JESUS COLLEGE, CAMBRIDGE

Survey and Recording of the Chapel Nave Roof

Alison Dickens, Richard Darrah, Ian Tyers

CAMBRIDGE ARCHAEOLOGICAL UNIT
UNIVERSITY OF CAMBRIDGE

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Alison Dickens MIFA
Richard Darrah
Ian Tyers

Survey Team: Marcus Abbott, Donald Horne
Photography: Nigel Randall, David Webb

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University of Cambridge
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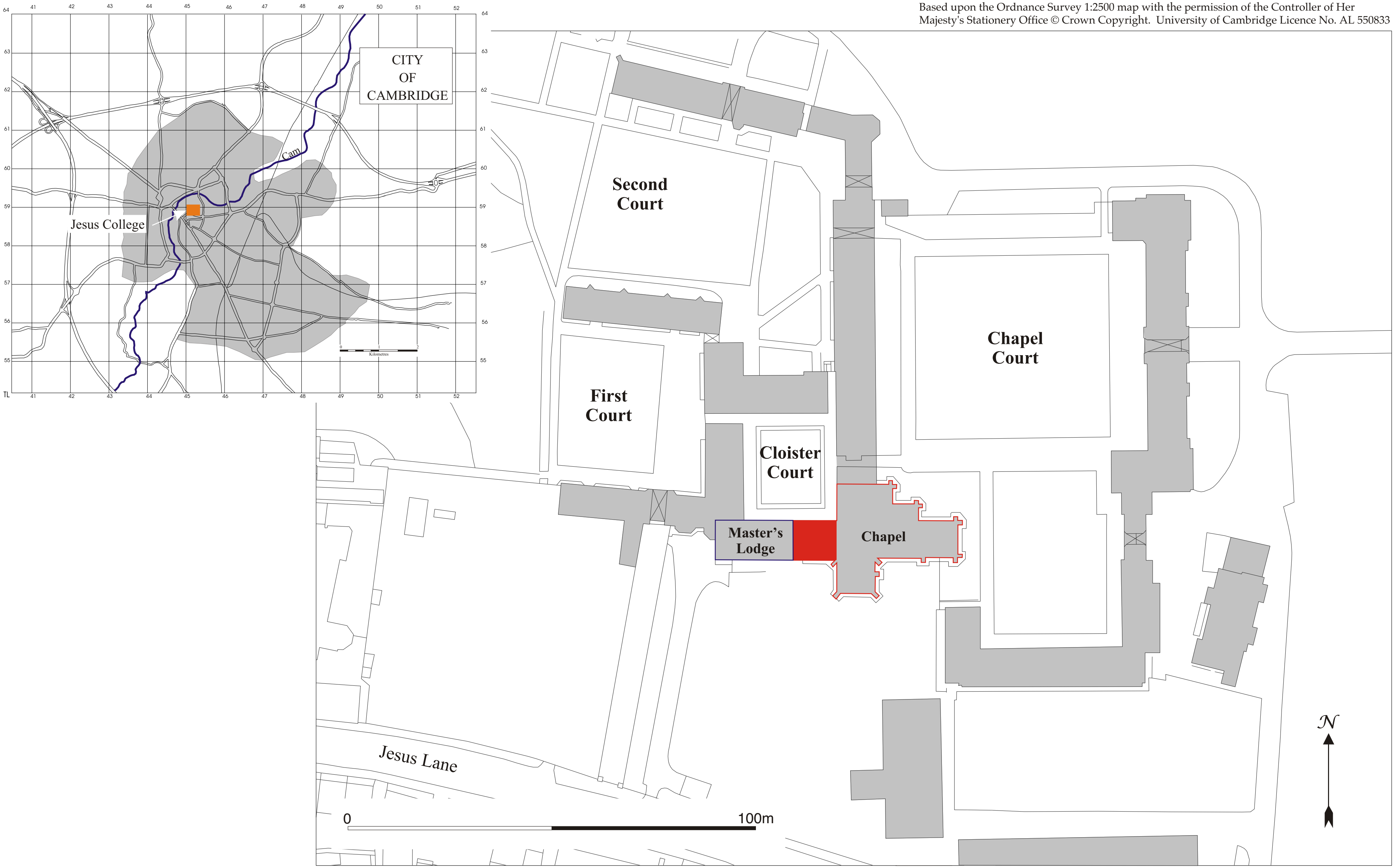


Figure 1: Jesus College location (chapel nave roof in red)

Introduction

During scheduled works on the roof of Jesus College Chapel nave (designed to alter the pitch of the roof and increase the fall of the box guttering) it was observed that re-used timbers were incorporated in the roof structure. The Cambridge Archaeological Unit (CAU) were contacted and asked to make a detailed survey of the roof as it was exposed. The survey was carried out during August and September 2006 and took several forms: a physical survey using a Leica TPS (TCRP 1205); an extensive photographic survey; detailed notes and descriptions of joints, marks, working etc were made by Richard Darrah; and a dendrochronological study was made by Ian Tyers (Dendrochronological Consultancy Ltd.). This report draws together all of these records to describe the roof and interpret its development.

Historical background

The history and architectural development of Jesus College and the preceding St. Radegund's Nunnery are discussed in detail elsewhere, as are previous surveys of the buildings by CAU and others (Willis and Clark 1886, Gray and Brittain 1960, Richmond 1990, Dickens 1995, Dickens and Evans 1995, Evans *et al* 1997, Dickens 1998, Baggs *et al* 1999, Begg 2001). Only the briefest of backgrounds is outlined here.

Jesus College was founded in 1497. The College took over more or less intact the buildings of the former St Radegund's Nunnery, including the conventual church, the east end of which is now the College chapel. There have been several important phases of alteration and building since the College's foundation, particularly in the late 15th century under John Alcock (1486-1500), Bishop of Ely, who had brought about the suppression of the nunnery and founded the college. The work accredited to him was certainly completed after his death in 1500, but is generally supposed to have been largely to his design intentions. This certainly included work on the church/chapel. Other significant works were carried out in the college in the 18th and 19th centuries, the latter including work by Pugin, Burne Jones and William Morris.

The survey

The roof leading had already been removed prior to commencement of the survey. The roof was exposed in three stages by removal of the planking immediately beneath the lead; SE quarter; SW quarter; N half. This permitted almost all of the roof structure to be observed and recorded safely and allowed limited views into the structure of the roof above the Master's Lodge.

Numbering system

To allow each piece of wood to be allotted its place in the recording scheme, each has been allocated a unique number based on its position in the roof (Figure 3). The roof is divided into eight sections with each section defined as the space between principal rafters and the ridge board. For example Section 1 is defined as the space between principal rafter 1 (PR1), principal rafter 2 (PR2) and the ridge board. Section 1

