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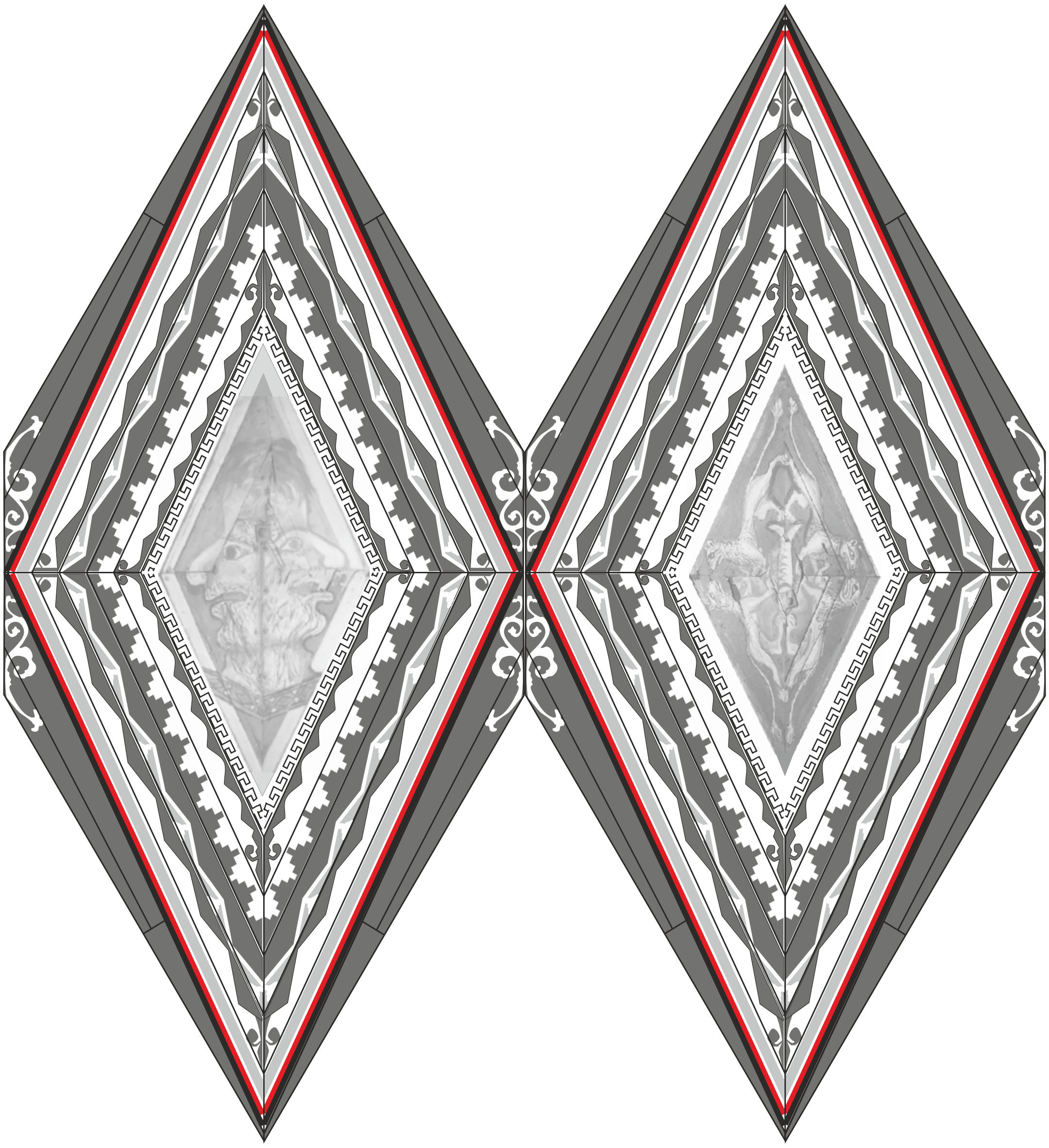

PETERBOROUGH CATHEDRAL: THE NAVE CEILING

PHASE 1: ROWS 36 - 40

CONDITION SURVEY AND CONSERVATION TREATMENT

JANUARY - JUNE 1998

VOLUME I TEXT AND GRAPHICS

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ABSTRACT

This report is a record of treatment carried out from January/June 1998 to the easternmost section of the Nave Ceiling: *Panels 36/40 I/II/III/IV* and associated Ashlar boards. Included in this report is a detailed written, graphic and photographic condition survey and treatment record of both the Ceiling structure and painted decoration; references to previous recorded treatment and investigations; a record of tests conducted as a preliminary to this treatment phase; and observations and findings made during the condition survey and treatment.

ACKNOWLEDGEMENTS

The Perry Lithgow Partnership and Hugh Harrison wish to thank the Dean and Chapter of Peterborough Cathedral and English Heritage for their enthusiasm and commitment to the conservation of the Nave Ceiling.

We are grateful to the Project Team whose members have directed and advised on all aspects of the works; in particular, to Julian Limentani, Cathedral Architect to the Dean and Chapter. Gillian Lewis, Consultant Conservator to the Cathedral has given invaluable guidance and practical support throughout. Paul Bryan and his English Heritage Survey Team have supplied the images and photogrammetric drawings which form the basis for our graphic documentation: in addition, they have provided us with the benefit of their considerable technical and practical expertise in resolving a number of difficulties encountered during the survey. The analysis and investigations conducted by Helen Howard and Adrian Heritage are central to this project: they have informed and influenced our treatment approach as well as advising on aspects of documentation. The research carried out by Donald Mackreth, Cathedral Archaeologist, and Paul Binski, Art Historian, has contributed significantly to our understanding of the Ceiling structure and the painted scheme.

We would also like to thank Peter Meehan and his colleagues at the Science Museum Wroughton for for their technical comments on the conservation of the ceiling bolts. Also to Julie Wakefield, curator of the Brooking Collection of Architectural Detail at the University of Greenwich for help with dating the technique of jointing boards with tongue and groove boarding.

WEST

NORTH | SOUTH

0/I	0/II	0/III	0/IV
1/I	1/II	1/III	1/IV
2/I	2/II	2/III	2/IV
3/I	3/II	3/III	3/IV
4/I	4/II	4/III	4/IV
5/I	5 /II	5/III	5/IV
6/I	6/II	6/III	6/IV
7/I	7/II	7/III	7/IV
8/I	8/II	8/III	8/IV
9/I	9/II	9/III	9/IV
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34/I	34/II	34/III	34/IV
35/I	35 /II	35/III	35/IV
36/I	36/II	36/III	36/IV
37/I	37/II	37/III	37/IV
38/I	38/II	38/III	38/IV
39/I	39/II	39/III	39/IV

EAST

Figure 1. *Plan of the Nave Ceiling, Peterborough Cathedral.*

PART 1: INTRODUCTION

1.1. Scope of Phase 1

Treatment was confined to the Eastern Bay of the Nave (see **Plate 3**): comprising Ceiling panels *(36/37/38/39 I/II/III/IV)*[1] and associated Ceiling structure. In addition, the *Eastern Infill Panels* against the central Tower *(Panels 40 I/II/III/IV)* and the north and south vertical Ashlar boards *(36 - 40)*.

1.2. Objectives

- To investigate the original construction and painting techniques of the Ceiling
- To investigate and record the present condition of the Ceiling
- To investigate and record previous interventions and additions
- To conserve the structure, boards and decoration of the Ceiling
- To remove the grime from the painted surface
- To investigate the way the present structure works and how effective it is in holding the Ceiling in place
- To leave the Ceiling in a stable state and minimise the need for further interventions for a period of fifty years
- To provide a recommended schedule of inspection and maintenance assuming a close inspection via hydraulic cradle every five years

1.3. Conservators

Treatment of the Ceiling boards and Ceiling structure was carried out by Hugh Harrison - Rincombe Farm, West Anstey, South Molton, Devon EX36 3NZ - and his team: Bob Chappell, Cameron Stewart, Brett Wright, Peter Ferguson RIBA, David Luard.

Treatment of the painted decoration was carried out by Richard Lithgow, Mark Perry and David Perry of the Perry Lithgow Partnership, Todd's Cottage, Church Street, Kingham, Oxon OX7 6YA. Assistant conservator - Peter Martindale.

1.4. Documentation

Richard Lithgow and Hugh Harrison have collaborated in compiling this document. All sections relating to the Ceiling structure have been written by Hugh Harrison; sections relating to the painted decoration by Richard Lithgow.

A principle objective of Phase 1 was to gather and record as much information as possible about the Ceiling structure and painted decoration. The emphasis has been on the collection rather than the display of information. An enormous amount of data is now available in written and graphic formats, not all of which is presented in this report. All source material has been submitted to the documentation co-ordinator for this project.

[1]These reference numbers refer to Nave Ceiling panels identified in **Figure 1.** Plan of the Nave Ceiling.

1.4.1. Graphic Record - A detailed graphic record has been made of the Ceiling structure upper side. The location of all elements of the structure and interventions made during this phase of treatment have been plotted onto photogrammetric plans of the Eastern Bay. Similar graphic records have been generated of the Ceiling structure lower side: these locate all visible fixings and previous alterations. For the condition survey of both the structure and the painted decoration categories of damage and deterioration have been plotted onto the photogrammetric plans: the individual panels (15:1 scale); the eight figurative lozenges (10:1 scale); the vertical Ashlar boards (10:1 scale). For the treatment record all interventions made during this phase have been similarly plotted and identified. All this information has been transferred onto overall plans of the Eastern Bay and has been reproduced at 35:1 scale in Part 13 of this report.

As an aid to reference, the graphics for the lower side of the Ceiling have been plotted over photographic images of either the overall Eastern Bay, individual panels, lozenges or Ashlar boards[2].

The graphic record has been digitised so that any combination of categories may be generated in any format on an overall plan of the Eastern Bay Ceiling or on plans of the individual panels. Parts 1 to 12 of this report - as well as graphics containing some 30 categories of damage and treatment - have been put onto CD-Rom. A copy of the disk, along with all source material associated with Phase 1, has been submitted to the documentation co-ordinator for this project.

1.4.2. Written Record - To compliment the graphic records many aspects of the construction and condition of the Ceiling boards have been noted in tabulated records of each Ceiling panel (see example in **Appendix 3**). Information relating to the structure includes: wood type, measurements and shape, joints, displacement, interventions, forms of insect damage and decay.

A board by board condition survey of the paint has been drawn up in tabulated form (see examples in **Appendix 4**). This records the decoration on each board, visible underpaint, surface accretions and alterations to the paint surface as well as descriptions of damage and deterioration.

It is intended that the information contained in these tabulated records will be put onto a database for ease of collation and retrieval.

1.4.3. Photographic Record - The photographic record includes identical sets of colour transparencies and prints. In a effort to keep the number of record photographs for this phase within manageable proportions the following strategy was adopted:

All areas were photographed from the scaffolding, both before and after treatment using moderately angled flashlight. The larger, horizontal panels *(II/III)* are covered by three photographs each, the canted panels *(I/II)* by two. The 4 full and 4 half figurative lozenges included in Phase 1 were photographed as individual objects. Each figurative lozenge crosses over 4 panels.

Examples of deterioration and phenomena categorised in the graphic and written records have been photographed repeatedly in different lighting conditions before, during and after treatment. The area covered by each photograph and the lighting conditions

[2] Images taken from photographs used by English Heritage Survey Team as part of the photogrammetric survey.

employed are recorded on reference sheets (see example in **Appendix 5**). In addition, the Plate Reference Sheets in Volume II locate the area of the Ceiling covered by each Plate.

1.4.4. X-ray photography - Mobile Radiographic Services Ltd spent a day on-site exploring the capabilities of X-ray photography in detecting underpaint and hidden metal fixings. The experiment proved to be of no help in identifying underpaint, possibly due to the extensive use of lead pigments in the original scheme and subsequent restorations. Metal fixings were clearly identified; as a consequence, the photographs were of particular use in illustrating certain structural features (see **Plates 162, 163, 164, 165**). Unfortunately, overall coverage would be impractical due the small area covered by each photograph relative to the scale of the Nave Ceiling.

1.5. Parallel investigations and works

The condition survey and treatment carried out during Phase 1 and recorded in this document is only a part of a comprehensive, ongoing investigation of the Nave Ceiling undertaken by the Project Team and others.

- Photogrammetric survey - English Heritage Survey Team
- Dendrocronology - Sheffield University, Dendrocronology Unit?
- Paint sample analysis - Helen Howard, Courtauld Institute
- Archaeological survey - Donald Mackreth, Cathedral Archaeologist
- Art historical research - Paul Binski, Art Historian, Cambridge University
- Environmental monitoring - Barry Knight, English Heritage

Aspects of these investigations and research are referred to in this document; although, at the time of writing, results are not fully available. The findings are to be presented as separate reports by the specialists concerned.

PART 2: DESCRIPTION OF THE NAVE CEILING

2.1. General

The wooden Nave Ceiling at Peterborough is an extremely important survival. There are three Ceilings of comparable age in Europe but all are smaller: St Martin's, Zillis in Switzerland (c. 1150); St Michaels, Hildesheim in Germany (c. 1200); Dädesjö, Smaland in Sweden (c. 1275). Of the painted decoration Binski[3] suggests: *'it stands with a very few other English instances of painted vault or Ceiling decoration: the overpainted mid 13th- century choir and presbytery vaults at Salisbury Cathedral; the (lost but recorded) paintings of c. 1220 on the vaults of the Trinity Chapel at Canterbury cathedral; the late 13th-century wooden painted vaults of the presbytery at St Albans; the Chapterhouse vault at York Minster; and the (secular, but adorned with religious subject-matter) Ceiling of the Painted Chamber in the Palace of Westminster of c. 1263'.*

[3] Unpublished lecture notes. Paul Binski, Cambridge, April 1998.

No further information regarding the dating of the Ceiling was retrieved from the woodwork during this Phase of work, other than from dendrochronology that is reported elsewhere in this Report.

2.2. Measurements

- Nave Ceiling: 204 ft (62.2 m) x 35 ft (10.7 m)
- Horizontal panels within rows (II/III): 11 ft (3.35 m) x 5 ft 3 ins (1.61 m).
- 45° canted panels in the outer rows (I/IV): 8 ft 5 ins (2.56 m) x 5 ft 3 ins (1.61 m).
- Central lozenges (boards within the key -pattern): 7 ft 7 ins (2.31 m) x 3 ft 9 ins (1.15 m).
- Outer canted lozenges: 5 ft 9 ins (1.76 m) x 3 ft 5 ins (1.05 m).
- The vertical Ashlar boards running the length of the Nave immediately beneath the Ceiling on the north and south walls: 19 ins (0.48 m) high .

2.3. Roof Structure

The roof from the central tower to the western vaulted bay consists of 26 main trusses of which 15 are of the same design. The trusses are a scissor braced type truss built up for the most part with coupled timbers of standard scantling. The principals are held in caste iron shoes built into the wall head and are spaced at 2600mm – 2900mm centres. There are 5 common rafters between each principal. The structure differs from what might be called an original type scissor braced roof as can be seen over the North Narthex vault (see **Plates 29 – 31**), in that the roof is basically bolted together using caste iron couplings and stiffeners, there is also a vertical central post linking the tie beam with the ridge and there are two collars spaced fairly evenly in height between the tie beam and the ridge. The tie beam is also coupled with single beams placed on each side of the principal rafter (see **Drawing 1**). All this structure is made of softwood except a number of common rafters that are oak, possibly from the original roof.

No further positive information came to light that increases our knowledge of the original roof structure but it is the general consensus that it was probably similar to the existing roof over the North Narthex.

From the evidence of the present roof structure and the information given by the Cathedral's architect, Leslie Moore, in his report[4] (see **Appendix 1**) it is now clear that the vast majority of the present structure was created by Edward Blore in 1834. Gavin Simpson[5], includes a drawing by Samuel Ware of the original roof structure before it was restored by Blore (see **Figure. 2**). This would seem to show that Blore copied the original roof structure quite closely in his reconstruction. Blore also inserted the longitudinal beams both near the outer edges and over the centre of the flat part of the Ceiling, which allowed the original joists to be suspended with hanging bolts, which is the system that still survives today. All the longitudinal beams at ceiling level, including those inserted by Moore in the 1924 restoration of the roof are termed binders. Some original rafters were re-used by Blore.

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[4] *Peterborough Cathedral – Report on the Structural Condition of the Nave Roof and Ceiling.* Leslie Moore, circa 1920.

[5] *Peterborough Cathedral – Proposals of the Archaeological Survey and Dating of the Nave Roof and Ceiling.* Gavin Simpson, 26th May 1995

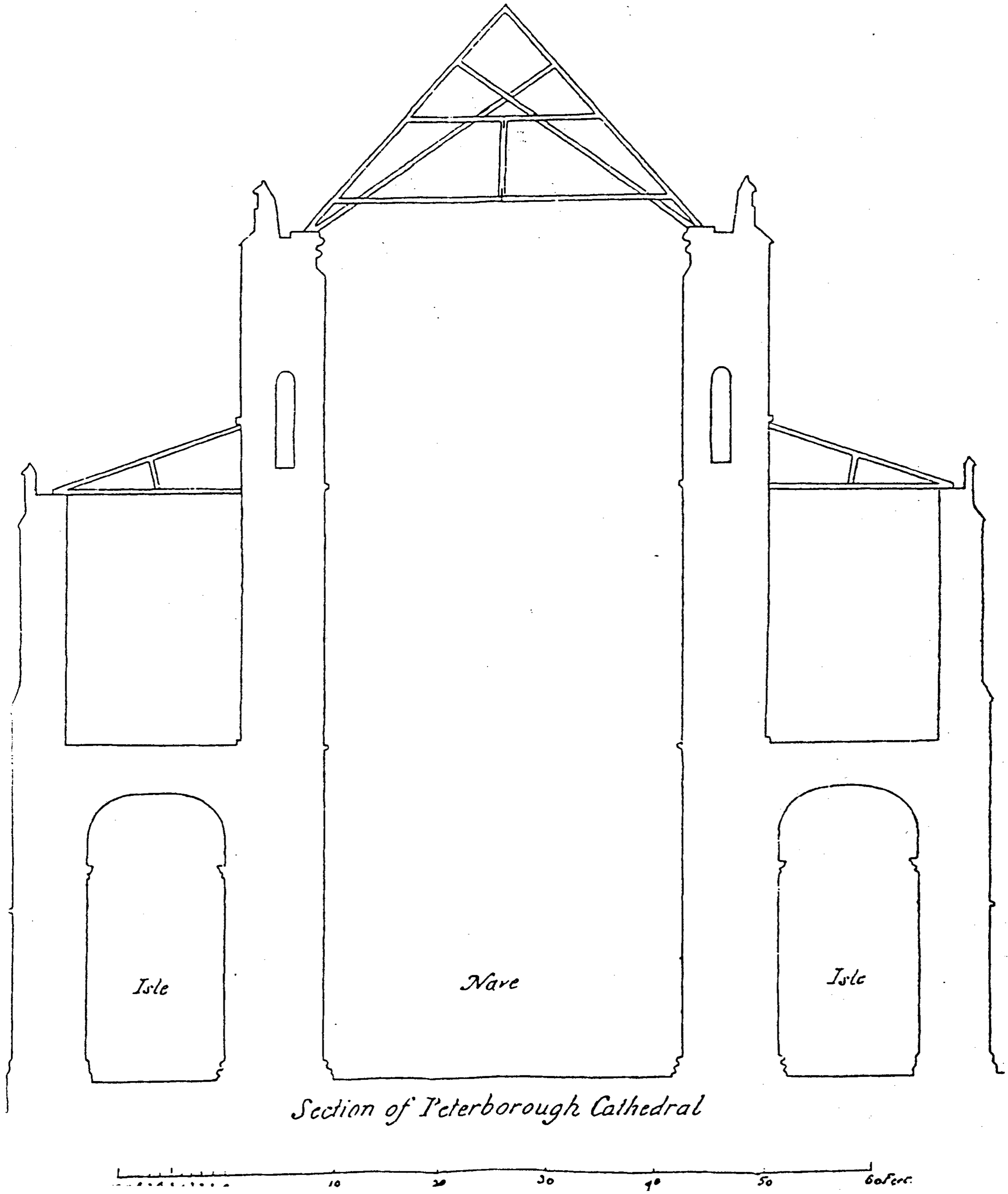


Figure 2. *Section of Peterborough Cathedral - Drawing by Samuel Ware, ca. 1805*

In 1924, Moore renewed/restored the slates and carried out treatment against woodworm infestation using Silvertown solution[6]. It is possible that he inserted additional stiffeners into the roof structure but I have no concrete evidence for this. Perhaps Moore's work should be identified in future Phases of the current programme of works to complete the archaeological study of the roof structure.

2.4. Ceiling Structure

2.4.1 Upper Side - The Ceiling is fixed directly to the underside of a set of ceiling joists halved at their ends with the sloping ceiling joists. All ends of joists beyond the halving joint have been cut off (see **Plates 32**). The English Heritage Survey Team has undertaken to produce a conjectural drawing of the original roof structure based on analysis of the information contained in the present timbers. It is hoped that this survey would reveal whether the ceiling joists are part of the original Roof or are a self-contained structure built to hold up the wooden ceiling. Running between the joists, at the feet of the sloping joists, at the junction of the sloping joists and the flat ceiling joists, and in the centre of the Ceiling are noggins, birds beak jointed to the underside of the joists. (see **Drawing 2 and Plates 32 - 36**).

All original structural timbers are oak.

2.4.2. Lower Side - The Ceiling is formed of riven boards nailed clinker-fashion directly to the underside of the joists. There are three basic moulds for the board edges and those in the centre of the lozenges have also been shaped differently (see **Figure. 3** and **Drawing 3**).

The boards are nailed both to the underside of the joists and noggins and along their edges to each other (see **Graphic 7**)

There are two further areas of boarding in this part of the Ceiling. The first is the area between the east end of the Ceiling and the Tower called the Eastern Infill boarding (see **Figure. 4**) and the second is the Ashlar boarding which is the area of boarding below the sloping sides of the Ceiling running the length of the Nave walls.

The Eastern Infill boarding in its present form is thought to have been inserted when the Tower was rebuilt in the 14th century and the arch changed from rounded to pointed. This made the arch project above the line of the flat section of the original Ceiling.

The Ashlar boards are nailed to oak studs that are halved over the feet of the sloping joists. In the next Phase, these studs should be tested for dendrochronology (if they are big enough) and the feet of the sloping joists should be further examined for evidence of original construction. It seems important to try to establish whether the Ashlar boarding has always been part of the Ceiling design.

2.5. Painted design

2.5.1. Date - Binski states: *'the Ceiling appears on present evidence to have been painted c. 1210-1230. The closest analogies are with a group of Psalters produced for Peterborough and St. Neots c. 122O. Some subject-matter, e.g. the musical angel, is compatible with a 13th-century date. The most likely period of' activity is under .Abbot Robert de Lindesey, 1214-22'.*

[6] Silvertown solution – An early insecticide formulation containing sulphur chloride and carbon bi-sulphide.

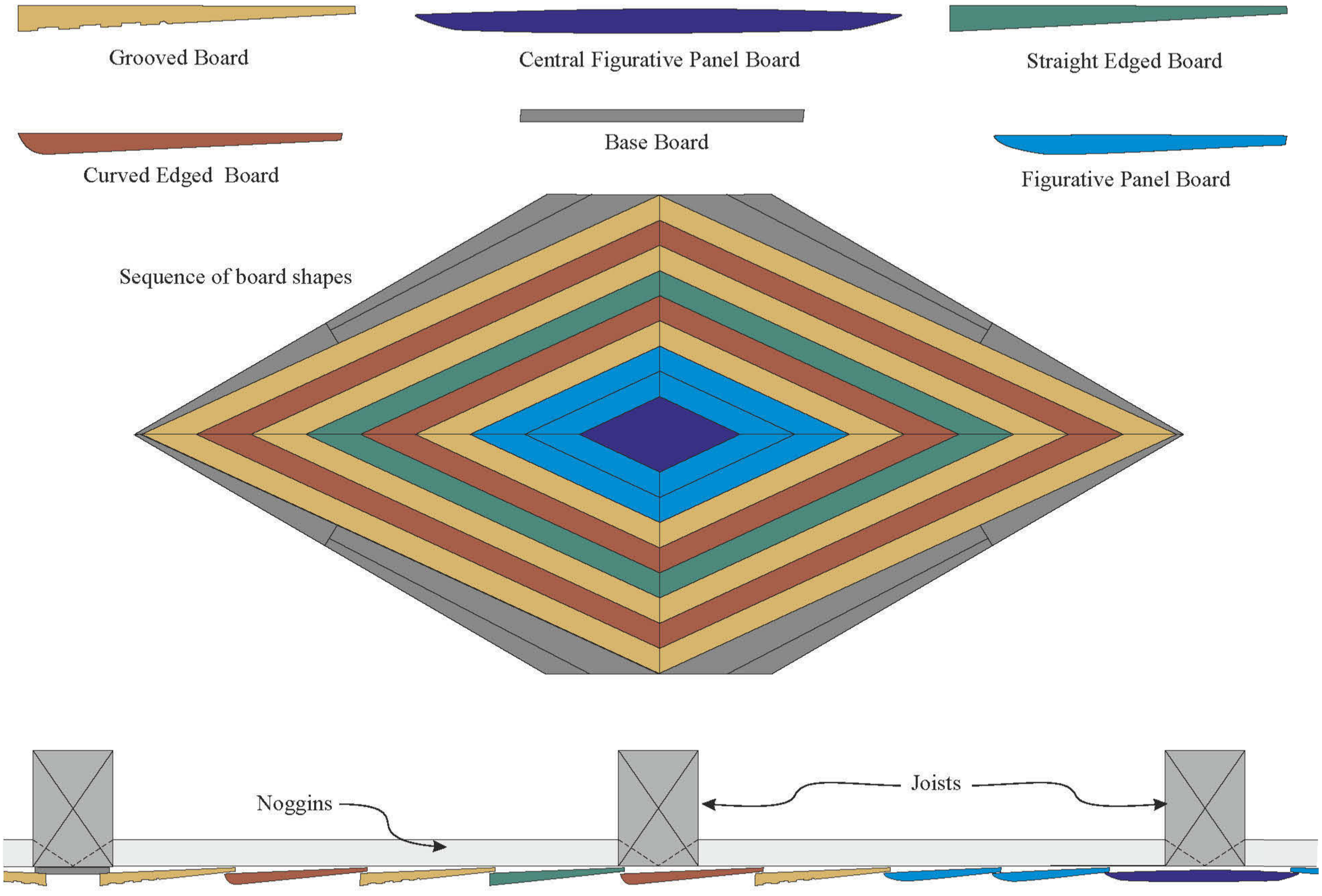


Figure 3. *Diagram of a typical lozenge showing the sequence and arrangement of the different board sections.*

Figure 4. *Eastern Infill boards (Panels 40 I/II/III/IV). Images courtesy of English Heritage Survey Team.*

The painted scheme is known to have been restored between 1740 and 1750 and again in 1830s. There are no detailed records of these restorations; although, it clear that repainting on both occasions was extensive and inept.

2.5.2. Subject matter - The painted design follows the arrangement of the Ceiling boards. It consists of three interlocking rows of diamond-shaped compartments, with a further row of half diamond-shaped compartments on the north and south sides. The inner boards of each compartment are decorated with a figurative subject. The subjects include: kings, bishops and archbishops; the sun and moon; the Liberal Arts and musicians; an Agnus Dei, St Peter and St Paul. Within the Eastern Bay - treated in Phase 1 - are the head of Janus four loins circling a fish, grotesques representing demonic forces, and foliated ornament.

2.5.3. Decorative designs - The figurative elements are small in scale relative to the surrounding decorative borders. The border ornamentation is similar for each diamond; although there are minor variations. The inner band a black key pattern on an off-white background. A black chevron or wave pattern with fleur-de-lis at the corners, also on an off-white ground. A crenellated or stepped chevron pattern, black on off-white. A grey, extended chevron pattern separated from the black background by a white line; the chevrons have white embellishments. An extended, black chevron or wave pattern with fleur-de-lis at the corners, all on an off-white ground. The outer design is of coloured bands, brown and off-white; the off-white band forming the background to a red and a black line. The base boards filling the spaces between the diamond-shaped compartments have a white scroll design with trefoil ornament on a black background. **Figure 5** illustrates the border decoration and identifies each design.

The border decoration varies for the smaller, half diamond-shaped compartments on the north and south sides and the two half diamond-shaped compartments abutting the infill boards at the east end. These boards have keyhole and dog-tooth patterns - both in black on off-white - in place of the stepped chevron and wave patterns. In fact, there is considerable variation even in these details within the smaller, half diamond-shaped compartments on the north and south sides (see **Plates 167, 187, 207, 227, 185, 205, 225, 245**).

Observations made during the technical survey of the painted decoration question the extent to which the 1740s restorers may have altered the original border designs. These are discussed in the section on previous interventions (Item 9.3).

2.5.4. Eastern Infill boards (see **Figure 4.**) - Panels *40 I/II/III/IV* panels have been repaired, partially replaced and repainted on a number of occasions so that now the decoration and paint is slightly different on each panel. The overall scheme is a stylised foliate scroll pattern, characterised by a simple but rather globular depiction of the leaves and tri-lobed flowers. The design is freely and sketchily executed in black with white and grey hatching and highlights in a red background.

2.5.5. Ashlar boards - Running the length of the Nave over the top of the north and south walls is a decorative frieze pattern: a scrolling design of stylised tendrils - in black, red and white - with recognisable flowers depicted in every downward loop alternating with stylised 4 petal flowers. Apart from the rose, the flowers are difficult to identify, but look similar to common garden plants, such as the mallow, and cranesbill. This design was painted during the 1830s restoration and covers an earlier more complex scrollwork, stylistically seeming to date from the late 17th or early 18th century[7], although probably dating from the programme of restoration between 1740 1750. This earlier pattern is discernible with raking light. It is Donald Mackreth has produced measured drawings of the design; his drawings have been traced, overlaid on images of the Ashlar boards and are reproduced in **Figure 7**.

[7] D F Mackreth letter to J Limentani 24.04.98 and letter to r Lithgow 15.09.98.

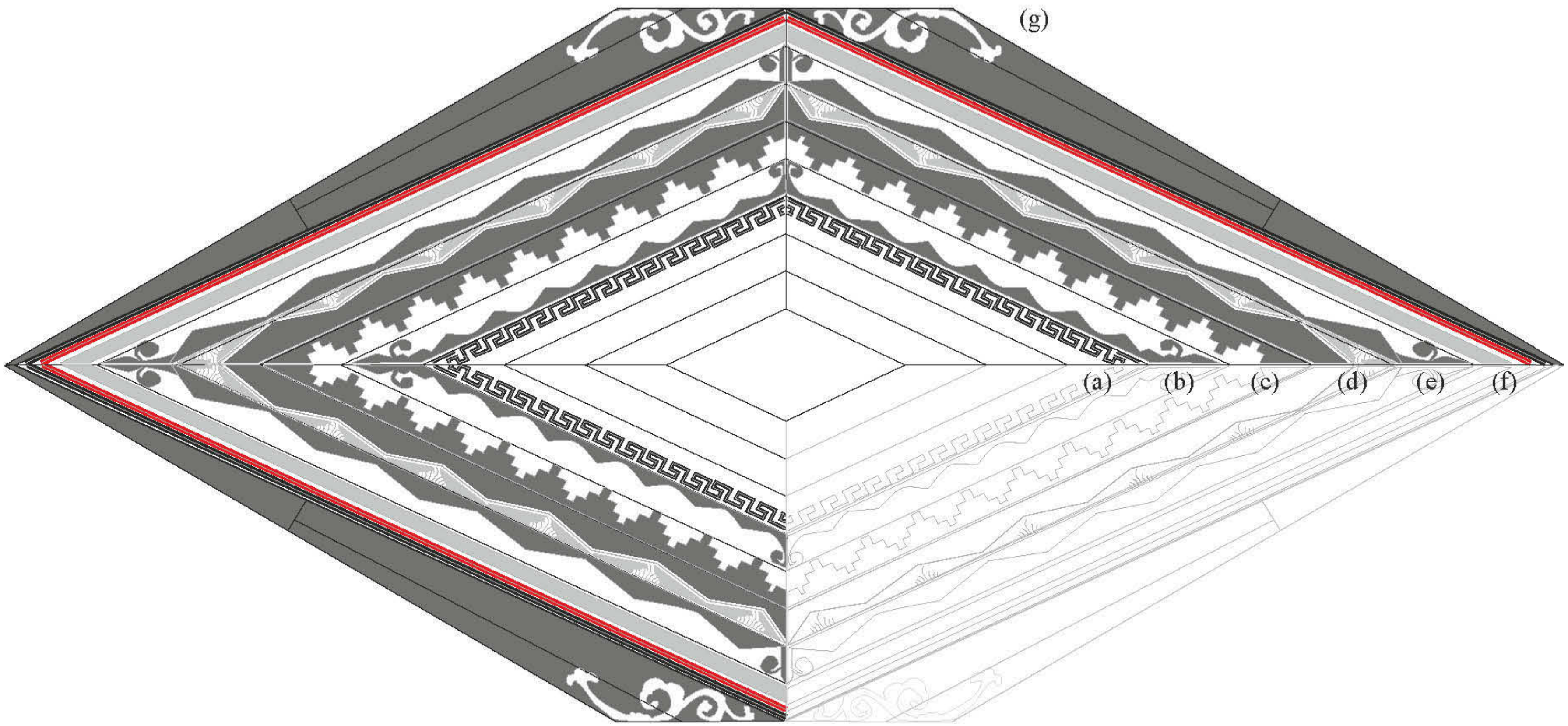


Figure 5. *The diamond border ornamentation: (a) key pattern; (b) wave pattern; (c) stepped chevron pattern; (d) grey chevron pattern; (e) extended chevron pattern; (f) coloured bands: (g) base board scroll.*

PART 3: TECHNICAL SURVEY: THE CEILING STRUCTURE, UPPER SIDE

All the drawings referred to below can be found at the end of this Part 3.

3.1 Original Technique and Construction

3.1.1 Timbers - Investigations in the present Phase of work have revealed what we think is the original construction of the Ceiling. Firstly, there is no evidence of the Ceiling originally being flat and then converted into its present shape at a later date. Secondly, there is no evidence either way that confirms whether the boarded Ceiling was an intrinsic part of the design of the original roof structure. My reason for saying this is that if it is accepted that the ceiling joists are part of the original roof structure, the only additional structural members inserted to enable the boarded Ceiling to be erected are the noggins (approximately 75 mm x 50 mm) that span between the original joists. Each of these noggins is bird beaked to the under sides of the joists (see **Plates 33 – 36**) and nailed each with two nails. The only purpose of these noggins can have been to carry the ends of the boards. So the Ceiling could have been inserted after the roof structure had been designed. The nails used to fix the noggins are the same nails identified as being original as those used to fix the boards themselves. Had the noggins been tenoned between the joists, they would have had to be part of the original construction and it would have been very likely that the present boarded ceiling was definitely conceived as the original ceiling to the Nave in conjunction with the design of the roof itself.

3.1.2 Fixings - The only fixings from the original construction above the Ceiling are the surviving wooden pins holding the small number of complete halving joints at the intersection of the flat and sloping ceiling joists.

3.1.3 Boards - No information is available on the top surface of the boards as they are now hidden by the hessian. Some information was gleaned in the course of this Phase of work by lifting small areas of the hessian.

3.1.4 Dendrochronology - Samples from the joists were taken throughout the length of the roof by University of Sheffield, Dendrochronology Department, however to date the report is unpublished.

3.2 Previous Interventions

It has already been recorded earlier in this Report that the roof was substantially renewed in 1834 and restored again in 1924. It has also been mentioned that the Tower was rebuilt in the 14th century. In 1740 to 1750, the Ceiling was largely repainted and it is quite possible that some structural work was carried out at that time. In the 1880s, the Tower was once again rebuilt, which presumably would have affected the Eastern Infill panels. This section investigates evidence for these interventions.

3.2.1 14th Century – In consequence of rebuilding the central Tower in the 14th century, one must assume that some of the Nave ceiling adjacent to the Tower must have been disturbed to allow the rebuilding work to proceed. No firm evidence has been found for either original infill boarding or the boarding installed after the Tower was rebuilt. However, as the Ceiling has been largely restored in either 1740 or 1830, and this particular area was again disturbed when the Tower was rebuilt in the 1880s, perhaps this is not surprising. There are five empty slots for bird's beak joints cut on the underside of the east face of Joist 1 which would seem to have been part of either the original construction of the Ceiling or the work associated with rebuilding the Tower in the 14th century (see **Graphic 3**). However, no bird's beak slots occur on the east side of the joist, in the same position as those on the west for the noggins which carry the ceiling boards, so it is unlikely that the lozenge pattern boarding continued in any form between Joist 1 and the Tower wall. There is one much wider noggin still surviving, which in view of the difference of its size compared with the original ceiling noggins, could be 14th century. It might be worth testing this noggin for dendrochronology.

3.2.2 18th Century - It is recorded that the Ceiling was re-painted in 1740-1750. There is no evidence in the Ceiling structure of any intervention at that date.

3.2.3 1830s - Edward Blore largely renewed the Roof in 1834-1835 in imported deal. At that time Blore installed the wrought iron (as confirmed by The English Heritage Laboratory, April 1988) hanging bolts to carry the flat part of the Ceiling, and the high level binders above the sloping joists only in the East Bay of the roof on both the north and south sides. This support system for the sloping joists still survives in its original form on the south side (see **Plate 27**). The only evidence that it existed on the north side is one hanging bolt in Joist 3, now cut off above the joist, and a hole cut in the boarding for a further hanging bolt in Joist 2.

The system of repair incorporating high level binders was rejected after completing these first two bays. In the rest of the Roof, where the sloping joists needed additional support, Moore records that this was achieved by fitting strengthening timbers alongside. Moore reported (see **Appendix 1**) these had become significantly infested with Death-watch Beetle (DWB) by the time he carried out his work in 1924, and he had them taken out. Further insights into Blore's work can be found in Moore's Report.

In the current Phase of work, at the south end of *Panel 37 III* one nail was found clenched over on the underside of the Ceiling (see **Plate 53**). Almost certainly this is a fixing through a patch added above the boards from either the 1740's re-paint or the Edward Blore restoration. Evidence from other sections of the Ceiling further to the west, indicate a much larger number of patches nailed from above than occurs in this section. These should be studied further to try to place them in one or other of these Phases of restoration.

One would have hoped that distinctive types of nails would have characterised the different Phases of work, but to date insufficient analysis has been done to help produce reliable evidence.

3.2.4 1880's - The Tower was completely dismantled by Pearson and rebuilt. There is no obvious evidence of any work at this time.

3.2.5 1924 – Moore made substantial alterations to the Ceiling structure. He stripped out all of Blore's "rough and ready" work of supports to the sloping joists and presumably he also took out Blore's hanging bolts to the sloping joists on the north side (although this could of course have been done by Pearson in the 1880s). He then inserted his own system of support to the sloping joists and reinstated some rigid connections between the sloping joists and the ceiling joists where these had decayed. Moore renewed some of the main ceiling joists and some of the sloping joists and inserted a complete new system of noggins to support the ceiling boards. In addition to the noggins, he also put in random patches to support what were presumably localised areas of weakness in the ceiling boards. He then reinforced the original noggins with laminated structures and had the whole roof treated with Silvertown Solution, and lastly, he covered the whole ceiling, except his noggins and the original and composite joists, with hessian.

