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HIRST

Conservation

NAVE CEILING, PETERBOROUGH CATHEDRAL

Report on the painted wooden Nave Ceiling
of Peterborough Cathedral.

"...one of the very few, and for that reason, very important painted wooden ceilings which still remains in Europe from the twelfth and thirteenth centuries."

Folke Nordstrφm

"...a marvellous example of English Medieval Art."

Eve Baker

OCTOBER 1995

NAVE CEILING,
PETERBOROUGH
CATHEDRAL

ABSTRACT

This report details the results of an investigation of the Eastern bay of the Nave Ceiling at Peterborough Cathedral taking into account comments from other specialist reports. The fabric of the ceiling is described and evidence of previous interventions considered. The condition is assessed and a conservation strategy proposed. The recommendations are presented in the form of a discussion document for further debate. Photographs, diagrams, drawings, photomicrographs and results of analysis are included as appendices.

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1 INTRODUCTION

1.1 The Survey

Hirst Conservation undertook the survey during the months of April to July 1995. Elizabeth Hirst, Deryk Brown, Paul d'Armada and Andrew Hirst and other consultants representing Hirst Conservation were involved in the investigation, analysis, recording and preparation of this report. Julian Limentani (Cathedral Architect), Gillian Lewis (Conservation consultant), Don Mackreth (Archaeologist, Peterborough Cathedral), Andrew Durham (English Heritage) Barry Knight, Ken Waterman and David Imison (English Heritage - monitoring), David Goode (Structural Engineer) Barry Singleton, (Morley College), Julian Mumby (Medievalist, Oxford) all made contributions to this report. We are grateful to Nick Drewett (Head Verger) and the Cathedral Staff for their help and support with this survey.

Hirst Conservation would like to thank the Dean and Chapter for this opportunity to study this important painted ceiling.

1.2 Access

Scaffolding was made available for the survey. This spanned the width of the nave, close to the east end wall was 3 m wide and 1.5 m from the east wall (see Appendix C for diagram). The results, conclusions and recommendations of this investigation cover the specific area of the ceiling accessible from the scaffolding. The area was gridded out with string in $1m^2$ for reference purposes. The roof space investigations have been confined to the area between the first and second roof trusses. However, the results and recommendations included in this report provisionally apply to the whole ceiling. See the photomosaic (approximate scale of 1:7).

1.3 The Scope and Aims of the Survey

The principal aims of the survey are as follows:

- To provide a description, primarily technical rather than art historical, and to incorporate a structural survey, of the ceiling based on what could be ascertained from the access available and from other recent specialist reports.

- As part of such a description to identify and describe the full range of materials and fixing methods in the sample area.

- To identify, where possible, the scope and nature of previous interventions.

- To provide a photographic record of the sample area.

- With particular reference to the painted surfaces to take and analyse samples in order to attempt to identify the pigments and media present.

- To note causes for concern with respect to the condition of the ceiling.

- To present a proposed conservation approach, in order to form a basis for further discussion.

2 DESCRIPTION

2.1 General

The nave ceiling is constructed of timber and is painted in a decorative scheme. It spans 10.7 m (35 ft) across the ceiling and is approximately 62.2 m (204 ft) in length. The panelling has a flat central section and is canted along the north and south sides (see diagram). The full width of the ceiling if flattened out would be approximately 13.7 m. The total area is approximately 660 m2 and is divided into 20 bays, each containing eight diagonally boarded panels (or two full diamonds). Although it might be expected that these bays would align with the roof trusses supporting them this is not the case; there are twenty-six trusses to the twenty bays. There is also a further panelled strip to the east end of the ceiling. This disparity can be accounted for by relating it to the alterations outlined by D. F. Mackreth. (See frontispiece).

The nave ceiling is one of very few of the type remaining. Other comparable ceilings survive at St. Michael's, Hildesheim, Germany; St. Martin's, Zillis in the Grissons, Switzerland (c.1150); and at Dadesjo, Smaland, Sweden (c.1275) (Cave & Borenius, 1938, p.307).

Peterborough Cathedral as seen today is understood to be the result of 3 principal architectural phases, associated with Abbots William de Waterville, Martin de Bec and Benedict. The execution of the painting to the ceiling is thought to have been carried out during one or more of these phases.

2.2 Structural Aspects

2.2.1 General

From both above and below there are differences in the surface character, condition, preparations and types of timber boards as well as different fixings which indicate different periods of repairs. Medieval boards of cleft oak have often been grooved. The ceiling boards form a continuous, stepped diamond pattern (see plate I and II). A description of the roof space construction is best provided by diagrams and drawings. The nave roof has 26 trusses (spanning north - south), each with a scissor - brace construction.

2.2.2 Fixings

There are a number of different types of fixing visible.

Those visible from below: (see plates III and IV and V)

a) The earlier fixings are large cast iron clout headed nails, corroded (some heads no longer exist) and with signs of advanced creeping leading to loss of grip

approx. head diameter: 16 mm

approx. length: 60 mm

b) Smaller, clenched iron nails used to fix up the ceiling board edges at the point of overlap, refixing split elements and small repairs.

approx. length: 40 mm

c) Cut brad nails with small heads

approx. length: 75 mm

d) Only very few screw heads are visible from below, but many tips (both galvanised and corroded steel) can be seen - some pushing and splitting the timbers apart (19th and 20th centuries).

e) Very large, rusted bolts and washers visible (19th century). These have been fixed from below and some have overpaint on them so cannot date from the 1920's work.

head diameter 45 mm (10-15 mm deep)

rectangular washer dimensions 70 x 80 mm (x 8 mm deep)

Those visible from above: (see plates VIII to XIII)

a) Heavy iron bolts (1885?) from which the ceiling joists/beams are suspended which in turn are secured to heavy binders haunched over and fixed to the lower truss collars. Some of these offer no support to the ceiling which has risen by up to 10 mm at certain points.

b) Galvanized screws applied from above, downwards through the noggings which penetrate through the painted surface of the boards (1926). These generally give extra support to the longer ceiling boards.

approx. diameter: 6-8mm

approx. length: 120mm.

c) Steel (or galvanised) screws applied from above along some of the ceiling board edges, partially rusting and penetrating the painted boards (1926).
approx. length: 40 mm

2.2.3 Wood

There are a number of different types and periods visible:

a) i) Oak boards (probably Quercus pedunculata), riven and grooved possibly by a primitive plane or scratch stock giving 3 parallel grooves each 1mm deep and 10mm wide. these appear to be the earliest boards present. The bottom of the grooves may have been smoothed or filled at the painting stage as the surface is very smooth and regular. The grooves are considerably smoother than the rest of the boards, which have been left open grained and coarse.

ii) There also appear to be later oak boards.

b) Mahogany boards straight grained and thought to be later in date than the oak (1715 is the earliest known date of mahogany in Europe) .

c) Softwood boards (probably Pinus Silvestris), a European Redwood species; (Northern, Scott or Baltic pine). There are two kinds of softwood boards present, both fixed from below and both bearing overpaint from different phases of restoration. The later, unplaned boards show milling marks, visible through the paint layer and can only be as recent as the 1880's, and so the earlier, planed boards must date from the 1840's or earlier.

d) Softwood boards, laid horizontally, to the vertical faces at the north and south sides. These are planed smooth and directly abutt each other.

e) Positive identification of the wood could be achieved by taking appropriate samples and submitting them to the Timber Research and Development Association or another suitably equipped body.