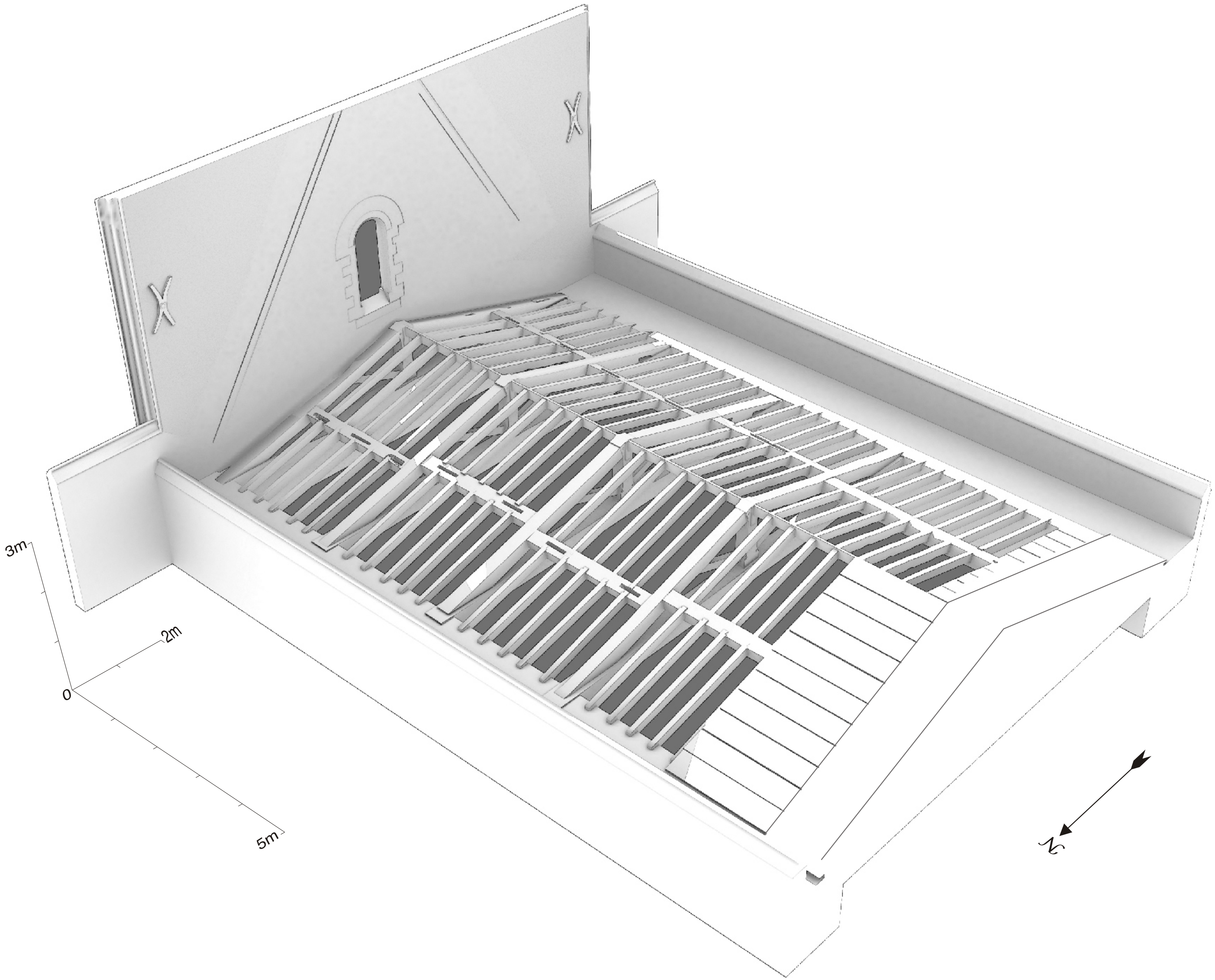


Figure 2: 3D model of the extant roof as surveyed 2006

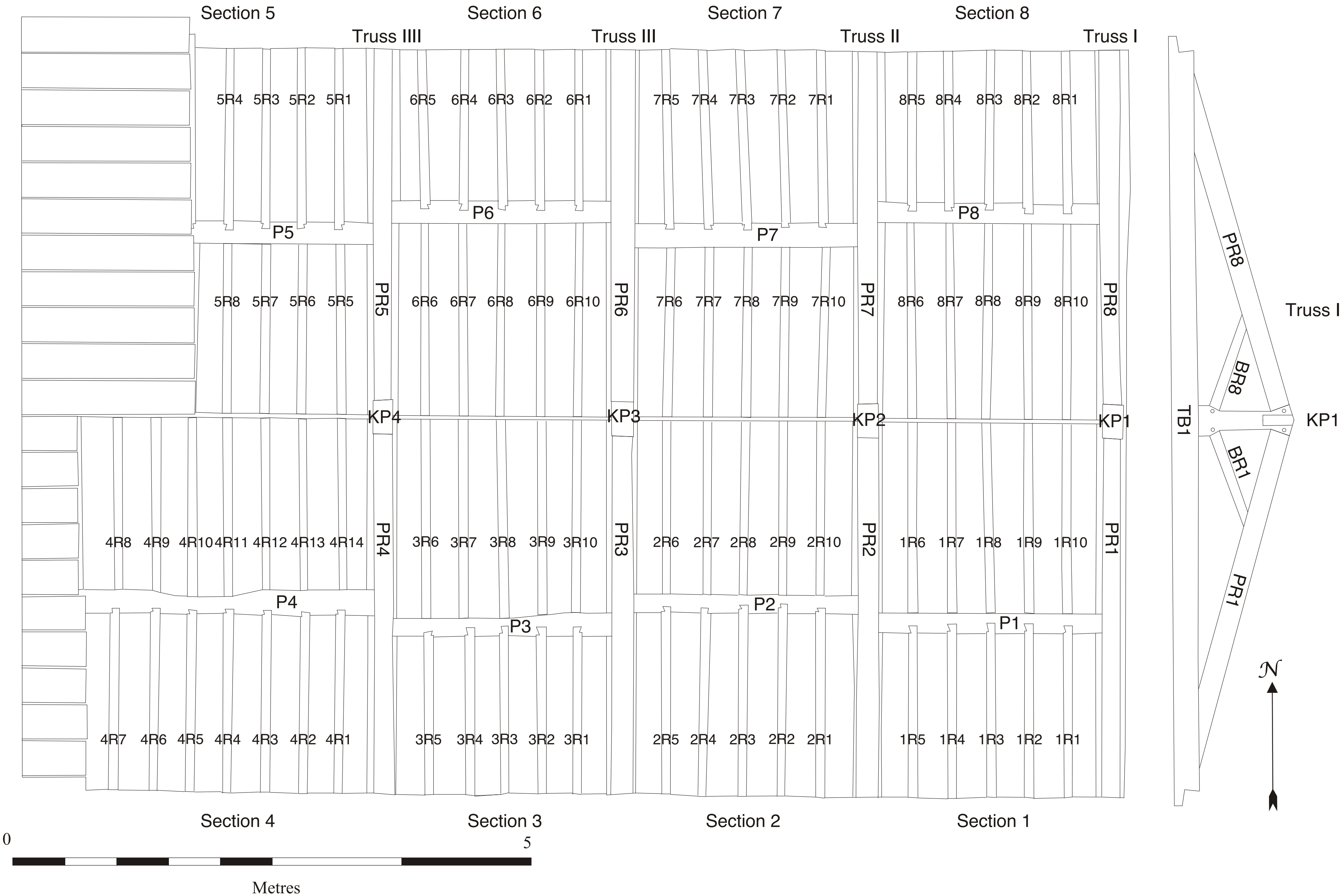


Figure 3: Plan of existing roof showing recording numbering system

contains common rafters 1 to 10 and purlin 1. As each section, therefore, has rafters labelled from 1 onwards the rafter ID is prefixed with the section number e.g. 1R1, 1R2 etc. The principal elements have their own number sequence for example: purlins (P then its number), tiebeams (TB then its number), principal rafters (PR then its number) and king posts (KP then its number). The braces from the kingposts to the principal rafters share the same number as the principal rafter they are attached to but are prefixed with BR. These objects can then be grouped to form a larger structural unit e.g. Truss I is constructed from TB1, PR1, PR8, KP1, BR1 and BR8. The numbering system is shown in Figure 3. The north and south ends of each of the trusses are supported on wooden wallplates laid on the top of the stone walls of the building. Only one of these has been given a formal designation (WP4), which is a smaller piece of reused wood on the south side of Bay 4 between Trusses 4 and 5 (see below).

Description of the present roof
(Terms used in the description and elsewhere in the text are defined in the Appendix 2 glossary)

The structure revealed after removal of the planks was a king post truss roof of four trusses (forming four bays), with single staggered tenoned (or butt) purlins on each side, and a ridge plank (Figures 2, 3). The upper faces of the rafters were flush with the top of the purlins forming a flat plane with the principal rafters. Pine boards were nailed to the rafters to support a lead roof. Each truss consisted of a tiebeam, two principal rafters, a king post and two braces between the king post and the principal rafters. The entire roof is constructed from oak save the pine ridge plank and its support brackets.

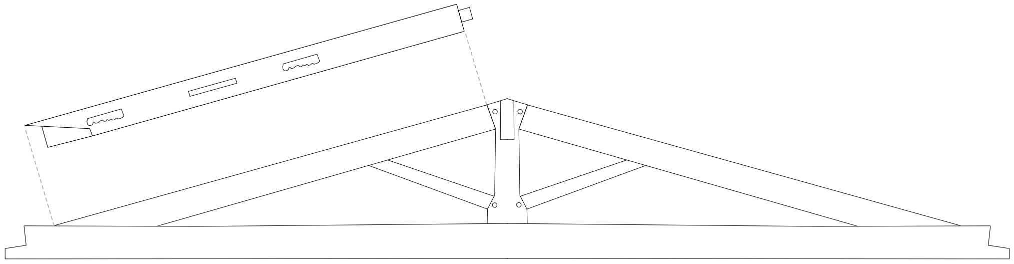
Details
(Figure 4)

There were four king post trusses in the roof space above the Chapel, however the fourth pair of purlins joined to a similar fifth truss within the roof space of the Masters Lodge and further trusses could be seen within this roof space (see below). This fourth bay had at least nine sets of common rafters compared with the five of the three eastern bays.

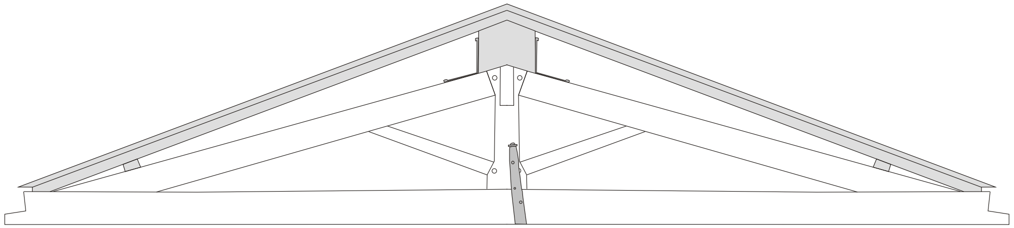
Each truss is made up of a tiebeam (7.80 x 0.29 x 0.24m); a king post (1.025 x 0.285 x 0.155m) tenoned into the tiebeam (the king posts have joggles at both the top and bottom); principal rafters 3.80m long tapered towards the top (~ 0.195 x 0.195m) tenoned into the joggles at the top of the king post and pegged with a single 20mm peg. The lower ends (~0.22 x 0.22m) are tenoned, pegged and bolted to the tiebeam near its outer ends. Braces run from the lower joggle on the king post to the underside of the principal rafter. These braces are tenoned at both ends and held with a 25mm peg. The tenon at the base of the king post fits into a blind mortice and is held with two 25mm oak draw pegs, no metal strap was used at this fixing, although straps were visible on at least two of the trusses within the Master's Lodge roof[1]. The struts are joined to the principal rafters approximately 900mm from point where the latter are tenoned into the joggle on the king post. The trusses were clearly framed by a skilled carpenter who had carefully scribed the top of the principal rafters to fit around the curve of the sapwood on the joggles of truss TR3.

There are eight purlins between the five trusses, four single staggered tenoned purlins on each side. The purlins have central tenons with a diminished haunch (Hewett 1980: 215) and are face pegged with single pegs. Purlins P1 and P8, P2 and P7 and P3 and P6, are all approximately 2.15 x 0.25 x 0.20m (see Table 1). Purlins P4 and P5 are 3.20 x 0.27 x 0.18m.

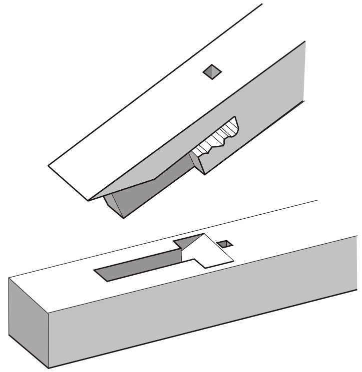
[1] Yeomans mentions that it was common not to use straps with oak. (Yeomans 1992: 140).



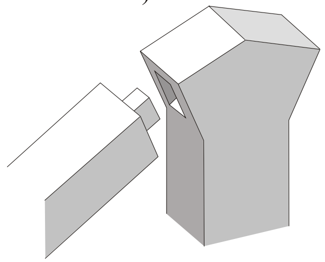
A: King post truss showing example of reused timber



B: Addition to Master's Lodge truss to elevate the roof and alter the pitch



E: Detail of tenon joint fastening principal rafter to tiebeam (evidence of reused timber)



F: Detail of principal rafter tenon joint to king post

C: Trusses in the king post roof (KP2 at front)

D: Master's Lodge truss showing metal strap at base and brackets securing the added block (6th truss from tower end)

G: Intact draw pegs, points facing tower wall, indicating *in situ* truss construction (PR1 on Truss I)

Figure 4: Details of extant roof

The sawn pine ridge plank (0.35 x 0.195m) is variously lapped into the face of the king post or slotted into a lap cut in a pine board nailed to the face of the king posts. The top edge of this plank has a double bevel matching the pitch of the roof.

The upper common rafters are tenoned into the purlins and butt up to and are nailed to the ridge plank with a single rose-headed nail. The lower of the common rafters are housed in lap dovetails and nailed both to the purlins and the top of the wall plates. These common rafters are between 0.09 x 0.14m and 0.075 x 0.145m and have a consistent width and depth throughout their lengths. As the purlins are staggered the lengths varies between 1.81m and 1.53m above and below the purlins. The upper faces of the rafters are flush with the top of the purlins forming a flat plane with principal rafters. Some of the common rafter faces had been planed, but it was not clear whether this was done once they were *in situ* or before they were fitted, however no plane marks were seen on the face of the purlins they are butted up to.

The pointed ends of the draw pegs on joints between the tiebeams and the principal rafters were left in situ between the truss and the tower at the north side, and within the Masters Lodge between the truss and the dividing wall. These peg ends were undamaged and there was no damage to the peg holes that might have suggested dismantling and reassembly. The implication is that the trusses were constructed *in situ* rather than on the ground or flat at roof height and then moved into position as this would either have broken the peg ends or the ends would have been removed to facilitate the lift.

Beyond where fourth set of purlins on each side (P4 and P5) butted up to the fifth truss, (within the roof space of the Masters Lodge), the remainder change to back purlins. Redundant mortices for the tenoned purlins, cut to house a diminished haunch, were visible on the sides of the principal rafters indicating that there had originally been tenoned purlin trusses in the Masters Lodge roof as in the Chapel.

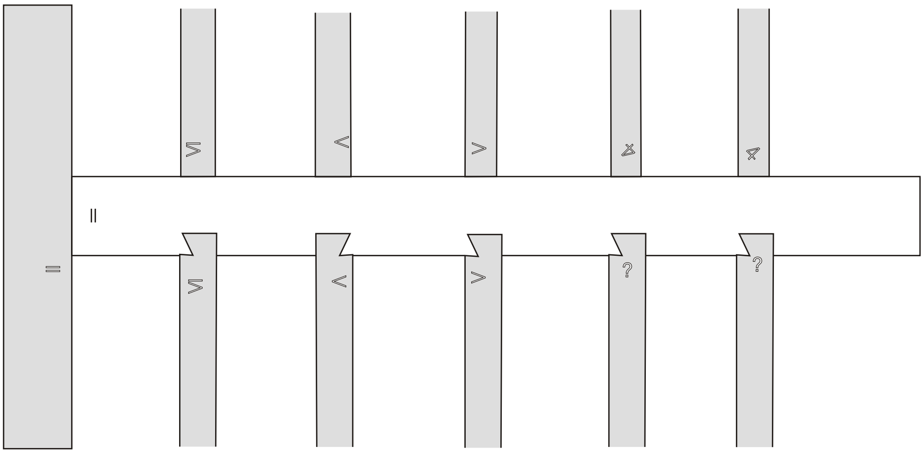
The roof of the Master's Lodge has a different pitch to that over the chapel. The trusses were constructed in the same way, but the pitch had been increased using a block on the top of each king post, held in place by an iron bracket each side, to raise the ridge by approximately 0.40m. A second ridge plank had been inserted by raising the purlins above the principal rafters and forming a common rafter roof. As noted above an iron strap had also been added from the front of the king post to the back wrapping beneath the tiebeam. Scars on the retained lower ridge plank show that the common rafters had been nailed to it and that both the Chapel and Master's Lodge roofs were originally the same.

Truss roof numbering system
(Figure 5)

There are three numbering systems relating to the extant truss roof. All are V-profile chisel-cut Roman numerals. Two chisel widths were used 25mm and 56mm wide (1 inch and 2¼ inches).