3.2.5.1 Sloping ceiling binders - Softwood binders were inserted near the top and bottom ends of the sloping joists (see **Drawing 1**). The top binder was carried on a steel hanger. The lower binder was supported on the projecting flange of the cast iron shoe made for the feet of the scissor braces. Galvanised coach screws (265mm x 18mm) (see **Plate 87**) were used where each binder passed over the joist beneath. This system is perfectly satisfactory so long as the sloping joists remain in good condition, but should they ever decay the carrying capacity of the coach bolts, which is limited to the grip of their threads, would be rapidly lost.

3.2.5.2 Joist Connections - Moore seems to have had an inconsistent policy of creating rigid connections between the sloping and flat ceiling joists where these had either been cut back by Blore or had decayed. In some instances, such as at the north connection in Joist 9 (see **Plate 13**), Moore reinstated the joint using a laminated softwood system.

3.2.5.3 Composite Ceiling Joists – Moore renewed the whole of Joist 6 and north sloping Joist 7 using a laminated construction (see **Drawing 4**). They have the same laminated joints at the angles as referred to above and shown in **Plates 14 and 75.** The work of renewing these joists is remarkable as all this work was carried out with no scaffold below the Ceiling. A system of support would have been necessary to hold a whole panel of ceiling boards once the original joist had been removed and before the new joist had been installed. It may be worth noting here that whilst the boards were in "transition", the hessian was applied as it runs beneath these composite joists.

3.2.5.4 Noggins - A whole series of noggins were inserted of two distinct designs. The only design used at the east end of the Ceiling up to Joist 7 can be seen in **Drawing 5 (Items A and B) and Plate 27**. This design used half inch impregnated softwood laid two laminations deep with screws through both laminations into the ceiling boards. Support brackets were nailed to the sides of the adjacent joists immediately above the top lamination and a 50mm x 50mm stud with bare faced tenon at each end was nailed or screwed into the laminations with the tenon located in the notches cut in the brackets. This system did transfer some weight of the Ceiling between the joists back to them. The second design, of which there is one example found first to the west of Joist 7 and throughout the next bay, except on the north sloping ceiling (see diagram on **Graphic 3**) with triangular support pieces fixed to the joists and triangular central stud on top of the laminates (see also **Plate 21).** It should be noted that in the east bay of *Panels 36 II and III*, the proximity of the double tie beam above Joist 8 prevented the fixing of the brackets or triangular support pieces on the side of the joist.

It is thought that one of the reasons for using the thin laminated wood for all these repairs is that wood of this thickness could be fully impregnated with insecticide/wood preservative. It can be seen from Moore's report that this concern was a high priority, particularly in view of the infestation he found in the new timbers inserted by Blore.

3.2.5.5 Patches - In two places (*Panels 37 II* and *38 II*), patches were revealed by carefully easing off the hessian (see **Graphic 6**). Both patches were screwed with random length screws (see **Item D**, **Drawing 4**). The patch in *Panel 38 II* is oak and approximately

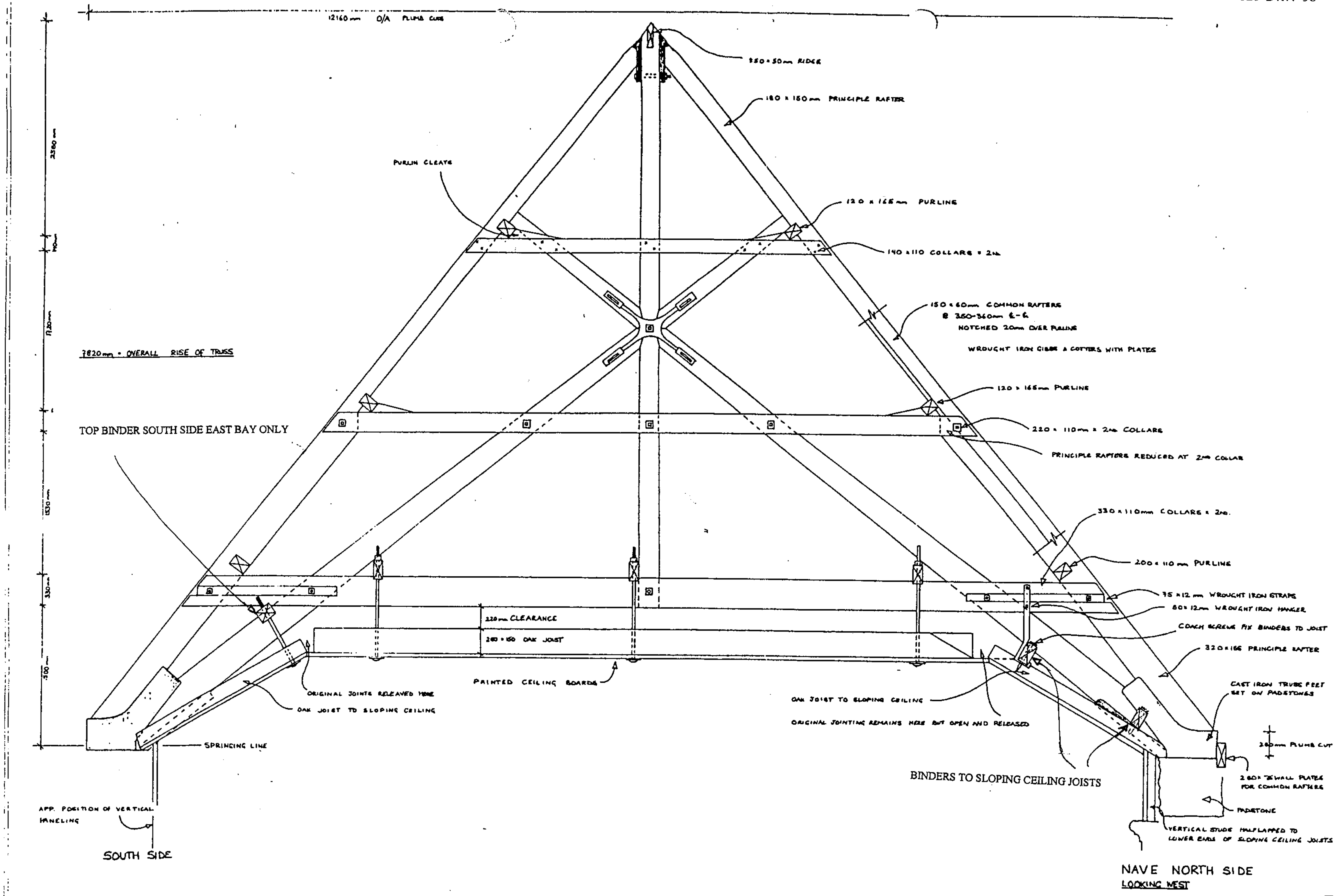
18mm thick (see **Plate 77**), and that in *Panel 37 II* is softwood and approximately 13mm thick (see **Plate 76**). The latter is untreated softwood, not the impregnated wood used for laminations and the oak seemed like a rough off-cut. The use of random screws that match those in the noggins, must date these patches to the 1924 restoration. In both these patches the screws were placed so that they secured the original boards beneath within 25mm to 35mm of their thick edge.

3.2.5.6 Original Noggin Reinforcements - In addition to the laminated noggins, Moore incorporated laminated reinforcements adjacent to, (or possibly sometimes replacing) original noggins. Two laminated reinforcements were examined by removal of the hessian, at the south end of the West Bay of *Panel 38 III* see **Plate 84**) and at the south end of the East Bay of *Panel 39 III*. The construction of these laminates are illustrated in **Item C of Drawing 5**. It is interesting to note that there was no attempt to transfer the weight of these laminates, and the ceiling boards to which they are attached, to the adjoining joists. The design of the reinforcement whereby the laminates are built up higher than the original noggin in the centre with a central laminate spanning the side ones and screwed down into the ancient wood, however, is a perfectly valid means of reinforcing the noggin and spreading the weight over the surrounding area. Where these laminates occur adjacent to noggins at the angles of the Ceiling, the top laminate is canter-levered over the noggin with or without a matching and supporting laminate on the lower side (see **Graphic 3**).

3.2.5.7 Timber Treatment - Moore recorded that he had already used Silvertown Solution to treat the North Transept Roof, and in his report he specifies its use on the Nave roof.

3.2.5.8 Hessian - On completion of all the patching and reinforcing work, Moore had the whole upper surface of the Ceiling covered in hessian adhered with animal glue. No further analysis has been carried out on this glue since the initial work carried out by the Courtauld Institute of Art's original investigations reported by Helen Howard in 1997 *Peterborough Cathedral, Nave Ceiling: A Scientific Examination of the Original Decoration*. It is recommended that more thorough research should be carried out into the nature of this glue in the next Phase of work.

The hessian was applied in two layers. The first layer comprised of strips approximately 50mm wide which were applied roughly perpendicular to the boards at approximately 200mm centres. A second overall layer was then laid over the whole surface and was taken approximately 25mm up the sides of the joists (see **Plate 158** showing the hessian part removed by Hirst Conservation in *Panel 38 III).* I recommend that a sample of the hessian is analysed as part of the next Phase of work.

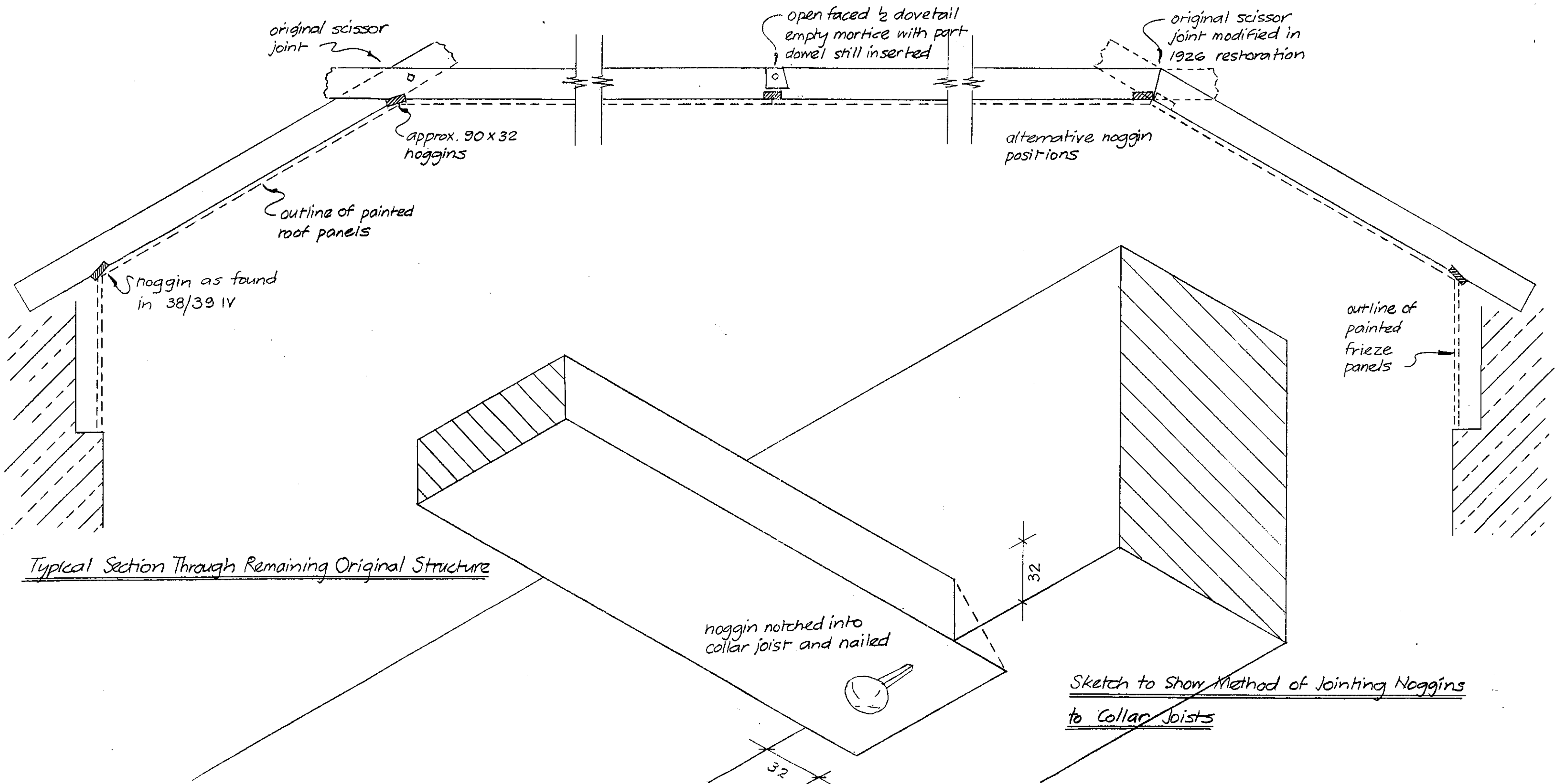


NOTES

- TRUSSES ARE CONSTRUCTED USING BALTIC PINE THROUGHOUT.
- THE NAVE ROOF CONSISTS OF 25No. TRUSSES AS SHOWN PLUS 1No. NOW COVERED AS FIRE SCREEN
- THE TRUSS SHOWN IS THE SECOND FROM THE CENTRAL TOWER AND IS VIEWED LOOKING WEST
- JOIST DETAIL SHOWN HERE APPLY TO BAY ONE BETWEEN FIRST AND SECOND TRUSSES ALTHOUGH THE DETAIL SHOWING THE SUSPENDED SLOPING CEILING JOIST TO THE SOUTH SIDE OF NAVE IS NOT COMMON WITHIN THE GENERAL CEILING CONSTRUCTION
- JOIST SHOWN ARE THOSE CLOSEST TO THE EASTERN SIDE OF THE 2nd. TRUSS
- ROOF PITCH IS BETWEEN 61°-62°
- THE WALKWAY WHICH RUNS TO THE SOUTH SIDE OF THE TRUSS POST IS NOT SHOWN HERE.

DRAWING NO: 01

PC 44.4	PETERBOROUGH CATHEDRAL NAVE CEILING	NAVE ROOF & CEILING CONSTRUCTION DETAILS (from drawing by Hart Construction)	SCALE 1:20	J. D. LIMENTANI, RIBA HARCOURT OFFICES, HEMINGFORD GREY, HUNTINGDON	NOVEMBER 1996



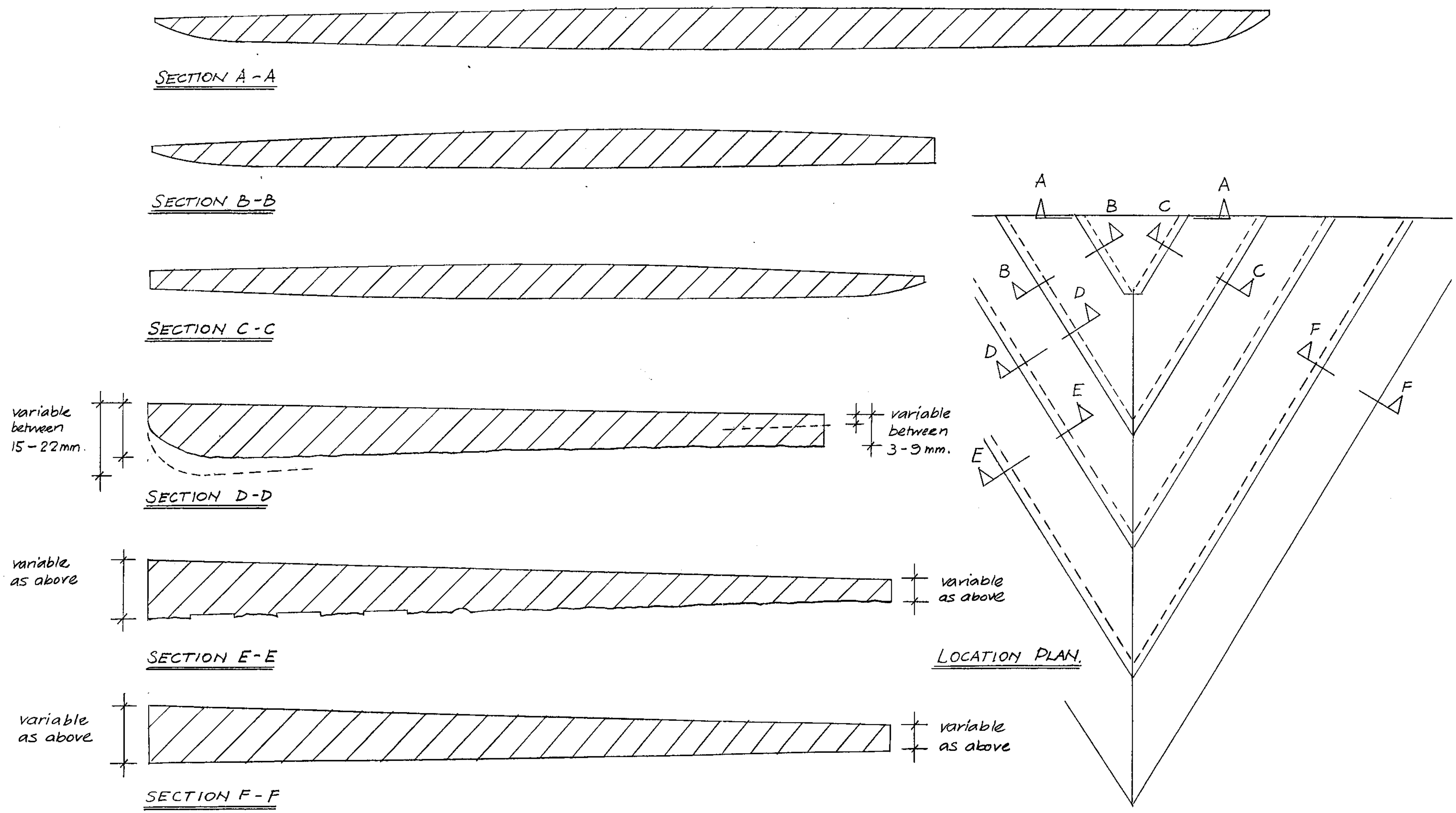
Typical Section Through Remaining Original Structure

Sketch to Show Method of Jointing Noggins to Collar Joists

PETERBOROUGH CATHEDRAL Existing Original Nave Roof Structure (1926 roof structure to which it is bolted not shown) Scale 1:20 ½ F.S.

HUGH HARRISON CONSERVATION March 1998 drawn P.G. Ferguson.

DRAWING NO: 02

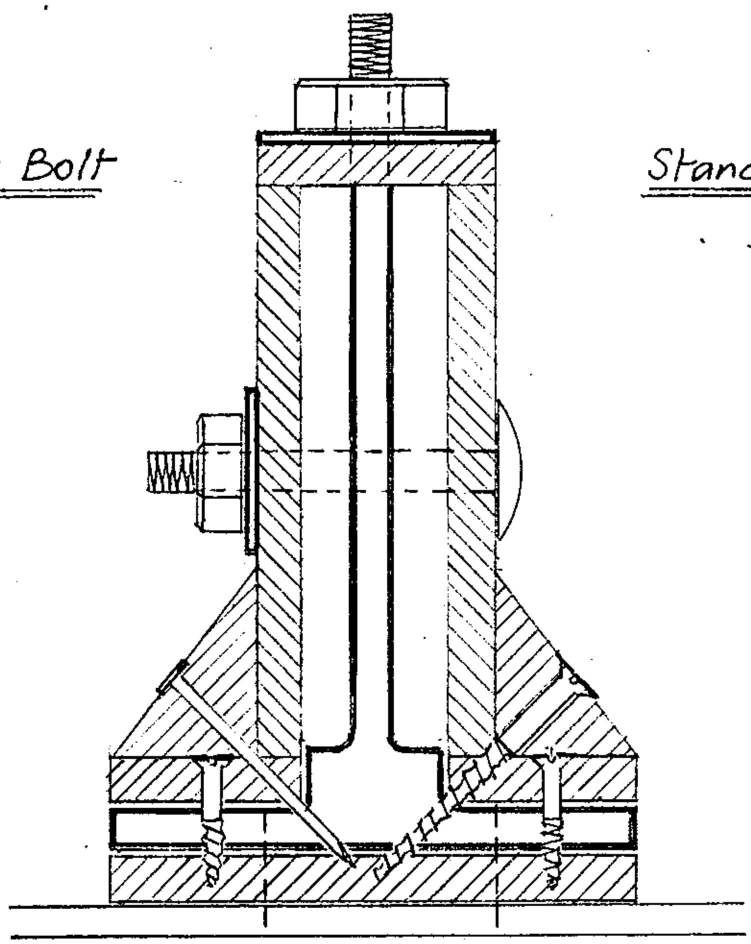


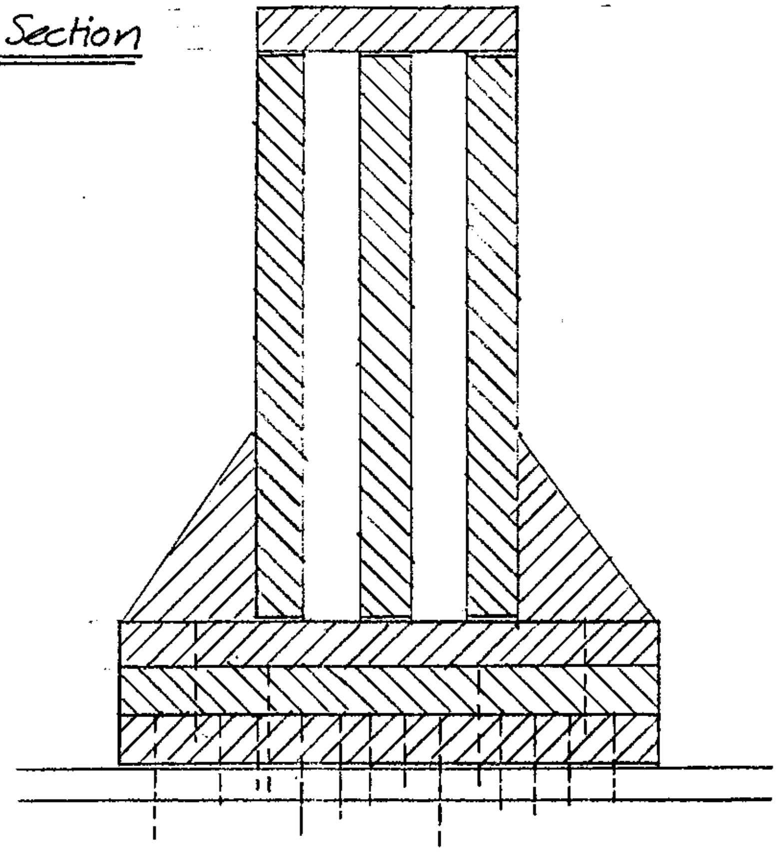
PETERBOROUGH CATHEDRAL Typical Sections Through Nave Ceiling Boards.

Scale 1:10, F.S.

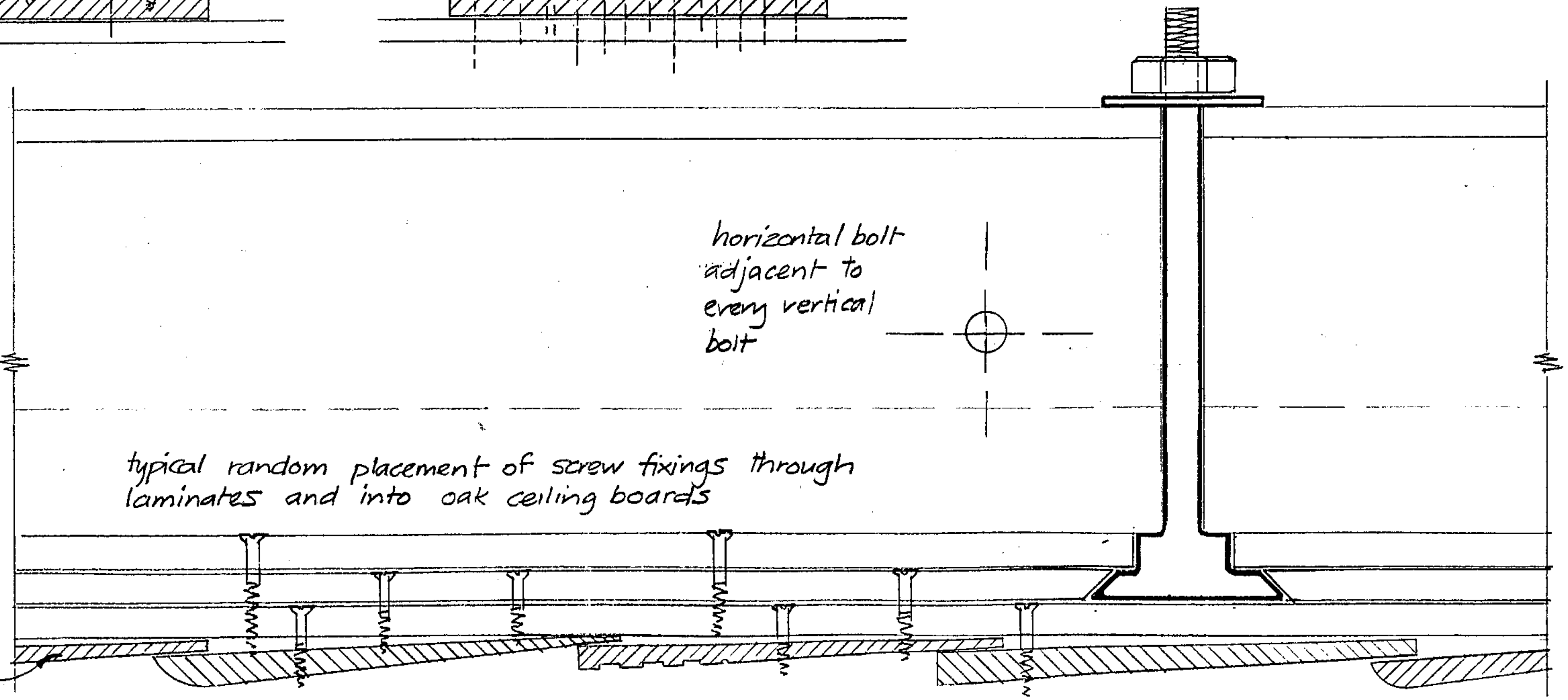
HUGH HARRISON CONSERVATION March 1998 drawn P.G.Ferguson.

DRAWING NO: 03





CONSTRUCTION OF 1926 COMPOSITE BEAM cross sections and longitudinal section showing steel bolt and plate strengthening



PETERBOROUGH CATHEDRAL Details of 1926 Strengthening

HUGH HARRISON CONSERVATION March 1998 drawn P G Ferguson

Scale ½ F.S.

DRAWING NO: 04

'A'

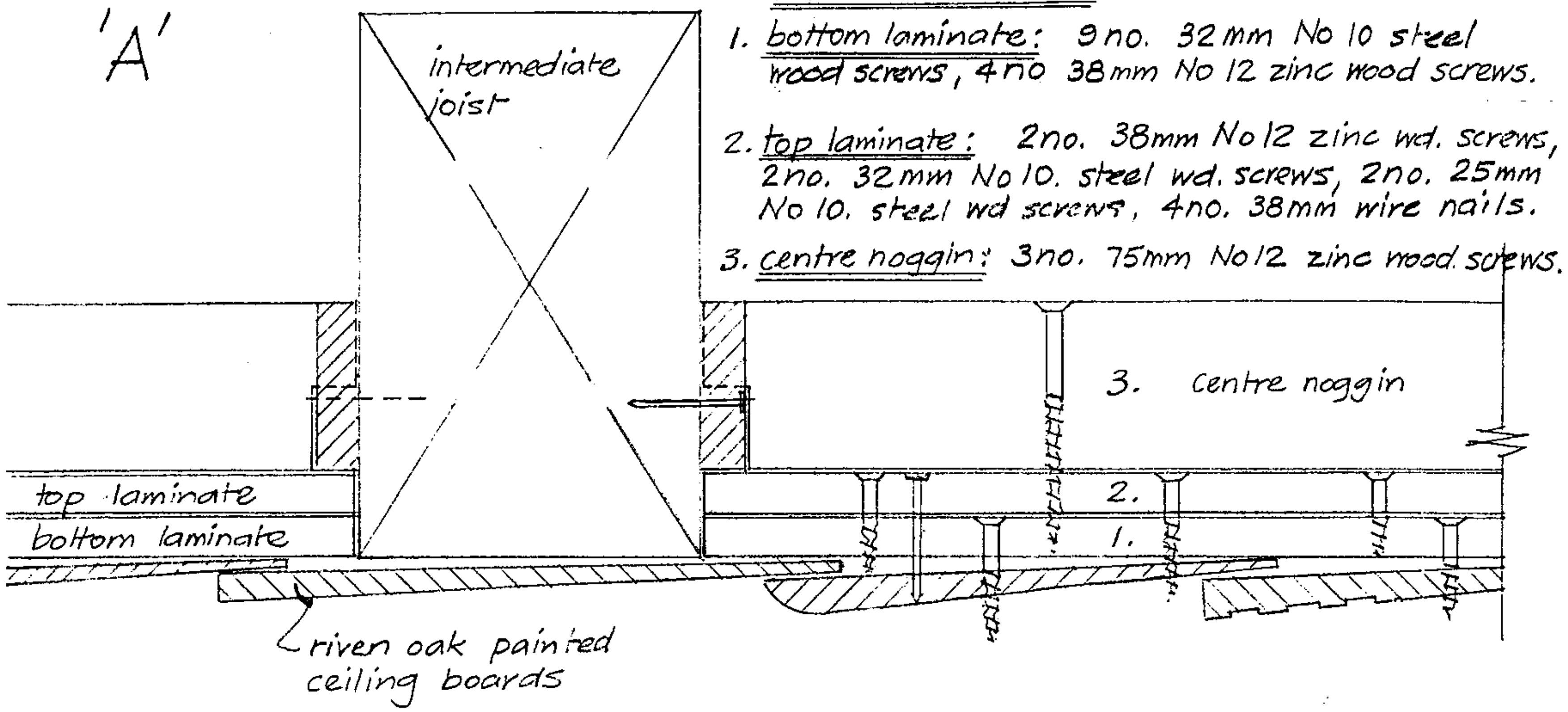
FIXING SCHEDULE

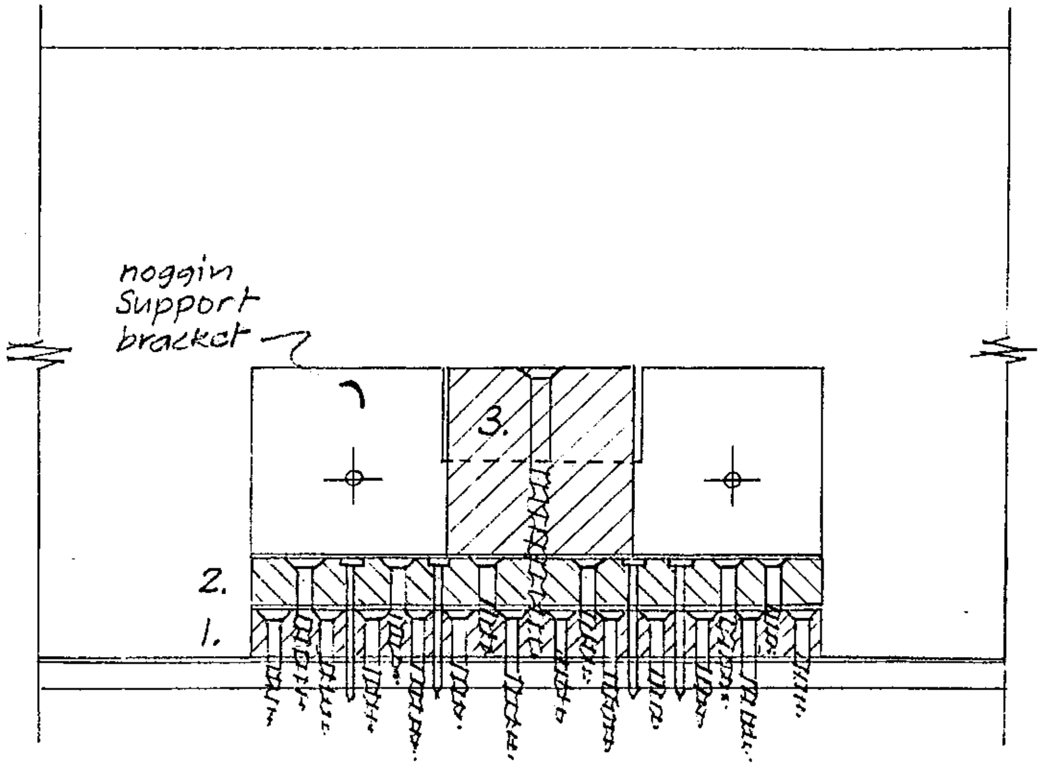
1. bottom laminate: 9no. 32mm No 10 steel wood screws, 4no 38mm No 12 zinc wood screws.

2. top laminate: 2no. 38mm No 12 zinc wd. screws, 2no. 32mm No 10. steel wd. screws, 2no. 25mm No 10. steel wd screws, 4no. 38mm wire nails.

3. centre noggin: 3no. 75mm No 12 zinc wood screws.

'B'



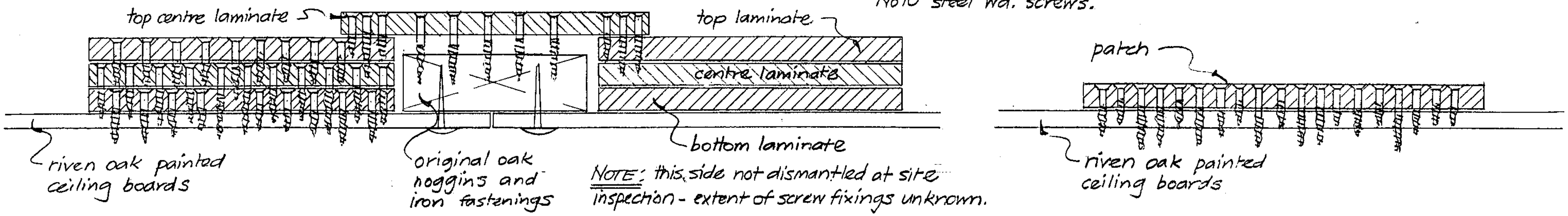


CONSTRUCTION OF 1926 NOGGIN - South Noggin Panel 38 II East Bay Sections through 'A' Joist and 'B' Noggin.

FIXING SCHEDULE top centre laminate: 1no. 38mm No 12 zinc. wd. screw, 2no. 32mm No 10 steel wd. screws, 12no. 25mm No 10 steel wd. screws, top laminate: 4no. 38mm No 12 zinc wd screws, 5no. 25mm No 10 steel wd. screws, middle laminate: 3no. 32mm No 10 steel wd. screws, 5no 25mm No 10 steel wd. screws, bottom laminate: 9no. 32 mm. No 10 zinc wd screws, 1no. 25mm No 10 steel wd. screws.

'C'

'D'



CONSTRUCTION OF 1926 CENTRE REINFORCEMENT 'C' AND PATCH REINFORCEMENT 'D' Cross sections

PETERBOROUGH CATHEDRAL Details of 1926 Strengthening

Scale ½ F.S.

HUGH HARRISON CONSERVATION March 1998 drawn P.G. Ferguson.

DRAWING NO: 05

PART 4: TECHNICAL SURVEY: THE CEILING STRUCTURE, LOWER SIDE

4.1 General

The underside of the Ceiling is entirely boarded and the area of ceiling covered in this Phase of work has three different categories of boarding. The ceiling boarding with the lozenge design that occurs on the flat part of the Ceiling and the two sloping sides, the Eastern Infill boarding, and the Ashlar boarding.

The ceiling boarding comprises the original oak boards and those replaced in softwood at various times. The Eastern Infill is all softwood, also of indeterminate age, but with one short length of original oak boarding which may or may not be original to this area of the Ceiling. The Ashlar boarding is softwood tongue and groove boarding, probably 18th or 19th century in date.

4.1.1 Original Ceiling Boards - The original boards are riven or cleft oak and mostly have a tapered section. The boards are on average 200mm wide, and with a thickness of 15-22mm on one edge, and 3-9mm (see **Figure. 3**) on the other. A maximum average length would be 2250mm with a very few boards up to 200mm longer. To acquire this tapered section the boards would have come from near the centre of a log of slim girth (probably less than 600mm in diameter), and would therefore have spanned the radius of the log from sap to pith. This accords with the 'wild wood' type forest where these trees might have been growing as suggested by Ian Tyers of the University of Sheffield, Dendrochronology Department.

Figure. 3 shows the diversity of design of the boards which is impossible to appreciate from the floor of the building (see **Plates 38 - 42**).

The first point to note is that the outer boards have three different edge mouldings; one is rounded, one is square and the third is square with a triple furrow adjacent to its outer edge. The position of the boards within each lozenge seems to be constant (see **Graphic 8** and **Figure. 3**). In the centre of each lozenge the section of the board changes so that the centre, first and second boards adjacent are shaped so they form undulating panels without the projection of the thick edges of the outer boarding. This must have been designed so that in the picture in the centre of each lozenge would not be distorted by the profile or shadows cast from the projecting edges of the main lozenge boarding design.

The difference in length between the lozenge that spans the flat ceiling and that which is centred on the angle in the Ceiling, forms the tapered between the lozenges. I have called this space the 'base-board' as it would have been the first area to be fixed before the lozenge was boarded. These baseboards actually consist of three boards each, a single one in the narrow part of the taper and two to the wide part. These boards are butt jointed and doweled along their edges approximately at 600mm to 900mm intervals and scarfed in length.

The baseboards seem to be parallel in thickness, which must have been part of the original design to provide the maximum definition for the outer edge of each lozenge. The flat areas of these baseboards created a space for the foliated designs at the ends of the short lozenges.

In order to create the same baseboard between lozenges on the sloping sides of the Ceiling, the half lozenges whose base is the bottom edge of the Ceiling, have been made artificially shorter.

This seems to show a fully developed and integrated design to accommodate pictures as part of the overall design and a disposition of boards to provide the maximum visual impact that their physical size would allow.

Scarf Joints - Many of the boards are jointed in length and where this occurs scarf joints have been used. The length of the longest board, where a scarf joint has been used, was measured and recorded in the Board by Board Survey. The purpose of this was to see if the boards were originally supplied in standard lengths. 110 boards were measured and 59 were in a broad band of 1500mm - 2150mm in length, with the rest fairly equally split in a range of lengths down to 200mm. The majority of the longer length boards (34) were 1900mm - 2150mm. The longest measured was 2460mm so there does not appear to be any standard length.

The position of these scarf joints provides an interesting insight into original practices both in terms of manufacture and possibly the value of the material as against the cost of labour. In several cases scarf joints appear almost at the end of boards and in one case, in *Panel 36 II*, the additional length achieved with the scarf is actually shorter than the length of the scarf joint itself (see **Plate 47**).

