously concealed over the common rafters during cleaning

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Fig 25:

Administration Office G-I, South gable; showing upper purlin that was decayed at it's bearing end

The deep moisture content of the purlin was 8 per cent w/w suggesting the decay was historical



Fig 26:

Administration Office G-I South gable; showing a close-up of a screwdriver penetrating the upper 1/3rd of the decayed upper purlin

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Fig 27:

Administration Office G-I; showing area of roof which was inaccessible for close inspection due to a void on the second floor



Fig 28:

Conference Room I-K; showing a general view of the roof. Note the absence of original cross-bracing between the collars and tie beams

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Fig 29:

Conference Room I-K; showing the north face of the tie-beam to truss at gridline 6. The tie beam was significantly decayed for a length of ~1200mm. Decay was historical and pre-dated the redevelopment of the building



Fig 30:

Conference Room I-K; showing decay to a depth of ~70mm in the tie beam. Decay was just under 1/2 the depth of the 170mm deep tie beam

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Fig 31:

Conference Room I-K; showing remnants of decayed tie beam that could be easily removed by hand



Fig 32:

Conference Room I-K; showing water staining to the underside of the valley gutter. The gutter boards and valley beam were partially decayed in this location

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Fig 33:

Conference Room I-K; showing the underside of the gutter board in Fig 32. The board and inside face of the valley beam were partially decayed by wet rot. However, the deep moisture content of timbers in this area were below 8 per cent w/w suggesting the decay was historical



Fig 34:

Conference Room I-K, North gable plant room; showing decayed sarking boards. A surface moisture content of 8 per cent w/w was recorded indicating decay was historical

Note that the void behind these boards was obstructed by the partition

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Fig 35:

Conference Room I-K, North gable plant room; showing water staining to the timber repair at the bearing end of the lower purlin and on the masonry

Please note H+R could not access these timbers due to plant so timber condition and deep moisture contents could not be recorded

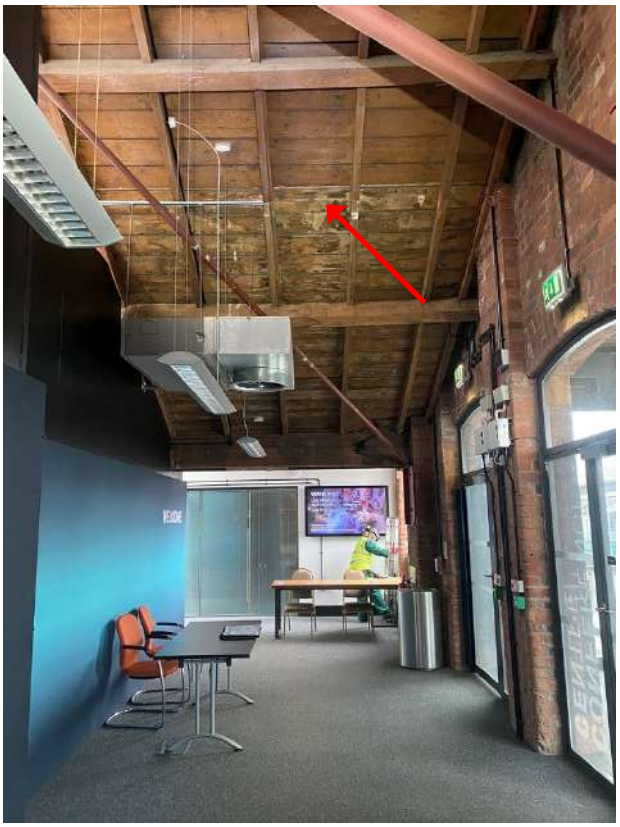


Fig 36:

Conference Area Corridor K-M; showing distinction between original sarking boards and late 20th Century replacements

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Fig 37:

Conference Area K-M; showing a general view of rooflight area accessed by scaffold

Note the disintegrated expanding water barrier, buckets and mats used to mitigate previous water penetration



Fig 38:

Conference Area K-M; showing active water penetration identified at the East end of the roof space. Water penetration was via the rooflights. Note water in the bucket

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Fig 39:

Conference Area K-M, West end of the rooflight; showing evidence of recent water penetration. The timbers and bucket were dry. No significant decay was noted



Fig 40:

Conference Area K-M, North plant room; showing a general view of the roof structure which could not be accessed due to plant

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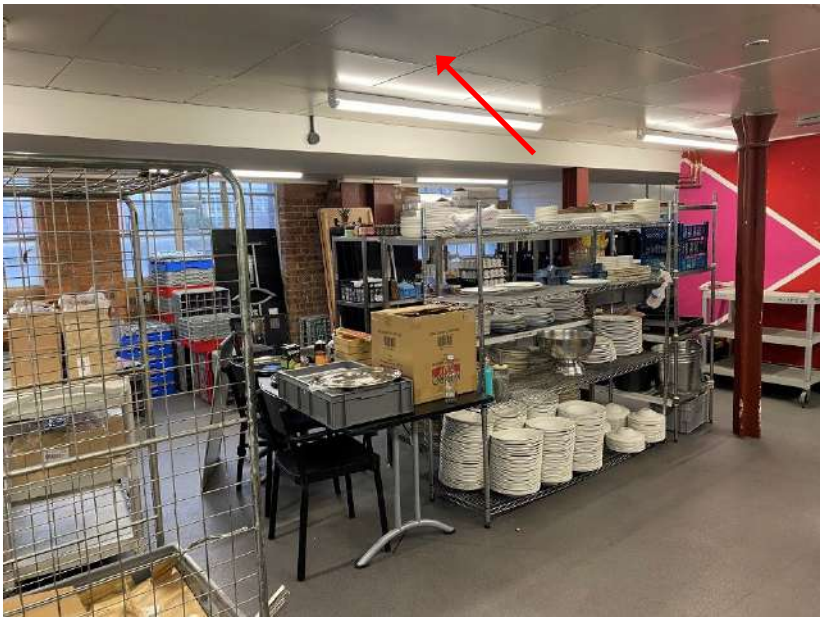


Fig 41:

Conference Area K-M, Kitchen and catering area; showing roof concealed by a suspended ceiling



Fig 42:

Offices and Meeting Rooms M-P, roof space at North gable; general view of roof access portal above lift

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Fig 43:

Offices and Meeting Rooms M-P, roof space at North gable; showing water-staining of common rafters and sarking boards



Fig 44:

Offices and Meeting Rooms M-P, roof space at North gable; showing decay in the sarking boards and top of a common rafter. Deep moisture content was at 8 per cent w/w

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Fig 45:

Offices and Meeting Rooms M-P, roof space at North gable; showing a historical timber partner repair to the bearing end of a decayed upper purlin. This repair likely pre-dates the 1980's restoration



Fig 46:

Offices and Meeting Rooms M-P, roof space at North gable; showing steel tension tie missing along the ridge where plant has been installed

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Fig 47:

Offices and Meeting Rooms M-P, roof space at North gable; showing a notch through a beam to accommodate the steel tension tie



Fig 48:

Offices and Meeting Rooms M-P, roof space at North gable; showing a close-up of the notch

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Fig 49:

Offices and Meeting Rooms M-P, roof space at East wall; showing internal rainwater downpipes which serves a short section of valley gutter. The area was subject to ongoing water penetration providing the conditions for damp and decay



Fig 50:

Offices and Meeting Rooms M-P, roof space at East wall; showing a deep moisture content of 55.4 per cent w/w in the principal rafter. No significant decay had yet occurred but the timbers were vulnerable to decay so long as water penetration is allowed to continue

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Fig 51:

Meeting Rooms P-Q; showing softwood king-post truss with a steel tie -rod acting as a king-post