1. The trusses themselves are numbered starting with I on the truss next to the tower, up to IIII. These numbers are cut on the west face of the king posts of each of the trusses. Both chisel widths are used in these numbers.
2. The joints between purlins and principal rafters have Roman numerals cut with a 25mm chisel.
3. The common rafters are numbered above and below the purlins with 56mm wide numbers, generally a group of four of these have been given the same number (i.e. two above the purlin and two below the purlin). These numbers are cut on the edges of the faces of the common rafters facing each other. The numbers are regularly spaced above and below the purlin and even face each other across opposite sides of principal rafters.

Within this truss roof structure timber from at least two phases of activity have been used. The following timbers were cut from new oak:



A: Common rafters between PR2 and PR3 (section 2). Note that the numbers are placed symmetrically facing each other in groups, but that the dovetail laps are not symmetrical. The '4' is actually a V with a line across it.

B: Marks where principal rafter PR4 meets king post KP4

C: Marks where principal rafter PR3 meets tiebeam TB3

D: Marks where purlins P6 (rhs) and P7 (lhs) meet principal rafter PR6

E: Common rafter marks in section 6 (6R7, 6R8 to left, 6R4, 6R3 to right)

Figure 5: Carpenter's marks on the extant roof

- Tiebeams (boxed heart)
- King posts (halved)
- Most wall plates (boxed heart)
- Long purlins P4 and P5 (boxed heart)
- The braces between the king posts and the principal rafters (small sections of timber)

The remaining timbers are all reused structural timbers:

- Principal rafters
- Common rafters
- Purlins P1, P2, P3, P6, P7 and P8.
- One wall plate.

The reused timbers within the roof construction.

The reused timbers were identified from the following features:

- Redundant joints
- Re-hewn and planed surfaces
- Redundant carpenter's numbers with a U-shaped profile cut with a race knife

Evidence for reshaping of the re-used timbers was seen as:

- Truncated housings
- Auger holes for pegs cut through,
- Truncated carpenter's numbers,
- Re-hewn and planed surfaces
- Broken *in situ* tenons damaged by hewing across the grain.

Based on these observations three groups of earlier timbers were identified: (Figure 6)

Group 1: Ten timbers each with two scribed ogee housings backed by up to four mortice holes.

Group 2: Five timbers each with two long mortice holes on one side and a single long mortice hole on the opposite side.

Group 3: More than 50 timbers (and probably all 96) that had been recut for use as common rafters.

Group 1: The ten reused timbers
(Figure 7, 8)

Eight of these timbers had been reused as the principal rafters (PR1 to PR8) in the four trusses numbered I to IIII. They had been reshaped so that they tapered from their lower ends up to their tops. One timber had been reused as purlin P8 on the north side of the roof at the tower end, but this was the same width at each end. The tenth had been used as a lower wall plate, WP4, on the south side of the roof between the fourth truss and the brick cross-wall at the east end of the Masters Lodge. The tenth

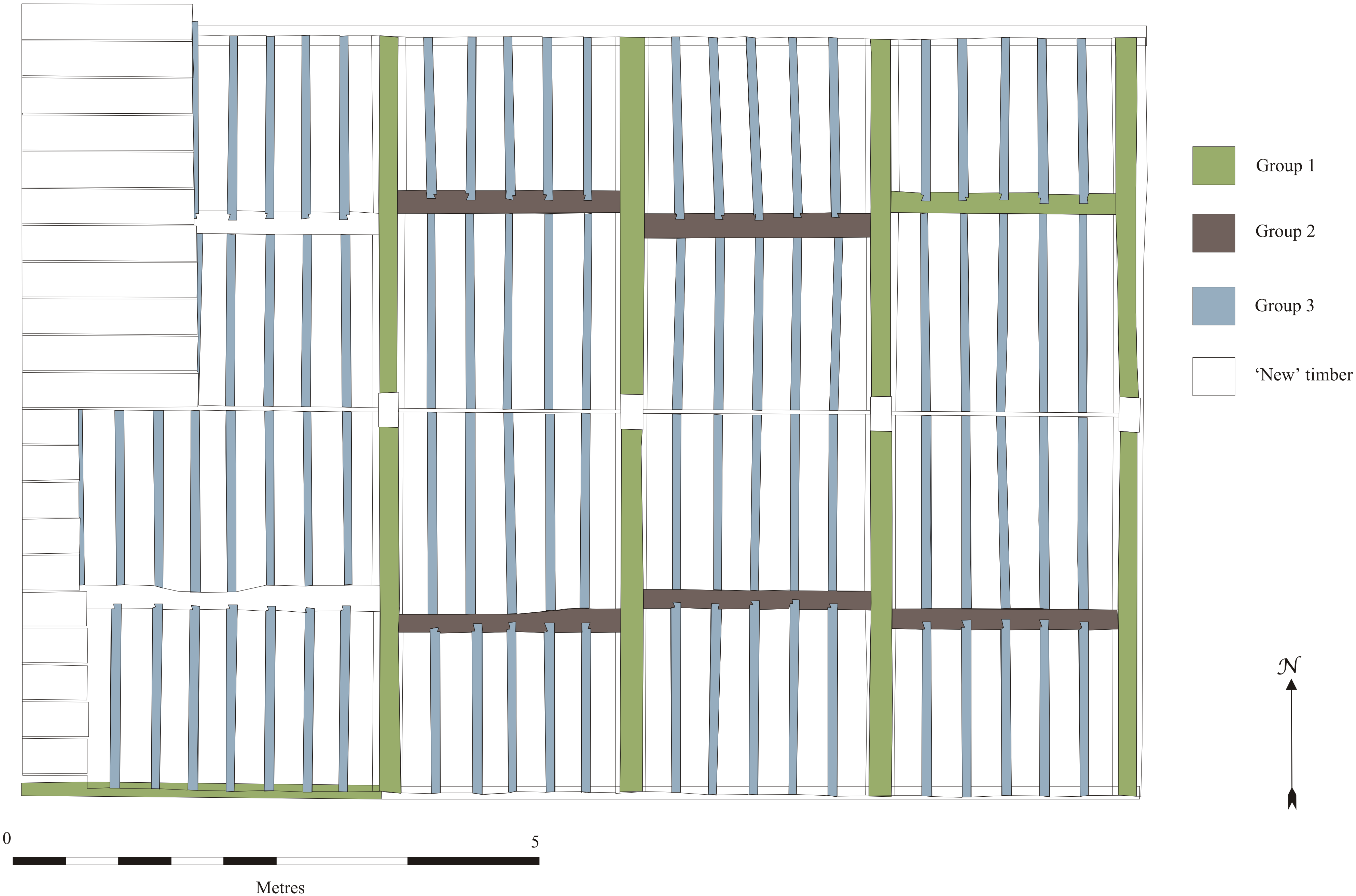
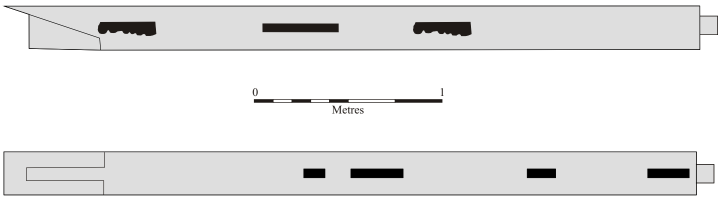
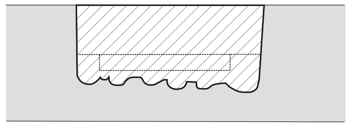


Figure 6: Location of reused timbers



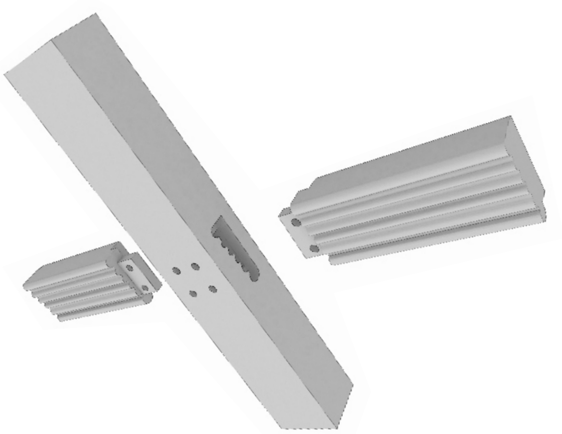
A: Moulded and plain mortice holes in reused timber (PR8)



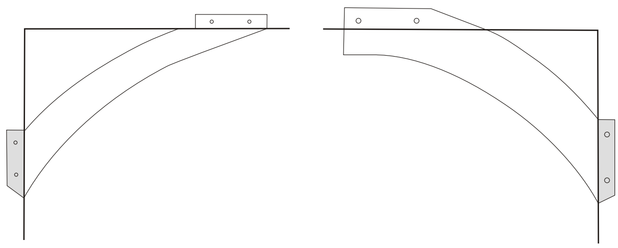
B: Reconstructed cross section of moulded purlin

C: Sawn off remnant of moulded purlin in WP4

D: Empty mortice in PR6 showing moulding, slot for tenon and pegs still *in situ*



E: Reconstructed joints of moulded purlin



F: Alternative brace arrangements based on the plain mortice holes

Figure 7: Features of Group 1 reused timbers

timber, reused in wall plate WP4, still had substantial cross sections of ogee mouldings on the face, with fragments of the beams remaining inside the housings, the beams having been sawn off flush with the face of the wall plate timber. The housing of the beam end was 320mm long and tapered from 100mm down to 55mm so that the front of the housings angled out as the rear was parallel with the back of the timber and flush with the back of the mortice. Where these joints occurred on both sides of the beams through mortices had been cut. The tenon was 370mm long by 35mm thick and 120mm deep and was held with two 21mm diameter pegs. The grain of this tenon was at an angle of forty-five degrees to the socket giving an angle to the mortice that suggests that this was the tenon of a brace (Figure 7.F). The distance from the top of this mortice to the housing above was 529mm. The lower edge of the tenon was angled which would have enabled the brace to be fitted after the structure was assembled. The front shoulder of this moulded beam was housed to a depth of 55 to 60mm. and backed by a tenon. The mortices were 210 x 60x 60mm, were parallel to the back of the beam and 92mm from it. These joints occurred on both sides of six timbers (principal rafters PR2, PR3, PR4, PR6, purlin P8 and wall plate WP4) and on one side only of four timbers (principal rafters PR1, PR5, PR7 and PR8).

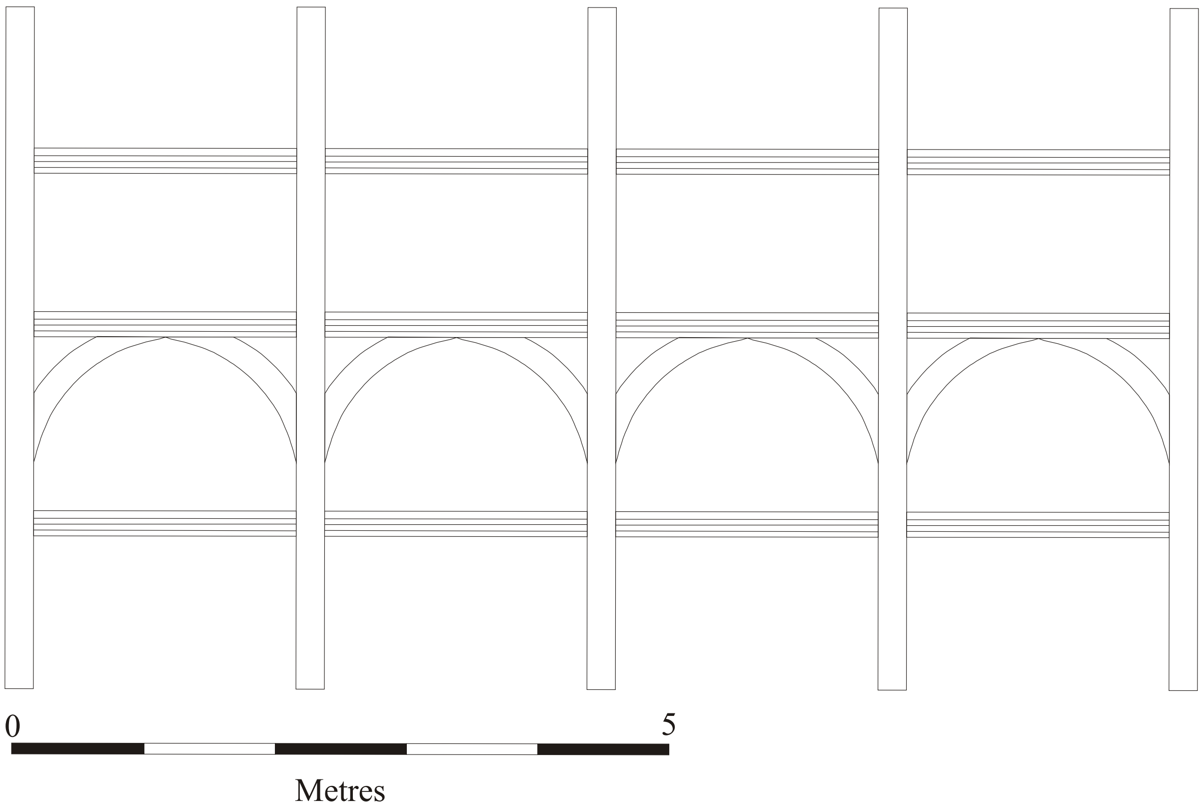
All these timbers were cut just below where the lower housing had been carved to fit around the face of the timber tenoned into it. This means that no evidence of the joints below this housing survived. Above the top housing there was 1.23m of timber without mortice holes.

