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12 Keats Grove
Existing Roof

Structural Inspection Report

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Job Number: **28412**

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March 2021	1	Issued for Information

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Note:

This report has been prepared for Kylie Richardson and her advisors, for the purposes noted in Section 1, using the information available to us at the time. It should not be relied upon by anyone else or used for any other purpose. This report is confidential to our Client; it should only be shown to others with their permission. We retain copyright of this report which should only be reproduced with our permission.

Contents

1 Introduction

Background

Price & Myers have carried out various elements of structural design work on 12 Keats Grove including the basement impact assessment and structural design work associated with the proposed side extension and extended basement works. We have been asked to review the condition of the existing roof of the house.

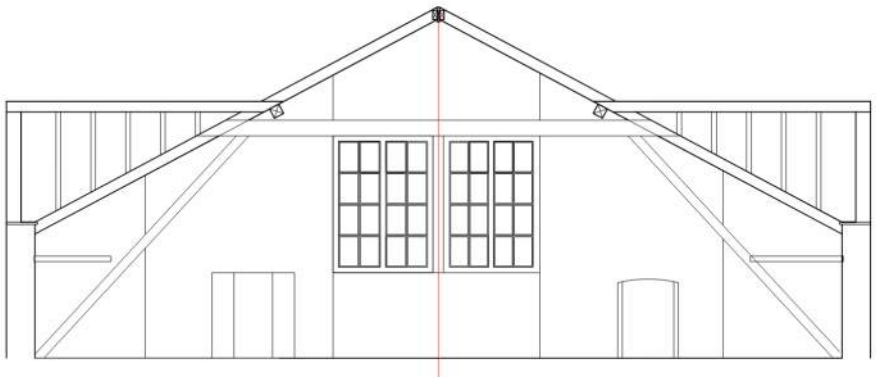
Price and Myers have extensive experience in conservation and a sensitive & careful approach to the engineering of heritage and listed buildings. Our current and past work includes conservation and refurbishment work to the historic fabric of Somerset House, Hampton Court Palace, Lambeth Palace, Chatham Dockyard, Beverley Minster, Clandon Park following its recent destruction by fire and work at Blenheim Palace. The author of this report, Tim Lucas has advised on the conservation of buildings for clients including the Royal Parks, the Church Commissioners & the National Trust. As a practice, we feel that we probably have the greatest concentration of engineers experienced in heritage buildings of any UK consultant.

Existing building

12 Keats Grove is a detached four-story house that is approximately 10m wide and 9m deep in plan. It is Grade 2 listed. It was constructed in approximately 1818. The house faces north - south and has gabled walls on its east and west flanks. The roof has a central ridge that runs east west along the house between the two gables and single pitches down to the front and back walls. These front and back roof slopes both have two dormer windows in them. The flank walls both have a pair of chimney breasts and associated flues along with central window openings.

The pitched roof of the house forms an attic type space over the second floor. The front and back walls of the house rise to around 1.3m above floor level and the roof pitches in at an angle of around 30 degrees to the central ridge.

There is a brick filled stud partition that divides the second floor space along the middle of the house. This wall is a continuation of a load bearing spine wall that runs north - south across the middle of the house.



Cross section through roof and dormer windows facing eastern gable flank wall

2 Description of existing roof structure

Broadly speaking, the existing roof structure is constructed in timber with rafters running up the two roof slopes between a timber wall plate on the front and back walls and a central ridge. There is a purlin at approximately the mid span of the rafters that spans across the house between the gable walls. The purlins are supported on a timber frame at both flank walls so as not to penetrate the chimney breasts and they are also supported on the central loadbearing partition.

It is evident that that the roof has been significantly modified at least twice in the past and that this work has changed the original structural action of the roof and has caused damage to the supporting timber.

The condition of the roof structure and a description of the impact of earlier modifications is described in the report below.

General view of the roof space looking south on the western side of the house, showing fractured purlin and modern timber roof elements.

View of the roof space looking east along the central axis of the roof at the central partition and eastern gable wall beyond.

View of the upper roof space looking east along the central axis of the roof.

3 Observations

Existing rafters & wall plates

The existing rafters appear to be contemporary with the construction of the original house in the early 19th century. The rafters are generally 100mm deep and 60-70mm wide and are in continuous lengths from the wall plate to the ridge.