Close examination of the scarf joint illustrated in **Plate 44** would seem demonstrate the sequence of manufacture of a scarf joint as follows:

- The actual scarf joint is shot in two square edged boards.
- The un-nailed scarfed boards must have been held in a clamp and the round edge formed with a plane, spokeshave or chisel. In the example in **Plate 44**, slight irregularities in the rounded edge can be seen on both sides of the joint.
- The joint was nailed after the mould had been worked, as the nail head projects over the moulded edge. The nails must have been driven whilst the boards were still clamped and presumably the ends of the nails clenched over (see evidence from x-ray photographs **Plate 163**).
- The scarfed board was nailed in place in the Ceiling.

In many instances the boards were cut so that the scarf joint came beneath an intermediate joist in which case the scarf was nailed straight through in to the joist.

A number of scarfs seem to have been carelessly made so that the top scarf projected over the underboard and then had to be roughly chamfered level with the under-board (see **Plate 45**).

Although most scarfs are close to perpendicular to the edge of the boards, some are angled (see **Plate 46**).

It is interesting to note that there appears to be an original noggin above a scarf joint between Joists 2 and 3 in *Bay 39 III* (see **Plate 37**). There is no proof that it is an original noggin except that it is jointed with bird's beak joints and would therefore be almost impossible to insert at a later stage. There is also no proof that it is specifically inserted to support the scarf but there is no other apparent reason for its existence. Does this suggest that the original boarding of the Ceiling started at the east end and that it was the intention to insert noggins above all scarf joints that came between joists?

4.1.2 Eastern Infill Boards – The bird's beak joints on the underside of the east face of Joist 1 would seem to indicate that there must originally have been some form of boarding to fill this space. Board (b), *Panel 4 III* is the only existing oak board in this section of the Ceiling. It is worth noting that this board does not look to be tapered and there is the clear imprint of the head of an original nail on what would normally be the tapered edge of the board. If this board had originally been one of the outer lozenge boards, the nail head would have been close to the outside (thick edge) of the board. If this board is not tapered, it may be the only surviving example of an original board from either from this Infill boarding or the Ashlar boarding.

4.1.3 Ashlar boards - All this boarding is softwood and must date from the 18th or 19th century.

Further examination of the studs to which the Ashlar boarding is nailed should be carried out in Phase II, as should the joints between these studs and the sloping ceiling joists to provide more information on the existence of this boarding as part of the original construction.

4.1.4 Fixings – It would seem that the original nails are those with round heads, approximately 18mm in diameter, and small square shanks, approximately 3mm square and 65mm inches in length (see **Plate 52**).

When these particular nails are identified and plotted separately (see **Graphic 7**) the fixing of the original ceiling becomes much clearer.

The boards are usually nailed with two nails at each end of the board and with one or two nails where the board passes beneath the intermediate joist. The pattern of nailing at Peterborough makes no provision for the subsequent expansion or contraction of the boards. The boards were further nailed at comparatively regular intervals along their edges (approximately 450mm) and these nails were clenched over above the top board (see x-ray **Plate 165)**. All nails are driven from the underside of the Ceiling and no marks were found where a carpenter had missed the nail and hit the adjacent timber. This problem may have been solved by the use of a shaped punch that 'fitted' the shape of the nail head.

In view of the potential difficulties of driving a slim wrought iron nail into solid oak, I had some sample wrought iron nails of the same dimension made and can confirm that they could be driven into solid oak without bending them and without drilling pilot holes first. Before carrying out these trials we did consider the option of pre-drilling and evidence seems to exists in some places for the original nails with square shanks being driven into round holes. **Plate 54** shows rectangular holes in a replacement softwood board made by 18th or 19th century nails with what look to be round holes in the adjacent oak boards. However, one must be careful to emphasise that the corrosion of a square shank, over the length of time since the Ceiling was constructed could produce a round hole. Perhaps all one can say at this time is that this question should remain open until clear evidence, either way, comes to light.

4.1.5 Dendrochronology - In view of the difficulties of springing boards, Cathy Groves of the University of Sheffield Dendrochronology Laboratory experimented with a new technique for examining the tree rings. Impressions were taken from the ends of the boards using a moulding material which were then cast in resin and the annual ring sequences analysed. Their report is not yet to hand (see **Plate 43**).

4.2 Previous interventions

There is little evidence of early repairs to the boards but the mass of softwood boards inserted amongst the oak boards implies substantial intervention from, say, the 16th century onwards. The earliest recorded date of a restoration is that carried out in the 1740s and this is certainly a plausible date for the introduction of softwood instead of oak.

4.2.1 14th Century - It is possible that the cuts through the boards in *Panels 39 II* and *IV* (both supported by oak noggins above) are evidence of the temporary dismantling and rebuilding of parts of the Ceiling that was necessary to enable the reconstruction of the Tower to take place. It should be noted that the noggins are butt jointed between the joists, and that although there is a continuous cut through several adjacent boards in *Panel 39 IV,* those in *Panel 39 II* are cut at right angles to each board (see **Graphic 3**).

There is no evidence of boarding of this date in either the Eastern Infill boarding or the Ashlar boarding.

4.2.2 1740s

4.2.2.1 Ceiling Boards – There is evidence of the repainting of the Ceiling in the 1740s[8] but there is no information on structural repairs at that time. Since it is thought that the Ceiling has only been scaffolded once since this date, it seems likely that since many of the replacement boards show evidence of at least one earlier re-nailing, some boards must have been inserted in the course of this restoration of the painted surface.

Graphic 8 shows the extent of the replacement boarding. This shows all softwood boards except a very few places where original boards were nailed over softwood boards (see **Plate 67**) as patches. The softwood boards have some different surface characteristics. Some are very smooth, some have considerable surface damage where knots or opposing grain has been ripped out by rough planing and there are a scattering of boards that have not been planed at all and are straight off the saw (see **Plate 64** and **65**). Other replacement boards have themselves already been used elsewhere. **Plate 68** shows a board in *Panel 37 I* that has an under-painting below the present scheme.

With our current knowledge the replacement boards can only be of two periods, 1730s or 1840s. Some, in the vicinity of the Tower, could have been replaced in the 1880s. We have not yet found conclusive evidence from either the boards themselves, or the fixings, or the painting technique to categorise the date of the replacement boards. The multiplicity and variety of nails in the boards, as well as the number of empty nail holes, give the impression that there have been two or three periods of renewal of boards and repositioning of these boards.

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[8] *Peterborough Cathedral, Nave Ceiling: Scientific examination of the original decoration*. Helen Howard, Sept.1997

Whereas in this Phase of work our attention was focused on analysing the original construction, the next Phase should concentrate on analysing the 18th and 19th century restorations.

4.2.2.2 Eastern Infill Boarding - No evidence has been found to date to prove the date of this boarding. Groups of adjacent boards have different characteristics that group the boards together, but none have any specific evidence to point to a certain date. There are probably at least three different dates of painting, and the painted pattern does not follow on from one Panel to another (see **Figure. 4**). The noggins to which these boards are fixed are oak and apparently in good condition, it is difficult to understand why these noggins, which look old, have remained in good condition yet all the boards have had to be renewed. Although the Ashlar boarding seems to have a similarity of construction throughout its length (from what can be seen to date), the Infill boarding certainly does not. One might have thought that the Infill boarding could have been renewed with the same material as the Ashlar boarding, but there seems no sign of this.

4.2.2.3 Ashlar Boarding - No evidence has yet been found to prove the date of this boarding except that it is tongue and grooved, which must provide some sort of date even if it is only the earliest likely date. I have consulted Julie Wakefield, Curator of The Brooking Collection at the University of Greenwich, which has a huge collection of dated architectural features, but sadly it has no tongue and grooved boarding. After consulting several specialists in the field, all advice that I have had is that it is thought that tongue and groove boarding is quite commonly found from the mid 18th century, but not earlier. It is difficult to understand why all the Ashlar boarding was renewed at one time. The oak studs to which the boards are fixed seem old and in good condition. It would be unlikely for only the boarding to be in such bad condition that it needed renewing entirely, yet the studs to which the boards were fixed, did not.

Does this suggest that there was no earlier frieze and that it was created at this time? This seems unlikely in view of the halving joints at the foot of the sloping joists, and the fact that the sloping ceiling finishes some distance out from the face of the set back at the top of the wall.

4.2.2.4 Fixings - Several types of nails can be found in the replacement boards. There is no evidence at the present time of their date. These should be further investigated in the next Phase of work.

4.2.3 1830s

4.2.3.1 Ceiling boards - As seven hanging bolts are completely or partially hidden by replacement boards fixed beneath them, this must show that some of the replacement boards were inserted at this date, or that the ceiling was substantially restored at this date. In future Phases, the nails which fix the boards which cover the hanging bolts should be recorded and identified, and these could provide a datum for what must be 1830's work, anything different must then be 1740 or an unrecorded restoration. All different nails should be recorded in the next Phase of work.

4.2.3.2 Eastern Infill Boards and Ashlar Boards – There is no direct evidence whether any boarding was inserted in these spaces at this time.

4.2.3.3 Fixings – A number of different types of nail have been used in all the boards throughout the Ceiling, Eastern Infill and Ashlar boards. There is a predominance of two different types of fixings; a round headed nail with a 12-15mm head, and a square cut brad (see **Plate 52**). Evidence of previous nailing exists in many boards as well as both types of existing nails described above and other types of nail as well. Only *Panel 40 IV* has only the round headed nails with no evidence of previous nailing. It is interesting to note the frequency of panel marks on the boards adjacent to 18th and 19th century nails, where the carpenter missed the nail head (see **Plate 55**), in comparison to the lack of marks adjacent to the original nails.

4.2.4 1880's

4.2.4.1 Ceiling Boards - It is interesting to note that as well as the cuts mentioned above in *Panels 39 II* and *IV,* there are several long cuts either parallel to Joist 2 or running down the centre of Joist 2 (see **Graphic 3**). It would be easy to conclude that these are all places where boards have been cut back to allow building works to the Tower to proceed. This is not likely to be the case however as there are different boards on either side of the cuts and there is no evidence from the painted decoration that any boards were renewed in the 1880's. Some boards were definitely taken down and re-fixed, as they were re-fixed with screws from beneath. These screws are recorded on **Graphic 4.**

4.2.4.2 Eastern Infill Boards - Groups of boards nailed with the same style of nail makes it look as though sections of boards were renewed at one time and were taken down and replaced in groups. If all the boards had been taken down singly and replaced singly one would expect them all to be re-nailed with the same nails. In view of the difficulty of taking down groups of boards, only one of which may span one or two noggins whilst the others do not, suggests that none of the Infill boarding was taken down, except *Panel 40 IV* which was renewed completely.

4.2.4.3 Ashlar Boards - There is evidence of disturbance to the east section on each side. On the north side, many nails are missing at the east end, and all other nail heads in this section are unpainted. On the south side, it looks as though the tongues of the tongue and grooved boarding have been cut and like the north side, all the nail heads are unpainted. This is no proof of work in the 1880s, but dismantling and rebuilding these sections seems more likely in the 1880s than in the 1830s.

4.2.4.4 Fixings - These have all been included in the analysis and description of the boards.

4.2.4.5 Dendrochronology - It had been hoped that dendrochronology could be used to help date the softwood replacement boards. Unfortunately the technology was not felt to be sufficiently advanced to be used on this occasion. This possibility should be kept in mind for future Phases.

PART 5: CONDITION: THE CEILING STRUCTURE, UPPER SIDE

5.1 Roof Timbers

Evidence of old infestation by Common Furniture Beetle (CFB) can be found in the softwood roof timbers extensively but not intensively. No evidence of current infestation was found.

5.2 Ceiling Timbers

No evidence of CFB infestation was found in any of the 1924 softwood noggins, joists, binders, or patches where they were revealed.

Intensive Death-watch Beetle (DWB) infestation was found in some of the ancient noggins (see **Plate 33**), but none was seen to be active. The flat and sloping joists are almost entirely free of any signs of any past infestation from either DWB or CFB.

5.3 Boards

Where the upper sides of ceiling boards were exposed, most showed signs of previous infestation by both CFB and DWB. None was seen to be active, nor had been active for many years. Surface decay was also extensively found, noticeable as a general softening of the surface and by miniature cross checking. On some boards, the surface was eroded by infestation and decay so that the thickness of the timber was reduced to 3-4mm.

5.4 Fixings

5.4.1 Pre 1830s - The only fixings that come in this category are the surviving pins holding the small number of complete halving joints at the intersection of the flat and sloping ceiling joists. Although no pins were extracted, the visible ends are in good condition and one would assume that they are sound throughout their length.

5.4.2 1830 - Light surface corrosion was found on the hanging bolts and nuts used by Blore.

The caste iron shoes are well painted, as was recommended to be carried out by Moore in his programme of works in 1924.

5.4.3 1924 - The steel hangers used for the binders over the sloping ceiling were painted by Moore with a red oxide type paint along with the Blore iron work. Although steel was presumably used by Moore rather than the caste iron used by Blore, the paint surface still looks in good condition.

The visible heads of coach screws through the binders into the sloping ceiling joists and those used in the construction of the laminated joists seem to have a zinc or galvanised coating and are in satisfactory condition. Similarly, screws used to fasten laminated patches to the studs/noggins are in a satisfactory condition. Nails used in the laminations and the triangular side pieces on the joists were found to be in very good condition (see **Plate 87 and 90**).

5.5 Hessian

There are no signs of rot in the hessian and the hessian is still acting in conjunction with the glue as a substantial reinforcement for the boards. Where patches of hessian were lifted to investigate the structure beneath, it was found to have lost some of its strength, i.e. it can be easily torn. Its current strength lies, therefore, in its cohesion with the glue. The hessian was lifted by cutting along an edge where it had to be lifted, and carefully sliding a round ended table knife beneath it and slowly to work the blade along to part the hessian from the glue on the surface of the wood. Once an edge had been lifted, this could be held up so that the end of the blade could be visually guided as necessary.

There are areas where the hessian is not bonded to the entire area of the board beneath, although this mostly occurs where hessian is stretched over a cavity or a step in height of the boards beneath. I suggest that this happened during the initial period of contraction as the glue dried. Everywhere else the bond appeared extremely strong.

The hessian and roof timbers have a light covering of dust which includes some masonry debris at eaves level. See **Plate 157** showing *Panel 37 II* part cleaned.

PART 6: CONDITION: THE CEILING STRUCTURE, LOWER SIDE

The drawing referred to below can be found at the end of this Part 6.

6.1 Boards

The condition of each board is described in the 'Board by Board Survey' and illustratively on various graphics (**Graphics 1, 2 and 4**). All boards in all parts of the Ceiling covered by this Phase of work, are included as two sections – Original and Replacement - in the description of each category of damage.

The boards are suffering from the following categories of damage

- Splits
- Wood losses
- Infestation by CFB and DWB
- Wet rot
- Lead shot
- Surface degradation
- Subsequent restorations (including repositioning and splinters from screws).

6.1.1 Splits

6.1.1.1 Original Boards - It would seem that almost all the splits are associated with the wood drying and contracting after being fixed in the Ceiling. The splits are either in line with the nails or between the nails (see **Graphic 2**). **Plate 50** shows a nail through an edge of a board, and the main part of the board has moved away from it. What is interesting is that this happened after the last coat of paint was applied, as the wood is bare where it has emerged from beneath the nail. **Plate 51** shows a similar split in the end of a board, and similarly the area of wood that has emerged from beneath the nail is unpainted. Assuming the paint is 1740's, this shows that all the movement has taken place since then.

What evidence is there to show that these splits were not created when the nail was first driven or has been caused by subsequent corrosion and expansion of the nail shank? First the holes may have been pre-drilled, though I have my doubts on this, and second, I do not believe that fresh oak would split with this size nail shank, and if it did it would only be a tiny split say 10mm long. If it was corrosion, the splits would emanate equally on either side of the nail, and they would be very unlikely to be more than 25mm long. It is also quite clear from **Plates 50 and 51** that the wood is still tight to one side of the nail and has moved away from the other. Incidentally there is little evidence of corrosion on the nail shanks that have come loose and can be examined (see **Plate 52**).

6.1.1.2 Replacement Boards - It is interesting to compare the splits in the softwood replacement boards with those in the oak boards. Although the replacement boards are split for the same reasons as the oak boards, the characteristics of the splits are quite different. These splits are not so wide, but they are very much longer. Splits between nails are also narrower and often they are very long – sometimes extending for the full length of the board. As there are knots in the softwood boards, there are also curved splits around the knots (see **Graphic 2**).

6.1.2 Wood Losses

6.1.2.1 Original Boards - All wood losses can be attributed to decay and infestation. The few other losses are small areas of damage that occurred when boards were cut back and moved around when the replacement boards were inserted. All wood losses are shown on **Graphic 1**.

6.1.2.2 Replacement Boards - The only wood losses in the replacement boards are those incurred during fitting or subsequent restoration. There are none attributable to beetle infestation or decay.

6.1.3 Infestation by CFB and DWB

6.1.3.1 Original Boards – Infestation by CFB and DWB is widespread (see **Graphic 1**) and occurs both as general outbreaks throughout part of a board (see **Plate 104**), or is concentrated along an edge of a board (see **Plates 106 and 107**). It may be heavy infestation or isolated. Where it has been intense, so much of the wood has been consumed that it has crumbled away completely, and the adjacent areas that have survived are very fragile and vulnerable to damage. The intensity of infestation has been assessed for every board and both the type of infestation and the area of the board considered to be infested (based on the concentration of exit holes) recorded in the Board by Board Survey sheets. No signs of current activity of either DWB or CFB were observed.

Presumably the upper surface of the boards were treated with Silvertown Solution in 1924, as specified by Moore.

There is slightly more infestation by DWB than CFB as one would expect in oak. As the upper surface of the boards is covered by the hessian, it is impossible to compare the incidence of exit holes through the upper unpainted surface with that through the lower painted surface. In view of the general surface decay that was observed where the trial areas of hessian were removed (see **Plate 127**), one would expect the incidence and concentration of activity to be higher on the upper surfaces than on the lower.

Graphic 1 highlights the fact that generally few boards remain clear of infestation and that the heavy infestation in the few remaining original boards in *Panels 38 III* and *39 III* may indicate an earlier high level of infestation in this area. This may be why there are now a large number of replacement boards in these two panels. Generally I would suggest that there is insufficient evidence at this stage to generalise on overall patterns of infestation.

In view of the general preference by DWB to emerge through unpainted surfaces rather than through painted surfaces, many of which contained lead (though whether this is relevant or not, I do not know), it would be interesting to plot the exit holes through the trefoil and other ghosted areas compared with the abraded areas. If there is a provable reduction in holes in the former, this might indicate differences in composition of paint used on different areas.

There are many incidences of infestation along the outer (thick) edges of boards (see **Plates 106 and 107**). If the tapered section of the boards correctly identifies them as having been cleft straight off the log with only minor further working to the painted surface then, as mentioned above, the logs must have been of quite narrow diameter. In this case the frequency of this infestation is likely to reflect the retention of sapwood along the outer edges of the boards. If this is correct, these boards would be good examples for dendrochronology which is so much more accurate if the sap wood exists.

6.1.3.2 Replacement Boards - There is sporadic infestation by both CFB and DWB, but it is often just one or two exit holes in the whole of a board. *Panels 36 I, 37 III,* and *39 III* seem to have more recorded infestation than elsewhere. There is no evidence of infestation in either the Eastern Infill panels, or the Ashlar panels.

6.1.4 Wet rot

6.1.4.1 Original Boards - There are surprisingly few signs of wet rot though small areas do occur as shown on **Graphic 1**. It is likely that much more extensive areas used to exist and it these areas which have been renewed with the replacement boards. **Plates 102, 103 and 109** show localised miniature cross checking of the surface and **Plate 127** shows similar decay on the top surfaces of the boards. It should be emphasised that all this decay only exists on the surface. **Plate 110,** however, shows a much larger cross check crack and, although it is only a single crack on the front surface, it almost certainly extends the full thickness of the board and signifies general decay in this area.

6.1.4.2 Replacement Boards - There is no evidence of wet rot in any of these boards.

6.1.5 Lead shot

6.1.5.1 Original and Replacement Boards – **Graphic 1** shows the extent of lead shot. Don Macreth noted in his letter to Julian Limentani of 24th April 1998 that the shot lodged near the surface is unpainted. This does not help much with dating because we do not know the date of the replacement boards, or the extent of any repainting in the 1830's. Conversely, if a weapons expert could date the shot, this might help date the replacement boards and the polychrome. The shot in *Panel 39 II* and Boards (d) and (g) in *Panel 40 III* is more interesting as it is thought that all or some of this boarding was taken down to carry out the work to the Tower in the 1880's. If it was, this shows it was replaced in the same position as it had been originally (unless the shot is post 1880). The original Board (b) in *Panel 40 III* is interesting because the shot is confined to this one board and does not occur on Boards (f), (j), and (k) which surround it (see **Plate 113**).

The raking light used to illustrate Board (b) in *Panel 40 III* shown in **Plate 113** seems to indicate the shot entered the wood at an acute angle from the right side and virtually perpendicular to the length of the board. If this piece was in its present position when it was shot at, the shot would have had to be taken from an impossible position near the base of the Ceiling, directly opposite the present position of the board. A possible scenario is that this board was once an Ashlar board and situated just above the stone cornice at the bottom of the Ashlar boards. If the offending pigeon was sitting on the cornice in front of the board, where it became the target for a shot from directly below, the excess shot would have entered the board at exactly the angle it is in.

6.1.6 Surface Degradation

6.1.6.1 Original Boards - **Plate 110** is one of a large number of examples where the present or previous pattern is in. In this instance, the relief cannot be a paint layer as the projection is too high. This raises the question as to whether the other raised areas on other boards are also not paint but the surface of the wood itself. It has been suggested that this relief is created by shallow carving, and **Plate 110** shows an area where the edges of the relief are so well defined that this would seem to be likely. **Drawing 6** (see end of Part 6) taken from **Plate 110**, however illustrates the unlikelihood of the relief being carved. The evidence for this is the medullary rays that span the ground between the parts of the scroll in the area between the Section BB and the lower nail head, also the medullary rays drawn in heavily immediately to the right of this nail head also, in particular, those spanning the indentations in the triple lobed amulet. These medullary rays are still level with the raised pattern and have not therefore been carved back. It is also inconceivable that the carver would have carved the lower ground between the medullary rays.

Another aspect to consider is the gradual slope of the medullary rays receding from the upper level of the scroll to the ground on the right-hand side of the right-hand lobe of the amulet (also shown in heavy lines). The carver will always express the profile of any line with a pared edge (that will show up) rather than a feather-edge (that would not be seen) which is how the area just referred to, would have been carved. I would suggest that the relief formed by the lower ground is caused by surface fungal decay. It is known that medullary rays are resistant to fungal attack and their projection above decayed surfaces is a common characteristic. I recommend that this issue is taken up with English Heritage through their Woodcare Project as part of the next Phase of works. In particular, I recommend that Colm Moore, at the Department of Botany, University College Dublin, should be consulted. He recently gave a paper entitled '*Fungi, primary modifiers of oak heartwood – Recent studies of oak rot fungus (Donkioporia expansa)* at the Woodcare Conference – 'Death-watch beetle decay and its treatment' on 23rd September 1998.

The same surface characteristics can be seen on the unpainted oak board in the centre of **Plate 111**. I suggest that this is an original board that was never repainted in either the 1740s or 1830s. If this is the case, it would show how little paint existed before the

1740s repaint. The only difference in the surfaces in **Plates 110 and Plate 111**, is that the former is painted.

This surface characteristic applies only to the original oak boards.

6.1.7 Subsequent Restorations

Many of the boards, both original and replacement have been damaged by later interventions. These can be put into three categories,

6.1.7.1 Repositioned Boards – These are boards that have been removed and replaced out of alignment in either 1740 or 1830, and are recorded on the Board by Board Survey sheets as 'Repositioned'. For a typical example see Boards (a) and (a1) in *1 Panel 37 I.* These boards have been re-fixed 30mm to the north and west, as shown by the distance they are out of register with the paint lines on Board (b) *Panel 37 I* and Board (x) *Panel 38 I.* See **Plate 209 -** there is only one recorded Repositioning of a replacement board which is Board (e) *Panel 36 IV.*

6.1.7.2 Displaced Boards – these are boards which were displaced vertically by screws inserted in the 1924 restoration and are also recorded on the Board by Board Survey sheets as 'Displaced', with the distance in millimetres that the board has been displaced. The cardinal point recorded in the next column identifies the edge of the board where the displacement has been recorded. A good example can be seen in **Plate 92**.

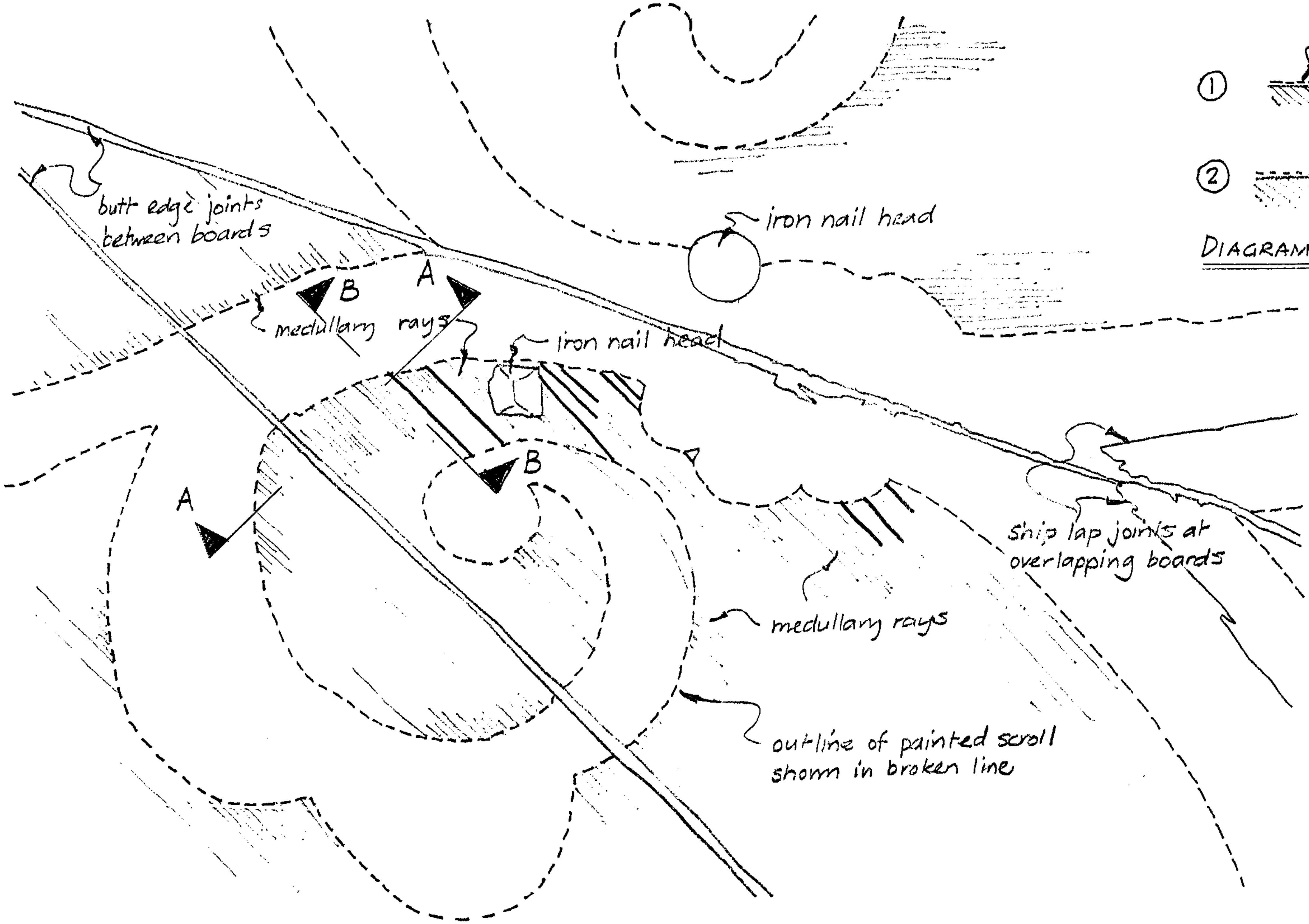
6.1.7.3 Splinters - As screws were inserted from above in the 1924 restoration, when they emerged through the underside of the Ceiling board, many splintered the surface. A good example in an oak board can be seen in **Plate 94** and an extraordinary example in a softwood replacement board in **Plate 98**.

6.2 Fixings

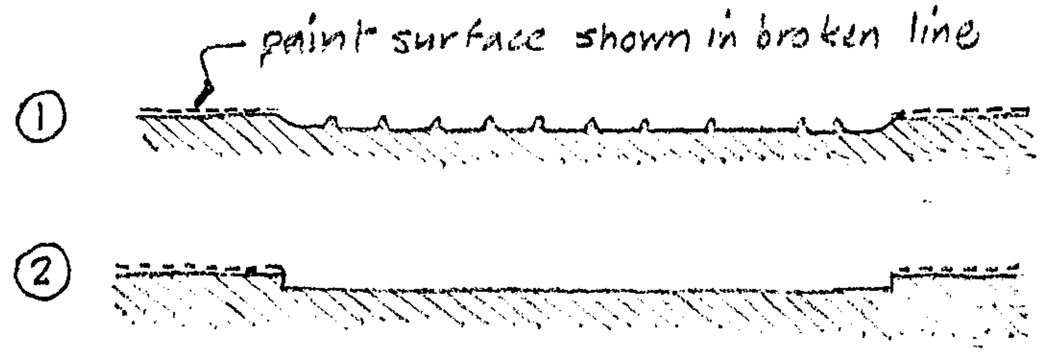
There is slight surface corrosion on the nail and hanging bolt heads wherever the paint has detached. Some original nails have come loose and were taken out by Julian Limentani during his initial inspection. A small number of other nails were loose but could not be extracted as they were clenched over above the ceiling boards.

Nearly all the screw ends from the 1924 restoration showed signs of corrosion, whether they are steel or zinc plated. There was no sign of the shanks having corroded to the extent that they were putting sufficient pressure on the wood to split it. See **Plate 88** as typical of the existing situation and **Plate 90** shows the screws after extraction. Note how little corrosion there is on that part of the screw that was in the wood.

It was observed that three hanging bolts were not fixed tight beneath the ceiling boards, these were the north and south bolts on Joist 6 and the north bolt on Joist 8.

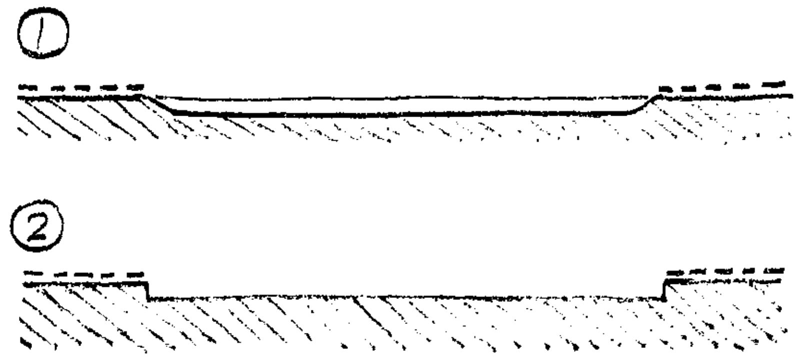


PLAN VIEW FROM PLATE 110



DIAGRAMMATIC SECTION A – A

showing ① as existing with medullary rays continuous with level of painted scroll surface and ② as re-constructed with shallow carved surface.



DIAGRAMMATIC SECTION B – B

see above notes which apply.

HUGH HARRISON CONSERVATION

PETERBOROUGH CATHEDRAL NAVE CEILING detail plan and section through typical painted scroll condition October 1998

DRAWING NO: 06

PART 7: TREATMENT TESTS: THE CEILING STRUCTURE

7.1. Hessian

The Tender Specification called for investigation into the condition and life expectancy of the hessian. Sufficient areas of hessian were lifted in the course of other investigations that there was no need to specifically lift areas of hessian merely to examine its condition. The lifting procedure is described in 5.5 above. The life expectancy of the hessian must be limited in view of the existing deterioration which has occurred between 1924 and 1998 and which is almost entirely due to age alone rather than specific decay mechanisms such as water ingress. **Plate 159** shows how the hessian is not bonded at the junction of adjacent boards, and it also shows frayed threads, where attempts to lift a hinge (as in the centre of the photograph) to reveal a screw beneath, resulted in the hessian falling apart. However, as a support for the glue which has an indefinite ageing limit (providing it stays dry and within current temperature limits), there is no reason why the combination of both hessian and glue should not last for an indefinite period with the understanding that there will be a gradual weakening of the fabric of the hessian.

In view of the strength of the bond of the hessian coating and the strength of its bond with the wood, allied to the fact that there is likely to be existing decay to the upper surface of the boards, removal without damage will be almost impossible. The fact that large quantities of glue will be left on or in the surface after the hessian has been removed and the fact that the hessian is contributing to the support of weak areas of boarding (which would need alternative support if the hessian were removed) undoubtedly leads one to conclude that the hessian should be left in place.

It should be kept clean, as films of dust will increase moisture retention, thus encouraging fungal activity.

As a corollary to the question regarding the contribution the hessian/glue layer is making to the support of the Ceiling, the issues raised at the Tender stage were that the hessian and glue layer had the potential to create damaging stresses to the ceiling boards.

It is my view that the glue/hessian did shrink during initial drying contributing to the voids at the junctions of overlapping boards. Now that the decay to the upper surface of the boards has been revealed, it would seem that there is a weakened boundary layer between the glue/hessian coating and the sound oak in the centre of the boards. This boundary layer should be able to absorb the stresses between the two disparate layers on either side. This is not a situation one would encourage but as the decayed surface is already not contributing to the strength of the board, its contribution as a sacrificial layer is valuable.

With gradual further deterioration of the hessian, its ability to exert stresses following cycles of wetting and drying leading to changes of tension within the material itself, will reduce.

7.2 Boards

The boards were examined from below and in one area in *Panel 38 II* from above after the 1924 repairs had been removed. Each board was recorded as specified in the Board by Board Survey. No experiments were carried out in regard to the use of epoxy resin consolidation as specified in the Tender, as this system was only used in one very small area that will de described later.

7.3 Hanging Bolts

The Tender specified the replacement of the original hanging bolts with new stainless steel bolts. At the Team Meeting on 13 March 1998 it was agreed that 1 Hanging Bolt should be removed as a trial, and that a decision would be made on replacing or retaining the bolts after the first bolt had been inspected. The description of the removal, the condition of the bolt and the arguments for and against replacement were set out in Hugh Harrison's letter to Julian Limentani of 4 April 1998 and is included in full below:

Hanging Bolts

The Hanging Bolt from joist 8, the north end of the flat ceiling, was removed for trial purposes to measure the corrosion of the bolt, particularly where it passed through the oak joist. This bolt was chosen because the washer on the underside of the ceiling was free, showing that the bolt was not actually carrying any weight.

The technique to extract the bolt consisted of first securing the joist adjacent to the bolt using the joist hanger (repaired!) and the bolt was secured in its present position using the bolt grips. These were actually placed 25 mm above the top of the oak joist. A telltale, supplied by David Goode (thanks for prompt delivery), was then fixed between the joist and the main truss adjacent to it. The joist hanger was wound-up until a softwood Spacer, which had been inserted between the upper side of the joist and the underside of the Binder and was just loose, could not be removed. The telltale was checked and the joist was found to have been raised by 1.5 mm. A monkey wrench was used on the nut which had been previously treated with WD40 (a lubricant used to free-up old steel fastenings), and the nut moved with surprising ease. Having been turned one half turn with the wrench, it could be undone by hand.

The nut was unwound until it covered the end of the bolt when it was driven gently, but with sufficient force, to move the bolt. There was no initial resistance, as one would expect if the bolt was rusted up inside the joist, and each blow from the hammer slowly eased the bolt downwards.

It was apparent that the bolt had a square shoulder immediately above the head, and that the washer had a square hole so that it loosely fitted the square shaft of the bolt. This configuration died away into a round shaft approximately two inches above the head. All the time that the bolt was being driven, I was holding the bolt from below and Richard Lithgow was checking the boards in the vicinity. We were both nervous at the vibrations caused by the hammer blows and as soon as the washer was clear of the painted boards, including the space required to use a wrench on the square shoulder above the head, the bolt was twisted around from below using the thread at the top of the bolt, located within the Binder, to actually wind the bolt downward. As soon as the bolt became free of the Binder, it could be extracted by hand through the joist.

The condition of the bolt seemed to very good with almost no surface corrosion. The thread seemed as good as new.

If more bolts are to be extracted, then more gentle means must be found that does not involve the vibrations caused by using a hammer. I suggest that an extractor is made up using a heavy steel angle with a slot cut out so that the angle can be placed beneath the Binder and connected with bolts on each side of the Binder to a plate with a hole drilled in the centre which fits over the top of the existing bolt. The side bolts can then be tightened, pushing the Hanging Bolt down until it is level with the top of the Binder, at which time it should be able to be unwound from the underside as well as being pushed by a centre bolt through the centre of the top plate which would push down on top of the bolt within the hole in the Binder.

I am confident that we therefore have a system to remove the bolts safely if we decide that this should be done.

Pros and Cons of removing Hanging Bolts

Pros	Cons
1. If a bolt is extracted, it can be checked for condition so that the doubts of using old, wrought iron hangers can be dispelled.	1. Any disturbance to a system which has been in place for nearly 200 years can set in train additional disturbance and repairs which would not have been necessary had the initial action not been taken. In other words, if ain't broke, don't fix it.
2. The bolts seem to be somewhat uneven in their support to the ceiling, i.e. some bolts appear to be crushing the ceiling boards and other bolts are not taking any weight at all. If the bolts are removed, those not taking any weight can be tightened and those that are crushing boards can be loosened and the damaged boards reinforced from behind, so that they are not distorted when the bolt is re-tightened.	
3. Retention of the 1834 fixings is ensured.	
4. The expense is spared of making new Hanging bolts.	

Recommendations

My recommendation is that in this Phase of work at least half the Hanging Bolts are removed, checked and, if in good condition, reinstated. The bolts would need painting with Genolite* and an inert washer inserted between the steel washer and the ceiling boards. I suggest eighth inch balsa, cut to the shape of the washer and perhaps the Team may have comments on this or another material. The reason for taking out so many bolts, is to ensure that the spread of sound bolts is consistent across the ceiling and that we do pick up cases of slackness or over-tightness and the ramifications of dealing with these are sorted out in this first Phase. If all the bolts are in good condition, I would recommend testing a representative number in subsequent Phases, but substantially less than half, and on completion of reinstatement and tightening, the exposed threads of the bolts should be thoroughly greased.

(*Not used.)

See **Plates 141 - 153** showing the sequence for the removal of the trial hanging bolt.

7.4 Coach Screws

The north coach screw, Joist 7, south side was taken out, examined, photographed and replaced. Its condition can be seen in **Plate 87** and is entirely satisfactory.

7.5 Screws

A further category of work was added to that specified in the Tender, which was the removal of the screws.

On starting work it began to look as though many of the screws which emerged through the underside of the Ceiling originated in the 1924 noggins which are above the hessian, and patches which are below the hessian. As there are such a number of screws, as so many have splintered the underside of the boards, and as some corrosion had started on the projecting screw ends, it seemed important to investigate where and how the screws were inserted.