	PR1	Tenon length	PR2	Tenon length	PR3	Tenon length	PR4	Tenon Length
top	0		0		0		0	
top mortice 1	60		115		110		118	
bottom mortice 1	285	225	280	165	275	165	335	
top mortice 2	755		760		755		775	
bottom mortice 2	920	165	905	145	895	140	910	
top mortice 3	1600		1610		1580		1590	
bottom mortice 3	1905	305	1900	290	1880	300	1895	325
top mortice 4	2040		2025		2010		2025	
bottom mortice 4	2155	115	2145	120	2135	125	2154	128
top scribed joint							1230	
bottom scribed joint	1535	322	1540		1540			
top wind brace joint	2011							
bottom of wind brace joint	2421	410						
top of lower scribed joint	2941							
bottom of lower scribed joint	3264	323						
bottom	3770							
top width					195			
bottom width					280			
mortice 3 angle	55		60				55	

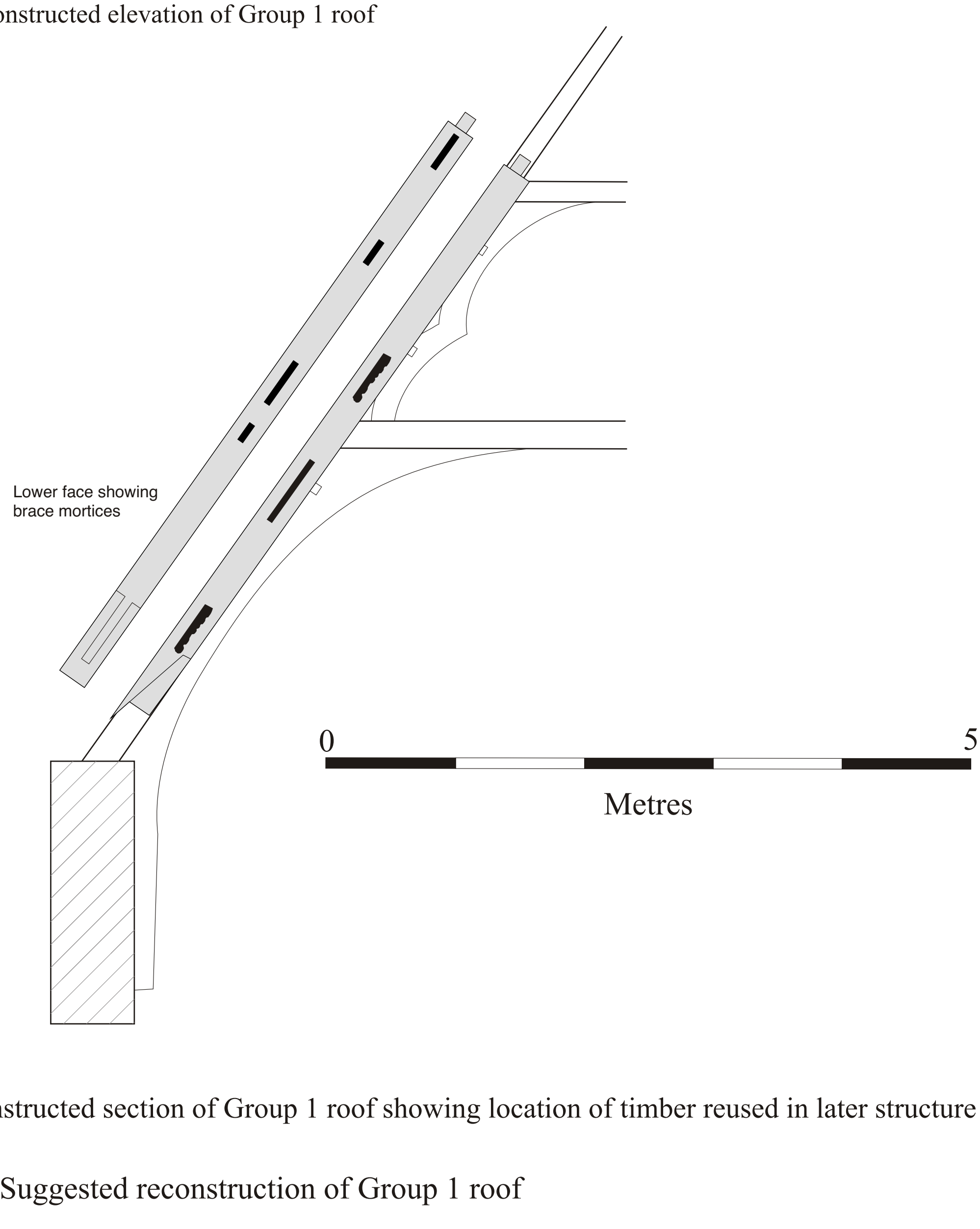
Table 1: Measurements of earlier features on Group 1 principal rafters (measurements taken from top end in each case)

Reconstruction of a Group 1 Roof
(Figure 9)

The joints from the eight principal rafters, wall plate, and purlin P8 were identical, each having two housings scribed and carved to fit around moulded timbers, originally 60mm deep. These housings had flat bottoms cut by the mortices housing the later tenons on the ends of the timbers. The earlier tenons had all been pegged with pairs of pegs and where the sawn off timber survived *in situ* the face was moulded. This face was angled so that the upper end of the moulded surface was 50mm nearer a face (soffit) of the timber. These joints occurred on two sides of six



A: Reconstructed elevation of Group 1 roof



B: Reconstructed section of Group 1 roof showing location of timber reused in later structure

Figure 8: Suggested reconstruction of Group 1 roof

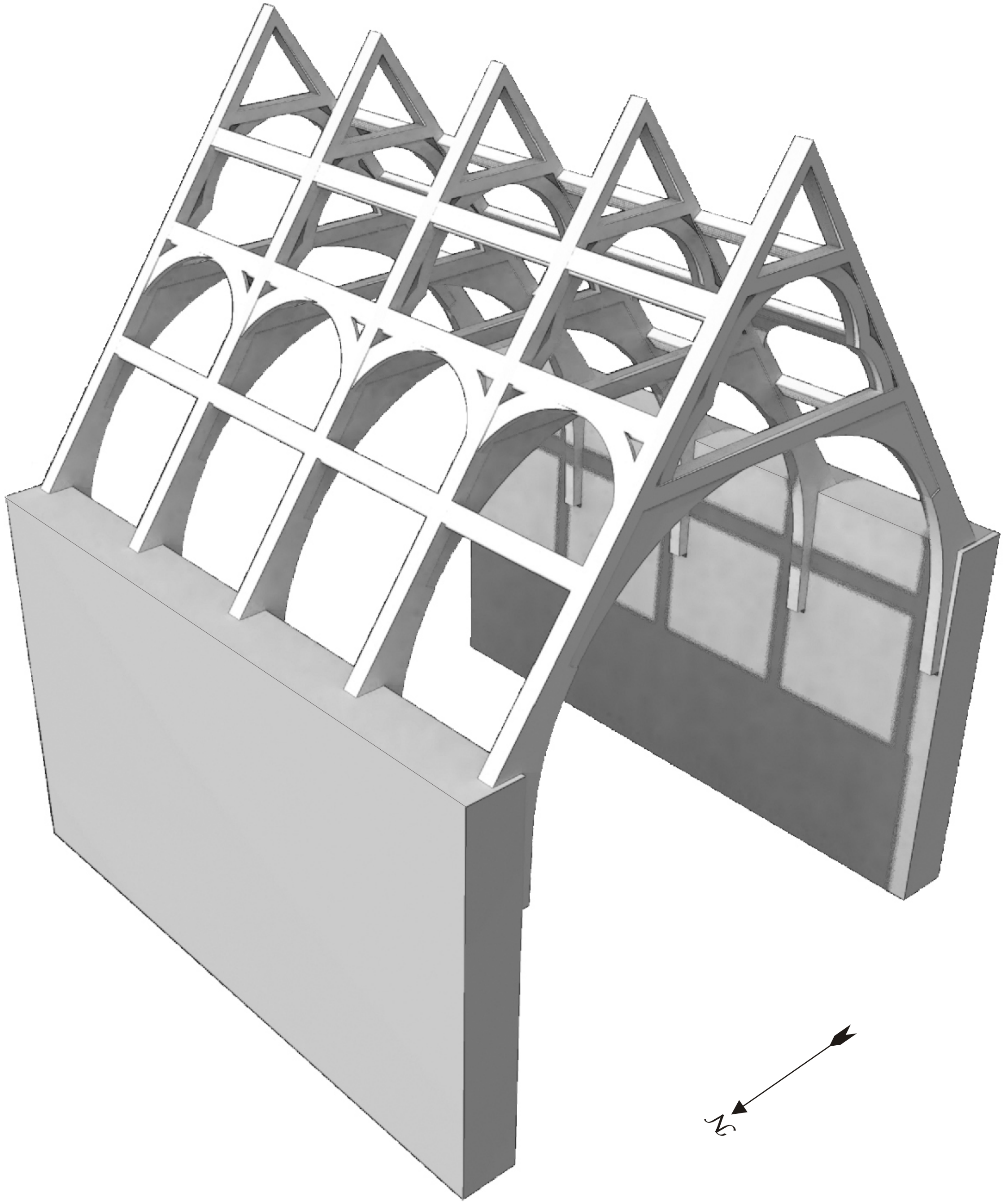


Figure 9: 3D reconstruction of Group 1roof set on chapel walls

timbers (P8, PR2, PR3, PR4, PR6, WP4) and on a single side of four timbers (PR1, PR5, PR7, PR8). The pairing across opposite sides of six timbers together with shared mortice slots and the angled face suggests that these timbers were principal rafters and that the sawn-off timbers are the surviving ends of moulded purlins where, unusually, the moulded section of the purlin was let into the face of the rafter (see below). This interpretation is further supported by the lack of evidence for joints on the back of these timbers. The double and single sided timbers give six double rafter sets and four single rafter sets, the numbers required for a four bay roof. The faces of the moulded timbers are tilted forward suggesting that these timbers were set at an angle so that the moulding would be visible from below, which indicates the roof was designed to be open above the structure below i.e. without a ceiling. Between each set of moulded mortices was a long plain mortice. Where the tenon survived *in situ* the grain of this long tenon was angled towards the upper purlin at 45°. This suggests a brace extending from the side of the sloping timber (the principal rafter) to the underside of the upper moulded purlin. The point at which the principal rafter timbers had been cut for their reuse in the later roof has removed any evidence to determine whether the lower purlin was similarly braced.

On each of these timbers one of the faces at 90º to those with the moulded mortices is a second set of plain mortices. These would appear to be designed to house bracing forming each pair of principal rafters into a truss. The suggested reconstruction (Figure 8) uses a pitch angle of between 55 and 60º based on that suggested by the angle at the top of the wide tenon housing the collar brace.