View of timber rafters

Existing purlins

The purlins under the north and south roof pitches are continuous across the whole width of the house. They are 100mm deep and 125mm wide. Again, they appear to date from when the house was built.

Both the front and back purlins have significant deflection of over 100mm. They both have diagonal fractures though their full thickness. The deflections of the purlins are shown on the survey drawing in the Appendix along with the sizes of the timber elements of the roof.

View along north purlin looking west showing continuity over spine wall and deflection at dormer heads.

View along south purlin looking west again showing continuity and deflection.

Timber species & condition

The timber appears to be pine or another softwood and is characterised as being slow grown with a closely spaced ring structure. It is installed in long lengths which is typical of early 19th century timberwork.

The timber in the roof is generally in good condition despite its deformation, it appears to have been well ventilated and kept dry through its life and does not show sign of decay.

Modern timber elements within the roof are made from tanalised softwood.

Dormers

A total of four dormer windows have been cut into the existing roof. Historic photos confirm that this work was carried out after 1920. The dormers are timber framed with the side cheeks and roof of each dormer spanning from the house wall to the line of the purlins. Existing rafters have been cut and removed to accommodate the dormers.

View of dormer at south west corner of house.

Removed diagonal bracing

There are remains of diagonal bracing that was originally in the plane of the rafters on both sides of all four dormers. One of these diagonal timbers can be seen in the photograph below. Trimmed diagonal members and notches in the existing rafters confirm that the lower portion of the roof pitch below the purlin was trussed before the dormers were cut into the roof. The removal of the diagonals has disrupted the truss action of the roof.

View of cut diagonal roof truss member.

Chimney breast frameworks

To prevent the purlin from penetrating the brickwork of the chimney breast and being exposed to fire, there is are a pair of timber frames on either side of the house. These are made up of a 150x45 timber beam supported on two 100mmx60mm diagonal braces which are in turn notched into the floor joists of the second floor.

View of chimney breast frame on western gable.

View of purlin notched into chimney breast beam.

View of diagonal member of chimney breast frame work notched onto floor joist.

The diagonal brace at the north west corner of the house has a fracture through it and an attempt to restrain it to the adjacent brickwork has been made in the past.

Fracture in diagonal brace

Ridge beam

The original ridge plate of the roof has been augmented by two 150mm deep x 50mm wide modern timbers. The original timber plate is in place but has been made structurally redundant by the new timbers. The original rafters have been but back to fit against the new ridge beam and a central strut under the ridge beam connected to a modern tie beam forms a rudimentary truss.

View of new ridge beams and central strut/truss.

Modern tie beams

Modern tie beams have been introduced into the roof. These are placed at every second or third rafter, both above and below the height of the purlin. Their positions and sizes are shown in the survey drawing in the appendix.

Firring pieces

Firring pieces have been installed on all rafters except for the rafters adjacent to the chimney breasts and the northern rafter over the spine wall. The depth of the firring pieces varies between 15mm and 100mm. They are modern in nature and appear to have been installed at the same time as the tie beams and ridge beam. We understand that the house was comprehensively refurbished in around 2000 and this work may have been carried out then.

View of modern tie beams across the roof and firring pieces on top of the rafters

The size of the firring pieces indicates that the rafters have a deflection of around 100mm along their 5m length.

Broken rafters & velux window

Several rafters have been fractured in the past and have been replaced with lengths of modern timber. In addition to this a modern Velux window has been installed over the staircase.

4 Discussion

Introduction of dormers

Historical photos confirm that the dormer windows were added into the roof between 1920 and 1943. This is consistent with the appearance of the dormer timber work.

Photographs of the house taken in 1920, 1943 and 1967 showing introduction of dormer windows.

Removal of original truss structure

When the dormers were introduced into the roof, existing diagonal members within the plane of the rafters were cut and removed.