Various noggins and patches were removed, as shown on **Graphic 6** and **Drawing 5,** the results of the investigation were summarised in Hugh Harrison's letter to Julian Limentani dated 4th April 1998 and is reproduced below:

<u>1924</u>

To the existing nails of 1200, 1740 and 1835 were added the huge number of screws mentioned in my earlier report. However, because these were inserted from above and not from below, none are into the normal fixing areas (that is into the ends of the boards and in the area of the board beneath the joists). All these new fixings were into overlapping edges, through new patches, through noggins, through replacement joists, and through specific areas of reinforcement adjacent to the ends of the boards. Some of these screws penetrated right through the boards but the majority are located into the back of the boards.

<u>Effect</u>

The most damaging effect of this intervention is where screws, having passed through the upper board, did not penetrate the board beneath but merely pushed it off. Other commonplace damage caused by the screws is the splintering of the timber as they emerge through the underside. This splintering is typically worse on the softwood boards than on the oak boards.

In one or two instances, there is evidence that the original insertion of the screw caused some very slight splitting.

There is no evidence of general distress caused by the increased number of fixings, nor of subsequent splitting of the timber due to corrosion of the screws.

Options for treatment

Any metal fastening through a wooden board is potentially damaging. We should therefore consider either removing all the nails and screws or all or some of the screws, only.

Remove all nails and screws

I exclude the original nails from this option, both on ethical grounds and on the basis that they do not generally seem to be the cause of any major damage to the boards.

Pros	Cons
1. The boards would be freed of all constricting fixing points (although the boards would still be partially restricted by the overlying hessian).	1. I think that it would be impossible to withdraw all the nails by direct extraction beneath the ceiling without damaging the painted surface, in which case they would have to be driven or pushed down from above. This would involve supporting each board adjacent to the nail and I feel certain that the damage through supporting the board from the underside and vibration in driving the nail down from above would be too severe to make this suggestion a viable option.
2. There is no ironwork in the wood to rust and therefore split the boards in the future.	2. In addition to the above, large areas of hessian have to be taken up to give access to all the nails.
3. A new system of supplementary support for the boards can be designed which would allow comprehensive support for all boards wherever that support was considered necessary. This could be supplied by a variety of new noggins and intermediate joists using stainless steel screws with washers, either along edges of boards or in old nail holes in one edge of each board.	3. The destruction of the earlier fixing systems could be considered an unacceptable loss of history of the ceiling.

On the basis that removing the nails is not an option, our recent work has shown that it is a viable option to remove all the screws. I will therefore set out the pros and cons of removing all or some of the screws. I suggest that the four following categories of work cover the various levels of reducing the number of screws in the ceiling.

1. Remove all the screws.
2. Remove all the screws which emerge beneath the boards.
3. Remove the screws which emerge which are only covered by hessian above.
4. Do not remove any screws.

1. Remove all the screws

Pros

1. Reduces the number of iron fixings within the wooden boards and would therefore allow a degree of desirable flexibility, remembering that all the existing iron nails are still in place and that the hessian is still, to a greater or lesser extent, reducing flexibility.

2. The removal of the screws would reduce the number of potential points of corrosion within the boards.

3. The improvement in the close up appearance of the ceiling would be significant.

4. Having taken out all the projecting screws, all the displaced boards can be returned to their former position and all the splinters of wood can be glued back onto the surface of the board.

Cons

1. From the evidence of the Panel where we have extracted all the screws, it is likely that additional support to the boards will be needed either by a new system of support or by replacing the existing system using stainless steel screws.

2. All the hessian over the patches and reinforced areas will have to be carefully pared away and in many cases replaced with new hessian with a different adhesive.

3. The disruption to the status quo is significant and undoing the present system may create new situations requiring more significant work than is envisaged at this time before the work has begun.

4. The dismantling of the replacement joists to extract the screws beneath them is a major intervention to the structure and security of the ceiling.

5. On ethical grounds the destruction of the 1926 reinforcement system may be considered unacceptable, remembering that at this time it is not causing any particular problems.

It is my recommendation that the removal of the screws from beneath the replacement joists is not undertaken and that these screws are therefore left in situ.

2. Remove *all* the screws which emerge beneath the boards (except those beneath the replacement joists

Pros	Cons
1. All splinters from these screws can be re-glued.	1. All the noggins and reinforcing laminates will have to be dismantled and rebuilt as the screws are mostly fixed though the bottom laminate.
2. All displaced boards can be re-fixed.	2. The screws which emerge may coincidentally be important in reinforcing a fragile board in that particular area. Where this occurs, different reinforcing, presumably with stainless steel screws and washers or nuts and bolts, may be required and the noggins and reinforcing patches rebuilt with stainless steel screws, either through the same holes or new ones.
3. In order to remove these screws all the noggins and reinforcing laminates will have to be dismantled and the opportunity can be taken to rebuild them with stainless steel screws.	3. The extraction of the screws from the area in *Panel 37 I* will reduce the support to these very fragile pieces of wood to such an extent that merely reinstating support from below with stainless steel washers and screws may be considered insufficient and these fragments may therefore require far more extensive consolidation and re-backing. Or, the replacement of the existing number of steel screws by stainless steel screws with washers, or nuts and bolts with washers could be considered a more invasive treatment than the present system.
4. The appearance would be improved considerably.	4. The hessian over the reinforcing patches will have to be removed and made good.
5. The reduction of these screws will allow some extra flexibility of the boards.	5. The ethics of disrupting the entire 1926 scheme by dismantling it and rebuilding it using stainless steel fastenings may be considered unjustified.

3. Remove the screws which emerge that are only covered by hessian above.

This category would cover screws through some patches and all screws through the edges of boards. The pros would be a smaller increase in flexibility, some aesthetic benefit and the ability to re-glue some splinters.

The cons would be the need to possibly reinstate some or all of these fastenings with new fastenings and the whole problem with the patch of screws in 37 I as described in the category above.

4. Do not remove any screws.

Pros	Cons
1. No disruption to the existing system.	1. Potential damage of corrosion from a large number of steel fastenings inserted in concentrated patches and individually in vulnerable edges of boards.
2. No ethical conflict by maintaining entire 1926 intervention in its original form.	

I have not entered the economic consequences of any of this work. In general terms, obviously the last option will provide significant savings on my quotation and Option 3, some savings.

Options 1 and 2 would both involve additional work not allowed for in the tender.

Schedule of work

If all screws left in situ:

1. Gently clean off most corrosion products on screw ends and paint with Genolite.

2. Either extract all screws which are displacing boards or cut them off beneath the hessian. Re-fix these boards either with stainless steel screws and washers through existing nail holes or along the edges of the boards into patches above, where they exist. Where they do not exist, insert new noggins of treated softwood fixed to adjoining joists.

3. Check for all other "loose" fragments of boards and secure as mentioned in 2 above. Where the softwood is loose, I suggest fixing through a new noggin down into the softwood so there is no visible fixing beneath the ceiling.

4. Where steel screws were inserted during work to the Tower in the 1890s, these screws should be taken out and new stainless steel screws inserted.

5. There are boards which have no visible support from the underside and these should be tested using a metal detector for screws fixed through patches above. If there is any doubt as to the security of these fragments, then insert new stainless steel screws around the edges if an original oak board, or through the patch from above if it is a softwood board.

PART 8: TREATMENT: THE CEILING STRUCTURE

8.1 General

The overall strategy for conservation of the ceiling boards was set out in Hugh Harrison's letter of 4th April 1998 to Julian Limentani as set out below:

The aims of the present conservation should be to ensure that the ancient painted boards survive for 75 to 100 years in their <u>present</u> condition and that their fixings will ensure their security for the same period.

This was confirmed with modifications to the policy of screw insertion, as set out in Item 5.5 in the minutes of the Team Meeting of 6th April 1998, as follows:

<u>Option 5</u>

As a result of the discussion, another option was thought to be the most likely to succeed and is intended to be implemented;

(a) The screws pushing boards down should be extracted if it is possible to extract them, i.e. if they are not in the base of a laminated joist. If they could not be extracted, the end is to be cut off with hacksaw or other and the end treated before fixing back the board at its end with either a stainless steel screw with an washer in an existing hole (if oak), or holding the end. Alternatively, if into softwood, new holes could be made.

(b) The possibility of Genolite or Zapon (German product) to protect the rusting screw ends with something like Paraloid B72 to seal it. (Use of B72 was confirmed by Mike Corfield in his letter to Julian Limentani dated 15th April 1998.)

(c) If screws can be easily extracted they would be extracted, otherwise cut off and protected as above in (b) or if extracted would be replaced, as in (a) above.

8.2 Hessian

Rather than to try re-adhering large and small hinges of hessian removed for trial purposes and removal of screws, it was agreed that the open patches should be covered with sailcloth (code no. 00169/23A manufactured by Richard Hayward & Co.) and attached with Beva 371 (supplied by Conservation Resources (U.K.) Ltd.). Four coats of Beva 371 was first applied to the sailcloth and allowed to dry, then the coated sailcloth was cut into patches to fix over the windows in the hessian and adhered using a heated spatula. The bond was poor, so Beva 371 was applied to the hessian and allowed to dry. The sailcloth was then bonded with a heated spatula and a domestic iron on a low setting. See **Plates 160 and 161** for general views of the hessian repaired with the sailcloth. The position of all new patches is recorded on **Graphic 6**.

8.3 Screws

It was finally agreed that only the screws that had damaged the Ceiling by creating splinters and that could be accessed from above the Ceiling merely by cutting windows in the hessian, should be extracted.

Using an existing graphic of screws that had penetrated below the Ceiling, each screw was examined and those that had splintered the boards were marked. A joiner working above the Ceiling then located (using a wiring detector) those screws that could be accessed by cutting windows in the hessian. The hessian was cut to form a hinge, to reveal the screw. The screw was carefully loosened and withdrawn. Throughout this work the joiner above the Ceiling was in contact with his colleague below using the walkie-talkie system so that if any splinter seemed in peril as the screw was withdrawn, the operation could be stopped whilst the splinter was temporarily supported.

8.4 Splinters

Where possible splinters of wood that had been displaced by protruding screw ends were repositioned and adhered with a solution of Plextol B500[9] (diluted 1:1). Where necessary presses were applied overnight to ensure a firm bond (see **Plates 95, 99, 100)**.

8.5 Consolidation with Paraloid B72

To prevent further wood loss from small areas of boarding that were unstable due to decay or infestation, exposed wood was consolidated with infusions of Paraloid B72[10] (10% in xylene) (see **Plates 104/105, 140**).

8.6 Fillings

As an added precaution against loss of both wood and overlying paint, following consolidation treatment, a filler was inserted to secure vulnerable edges. The filler consisted of: 1 part Polyfilla, 1.5 parts fine oak dust, 1 part Plextol B500 (10% solution) (**see Plates 104-105**).

8.7 Consolidation with Bencon 19 Epoxy Resin

The south end of Board (u) *Panel 37 II* was very decayed, and the downward pressure of the emerging screw had fractured this narrow finger of wood across its width. This fragment was so fragile that merely supporting it with stainless steel screws and washers was not considered sufficient. It was decided that the fragment should be consolidated and that Paraloid B72 would not provide sufficient strength to hold the fragment at the end of a board that was vulnerable to vibrations from movement above the Ceiling. It was decided, therefore, to consolidate the upper surface of the fragment with Bencon 19 epoxy resin[11].

The painted surface was first consolidated with Paraloid B72 to prevent or reduce contact between the paint and the epoxy resin. Initial consolidation with the epoxy resin alone

[9] Plextol B500 is an aqueous dispersion of a thermoplastic acrylic resin. A product of Röhm.
[10] Paraloid B72 is an ethyl methacrylate co-polimer. A product of Röhm Hass.
[11] A low viscosity Bisphenol A epoxy resin containing reactive diluent supplied by Benring Consultants

was introduced by hypodermic syringe onto the upper surface of the splinter, followed by subsequent applications of resin and sawdust with increasing amounts of sawdust per application. The sawdust helped to fill cavities in the decayed wood, and to actually create a thin layer of solid resin that reinforced the delicate fragment of wood below it. There is no Plate for this repair as it could not be photographed from above.

8.8 Stainless Steel Fixings

Each board was examined and the specification for each repair was listed as below:

Panel	Board No.	Specification
36 I	S	East edge, inject Plextol to secure.
36 II	DD	North end, screw through existing hole with washer
	X	Inject with Plextol south end east edge.
	E	North end, screw with washer through nail hole.
	B	North end, screw and washer through hole by nail.
	Y	Screw through old nail hole west end.
	B	Screw along side edge of split to retain.
36 III	C	North end, Plextol and small wedge.
	C	Fuse fragment at south end split off by nail.
	D	North end, screw and washer through existing hole.
	C	East edge, angle threaded bolt through edge of board (screw used).
	M	South end, screw with washer through existing hole.
	UI	West edge, screw.
	W	North end, screw through existing hole to help secure adjacent board above.
36 IV	Y	North end, screw through end of board by softwood patch.
	R	North end, remove nail and replace with screw and washer.
	X	North end, screw through existing hole.
	T	Secure split edge with bolt through existing hole.
	N	South end, glue fragment above empty nail hole with Plextol.
	J	North end, screw through east and west existing holes with washers.
37 I	E	South end, threaded bolt at 90^0 to south edge on west edge beside softwood patch.
	K	Remove existing screw from above and replace with stainless steel screw from below. One other screw and two angle bolts to be inserted as shown on diagram.
	FI	Screw with washer through existing hole.
	B	Screw on north side of fragment to retain.
37 II	CC	South end, fix through existing hole or through south edge with threaded angle.
	BB	Four angles as shown on illustration.
	X	North end, inject Plextol to secure splinter.

	Panel	Board No.	Specification
J			Fix four angles as shown on drawing. Consolidate end of board as directed.
	AA		Fix through base boards at south end, east edge approximately 4 foot from end with threaded angle.
	S		Screw through north end, west side in space.
	C		Screw and washer through existing nail hole in north end of board.
37 III	K		Screw through split in north end of board. In middle of board on west side, wedge off adjacent board and glue with Plextol.
	C		Screw through existing nail hole, west edge.
	BI		Make U-shaped threaded fixing, fix 3 inches from south end to follow black paint line.
	B		Fix with two screws and angle, as shown on plan.
	E		Either extract or cut off screws and then fit with angle bolt at north end.
	L		Fix screw along side shake.
37 IV			No repairs required.
38 I	K		South end, screw through existing space between boards.
38II	A		Fix with screw from under side into laminate above.
	B		Screw from under side through existing screw hole.
	BB		Screw and washer from north end to secure fragment.
	M		South end, fix with threaded angle as shown.
	S		North end, secure detached fragment with threaded angle.
	L		West edge, secure detached edge with threaded angle through Board N (angled).
38 III	U		North end, screw through existing nail hole.
	X		East edge, middle of board, secure with screw.
	R		Screw through west edge to secure loose fragment.
	Q		Screw through east edge with threaded angle, and fix with screw and washer.
	C		Glue fragment with Plextol.
	G		Screw through edge of softwood fragment, also support end with screw and washer.
	R		North end, glue back paint fragment using Plextol.
	N		North end, screw through existing hole.
	G		North end, west edge fix with screw and washer or threaded angle.
	D		South end, screw through west edge through existing nail hole.
39 I	F		Screw into joint at north end.
	L		South end, threaded rod to middle of extended part of the board.

Panel	Board No.	Specification
	P	South end, east edge, one threaded angle to secure.
	Q	Two screws to support split.
	H	North end, screw through west split, screw on west side.
39 II	EE	Secure fragment south end with screw through edge of board.
	LL	Secure end through old nail hole with screw.
39 III	CC	Centre north end, screw through original split.
	DD	Fit screw to east edge through old nail hole.
	WI	Screw and washer.
	M	Screw and washer through north end.
	P	West edge, screw and washer.
39 IV	A1	West edge, secure with screw and washer.
	C	South end, screw and washer.
	BB	Remove slotted steel screws and replace with stainless steel screws.
	DD	North end, screw and washer through existing nail hole.
	S	Screw and washer to secure loose fragment.
	E	Plextol loose edge.
South Frieze	Panel 4	
		East end, secure detached fragment with screw and washer in to join at north end of board.

The basis for the specification for repair was an assessment of how secure each board or fragment was. The repairs consisted of securing loose pieces with 3mm threaded stainless steel studding bent over to form an angle with an average length across of 12mm, fixed above the Ceiling with nuts and washers. In some instances the studding was bent a second time to form a hoop, with either the second leg cut off say 3mm above the angle, or returning above the Ceiling and secured with a second nut and washer. The third type of fastener used were stainless steel screws with washers, average size 25mm No 8's, some were a little longer and some a little shorter.

Wherever possible old screw holes were used, or the fixings were placed between boards, or in splits. If no suitable hole or split was available, the type of fixing may have been changed from a screw to an angle if that enabled the fixing to be inserted without drilling through an original board. Tiny pieces of Melinex[12] were inserted between the angle bolts and the painted surface. All stainless steel fixings below the Ceiling were touched in with acrylic colour to prevent any chance of reflecting the light and being seen from the floor.

Plates 117 - 121 and 129 - 131 show sequences of fitting the angle bolts and painting them in. **Plates 132/133** show the use of a half hoop, and **Plates 134 - 138** show screws

[12] Archival polyester (ICI Melinex®) 75mc

before and after painting in. **Plate 139** shows the angle bolts with nuts and washers above the Ceiling.

8.9 Splits

Splits were injected with Plextol B500 by hypodermic syringe before stainless steel fastenings were inserted to hold joint together.

8.10 Repair Lion Lozenge

Plate 122 shows the Lion lozenge with a fragment of wood jammed into the centre of the lozenge. The fragment was loose and could easily be extracted and was found to be painted on its upper side (see **Plate 125**). It was exciting to find the paint lines matched up with the broken edge of the centre board. Coincidentally in this case alone, the centre board was only held by the hanging bolt, so that when this was extracted, the board came with it. It was decided to glue the two parts of the centre board together using Plextol B500, and to additionally to secure the fragment to the Ceiling with a stainless steel screw (see **Plate 128**). **Plates 126/127** show the two pieces of the centre board before rejoining. The opportunity was also used to replace the washer to its correct painted alignment. **Plates 122/123** show it as originally turned 180°. This must indicate that this bolt was removed or loosened in the course of the 1880's work.

When the centre board was removed, it was particularly useful to be able to examine the joints beneath the joist where two original noggins are fixed with two nails in the end of each noggin, see **Plate 124**.

8.11 Noggins

The noggins removed for trial purposes (see **Graphic 6**) were replaced using stainless steel screws in existing holes. Wherever an existing screw had emerged through the Ceiling, a shorter screw was used which would remain within the thickness of the ceiling board. Where shorter screws were used the gauge was increased to maintain the grip in the hole that exceeded their length. With access to the underside of the Ceiling, which allowed close examination of the boards beneath the noggin or patch to be refitted, if it was judged that the boards were in sufficiently good condition, fewer screws were used in refitting the noggin or patch above.

8.12 Hanging bolts

At the Team Meeting on 6 April 1998, it was decided to take out and examine half the hanging bolts and to insert spring washers wherever possible. Subsequent discussions between Julian Limentani and David Goode resulted in the decision to take out all the hanging bolts and insert spring washers throughout. The specification for the work was contained in the facsimile transmission from David Goode to Julian Limentani on 6th May 1998, as follows:

I calculated the load on each bolt as about 2.5 – 3 km and think that a spring rate of 3 km/mm would suffice, so that if the load changed by 50%, then there would be a 0.5mm movement. I have been discussing this with Skegness Springs who make these to order, but can respond quickly. My suggested installation sequence would be:

1. Check and mark the current position of the Ceiling relative the to hanger beam (with a telltale or otherwise).

2. Support the ceiling joist with Hugh's clamp, so detensioning the bolt. Put a clamp on the bolt shank so that it cannot fall through the Ceiling.

3. Remove the hanger nut, but leave the square washer in place. Clean the threads if necessary.

4. Place two spring washers on the bolt, with the small end upwards on the lower and downwards on the upper. Grease the threads and washer.

5. Place a new flat steel washer on the spring assembly and replace the nut.

6. Tighten the nut so that there is no slack in the bolt, then tighten one third of a turn further. This should tension the bolt sufficiently to support the Ceiling. The washer assembly should compress 1mm.

7. Check that the Ceiling is in its correct position relative to the hanger beam.

The Science Museum was consulted by Gillian Lewis on what materials should be used to paint the bolts and grease the nuts and also what should be used as a packer between the painted surface of the Ceiling and the top side of the washer. Their advice was to use Trimite SAP3 2 Pack Self Etching Primer[13] with Trimite 2 Pack Acrylic finish AE262[14] for the paint system and Castrol LMX Heavy Duty Grease[15] for the nuts. The decision to use Plastazote LD45[16] arose out of discussions within the team, as the Science Museum had no particular views on the best material to use. The use of Plastazote LD45 was discussed with the Science Museum and they could see no problem with the use of this material for this particular application. We would like to thank the Science Museum for all their help in this matter.

Accordingly, the joist lifting gantry was positioned so that two or three bolts could be taken out at a time and exchanged for stainless steel temporary bolts. Before each bolt was extracted a telltale was set up to measure any change in relative distance between the binder and the joist.

The bolts were rubbed down lightly and painted with first the Trimite SAP3 2 Pack Self Etching Primer, then within 16 hours the Trimite 2 Pack Acrylic finish AE262. This was then left to harden for 24 hours before the bolts were replaced. The thread was not painted, nor the head of the bolt. This was coated with Paraloid B72 by the Perry Lithgow Partnership. The top washer was painted both sides, and the bottom washer, only the top surface. The sides and bottom of this washer were coated with Paraloid B72 by the Perry Lithgow Partnership.

The empty holes in the joists and binders were carefully but thoroughly cleared through with the 22mm threaded stud used for the temporary bolts.

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[13] A 2 pack Primer consisting of a zinc tetroxychromate pigmented base and an acid solution, supplied by Trimite Ltd.
[14] A 2 pack acrylic Finish free of isocyanates, supplied by Trimite Ltd.
[15] A high performance lithium complex Grease, supplied by Castrol Lubricants.
[16] Plastazote foam is a closed cell, low density, cross-linked polyethylene foam, supplied by Polyformes Ltd.

The hanging bolts were loose (north Joist 8 and north Joist 6) simply because the bolts were too long and there was no more thread to tighten up. The south bolt Joist 6 on the other hand was too short so the binder was notched out to allow the thread to catch. With the spring washers inserted, the bolts which were too long are now quite satisfactory but that which was too short required the notch to be deepened. After discussing this with David Goode, it was agreed that the notch could be deepened a further 25mm without compromising the strength of the binder.

The hanging bolts were assembled as per David Goode's Specification (see above) using 40mm x 20.4mm x 2mm spring steel washers, supplied by Skegness Springs Ltd.

After setting up each bolt, a simple telltale system using one piece of batten screwed to the binder and another to the joist was fitted so that the corners of the two battens just touched. It will be easy to measure any deflection in the future by measuring either the gap between the pieces, or the overlap.

Plate 154 show two bolts after painting, and **Plate 155** with the bolt refitted with spring washer and telltale battens. **Plate 156** shows a bolt head and washer after treatment with Paraloid B 72, with the Plastazote LD45 packer between the washer and the Ceiling.

PART 9: TECHNICAL SURVEY: THE PAINTED DECORATION

9.1. Paint sample analysis

In 1995 a number a paint samples were taken from the Eastern Bay and examined as part of the survey conducted by Hirst Conservation[17]. In 1996, Gillian Lewis obtained a number of paint samples during the inspection of the entire Nave Ceiling from a mechanical hoist: these were examined and analysed by Lewis and Howard. In 1997, as part of the emergency treatment phase, a technical study of the paint layer was conducted by Helen Howard and Adrian Heritage[18]. Howard obtained an additional 16 paint samples from the Eastern Bay Ceiling in January 1998[19]. Only preliminary results were available at the time of writing this report.

The paint samples analysed by Howard in 1998 were chosen specifically to answer queries raised by the emergency phase of treatment and were obtained prior to the start of Phase 1 on-site work. Frustratingly, Howard's schedule did not allow an opportunity for her to obtain additional samples as Phase 1 progressed. As a result, for the time being certain interpretations and theories posited as a result of Phase 1 investigations are not corroborated by paint sample analysis.

Uncertainty remains as to the nature and date of a number of interventions. In the absence of positive evidence deriving from the boards themselves or the fixings, it may be that analysis of paint samples from each replacement board will be the only way to determine when it was put in place.

9.2. Original technique

Examination of paint samples obtained in 1997 and 1998 indicate that original paint layers (dating to *c.*1220) exist in a number of areas, usually beneath layers of eighteenth and nineteenth century overpaint. Howard notes: '*of particular interest is the use of green underpainting for some of the flesh tones, in azurite combined with lead white and yellow iron oxide. It is significant that azurite was also used to indicate shadows in the flesh tones in the Ceiling fragments from the Painted Chamber of Westminster Palace, dating from c. 1263-6. These panels, which survive in remarkably good condition, provide perhaps the closest surviving English parallel in terms of original function and date to the original scheme at Peterborough.*'

Due to the subsequent interventions it is not certain if a preparatory sealant such as animal glue was used originally on the Ceiling boards. Animal glue was identified at the wood paint interface in some samples; in addition, calcium sulphate and a clay-rich material identified at the interface may have been employed to bulk out a sealant.

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[17] *Nave Ceiling Peterborough Cathedral* Hirst Conservation, October 1995.
[18] *Peterborough Cathedral, Nave Ceiling: Scientific examination of the original decoration*. Helen Howard, Sept.1997.
[19] *Peterborough Cathedral: Nave Ceiling. Preliminary results of the examination and ana1yvis of paint samples from the E. end of the Ceiling (bays .36-39).* Helen Howard, 1998.

Traces of lead white ground were identified in samples where original paint layers are almost certainly present. The following pigments are present in apparently original paint layers: natural azurite, vermilion, red lead ,basic verdigris, carbon black, lead white, red iron oxide and yellow iron oxide. The original flesh tones were produced from varying combinations of vermilion and lead white and in some places the addition of yellow ochre and carbon black. Oil was employed as a binding medium in these layers; although, it is possible that a proteinaceous material was also used.

The presence of calcium sulphate at the wood/paint interface, and also at varying concentrations throughout the paint layers, confirms that the painted decoration is profoundly sensitive to moisture.

9.3. Previous interventions

The painted scheme is known to have been restored between 1740 and 1750 and again in 1830s. There are no detailed records of these restorations; although, it clear that repainting on both occasions was extensive and inept. It is not known if there were significant interventions to the painted decoration prior to 1740; however, it would be remarkable had nothing at all been done to the scheme during the intervening 500 years. Some structural alterations would have been made to the east end of the Ceiling when he tower arch was remodelled in the 14th-century; subsequent structural intervention when the tower wall was rebuilt in the 1880s has confused indications of previous works.

In the absence of evidence to the contrary this survey assumes the earliest repaint to date from the 1740s.

The additional paint sample analysis and lengthy visual examinations of the painted decoration during Phase 1 has improved our understanding of the original decoration and the interventions made in the 1740s, 1830s, and at the east end when the tower was rebuilt in the 1880s. However, interpretation of analysis results is proving particularly difficult for a number of reasons. In most areas the layers of repainting were applied directly over existing paint. Some of these pigments are identical to those employed in the original paint layers; as a result it is not always possible to assign a date to each example of later painting. In many areas - presumably where the 18th-century surface washing was undertaken more vigorously - there is no clear interface between the original and various later painting phases. In some cases, the lack of distinction between the layers may also be due to the pigment alterations which appear to be ongoing in both paint layers, resulting in the transport of particles towards the upper surface.

9.3.1. 1740 to 1750 - In 1789 Govenor Pownall wrote that the whole Ceiling had been repainted in oil some forty years before; the original distemper was dirty and flaking. According to Cave[20] the restorer told Pownall that he *'only retraced the figures'*, also, that *'parts came clean off the wainscot'*. The Ashlar boards may have been replaced at this time; although, Macreth[21] doubts that the overpainted early scroll-work is as late as 1740. However, from the examination of paint exposed from under temporally removed 1830s Ceiling bolts (see **Plates 303, 304**) and other areas where there are two distinctly different versions of a colour (see **Plates 298, 301**) it is now certain that the most significant intervention to the main Ceiling scheme took place in the 1740s. The figurative subjects within the diamond-shaped compartments were heavily repainted at

[20] *Archaeologia LXXXVII* 'The Painted Ceiling in the Nave of Peterborough Cathedral' Cave and Borenius 1938.
[21] Letter to L Limentani. 24 April 1998.

that time and the surrounding decorative elements were entirely repainted. Also, a number of alterations were made to the border designs.

A trefoil pattern terminating in an elaborate scroll design is discernible, with raking light, under the extended chevron pattern on many original oak boards (see **Figure 6**) and **Plates 286-289**). There is clear visual evidence that the overlying extended chevron design was painted in the 1740s. Sample analysis indicates that a combination of vermilion with lead white was employed to create the underlying trefoil pattern. From samples taken in 1997 Howard concluded the design was unlikely to be original as the lead white overpaint covering the pink trefoil layer appeared to have been painted almost wet-on-wet. However, her preliminary 1998 findings suggest that the trefoil design may indeed by original. Visual examination suggests that the relief effect first thought simply to be impasto paint is in many places too pronounced for the thickness of the paint. Furthermore, the impasto effect appears and fades along the boards with no evidence that some of the layer may have flaked. These observations - coupled with Howard's finding in 1997 that a similar pink layer was detected in a sample taken from an area further along the board, but where no trace of an underlying design is visible even in raking light - may suggest that a thin, less stable, original background paint layer may have been partially lost at an early date. The surface of the exposed areas of board deteriorated marginally as a result of environmental factors before being overpainted in the 1740s, while the protected timber under the original oil-based paint of the trefoil design was unaffected. This is just one theory that may explain the phenomenon. Further paint sample analysis is required to test the hypothesis.

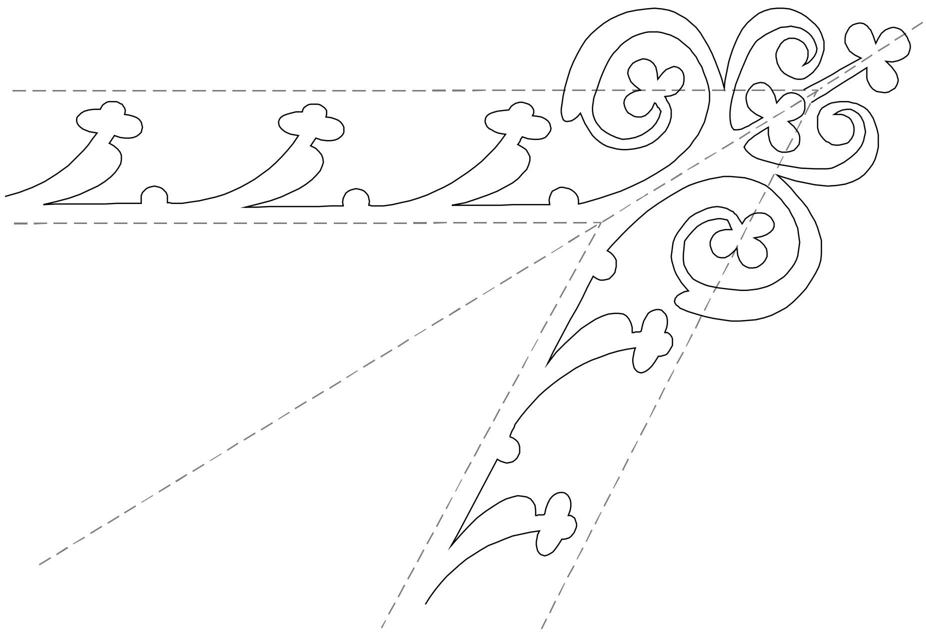


Figure 6. *Outline of the trefoil pattern which terminates in an elaborate scroll design. It is discernible, with raking light, under the extended chevron pattern on many of the original oak boards.*

There are other examples of underpaint showing the outlines of border designs in relief on boards with otherwise 'weathered' surfaces: the black stepped chevron designs on original boards appear to be edged with exaggerated impasto underpaint (see **Plates 365, 290**); the dog-tooth pattern underpaint shown in **Plates 292** appears to have been painted in outline only.

Overall the Ceiling the 1740s repaint places the key pattern as the first in the sequence of border designs radiating out from the figurative lozenges. The key pattern is painted on the outer part of the board so covers grooving on original straight-edged boards (see **Plate 292**). It is at least questionable whether the 13-century creators would have chosen to disguise in this way the carefully constructed sequence of boards having rounded edges, straight edges and straight-edges with grooves. **Plate 293** shows a round-edged original board, repositioned and repainted in the 1830s, with key pattern underpaint visible on the inside edge. Although the date of the underpaint is uncertain and is the only example within the Eastern Bay of a round-edged board with key pattern it does raise a query regarding the original border designs and highlights another area of continued uncertainty to which only paint sample analysis is likely to find an answer.

Plates 293 shows a re-used original board with the key pattern design visible in raking light beneath what appears to be 1830s paint. Notice that this board is round-edged and unproved, also that the key pattern is painted on the inside half of the board. The 1740's scheme has the key pattern is painted on the outer half of grooved, straight-edged boards.

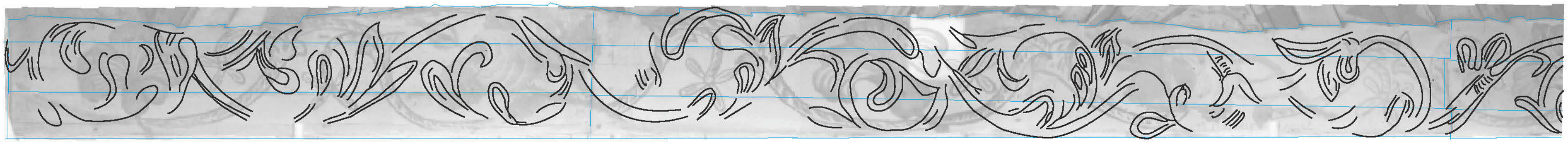
The white embellishments on the grey chevron border design within the Eastern Bay (see **Plate 314**) differ from the equivalent embellishments within the areas of Ceiling accessible during the emergency phase of treatment; in addition, there is no evidence of the underpainted, impasto motif on the Eastern Bay grey chevron boards. In both areas the repaint appears to be 1740s. Further paint sample analysis is required during Phase 2 - or when this impasto motif is accessible - to establish whether the 1740s restorers applied the impasto motif before deciding on different embellishments or whether it forms part of an earlier scheme.

The more complex scrollwork decoration underlying the visible frieze decoration on the Ashlar boards (see **Figure 7**), and the Ashlar boards themselves, are thought to date from the 1740s. Nothing survives of the 13th-century frieze. Further paint sample analysis is required to establish the nature of the 1740s scheme underpaint on the Ashlar boards (see **Plate 295**).

The painted scheme on the Eastern Infill *Panel 40 III*, which appears to be the earliest of those four panels, is similar to the first painted scheme on the Ashlar boards. It may be that both originated in the 1740s.

9.3.2 1830s - This renovation had a major impact on the structure of the Nave Ceiling and the painted scheme. As well as decorating the large number of boards replaced during the structural repairs the restorers overpainted much of the existing scheme. Nevertheless, it appears that this restoration was less inventive. Whereas there is some evidence to suggest that alterations were made to the border designs in the 1740s, this restoration consisted mainly of a rather crude repainting of the blacks and highlights across the Ceiling. **Plate 298** shows clearly the different black paints: the darker 1830s paint was applied in a slapdash manner over the lighter, slightly mottled, brown/black paint from the 1740s. **Plates 299-301** show the slightly darker off-white 1830s paint was also applied without precision.

South Ashlar Boards



North Ashlar Boards

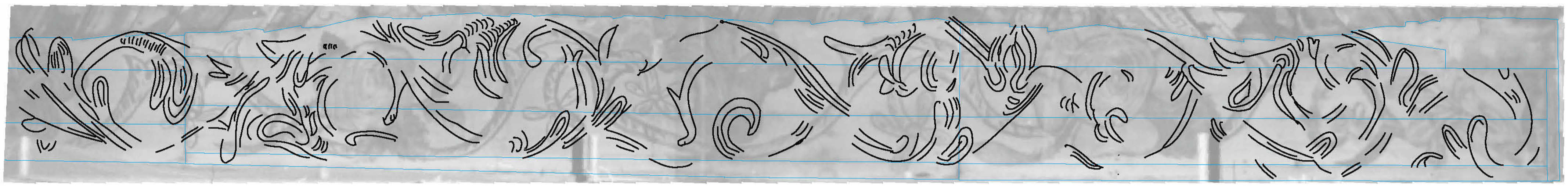


Figure 7. *North and south Ashlar boarding in the Eastern Bay. The earlier painted scheme is overlaid in black.*

There appear to be two distinct black paint used by the 1830s restorers: a very matte and very saturated black often seen on wave or dog-tooth pattern boards; a shiny black, with a metallic sheen to it. The latter may occur over a whole board or in small areas on 19th century replacement boards and as a strengthening over 18th century black. It frequently occurs on the edges of shapes, strengthening their outlines. In 1997 Howard discovered evidence of surface coatings on two samples of this type of black paint: '*Sample(17/2109) from the stepped chevron pattern surrounding the St. Paul lozenge has a thin coating (or layer of consolidant) which produces a "metallic sheen". The silvery sheen on the surface of the paint layer in Sample (18/2110), also from the stepped chevron pattern surrounding the St. Paul lozenge, is due to a pale coating which has not yet been identified*'. Further research will be required to establish whether or not a surface coating was applied to this black paint.

The frieze decoration was entirely redesigned and repainted in the 1830s; but it is by no means certain that the same restorers were responsible for both the Ceiling and frieze decoration. Mackreth suggests the easternmost set of Ashlar boards on the south side - 19th-century replacements - and the adjacent, 18th-century set were painted by W. Stallard in 1838 to match the 1740s design. In **Plate 306** the name W Stallard and the date 1838 is just visible beneath the off-white overpaint at the east of the south Ashlar boards. Subsequently this section and all the frieze decoration was overpainted with the existing design: the names of I Shaw and C Neal are painted on the south frieze decoration (see **Plate 305**). As no record has been found of another programme of restoration before 1880 - when only the east end of the Ceiling was accessible - it must be assumed that the overpainting took place directly after Stallard's work. It may be that Stallard himself was involved as his name is written in red paint on the north frieze decoration (see **Plate 307**): the same red paint was used for setting out the 19th century design (see **Plate 397**).

The available evidence does indeed indicate that the visible Ashlar board decoration was painted as part of the 1830s restoration, nevertheless a number of observations give rise to queries to be addressed further in Phase 2:

- The white lead paint used on the Ceiling boards in both the 1740s the 1830s was bright white in colour (see **Plate 303**) showing paint from both restorations that had been protected from subsequent surface discoloration by a hanging bolt washer). Why then was the frieze decoration tinted overall with what appears to be a water-colour wash in order to tone down the colour of the background (see **Plate 296**) when at that time the Ceiling decoration would have had little or no surface discoloration?

- A limited number of boards within the eastern half of *Panels 40 I/II/III/IV* have white background paint very similar to that used for the frieze decoration; for instance, the keyhole and key pattern boards in **Plate 297** appear to have been painted with the lighter background paint on the frieze and then darkened down with a tinted wash.

- Why has the paint surface on the Ashlar boards not discoloured to the same degree as the 1830s Ceiling repaint?