2.2.4 Design

The boards which constitute the ceilings' diamond panel design are fixed overlapping each other, and are square edged and parallel. From this fact the order in which the boards were laid out and fixed can be deduced. The relative positions of the different types of fixing are illustrated by drawings in the appendices. Long, tapering (grey or black) boards were laid out first, followed by successively shorter, parallel boards, working towards the centres of each diamond. The vertical boards on the sides of the ceiling are all softwood and flatly abutted rather than overlapping. The fact that they are cut to fit around the ends of the sloping ceiling boards indicates that they are a later addition (or replacement).

2.2.5 Roof Construction

Timbers used within the roof space for ceiling carcassing and roof construction are also both hardwood and softwood, some of which show evidence of re-use. Oak joists/beams are present alongside those of softwood within the existing joisting system of the horizontal and sloping ceilings. The oldest elements are of oak with later repairs in both oak and European redwood. Built up joists may be of western red cedar. See drawings in appendix C.

2.2.6 Supports

There is evidence of much variance in the method of support given to the binders and ceiling joists. All ceiling joists are hung from binders with 25mm iron bolts, nuts and washers uppermost and with 220 - 440mm between binders and ceiling joists (see plate XI and overlay).

2.2.7 Noggings

There are many examples of diagonal softwood noggings (1926) between the joists/beams, running approximately square to the lay of the ceiling boards. Their details of construction vary, there are 6 or 7 different styles. All appear to have been built up of 2 or 3 wide boards laid flat on top of the ceiling boards, with stouter stiffening pieces fitted centrally on top of them and fixed to the joist sides. These stiffeners are of triangular or rectangular in section. The number of wide boards used depended on the size of gap between the ceiling boards and the undersides of the oak joists (see plate X).

2.2.8 Some effects of the 1920's work to the roof structure

Since Moore's repairs to the roofspace in the 1920's the area has been well ventilated. Also of note is the fact that some glazing was put in at both sides along the bottom which let some sunlight in.

2.2.9 Hessian backing

There is a coarse hessian backing over the backs of all the ceiling boards, visible from inspection of the roofspace. It is adhered throughout with animal glue size and can be removed with heat and moisture.

2.3 Painted Surfaces

2.3.1 General

Preliminary visual examination gives a rather confused reading of a ceiling with painted replacement wooden panels, overpainted older or original panels and a few areas which appear to bear only their original paint layer (see Appendix C large scale photo-mosaic).

In addition, the build-up of both surface lying and imbibed dirt and dust on the paint surface partially obscures the painted detail. This has presumably originated from a number of sources, the principal ones being:

- The Cathedral's central heating system
- Past burning of candles and incense
- General environmental pollution.

2.3.2 Quality

The quality of the repainting or overpainting is relatively crude, with clumsy outlines and colour mismatches, e.g. overpainted black areas have a blue-grey cast compared to the brown cast of earlier paint, this is only partially accounted for by changes in paint colour as it has aged.

2.3.3 Paint media

The ceiling has mostly oil paint visible on it today though some of the more friable black areas and green areas are likely to be proteinaceous paint e.g. glue-bound distemper or egg tempera. Comments were recorded during the 1740's restoration that some of the paint would come off the boards with a wet sponge. The ease of paint removal could have been due to the degradation of the paint media rather than its solubility in water.

2.3.4 Impasto

Earlier, overpainted paint layers are visible as impasto (seen in raking light) showing that changes in the design have occurred to specific boards. For example, zigzag and trefoil patterns have been overpainted, possibly indicating removal or reuse of boards.

2.3.5 Inscriptions/Graffiti

There are inscriptions in pencil on the south side of the sloping ceiling which read:

"M. Hatton (?). July 27th 1885."

and:

"J.B. Bullock (?) July 28th 1885." (see plate VI)

2.3.6 Candle marks

There are two small, circular soot marks with burns, on section D1 of the ceiling. It is thought that these were caused by naked flames, possibly candles, used during the 18th century restoration.

3 PREVIOUS INTERVENTIONS

3.1 General

There appears to have been approximately seven phases of repairs and restoration to the ceiling and roof structure, some of which have involved work to the painted surfaces.

3.2 Suggestions that the ceiling was intended to be temporary

It has been suggested that the painted wooden ceiling was originally intended to be a temporary structure, the suggestion supported primarily by architectural details (Mackreth 1995a). This question is open for discussion, as it may furnish arguments relating to the dating of the ceiling. It is beyond the scope of this report to discuss it in detail. However a summary of the salient points of Mackreth's argument are as follows.

a) The hood mould arch around the triplet openings on the clerestory have been inserted in bay 1 (next to the tower), whilst they are inbuilt to the rest of the nave. The haunching inside the clerestory wall was put in as the clerestory was built, shown by the fact that the ashlar rises over the vaulting. This could have constituted an early stage of support for subsequent vaulting, logically to have been followed by buttresses.

b) The ceiling was designed to fit the roof structure after the nave extension to the west, and was in place before the western closing arch was built, otherwise the boarding would probably have been erected on the eastern side of the wall.

c) The west end of the nave has springers for a stone vault. A temporary ceiling would be a logical construction measure prior to the erection of a stone vault.

The reason for this is that it would have provided temporary protection and cover until a stone vault was ready. However, whether the springers are original or not, or why they only exist at the west end are still outstanding questions. It may indeed be argued that, since the east end has been rebuilt twice any evidence of original intentions is long gone - or at the least considerably diminished .

d) Given that the chancel is not vaulted, why then consider vaulting the nave?

e) Timber ceilings were a feature of the great Roman churches e.g. St. Paul's outside the wall and the Old St. Peters (both 4th century precedents, and well known through the importance of the Roman church throughout the medieval period). These would have provided the model for church architecture throughout Christendom. However, from the 11th and 12th centuries onwards stone vaulted ceilings began to be built. This puts the building of Peterborough Cathedral in a transitional period when most patrons would probably have wanted to emulate the Roman "grand style" with a decorative wooden ceiling, but when stone vaulted churches were still being built.

f) The contemporary choir being built by William de Sens at Canterbury must have been very much in abbot Benedict's mind, not least because he had only recently come from there.