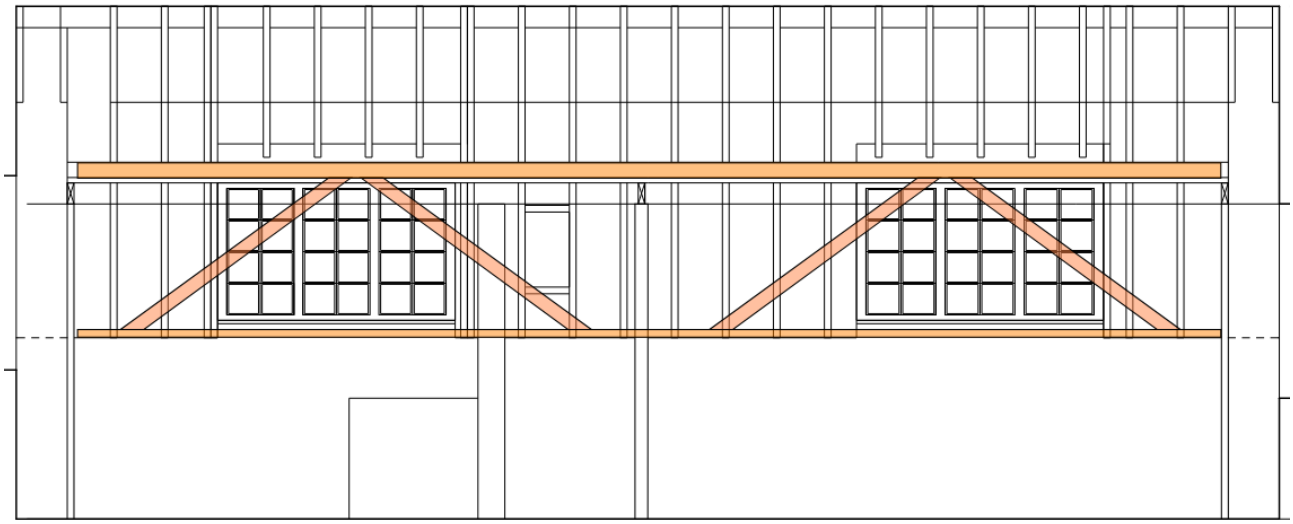
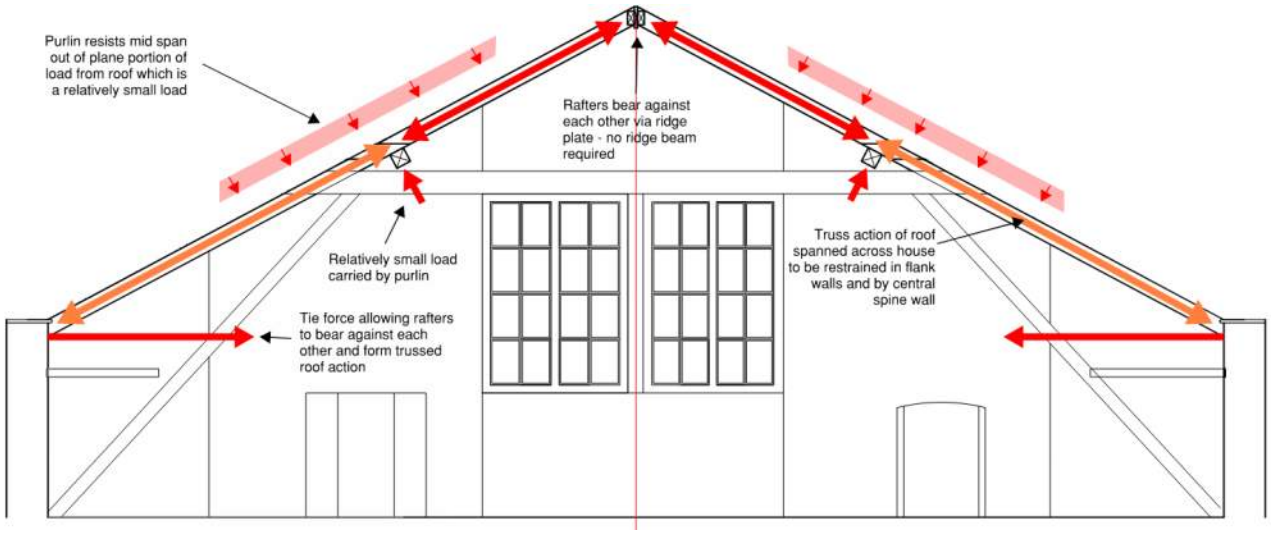
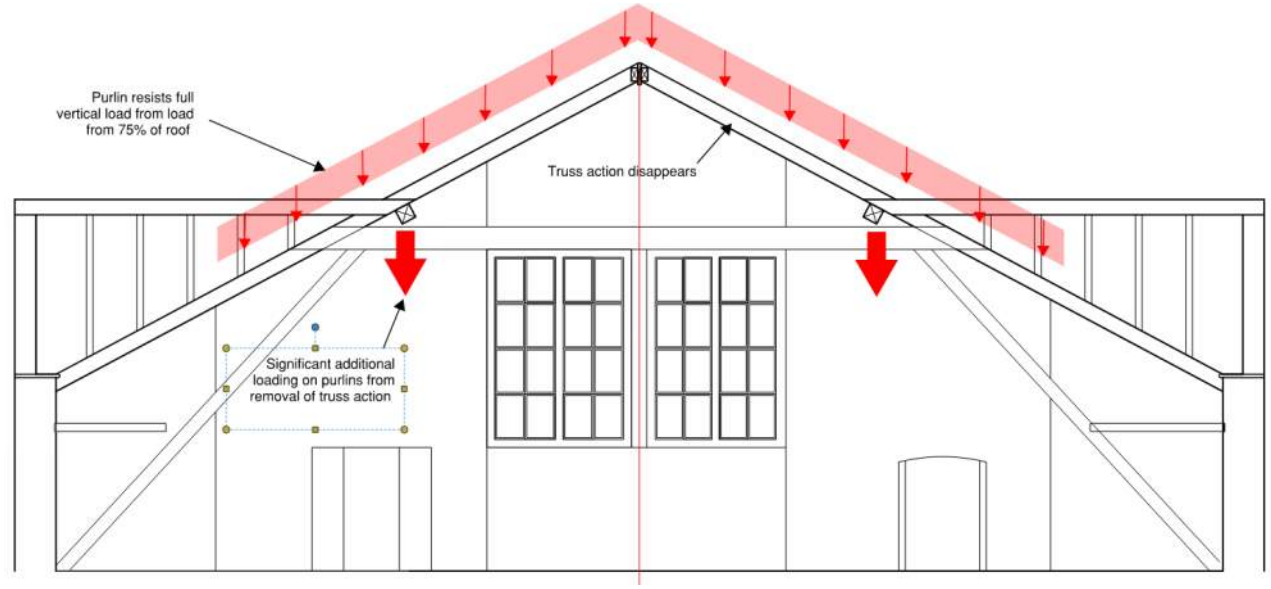