- This observation relates more to the structure than the painted decoration - how were the 1830s restorers able so accurately to scribe and cut the top of the Ashlar boards to accommodate the many replacement boards in the canted panels, and - assuming there must have been some distortion or slight repositioning of the canted joists and

Ceiling panels as a result of the work above - why are there no resulting gaps or inserts above the Ashlar boards?

As would be expected, most of the many replacement boards inserted in the 1830s have a single layer of repaint. **Plate 288** includes an obvious replacement board with 1830s repaint and the frieze scheme visible as underpaint. Within the Eastern Bay there are only 7 boards with the frieze scheme as underpaint: 6 of these are in canted panels on the north side, the other in *Panel 39 IV*. Such boards occur much more frequently within the areas of Ceiling accessible during the emergency phase of treatment where they are not confined to just the canted panels. As yet there is no convincing explanation for the presence of this underpaint. The 1830s decoration on the Ashlar boards was clearly applied in situ; therefore, why would there be surplus decorated boards available for use as replacements? Further paint sample analysis is required during Phase 2 to establish whether the early frieze scheme is present on these replacement boards.

Visual examination of the paint on *Panels 40 I/II* (see **Plates 247, 231, 233**) suggests they were replaced with new boards and painted in the 1880s. **Plate 308** depicts the letters 'BLEY' painted on the extreme north end of *Panel 40 I*. This may refer to Cobley & Co., the firm thought to have been responsible for the 1830s restoration.

9.3.3. 1880 - Rebuilding of the tower wall. The extent of intervention to the Ceiling boards and paint layer within the Eastern Bay is uncertain. Pencilled graffiti dated 1885 (see **Plate 309**) suggests the east of *Panels 37* was accessible at least. Certainly a number of boards from *Panels 39/40* were removed and repositioned and some even replaced; although the extensive nature of previous restorations in this area has created a confusion of evidence for both the paint and structure conservators. It appears that *Panel 40 IV* (see **Plate 249**) was entirely replaced with new boards and painted; also, the easternmost boards of *Panels 40 II/III*. The group of boards with discoloured decoration east of the cut in *Panel 39 I* (**Plate 226**) were not repainted in the 1830s so must have been positioned there in the 1880s.

9.3.4. 1920s - In the 1920s a great deal of work was carried out to the Ceiling structure from above (within the roofspace) but there was no access to the Ceiling from below and therefore no alterations to the decoration.

9.4. Condition survey

A board by board detailed condition survey of the painted decoration in the Eastern Bay has been recorded on tabulated sheets (see example in **Appendix 4**) and is presented in graphic form in Part 13 of this report. This section defines the categories of damage, surface accretions and other phenomena; most of which are plotted on the graphics.

9.4.1. Flaking Paint (**Graphic 11**) - The primary cause of flaking paint on the Nave Ceiling is long term water infiltration leading to deterioration of the wood support and subsequent loss of adhesion. Paint sample analysis has not as yet determined whether certain materials or aspects of technique have contributed to this damage, but the findings of this condition survey indicate which of the paints are susceptible to flaking and which are resistant. Not surprisingly, by far the majority of flaking paint was found to occur on original oak boards. These have thicker layers of paint and have been subjected to periodic water infiltration for at least 500 years longer than the replacement boards. There were practically no instances where the off-white, lead-based, background paint had flaked (nail heads excepted). Within the figurative lozenges the18th-century granular green background paint and the black line drawing are particularly prone to flaking; and the red less so - the detached green paint does not tend to lift and curl as much as the red or black (for examples see **Plates 318, 320, 322**). On the slightly spongy surface of deteriorated boards the thick 17th-century brown/black paint, usually on stepped chevron and grey chevron boards, detaches and lifts in the characteristic manner shown in **Plate 324**. The thinner 19th-century black paint that occurs on the wave pattern designs and on the outline drawing of the figurative lozenges is, of all the paints, the most susceptible to micro-flaking and loss (see **Plate 323**). It is clear that any moisture in the wave or extended chevron pattern boards failed to escape through the resistant off-white paint but was able to do so by disrupting black paint layer. Flaking paint caused by the contraction of overlying glue deposits is described in Item 9.4.6.. Many of the metal fixings visible on the underside of the Ceiling have corroded to some degree and caused the overlying paint to flake (see **Plate 329**). The percentage of paint remaining on each nail head is recorded graphically.

9.4.2. Powdering Paint (not shown on graphics) - The dry, granular surface of the 1740s paint together with the surface coating of dust gives the appearance of a powdering, unstable paint layer lacking cohesion. However, surface cleaning with Wishab sponges proves this is not the case. With the exception of *Panel 40 III*, paint on all boards within the Eastern Bay is adequately bound: dirt can be removed without loss of pigment. Much of *Panel 40 III* had a thin and very powdery layer of decoration painted directly onto the softwood boards (see **Plate 328**): as yet it is not clear when these boards were put in place and decorated.

9.4.3. Pigment alteration (not shown on graphics) – Paint sample analysis by Howard in 1997 identified some evidence of pigment alterations in both the original and later phases of painting. This includes the transformation of natural azurite to copper oxalate, which indicates deterioration of the original painting, and which may be partly due to an episode of high humidity at some time in the past. Similarly, the alteration of verdigris to form copper chloride. It seem likely that Silvertown treatment, applied in 1926 as an insecticide, may also be implicated in this alteration, since it would have provided a ready source of chlorides.

9.4.4. Surface discoloration (not shown on graphics) - The extent of surface discoloration remaining after surface cleaning with Wishab sponges to remove the thick layer of dust and dirt on the paint surface is illustrated in **Plates 303, 304**. These photographs suggest the discoloration is superficial.

9.4.5 Graffiti (**Graphic 9**) - The names of I Shaw and C Neal are painted on the south frieze decoration (see **Plate 305**). The name W Stallard and the date 1838 is just visible beneath the off-white overpaint at the east of the south frieze (see **Plate 306**), and in red preparatory drawing time on the north frieze (see **Plate 307**). **Plate 308** depicts the letters 'BLEY' painted on the extreme north end of *Panel 40 I.* This may refer to Cobley & Co., the firm thought to have been responsible for the 1830s restoration. A number of examples of pencilled graffiti exist on the south canted panels (see **Plate 309**) but only one example elsewhere in the Eastern Bay, on *Panel 37 II.* By intention the examples of pencilled graffiti were not removed during surface cleaning.

9.4.6. Glue (**Graphic 11**) - Liquid glue used in the 1920s as an adhesive for the hessian backing material has in places penetrated between the boards, dried on the painted surface and caused the paint to flake. Ultra-violet light is particularly helpful when checking for glue residue. On the horizontal central panels the glue tended to travel vertically down the edge of a board and drip onto the floor below; often leaving thick, raised droplets over the paint on the edge of a board (see **Plates 353, 354, 357**). Many of these thick droplets have contracted in the dry environment and caused the underlying paint to flake (see **Plates 373, 375**).. On the canted side panels the glue residue is more extensive. On penetrating the boards the glue travelled in rivulets across the canted surface before drying (see **Plates 350, 366**). In general, the glue has caused paint flaking only where it has collected in thick droplets or runs. The white background paint is less liable to flake as a result of surface glue deposits.

9.4.7. Surface Staining (**Graphic 14**) - Analysis results of samples taken from stains are not available at the time of writing. There are a number of different categories of staining, all resulting from liquid material penetrating down between the boards or through cracks in deteriorated boards. A number of boards in *Panel 36 I* have whitish opaque drip trails across the paint surface (see **Plate 166**); these appear to be water damage. Other stains resulting from water infiltration exist on the paint surface (see **Plates 399, 405**). **Plates 342,343 (UV)** show a dark stain over the 1830s repaint: it is probably a preservative material used to coat the roof timbers. **Plate 334** shows staining from a clear liquid that has penetrated a replacement board. The brown stain shown in **Plate 345** has come through the thickness of the paint. **Plates 346, 347, 348** - before and after treatment and UV - show a major spillage of dark liquid material occurred above these boards. In this instance, much of the residue was removed and the stain reduced using acetone swabs. **Plate 349** shows characteristic light-brown drips on the edge of an original board: these occur in a number of places across the Eastern Bay.

9.4.8. Efflorescence (**Graphic 12**) - The 'white chalk line' form of efflorescence depicted in **Plate 338** occurs on a number of the original, wave pattern boards with the matte, saturated, black paint from the 1830s. Localised water infiltration has resulted in extensive micro-flaking and some loss of the black paint; the off-white paint is unaffected except for this tide mark of salts efflorescence at the interface. Preliminary analysis results indicate at least two different salts are present: chloride and sulphate. Further examples of this phenomenon are shown in **Plates 365, 366, 367**. **Plate 293** shows a different example of salts on black paint. Other less characteristic forms of efflorescence occur: samples of these will be analysed as part of Phase 2.

9.4.9. Surface Bloom (**Graphic 12**) - Three forms of bloom are included in this category. One is the whitish veil covering the paint surface on some 1830s replacement boards; particularly within the figurative lozenges and east end infill panels (see **Plates 280, 283, 308**). This bloom cannot be removed with a soft brush - as is possible with the efflorescence - but is removed by Wishab cleaning. Another form of surface bloom is the opaque metallic sheen that occurs in patches on the shiny, 1830s black paint (see **Plate 290**). Howard refers to this as an unidentified surface coating; it remains unaffected by Wishab cleaning. The third form of bloom occurs on only one board in the Eastern Bay (see **Plate 316**). This very noticeable bloom is on an unidentified surface coating over the black paint on a replacement board. It was unaffected by Wishab cleaning.

9.4.10. Microbiological Growth (**Graphic 13**) - Residues of what may be three forms of microbiological growth were found on the paint surface. These residues are widespread across the Ceiling and will be analysed as part of the Phase 2 investigations. **Plate 334, 335** details before and after surface cleaning: faint traces of this residue remain after cleaning with a Wishab sponge. **Plate 336** shows a purplish powder residue on the thick impasto paint (also detailed in **Plates 314, 315**). **Plate 337** shows a white bloom or stain on the paint not removed by Wishab cleaning: the fine tendrils suggest this results from microbiological growth.

PART 10: TREATMENT TESTS: THE PAINTED DECORATION

10.1. Previous Treatment Testing

Hirst Conservation conducted extensive cleaning trials using solvent solutions (see **Plates 222, 262, 390, 391, 402** and **Graphic 10**): these tests are documented in Hirst Conservation's 1995 report.

As part of the Emergency Conservation Treatment Phase in 1997 the Perry Lithgow Partnership carried out an extensive series of tests to determine appropriate techniques, materials and methods of application for the re-attachment of flaking paint, the removal of glue film and surface cleaning. Our report of October 1997 includes detailed records or these trials.

From the analysis, testing and treatment conducted in 1997 the painting was known to be profoundly sensitive to moisture. Traces of calcium sulphate were identified at the wood/paint interface and also at varying concentrations throughout the paint layers. In addition, some 19th-century paint layers were also found to contain high concentrations of both calcium sulphate and clay-rich minerals. The clay-based materials swell readily in the presence of moisture as was demonstrated by the severe blanching of some of the paint following even brief contact with water. This discovery is highly significant and affects all aspects of treatment. Only certain of the nineteenth century paint colours are prone to blanch after contact with water; these are identified in Table 1 below.

Table 1
1997 tests identifying paint layers susceptibility to water-induced blanching

ST PETER	POSITION	EFFECT/BLANCHING
Red drapery	To east of central lozenge etc	Insignificant
Pink shading on red drapery	To west of left hand	Present when swab used; not present when wiped with damp slurpex
Yellow/white highlight on red drapery	Sleeve of left arm	Minor
Flesh tones	Left hand	Minor
Flesh tones	Left foot - after full consolidation	Present
Light blue drapery	Over left foot - after full consolidation	Present
Black outlines	Several areas	Insignificant or not present, unless already present
Dark blue drapery	Over left foot - after full consolidation	Insignificant
White/cream	Background to 'patterns'	Insignificant with swab, but present after prolonged treatment
Light blue/green	Background to figure	Insignificant/acceptable; but earlier tests were affected by prolonged heat/moisture
Yellow/brown/white	Hair	Minor; mainly appears on the brown, tho' may simply be cleaner
ST PAUL		
Green	Background to figure, by foot	Minor. Previous tests show it can be removed
Yellow/brown	Drapery by sword handle	Took a long time to dry but no apparent blanching
Light blue	Cusped frame	After full consolidation it was very evident, but only occurred occasionally
White/yellow	Sword - after full consolidation	No obvious blanching
Brown/grey	Hair	Possible blanching- or is it just cleaner?
PSALTERY		
Light green	Background to figure	Minor; previous tests indicate it can be removed
Pale pink/cream	Cusped frame	Minor - acceptable
Red	Background	Minor/insignificant
Grey/brown	Frame of instrument	Present
Blue/green	Repaint on background	Minor
Cream	Background to key pattern	Insignificant

10.2. Phase 1 Treatment Tests

Visual examination of the painted decoration during the condition survey and preliminary analysis of paint samples removed from the Eastern Bay confirmed that the same original and added materials were present[22]. Subsequent treatment tests conducted on *Panel 39 IV* corroborated the 1997 findings.

[22]***Peterborough Cathedral: Nave Ceiling - Preliminary results of the examination and analysis of paint samples from the E. end of the Ceiling (bays .36-39)***. Helen Howard, unpublished notes, 1998.

The methods and materials identified as appropriate in 1997 were re-tested before the start of Phase 1 treatment. Paint on *Panel 39 IV* exhibited typical examples of damage and deterioration so was chosen as a trial area. On completion of the tests and the entire panel was treated to a finished level and approved by members of the project team.

10.2.1. Paint Re-attachment - This process was the subject of exhaustive trials in 1997. The methods and materials chosen and used to re-attach flaking paint on the St Peter, St Paul and Psaltery Player lozenges were re-tested successfully on *Panel 39 IV*. The following is a summary of the 1997 test results:

- *Paint relaxation* - Preliminary trials with a Preservation Pencil established that moisture was the prime cause of surface blanching. The Preservation Pencil, used with an ultrasonic humidifier, is capable of providing a fine, delicate jet of moisture or dry air from ambient temperature to 100ºC. Blanching depends on the type of moisture output which is controlled by the varied heat and moisture settings, and types of nozzle, available on the Preservation Pencil. Moisture, rather than temperature, causes the nineteenth century paint to blanch. It was found that warm dry air can be used to relax the paint flakes without adverse effect. A satisfactory level of paint relaxation is achieved using the larger nozzle on the Preservation Pencil at 40ºC and on minimum moisture setting - any moisture emitted by the Pencil at this temperature setting evaporates without affecting the paint surface. The nozzle is held close to the surface for 3-5 minutes, depending on the thickness of the paint and the level of distortion. Immediately following this process undiluted industrial methylated spirits (IMS) is injected behind the flake to pre-wet the void. IMS applied in this way does not cause surface blanching or adversely affect the adhesives effectiveness.

- *Adhesives* -. Trials were conducted using three fixatives - Plextol B500, Paraloid B72 and Isinglass - each known to have good ageing properties and an ability to withstand at least some variation in environmental conditions. The tests were to establish appropriate solution strengths and devise effective methods of application in these circumstances, rather than to test the properties of various fixatives. Plextol B500 was .been identified as the most suitable material for re-adhering paint flakes on the Nave Ceiling. Plextol B500 is an acrylic dispersion and therefore water-based: its stability is good and it has appropriate handling properties. It is now widely used as a paint fixative on both wall paintings and panel paintings. Through testing we were able to identify an efficient method of applying the adhesive and pressing back the flakes which involved minimal contact of moisture with the paint surface. A 15% solution in deionised water is required when re-laying large, distorted flakes where the paint layer is relatively thick; a 5-10% solution is adequate for securing the small thinner flakes. Following paint relaxation and pre-wetting very small droplets of the adhesive solution are injected, through a fine syringe needle, behind an individual paint flake (see **Plate 332**). The flake is then pressed back into place with a small pad of dry cotton wool covered by Japanese tissue (see **Plate 333**). The dry cotton wool immediately absorbs the majority of excess adhesive displaced as the flake is re-laid. The tissue is carefully peeled from the surface after the cotton wool is removed. Cleaning tests established that any residual adhesive on the surface following re-attachment by this method will not significantly impair subsequent removal of surface dirt.

  A different method is necessary for re-laying distorted paint flakes underlying thick glue deposits (see **Plates 373, 375**). Glue has to be very soft before the underlying paint flake becomes relaxed enough to be re-laid. The best results were obtained by carefully dabbing the coated flake with a small piece of sponge to remove as much glue as possible; then - using the same sponge - delicately easing the relaxed flake back into position. Injecting Plextol B500 solution behind the such flakes is less successful than relying on residual animal glue alone as the adhesive. There is some risk of failure: if a flake detaches while the glue is being removed, any attempt to re-position it fails because the remaining surface glue sticks to the intervention layer. However, these tests were conducted on very distorted paint flakes: where the paint is only slightly cupped or lifted on one side there is little risk of loss.

- *Flaking paint on* nail *heads* - Flaking and lifting paint on nail heads was found to be brittle; there was no flexibility in the paint (see **Plate 329**). Tests revealed that to secure the flaking paint up to two applications of Paraloid B72 (10% in acetone) had to be applied by syringe. Once the solvent had evaporated a localised heat source (Preservation Pencil) was applied to the flakes relaxing them sufficiently and enabling them to be secured by gently pressing into place with a small spatula. Sufficient B72 was required to allow the flake (sometimes bent back at 90' to the original position) to be eased back into position. Tests indicated that a single application of 10% B72 in acetone would provide an adequate protective coating for unpainted and corroded metal fixings.

10.2.2. Consolidation of the Paint Layer - With the exception of *Panel 40 III*, paint on all boards within the Eastern Bay was adequately bound and required no further consolidation. Much of *Panel 40 III* had a thin and very powdery layer of decoration painted directly onto the softwood boards (see **Plate 328**). Trials were carried out using different dilutions of Paraloid B72 in both xylene and acetone. Paraloid B72 is a ethyl methacraylate co-polymer which through tests has been classed as one of the most stable synthetic resins available to conservators and is a preferred material for this treatment process. The consolidant was applied by brush through Japanese tissue paper: the paper carefully peeled away from the paint surface immediately after application. A 5% solution of B72 in acetone was identified as the most appropriate solution. Generally the powdery pigment was consolidated adequately after a single application. The process did not darken the paint or result in a shiny surface. It was found that more than one application of a similar strength solution of B72 in xylene was required to achieve the same effect. The less volatile solvent apparently caused the consolidant to penetrate further into the support where it was not required.

10.2.3. Surface Cleaning - Tests in 1997 indicated that a 'dry' method of cleaning using Wishab sponges produced good results[23]. This cleaning technique was preferable for a number of reasons: some solvent-based solutions were ineffective; all proved difficult to control and produced different cleaning levels on the various colours and paints; most caused the paint surface to shine; in addition, much of the paint surface blanched after contact with water. By contrast, cleaning tests with Wishabs demonstrated it was relatively easy to achieve an uniform level of clean; the majority of the paint was stable and withstood the gentle surface abrasion necessary without need for preliminary consolidation; surface dirt could be removed without causing the paint surface to shine; Wishab cleaning is not thought to deposit significant, potentially harmful residues on the paint surface.

[23] Wishab sponges are cakes of synthetic rubber granules that collect the dirt and self-abrade when rubbed across a surface.

As part of their preliminary technical examination of the paint surface within the Eastern Bay Howard and Heritage tested the effect on the paint surface of cleaning with Wishab sponges[24]. The trials areas were examined on-site using a video microscope and samples were taken for further testing in the laboratory. Results of investigations to determine the presence of residues deposited on the paint surface by Wishabs are not yet available. Other preliminary results indicated:

- In general, an appropriate cleaning level could be achieved using the medium and hard grades of Wishab with minimal damage to the paint surface.
- Variations in texture, colour and the condition of the paint would lead to differences in both *real* and *apparent* cleaning levels unless care is taken to ensure that the white is not cleaned to greater level than other colours that are less easy to clean, and for which such a 'good result' is not possible.

Howard recommends the following procedures for Wishab use on the Nave Ceiling:

- Brush surface with soft sable brush before use of Wishab.
- Use small, shaped piece of the sponge which can be applied to a small area, and with considerably more delicacy than the whole sponge surface.
- Monitor cleaning process by regular checking at magnification (at approx. 8-10x, perhaps with *Binomag*. or similar apparatus).
- Brush off surface with soft brush after application of Wishab to remove any residual particles of the sponge and loosened dirt.

10.2.4. Glue Removal - The techniques identified as most successful during extensive trials in 1997 were re-tested and found to be appropriate for use in Phase 1. The following is a summary of the 1997 test results:

Tests indicated that there is no alternative but to use water to remove the animal glue film. Solvents had no effect; heat, rather than having a softening effect, made the glue brittle and contract further. The glue is more easily removed using warm rather than cold water; although, on vulnerable colours the shorter contact time is not noticeably reflected by a lessening of surface blanch.

It appears that some of the paint surface was affected by the liquid glue before it dried. In one test area the off-white paint appears cleaner following glue removal than an adjacent area that had not been coated with glue but was intentionally cleaned with a warm water swab for a comparable time as a control.

Where the glue deposits are relatively thin and the underlying paint stable, the glue is best removed using warm water (c.a. 55ºC) on small cotton wool swabs. This method is more precise than using the Preservation Pencil which may affect adjacent non-glue covered areas. For the thick, raised droplets of glue, whether or not the underlying paint is flaking, it is necessary to use the Preservation Pencil on maximum moisture setting at 40ºC and gradually dab the dissolved glue away with a small sponge. Warm water on a cotton wool swab does not remove the thick runs or droplets completely, even when applied for a considerable period. Tests have shown that glue removal, using warm water on cotton wool swabs, leaves the treated areas noticeably 'cleaner' than their surroundings and causes some of the paint to blanch (see **Plates367, 369**). It is necessary to disguise this effect with water-colour paints.

[24] ***Peterborough Cathedral Nave Ceiling -*** *Tests to determine the effects of surface cleaning with Wishab* Helen Howard, unpublished notes, 1998.

10.2.5. Removal of Surface Staining - The removal of staining was not an objective for Phase 1 treatment. Only during the surface cleaning process did it become evident that a some stains were particularly distracting and would be apparent from floor level. In consultation with members of the Project Team a decision was made to remove, reduce or disguise a limited number of stains (identified in **Graphic 14**). Tests revealed the dark brown material shown in **Plate 346** could be reduced using acetone swabs; the dark grey stains in the Ashlar boards (see **Plates 399, 345**) were removable using deionised water swabs but had the same effect on the underlying paint as glue removal.

10.2.6. Reintegration - As part of the Phase 1 testing on *Panel 38 IV* the Hirst Conservation cleaning tests were reintegrated with water-colour paints to match the surrounding Wishab cleaned paint surface (see **Plate 393**). The 'blanched' or 'cleaner' areas of paint resulting from glue removal on *Panel 38 IV* were similarly treated. As with all other tests conducted as a preliminary to treatment the results were inspected and approved by members of the project team.

PART 11: TREATMENT: THE PAINTED DECORATION

For most categories the extent and location of treatment is plotted on the graphics in Part 13.

11.1. Paint Re-attachment (Plates 318-333)

All the flaking paint plotted on **Graphic 11** - including flaking paint underlying thick glue deposits (categorised as 'Flaking & Glue') - was re-attached in Phase 1; the methods and materials used were devised to minimise water contact with the paint surface and identified as appropriate through the testing procedure. Where possible the flakes were treated individually; although areas of micro-flaking and some interconnected larger flakes had to be re-laid in groups.

Distorted, thicker paint flakes were relaxed to a point where they could be eased back into place without fracturing. This degree of flexibility was achieved by applying a delicate jet of warm dry air from a Preservation Pencil, set at 40ºC and to minimum moisture output. The nozzle was held close to the surface for up to 5 minutes. Industrial Methylated Spirits (IMS) was injected through a fine needle behind each relaxed paint flake to pre-wet the void. The IMS was followed immediately by small droplets of the adhesive solution - a 5% or 10% solution of Plextol B500 in deionised water (depending on the distortion and thickness of the paint). The flake was then eased back into place with a small pad of dry cotton wool through Japanese tissue: the dry cotton wool absorbing excess adhesive displaced as the flake was pressed back. Preliminary relaxation with the heat source was not always necessary for the less distorted or thinner paint flakes; particularly the 19th-century black paint.

Treatment of flaking paint underlying thick glue deposits is addressed in 11.4.. below.

In **Graphic 10** the visible nail heads are grouped according to the percentage of paint surviving (100-70%, 70-30%, 30-0%). The groupings do not signify whether or not the remaining paint on each nail is flaking. Recording that information was considered unwarranted given that the same material in the same solution (B72: 10% in acetone) was used both to re-attach flaking paint on nail heads and to coat exposed metal. Flaking paint on the nail heads was brittle: there was no flexibility in the paint. Up to two applications of the B72 solution by syringe were required to secure the flakes; the solvent was allowed to evaporate before the paint was relaxed with warm air from the Preservation Pencil (40ºC) then pressed back into place with a small spatula.

11.2. Consolidation of the Paint Layer (Plate 328)

Only the thin and very powdery paint on *Panel 40 III* required this treatment. A 5% solution of B72 in acetone consolidant was applied by brush through Japanese tissue paper: the paper carefully peeled away from the paint surface immediately after application. Generally the powdery pigment was consolidated adequately after a single application. The process did not darken the paint or result in a shiny surface.

11.3. Surface Cleaning (Plates 337-389)

The guidelines recommended by Howard recommends for Wishab use on the Nave Ceiling were followed throughout. Loose surface dust particles were brushed from the surface, using small and very soft brushes; the dust sucked into a vacuum cleaner nozzle held close by. Small, shaped piece of the Wishab sponge were applied to the paint surface with gentle circular strokes; with constant attention to guard against surface shine as well as disruption of loose paint or raised, granular particles. The particles of Wishab remaining on the surface were removed with a soft brush. This method achieves an satisfactory and uniform level of clean, removing much of the efflorescence and bloom as well as most surface dirt; however, a slight surface discoloration remains. Cleaning with deionised water would remove this surface deposit - as proved by previous tests and the paint surface where glue has been removed - but this is not an appropriate option given the extreme moisture sensitivity of the paint. As it is, the slightly yellowed deposit will serve to isolate the paint from future accretions.

11.4. Glue Removal (Plates350-376)

Thin deposits of the glue film were removed by swabbing with warm deionised water. Raised droplets and thick runs overlying flaking paint would not be dissolved completely by this method. It was necessary to use the Preservation Pencil on maximum moisture setting at 40ºC and gradually stroke dissolved glue away with a small sponge. Using the smaller of the two round-ended nozzles confined the spread of the moisture. This advantage is somewhat off-set as the moisture output is considerably reduced, thus slowing the process: the small area of paint surrounding the glue is subjected to less moisture but for a longer period.

Re attaching distorted paint flakes underlying thick glue deposits involves some risk of failure: if a flake detaches while the glue is being removed, any attempt to re-position it fails. A small number of paint flakes were lost during this process but the majority were re-attached successfully. The glue was softened by warm moisture from the Preservation Pencil and, as far as possible, absorbed into a small sponge stroked carefully across the surface. Each paint flake was eased back into place with the sponge once most of its overlying glue had been removed. Residual glue carried behind the flake as a result of the softening process serves as the adhesive.

11.5. Removal of Surface Staining (Plates 342-349)

The removal of staining was not an objective for Phase 1 treatment - only during the surface cleaning process did it become evident that a some stains were particularly distracting and would be apparent from floor level. In consultation with members of the Project Team a decision was made to remove, reduce or disguise a limited number of stains (these are identified on **Graphic 14**). Those on the Ceiling boards were reduced using acetone swabs; dark grey stains in the Ashlar boards were removed using deionised water swabs.

11.6. Reintegration (Plates392-406)

The 'blanched' or 'cleaner' areas of paint resulting from glue or stain removal and the Hirst Conservation cleaning tests were toned down with water-colour paints to match the surrounding Wishab cleaned paint. All visible stainless steel fixings inserted during Phase 1 treatment were painted in neutral colours using acrylic-based paints.

11.7 Surface Coating

Following the removal of loose rust particles a single coating of 10% B72 in acetone was applied as an isolation layer to all corroded metal exposed as a result of paint loss from metal fixings. No surface coating was applied to the painted decoration on the Ceiling or Ashlar boards.

PART 12: REFERENCES

Articles and Books

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<u>Reports</u>

Eve Baker (8 Aug.1977)	Peterborough Cathedral.
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Barry Knight (Dec.1994)	Peterborough Cathedral: Pollution Test.
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English Heritage (10 Jan.-4 Apr.1995)	Peterborough Cathedral. Environmental Monitoring.
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English Heritage	Peterborough Cathedral. Environmental Monitoring.

(2 Nov.1995-31 Jun.1996)

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Hirst Conservation (Oct.1995) Peterborough Cathedral. Nave Ceiling Part 1. Photographs.

Hirst Conservation (Oct.1995) Peterborough Cathedral. Nave Ceiling Part 2. Photographs.

J. Limentani (5 Dec.1995) Peterborough Cathedral. Nave Ceiling: Report on progress of the monitoring and investigation.

David Starley (Jan. 1996) 'The Examination of the Nails from Peterborough Cathedral: English Heritage AML.

J. Limentani (19 Feb. 1996) Peterborough Cathedral Nave Ceiling – Report following the examination of the Ceiling from a Mechanical Hoist.

Gillian Lewis (Feb 1996) Peterborough Cathedral Nave Ceiling: Updated Condition Notes.

J. Limentani (8 Mar.1996 rev. 16 Sep.1996) Peterborough Cathedral: Nave Ceiling: A Method Statement of the Proposed Repairs.

Gillian Lewis (Sept. 1996) Peterborough Cathedral: Nave Ceiling Urgent Work.

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Don Mackreth (Feb.1997) The Medieval Nave Roof and Ceiling of Peterborough Cathedral.

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J. Limentani (6 Dec.1996) Scaffolding to carry out minor works to two areas of the Nave ceiling.

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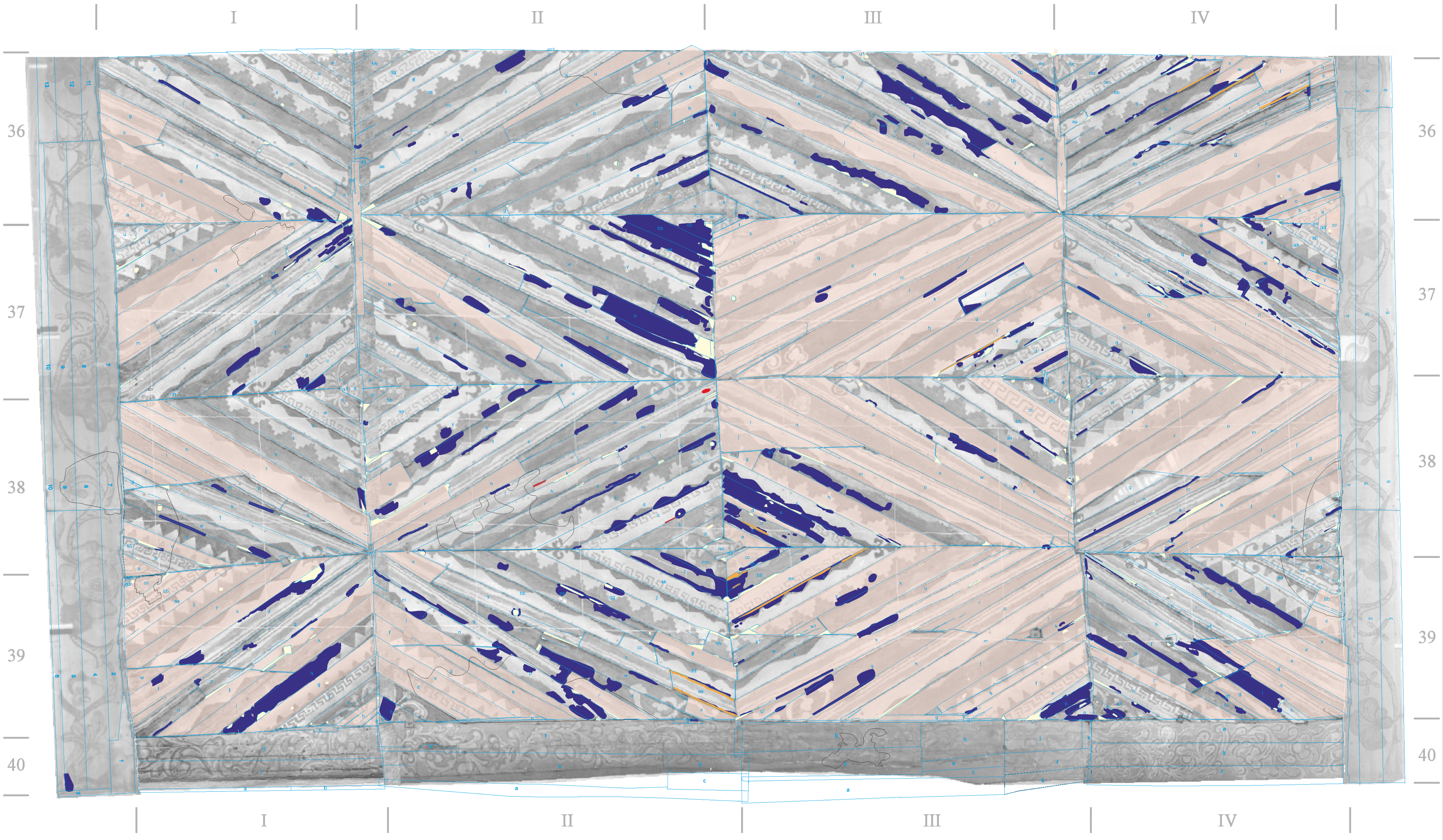
H. Howard (Sept.1997) Peterborough Cathedral, nave ceiling: Scientific examination of the original decoration.

PART 13: CONDITION AND TREATMENT GRAPHIC RECORD

The following **Graphics 1 to 14** constitute detailed condition and treatment records of the painted decoration and the Ceiling structure upper and lower sides.



KEY FOR DAMAGE TO CEILING BOARDS

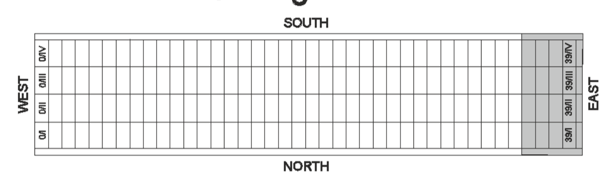
- Wood loss
- Shot damage
- Insect damage
- Wet rot & insect damage
- Impact damage
- Replaced boards

GRAPHIC NO: 1

SCALE 1:35

0 1m 2m 3m

POSITION **Ceiling Panels**



TITLE
PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE **CONDITION SURVEY AND TREATMENT**

DESCRIPTION **Lower Side of Structure Damage to Ceiling Boards**

Photogrammetry courtesy of English Heritage Survey Team

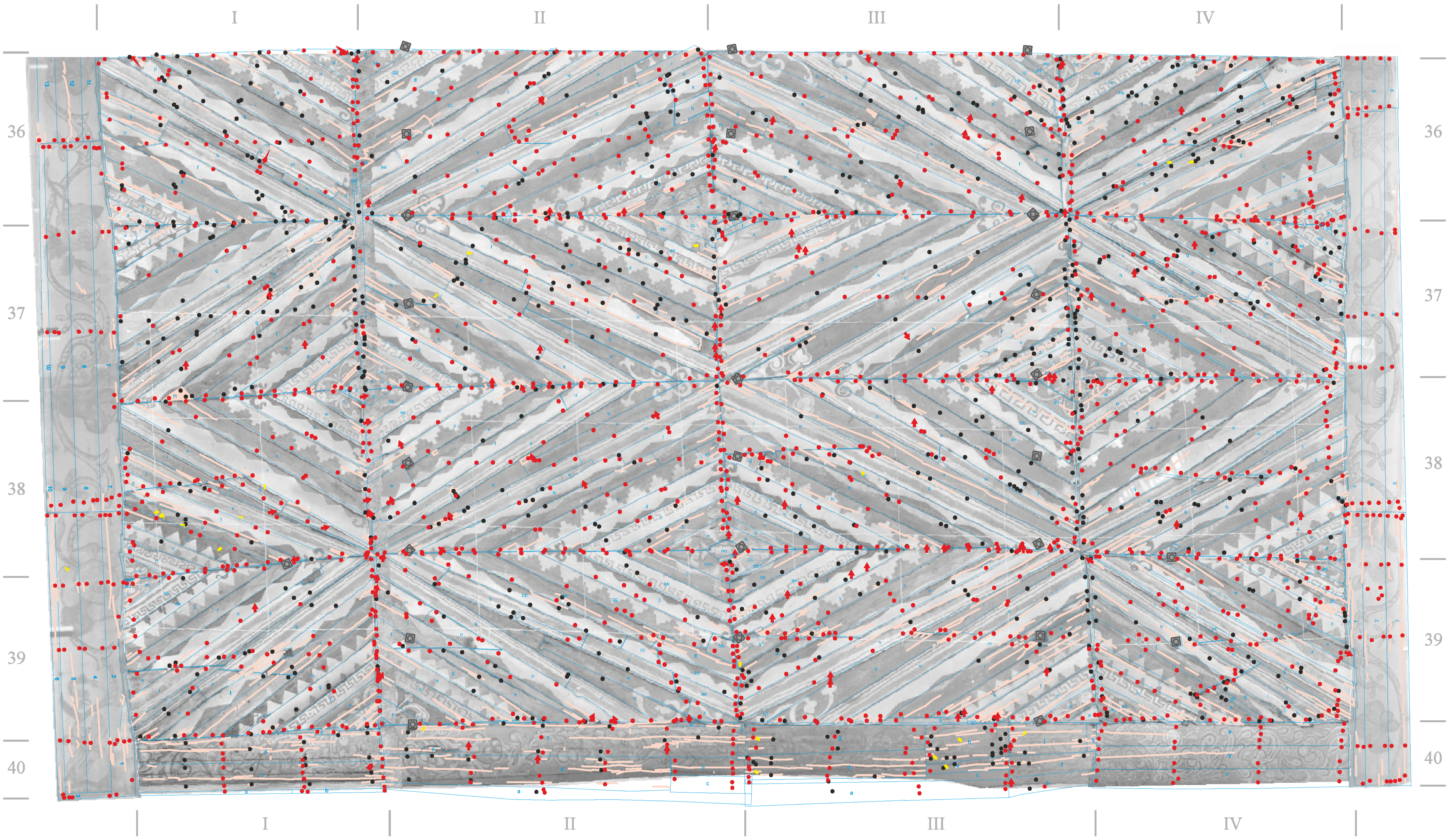
The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham,
Oxon OX7 6YA Tel. 01608 658067

NOTES

The area of replacement boards prevents a proper analysis of the extent of infestation and fungal decay. There is slight evidence of increased numbers of infested original boards in the centre of the Ceiling and the number of replaced boards. Generally the picture shows a predominance of infestation and decay along edges of boards, with few general patches.

Wood losses are mostly found in areas of infestation.

The shot damage appears random, it is interesting to note the single board in *Panel 40 III* which must have been moved since it was shot damaged.



