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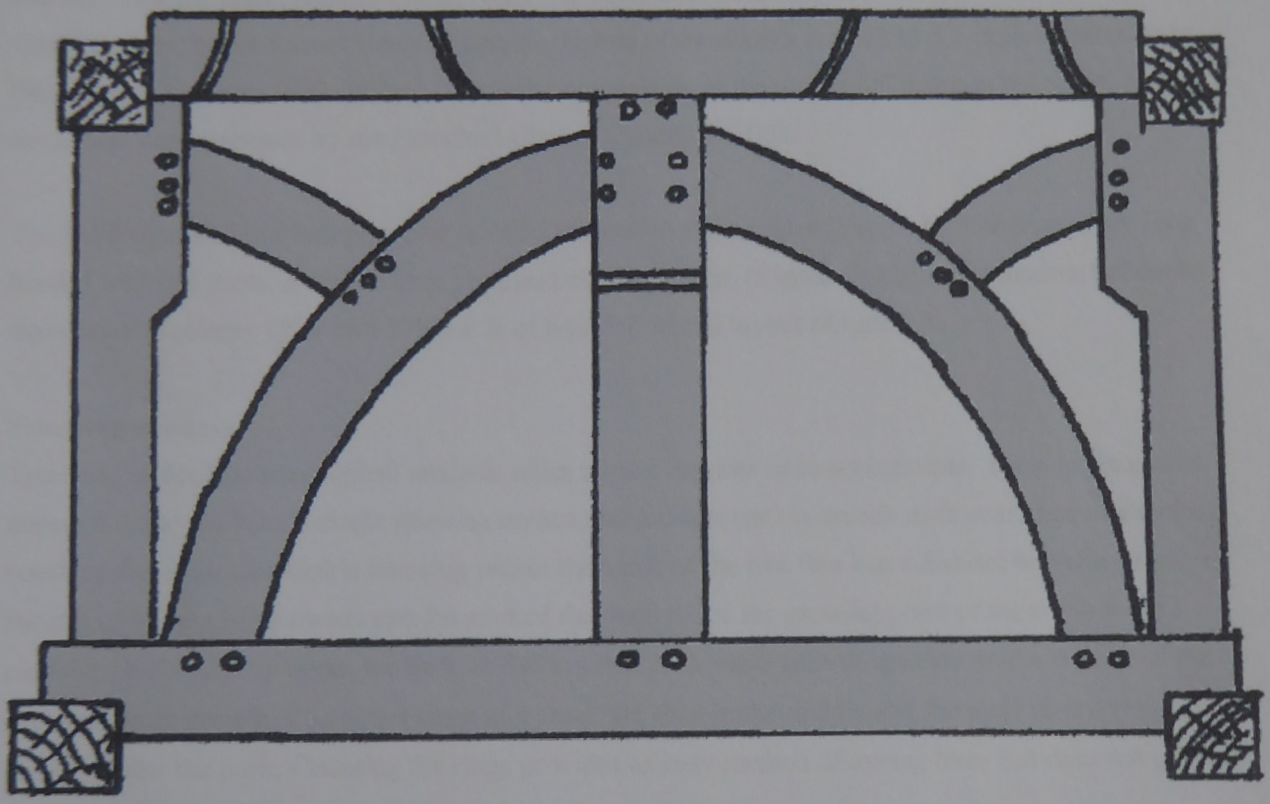
Project Report 717g

The tree-ring analysis of the Bellframe at the church of St Bartholomew the Less, London EC1



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Prepared For:

The Parochial Church Council
St Bartholomew the Less
Smithfield Gate
London EC1

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Introduction

The Hospital and Priory of St Bartholomew were founded c 1123, with the Priory being suppressed during the Dissolution. The parish of St Bartholomew the Less, which was constituted 1546/7 is unique in that it consists solely of the precincts of the Hospital of St Bartholomew. The church of St Bartholomew the Less (Figures 1 & 2; NGR TQ 3188 8160) consists of a fifteenth century tower and vestry derived from a former Hospital chapel, the rest of the church is of 1823-5 with later alterations (Bradley and Pevsner 1997, 203-4). The tree-ring analysis of the timber bellframe at the top of the tower was commissioned by the Parochial Church Council in 2003.

The bellframe is of five bell pits, four parallel and one at right angles (Figure 3). The trusses are long headed with end posts, a central king post, and curving braces (Figure 4). Using the modern bellframe classification scheme (Pickford 1993) it is of type 5.F with a layout of type 5.3.