Diagram showing original trussed rafter arrangement of the structure.

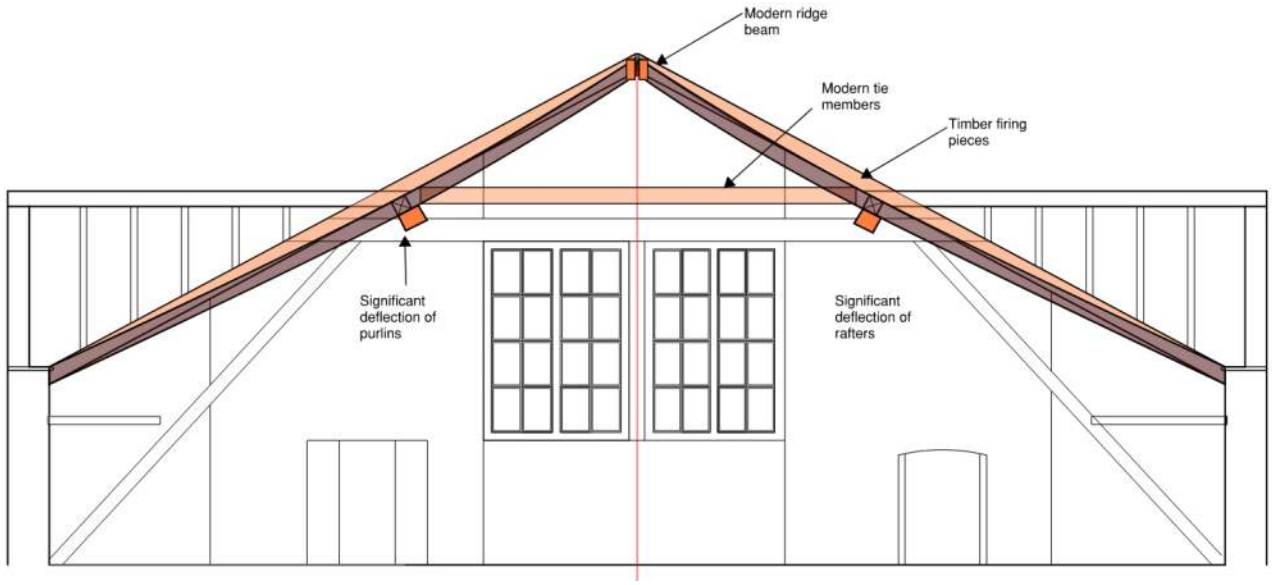
This truss structure played an important part in the strength of the original roof structure. The diagram below shows how the roof structure originally would have worked.