KEY FOR FIXINGS & DAMAGE

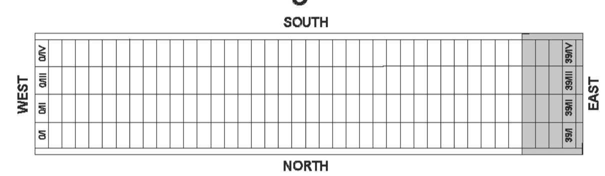
- Ceiling bolts
- Nail holes
- Nail Heads
- Protruding nail heads
- Nail ends
- Protruding nail ends
- Splits in Ceiling boards

GRAPHIC NO: 2

SCALE 1:35

0 1m 2m 3m

POSITION **Ceiling Panels**



TITLE
PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE: CONDITION SURVEY AND TREATMENT

DESCRIPTION: Lower Side Structure Fixings & Damage

Photogrammetry courtesy of English Heritage Survey Team

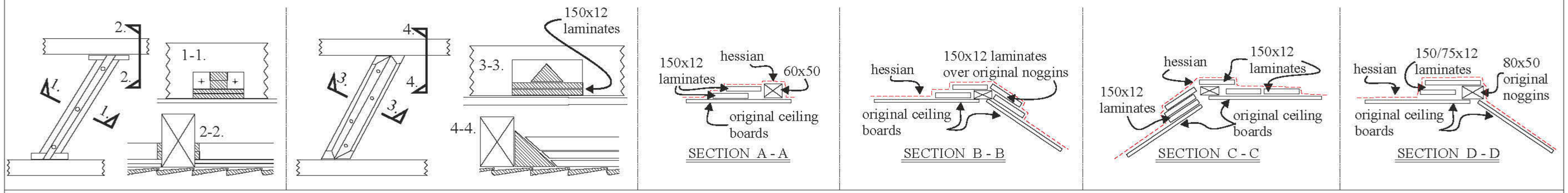
The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham, Oxon OX7 6YA Tel. 01608 658067

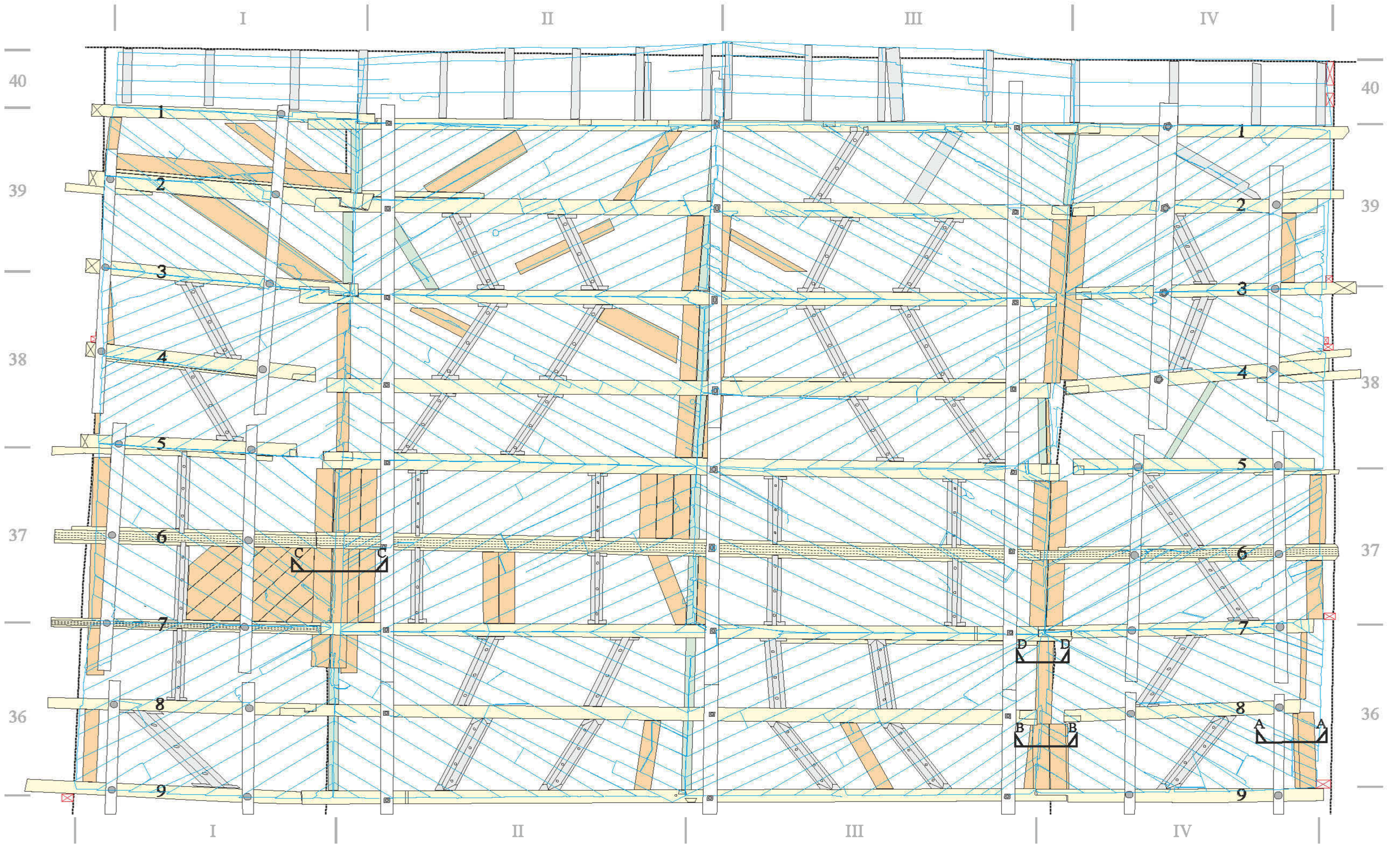
NOTES

It will be seen that the great majority of splits are associated with nails. The splits in replacement boards tend to be very long, with those in the original boards only extending a short distance from each nail. This is the pattern to expect in these two different types of timber.

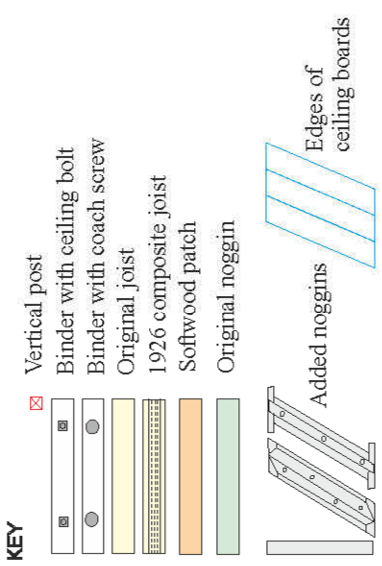
Note how few nail-ends there in this section of Ceiling.

EXPLANATORY SECTIONS





KEY



NOTES

This graphic shows what remains of the original Ceiling structure and the reinforcements inserted during subsequent restorations.

There seems no apparent reason for the change in noggin design to the west of Joist 7, other than it is a slightly easier design to install. It should be noted that the lack of brackets on the east side of Joist 8 is due to the proximity above of a tie beam which would prevent access to this end of the noggins. The top studs of the noggins on either side of the composite joists are continuous. Note should be taken of the use of the intermediate joist in each bay (numbers 2, 4, 6 and 8) for the position of scarf joints in the original boards, though the number of these in *Panel 36* is less than the panels to the east.

GRAPHIC No: 3

SCALE 1:40

TITLE PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

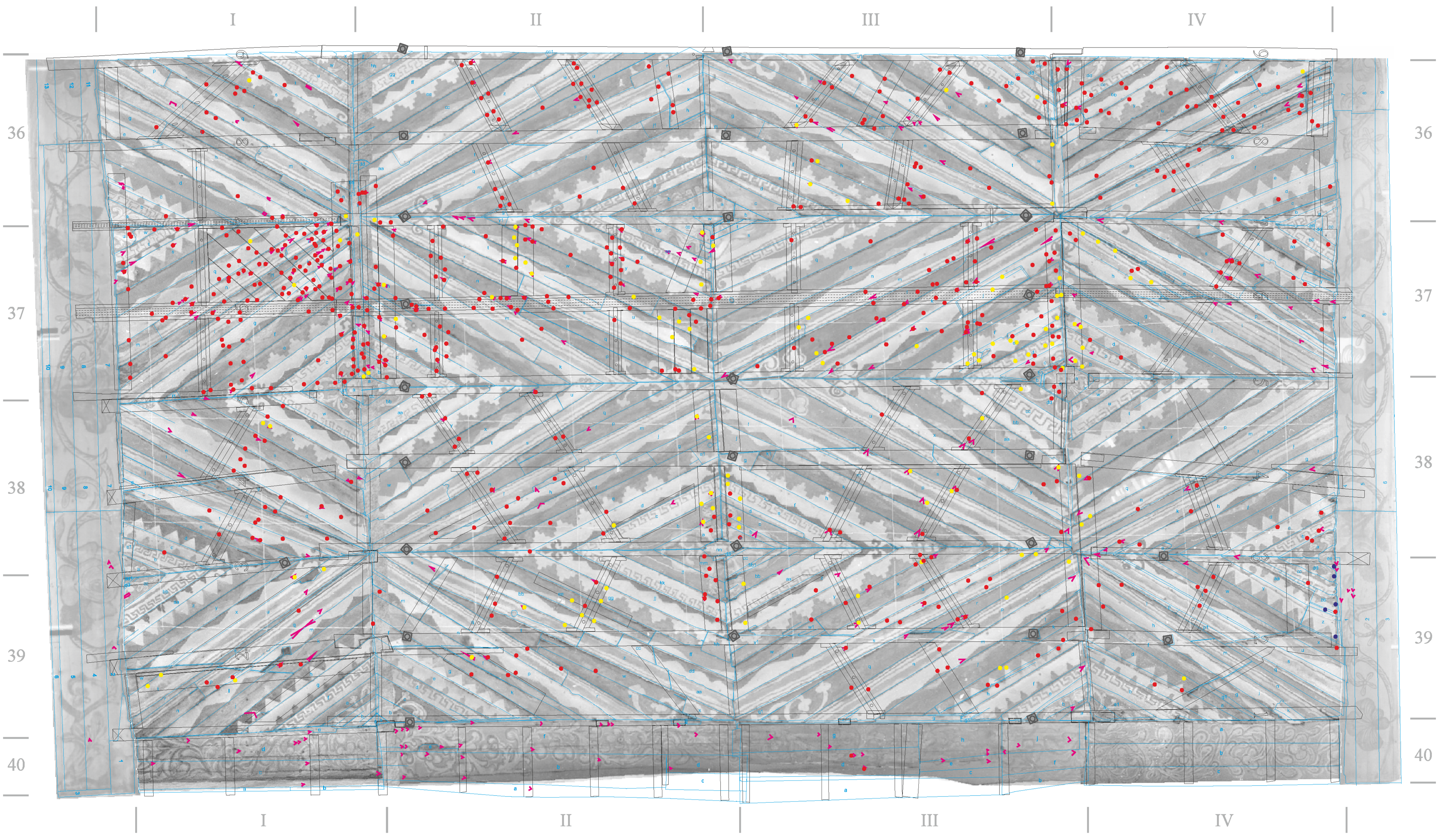
STAGE PRELIMINARY CONDITION SURVEY

DESCRIPTION Ceiling Structure, Upper Side

POSITION Ceiling Panels

Photogrammetry courtesy of English Heritage Survey Team

The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham,
Oxon OX7 6YA Tel. 01608 658067



KEY FOR FIXINGS & DAMAGE

- Ceiling bolts
- Steel screws
- Galvanised screws
- Screw heads
- Surface splintering
- Outline of structure, upper side

GRAPHIC NO: 4

N

SCALE	1:35
TITLE	PETERBOROUGH CATHEDRAL - NAVE CEILING Conservation Programme Phase 1 (Jan - May 1998)
STAGE	PRELIMINARY CONDITION SURVEY
DESCRIPTION	Lower Side Structure Fixings & Damage

0 1m 2m 3m

POSITION
Ceiling Panels
SOUTH
WEST
EAST
NORTH

Photogrammetry courtesy of English Heritage Survey Team

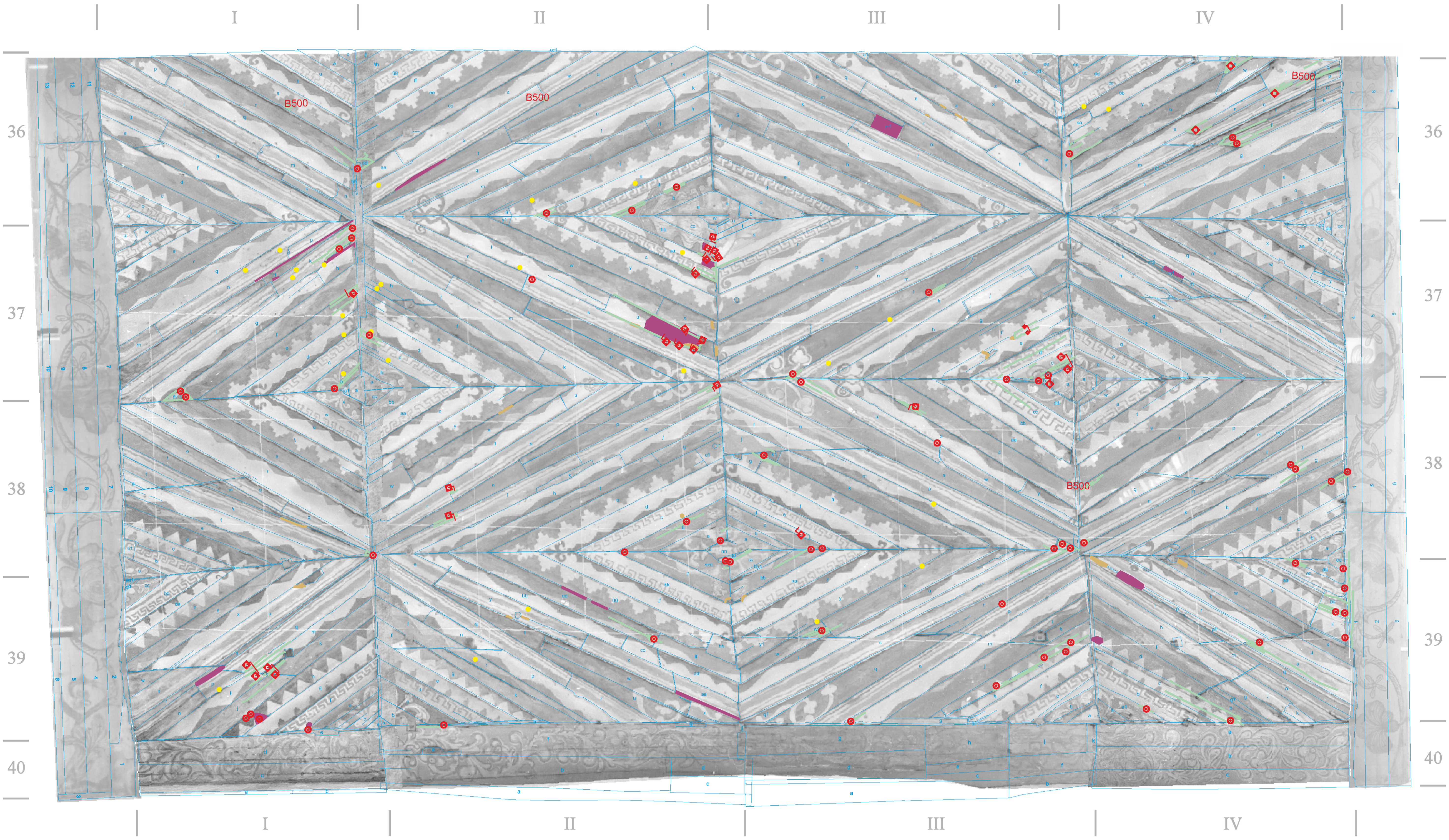
The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham, Oxon OX7 6YA Tel. 01608 658067

NOTES

All screws (except a very small number coloured blue, which must have been inserted in the 1880s) were inserted in the 1926 restoration by Leslie Moore. Distribution relies solely on the judgement of the staff involved at the time from their perception of the fragility of the boards viewed from the upper side of the Ceiling.

It can be seen that concentrations of screws relate to patches, noggins and composite joists.

There seems no apparent rationale for the choice of steel or galvanized screws. Neither is there for the occurrence of surface splintering.



KEY FOR REPAIRS TO CEILING BOARDS

Secured

Screws Removed

Consolidation:

B72

Bencon 19

Fills

B500 Adhesive

Stainless steel fixings:

Screw & Washer

Angled Rod

Threaded Rod

Bolt

GRAPHIC NO: 5

N

SCALE 1:35

0 1m 2m 3m

POSITION

Ceiling Panels

SOUTH

WEST

EAST

NORTH

TITLE

PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE CONDITION SURVEY AND TREATMENT

DESCRIPTION Lower Side of Structure Repairs to Ceiling Boards

Photogrammetry courtesy of English Heritage Survey Team

The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham, Oxon OX7 6YA Tel. 01608 658067

NOTES

It is noticeable that consolidation by Paraloid B72 and fillings has been used in areas of insect damage and fungal decay.

Stainless steel fixings have been used to secure unstable splinters and fragments of the ceiling boards.

KEY FOR INVESTIGATION AND ADDITIONS

- Windows in hessian
- New sailcloth
- Woodwork investigated
- Trial ceiling bolt removed
- Coach screw removed for examination

GRAPHIC NO: 6

SCALE 1:35

0 1m 2m 3m

TITLE

PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE INVESTIGATION AND ADDITIONS

DESCRIPTION Upper Side of Structure

POSITION Ceiling Panels

SOUTH

WEST

EAST

NORTH

Photogrammetry courtesy of English Heritage Survey Team

The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham,
Oxon OX7 6YA Tel. 01608 658067

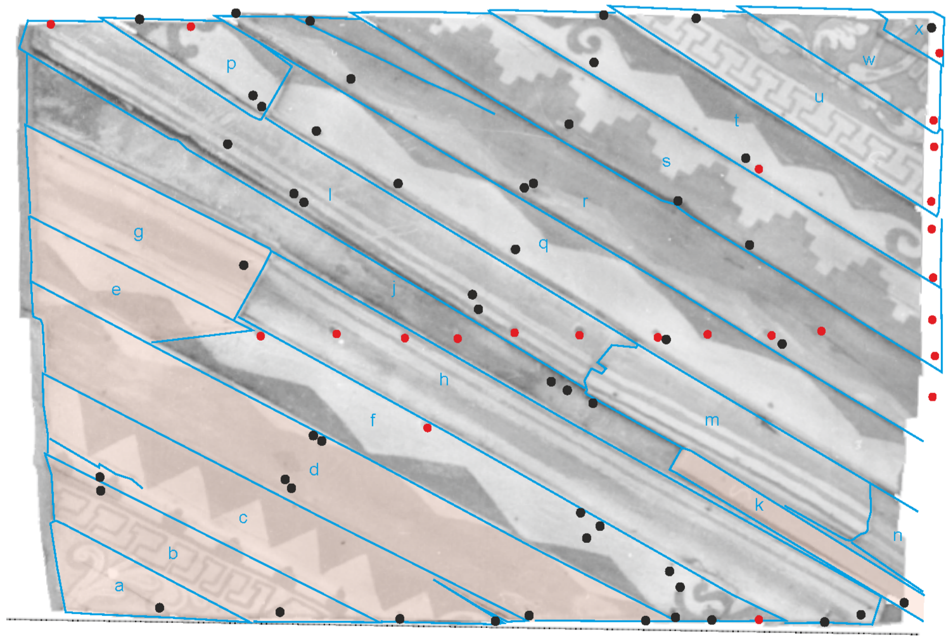
NOTES

In order to understand the complex support systems to the Ceiling, above and below the hessian, the areas shown in this graphic were opened up to clarify the methodology of earlier restorations and original technique.

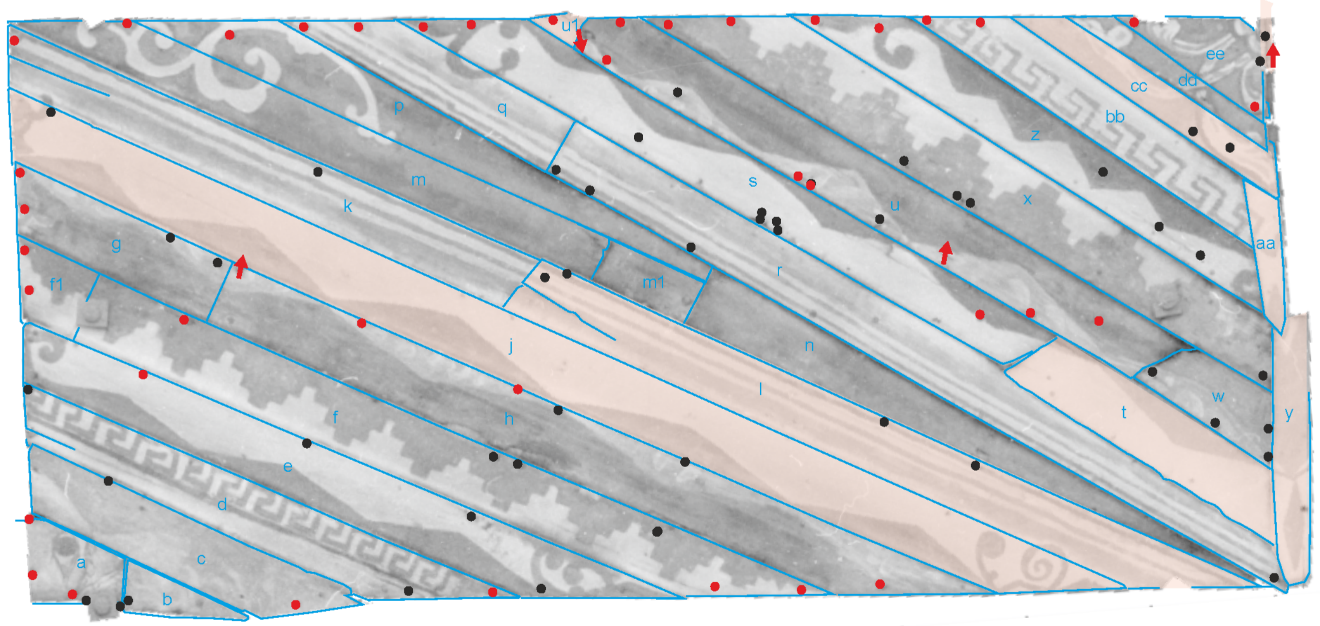
KEY FOR UPPER SIDE STRUCTURE

- Binder & ceiling bolt
- Binder & coach screw
- 1926 composite joist
- Original joist
- Softwood patch
- Original noggin
- Added noggins
- Edges of ceiling boards
- Vertical post

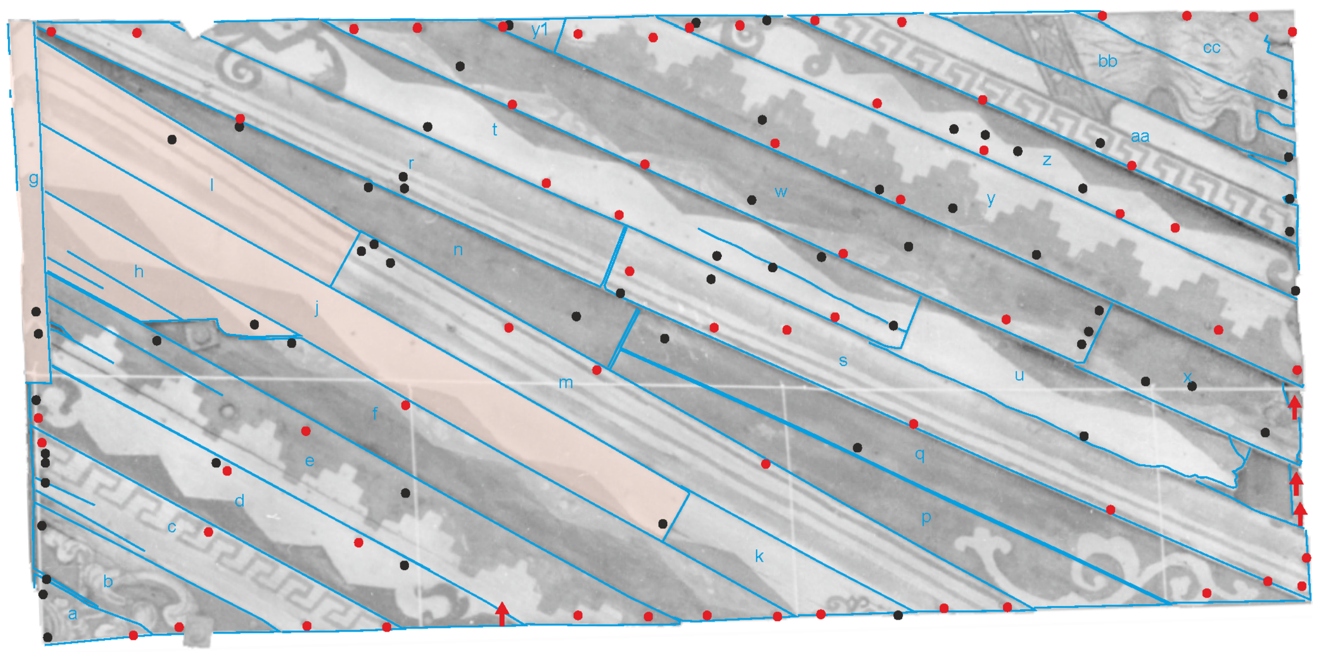
36 I



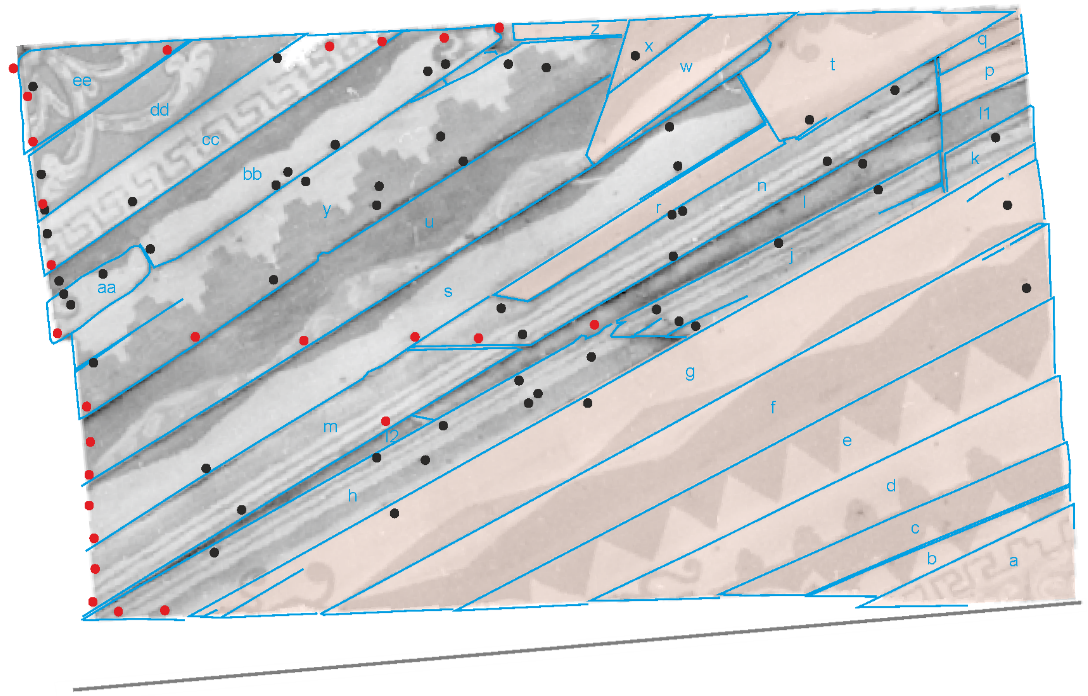
36 III



37 II



36 IV



KEY FOR ORIGINAL FIXINGS

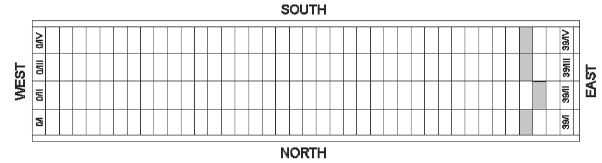
- Nail Heads
- Nail holes
- Protruding nail heads
- Replaced boards

GRAPHIC NO: 7

SCALE 1:20

0 — 1m — 1.5m

POSITION **Ceiling Panels**



TITLE
PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE PRELIMINARY CONDITION SURVEY

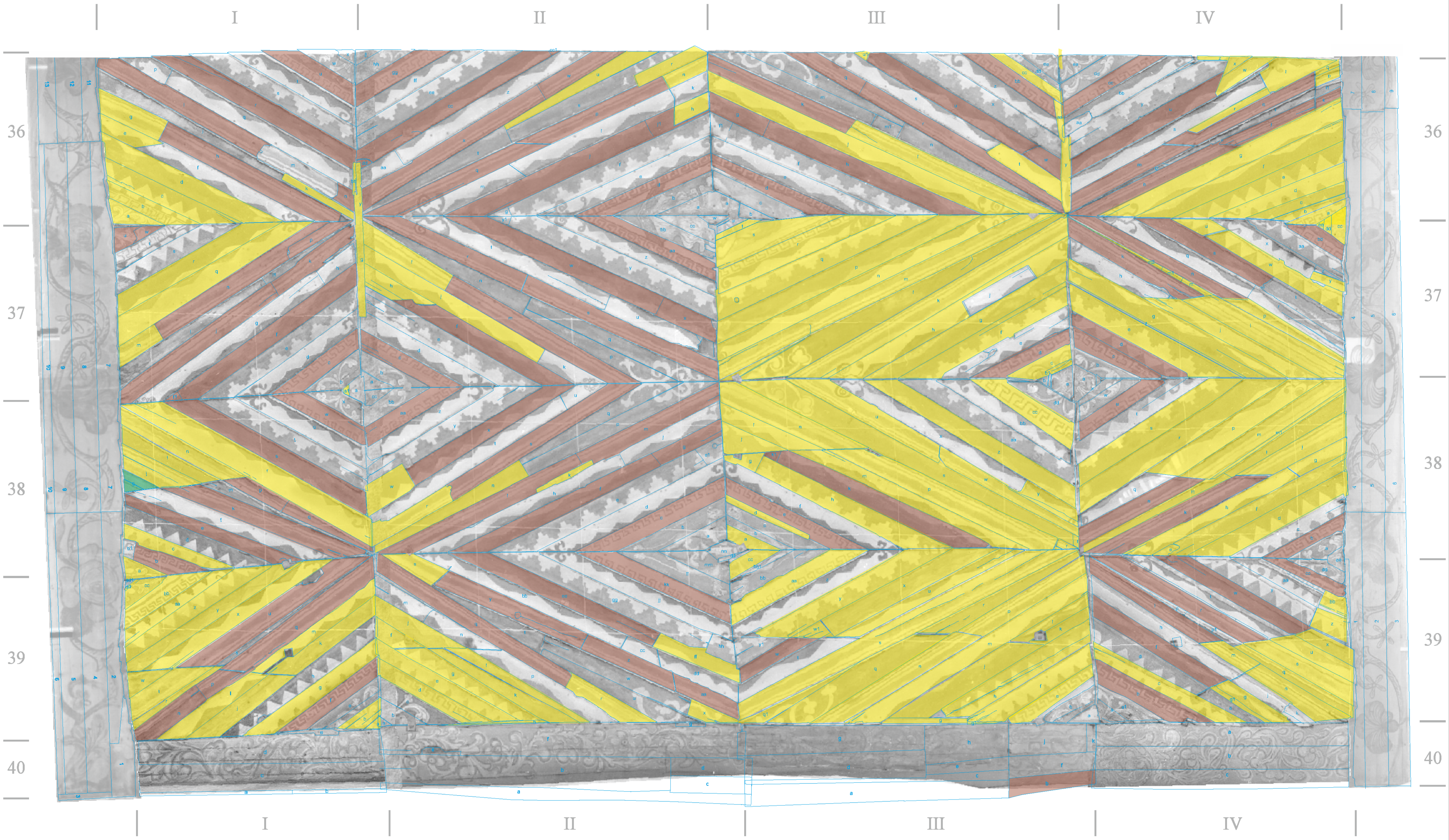
DESCRIPTION Lower Side Structure Original Fixings

Photogrammetry courtesy of English Heritage Survey Team

The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham,
Oxon OX7 6YA Tel. 01608 658067

NOTES

Random panels were selected to identify original nails from later nails. When this was done the pattern of nailing at the end of the boards and into the intermediate joists became clearer. As comparatively few original nails survive through the edges of the original boards, it is necessary to also study nail holes, though it should be noted that many of these are not from original nails. A correlation of surviving original nails through the edges of the boards can be compared with the nail holes to show that the pattern of edge nailing was fairly consistent.



KEY FOR CEILING BOARDS

Replacement softwood Ceiling boards

Grooved boards

GRAPHIC NO: 8

SCALE 1:35

0 1m 2m 3m

POSITION Ceiling Panels

SOUTH WEST EAST NORTH

TITLE PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE PRELIMINARY CONDITION SURVEY

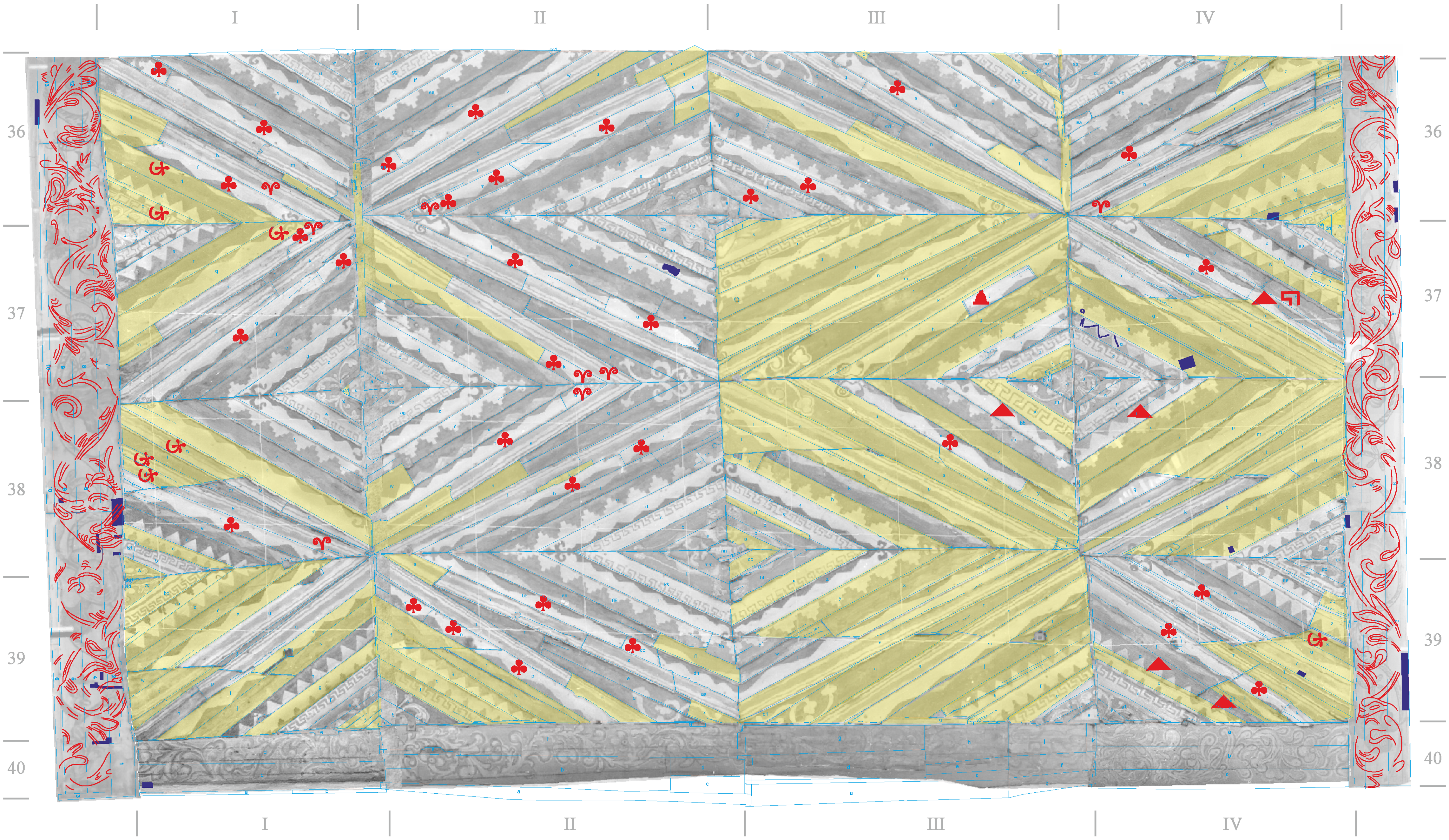
DESCRIPTION Lower Side Structure Ceiling Boards

Photogrammetry courtesy of English Heritage Survey Team

The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham, Oxon OX7 6YA Tel. 01608 658067

NOTES

The disposition of boards with grooving is shown and the explanation for the fragmentary evidence is the substantial inclusion in the Ceiling of the softwood replacement boards. As the categorization of the eastern infill panels and Ashlar is unknown, they have not been shown specifically as replacement boards (except the one oak board in *Panel 40 III*).