3.3 Structural

3.3.1 Probable dates

The dates of the major interventions seem most likely to be:

a) 14th century - original defects corrected, alterations made, crossing arches rebuilt

b) 15th century - clerestory fenestration and west porch built

c) 16th and 17th centuries - no conclusive evidence

d) 18th century - 1740's to 1750's - repainting of ceiling recorded (Pownall 1788).

e) 19th century - two phases; in the 1830's by Blore and in the 1880's when the central tower was rebuilt by Pearson, involving work to the east end of the ceiling. (Cave & Borenius 1938, p.1)

f) 20th century - in the 1920's the nave roof was rebuilt by Moore (no scaffolding) (Moore, c.1924).

3.3.2 Open joints

With reference to the open joints between the oak sloping ceiling and the horizontal ceiling joist. There is a lot to learn of the history and dating of the ceiling from further examination of the open jointing of the medieval oak work within the ceiling. A report by Don Makcreth states that the sloping ceiling and the horizontal ceiling joist were once part of the earlier roof construction. The sloping ceiling (sceiling) would have been the lower half of the original rafters whilst the horizontal ceiling joist would have formed the collars which framed out the earlier collar tie roof. Also, the higher or top half of the collar tie principles were at some time removed to make way for the earlier scissor beam roof (predating the one we see today). This seems to be a reasonable possibility.

3.3.3 Released joints

Attention should be drawn to the open jointing at the collar intersections to the rafters (now ceiling joists). By applying a horizontal saw cut, it can be observed that the top section of the roof could have easily been removed. The question is whether the joints remaining after this operation were opened up or deliberately released?

they deliberately released (see plate XIII). Some of the open joints are intact, but parted. Others are released by cutting a square cut a little way back from the position of the original joint and cut vertically down to the top side of the ceiling boards. The question is why? The reasons for this action, it appears, would have been the possible reuse of timber thus released or to straighten the "original" distorted structure. This would at least seem logical from a practical point of view. If the original roof was straightened at sometime in the past in the manner suggested here, the following questions arise:- were the ceiling boards removed for this operation or were they there prior to the straightening process of the old distorted roof carcass? If the rafter collars of the original roof remain in their respective position, an assessment should be made for evidence of associated roofing activity that may be displayed on the cheeks of these rafter/collars (now joists). None have been noted to date.

3.3.4 Straightening

With reference to the possible straightening of the "original" structure, if the roof (now the ceiling) were straightened in the past, one would assume that the line of intersection between 'straightened' and 'unstraightened' would display gaps and easings of joints. Could it be argued that the ceiling did not require attention in this manner and indeed has not had a straightening operation? Apart from decay, why cut away the jointing at the collar intersection or open up the jointing in such a way as to render it useless where a firm joint would be desirable? In fact it is most likely that the joints had to be opened as part of Pearson's repairs to the tower in the 1880's, since they only occur at the east end of the nave. A closer examination of the tops of the ceiling boards for evidence of saw scarring arising from the square cutting of the original roof collars (now ceiling joists) would be useful. It is highly unlikely that the sloping ceiling joists were removed from around the old rafter collar joint without scarring the boards, if the boards were in place at the time. This type of realignment described which may have occurred would surely have necessitated removal of the ceiling boards from the under side. If future assessment determines

there is no scarring of the ceiling boards around the released joints, the question then arises: were the ceiling boards there at the time of the "improvement" by 'possible' straightening?

3.3.5 Side panels

The side panels of the ceiling appear to have been cut to fit the boards of the sloping ceiling, which indicates that these side panels are of a later date. Cross sections seem to confirm this (see Appendix B).

3.3.6 Nogging details (see plates VIII and IX)

Further investigation is required to determine whether ceiling board fixings to the 1926 built up joists exist (see plate XII), and also whether the iron fixings were severed to release the original joists which were replaced. Bearing in mind that no evidence exists of a scaffold underneath the ceiling in 1926, then it is safe to assume that no upward fixings through the ceiling boards in to the new, built up joists, are in place. This would place greater structural reliance on the nogging system employed at the time. The new joists support the noggings which in turn support the ceiling boards. Some of the noggings appear to pass through the built up joists, indicating that they were fixed before the built up joists.

3.3.7 Summary of future research still required

Several areas of uncertainty are yet to be clarified:

a) The precise make up of its original construction.

b) Is the ceiling attached to the joists/beams by means of hidden fixings?

c) If iron fixings have been severed in the past to enable the removal of the earlier joists and if these severed nails are related to the vacated nail holes as seen from below?

3.3.8 Preservative treatment

There is no visual evidence of preservative treatment of the ceiling timbers, although heavy balks of the trusses and roof components were apparently treated in the 1920's. (Moore 1924?) No analysis of preservatives in the roofspace has been undertaken during the compilation of this report.

3.4 Painted Surfaces

3.4.1 The original work

The first painted scheme is thought to date from c.1220 (on art historical grounds), possibly commissioned by Abbot Benedict.

3.4.2 Documented comments

Documentary sources give some evidence relating to the history of previous interventions:

> "The first repainting was done about 1740 - 1750" (Pownall 1788).
>
> "Much repainting was carried out in the 18th century and again in the 19th century (1834-5)", (Baker, 1977).
>
> "£30 was paid to Charles Leyton in 1835 for repainting of the ceiling", (Cave & Borenius 1938).
>
> Parts of the ceiling (in 1745) were sufficiently robust to be wiped clean with a sponge without suffering damage (which indicates that these parts of the painting were in oils) but elsewhere the painting was said to be painted in distemper and it "came clean off the wainscot" (Pownall 1788, quoted in Simpson, 1995).

3.4.3 Extent of repainting

Observations made from the scaffold platform combined with the historical evidence outlined above, lead one to believe that much of what is visible today is repainted work dating from several periods. Limited areas of the earlier paint layer survive either visibly or beneath the later oil layers (see photomicrographs and analysis).

3.4.4 Degradation of paint

Over the bay examined from the scaffolding the most degraded areas, and the most detached from the substrate, appear to be the earliest paint. This may be as little as 5% of that visible in this bay. The earliest layers are notable for its relatively large pigment particle size, especially the green (see sample appendix). The paint surfaces have also been affected by size which must have dripped down from above during the 1920's work.