Group 2: Five reused timbers
(Figure 10)

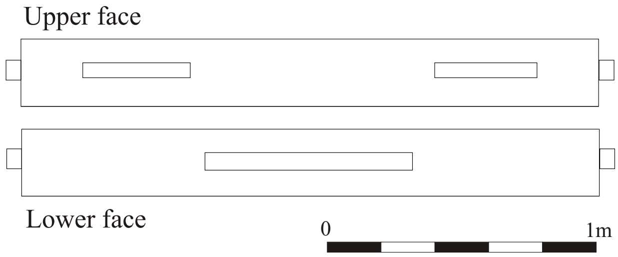
Five of the purlins in the king post truss roof (P1, P2, P3, P6, and P7) were very similar. All had two long mortices on their upper faces (~ 0.40m long) and a single long mortice underneath (~ 0.75m long). In each case the lower mortice was placed centrally to the two on the upper face. The inner ends of the pair of upper mortices were angled at between 50 and 55°, and both ends of the lower tenons were angled at between 55 and 60°. The position of the peg holes was asymmetrical about the upper tenon suggesting that this was for a windbrace, the timbers themselves probably purlins.

Reconstruction of a Group 2 Roof

Initially it was explored as to whether the five Group 2 timbers could actually be collars within the Group 1 roof. Although there are five such timbers and the Group 1 roof could have had five collars, the pattern of mortice holes on the Group 2 timbers suggests that they actually come from a different structure. The pattern of a central long mortice below and two mortices above indicates an arrangement of braces, each with angled ends indicating the direction of the braces, like that shown in Figure 10.C. It would not be possible to incorporate such an arrangement into the reconstructed Group 1 roof either within or between the trusses. It is most likely that the Group 2 timbers are purlins from a different roof, although probably still within the college.

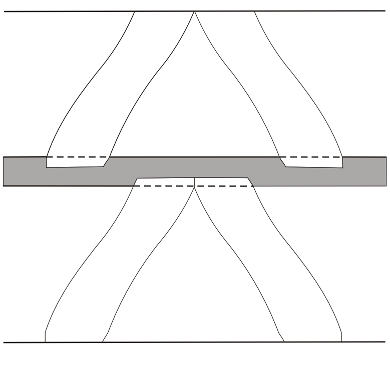
Group 3: Timbers reused as common rafters.
(Figure 11)

The common rafters were 140mm deep by 90mm wide. The main physical evidence that the common rafters were reused timbers was that some of them had race knife cut carpenters numbers on them and that some of these numbers had been truncated indicating that the timbers had been cut down in thickness. These race knife marks survived on both hewn and sawn surfaces.



A: Group 2 mortice arrangement

B: Group 2 timber reused as purlin P7 above compared to Group 1 timber reused as purlin P8 below



C: Brace pattern indictaed by mortice arrangement in Group 2 timbers

Figure 10: Group 2 timbers and reconstruction

A:Race knife mark on common rafter 8R6

B: Truncated race knife mark on common rafter 2R7

C: Race knife mark on common rafter 6R8

D: Race knife mark on common rafter 5R7

E: Truncated race knife mark on common rafter 6R10

Figure 11: Group 3 timbers showing race knife carpenter's marks from earlier use

Reconstruction of a Group 3 Structure

The cross section of the common rafters was 140 by 90mm with slight variations, the truncated numbers on the wide sides suggest that they had been cut down by an estimated 50mm, suggests an original thickness of around 190mm. As the majority, if not all, of these timbers appear to be reused, this means that up to ninety-six similar timbers were available that could be cut down to make rafters but that did not have any distinguishing joints or details on the cut down pieces. If these timbers had been the original medieval common rafters from either the Group 1 or Group 2 (or indeed any other) roof they would be expected to be tapered over their length from 150 x 150mm to 120 x 120mm, and to have been made from small trees squared up (Rackham 1980: 146). This suggests that these timbers were not cut down from existing common rafters but derive from some other source. One suggestion is that they were wall studs such as those still visible on the staircase in further down the building.

Dendrochronological Evidence
(see Appendix 1 for detail)

Tree-ring dating or dendrochronology is an independent dating technique that utilises the pattern of ring widths within a sample of timber to determine the calendar period during which the tree grew. From England there are a large number of oak (*Quercus*) ring-width reference chronologies against which new sequences can be tested. The geographical and temporal coverage of these ring-width reference chronologies is constantly being extended and a series of strong regional chronologies can be produced for almost the entire area. If suitable ring sequences can be obtained, and these can be matched to reference chronologies, precise dates can be provided for buildings for which the date is either unknown or uncertain.

Initial inspection showed the nave roof to contain a mixture of fresh and re-used oak timbers, many of which appeared to be suitable for tree-ring analysis. The sampling was intended to identify the date of the fresh timbers used in the nave roof structure, and it was also intended to identify whether only one, or more than one, phases of re-used material were also present. The timbers in the roof were carefully examined for indications of the numbers of rings present and any sign of the presence of sapwood and bark.

Results

Eighteen timbers were selected for tree-ring sampling from the roof. The sampled timbers comprised three king posts (KP1. KP3, KP4), one tiebeam (TB4), two principal rafters (PR5, PR8), five purlins (P2, P3, P4, P6, P8), and seven common rafters (1R10, 2R2, 5R2, 5R7, 6R6, 6R7, 8R10). These samples were assigned numbers 1-18 inclusive (Figure 12, Table 2). One of the samples, from P8, contained an unmeasurable sequence. The remainder included six that were complete to the bark-edge, and a further six that retained significant quantities of sapwood. Following their measurement all of these series were found to cross match forming two separate groups (Appendix 1 Tables 3 and 4). A composite series was constructed from each group of correlated samples, a group of twelve timbers formed a sequence of 131

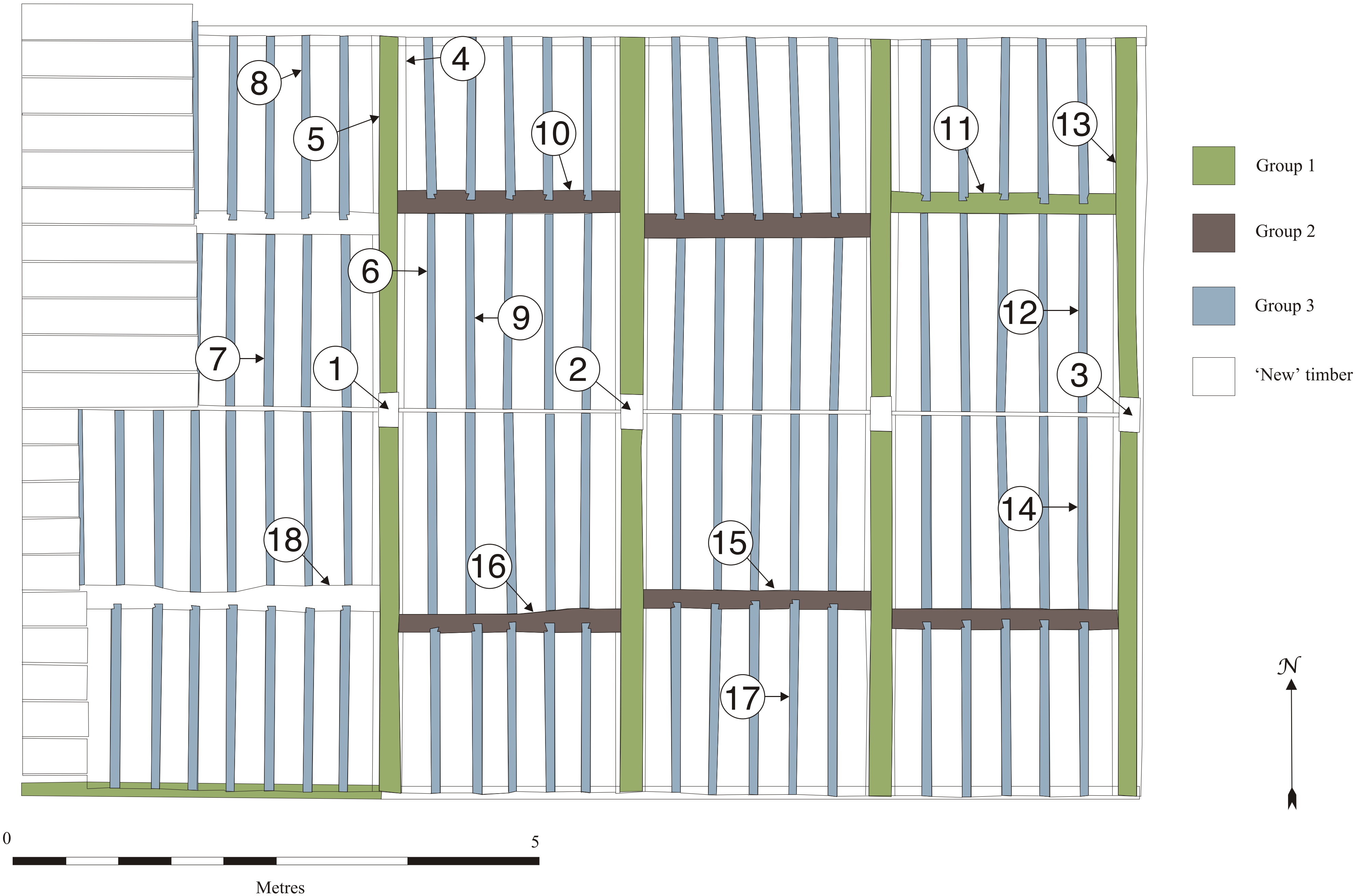


Figure 12: Location of dendrochronology samples

years length, whilst a group of five timbers formed a group of 114 years length. Each sequence was cross-matched with a large number of reference chronologies at a single consistent position (Appendix 1 Tables 5 and 6). These correlations indicate the rings in the composite series date from AD1379 to AD1509 inclusive, and AD1625-1738 inclusive. Table 2 lists the dates of the individual samples derived by this process.

All of the dated samples are from either the primary structure of the extant roof or the re-used timbers within it. The sequence dated AD1625-1738 comprised samples from three king posts (KP1, KP3, KP4), a tiebeam (TB4) and a purlin (P4) and includes a king post with surviving bark-edge (KP4). This timber was felled in the winter of AD1738, another king post (KP1?) was derived from the same tree. Felling date ranges could be calculated for the other three dated samples in this group by adding the minimum and maximum likely numbers of rings of lost sapwood to the date of the last heartwood ring for each of these samples (see Table 2 and Figure 13 for details). These calculations are superfluous given the precision obtained from the king post sample.

Core No.	Origin of sample	Cross-section size (mm)	Total rings	Sap rings	Growth rate	Date of sequence	Interpretation
1	KP4	280 x 160	71	16+Bw	1.49	AD1668-1738	AD1738 winter
2	KP3	280 x 160	59	-	1.51	AD1657-1715	after AD1725
3	KP1	250 x 185	104	7	1.36	AD1625-1728	AD1731-67
4	TB4	290 x 240	53	H/S	1.67	AD1658-1710	AD1720-56
5	PR5	250 x 175	131	22+Bw	1.41	AD1379-1509	AD1509 winter
6	6R6	130 x 90	78	35+Bs	1.00	AD1432-1509	AD1510 spring
7	5R7	145 x 75	84	?H/S	1.22	AD1406-1489	AD1499-1535?
8	5R2	140 x 90	121	32+Bs	0.90	AD1389-1509	AD1510 spring
9	6R7	135 x 90	95	27	0.85	AD1410-1504	AD1504-23
10	P6	225 x 175	86	H/S	1.15	AD1393-1478	AD1488-1524
11	P8	210 x 200	-	-	-	unmeasured	-
12	8R10	140 x 75	66	37+Bw	0.60	AD1444-1509	AD1509 winter
13	PR8	200 x 175	116	20+Bw	1.64	AD1394-1509	AD1509 winter
14	1R10	140 x 90	93	15	1.30	AD1396-1488	AD1488-1519
15	P2	200 x 175	55	9	1.00	AD1435-1489	AD1490-1526
16	P3	240 x 210	40	-	1.24	AD1406-1445	after AD1455
17	2R2	140 x 90	92	24	1.39	AD1416-1507	AD1507-29
18	P4	270 x 180	97	5	1.59	AD1634-1730	AD1735-71

Table 2: List of dendrochronology samples and results

Growth rate = mm/year, H/S = heartwood/sapwood boundary, ?H/S = possible heartwood/sapwood boundary, +Bs = bark-edge with an incomplete annual ring indicating the tree was felled in spring, +Bw = bark-edge with a complete annual ring indicating the tree was felled in winter.