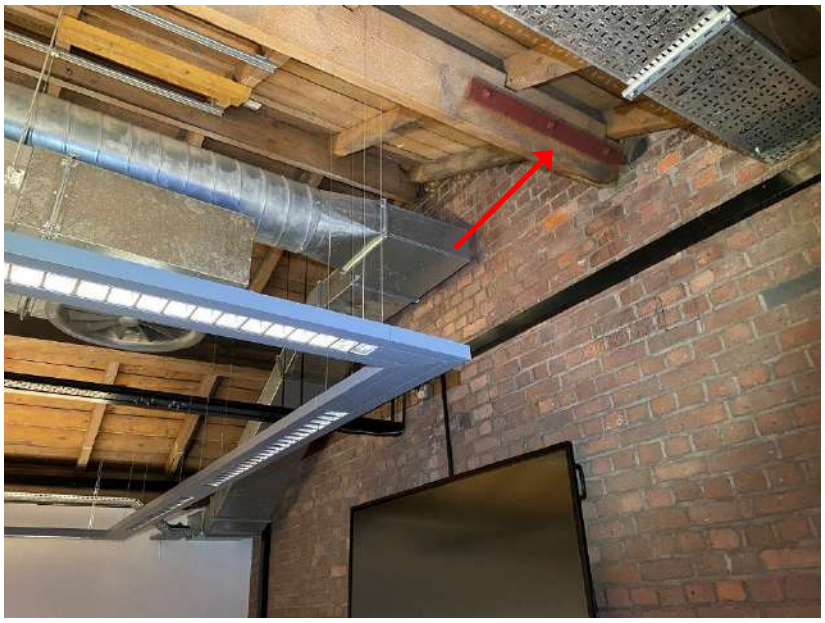


Fig 52:

Meeting Rooms P-Q, North gable; showing a purlin reinforced with a steel tie that appears to penetrate the gable wall. This corresponds with a pattress plate on the exterior

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Fig 53:

Administration Office G-I, Director's office; showing decay in the loading doors to the north wall



Fig 54:

Administration Office G-I, Director's office; showing decay in the loading doors to the north wall

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Fig 55:

First floor ceiling; showing the underside of the Second floor. The floor comprised metal tongued millboards that spanned over riveted metal beams



Fig 56:

First floor; showing area of localised decay in the millboards. Note the exposed metal tongue (circled)

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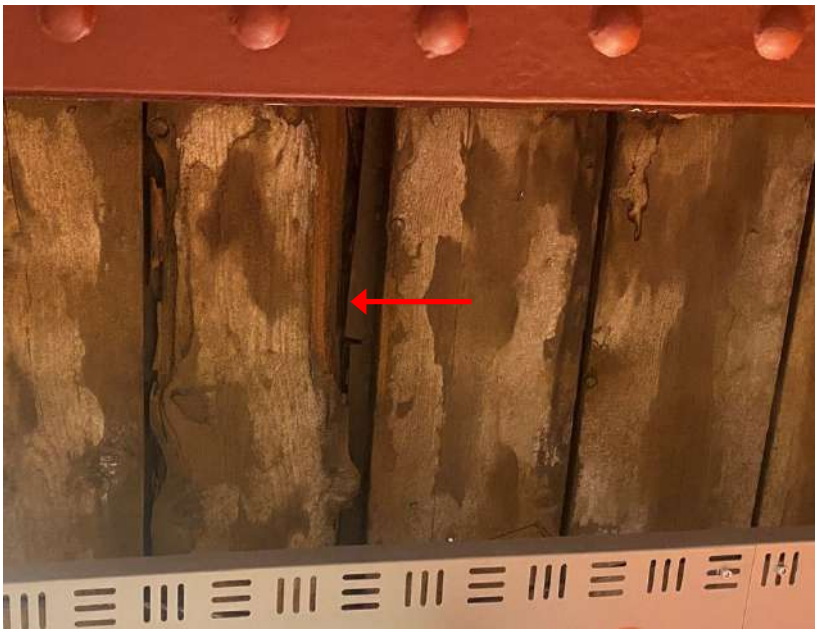