Tree-ring analysis

Tree-ring or dendrochronological analysis relies upon a number of basic concepts. Trees in temperate zones of the world have a single growing season and a single resting season each year. The anatomical result of this is an identifiable tree-ring within the trunk of the tree that has a distinct boundary marking the end of one growing season and the start of the next. Since the growing point of the trunk is the cambium layer directly under the bark, it follows that each years growth appears on the outside of the previous years growth. The oldest rings of a trunk are thus in the middle and the most recent rings are directly under the bark. Counting the rings provides as easy method of ageing trees but does not provide a method of dating the trees.

In contrast, dendrochronology attempts to provide absolute dates for the rings present in individual timbers. This is achieved by measuring very precisely the widths of each successive ring within a sample and comparing the pattern of narrow and wide rings with reference chronologies built up by previous work. The technique can be successful and reliable only when a number of conditions are met. Firstly, there have to be contemporary chronologies of the relevant species, or genus, of timber from sufficiently nearby that some degree of cross-correlation is possible. For Britain and Ireland there is now a composite tree-ring chronology for oaks stretching back just over 7000 years. There are some periods and areas that are under-represented in this composite. However for the last 1500 years almost any building or archaeological structure should, all other things being suitable, manage to be reliably

dated by the method. However, the timbers have to have a long enough sequence of tree-rings that they match in only one position to other chronologies. For oaks from Britain a widely accepted minimum for each sample is 50 annual rings. However, it is actually almost always necessary that at least some samples from a building contain significantly more than this minimum figure.

Analysis of many thousands of timbers across Britain has also revealed that there is a consistent number of samples for which no reliable date can ever be obtained, even when many more than the minimum number of rings are present. Usually, for any sample group, between a quarter and a half of all samples cannot be reliably dated, although at some sites virtually every timber dates and at a few sites none can be dated. There are several interesting observations that can be made about undatable material. It seems fast growing trees are more likely to be undatable and trees that have suffered extreme growth reductions at certain points always give problems. Since many of these influences are potentially anthropogenic in origin it follows that at times of extensive woodland exploitation more timbers are potentially unsuitable for analysis than when under-exploited woodlands are being used.

Finally, the technique can only date the rings in a sample. The outer rings are the most recent (and only the ring directly under the bark is capable of providing the actual felling year of the tree), and these outermost edges of trees are often cut off during the process of converting round trees into square beams. In oak these rings are also sapwood, rather than heartwood, which makes them much more vulnerable to beetle attack or physical abrasion. Hence, it is only by careful selection of the available material, and no small amount of skill and luck, that samples that provide dates precise to the felling year are obtainable, otherwise estimates of the numbers of missing rings have to be made which provide a less precise date for the structure of interest.

Methodology

The general methodology and working practises used at the Sheffield Dendrochronology Laboratory are described in English Heritage (1998).

Each timber in the frame that could be safely accessed was carefully examined for indications of the numbers of rings present and 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 initially selected for sampling. The results of this preliminary assessment were reviewed to provide the most efficient approach to sampling the structure.

It was clear from the assessment visit that there was significant diversity of the timbers present within the structure. Some of the timbers contained too few rings for reliable dendrochronological analysis,

and the extensive chamfered decoration meant that there was significant constraint in terms of which timbers were suitable for sampling.

The sampling was undertaken in early June 2003. For the selected timbers within the bellframe the precise location of the sample was determined by factors such as the local presence of either sapwood and bark-edge, and ease of access. The sampling locations were designed to maximise the numbers of rings obtained. No timber included all the sapwood or the original bark-edge of the tree. Sampling was undertaken on the selected structural elements using a 15mm diameter hollow corer attached to an electric drill. Despite selecting positions that initially included sapwood and bark the resultant cores do not always retain these delicate structures, since sapwood that has been attacked by woodworm, or other pests, will often crumble to dust the instant the coring is begun. There are mixed views as to whether core holes should be filled after sampling. Generally accepted practise in buildings is to fill core holes only where aesthetic considerations require them, here the core sampling locations were left open to aid ventilation.

In the laboratory the ring sequences in the cores were revealed by sanding them in the original horizontal plane of the parent tree. The complete sequences of growth rings in the samples were measured to an accuracy of 0.01mm using a micro-computer based travelling stage. The ring sequences were plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition cross-correlation algorithms (e.g. Baillie and Pilcher 1973) were employed to search for positions where the ring sequences were highly correlated (Tyers 1999). These positions were checked using the graphs and, where these were satisfactory, new mean sequences were constructed from the synchronised sequences. The *t*-values reported below are derived from the original CROS algorithm (Baillie and Pilcher 1973). A *t*-value of 3.5 or over is usually indicative of a good match, although this is with the proviso that high *t*-values at the same relative or absolute position must be obtained from a range of independent sequences, and that these positions are supported by satisfactory visual matching.