Structural flow of forces in original roof



Alteration of load path with removal of truss members



Deflected form following removal of truss action.

Impact of truss removal

The trussing members in the roof were removed sometime after 1920 and before 1943. The impact of this was to significantly increase the loading on the purlins. The purlins as a result have deflected by over 100mm which is a large deflection. The existing rafters that are fixed to them have also dropped down with this deflection and appear to have deflected along their length also.

Purlin deformation

The existing purlin is undersized for the loads that it began to carry following the truss removal. The visible deflection is a symptom of that and has occurred by the timber creeping under high stress. Creep is gradually increasing deflection over time and occurs when timber is overstressed in bending.

Purlin fractures

Both the north and south purlins are fractured. The south purlin has been temporarily propped at the position of the crack.

Modern timber elements

The modern timber elements include tie beams, a pair of ridge beams, tapering Firring pieces and spliced rafter repairs where original rafters are missing or damaged. The tie beams do not form an adequate trussing action and may have been installed in the past to provide a loft floor or storage space.

5 Conclusions

As stated at the start of the report, it is evident that that the roof has been significantly modified at least twice in the past and that this work has changed the original structural action of the roof and has caused damage to the supporting timber.

The installation of dormer windows about 100 years ago changed the way the roof structure worked. This has caused loading on the purlins and rafters to increase. This increased load and the general age of the roof has caused significant deformation of the original timber structure.

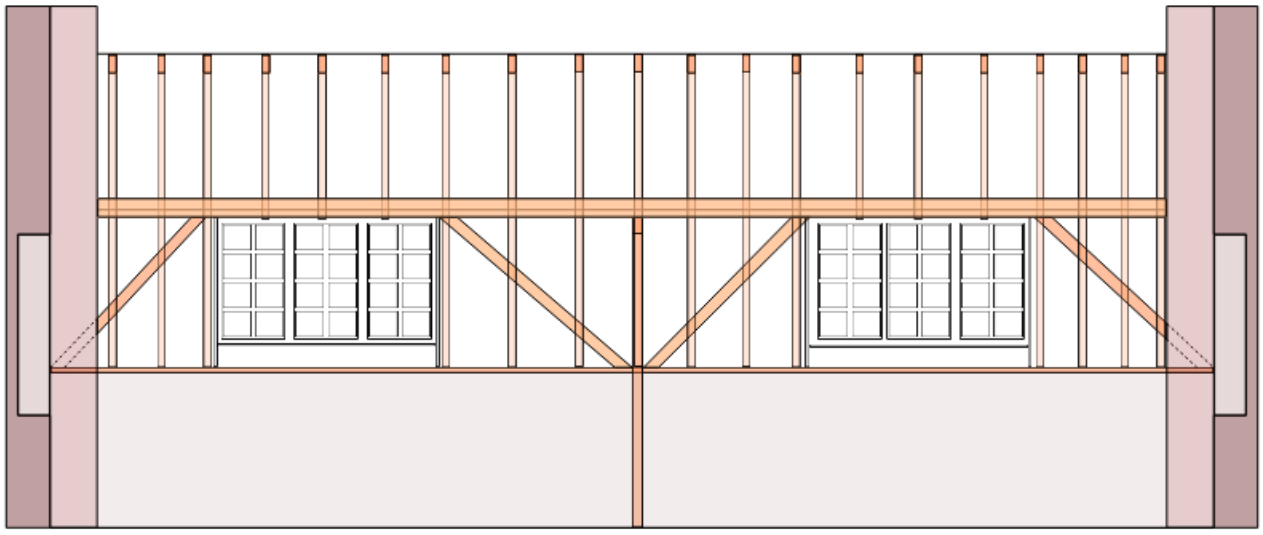
This deformation makes repairing or strengthening existing timbers unfeasible. New timber is inevitably straight. Splicing new timbers against the original highly deformed timbers is not viable.