4 CONDITION REPORT

4.1 General

The overall condition of the roof structure supporting the ceiling is sound, although it has particular problems which require attention. The condition of the ceiling boards and their fixings is unsatisfactory. Previous repairs and restorations have kept the ceiling intact and in place whilst causing some damage. There are a number of loose nails and partially detached boards. Evidence of past insect infestation can be seen. The original painted scheme has been overpainted or replaced to a great extent, particularly at the east end. A breakdown of the findings of the survey should be cross-referenced with the large scale plan drawing (Appendix C) and the analysis of paint samples (Appendix B).

4.2 Structural

4.2.1 General

The overall roof construction and joisting system are in sound condition. The area of structural weakness that causes most concern is that of the condition of the ceiling boards themselves and that of the iron nails of three types, screws of two types and bolts of one type that secure them.

4.2.2 Cut Joists

The cutting away of the sloping ceiling joists at their junction with the horizontal ceiling joists gives added cause for concern. The joists thus relieved offer no continuity of support at the point of intersection.

4.2.3 Laminated Noggings

The purpose of laminating the 1926 repair noggings was probably to fill the differing gaps which had occurred between the ceiling joists and the ceiling boards, and to provide further support for the ceiling. Due to failing fixings which may have allowed the ceiling boards to move away downwards from the underside of the joists/beams. The laminated method of construction also offers advantages of lightweight individual pieces and ease of manageability in a difficult workspace. This, together with the fact that none of the 1926 screws are fitted from below strongly suggests that there was no scaffolding used during this particular phase of repairs. The noggings were fitted after the laying of the hessian to the top side of the ceiling boards.

4.2.4 Nail samples

Samples of the early cast iron clout headed nails were analysed by David Starley, Archaeometallurgist, English Heritage, with no conclusive analytical results. The typological dating gives scope for the nail to date from the Roman period to the 18th century (possibly a little later, though unlikely). The corroded condition of the nails was noted, as were the clenched points of the nails. Movement of the boards due to changes in relative humidity would put stresses on the nails, causing some degree of deformation to the wood and consequent loosening of the nails. This effect would in turn be counterbalanced by the clenched or bent points. It is also quite possible that some of the nails were never fully hammered into the timber.

4.2.5 Monitoring of board movement

Two "Scratch-a-tracks" were applied at two points on the ceiling to record any movement due to changes in temperature, relative humidity or structural movement. Throughout the survey no significant movement was noted.

4.2.6 Environment and Climate

English Heritage had set up a monitoring system to record changes in temperature and relative humidity at a point very close to the ceiling. The results from 10 January to 4 April 1995 and 5th April to 13th June 1995 were given. From the first set of results, the environmental conditions are within acceptable limits (mean temp. 16°C, mean RH 47%, both from ceiling height measurements). These figures and the report suggest that the environmental conditions are stable, with little temperature gradient between ground and ceiling. (English Heritage 1995a, English Heritage 1995b). It is understood that the recording will continue over a total period of fourteen months.

4.2.7 Heating

The heating in the Cathedral is provided by eight gas fired Gurney heaters. These were originally solid fuel and then oil fired until 1991. It has been cause for concern that the temperature near the ceiling may rise with a consequent effect of drying out the ceiling boards. However, the results of environmental monitoring suggested that this was not the case and that conditions are relatively stable. The principal changes in conditions from 1991 are a rise in average temperature of 4°C (at least that is the designed increase associated with the new heaters and a consequent drop of 20% R.H. This latter change, which has now stabilised if the environmental survey is to be believed, is most alarming and is likely to have been an immediate cause of loosening nails due to shrinkage of the wood.

4.2.8 Moisture content

A moisture test is understood to have been carried out on the wood itself in September 1994 and the result was that the wood had a moisture content of 11%. Moisture tests were undertaken by Hirst Conservation using a hand held moisture meter inserted some 10 mm into the wood during the survey period and recorded the moisture

content at between 11 and 14% over a range of timbers.

4.2.9 Hessian

The hessian backing was applied to the boards with the apparent intent to hold any loosening boards and provide a protection from penetration of dirt and moisture. The boards are still mostly held by the hessian though a few are not. The hessian has been a fairly effective moisture and dirt barrier and overall is currently, say 90% effective. However, the acidity of the glue size and hessian could cause problems for the wooden boards in the future and some of the smaller boards are not held by the hessian. A small section of the hessian backing to the ceiling timbers was removed using heat, moisture and scalpels. The swelling and reversibility of the adhesive indicated that this is an animal glue rather than casein. Chemical tests on the adhesive using Ponceau S stain confirmed the presence of protein, confirming the expected inference of animal glue. This material would also be in keeping with common practices of the period (1926). In addition, the reverse of the boards thus exposed were noted as being very friable. Obviously, at the present time the hessian prevents a proper evaluation of the condition of each board and its fixings.

4.2.10 Insect infestation

Insect attack has left some of the ceiling boards in a dangerous condition. There is evidence of beetle damage to several panels, for example the sloping ceiling on the south side (older, red painted panels). Large holes are visible, possibly large enough to be from deathwatch beetle. There is a slight possibility that some insect infestation is still active, even though no frass or beetle carcasses were seen, and should be further assessed. It should be noted that the main structure was replaced in the 1920's primarily due to insect infestation, so it is inevitable that some of the boards must have been affected too.

4.3 Painted Surfaces

4.3.1 General

Three main considerations informed the approach to the condition appraisal:

a) An appreciation of the known history of previous interventions, principally using the reports by Eve Baker (August 1977), Wolfgang Gartner (May 1988) and Don Mackreth (December 1994).

b) An integrated approach with the structural investigation.

c) An interpretation of the results of paint sample analysis (Appendix B).

d) Instrumental analysis of pigments could also be carried out by the National Gallery or English Heritage.

4.3.2 Paint condition

The condition of the visible paint is variable; the later overpaint is in good condition although yellowed, the earlier or original paint is underbound and flaking. The latest overpainting can only date from the 1880's, if there was no scaffold erected for the 1926 repairs. Furthermore, there are likely to be a fairly limited number of phases of restoration, given the expense and trouble of erecting scaffolding to the whole or part of the nave.

4.3.3 Glue size

There are traces of glue size on the surface of the boards, resulting from the application of the hessian in 1926. The fact that these obvious drips were not wiped off at the time further supports the supposition that there was no scaffolding in use at the time. The glue droplets have dried out, contracted and locally pulled the paint off the boards.

4.3.4 Overpaint / repaint

Variations in the colour of the overpaint are likely to be the result of the different periods of its' application, together with the differential effects of aging. In addition, the white paint on the newer (softwood) boards appears to have discoloured more than that on the older, grooved, oak boards. This became particularly evident during paint cleaning tests. The paint (c.1750 or 1885) has become orange-yellow on the more recent boards whilst it is yellow on the older boards. This may be due to the age and type of wood, although is also influenced by the type and number of undercoats / previous paintlayers. The variation in paint discolouration indicates that the wood or ground layers appear to have had some effect, perhaps due to the resinous material in the wood.