Any tree-ring dates can obviously only date the rings present in the timber. 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 to the bellframe before the dendrochronological dates given here can be reliably interpreted as reflecting the construction date of the bellframe.

Results and Interpretation

A total of 10 timbers were selected for tree-ring sampling, these samples are numbered **1-10** inclusive (Figure 3, Table 1). The sampling attempted to encompass as wide a range of elements as possible within the bellframe. One of the samples, from the northern transverse head, proved unusable, however all the others contained useful numbers of rings, two of these retained some sapwood and two others were complete to the original heartwood/sapwood boundary of the tree. All nine series cross-match (Table 2) and a mean series constructed from them was then compared with medieval and post-medieval oak sequences from throughout England, Wales, and elsewhere in Europe. It was apparent that this chronology matched a number of independent reference chronologies at a single consistent position. This position was checked visually and appears to be a reliable match. The correlation of the sequence to other oak reference chronologies indicates a date of AD1292-1480 inclusive for the rings in the series (Table 3).

If we assume all the samples are from a single phase of construction we can calculate a felling date for the group by adding the minimum and maximum likely values for the number of sapwood rings to the ends dates of those samples with surviving sapwood or ending at the heartwood/sapwood boundary. This calculation indicates the felling of this group of trees occurred between AD1481 and 1507 (Figure 5). Many timbers in the bellframe exhibit post-conversion distortions, for example originally flat sawn surfaces are now quite convex. This implies these timbers were initially utilised green, it is therefore appropriate to assume construction of the bellframe occurred within the felling date range identified for these timbers, i.e. construction of the bellframe occurred between AD1481 and 1507.

The frame has hitherto been considered on typological grounds to be of later sixteenth century date, and possibly no earlier than 1570 (Pickford pers comm.), the tree-ring evidence demonstrates the bellframe is somewhat earlier than that, and it is possibly as early as the 1480's. This bellframe is thus of significant importance; it is the earliest surviving bellframe in the City of London, and it is of typologically advanced form.

Acknowledgements

The analysis reported here was commissioned by Dr Paul Simmons on behalf of the Vicars and Wardens of the parish of St Bartholomew the Less. I would particularly like to thank Chris Pickford for

his practical help and enthusiasm during the sampling, for providing a copy of his NADFAS inventory report, and for his discussion the implications of the results, Paul Simmons was endlessly helpful by his practical and administrative assistance and his enthusiasm, and Margaret Davies, Conservation Architect, provided helpful discussion over the sampling interventions.

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Figure 3 Plan of the bellframe at St Bartholomew the Less, London EC1, based on Chris Pickford's undated NADFAS survey drawing. The plan shows the alignment of the frame, and the truss and pit numbering scheme followed. The smaller numbers with arrows show the approximate location of each sampled timber. Note that in this instance compass north is significantly different from church 'north'.