The roof has significant amounts of non-structural modern softwood elements within it. This includes firring pieces above the original rafters and, ridge beams and tie beams. These newer timber elements are not connected in such a way that makes them contribute to the structural stability of the roof.

The existing purlins are both broken. They require replacement, as do elements within the supporting chimney breast frameworks which are also broken. It is not considered feasible to repair the existing purlins. They are both under sized for the load they need to carry and are too deformed to allow strengthening timbers to be spliced onto them.

Calculations show that the purlins would need to be in the order of a 200mm x 150mm timber section to support the weight of the roof in the way that the structure currently works, this would appear significantly bulkier than the existing 100x125mm section. In addition to the enlarged purlins a ridge beam would be required to carry the rafters at the top of the roof.

We propose that an appropriate course of action would be to restore the original trussed action of the roof - but in a way that accommodates the dormer windows. This would be a new structure, constructed in a sensitive and traditional manner, using appropriately sized timber members, joined with traditional joinery details, and arranged in a similar layout to the existing roof.



Proposal for reconstructed timber roof with reinstated diagonal bracing, new purlins and rafters in a similar size and arrangement to the original layout.

The diagonal bracing within the plane of the roof should be reinstated on either side of the dormer windows to restore the in-plane stiffness of the roof and allow the rafters to work as originally conceived. This would minimise the size of the purlin and allow a similar sized timber element to be used to that that exists in the roof at present. The roof would not require a ridge beam and would have a ridge plate of similar size and proportion to the original plate that exists between the modern ridge beams timbers.

This approach will restore the lost structural action of the roof and provide a legible and coherent structure that is in keeping with what was built in the early 19th century. Timber would be slow grown pine or Douglas Fir to provide a continuity with the original fabric.

In this way we would assert that the unique character of the historic roof will be preserved and celebrated, and the skill and craftsmanship required to construct, repair and preserve it will be nurtured.

6 Appendix - Existing Roof Survey Drawings

R0: 100mm x 50mm modern timber
with 100 x 50 timber noggin at ridge beam

R1: 90mm x 60mm original timber

R2: 95mm x 70mm with 25mm firring on top

R3: 95mm x 60mm with 40mm firring on top
with 100 x 50 modern timber tie above purlin

R4: 95mm x 60mm with 50mm firring on top

R5: 80mm x 60mm with 55mm firring on top
with 100 x 50 modern timber tie above purlin

R6: 100mm x 55mm with 60mm firring on top

R7: 85mm x 60mm with 60mm firring on top

R8: 80mm x 60mm with 55mm firring on top
with 100 x 50 modern timber tie above purlin level

R9: 100mm x 70mm notched over puhrlin

R10: 100mm x 70mm cut and trimmed for rooflight with 15mm firring, with 100 x 50 modern timber tie above purlin level from which a vertical strut to the ridge beam has been added.

R11: Rafter fractured and missing at the top.
95mm x 60mm

R12 100mm X 65mm over spine wall.

R13: 100mm x 60mm with 30mm firring on top
and 100 x 50 modern timber tie.

R14: 100mm x 60mm original timber,
with 45mm firring on top

R15: 100mm x 60mm with 70mm firring on top

R16: 95mm x 70mm with 90mm firring on top
with 100 x 50 modern timber tie above purlin level

R17: 95mm x 60mm with 90mm firring on top

R18: 95mm x 75mm with 100mm firring on top.