Evidence gleaned from cross-sections and analysis indicate the presence of a primer layer to softwood boards added later, though apparently none of any primer on the earlier oak boards (unless it was a thin glue-size).

5 CONSERVATION PROPOSALS

5.1 Preliminaries

5.1.1 General

The ceiling requires structural treatment to secure failing and loosening fixings and panels from below; the removal of unsightly screws (from the 1920's) penetrating through to below; and structural reinforcement from above. The painted surfaces may require cleaning, consolidation and possible overpaint removal. The recommendations included here are intended to form the basis for a discussion towards the writing of a specification. Any works carried out should be reversible as far as possible, and not prevent any future conservation works.

5.1.2 Recording

Recording of the conservation works should include the following:

a) Production of 1:20 scale plan drawings of the ceiling from above and below, recording the condition of the boards prior to conservation and forming a record of the works.

b) A written account of the works as actually carried out, including details of tests, materials, techniques and relevant historical information with sources.

c) A photographic record of the works in colour print, transparencies and black and white archive quality prints.

5.1.3 Instrumental Analysis

Instrumental analysis of a number of elements of the ceiling would provide invaluable hard evidence leading to more precise dating of the ceiling. These could include the following:

a) A dendro-chronological survey of the wood, including the earliest identifiable elements. English heritage are ready to carry this out.

b) Further photomicrographs, especially from areas to the west of the scaffolded area, should be examined.

c) Paint media analysis could be carried out e.g. by Gas Chromatography Mass Spectrometry (G.C.M.S.) or Fourier Transform Infrared Spectrometry (FTIR), or as advised by an appropriate body, i.e.the National Gallery.

d) Instrumental analysis of pigments by X-Ray Diffraction (XRD) or Energy Dispersive X-Ray analysis (EDX) could be carried out by English Heritage or the National Gallery.

5.2 Structural

5.2.1 Stainless Steel Fixings

The removal of unsuitable, old fixings will be required, although the extent needs to be further assessed and discussed.

The use of stainless steel for new fixings throughout is recommended. Screws, fixed from below should be used to replace those in sound timbers where there is enough body in the wood. These would provide a considerable improvement on the existing

fixings and ease of reversibility. The new fixings should, wherever possible, replace existing ones using the same holes, utilising washers to spread the load where necessary, in order to minimise the need for new holes to be made.

5.2.2 Other metal fixings

Other forms of fixing should be further considered and assessed. One possibility, which arose during on-site discussions (although with considerable reservation), might be the use of pneumatically fixed nails. This form of nailing, using a serrated nail, may offer a secure and slightly flexible fixing with minimal damage to the boards. The nail hole is about 1mm in diameter and is countersunk into the wood. The pneumatic action transfers energy down the nail itself and so there is little danger of bruising the wood and damaging the paint. The impact is directed through the nail and there is one impact only. However, these nails are not as easily reversible as conventional nails as the head lies below the surface of the wood. It is thus recommended that this radical method should be carefully tested before the possibility of its use can be considered any further.

5.2.3 Joinery / structural work

From a structural perspective, it is suggested that oak hangers could be placed alongside each joist to rise up by one face of the binder. These oak hangers could be haunched on the relevant two faces, one at each end. This would provide a tight fit between the haunched shoulders and the top/bottom of the joist/binder. 27 m per truss bay would be required. A further binder should be placed against the new oak hanger and under the binder/beam from which the ceiling is hung. This new binder should be haunched or packed with oak packers or folding wedges to distribute the loading evenly and prevent individual ceiling joists rising. When the oak hangers are securely fitted the existing bolts which are known to be loose and carrying little load could be gently tightened to allow them to work effectively, through drawing the joist and

binder into a firm contact with the hanger shoulders. The new binders should be bored with clearance holes and the existing joists bored with pilot holes to enable 12mm galvanised coach screws to be wound in and to securely hold binder and joist. All coach screws should be greased prior to tightening. Iron gusset plates or straps should be fitted across the open jointed ceiling joist end at the point of intersection between the horizontal and sloping ceilings. See drawings on p. 32-34