The sequence dated AD1379 to AD1509 comprised samples from two principal rafters (PR5, PR8), three purlins (P2, P3, P6), and seven common rafters (1R10, 2R2, 5R2, 5R7, 6R6, 6R7, 8R10). Five of these samples had surviving bark-edge (PR5, PR8, 6R6, 5R2, 8R10), and each of these was felled in the winter of AD1509 (the two principal rafters and common rafter 8R10), or spring of AD1510 (common rafters 5R2 and 6R6). Felling date ranges could be calculated for the other seven dated samples by adding the minimum and maximum likely numbers of rings of lost sapwood to the date of the last heartwood ring for each of these samples (see Table 2 and Figure 13 for details). These calculations are superfluous given the precision obtained from the other five samples.

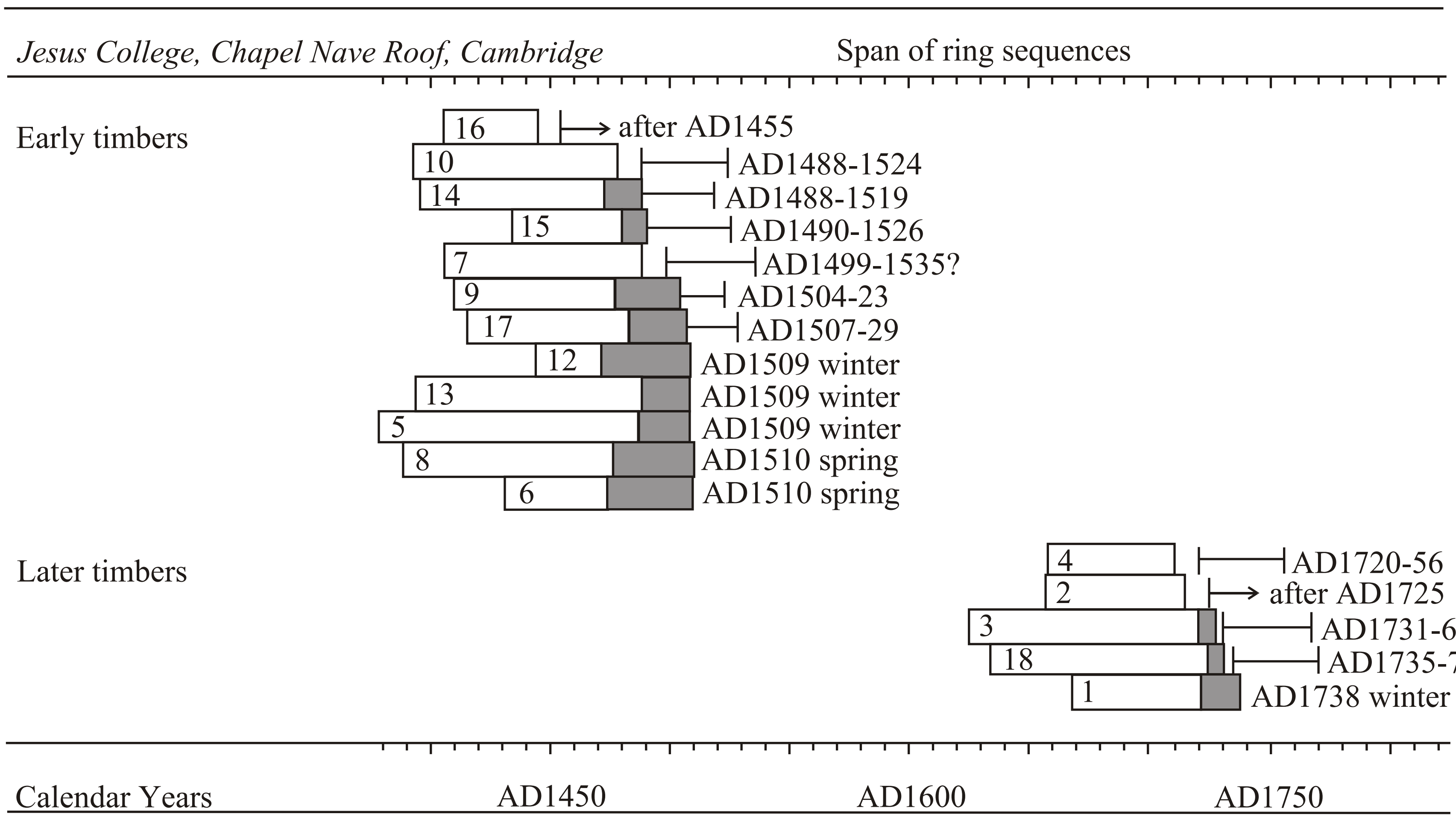


Figure 13: Bar diagram showing the relative and absolute positions of the dated samples from Jesus College, Cambridge.
(White bars represent heartwood, shaded bars represent sapwood. The felling date, felling date range, or *terminus post quem* date is also shown for each sample as appropriate)

There were clear examples of seasoning distortions on the king posts and some of the purlins that can only have occurred after they were squared. This observation suggests these elements of the framing were each prepared whilst their timbers were still green, effectively within a few weeks or months of their felling. It is thus reasonable to assume initial construction of this structure occurred at or shortly after the winter of AD1738.

It should be noted that the distinction between winter and spring felling in the AD1509/10 group may be negligible in terms of the actual day of felling. A group of oak trees in the same location at around Easter always includes some trees that have begun the season's new growth, whilst some are still dormant. Timbers felled at that time of the year would be expected to include material with slightly different apparent felling dates.

Discussion

The physical evidence visible in the Chapel roof reveals that the present structure was constructed from a mixture of fresh and re-used oak. The re-used timbers provide evidence of two earlier roofs and a third structure, possibly wall studs. As the dendrochronology results show the timbers fall into two main date groups; one to the spring of 1510; the second at or shortly after the winter of 1738.

Dealing with the later roof first. Prior to the survey a presumption was made that there were likely to be three distinct phases of timber evident in the present roof, including a later 19th century one indicating alteration to allow construction of the William Morris ceiling beneath in the 1860s. In the event this was not the case and it is clear that the Morris ceiling was fitted into an existing roof structure that was some 130 years older. That is not to say that there were not later 19th century alterations to other parts of the chapel and roof. The eastern roof was rebuilt to a design by Pugin in the 1840s which 'restored' it to a steeper medieval style pitch rather than the lower pitch evident in Loggan's 1688 engraving. Interestingly in the same image the western roof retains the steeper pitch, which it will lose some 50 years later.

The 1738 roof follows the standard design of truss introduced into the country in the 17th Century (Yeomans 1992: 30). It was similar in design to that shown in Plate G of Francis Price's *The British Carpenter* of 1733. When skilfully built, as this roof clearly was, the two principal rafters clasp the joggles at the top of the king post as the sides of an arch would clasp the keystone at the top. The principal rafter's lower ends were tenoned and bolted to the ends of the tiebeam that acts as the abutment to the arch. The result of this was that once the truss was built the king post was suspended from the joint with the principal rafters, and subsequently was able to support the centre of the tiebeam rather than resting upon it. This meant that structures could be built with more slender tiebeams than previously. Although some 17th century examples were constructed of pine it was still common for oak to be used in the 18th century as was the case here.

When oak was used metal straps were not generally considered to be necessary to hold the tension joint at the base of the kingpost to the tiebeam, however such straps were visible on trusses within the Masters Lodge roof. Yeomans notes that straps