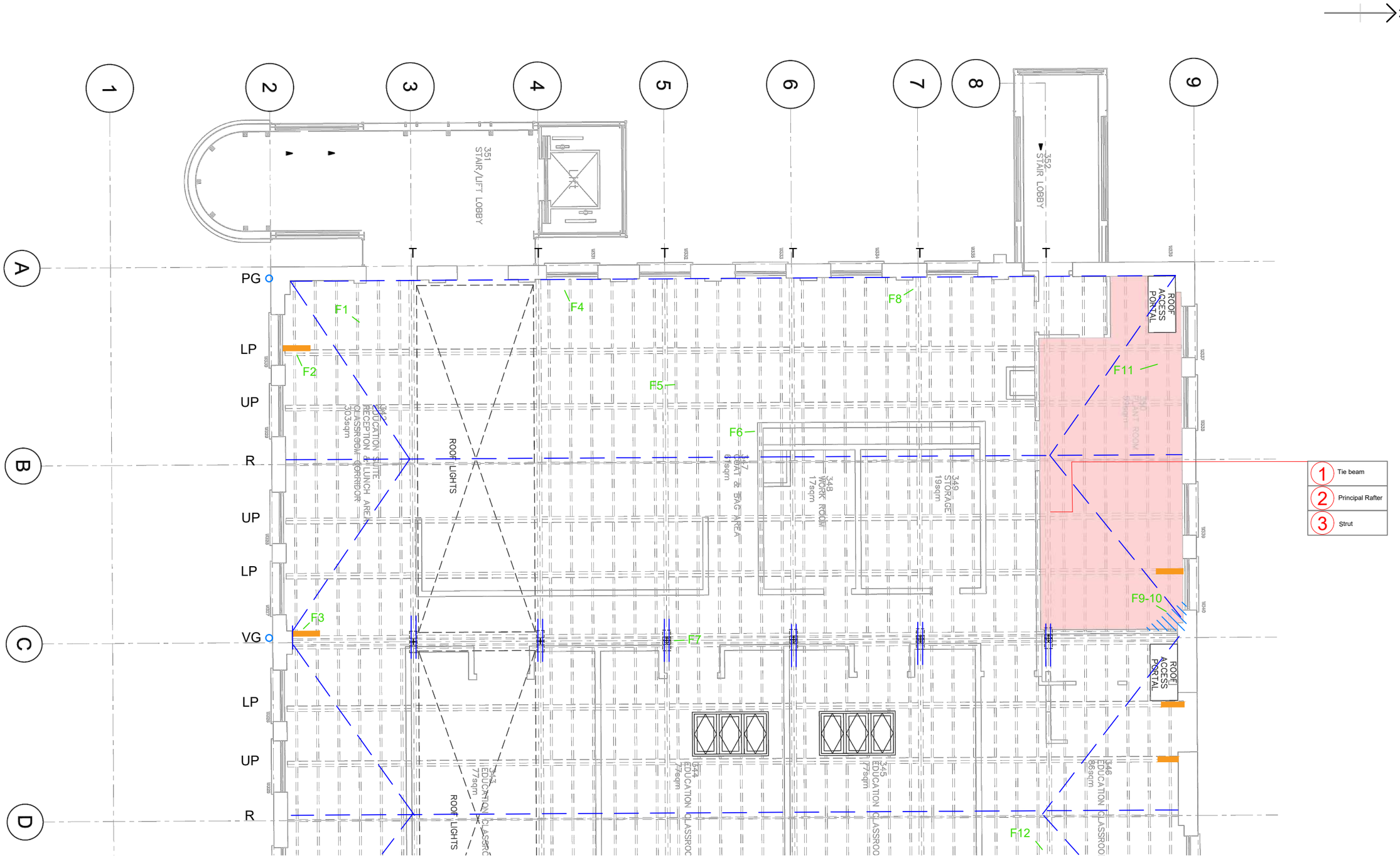
Fig 57:

First floor ceiling or underside of second floor; showing decay to the millboards exposing metal tongues

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Appendix F



Key:

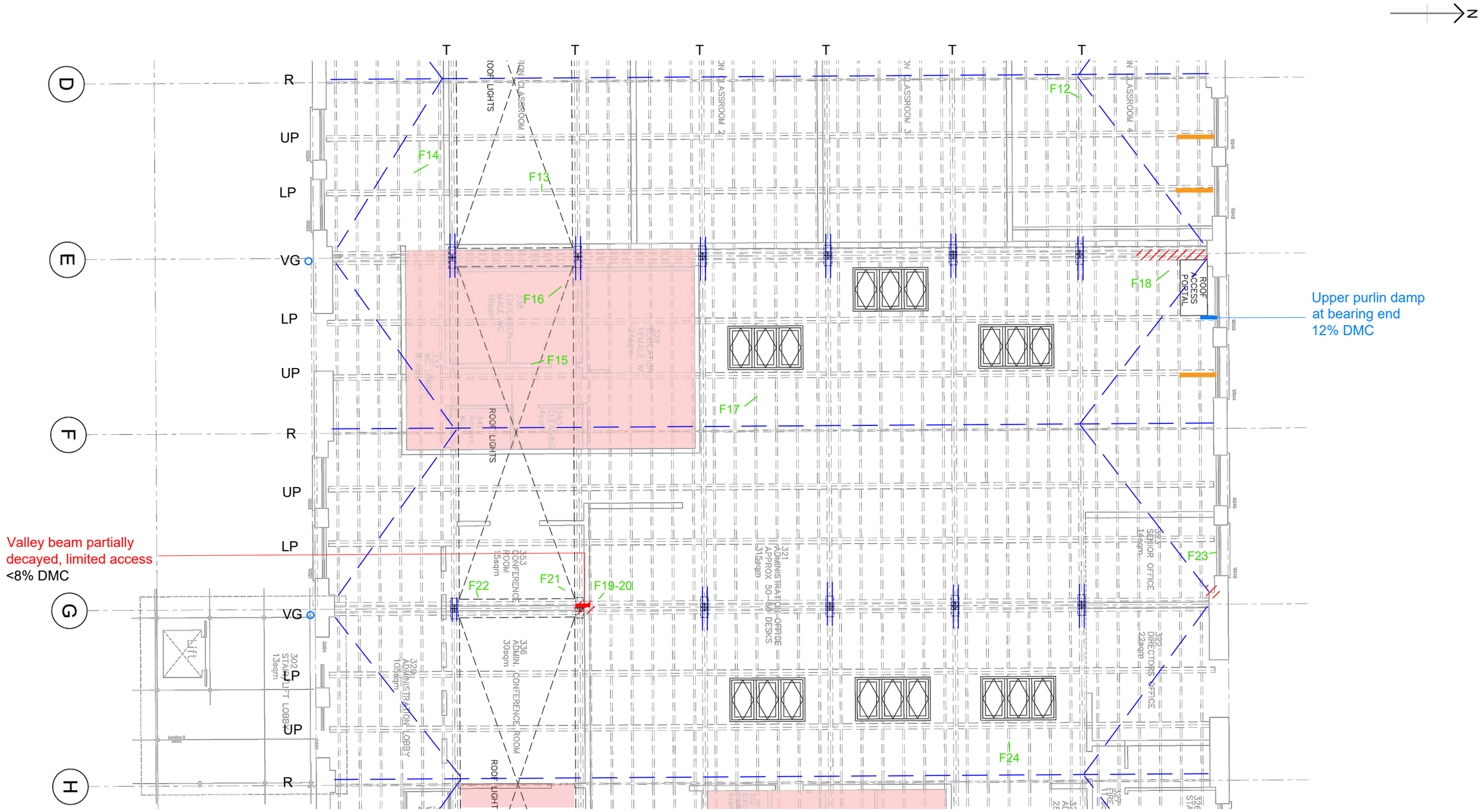
R	Ridge	— —	Previous steel reinforcement
LP	Lower Purlin	○	Rainwater downpipe
UP	Upper Purlin	▨	Area subject to water penetration
T	Truss	— F1	Photograph location
PG	Parapet Gutter	▬	Previous structural timber repair
VG	Valley Gutter	—①	Timber species sample location
		▭	Roof inaccessible