R19: 100mm x 60mm with 95 mm firring on top

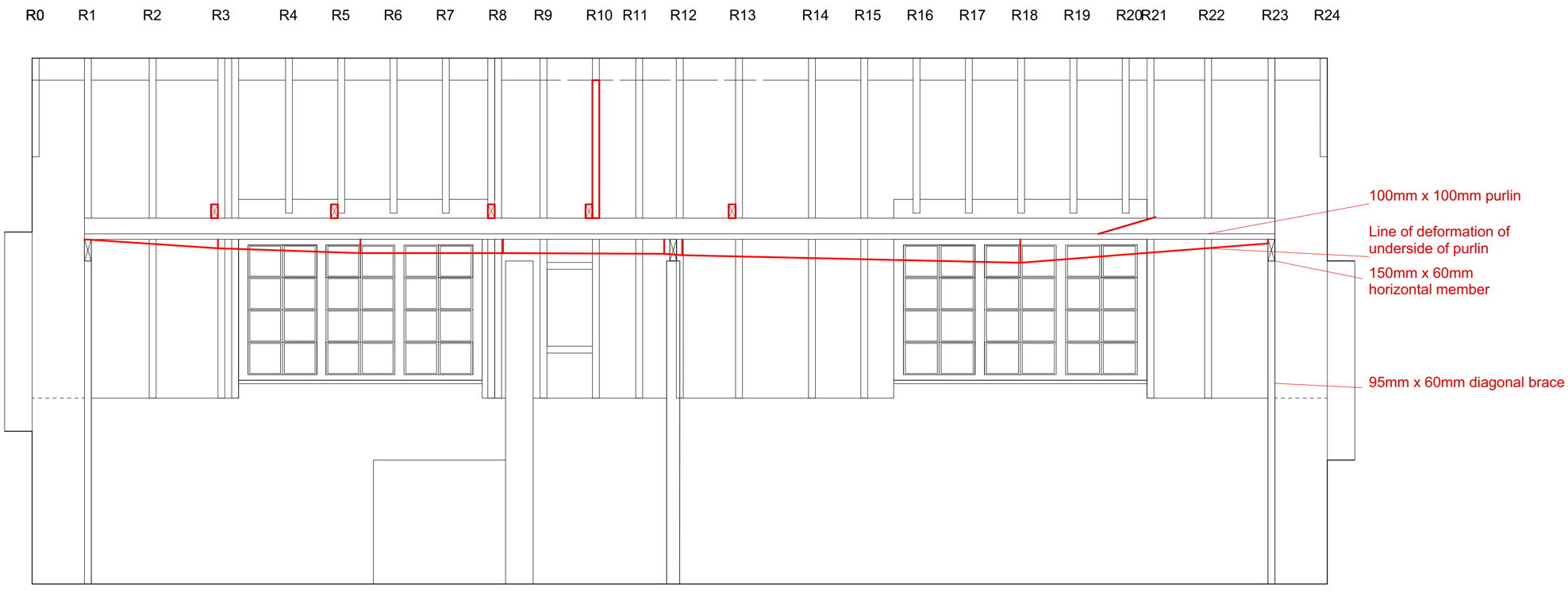
R20: 95mm x 75mm with 80mm firring on top.

R21: 120mm x 60mm, over fractured purlin
with 65mm firring on top

R22: 90mm x 105mm abive purlin and
100mm x 50mm below purlin.

R23: 95mm x 65mm with no firring braced
into end framing

R24: 95mm x 60mm



1 Rear Elevation
Scale: 1:25

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The Contractor shall submit full size drawings and specifications to 51% for approval, without which, manufacture shall not commence.

This drawing is to be read in conjunction with all the relevant consultants' and/or specialists' drawings/documents, and any discrepancies or variations are to be notified to 51% before work commences.

For further information please see other drawings and documents enclosed with this drawing. For information on Structure use Engineer's drawings. For further information on Services use Engineer's and/or Contractor's drawings.

Historic damage has been revealed caused by introducing the dormers and removing the original in-plane diagonal bracing.

The cutting of the bracing has removed the original truss action in the roof structure and increased loading on the existing perlin.

This has caused them to creep over time and required the addition of significant firrings in the recent past.

To form the dormers the bracing and rafters were cut and as a result the purlin is undersized for its current use.

51

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For Planning
RIBA Stage
Timber Condition Survey - Rear Elevation

Scale 1:50 @ A2

Drawn by PT, 2021_02_18

Issue Notes:

5002 -

R0: 100mm x 50mm modern timber
with 100 x 50 timber noggin at ridge beam

R1: 90mm x 60mm no firring.

R2: 100mm x 65mm with 25mm firring on top

R3: 95mm x 60mm with 50mm firring on top
with 100 x 50 modern timber tie above purlin

R4: 100mm x 60mm with 70mm firring on top,
over fractured purlin

R5: 110mm x 70mm with 70mm firring on top
with 100 x 50 modern timber tie above purlin

R6: 90mm x 60mm with 70mm firring on top

R7: 100mm x 60mm with 85mm firring on top

R8: 100mm x 60mm with 70mm firring on top
with 100 x 50 modern timber tie above purlin.