KEY FOR PAINT & SURFACE ACCRETIONS

- Replacment softwood boards
- Graffiti
- Ashlar boards underpaint

Ceiling Boards with Visible Underpaint:

- Frieze
- Trefoil
- Scroll
- Keyhole
- Key
- Chevron

GRAPHIC NO: 9

SCALE 1:35 — 0, 1m, 2m, 3m

POSITION: Ceiling Panels (SOUTH, NORTH, WEST, EAST)

TITLE: PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE: PRELIMINARY CONDITION SURVEY

DESCRIPTION: Paint & Surface Accretions

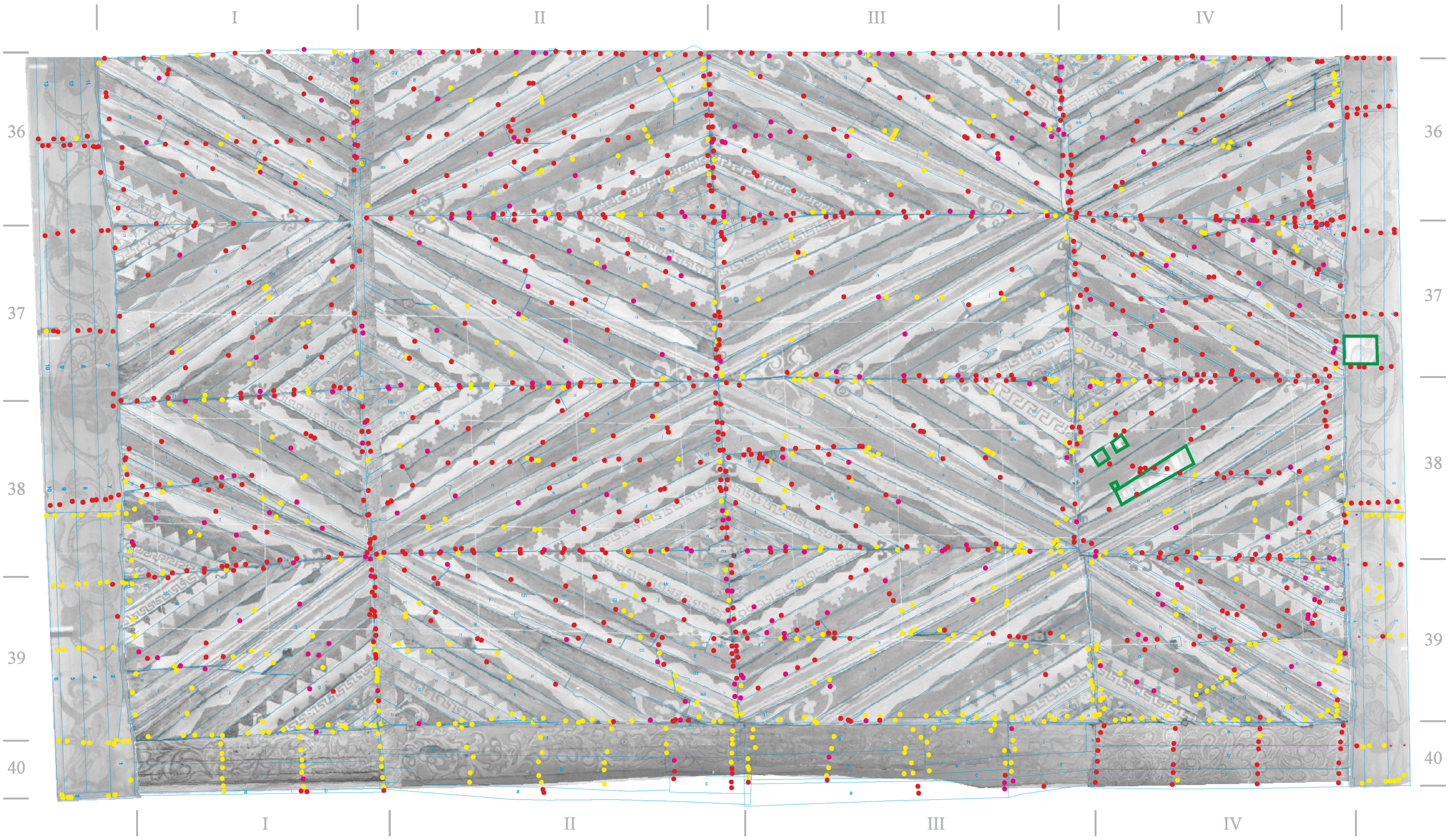
Photogrammetry courtesy of English Heritage Survey Team

The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham, Oxon OX7 6YA Tel. 01608 658067

NOTES

Visible Underpaint - Many examples of the trefoil pattern and its end scroll design are visible in raking light beneath the extended chevron pattern on many original oak boards. Impasto outlines only of the stepped chevron and dog-tooth/chevron patterns are visible. There are only 7 ceiling boards with the frieze scheme as underpaint and one re-used, round-edged board with key pattern underpaint on its inside edge.

Replacement Boards - The majority of these boards appear to have been inserted during the 1830s restoration work; some in the 1740s; a number at the east end, within Panels 39/40, were replaced when the tower wall was rebuilt in the 1880s.



KEY FOR PAINT & SURFACE ACCRETIONS

Hirst Conservation Cleaning Tests

Paint Surviving on Nail Heads:

- 70-100%
- 30-70%
- 0-30%

GRAPHIC NO: 10

SCALE 1:35

0 1m 2m 3m

POSITION Ceiling Panels

SOUTH
WEST
EAST
NORTH

TITLE

PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE CONDITION SURVEY AND TREATMENT

DESCRIPTION Paint & Surface Accretions

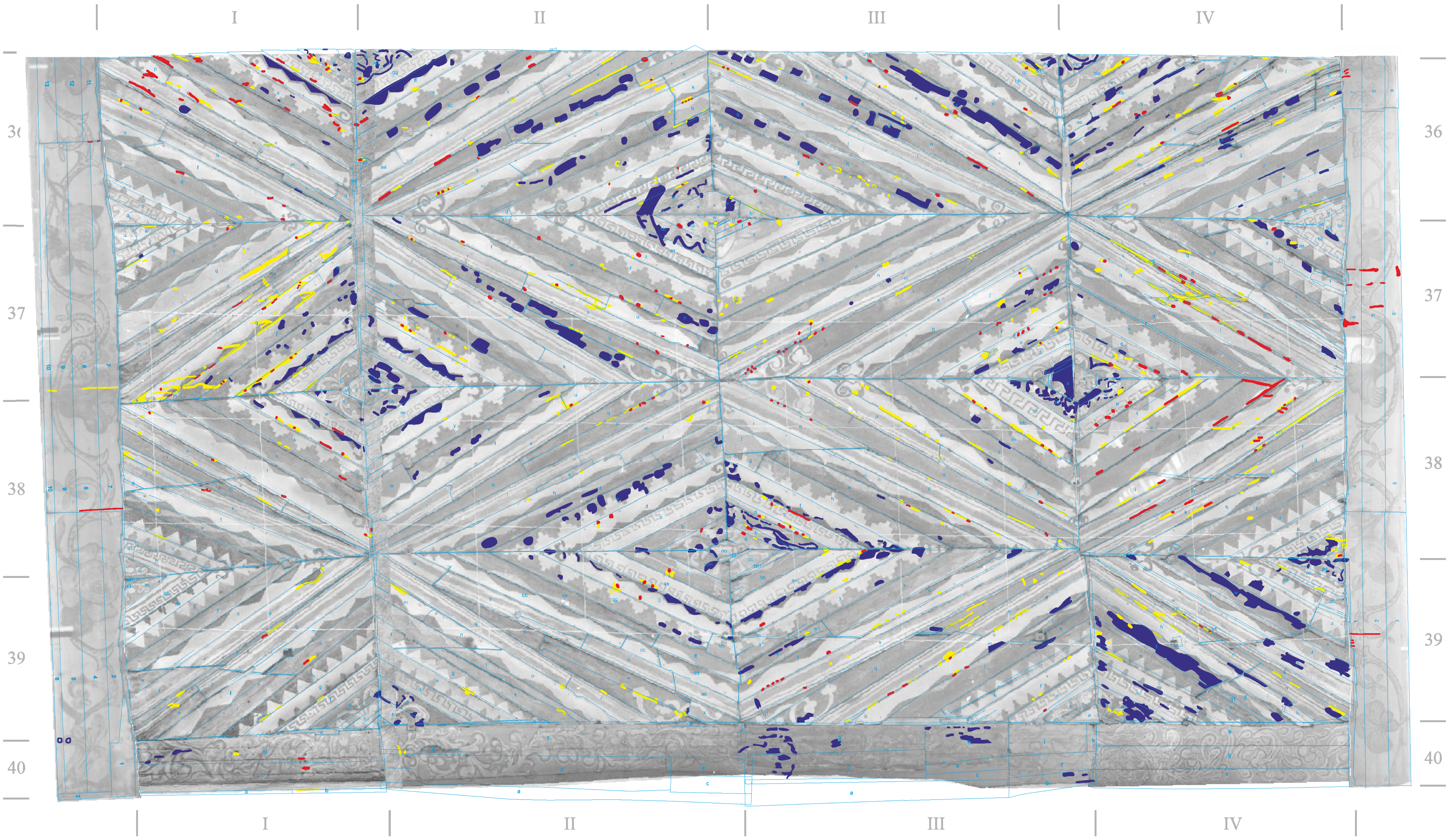
Photogrammetry courtesy of English Heritage Survey Team

The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham, Oxon OX7 6YA Tel. 01608 658067

NOTES

Hirst Conservation Cleaning Tests - Many of the cleaning tests carried out by Hirst Conservation in 1995, using a wide range of solvents, were still visible after surface cleaning with Wishab sponges. These cleaning tests were reintegrated using water-colour paints as part of Phase 1 treatment.

Paint Surviving on Nail Heads -The nail heads are shown here as oversized to aid visibility. The groupings signify the percentage of paint remaining on each nail but do not indicate whether the surviving paint was flaking. The same material in the same solution (Paraloid B72: 10% in acetone) was used both to re-attach flaking paint on nail heads and to coat exposed metal.



KEY FOR PAINT & SURFACE ACCRETIONS

- Flaking paint
- Surface glue
- Flaking & glue

GRAPHIC NO: 11

SCALE 1:35

0 1m 2m 3m

POSITION: Ceiling Panels

SOUTH / WEST / EAST / NORTH

TITLE

PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE: CONDITION SURVEY AND TREATMENT

DESCRIPTION: Paint & Surface Accretions

Photogrammetry courtesy of English Heritage Survey Team

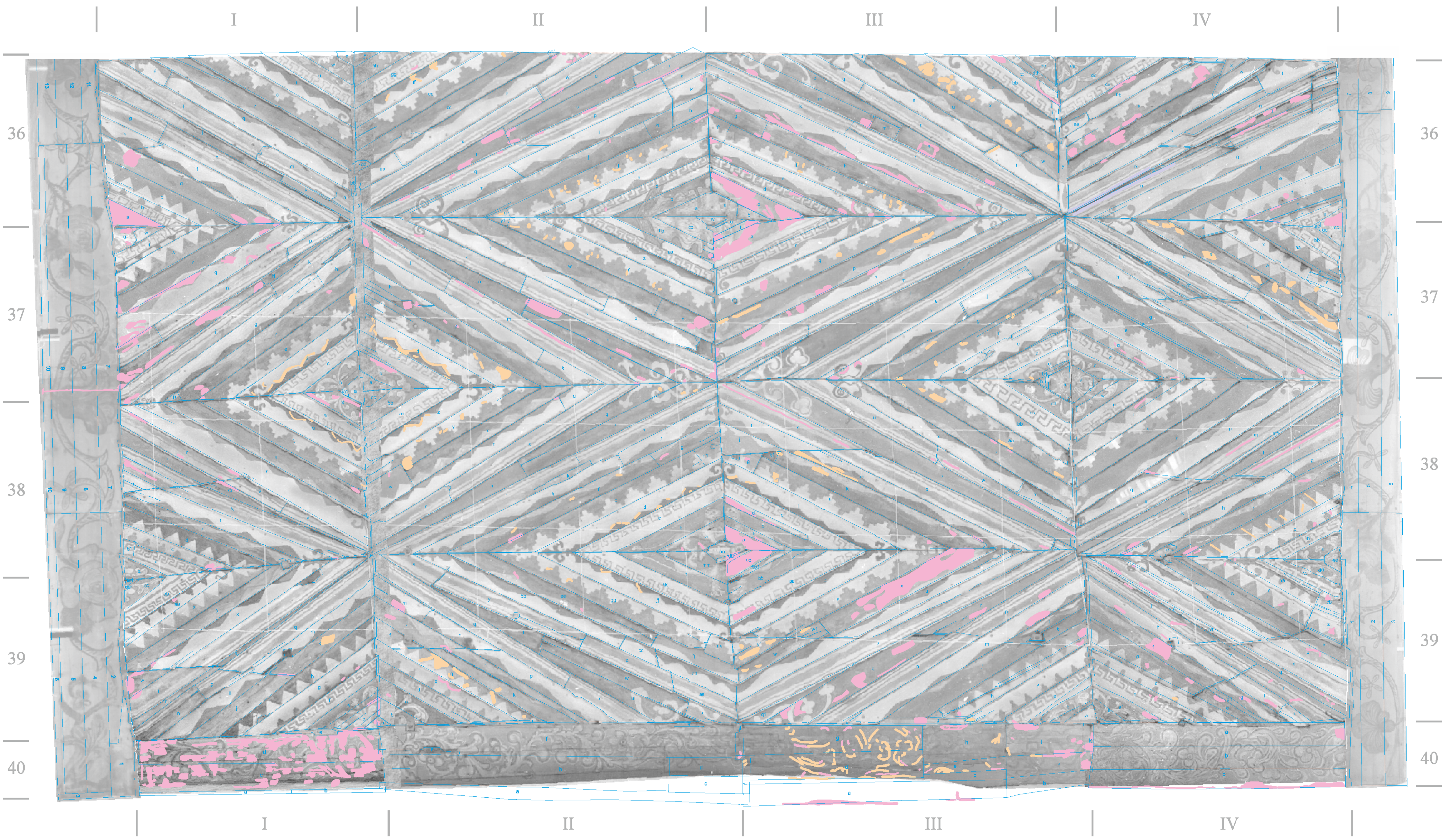
The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham, Oxon OX7 6YA Tel. 01608 658067

NOTES

Flaking Paint - The primary cause of flaking paint on the Nave Ceiling is long term water infiltration leading to deterioration of the wood support and subsequent loss of adhesion. All flaking paint was re-attached as part of Phase 1 treatment.

Glue - The extensive glue deposits on the edges of straight-edged boards cannot be shown here. As far as is possible all glue deposits on the paint surface were removed.

Flaking & Glue - In general, the glue caused paint flaking only where it had collected in thick droplets or runs. Glue deposits are less likely to cause flaking of the more robust white background paint.



KEY FOR PAINT & SURFACE ACCRETIONS

- Efflorescence
- Surface bloom

GRAPHIC NO: 12

SCALE 1:35

0 1m 2m 3m

POSITION: Ceiling Panels

SOUTH
WEST
EAST
NORTH

TITLE

PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE: CONDITION SURVEY AND TREATMENT

DESCRIPTION: Paint & Surface Accretions

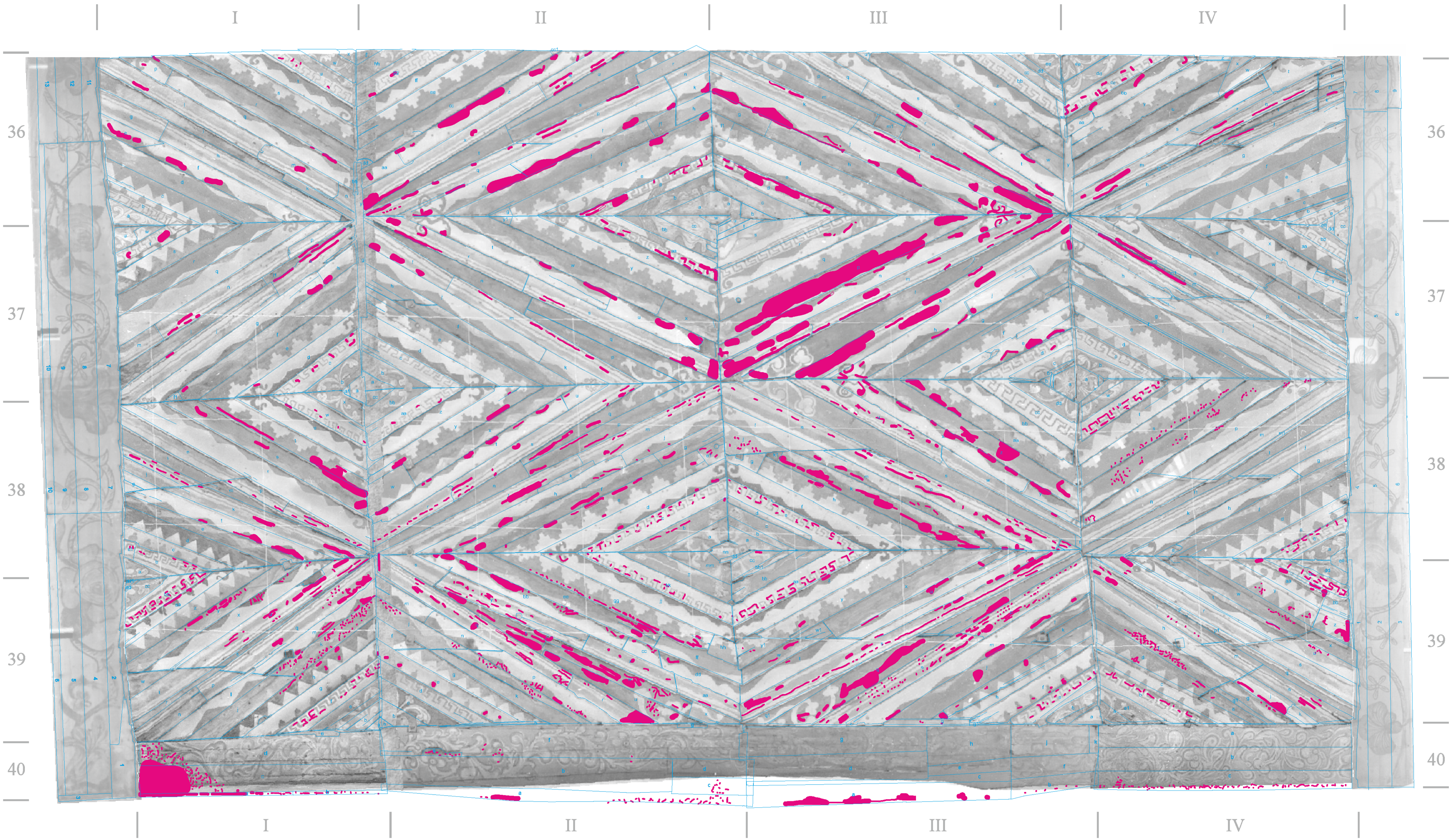
Photogrammetry courtesy of English Heritage Survey Team

The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham,
Oxon OX7 6YA Tel. 01608 658067

NOTES

Efflorescence - There are varying examples but most characteristic is The 'white chalk line' on a number of original, wave pattern boards with the matte, saturated, black paint: at least two different salts are present, chloride and sulphate. Further analysis of the different forms of efflorescence will be carried out in Phase 2. All efflorescence was removed during surface cleaning.

Surface Bloom - Three forms of bloom are included: a whitish veil covering paint on some 1830s replacement boards (removed during surface cleaning); an opaque metallic sheen that occurs in patches on the shiny, 1830s black paint (not removed); a very noticeable unidentified surface coating over the black paint on an 1830s replacement board (not removed).



KEY FOR PAINT & SURFACE ACCRETIONS

Possible Residue of Microbiological Growth

GRAPHIC NO: 13

SCALE 1:35

0 1m 2m 3m

TITLE
PETERBOROUGH CATHEDRAL - NAVE CEILING
Conservation Programme Phase 1 (Jan - May 1998)

STAGE CONDITION SURVEY AND TREATMENT

DESCRIPTION Paint & Surface Accretions

POSITION Ceiling Panels

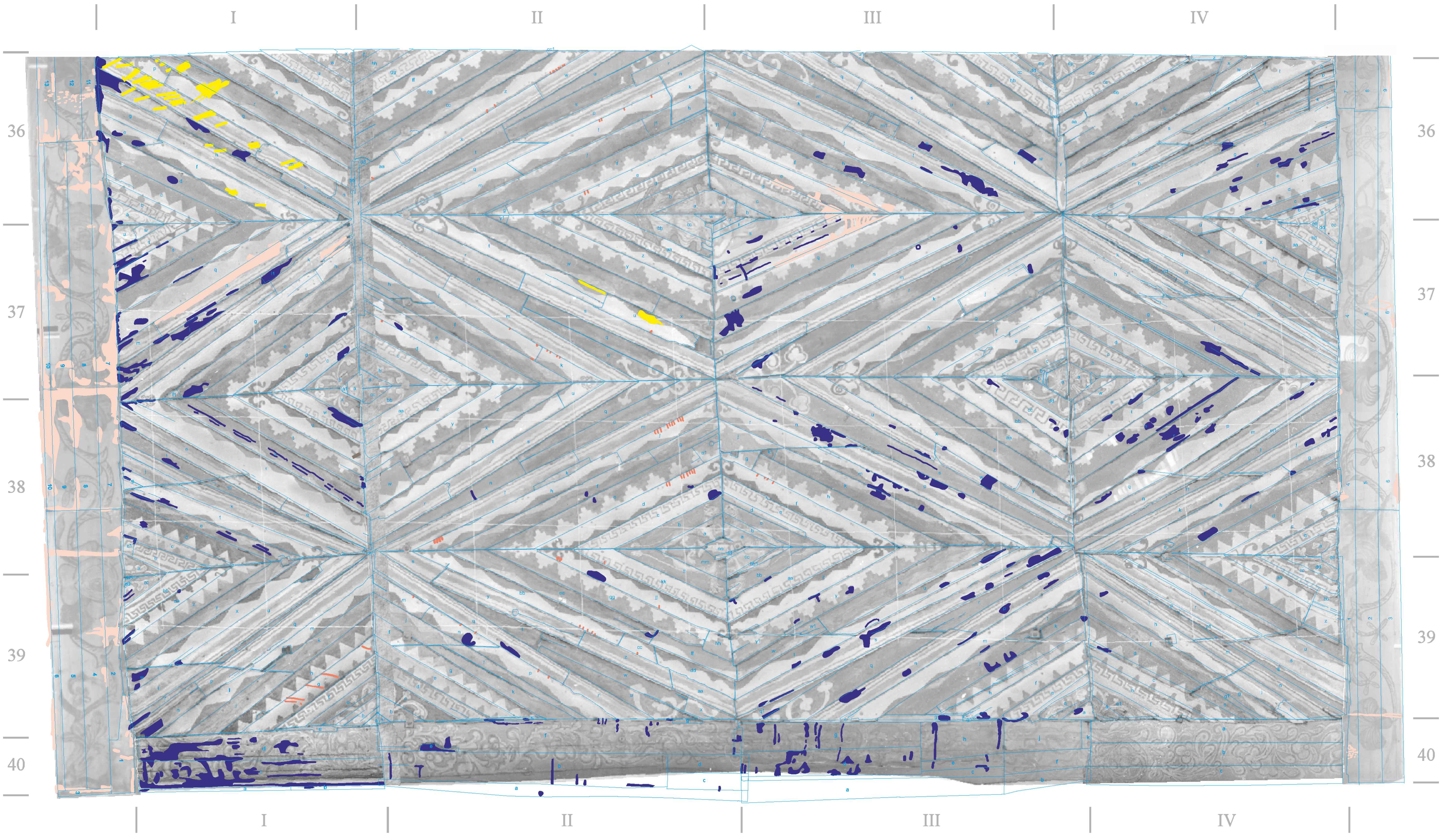
SOUTH / WEST / EAST / NORTH

Photogrammetry courtesy of English Heritage Survey Team

The Perry Lithgow Partnership
Todd's Cottage, Church St., Kingham, Oxon OX7 6YA Tel. 01608 658067

NOTES

Microbiological Growth - Residues of what may be three forms of microbiological growth were found on the paint surface. These were removed as far as possible during the surface cleaning process. These residues are widespread across the Ceiling and will be analysed as part of the Phase 2 investigations. The three forms of residue are: a spattering of light brown powdery flecks (faint traces of this remain after cleaning with a Wishab) sponge; a purplish powder residue; a white bloom or stain on the paint not removed by Wishab cleaning (the fine tendrils suggest this results from microbiological growth).

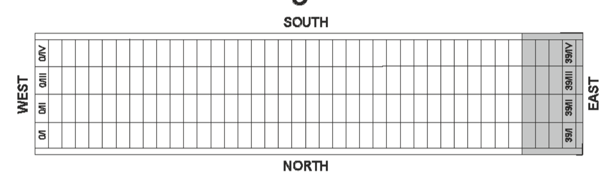


KEY FOR PAINT & SURFACE ACCRETIONS

- Staining
- Treated Stains
- Brown Drips
- Water damage

GRAPHIC NO: 14

SCALE	1:35 (0, 1m, 2m, 3m)
TITLE	PETERBOROUGH CATHEDRAL - NAVE CEILING Conservation Programme Phase 1 (Jan - May 1998)
STAGE	CONDITION SURVEY AND TREATMENT
DESCRIPTION	Paint & Surface Accretions
POSITION	Ceiling Panels



Photogrammetry courtesy of English Heritage Survey Team

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NOTES

Staining - There are a number of different categories of staining, all resulting from liquid material penetrating down between the ceiling boards or through cracks in deteriorated boards. There has been spillage of a dark liquid material (the worst of these stains have been reduced in this phase of treatment); also, a clear liquid that has seeped through small cracks. Dark grey stains on the frieze boards (caused by water infiltration) were removed using deionised water swabs.

Brown drips - Characteristic light-brown drips on board edges.

Water damage - Whitish opaque drip trails across the paint.

APPENDIX 1

LIST OF PLATES IN VOLUMES II AND III

1. NAVE CEILING

Plates 1 to 4 Nave Ceiling after Phase 1 treatment. **Plate 1** three easternmost bays; **Plate 2** two easternmost bays ; **Plate 3** Eastern Bay; **Plate 4** detail of Phase 1 section and adjacent untreated area.

2. DOCUMENTATION

Plates 5 to 12 **Plate 5** showing site computer. **Plate 6** information hand-drawn onto reference sheet is scanned into computer and digitised. **Plate** *7* Bill Blake of English Heritage Survey Team in roofspace with a laser guided digital theodolite used for accurate plotting of canted structure;. **Plate 8** example of Datum Point sited in on the central walkway in the roofspace by the English Heritage Survey Team. **Plate 9** environmental monitoring equipment: surface temperature and relative humidity probes on underside of the Ceiling. **Plates 10, 11** X-ray photography in progress; **Plate 12** example of X-ray photograph.

3. THE CEILING STRUCTURE

TECHNICAL SURVEY: THE CEILING STRUCTURE, UPPER SIDE

Plates 13 to 24 Upper side of the ceiling before treatment. **Plates 13-16** show *Panels 37, 37, 38, 39 I*, **Plates 17-20** show *Panels 36, 37, 38, 39 II*, **Plates 21-24** show *Panels 36, 37, 38, 39 III*, **Plates 25-28** show *Panels 36, 37, 38, 39 IV* .

Plates 29 to 31 The north Narthex roof structure, although later than the Nave roof, it could be similar to the original Nave roof.

Dendrochronology

Plate 32 The lap joint at the north end of Joist 3. This Plate shows the similarity of this joint in the Nave roof and in the north Narthex roof. Note also the holes drilled for dendrochronology.

Noggins

Plates 33 to 37 **Plate 33** shows the junction of noggins below the centre of Joist 3. Note the birds beak joint and two nails to each joint. **Plate 34** shows a noggin to the west of the north lap joint in Joist 8. **Plates 35 & 36** show the only evidence (in this Phase) of a noggin at the foot of the sloping ceiling where it meets the vertical boarding in *Panel 38 IV*. **Plate 36** shows the same joint with two nails on the west side of Joist 3. See also drawing by P.F.

TECHNICAL SURVEY: THE CEILING STRUCTURE, LOWER SIDE

Plates 38 to 42 **Plate 38** shows the base board. **Plate 39** shows the three different board edge details, with grooved at top fight, square in the centre, and rounded on the left side. **Plate 40** shows the grooved design with the surface of the board recessed inside the fourth raised strip. **Plate 41** shows a round bottomed groove inside the fourth strip, with the surface level with the strips. **Plate 42** shows the "flattened "profiles to the centre boards to produce the least distracting ground for the centre paintings that could be achieved with the riven boards at their disposal. Se also drawing by P.F.

Dendrochronology

Plate 43 Cathy Groves of University of Sheffield preparing the end of a board, before taking a mould for analysis.

Scarf Joints

Plates 44 to 49 **Plate 44** shows a typical scarf joint as described in the Report. **Plate 45** shows a different type (also quite frequently found) where the top board has been chamfered. **Plates 48 & 48** show the same very short piece scarfed on, with, and without, a tape measure. **Plate 49** shows the internal face of a scarf where the top board has been considerably displaced.

Fixings

Plates 50 to 55 **Plates 50 and 51** show original nails which have caused the boards to split with subsequent shrinkage. **Plate 52** shows three common types of nail, the lower one being the original. **Plate 53** shows a nail driven from above (through a patch) and clenched over underneath the ceiling. **Plate 54** shows a variety of nail holes, some apparently rounded (on the oak board to the left), some definitely square/rectangular(in the softwood board in the centre). **Plate 55** shows hammer marks on a replacement board where the carpenter has missed the head of the nail. None have been seen adjacent to the original nails.

Drawings

Plates 56 to 62 **Plate 56** shows Peter Ferguson recording all patches and details of the 1926 restoration, and any other additional woodwork to the main ceiling structure. Problems of accurately plotting items on the sloping sides proved extremely difficult due to poor access and lack of datum points relating to the boards. **Plate 57** is a drawing by Julian Limentani of the roof construction.

Plates 58 to 62 These are drawings by Peter Ferguson, and show the position of the original noggins in **Plate 58**, the construction of the ceiling boards and their section in **Plates 59-60,** and details of the 1926 reinforcement work in **Plates 61-62.**

Replacement Boards

Plates 63 to 69 **Plate 63** shows a softwood replacement board scarfed to an original board. **Plate 64** shows a replacement board with a sawn finish. If other similar boards are found in the next Phase, they should be assessed for method of sawing to see if this can prove or strongly point to a date, to help date all the replacement boards. **Plate 65** shows another sawn board, but this may have been inserted when the Tower was rebuilt in the 1880s. **Plate 66** shows a crude patch on an Eastern Infill board using a fragment from another similar board. **Plate 67** shows another patch, this time using part of an original oak board as a patch over a replacement softwood board. **Plate 68** shows the reuse of a softwood board from either an Ashlar panel or from the Eastern Infill panels as a replacement board. This is shown by the fragment of under-painting revealed as the board has shrunk. Plate **69** shows a typical patch of unknown date fixed above the ceiling boards.

1926 Repairs

Plates 70 to 87 All these details are drawn and can be seen on P.F. drawings 4&5. **Plate 70** shows a typical 1926 noggin and 1926 laminated joist. Plate 71 shows the same joist with the triangular side piece removed. **Plates 72-74** show different design noggins and different design attachments of the noggins to the original joists. **Plate 75** shows the laminated construction at the north angle in Joist 6. **Plates 76-77** show different types of patch revealed when the hessian was removed for investigative purposes. The patch in **Plate 76** is formed from two 1/2" softwood boards laid side by side, **Plate 77** shows a solid oak patch approx. 1" thick. The sequence of **Plates 78-81** show the dismantling of one noggin for investigative purposes, starting with Bob Chappell unscrewing the top laminate, and finishing with a view of the newly revealed hessian. The letter "A" in the last Plate is to denote the sequence of laminates to ensure they were replaced correctly. **Plates 82-86** show the progressive dismantling of a centre noggin support; showing it complete with the hessian removed, in **Plate 82**, then in **Plate 83** with the centre cover laminate removed, then with each north side laminate removed **(Plates 84-86),** to reveal the tops of the original boards and centre noggin in **Plate 86**. **Plate 87** shows a coach bolt removed for investigative purposes from a binder and sloping joist. A joist was chosen which had a solid joint at the top and bottom.

Screws and Splinters

Plates 88 to 98 — **Plates 88-89** show a typical array of screws projecting through the ceiling boards, note the mix of galvanised/coated screws and bare steel screws used. **Plate 90** shows a selection of screws and one wire nail (taken out of a 1926 noggin or joist), with a tape measure. **Plates 91-92** show boards displaced vertically by screws not entering the board but pushing it down. **Plate 93** shows Cameron Stewart using a detector for finding hidden electric wiring and plumbing to find screws beneath the hessian, whilst conferring with his colleague below using a walkie-talkie. **Plates 94** and **96** show splinters in the face of original ceiling boards after removal of the screws, and **Plates 95** and **97** show the splinters re-fixed. **Plates 98-99** show the same sequence in a softwood replacement board, but due to the resilience and fibre length of the wood, the splinter is extraordinarily long (approx. 100mm). **Plate 100** shows a prop made from a telescopic light standard to put gentle pressure on a splinter whilst the Plextol B500 adhesive is curing.

CEILING BOARDS: CONDITION AND TREATMENT

Decay and Woodworm

Plates 74, 86,126 — These Plates show the extent of surface decay to the upper sides of the boards.

Plates 101 to 109 — **Plates 101-102** show sporadic infestation by Common Furniture Beetle and Death Watch Beetle and cross checking which is invariably associated with fungal attack. **Plate 103** shows complete losses of wood due to severe infestation. **Plates 104-105** shows a small area of wood loss resulting from insect attack before and after repair. To prevent further wood loss from these unstable areas the exposed wood was consolidated with Paraloid B72 (10% in xylene) and repaired with a filler of: 1 part Polyfilla, 1.5 parts fine oak dust, 1 part Plextol B500 (10% solution).. **Plates 106-107** show losses of edges due to infestation, possibly because they contain sapwood. **Plate 106** shows infestation by Common Furniture Beetle, and **107** Death Watch Beetle. **Plate 108** shows more severe infestation and fungal attack that is probably limited to the front surface. **Plate 109** shows cross checking that goes right through the thickness of the board, and indicates more severe fungal attack.

Micro Surface Decay and Gunshot

Plates 110 to 113 — **Plate 110** shows differential in micro fungal decay on the surface between the "background" black area and the "foreground" white painted area. **Plate 111** shows what looks to be an original board that somehow escaped over-painting. Note the surface degradation that is similar to the black area on the previous Plate. **Plate 112** and **113** show areas of gun shot. The interesting point to note is that only the left hand board has shot in it, so if the style of painting is also taken into account, it would seem likely that this shot is between 1740 and 1830.

Repairs

Plates 114 to 139 **Plates 114-121**, and **129-131** show the sequence for two typical repairs. Plates **114-116** and **129** show the areas before treatment, (**Plate 115** is the same as **Plate 114** but taken with ultra-violet (UV) illumination). **Plates 117-119** and **130** show the stainless steel support angle bolts in place, **120** shows the angles being touched in, and **121** and **131** the finished work. Note the slight reflection from the Melinex sandwiched between the stainless steel angle bolts and the painted boards. **Plates 122-128** show the sequence of refitting a fragment from the original centre board in its correct relationship to the centre board, and refitting the washer for the hanging bolt so that it matches the paint lines. For an overall view of the finished work see **Plate ??**. **Plates 132-133** are of a situation where a long fragment required support, yet where it was not possible to fit a two legged stirrup, so a double angle on a single leg was fashioned. **Plates 134-135** show an unstable end of a board, and how existing holes were used for new supporting screws and washers. For other examples of the use of old nail holes for new screws see also **Plates 136-138** (**136-137** after touching in, **138** before). **Plate 139** shows the tops of the angle bolts above the boards with nuts and washers.

Plate 140 Show a section of deteriorated and damaged wave pattern board following repairs to small areas of wood loss resulting from insect attack. To prevent further wood loss from these unstable areas the exposed wood was consolidated with Paraloid B72 (10% in xylene) and repaired with a filler of: 1 part Polyfilla, 1.5 parts fine oak dust, 1 part Plextol B500 (10% solution).

HANGING BOLTS: CONDITION AND TREATMENT

Plates 141 to 156 **Plate 141** shows the joist supporter resting on two adjacent tie beams. **Plate 142** shows the clamp which grips the joist with adjustable spikes. This has tightened from one side only because of the closeness of some of the ancient joists with the 1830s tie beams. Note the lifting bar which can be moved to screw locations provided at 300mm centres. **Plates 143-144** show bolt grips for holding the original hanging bolts without turning as the hanging bolt nuts are loosened. **Plate 145** shows the specially made bolt pusher in position. The purpose of this is to push the hanging bolts down without having to hit them with a hammer, which causes unacceptable vibrations. **Plate 146** shows a tell-tale to monitor any deflection of the joist whilst the hanging bolt is extracted. **Plates 147-148** show the hanging bolt at the south end of Joist 1 selected for trial removal, and with cotton wool to prevent any lubricating oil running down the bolt and onto the painted surface. On consideration that this bolt may have been loosened at the time of the Tower rebuilding, and may not therefore be representative, trials on extracting the first bolt were carried out on the north bolt on Joist 8. **Plate 149** shows Hugh Harrison holding the bolt as it was wound down, note the use of the walkie-talkie to maintain contact with colleague working above. **Plates 150-151** show the bolt when first extracted and a temporary stainless steel bolt alongside it, also the Plate with the detail of the square forged shaft below the head of the hanging bolt. **Plates 152** and **153** show the temporary stainless steel bolt in position from above and below. **Plate 154** shows two hanging bolts after painting, and **Plate 155** shows a simple guide that is placed by each hanging bolt to record future movement in the ceiling. Note also the spring washer between the nut and washer. **Plate 156** shows the Plasterzote pad between the washer and the painted surface beneath the ceiling. Note also the head and lower side of the washers left with their existing finish.

HESSIAN: CONDITION AND TREATMENT

Plates 157 to 161 **Plate 157** shows part of the west bay of *Panel 37 II* after vacuuming, compared with the east bay of *Panel 36 II* still with its surface dirt. **Plate 158** shows the panel of hessian removed by Hirst Conservation. Note the lower narrow bands of hessian. **Plate 159** shows a window opened to reveal a screw which needed to be removed. **Plate 160** shows

Panel 37 II after the areas of hessian that had been opened up for investigative purposes or to remove screws, had bee recovered with sailcloth and Beva 371. **Plate 161** is a general view of the top of the ceiling after treatment.

TESTING

X-Ray Photographs

Plates 162 to 165 The value of these plates is substantial in view of the obliteration of all detail above the ceiling because of the hessian. **Plate 162** shows the laminated construction of the 1926 joists, and it can be clearly seen that the noggin is continuous right through the joist. In **Plate 163** one can see that nails are clenched over above scarf joints. If one compares **Plate 164** with **Plate 133**, one can see how many screws exist in the back of this board. **Plate 165** highlights the fact that original nails in the edges of boards are clenched over above the top board.

4. THE PAINTED DECORATION

CONDITION SURVEY AND TREATMENT RECORD

Plates 166 to 249 Sections of the Ceiling structure lower side and painted decoration in before and after treatment sequence. All ultra-violet (UV) illumination photographs taken before treatment. Refer to Plate Reference Sheets for locations.

Plates 250 to 266 Sections of the Ashlar boards and painted decoration in before and after treatment sequence. **Plate 311** shows *Panel 36 IV* and associated Ashlar boards after treatment contrasted with the untreated *Panel 35 IV.* All ultra-violet (UV) illumination photographs taken before treatment. Refer to Plate Reference Sheets for locations.

Plates 267 to 285 The eight figurative lozenges in before and after treatment sequence. All ultra-violet (UV) illumination photographs taken before treatment. Refer to Plate Reference Sheets for locations.

VISIBLE UNDERPAINT

Plates 286 to 289 Examples of trefoil pattern visible in raking light beneath the extended chevron pattern on many original oak boards. **Plates 286, 287** show variations in the trefoil shape and end scroll design on different boards. Visual examination suggests that the relief is in many places too pronounced for the thickness of the underlying paint alone to be responsible. **Plates 288, 289** depict an example and a drawing of the end scroll design. Also, in **Plate 288** the obvious replacement board has as underpainting the bold floral scheme on the Ashlar boards.

Plates 290 to 295 The stepped chevron and dog-tooth pattern underpaint photographed in raking light, **Plates 290, 291 (UV), 292**, appears to have been painted in outline only. **Plate 290** depicts also the opaque metallic sheen that occurs in patches on the shiny, 1830s black paint. **Plate 293** shows a re-used original board with the key pattern design visible in raking light beneath what appears to be 1830s pain. Notice that this board is round-edged and un-grooved, also that the key pattern is painted on the inside half of the board. The 1740's scheme has the key pattern is painted on the outer half of grooved, straight-edged boards. **Plate 293** also depicts an example of efflorescence on the black paint surface. **Plate 294** detail of an original board in raking light showing the keyhole pattern just visible beneath the 1740s overpaint. **Plate 295** detail of the south frieze in raking light showing the more complex scrollwork (possibly dating from the late 17th or early 18th century) beneath the 1830s design.