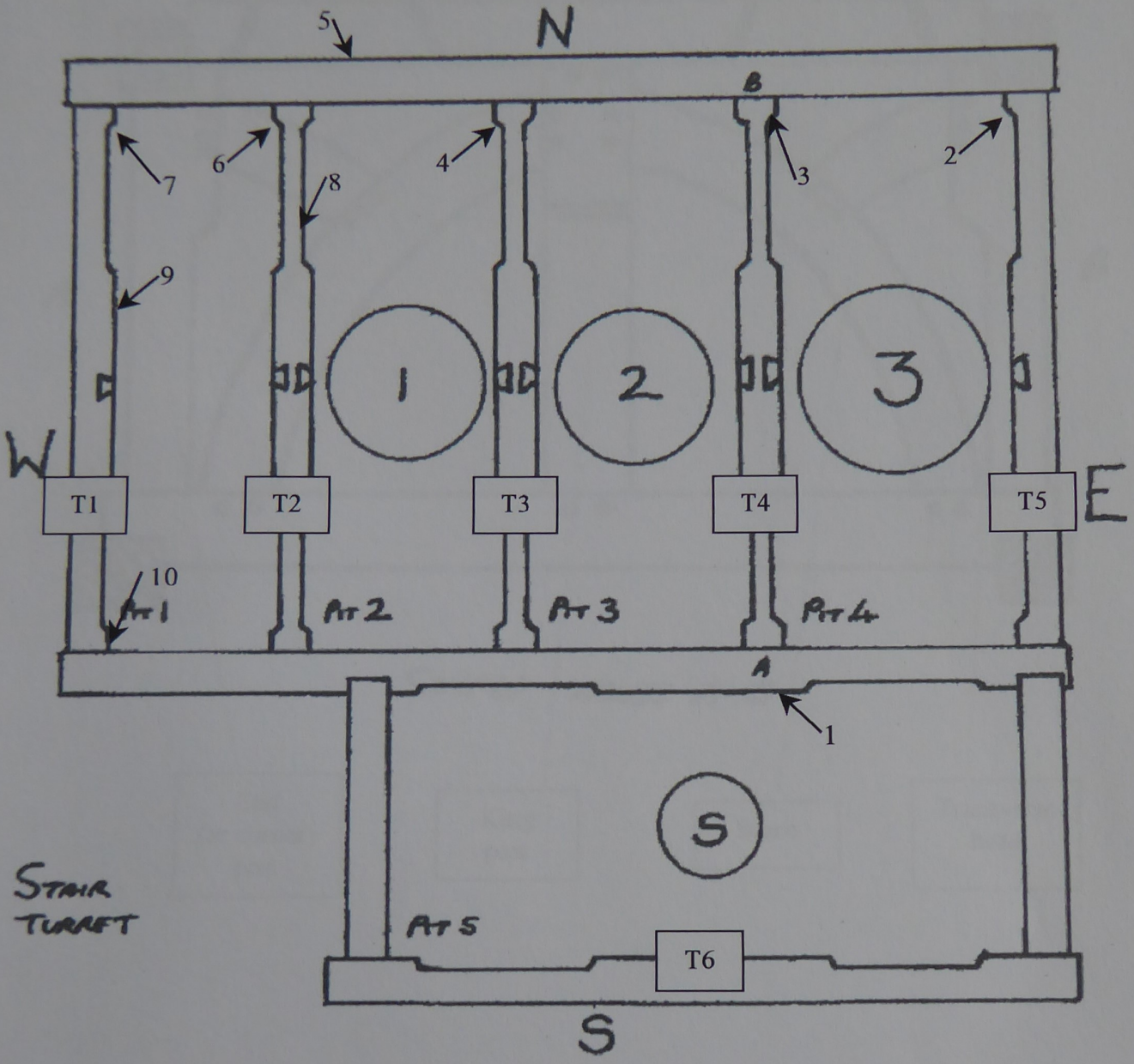

Figure 4 Elevation of Truss 4 from the bellframe at St Bartholomew the Less, London EC1, based on Chris Pickford's undated NADFAS survey drawing. The plan shows the nomenclature used in this report for the sampled structural elements.