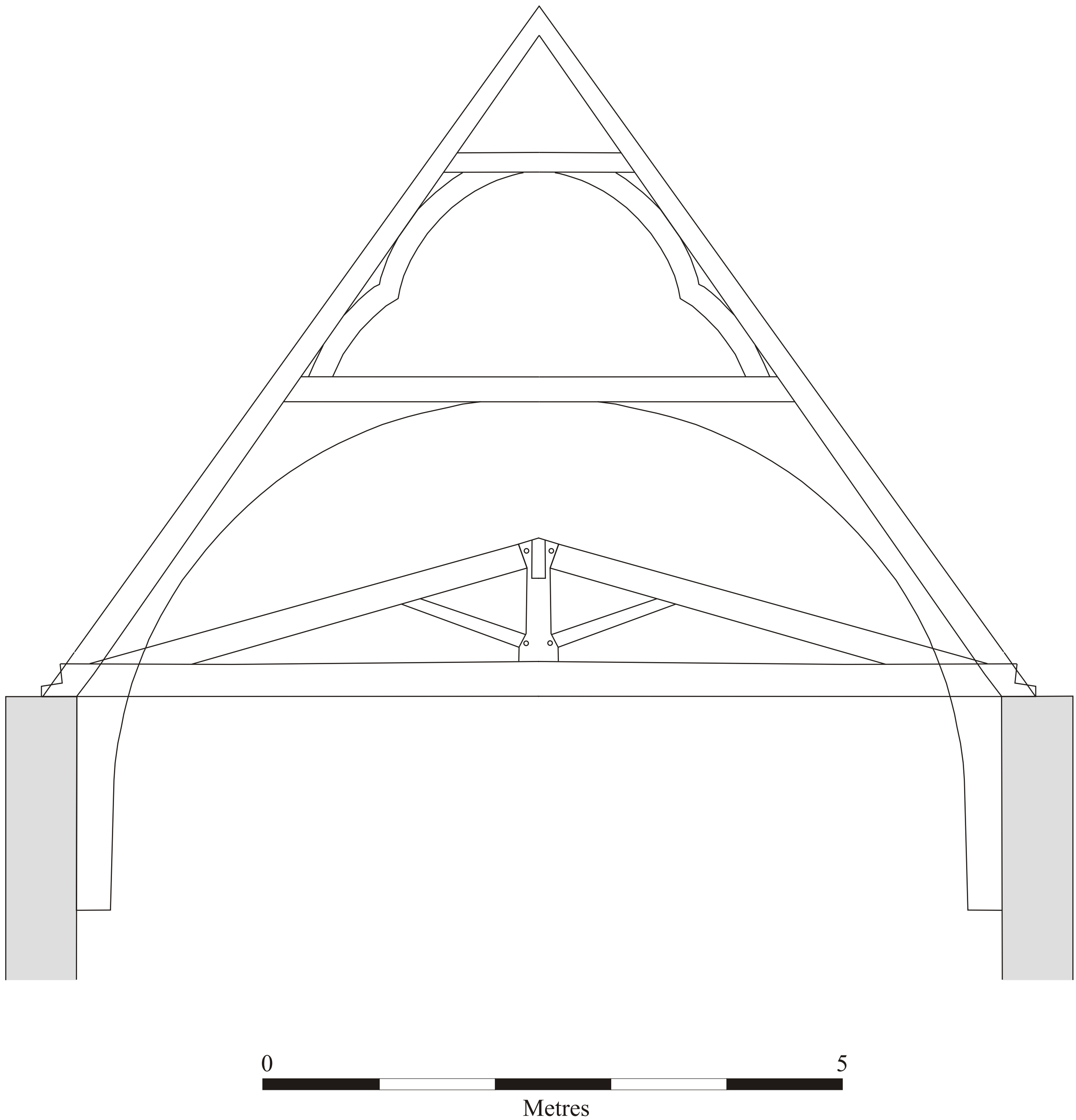


Figure 14: Section comparing the 1510 and 1738 roofs in position above the nave

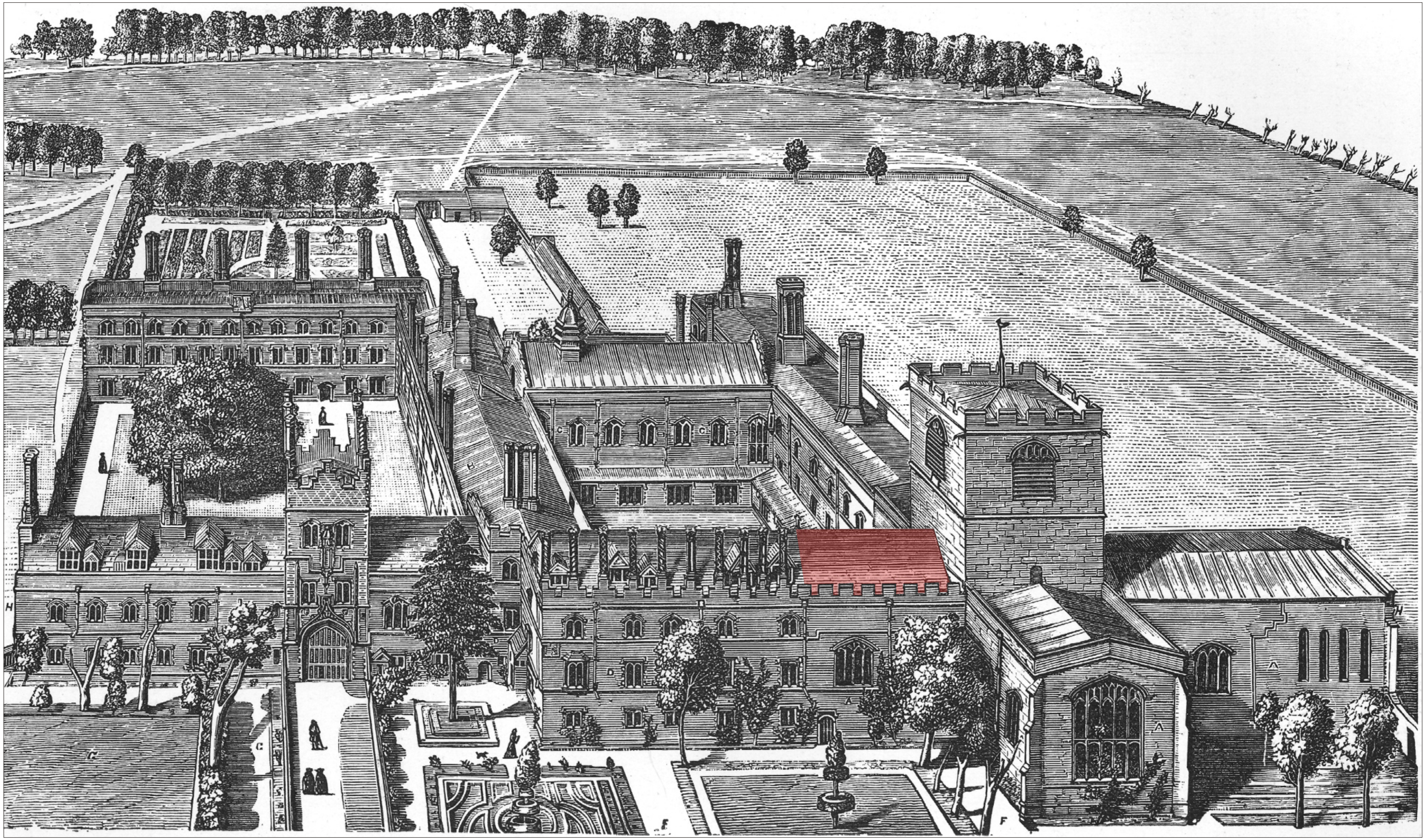


Figure 15: Loggan’s 1688 engraving of Jesus College (nave roof coloured)

were not considered necessary with oak trusses (Yeomans 1992: 40). This is clearly true as there is no evidence that this joint had opened. If it were an original feature it there should have been straps on all the joints between the tiebeams and king posts. Straps are, however, much more common on pine truss roofs of the 19th century and it is probable that this is when these were added - perhaps installed by a lesser carpenter than the man who original built the roof. The raising of the Master's Lodge roof took place in the 1980s, also to address drainage issues (Alan Fosbeary pers comm.). The evidence from the similar shape of the oak trusses (the draw pegs points had been left on the trusses in similar positions) the use of a pine ridge plank, and the redundant joints for butt purlins all suggest that the king post truss roof was originally a single structure over both the chapel and the Masters Lodge. The use of reused timbers at the tower end and pegging towards the tower and wall dividing the chapel from the masters lodge suggest that the roof was built from the tower end, the presence of the peg ends 100mm long indicates that the trusses were assembled on the roof possibly upright. Had they been assembled horizontally then raised the pegs would have faced away from the tower. Had the truss been built on the ground the pegs would have been cut off before it was lifted onto the roof.

Although this style was a relatively new roof form the carpenter clearly understood the design, but it is not clear why he had gone to the considerable effort of reshaping the medieval principle rafters unless the roof was to be view from below. If it was to be seen why then were the redundant joints not also filled in? The tapering of the principle rafters may just have been something a respected eighteenth century master carpenter had to do.

In considering evidence for the earlier structures, the chapel was certainly one part of the former nunnery upon which Bishop Alcock's mark is believed to have been set. To him is credited destruction of the nave and choir aisles, walling up of the arcades and separation of the western part of the nave from the rest by construction of a wall to provide first chambers and afterwards a lodge for the master (Atkinson 1897: 396). It seems likely that the work was to Alcock's design, but the dates provided by this study demonstrate conclusively that it was still underway some ten years after his death.

The reconstruction of the roof based on the Group 1 timbers fits very well on the space above the chapel nave. The calculations show that at a pitch of 55-60° and a W-E length of just over 9m, it sits neatly in the space available between the tower and the inserted wall separating off the Master's Lodge (see Figure 9). This would suggest that the Group 1 roof is the original 'Alcock' roof of the altered chapel, an interpretation supported by the dendrochronology results. This is the roof shown in Loggan's 1688 engraving of the college (Figure 15), a late medieval steeply pitched roof which the evidence suggests was open to the rafters with decorated purlins facing down into the body of the building. One very unusual feature of the roof is the way in which the moulded part of the purlins have been set into the body of the principal rafters (see Figure 7). One explanation is that this was an attempt to give greater rigidity to the roof, a function later fulfilled by the diminished haunch. Hewitt (1980) dates use of this joint to between 1510 and the end of the 17th century. The earliest use is usually credited to that in King's College Cambridge, but has more recently been pushed back to at least 1500/01 (and possibly earlier) at St. Aylotts near Saffron Walden in Essex (http://www.periodproperty.co.uk/ppom022004.htm). It is interesting to note that an existing solution, and one in use at precisely the same time at King's College, was not used by the Jesus College carpenter and that instead he devised his own unique version.

Loggan's image also shows that the roof over the Master's Lodge which, although of the same pitch, was very different in style to that of the chapel having dormer windows (indicating a roof space in use) and five sets of decorated brick chimneys. Although it is not possible to be conclusive this, perhaps, is the context for the second set of roof timbers incorporated into the 1738 roof. The Group 2 timbers are of broadly the same date as Group 1 and the presence of windbraces would suggest that they also come from a steeply pitched roof, the material from which was available for reuse in the 18th century. Perhaps, then, these belong to the Master's Lodge section of the 'Alcock' phase of work on the former nunnery church?

It is interesting to note that, although there are clear difference between the two principal roof structures (the 1510 'Alcock' roof and the 1738 roof) there are also some important similarities which cast light on the craft of the carpenter in this Cambridge College. First is the sourcing of the new wood in each structure and its quality. The dendrochrolonolgy results in particular show that in both cases English oak was being used and that it had been sourced from southeastern England. This is most significant for the later roof where, by this time, imported oak or pine might more commonly be used. Although much of the 1738 structure was of reused timber, significant elements, notably the king posts and tiebeams, were not. Distortions noted on the central sawn face of the king posts indicated that the timber was sawn in the green so at least some of the oak used in these trusses had been freshly felled for the job. Trees were cut intentionally to provided a timber that was large enough to provide joggles at both the top and bottom, indeed two of the king posts appear to come from the same tree (see above p.31). Oak of this size, again, was not that common in England at the time when imports, particularly from the Baltic region, were being brought in.

The other significant similarity between the two roofs was the skill of the carpenters that constructed them. Both demonstrate work of the highest quality. In the 1510 roof an independent, and possibly unique, approach to a problem solved elsewhere by the diminished haunch was the scribing in of the moulded part of the decorated purlins. This must have been time consuming and difficult and yet was executed with consummate skill. As already discussed above the 1738 trusses were constructed in such a way that the tiebeams were supported beneath the king posts rather than providing support for them. In effect the trusses acted as a series of arches across the roof space.

This exploration of one small part of the fabric of Jesus College has provided an important glimpse, not only into the skill and practice of late medieval and Georgian carpentry, but the development of part of a building as reflected in those skills and in the use of the materials involved. The dendrochronology sequence in particular has demonstrated that preconceptions should be treated with suspicion and that any future opportunities to pursue investigation of the constituent elements of the buildings are likely to be rewarding.

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Appendix 1
Tree-ring analysis of timbers from a building: The chapel nave roof at Jesus College, Cambridge
Ian Tyers

Introduction

Jesus College stands to the north of Jesus Lane, itself to the north-east of the centre of the City of Cambridge. The chapel is in the south-east corner of the chapel court (NGR *c*. TL 4523 5888). The tree-ring analysis of timbers from the nave roof of this building was commissioned by the Cambridge Archaeological Unit during recording of timbers revealed during repairs. Sampling was undertaken on 18 *in-situ* timbers from the nave roof. Dates were obtained from 17 of the samples, indicating 16th and 18th century timbers are present in the roof.

Tree-ring dating

Tree-ring dating or dendrochronology is an independent dating technique that utilises the pattern of ring widths within a sample of timber to determine the calendar period during which the tree grew. From England there are a large number of oak (*Quercus*) ring-width reference chronologies against which new sequences can be tested. The geographical and temporal coverage of these ring-width reference chronologies is constantly being extended and a series of strong regional chronologies can be produced for almost the entire area. If suitable ring sequences can be obtained, and these can be matched to reference chronologies, precise dates can be provided for buildings for which the date is either unknown or uncertain. It is not intended here to provide comprehensive details of the method as there is an extensive body of literature upon the subject. Details of the technique are given in Schweingruber (1988). The general methodology and working practises used are described in English Heritage (1998). A dendrochronological study is of real value only where integrated with detailed building recording. This report is for archive use and not intended for publication.

Several important aspects of the technique that need to be outlined here:

1). Trees put their new growth on the outside of their trunk, just under the bark. The most recent rings are therefore those originally most near the outside of the tree. A series of tree-rings from a sample run from the oldest which are those nearer the centre through to the most recent which are nearer the outside.

2). It is necessary that enough annual growth rings are obtained from any one sample in order to be able to find reliable cross-correlation with other tree-ring sequences. For oak the minimum acceptable number of rings is widely held to be 50, although some of the material from each site usually has to contain a minimum is 100 rings if dating is to be successful.

3). Since not all timbers contain datable sequences, it is appropriate to obtain samples from a number of apparently suitable timbers in any building for which a date is sought.

4). The date of the tree-ring sequence must not be confused with the date of usage of a tree. The felling year of a tree can only be determined by obtaining sequences that have complete sapwood and either bark or identifiable bark-edge. Such samples do not survive in every building. Many dendrochronological studies of buildings thus only provide felling date ranges or a *terminus post quem* dates.

5). The date of felling of a tree is not necessarily the date of its use. Observations relating to the toolmarks and conversion distortions can be used to suggest timbers were cut and framed whilst green. However it remains possible that timbers were re-used and that this has not been identified during the recording and interpretation of any particular structure.

6). The standard method of reporting correlation between tree-ring sequences employed throughout European dendrochronology is by use of coefficients calculated using the CROS algorithm of Baillie and Pilcher (1973). This algorithm produces *t* values. A *t* value of between -3.0 and 3.0 is normally found for each non-matching position of overlap between any two sequences. Values of between 3.0 and 5.0 may reflect the correct dating position. Values between 5.0 and 12.0 are usually reliable indicators of synchronous sequences. Values of 12.0 and above are usually found between two sequences derived from the same tree. Reference chronologies are composite series mathematically constructed from many separate data series. Reference chronologies correlate more strongly than individual series.

7). The *t* value tables (Tables 4 and 5) lists examples of matches between the two composite data sets from this building and independent reference series. These tables are intended to show that there is independent corroboration for the dating given here, the list of which chronologies match best is irrelevant, except that it indicates the general area of the country where the trees were originally derived from. These tables are not exhaustive, since both these sequences match many other reference series, the tables do not necessarily list the highest correlations available for either sequence.

8). The report uses a calendar year running from 1st January to 31st December. For medieval and post-medieval documents, until the calendar reform of 1751, official English documents conventionally used a calendar year that ran from 25th March, known as Lady Day. Any documents referring to the building programmes relevant to these timbers original usage would probably be using the date of the previous year during the period January 1st to March 24th.

Methodology

Jesus College chapel is the oldest College building in Cambridge. It was originally the church of the Benedictine nunnery of St Radegund and was completed in the 13th century. The nunnery was suppressed and its buildings appropriated for the new college by its founder John Alcock, Bishop of Ely and Lord Chancellor, in 1496. The college utilised the chapel, cloister, prioress's lodging and refectory, but Alcock soon modified the chapel, reducing it in scale to allow for expansion of the cloisters, and changing the pitch of the roof. The chapel was extensively restored by Pugin *c*. 1844 which is said to have removed Alcock's roof, and again by Bodley, *c*. 1864-67, the latter incorporating a ceiling painted by William Morris. In 2006 the chapel roof was the subject of a repair programme to protect the Morris ceiling from rainwater damage.