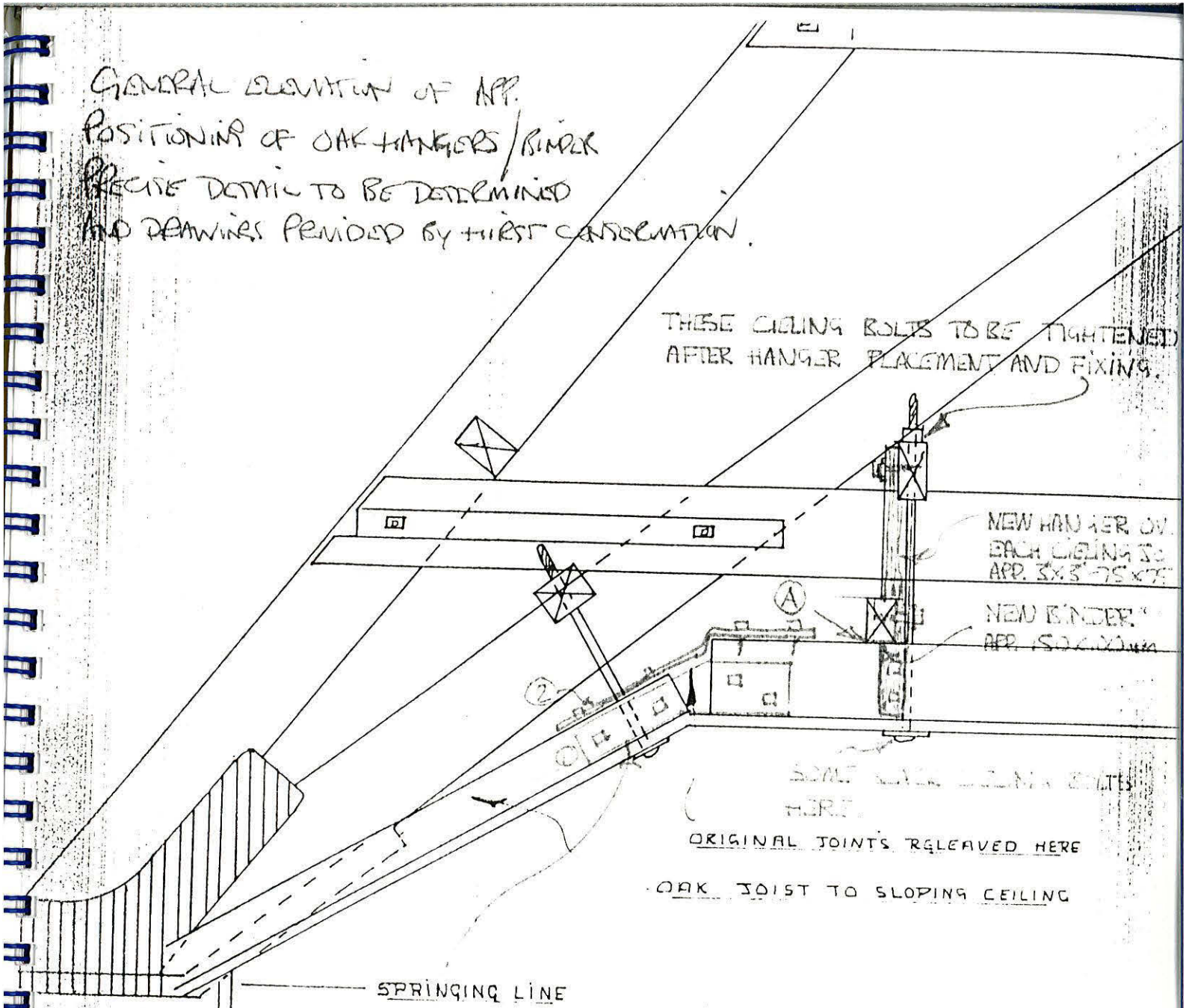
5.2.4 Additional noggings

Further noggings should be fitted to provide fixings for some of the loose ceiling boards. These could either be made to match those of the 1920's or could be designed as distinct 1990's work, albeit using traditional technology. The location of these noggings depends on an assessment of the suitability of other fixing types.

5.2.5 Hessian

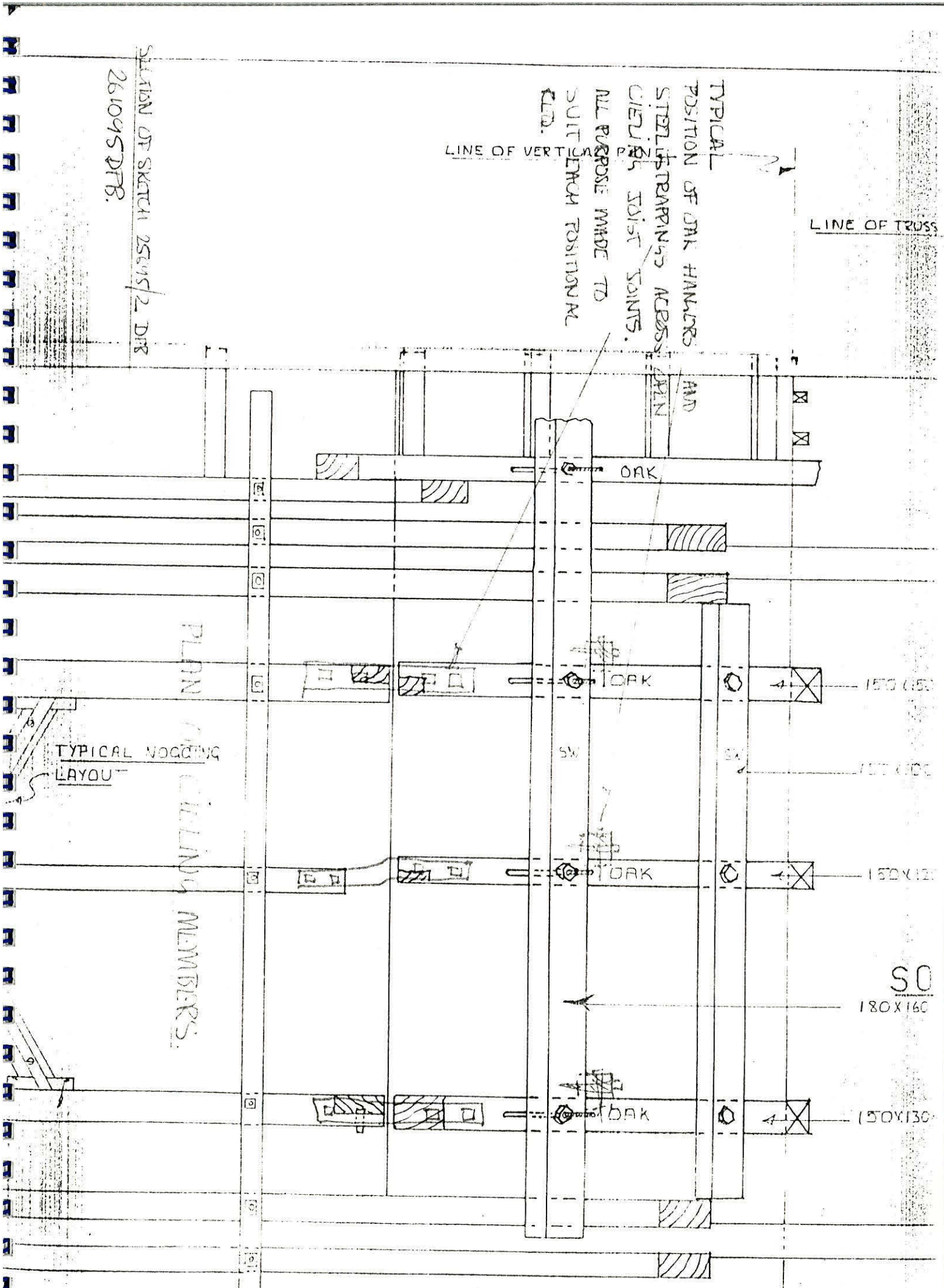
In our opinion, the hessian to the reverse of the painted boards should be removed in order to facilitate full examination and to allow fixing and consolidation works (see condition). The hessian can be removed using heat and moisture to swell the glue size layer, steam would probably provide the quickest and driest way of achieving this. Alternatively, the steam could be applied to sheets of paper pulp or blotting paper to distribute the moisture more evenly and prevent excessive moisture occurring in localised areas. It is assumed that hessian present under noggings should be left in place so as to avoid undue disruption. It is recommended that before the exact method of removing the hessian is specified further testing of, for example, a five square meter area should be carried out to ensure that the methods suggested above will be appropriate on a large scale.