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TIMBER CONDITION SURVEY OF ROOF STRUCTURE

23-25 January 2023

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TIMBER CONDITION SURVEY OF ROOF STRUCTURE

23-25 January 2023

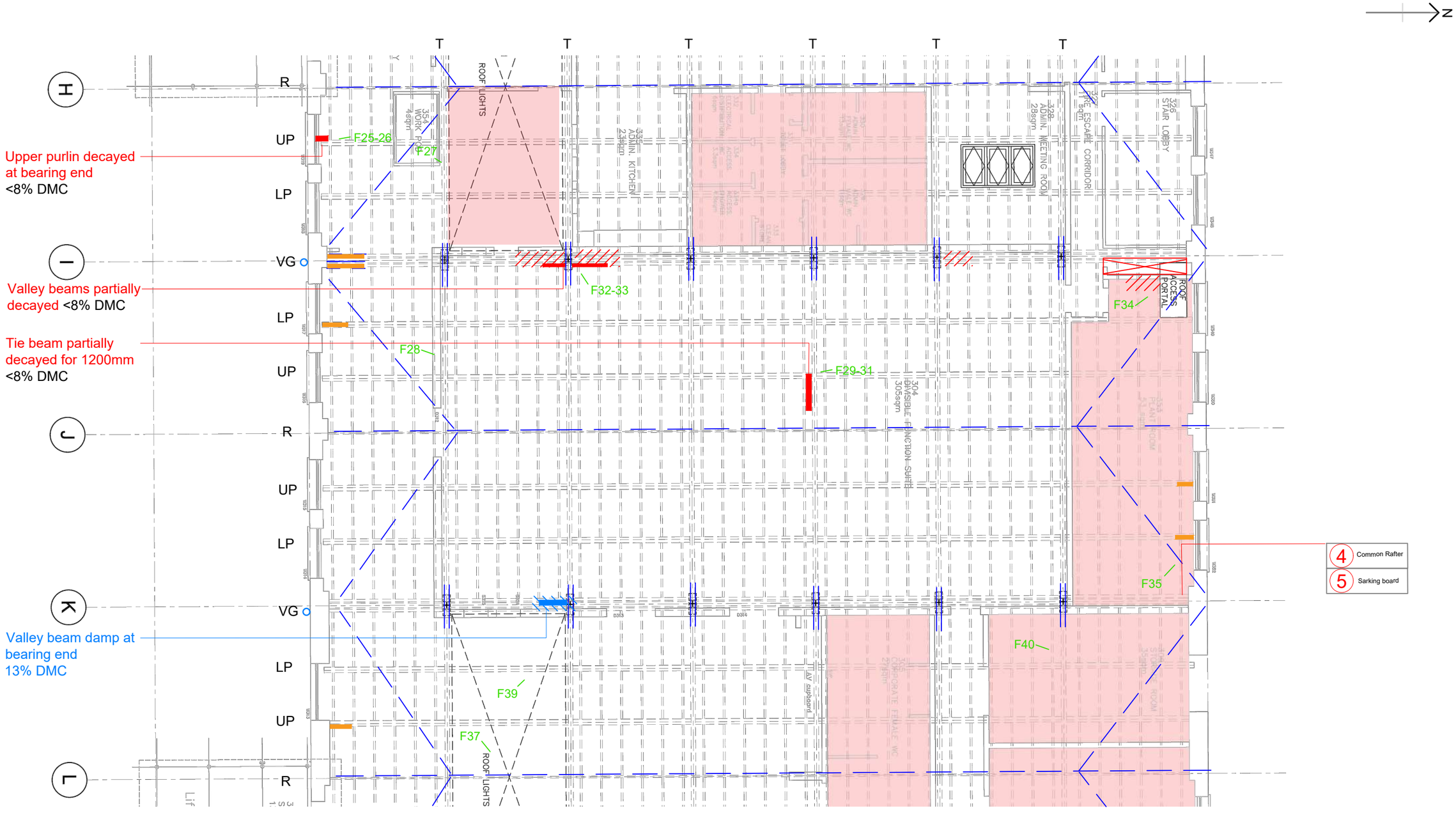
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Key:

R	Ridge	— —	Previous steel reinforcement
LP	Lower Purlin	o	Rainwater downpipe
UP	Upper Purlin	— F1	Photograph location
T	Truss		Previous structural timber repair
PG	Parapet Gutter		Roof inaccessible
VG	Valley Gutter		Sarking or gutter boards decayed

	Structurally decayed timber element
	Damp timber element at risk of decay
DMC	Deep moisture content of timber