The nave roof is aligned east-west and the eastern half was the area available for sampling. The initial inspection showed the nave roof to contain a mixture of fresh and re-used oak timbers, many of which appeared to be suitable for tree-ring analysis. The sampling was intended to identify the date of the fresh timbers used in the nave roof structure, and it was also intended to identify whether only one, or more than one, phases of re-used material were also present. The sampled area consisted of four low pitched roof trusses, with short king posts. Between each roof truss were five pairs of common rafters, consisting of short lengths housed into the single row of joggled purlins. The king posts, tiebeams and some of the purlins appeared to be original to the present structure, whilst the principal rafters, the rest of the purlins and the common rafters were derived from re-used timber. For the purposes of this report the trusses were labelled from the east (as T1 to T4, see Figure 3).

The timbers in the roof were carefully examined for indications of the numbers of rings present and any sign of the presence of sapwood and bark. Timbers that appeared to have more than the minimum necessary number of rings, that is those in which more than fifty annual rings appeared to be present, were considered suitable for sampling. The results of this preliminary assessment were used to provide a sampling programme. Eighteen timbers were selected as the most suitable for sampling. For the selected timbers the precise location of the sample was determined by factors such as the local presence of the bark surfaces, and ease of access. These locations were also intended to maximise the numbers of rings obtained within the samples, and maximise the likelihood of successfully obtaining bark-edge from the timbers. Sampling was undertaken on the selected structural elements using a 15mm diameter hollow corer attached to an 110v electric drill.

In the laboratory the sequence of ring widths in each core were revealed by preparing a surface equivalent to the original horizontal plane of the parent tree with a variety of bladed tools. The width of each successive annual tree ring was revealed by this process. The complete sequence of the annual growth rings in each of the samples were measured to an accuracy of 0.01mm using a micro-computer based travelling stage. The sequence of ring widths were then plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. Cross-correlation algorithms (e.g. Baillie and Pilcher 1973) were employed to search for positions where the ring sequences were highly correlated (Tyers 2004). These positions were checked using the graphs and, where these were satisfactory, new mean sequences were constructed from the synchronised sequences.

This initial analysis can obviously only date the rings present in the cores. The correct interpretation of those dates relies upon the nature of the final rings in the individual samples. If the sample ends in the heartwood of the original tree, a *terminus post quem (tpq)* for the felling of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of sapwood rings that may be missing. This *tpq* may be many decades prior to the real felling date. Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a felling date range can be calculated using the maximum and minimum number of sapwood rings likely to have been present. Alternatively, if bark-edge survives, then a felling date can be directly utilised from the date of the last surviving ring. The sapwood estimates applied throughout this report are a minimum of 10 and maximum of 46 annual rings, where these figures indicate the 95% confidence limits of the range. These figures are applicable to medieval and modern oaks from England and Wales (author unpubl.). The dates obtained by the technique do not by themselves necessarily indicate the date of the structure from which they are derived. It is necessary to incorporate other specialist evidence concerning the reuse of timbers and any repairs before the dendrochronological dates given here can be reliably interpreted as reflecting the construction date of any component of the structure.

Results

A total of eighteen timbers were selected for tree-ring sampling from the roof. The sampled timbers comprised three king posts, one tiebeam, two principal rafters, five purlins, and seven common rafters. These samples were assigned numbers 1-18 inclusive (Figure 12, Table 2). One of the samples, from a purlin, contained an unmeasurable sequence. The remainder included six which were complete to the bark-edge, and a further six that retained significant quantities of sapwood. Following their measurement all of these series were found to cross match forming two separate groups (Tables 3 and 4). A composite series was constructed from each group of correlated samples, a group of twelve timbers formed a sequence of 131 years length, whilst a group of five timbers formed a group of 114 years length. Each sequence was cross-matched with a large number of reference chronologies at a single consistent position (Tables 5 and 6). These correlations indicate the rings in the composite series date from AD1379 to AD1509 inclusive, and AD1625-1738 inclusive. Table 2 lists the dates of the individual samples derived by this process.

Discussion

All of the dated samples are from either the primary structure of the roof or the re-used timbers within it. The sequence dated AD1625-1738 comprised samples from three king posts, a tiebeam and a purlin and includes a king post with surviving bark-edge. This timber was felled in the winter of AD1738, another king post was derived from the same tree. Felling date ranges could be calculated for the other three dated samples in this group by adding the minimum and maximum likely numbers of rings of lost sapwood to the date of the last heartwood ring for each of these samples (see Table 2 and Figure 13 for details). These calculations are superfluous given the precision obtained from the king post sample.

The sequence dated AD1379 to AD1509 comprised samples from two principal rafters, three purlins, and seven common rafters. Five of these samples had surviving bark edge, and each of these was felled in the winter of AD1509 (two principal rafters and a common rafter), or spring of AD1510 (two common rafters). Felling date ranges could be calculated for the other seven dated samples by adding the minimum and maximum likely numbers of rings of lost sapwood to the date of the last heartwood ring for each of these samples (see Table 2 and Figure 13 for details). These calculations are superfluous given the precision obtained from the other five samples.

There were clear examples of seasoning distortions on the king posts and some of the purlins that can only have occurred after they were squared. This observation suggests these elements of the framing were each prepared whilst their timbers were still green, effectively within a few weeks or months of their felling. It is thus reasonable to assume initial construction of this structure occurred at or shortly after the winter of AD1738.

The re-used highly decorative material present throughout the structure is dated to the winter and spring of AD1509/10. This material contains different toolmarks, which are more characteristic of reprocessed seasoned timber. If this material was originally from the nave roof it suggests that the reconstruction work usually attributed to Alcock was not complete at the time of his death (which occurred *c*. 1500) but continued for a considerable time afterwards. The material may be derived from an entirely unrelated structure, although hopefully the archaeological recording and interpretation of these timbers would allow their original form and structure to be reconstructed.

It should be noted that the distinction between winter and spring felling in the AD1509/10 group may be negligible in terms of the actual day of felling. A group of oak trees in the same location at around Easter always includes some trees that have begun the seasons new growth, whilst some are still dormant. Timbers felled at that time of the year would be expected to include material with slightly different apparent felling dates.

	6	7	8	9	10	12	13	14	15	16	17
5	4.33	7.40	6.41	3.81	3.82	-	6.66	4.43	-	3.78	-
6		3.32	4.58	4.60	4.98	4.18	3.72	3.03	5.02	\	7.30
7			3.76	-	-	-	4.84	4.18	-	3.83	-
8				5.27	-	4.89	6.34	-	4.97	4.98	3.84
9					7.14	6.97	4.42	4.94	3.27	3.82	4.11
10						3.22	4.17	3.41	5.00	-	3.48
12							4.65	3.52	3.29	\	4.29
13								4.70	3.55	4.00	-
14									3.57	-	3.11
15										\	4.85
16											-

Table 3. Correlation *t*-values between the early group of dated samples from Jesus College, Cambridge. - = *t*-value less than 3.0, \ = little or no overlap between series.

	2	3	4	18
1	**13.74**	7.50	4.56	5.73
2		6.11	4.28	5.43
3			5.22	4.28
4				4.50

Table 4. Correlation *t*-values between the later group of dated samples from Jesus College, Cambridge. Bold value indicates these samples were derived from a single tree.

Reference chronology	Jesus 1, AD1379-AD1509
Bedfordshire, Chicksands Priory (Howard *et al* 1998)	8.61
Essex, Saffron Walden St Aylotts (Tyers 1996a)	7.34
Essex, Stambourne Church (Tyers and Groves 2000)	8.24
Essex, Strethall St Marys (Bridge 2004)	7.91
Essex, Widdington Priors Hall Barn (Tyers 2000b)	7.49
Essex, Widdington Priors Hall Outbuilding (Tyers 2001)	8.73
Hampshire, Mary Rose original timber (Bridge and Dobbs 1994)	7.76
Kent, Longport Farmhouse (Tyers 1996d)	7.78
London, Hays Wharf (Tyers 1996b; Tyers 1996c)	8.30
London, Sutton House building (Tyers 1991)	7.79

Table 5. Illustrative correlation *t*-values between the early mean sequence constructed from the dated samples from Jesus College, Cambridge and a number of independent oak reference chronologies.

Reference chronology	Jesus 2, AD1625-AD1738
Bedfordshire, Chicksands Priory (Howard *et al* 1998)	8.62
Berkshire, Windsor Castle (Tyers *et al* 1997)	7.24
Buckinghamshire, Claydon House (Tyers 1995)	7.80
Cambridgeshire, Wimpole St Andrews (Bridge 1998)	7.22
Essex, Coggeshall West Street Kings Mill (author unpubl.)	8.65
Hertfordshire, Wallingford Clothall Bury (Arnold *et al* 2003)	6.56
Lincolnshire, Benington Bay Hall (Howard *et al* 1999)	8.28
London, Fleet Valley (Tyers and Hibberd 1993)	6.20
London, Royal Arsenal Woolwich (Tyers 2000a)	7.40
Suffolk, Sudbury Ballingdon Bridge (Tyers 2002)	6.76

Table 6. Illustrative correlation *t*-values between the later mean sequence constructed from the dated samples from Jesus College, Cambridge and a number of independent oak reference chronologies.

Appendix 2
Glossary of Terms

BRACE/ANGLE BRACE: An inclined timber used to support and provide rigidity to roofs, partitions etc.

WIND BRACE:. A diagonal or arched member placed across rafters to stiffen and support a roof structure.

BOXED HEART: Technique used by a sawyer as the timber is sawn from the log in that the center of the log is 'boxed' within the timber.

COLLAR: A horizontal member connecting rafters or cruck blades at a point between their feet and the apex of the roof.

DIMINISHED HAUNCH: A refinement of the standard mortice and tenon joint where an backwards angled slope is cut on the upper shoulder of a tenon joint allowing part of the timber to be housed into the morticed timber.

JOGGLE: A notch or tooth in the joining surface of any piece of building material to prevent slipping. Alternatively wider sections at the head and foot of a post cut at an angle, to support the ends of rafters or braces
.

JOGGLE JOINT: a joint in any kind of building material, where the joining surfaces are made with joggles.

KING POST: An upright post set on a tiebeam or collar and used to support a ridge piece.

LAP DOVETAIL JOINT: A joint in which the dovetailed member is proud of the receiving member and is not finished flush with it.

LATH: The smallest piece of timber (2-5cms across) used in building, employed on rafters to support the roof covering or in a partition as a base for plaster or external render and wall covering.

MORTICE AND TENON JOINT: The most common form of joint between two timbers meeting at right angles or at an oblique angle, the mortice being a socket cut in one timber to receive the tenon projection of the other.

BLIND MORTICE:. A mortice that does not pass through the timber

PEG: A wooden nail, round or square in section, used to fix a joint.

DRAW PEG:. Peg with a slight offset on the hole to create a ‘draw’, which has the effect of pre-stressing the connection

PURLIN: A horizontal timber set in the plane of a roof's slope and supporting common rafters.

BACK PURLIN: A purlin that is joined to the back of a principal rafter.

BUTT PURLIN/TENONED PURLIN: A purlin that is joined to a principal rafter by a tenon joint

RACE KNIFE: A cutting tool with a blade that is hooked at the point, for marking outlines, on boards or metals, as by a pattern, -- commonly used in shipbuilding

RAFTER: An inclined member used to support laths under a roof covering. Normally one of a pair.

COMMON RAFTER: A rafter of uniform size placed at regular intervals along the length of a roof.

PRINCIPAL RAFTER: A structural member that supports a purlin and is also a common rafter.

RIDGE PIECE/RIDGE BOARD/RIDGE PLANK: The horizontal timber running the length of a roof and positioned at its apex.

TIEBEAM: A major horizontal timber spanning a roof space to connect a pair of principal rafters and prevent them spreading.

TRUSS: A combination of timbers to form a frame placed at intervals and carrying the purlins.

WALL PLATE: A longitudinal timber set on top of a timber frame, brick or masonry wall on which roof-trusses or rafters rest.