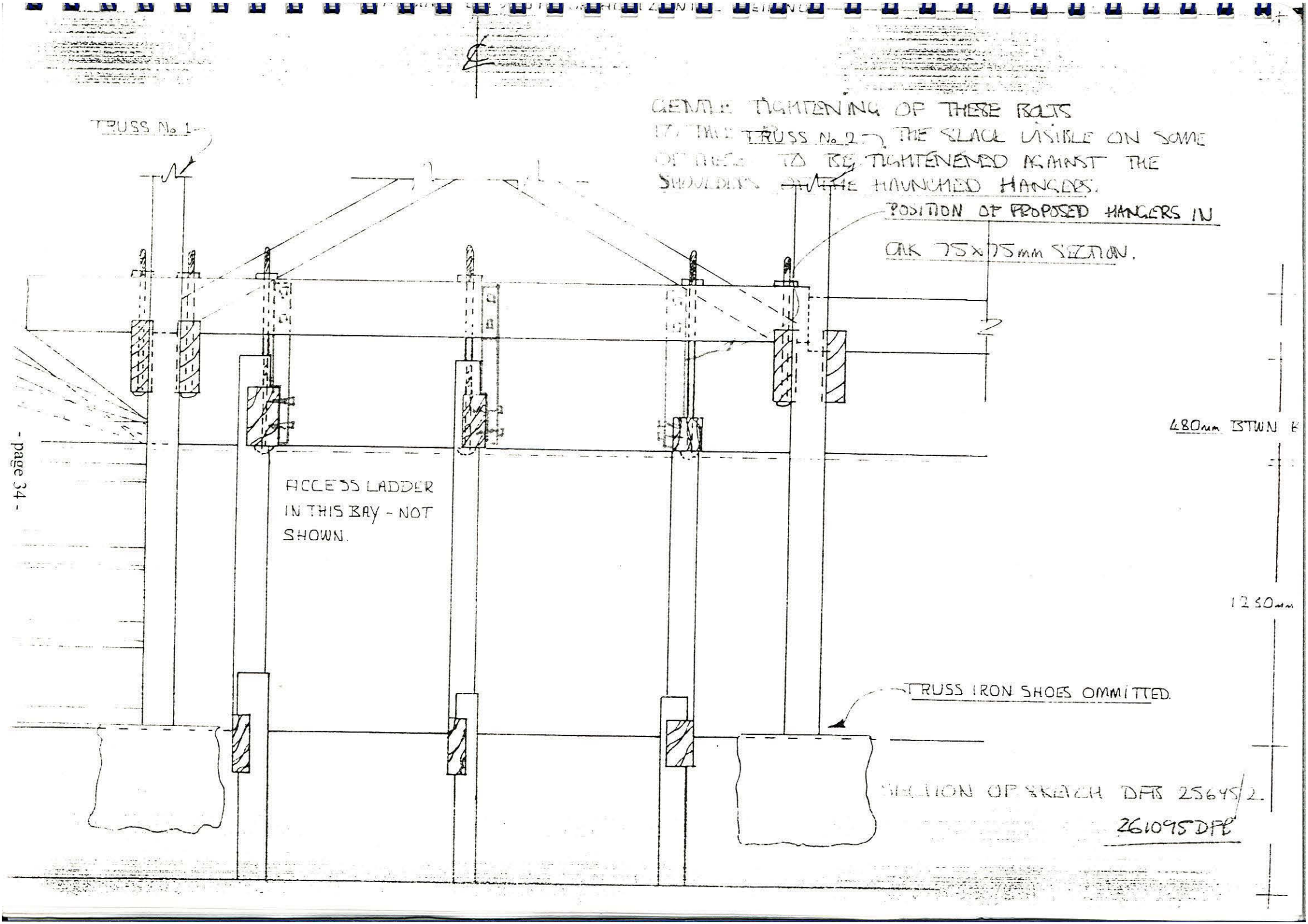
GENERAL ELEVATION OF APP.
POSITIONING OF OAK HANGERS / BINDER
PRECISE DETAIL TO BE DETERMINED
AND DRAWING PENDED BY FIRST CONFORMATION.



① – NEW 9mm STEEL GUSSET PLATES FIXED TO SPLIT JOINTED JOIST ENDS. 75mm x 12mm COACH SCREWS
② – ALTERNATIVE 75x12mm STEEL STRAPS FITTED ON JOIST TOPS NEW BINDERS TO BE HAUNCHED OVER OR PACKED OFF EXISTING JOISTS AT (A) AS REQ.

SECTION OF DRWNG NO. DFB 25695/1 16.10.15 D.F.B. FIRST CONFORMATION


SECTION OF SKETCH 25695/2 DTD 26/09/58 DTD.
TYPICAL POSITION OF OAK HANGERS AND STEEL STRAPPINGS ACROSS CENTRAL JOINT JOINTS.
ALL PURPOSE MADE TO SUIT EACH POSITION AS REQ.
LINE OF VERTICAL PIN
LINE OF TRUSS
OAK
OAK
OAK
OAK
SW
SW
150 (150
150 (150
150X120
180X160
150X130
TYPICAL NOGGING LAYOUT
PLAN SHOWING MEMBERS.


TRUSS No. 1
GENTLE TIGHTENING OF THESE BOLTS
IF TRUSS No. 2 THE SLACK VISIBLE ON SOME
OF THESE TO BE TIGHTENED AGAINST THE
SHOULDERS OF THE HAUNCHED HANGERS.
POSITION OF PROPOSED HANGERS IN
OAK 75x75mm SECTION.
480mm BTWN
ACCESS LADDER
IN THIS BAY - NOT
SHOWN.
1250mm
TRUSS IRON SHOES OMMITTED.
SECTION OF BRACH DFB 25645/2.
261095 DFB

5.2.6 Consolidation

Following removal of the hessian there will be good access to the boards to enable local consolidation, as is considered necessary, to be achieved from behind. Selected boards will require local treatment both for insect infestation (approximately 1% of total) and consolidation. Xylamon LX Hardening N may be a good choice for this operation, even though it is not strictly speaking reversible (any consolidant used would be difficult or impossible to remove entirely in this situation) and can be harmful to health (most applied woodworm treatments are). It is suggested that approximately 10% of boards may require consolidation.

5.2.7 Material replacement to rear of painted boards

Replacement of the hessian with a more durable alternative such as polyester sailcloth is recommended. The adhesive should preferably be reversible, for example Beva 371 (Ethylene vinyl acetate co-polymer), heat set to produce a nap bond. It is proposed that strips of the sailcloth are applied where structurally necessary to provide full support to the ceiling boards. A sample area would be the best way to evaluate this method. Over the top of this a pinned (unglued) material could be installed, as a dust sheet. The ease of temporary reversibility of this sheet would allow simple access for future monitoring, if it was used at all.

5.2.8 Ironmongery

All ironmongery in the roof space (straps, gibbs and cotters) should be rubbed down, prepared and repainted with a Zinc Phoshate primer/sealer followed by an Alkyd undercoat and finished with an Alkyd gloss to prevent further corroding.