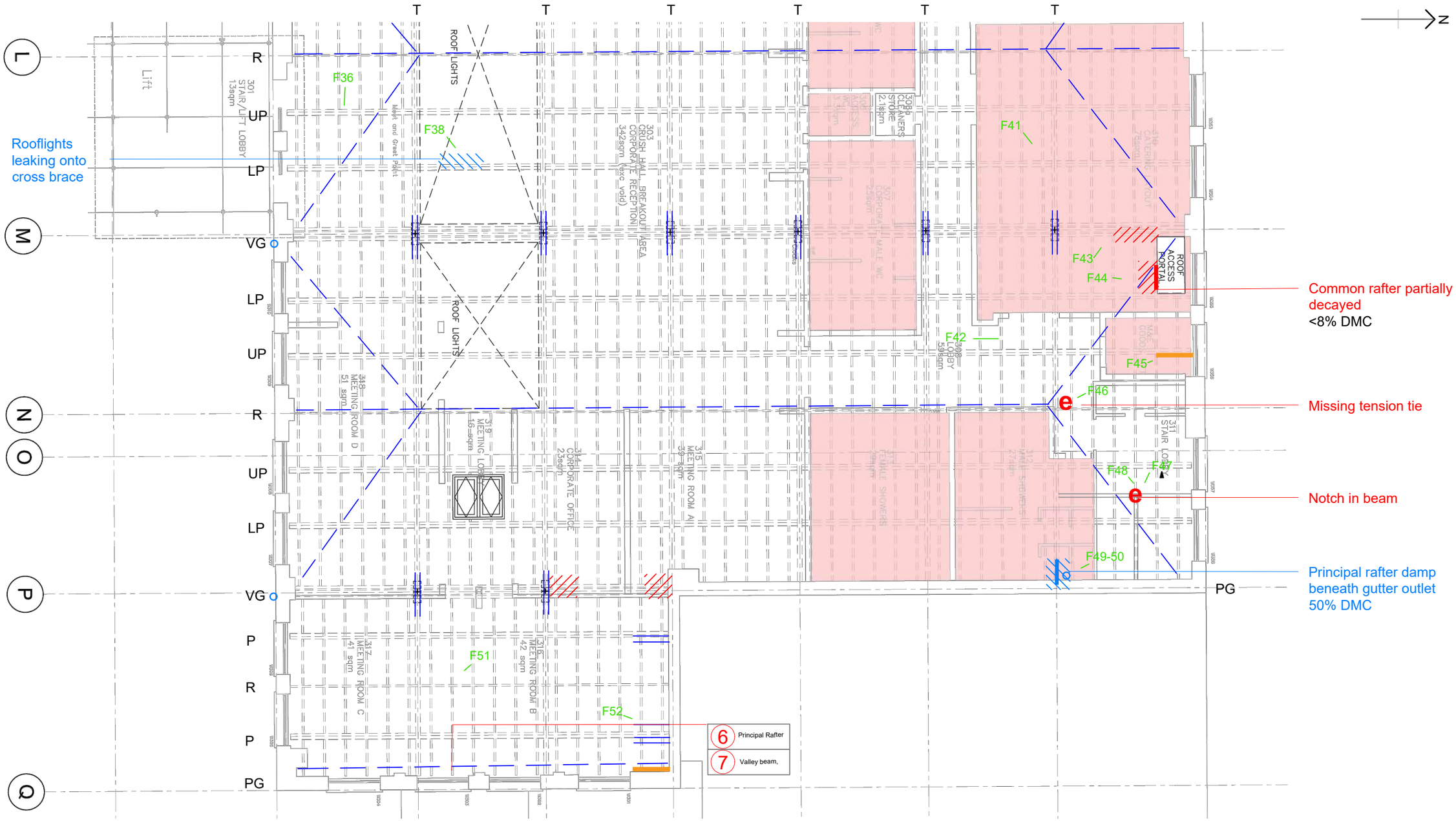
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TIMBER CONDITION SURVEY OF ROOF STRUCTURE
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Key:

R	Ridge	— —	Previous steel reinforcement
LP	Lower Purlin	○	Rainwater downpipe
UP	Upper Purlin	— F1	Photograph location
T	Truss	▬	Previous structural timber repair
PG	Parapet Gutter	—(1)	Timber species sample location
VG	Valley Gutter	▭	Roof inaccessible

▨	Sarking or gutter boards decayed
▬	Structurally decayed timber element
▬	Damp timber element at risk of decay
☒	Void inaccessible
DMC	Deep moisture content of timber
▨	Area subject to water penetration



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TIMBER CONDITION SURVEY OF ROOF STRUCTURE

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Key:

R	Ridge	— —	Previous steel reinforcement
LP	Lower Purlin	▨	Area subject to water penetration
UP	Upper Purlin	— F1	Photograph location
T	Truss	▬	Previous structural timber repair
PG	Parapet Gutter	—(1)	Timber species sample location
VG	Valley Gutter	▭	Roof inaccessible

▨	Sarking or gutter boards decayed
▬	Structurally decayed timber element
▬	Damp timber element at risk of decay
e	Structural engineer to comment
DMC	Deep moisture content of timber
—(1)	Timber species sample location