WATERCOLOUR WASHES

Plates 296 to 297 **Plate 296** shows a wider area of **Plate 301** with a moderately angled flash, after treatment. There is a light 'tide mark' on the background paint around the floral designs; this occurs overall the Eastern Bay frieze decoration. It appears that a tinted watercolour wash was applied to darken down the 1840s design. The wash being repelled by the medium rich paint; hence the tide marks. The keyhole and key pattern boards in **Plate 297** appear also to have been painted with the lighter background paint on the frieze and then darkened down with a tinted, watercolour wash. Paint sample analysis is required to confirm this theory.

1740S/1830S REPAINTING

Plates 298 to 307 It appears that the 1830s restoration was less inventive consisting mainly of a rather crude repainting of the blacks and highlights across the Ceiling. **Plate 298** shows clearly the different black paints: the darker 1830s paint was applied in a slapdash manner over the lighter 1740s paint. **Plates 299, 300, 301** - before treatment, with ultra-violet illumination, and after treatment - show the slightly darker off-white 1830s paint was applied without precision.

Plates 302 to 304 **Plate 303** shows the paint layer exposed from under a temporally removed 1830s Ceiling bolt and washer (**Plate 302**). What must be 1740s repaint (with a surface residue of rust) continues under the bolt on the original, grooved board; however, the small section of 1830s replacement board covered by the washer is unpainted. **Plate 304** shows the grey chevron design along with the lighter brown/black paint layer continues beneath a temporally removed Ceiling bolt. These photographs show the areas after surface cleaning so illustrates the extent of surface discoloration still remaining on both the 1730s and 1840s repaint.

GRAFFITI

Plates 305 to 308 **Plate 305 t**he names of I Shaw and C Neal are painted on the south frieze decoration. **Plate 306** at the east of the south frieze the name W Stallard and the date 1838(?) is just visible beneath the off-white overpaint. **Plate 307** overpainted in red preparatory drawing, again the name Stallard, this time on the north frieze. **Plate 308** depicts the letters 'BLEY' painted on the extreme north end of *Panel 40 I*. This may refer to Cobley & Co., the firm thought to have been responsible for the 1830s restoration. **Plate 308** shows also the whitish veil or surface bloom that occurs on some 19th-century figurative boards. **Plate 309** an example of pencilled graffiti dated 1885(?) on *Panel 37 IV*.

REPLACEMENT BOARDS

Plates 310 to 317 Series of photographs comparing paint on replacement and original boards under ultra-violet illumination. **Plates 310, 311** showing original and replacement boards from different restorations joined along a joist line: the UV light emphasises the different repaints. **Plates 312, 313** detail of a figurative lozenge with an 1830s replacement board and repaint surrounded by original boards with 1740s repaint. **Plates 314, 315** an original grooved board with 1740s grey chevron pattern repaint next to a replacement board which appears to have at least two layers of repainting. The uppermost paint layer appears much thicker than elsewhere (for detail see **Plate 336**). **Plates 316, 317** show a replacement board with an opaque white surface bloom on an applied coating over the black paint. No other board within the Eastern Bay has this surface effect.

FLAKING PAINT

Plates 318 to 325 In many instances loose paint on the figurative lozenge boards was difficult to identify even with raking light. **Plates 318, 319** detail before and after paint re-attachment and surface cleaning. Here much of the red and green background paint was detached from the support but had not lifted to form the much more easily identifiable flakes shown before and after treatment in **Plates 320, 321**. **Plate 222** depicts another example of delaminated green background paint before reattachment: although hard to illustrate even with close detail in severely raking light, much of this section of granular green paint was detached. **Plate 323** shows a typical instance of micro-flaking of thin repaint on an original board: this deterioration probably caused by localised water infiltration. **Plates 324, 325** details, before and after paint re-attachment, a section deteriorated original board: the relatively thick 1740s paint layer had lifted from the decayed timber surface. Notice the adjacent, much darker black 1830s repaint covering the 1740s layer.

Plates 326 to 333 **Plate 326** detail of decoration within the Janus lozenge, before treatment with raking light: it illustrates both the granular paint surface and micro-flaking. **Plate 327** an example of 1740s paint loss from an original board following the pattern of the medullary rays: it suggests the paint surface was perhaps washed down in the 1840s resulting in loss of paint weakly adhered to the smooth, denser wood. **Plate 328** a detail with raking light before treatment of the thin powdering paint layer on *Panel 40 III*. As yet it is not clear when these boards were put in place and decorated.

PAINT RE-ATTACHMENT

Plates 329 to 333 - **Plates 329, 330, 331** with raking light before, during and after treatment: detail of flaking paint on a nail head. The flaking paint is infused with two applications of Paraloid B72 (10% in acetone);.once the solvent had evaporated a localised heat source (Preservation Pencil) was applied to the flakes relaxing them sufficiently and enabling them to be pressed back into place with a small spatula. **Plates 332, 333** small drops of Plextol B500 (5%) being injected behind flaking paint after relaxation of the paint layer and pre-wetting with IMS. The paint flake is pressed back with a small pad of cotton wool wrapped Japanese tissue; this absorbs any excess adhesive.

SURFACE ACCRETIONS

Plates 334 to 337 Residues of what may be three forms of microbiological growth were found on the paint surface. These residues are widespread across the Ceiling and will be analysed as part of the Phase 2 investigations. **Plate 334, 335** details before and after surface cleaning: faint traces of these light brown flecks remain after cleaning with a Wishab sponge. **Plate 336** a purplish powder residue on the thick impasto paint (also detailed in **Plates 314, 315**). **Plate 337** shows a white bloom or stain on the paint not removed by surface cleaning with Wishab: the fine tendrils suggest this results from microbiological growth.

Plates 338 to 339 Before and after surface cleaning and paint re-attachment The 'white chalk line' form of efflorescence depicted here occurs on a number of the original, wave pattern boards with the matte, saturated, black paint from the 1830s.. Localised water infiltration has resulted in extensive micro-flaking and some loss of the black paint; the off-white paint is unaffected except for a tide mark of salts efflorescence at the interface. Preliminary analysis results indicate at least two different salts are present: chloride and sulphate. Further examples of this phenomenon are shown in **Plates 365, 366, 367**.

Plates 340 to 341 Before and after treatment. The paint layer has been scorched on this one board alone. This damage is on *Panel 39 II*, close to tower wall, and probably occurred during the 1880s rebuilding.

STAINING

Plates 342 to 349 There are a number of different categories of staining, all resulting from liquid material penetrating down between the boards or through cracks in deteriorated boards. A number of boards in *Panel 36 I* have whitish opaque drip trails across the paint surface (see **Plate 166**); these appear to be water damage. **Plates 342,343 (UV)** show a dark stain over the 1830s repaint. It is probably a preservative material used to coat the roof timbers. Analysis results of samples taken from stains are not available at the time of writing. **Plate 334** shows staining from a clear liquid that has penetrated a replacement board. The brown stain shown in **Plate 345** has come through the thickness of the paint. **Plates 346, 347, 348** - before and after treatment and UV - show a major spillage of dark liquid material occurred above these boards. In this instance, much of the residue was removed and the stain reduced using acetone swabs. **Plate 349** shows characteristic light-brown drips on the edge of an original board: these occurred in a number of places across the Eastern Bay.

SURFACE GLUE

Plates 350 to 356 **Plates 350, 352** before treatment and with ultra-violet illumination, show glue drips across the surface of canted replacement boards: the glue has contracted causing the underlying paint to flake. **Plate 351** shows the same area after surface cleaning, paint re-attachment, glue removal and reintegration. **Plates 353, 354, 355, 356** before treatment with raking light and ultra-violet illumination, show typical examples of the extent glue - used to adhere hessian to the Ceiling boards upper side - has penetrated between the boards and covered the board edges. Ultra-violet light is particularly helpful when checking for glue residue.

Plates 357 to 369 **Plates 357, 358, 359, 360** with raking light show areas with thick deposits of glue on the paint surface before treatment and after surface cleaning, glue removal and reintegration. Although the glue had contracted sufficiently in both cases to lift from the surface, the underlying paint had not flaked. Watercolour reintegration on the off-white paint after glue removal is just visible in **Plate 358**. In addition, notice in **Plate 357** the underlying trefoil design in relief as well as the suspected microbiological growth residue on the black paint (this is similar to the residue depicted in **Plate 334**). **Plates 361, 362, 363, 364** before treatment, with ultra-violet illumination, during and after treatment, show a section of deteriorated and damaged wave pattern board with glue drips on the surface. **Plate 363** shows the overcleaned off-white paint before reintegration with watercolour. In **Plate 364** the overcleaned off-white paint has been toned down and small areas of wood loss resulting from insect attack have been filled. **Plates 365, 366, 367** with raking light show stages of glue removal and surface cleaning on a section of original, glue affected, canted boarding: notice the salts efflorescence at the interface of the black and off-white paint. **Plate 368** shows the same area following treatment. **Plate 369** shows overcleaned white paint on the edge of a board following glue removal but before reintegration.

Plates 370 to 376 Examples of paint flaking caused by surface glue. **Plates 370, 371, 372** a section of the lions lozenge before treatment, with ultra-violet illumination and following treatment. **Plate 373** is a close up detail of the affected area showing the curled up paint flakes and surface glue: **Plate 374** a repeat after glue removal and paint re-attachment. **Plates 375, 376** Detail of curling paint caused by surface glue on the edge of a lozenge board shown before and after treatment.

SURFACE CLEANING

Plates 377 to 389 Sections of the Ceiling decoration during surface cleaning using Wishab sponges. This method of cleaning without the use of solvents achieves a uniform and acceptable cleaning level without causing the paint surface to shine. **Plates 386, 388** close up details, with raking light, of the partially cleaned Janus and Lions lozenges and **Plates 387, 389,** the same areas after treatment, show that this cleaning method does not abrade the granular paint surface.

HIRST CONSERVATION CLEANING TESTS

Plates 390 to 394 Many of the cleaning tests carried out by Hirst Conservation in 1995 using a wide range of solvents were still visible after the paint surface had been cleaned with Wishab sponges. **Plates 390, 391, 392** show the main area of tests before surface cleaning, with ultra-violet illumination, and during cleaning. **Plate 393** the tests had to be reintegrated using watercolour paints. Plate 394 shows the test area following treatment.

ASHLAR BOARDS

Plates 395 to 406 Surface cleaning using Wishab sponges on the Ashlar board decoration had a pronounced visual effect. **Plates 395, 396, 397, 398** show sections during and after cleaning. Notice the red preparatory drawing in **Plates 397,398**: this was presumably carried out by W Stallard in 1838 (see **Plate 307**). Plates 399, 400, 401 before treatment, with ultra-violet illumination and following treatment depict an area of the north frieze decoration severely stained as a result of water infiltration and across the surface a single thick glue drip causing the underlying paint to peel. The disfiguring stains were resistant to Wishab cleaning and had to be removed with swabs of deionised water. The overcleaned the off-white background paint was then reintegrated using watercolour paint. **Plates 402, 403, 404** a large Hirst cleaning test and surrounding area on the south Ashlar boards: after surface cleaning with Wishab sponges, during reintegration, and following treatment. **Plates 405, 406** another section of decoration on the south wall frieze, after cleaning with Wishab sponges, showing surface staining before removal with deionised water; the same section following treatment.

APPENDIX 2

PETERBOROUGH CATHEDRAL
Report on the Structural Condition of the Nave Roof and Ceiling.
Leslie Moore (written circa 1920).

Following the examination of the Choir Roof, I have now inspected that covering the Nave with the aid of the electric light. The clear span between the clerestory walls is 35"3".

Externally the roof is covered with Westmoreland slating nailed to 3½" x 1¼" sawn deal Battens and torched between with hair mortar. The key of this between the battens and on the underside of the slating is poor in places and a quantity has broken away and fallen on to the ceiling below which is covered with fragments of this plasterwork and is very dirty on the upper surface. Doubtless one of the principal objects of this torching was to prevent draught, the roof being without boarding. In several places where the torching has come away daylight can be seen through the slating and this is the only ventilation the Roof has. Proper ventilation at the ridge and elsewhere is most desirable. Two hatchways into the roof exist, one from the North gutter near the central Tower, and one approximately midway in the length on the South side. Some ventilation might well be introduced by means of perforated panels in these doors which lead on to the gutters. The Temperature in the Roof now is excessive and the air stagnant.

West does not appear to penetrate the covering to any extent. The same remarks as to recent repairs with blue Welsh slates apply here, as in the case of the Choir roof.

The North and South gutters which are of lead laid on boarding and Oak bearers and plates are in a fair state, their preservation being largely due to the wood lath snow grids that cover them. These however are worn and in places in need of repair and preservation, especially in the North gutter which is a customary route for visitors. I would recommend that these unpainted wooden snow grids be made good and the whole treated with a wood preservative such as Solignum or Silvertown Solution.

The gutters themselves, in some places where the boards beneath have decayed and sunk, so that the water is held up, should receive attention. The pointing to the stone coping of the parapets and also to the gutter apron flashing must be mentioned, for in places this is defective and fallen out. A condition that should not be allowed to remain.

The constructional timber framing of the roof proper is of imported deal and was probably executed about 1830. A small quantity of old Oak was reused in the rafters. In the length from the Central Tower to the Western vaulted bay there are 26 main principals, 25 of which are all of the same design, being a well conceived type of scissor braced truss built up from the most part of coupled timbers of standard scantlings, large sectional timbers being thus avoided. These principals are well framed and bolted together and afford a good tie. Special large cast iron shoes bedded on stone templates built on piles were adopted at the foot of these trussed principals which are spaced from 8'-6" to 9'-6" centre to centre and are for the greater part of the length braced longitudinally.

The pitch of the roof is 53º. The plate to the common rafters (10" x 4") and the three sets of purlins are of a good section (8" x 4½ deal) for their span and are very fairly sound.

The same may be said of the common rafters (6" x 2") which are mostly of deal with some odd ones in Oak; the latter appear to have been mediaeval rafters cut down in section.

Generally speaking the trussed principals throughout are in a very fair state, but some immature sappy timber was used which has been extensively attacked by the small furniture beetle and though this may possibly not be regarded as serious in itself, such a condition in pine timber which is old and lost all its resinous matter renders it liable to attack by the larger beetle – Xestobium tessaltum – and other forms of decay. Dry rot and beetle are very often found closely associated in the same wood, the ill-ventilated conditions which conduce to the one being also favourable to the development of the other. Although the larger (Death Watch) beetle is rarely found in pine wood, clear evidence and proof of its attack on such soft wood has been found in the North Transept Roof.

In my opinion the structural timber of the Nave Roof which, with the exception of decay due to the smaller beetle, is generally sound, has now, owing to its age, reached that state when it is no longer free from attack by the larger beetle and other more serious and destructive forms of decay, and the infected sappy wood referred to should be removed and the whole of the timber thoroughly cleaned with wire brushes and treated with at least two coasts of Silvertown Solution to preserve it from further attack which, if permitted, would be difficult and very costly to remedy. One coat should be applied in the month of May followed by another in August.

Wherever practicable the solution should be applied by brush and spray being used in accessible parts in the same way as the North Transept Roof has been treated. The upper surface of the rafters and where beams abut the ceiling, treatment is impossible.

All existing ironwork, including the cast iron shoes to principals, should be cleaned and painted.

In the Western section of the Roof, namely that over the vaulted bay between the West Towers and over the Portico, there are six main principals. This portion of the roof is fairly well lit by the windows in the West Front. The principals are of a Queen post type of truss with horizontal tie beams, the ends of which, where bearing on the main walls, have received attention during the past year. Stone templates being substituted for decayed timber plates under the ends of the beams and other repairs executed. Under the slating of this part of the roof there is boarding and the general condition of the timber is good, though the need of ventilation and treatment for preservation is no less pressing.

The necessity for the boarded partition between this section of the Roof and that covering the wood ceiling is obscure, indeed it appears undesirable.

In examining this large Roof of big span, with its unique ceiling, one cannot but be impressed by – not only the need for periodic examination, but the facilities for doing so. The confined spaced between the angle of the roof and the sloping sides of the ceiling is difficult of access and a cramped position for executing repairs. The seatings of the principals are in such an enclosed position that even with Electric light they cannot properly be seen. I am strongly of opinion that some direct daylight is desirable at these important points, and it could be easily obtained by the introduction of glass slates. While not suspecting any defects here it is impossible to report on or be responsible for what cannot be seen. Daylight is one of the best preventives of disease in timber and inspection of these points, vulnerable by reason of the dark, ill-ventilated and possibly damp situation, would be rendered practicable from the external gutters.

The structural timbers of the flat boarded ceiling are of Oak throughout and were doubtless formerly framed in with the roof which the present structure replaced. The joists (8” x 5”) to which the diagonal boarding is nailed, are set about 2’ – 3” apart and run transversely. The old Oak joists have at some time been attacked by both the large and small beetle and the ends of most are badly decayed.

At the present time these joists to the flat portion of the ceiling are suspended by bolts to (10½” x 4” deal – 3 to each bay) longitudinal beams bearing on the tie beams of the roof principals. This method of hanging the ceiling was adopted on the re-construction of the roof and at the same time some of the Oak ceiling joists were repaired, but, owing to the difficulty of removing the decayed joists and attaching the ceiling to new, strengthening timbers and in about six cases the added timber is now infected with decay from the older. In these instances both should be removed and replaced with new creosoted joists.

The Oak joists (6” x 4¾”) of the sloping sides of the ceiling are themselves in a fairly sound condition generally speaking but are very weak structurally. At both ends of these the halvings indicate that they were formerly framed to horizontal and vertical timbers at the top and bottom respectively, but at the present time they are merely hung from the roof and supported by short lengths of odd timber of a smaller section than themselves. This is most unsatisfactory especially as in by far the majority of cases the small timbers are in varying states of decay and are only nailed. This particular work is “rough and ready” workmanship (probably executed under difficulty with only light from lanterns) and the stability of the sloping ceiling joists cannot now be regarded as secure.

I recommend that the attachment of these joists at both ends by means of new strengthening timbers to each is very necessary and can be executed without much difficulty or any interference with the ceiling by means of new 5” x 3” creosoted deal timbers about 14 feet long coach screwed and bolted to the existing joists, and having a bearing on a new plate on the top of the wall and on the existing longitudinal beam at the angle of the ceiling. By this means the ceiling will be detached from the roof rafters. All the structural timber of the ceiling should be treated with Silvertown preservative solution as the roof.

The upper surface of the boarded ceiling itself is very dirty – as far as can be seen it is apparently free from decay. Many stiffeners to the boarding have been added from time to time in a haphazard manner and repairs executed in places. Being nailed upwards to the underside of the joists the condition of the nails is impossible to examine without scaffolding, but clearly no weight should be imposed on it and the fallen plaster work ought to be removed and the whole area cleaned.

APPENDIX 3

PETERBOROUGH CATHEDRAL NAVE CEILING - PHASE 1: PRE-TREATMENT CONDITION SURVEY – BOARDS

Panel No: 36 11

DESCRIPTION										JOINTS				CONDITION								
			Softwood							Scarf			Butt		Decay	Displaced		Repositioned				
Board No.	Orig/Rep/Pat	Wood type *Oak/Softwood*	*Smooth*	*Rough*	*Sawn*	Tapered	Lozenge Brd	Edge *Rnd/Straight*	Grooved	*Long Board*	*Scarf Length*	*Scarf to*	*Jointed to*	Insect Dam. *CBF/DWB*	*0-30% 30-70% 70-100%*	*mm*	*N/S/E/W*	*mm*	*N/S/E/W*			
A	O	O	/	/	/	T	L	R	/	/	/	/	/	/	/	/	/	/	/			
B	O	O	/	/	/	T	L	R	/	/	/	/	/	C/F/B	0-30	/	/	/	/			
D	O	O	/	/	/	T	/	S	G	/	/	/	/	C/F/B	0-30	/	/	/	/			
E	O	O	/	/	/	T		R		/	/	/	/	C/F/B	0-30	8	N	/	/			
F	O	O	/	/	/	T	/	S	/	2120	45	G	/	C/F/B	0-30	/	/	/	/			
G	O	O	/	/	/	T	/	S	/	/	/	F	/	/	/	/	/	/	/			
H	R	S	S	/	/	T	/	S	/	/	/	/	J1	/	/	/	/	/	/			
J1	O	O	/	/	/	T	/	S	G	/	/	J	H	C/F/B	0-30	/	/	/	/			
J	O	O	/	/	/	T	/	S	G	2120	100	J1	/	C/F/B	0-30	/	/	/	/			
K	O	O	/	/	/	T	/	CHA	/	/	/	/	L	C/F/B	0-30	/	/	/	/			
L	O	O	/	/	/	T	/	CHA	/	1675	95	M	K	C/F/B D/W/B	0-30	/	/	/	/			
M	O	O	/	/	/	T	/	CHA	/	/	/	L	/	C/F/B	0-30	/	/	/	/			
N	R	S	S	/	/	T	/	S	/	/	/	/	P	C/F/B	0-30	/	/	/	/			
P	O	O	/	/	/	T	/	S	G	1540	165	Q	N	C/F/B	0-30	/	/	/	/			
Q	O	O	/	/	/	T	/	S	G	1770	/	P	/	C/F/B	0-30	/	/	/	/			
R	R	S	S	/	/	T	/	CHA	/	/	/	/	S	/	/	/	/	/	/			
S	O	O	/	/	/	?	/	?	/	2040	?	T	/	C/F/B	0-30	/	/	/	/			
T	O	O	/	/	/	?	/	?	/	/	?	S	/	C/F/B	0-30	/	/	/	/			
U	R	S	S	/	/	T	/	S	/	/	?	T	/	/	/	/	/	/	/			
W	O	O	/	/	/	T	/	S	G	/	/	X	/	/	/	/	/	/	/			
X	O	O	/	/	/	T	/	S	G	2060	100	W	/	C/F/B	0-30	/	/	/	/			
Y	R	S	S	/	/	/	/	S	/	/	/	/	/	/	/	/	/	/	/			
Z	O	O	/	/	/	T	/	CHA	/	2090	90	AA	/	D/W/B	0-30	/	/	/	/			
AA	O	O	/	/	/	T	/	CHA	/	/	/	Z	/	/	/	/	/	/	/			
BB	R	S	S	/	/	/	/	S	/	/	/	/	/	/	/	/	/	/	/			
CC	O	O	/	/	/	T	/	S	G	2140	105	CC1	DD	C/F/B	0-30	/	/	/	/			
DD	O	O	/	/	/	T	/	S	G	/	/	/	CC	/	/	/	/	/	/			
CC1	O	O	/	/	/	T	/	S	G	/	/	CC	/	/	/	/	/	/	/			
EE	O	O	/	/	/	T	/	S	/	/	/	/	/	C/F/B	0-30	/	/	/	/			
FF	O	O	/	/	/	T	/	R	/	/	/	/	/	C/F/B	0-30	/	/	/	/			
GG	O	O	/	/	/	T	/	S	G	/	/	/	/	/	/	/	/	/	/			
HH	O	O	/	/	/	T	L	R	/	/	/	/	/	D/W/B	0-30	/	/	/	/			
JJ	O	O	/	/	/	T	L	R	/	/	/	/	/	/	/	/	/	/	/			

Panel No:

Board No	Observations
A	Good, one shot pellet hole.
B	North end spit by nail and loose - unstable, also spit on W. edge.
D	Small amount of C/F/B otherwise good.
E	Apart from displacement, good.
F	Small amount infestation S. end, W. edge of board, F scarfed over G.
G.	Good.
H.	Good.
J1	one C/F/B hole only on face, saw cut between H and F
J	producing screw N. end causing split, otherwise good. J scarfed over J1
K	Good.
L	Good, board J shrunk back on W. edge showing 12mm paint line on board L. (L SCARFED OVER M)
M	Good, board J shrunk back on W. edge, showing 12mm paint line on board L.
N	Good, some shot pellett holes.
P	Good, some shot pellet holes. P scarfed over Q.
Q	Badly split N. end, timber pushed upwards 18mm from face, behind bolt washer
R.	Good.
S	Base board, S scarfed over T. Good.
T	Base board, Good.
U	Good.
W	Good, a dozen or so shot pellet holes.
X	Good. board X scarfed over W.
Y	Good except for damage (see BB)
Z	Good. board Z scarfed over AA.
AA	Good.
BB	Board BB broken off board Y and secured with one nail.
CC	Board split around bolt - this board has the new S/steel bolt though it
DD	Board DD originally part of CC, held by one nail, unstable
CC1	Good.
EE	Infestation on N end E edge, otherwise good.
FF	Apart from slight C/F/B good.
GG	Good.
HH	Good.
JJ	Good.

APPENDIX 4:

Peterborough Cathedral Nave Ceiling - Phase 1 (1998)
Pre-Treatment Condition Survey

Panel No: 36/II Sheet 1 of 2

Board No.	**Pattern**	**Replace-Ment** ✓/*x*	**Visible Underpaint** *F/T/S/K/W*	**Paint** *Blooming/Staining/Flaking/Loss/Other*
a	Head of Janus	?		Possible re-used original board. Flaking and delamination at junction with 37/II. Black on mouth is repainted and blooming.
b	Edge of Janus	X		Flaking black paint on head outline. Minor blooming on red background, especially on apparent cleaning test. Glue and peeling paint through split to W edge. Brown paint of collar is very gritty and slightly powdering.
d	Key	X		Flaking black on collar and along continuous black line of key pattern. Isolated spots of brown mottling. Minor glue drips on W edge. spots of efflorescence on continuous black line
e	Wave	X		Blooming general on black. Glue drip peeling to centre. Heavy accumulation of sooty dirt at S, junction with 36/III.
f	Step chev	X	Step chev	Traces of stepped chevron underpaint = repainting. Blooming all along W edge. Patches of efflorescence on metallic sheen on black paint. Delamination at S end.
g	Apex deco.	X		Spot of efflorescence on metallic sheen and on nail head.
j	Grey chev.	X		Delaminating paint layer over all black/grey. Patchy blooming especially at N end. Glue penetration on W edge. Medium-thick white impasto, applied with random brush strokes.
j1	Grey chev.	X		Scarf joint to ‘j’. Delamination and loss on grey paint. Glue penetration through nail hole.
h	Ext. chev	✓		Patch: no attempt to match adjacent design. Glue drips and peeling paint on W edge. Background paint on earlier wood loss.
k	Ext. chev	X		Patch of ‘thick’ blooming at junction wth’l’; minor blooming on apex decoration at S. Glue drip through nail hole. Possible water penetration and associated dirt at junction with ‘l’.
l	Ext. chev	X	T	Upright trefoil type. Water ‘stain’ to S. Extensive brown mottling over all black paint.
m	Ext. chev	X	T and S	Upright trefoil type and scroll at N apex. Extensive mottling over all black.
n	Bands	✓		Staining penetration through knot holes. Lead shot holes. Decoration doesn’t match up and therefore = reused board. NB This is the only board in this immediate area with shot damage which identifies it as a reused board.
p	Bands	X		Patches of blooming on black paint. Glue penetration through splits to S end.
q	Bands	X		Isolated patches of blooming on black. Brown mottling especially at N end: some ‘tendril-like’ (MBG?)
r	Plain brown	✓		Patch repair over ‘n’, ‘p’ & ‘s’
s	Base board	X		Extensive delamination of paint layer – numerous losses at S end. Glue drips at junction with ‘u’. NB Scroll raised/underpainted design is followed by overpaint. Trefoil at S has been painted out with black.
t	Base board	X		Minor delamination to S. Patchy blooming.
u	Base board	✓		Patch repair – crude insertion: no attempt to reconstruct apex scroll decoration. Extensive glue penetration on W edge
w	Bands	X		Serious glue peeling paint on E edge to S.
x	Bands	X		Extensive brown mottling at N end: ‘tendril-like’. Visible bare wood at junction with ‘aa’ = displacement of ‘aa’. Extensive glue penetration and peeling paint layer along E edge.

Peterborough Cathedral Nave Ceiling - Phase 1 (1998)

Pre-Treatment Condition Survey

Panel No: 36/II Sheet 2 of 2

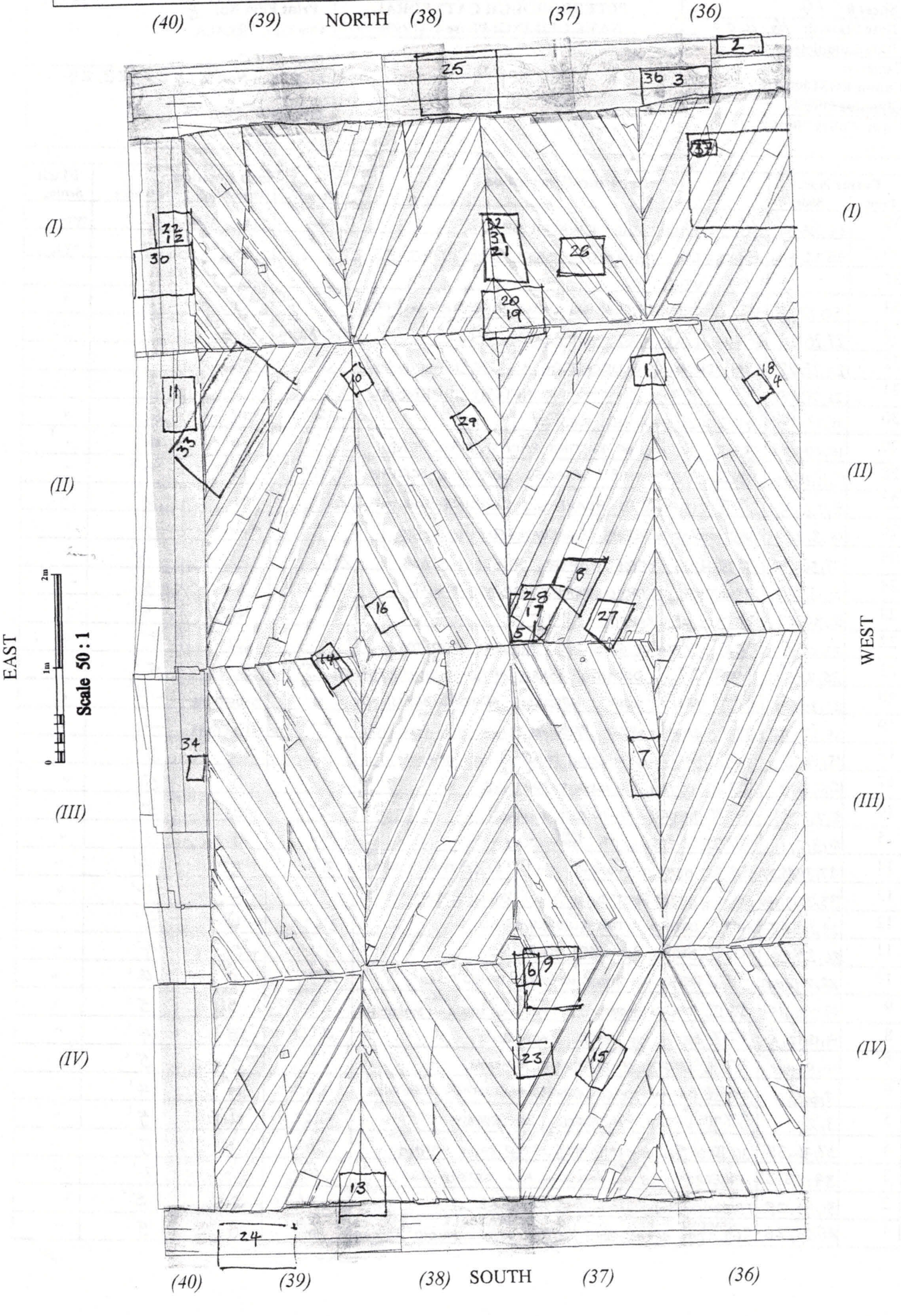
Board No.	**Pattern**	**Replace-Ment** ✓/*x*	**Visible Underpaint** *F/T/S/K/W*	**Paint** *Blooming/Staining/Flaking/Loss/Other*
y	Numerous	✓		Patch strip covering/bridging numerous boards. Very crudely inserted and painted.
z	Ext. chev	X	T	Upright trefoil type. Extensive brown mottling especially at S. Thick, compacted dirt (?) at centre junction with 'cc'. Blooming at S apex.
aa	Ext. chev	X	T	Continuation of upright trefoil type. Board slightly displaced at joint with 'z'.
bb	Plain background	✓		Large splintered piece of 'y'.
cc	Grey chev.	X		Minor delamination at centre. Patch of blooming at N. Minor losses of paint layer. Peeling glue drips along E edge and through split at S. 'Thin' white impasto – design unclear.
cc1	Grey chev	X		Tip of 'cc' – scarfed joint & therefore original
dd	Grey chev	X		Broken end of of 'cc'. Considerable paint layer loss. Small patch of efflorescence. Single peeling glue drip.
ee	Step chev	X	Step chev	Shadow of step chevron design beneath. Slight bloom along E edge. Small patch of efflorescence on metallic sheen at S. Minor delamination at N end.
ff	Wave	X		Extensive efflorescence over black, especially on leading edge of wave. Paint micro-flaking over all, especially on edge of wave. Thick, peling glue drips at N end and minor glue at centre.
gg	Key & loz.	X		Confused key pattern (hammer-like). Extensive flaking of black outline to foliate motif, especially at N end.
hh	Foliate loz.	X		Extensive delamiinating and flaking of black, green & red paint. Severely peeling glue drip.
jj	Centre of loz.	X		Red & black paint flaking badly.

APPENDIX 5

Sheet # 14 **Date Started:** 16-4-98 **Date Completed:** – Cameras: **Canon EOS1000 FN** ~~**Olympus OM1N**~~ Flash: **Cobra 700 AF**	**PETERBOROUGH CATHEDRAL** **NAVE CEILING: Phase 1 (1998)** Comments:	**Print Film No:** 8 **Film Type:** REALA **ISO:** 100 **Slide Film Nos:** 21, 22, 23, 24 **Film Types:** PROVIA **ISO:** 100

Frame Nos. Print	Frame Nos. Slide	Location/Description	Flash Position Height	Flash Position Orientation	Flash Position Distance	Flash Setting
37	36,35,34	36/I : WITNESS AREA & WATER DRIPS	—	SIDE ARM	—	TTL
36	33,32,31	FRIEZE (N): STAINING – FOR CLEANING TEST	4'	W	7'	TTL
35		VOID				
34	30,29,28	40/III : DETAIL OF FLAKING & POWDERING & BLOOM/EFFLOR.	7'	S	4'	"
33	27,26,25	39/II : 'DIRTY' WASH OVER BOARDS 'd & e'	FLOOR	N/E	4'	"
32	24,23,22	37/I : DETAIL OF GLUE ON EDGE, BEFORE CLEANING DIRT	5'	W	5'	"
31	21,20,19	" —— " —— AFTER DIRT REMOVAL				
30	18,17,16	40 I CLEANING RESULT	– 2'	N	6'	"
29	15,14,13	38 II DETAIL OF RUSTING PAINTED NAIL HEAD	3'	N	4'	"
28	12,11,10,9	37 ~~38~~ II DETAIL OF DISPLACED BOARD & SCREW	5'6"	N	6'	"
27	8,7,6,5	37 II DISPLACED BOARD & DISPLACING SCREW	5'	N	6'	"
26	4,3,2,1.	DETAIL OF SCREWS (GALVANISED AND STEEL)	4'6"	S.W.	4'	"
25	37,36,35	CLEANING – BEFORE & AFTER, FRIEZE N. WALL	2'6"	E	4'	"
24	34,33,32	SIGNATURE UNDER OVERPAINT FRIEZE S. WALL	3'	W	5'	"
23	31,30,29	DETAIL OF GRAFFITI 37 III	3'	N.W.	4'	"
22	28,27,26	40 I DETAIL OF GLUE DRIP THROUGH KNOT HOLE	3'	W	5'	"
21	25,24,23 22	~~40 II~~ 37 I DETAIL OF BOARDS AFTER GLUE DRIP REMOVAL	5'	S.W.	5'	"
20	21,20,19	37 I 'MAN AT WORK' INJECTING ADHESIVE BEHIND FLAKE	—	SIDE ARM	—	"
19	18,17,16	37 I 'MAN AT WORK' PRESSING FLAKE INTO POSITION	—	SIDE ARM	—	"
18	15,14,13	36 II DETAIL OF FLAKING PAINT ON NAIL HEAD	4'6"	N	5'	"
17	12,11,10,9	37 II DETAIL OF INSECT DAMAGE	2"	S	5'	"
16	8,7,6,5	38 II DETAIL OF INSECT DAMAGE	2"	S	5'	"
15	4,3,2,1	37 IV DETAIL OF ~~DRY~~ WET ROT	4"	S.E.	5'	"
14	37,36,35,34	39 III DETAIL OF WET ROT IN CENTRAL LOZENGE	2'6"	E	4'	"
13	33,32,31,30	38 IV & 39 IV JOIN SHOT DAMAGE (NOT ON LATER BOARDS)	0'	E	4'	"
12	29,28,27	40 I DETAIL AFTER GLUE REMOVAL	2'6"	W	5'	"
11	26,25,24	40 II DETAIL OF INSET REPAIR	6"	S	4'	"
10	22,21,20,19	39 II DETAIL OF PAINT UNDER REMOVED BOLT	2"	S	4'	"
9	18,17,16,15	37 IV DENDROCHRONOLOGY WOMAN AT WORK PREPARING GRAIN ON BOARD EDGE	2"	W	5'	"
8	14,13,12,11	37 II DETAIL OF OPENED SCARF JOIN	5'6"	S	4'	"
7	10,9,8	37 III DETAIL OF DRIP/STAIN REMOVAL	1'	S	5'	"
6	7,6,5,4	37 IV DETAIL OF GALVANISED AND OTHER SCREWS	4'6"	N	4'	"
5	3,2,1	37 II DETAIL OF SCROLL UNDERPAINT	5'6"	N.E.	5'	"
4	37,36,35	36 II DETAIL OF NAIL HEAD AFTER PAINT LAYING	4'6"	N	5'	"
3	34,33,32	FRIEZE (N) : AFTER STAIN REMOVAL AND RETOUCHING	4'	W	7'	"
2	31,30,29	FRIEZE (N) 36 I DETAIL OF SIGNATURE	3'	S.E.	5'	"
1	28,27,26	36 II 37 II JUNCTION CEILING BOLT, HALF TREATED WITH 5% PARALOID IN ACETONE	6"	S	5'	"

Sheet No: 14 Print Film No: 8 Slide Film Nos: 21-24.



APPENDIX 6: PHOTOGRAPHIC EQUIPMENT AND GRAHPICS SOFTWARE

Photography

Cameras	2 x Canon EOS1000 FN
Lens	2 x Canon 28-105 AF
Flash	Cobra 700 F
Slide film	Fuji Provia 100
Print film	Fuji Reala 100
Slide film for UV photography	Fuji Provia 1600

All visible light photography was carried out using the Cobra 700 F flashlight either on or off camera. Photography under UV illumination was carried out at night using 4 CLE blacklight long-wave, ultra-violet tubes (4 ft). A Lee UV2B filter together with a Hoya Haze-UV filter were used on the camera lens for all UV photography.

Software

Graphics Corel Draw 7.

Word Processing Microsoft Word, Version 6.