5.2.9 Replacement of later, painted timbers

Small inset wooden repairs or slips should be carried out to the ceiling boards, including insets and fillings, but should be kept to a minimum. The badly shaped, ill-fitting or inappropriate ceiling board repairs probably necessitate removal and replacement with well-seasoned wood to follow the design of the ceiling more logically. The choice of replacement wood will be dictated by the board being repaired. New replacement insets should follow the logical course of the design and be inpainted sympathetically. The safety of surrounding original or earlier boards should be carefully examined prior to removing and replacing these panels. It should be pointed out that all previous repairs now form part of the history of the ceiling. This should be taken into consideration when assessing the need for intervention as described above.

5.2.10 Working access

It should be noted that all works carried out in the roofspace will be undertaken with some difficulty, given the limited room for manoevre. In addition, extraction equipment will be necessary if solvent based treatments are used. Full and detailed consideration will need to be given to the health and safety aspects of any materials used in the roof space in particular.

5.3 Painted Surfaces

5.3.1 Consolidation

Consolidation of flaking original or early paint layers should then proceed, following tests with reversible materials. This may be done in tandem with the cleaning tests as some areas may be too fragile to clean without first consolidating. Materials

for this process should be chosen with care. Isinglass or gelatin may be suitable for distemper areas as moisture should help to reactivate the existing glue medium, Paraloid B72 or similar resin may be suitable for oil paint areas, again following tests.It is anticipated that approximately 5% of the total area may require consolidation of paint layers.

5.3.2 Surface cleaning

Surface cleaning should follow essential pre-consolidation of the decorative paintwork. This should be undertaken using materials which have a good pedigree of use in conservation and do not damage the paint layer being cleaned, following the evaluation of a series of tests (see sections and plates referring to cleaning tests).

5.3.3 Cleaning Tests

During the survey preliminary testing was carried out to determine the degree of difficulty with which the ceiling may eventually be cleaned. In addition the effects of cleaning will give all parties concerned the possibility to assess the visual implications. Note that this has formed only a minor part of our survey and any future works will necessitate a more in depth investigation.
Tests were made in the area to the sloping ceiling and vertical panelling on the south side. Initial visual examination and U.V. light examination revealed no evidence of any varnish layers.

100%	Deionised water.	Removes most of the surface lying dirt though not the ingrained dirt.
5%	Synperonic N / water.	A little more effective than deionised water in removing surface lying dirt.

2.5%	Tri-ammonium citrate / water.	Effective on surface lying and ingrained dirt. Rinsed with deionised water.
5%	Tri-ammonium citrate / water.	More effective, quicker than above.
5%	Ammonium hydroxide / water.	Quite effective in removing surface lying dirt and most ingrained dirt.
5%	Liniment of soap / white spirit.	Gentle but very effective in removing both surface-lying and ingrained dirt.
100%	White spirit.	Removes a good deal of surface lying dirt though not as well as water based cleaners.
100%	Acetone	Only removes a little surface lying dirt.
100%	I.M.S.	Only removes a little surface lying dirt.
100%	Propan-2,ol	Removes a little surface lying dirt.
100%	Xylene	Removes a little surface lying dirt.
Liniment of soap / White spirit / Acetone / Ammonia mix		Very effective on ingrained dirt. Use only on most problematic areas. This mixture was used to clean the painted ceiling boards at Ely cathedral, where necessary supplemented by potassium oleate soap.

In conclusion, most H_20 based cleaning agents worked well, surface cleaning is not problematic on oil painted areas. White spirit is also quite effective where water would be inappropriate. There are a few instances where cleaning leaves a patchy finish (due to surface irregularities) and these will require specific attention. The use of brushes (for crevices, board edges etc.) and cotton wool swabs is recommended.

5.3.4 Overpaint removal

If consideration is to be given to the removal of overpaint, this should be undertaken to selected areas only, as many areas do not appear to have much early paint left beneath them. The removal of overpaint could be considered where there is a good chance of there being some remains of an early scheme, following a series of tests. Layers and locations of overpaint to be removed should be identified beforehand in order to record the attempt and results. Much of the existing ceiling decoration may not be the earliest or best quality but the retouchings should be treated as part of the ceiling's history rather than as an aberration. However, it is proposed that the worst, most discoloured and degraded overpainting is either removed or overpainted. It is likely that overpainting will be the most logical and practical option. Overpainting will be quicker and less destructive (retaining the various paint layers underneath). For the purposes of discussion, upgrading the appearance of up to 10% of the total area of the ceiling could be considered. It should be noted that the east end of the ceiling is probably the worst area and would require the most attention in this respect. All traces of the glue size that dripped onto the lower surfaces of the ceiling during the 1920's work should be removed. It is recommended that further tests are undertaken prior to carrying out any of this work.

5.3.5 Inpainting

Any new replacement boards or indents should be inpainted with stable, reversible and lightfast materials to improve their appearance and integrate them into the whole

scheme. The final appearance of the scheme should be judged from ground level.

5.3.6 Protective applied surface coatings

Although applying a protective coating such as a varnish is possible, it is not recommended in this instance. It is not actually considered necessary in this instance. If used, it could prove difficult to reverse completely, even if a very stable material - which is unlikely to cross-link -is used.

5.3.7 Maintenance programme

Maintenance to prevent deterioration should involve the following:

- Prompt repair to any roofing problems.
- Regular (quarterly, except for the areas to the sides, which are difficult to obtain access to, where a more pragmatic programme may be needed) vacuum cleaning of the roofspace.
- Regular (quarterly) inspections for any new problems emerging.
- Ongoing environmental monitoring would be ideal, though at least should be carried out periodically and most especially when there are any major changes in the use of the building.
- Taking into account the results of environmental monitoring the heating of the building should be controlled so as to minimise fluctuations in temperature and relative humidity.

6 CONCLUSIONS

6.1 A basis for further discussion

This preliminary report offers a basic outline of the factors relating to the proposed conservation of the painted nave ceiling and relates primarily to the easternmost section to which scaffolding provided access. It should be considered as a discussion document for further review by all parties concerned. Thus the contents should not be regarded as conclusive.

6.2 The degree of urgency

The urgent need for intervention must be stressed. Not only is a most important and unique work of art actively deteriorating but its current instability is matter of great concern in an area to which there is public access. In the light of this situation, consideration should be given to temporary protective measures to ensure safety to both members of the public and the Cathedral community.

6.3 A phased programme of repair

In order to spread the cost of the repair programme over a longer period there would be much sense in conserving two bays at a time in a rolling programme over ten years, working from the east end (which is in the worst condition) to the west. Working in this way each phase might be carried out over approximately three months (for the sake of example) which, allowing for contract negotiations and other preliminaries could mean that the nave was free of scaffolding for six months of each year. However the cost effectiveness and convenience of working in such a way clearly needs further consideration.

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