R9: 95mm x 70mm with 50mm firring on top
120mm x 50mm modern timber tie below purlin.

R10: 100mm x 60mm with 40mm firring.

R11: 100mm x 60mm with 40mm firring.

R12 100mm X 60mm over spine wall and
30mm firring on top.

R13: 95mm x 60mm with 40mm firring on top
and 100 x 50 modern timber tie.

R14: 100mm x 60mm original timber, with 50mm
firring on top

R15: 100mm x 60mm with 75mm firring on top

R16: 100mm x 60mm with 75mm firring on top
with 100 x 50 modern timber tie above purlin level

R17: 95mm x 60mm with 70mm firring on top

R18: 90mm x 60mm with 75mm firring on top.

R19: 100mm x 60mm with 75 mm firring on top

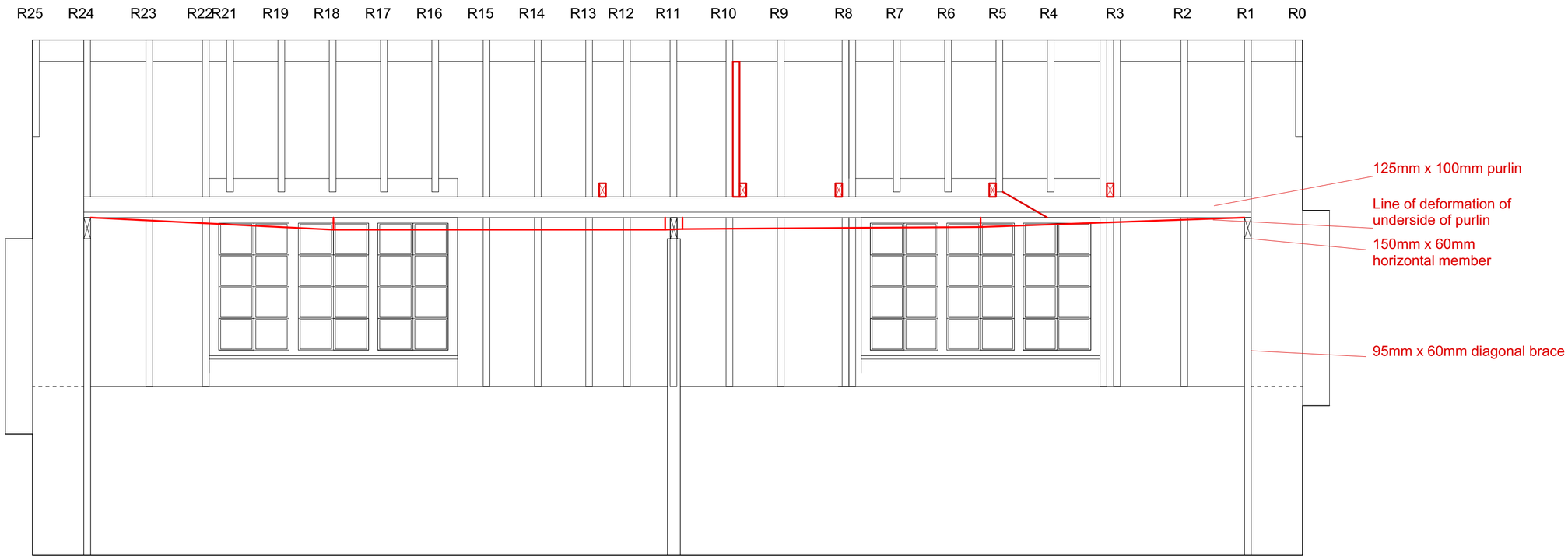
R20: 100mm x 60mm with 60mm firring on top.

R21: 125mm x 60mm, with 40mm firring on top.

R22: 100mm x 70mm with 25mm firring on top.

R23: 90mm x 70mm with no firring braced
into end framing

R24: 100mm x 60mm



1 Front Elevation
Scale: 1:25

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For Planning
RIBA Stage
Timber Condition Survey. Front Elevation

Scale 1:50 @ A2

Drawn by PT, 2021_02_18

Issue Notes:

5001 -