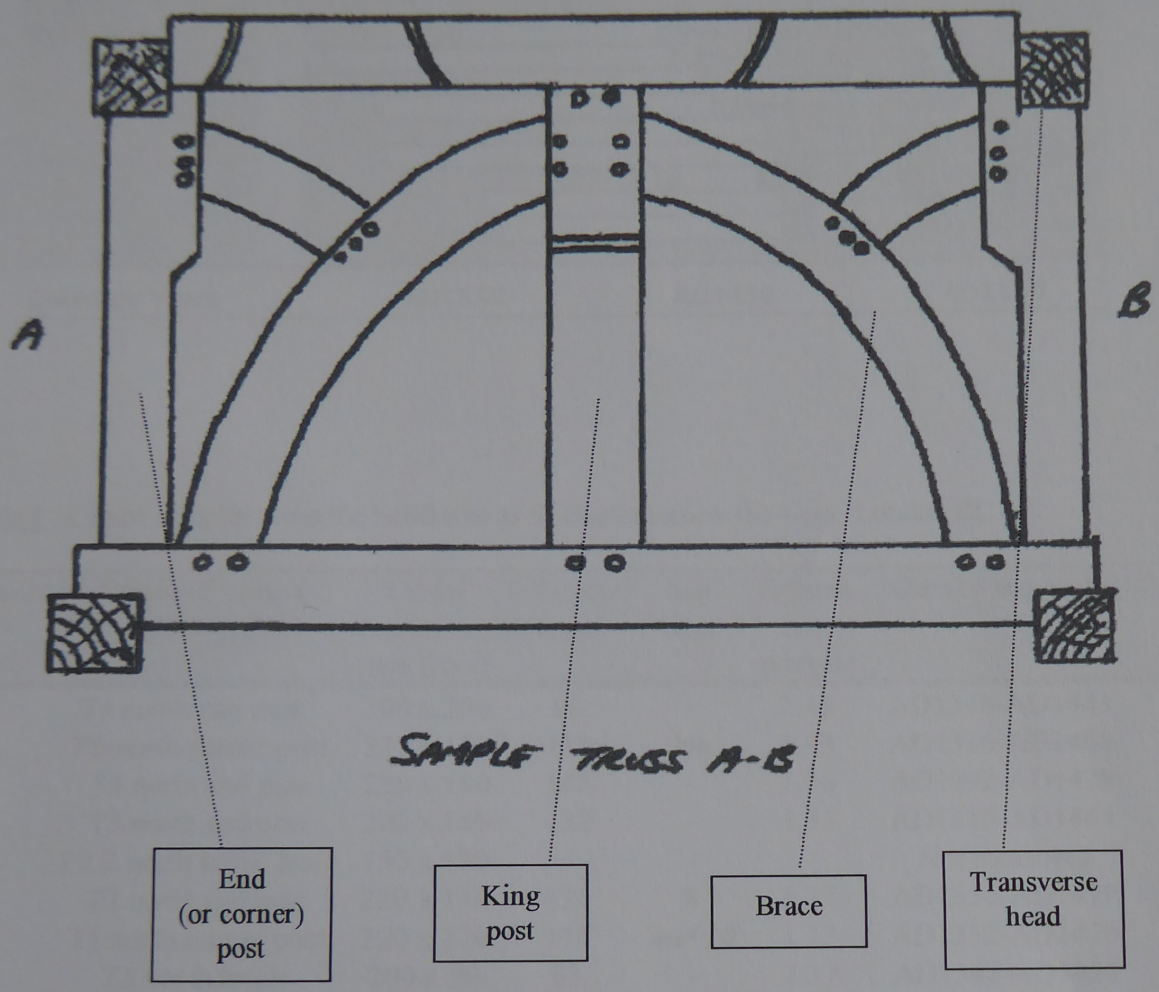

Figure 5. Bar diagram showing the relative and absolute positions of the dated material from the bellframe at St Bartholomew the Less, London EC1. White bars represent heartwood, hatched bars represent sapwood, the interpreted felling date ranges for each timber is also shown.

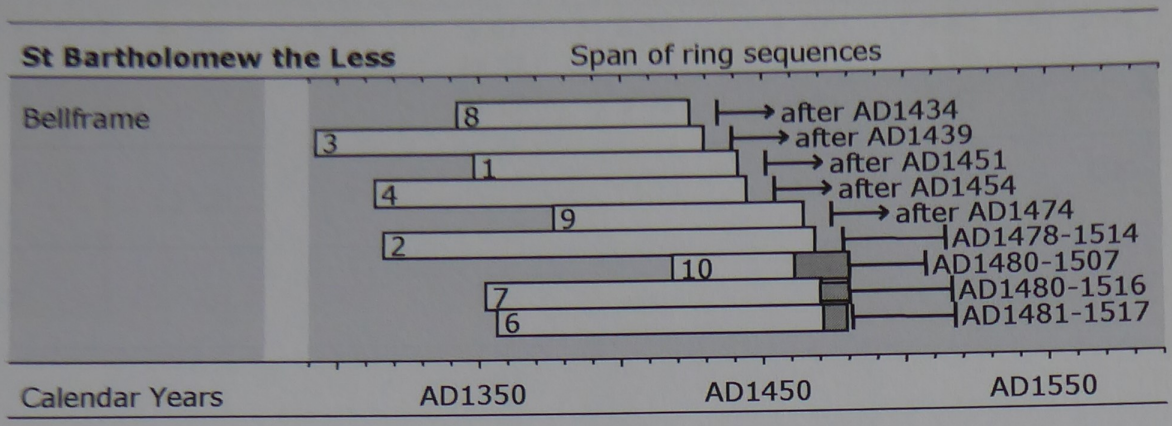

Table 1. List of samples from the bellframe at St Bartholomew the Less, London EC1

Sample	Origin of sample	Cross-section size (mm)	Total rings	Sap rings	Growth rate mm/year	Date of sequence	Felling date range
1	T4 south end post *	300 x 200	94	-	2.16	AD1348-AD1441	after AD1451
2	T5 north corner post	220 x 170	153	h/s	1.43	AD1316-AD1468	AD1478-1514
3	T4 north end post	220 x 160	138	-	1.36	AD1292-AD1429	after AD1439
4	T3 north end post	220 x 150	132	-	1.33	AD1313-AD1444	after AD1454
5	Pit 2 north trans. head	150 x 130	-	-	-	Not measured	-
6	T2 north end post	220 x 170	124	8	1.77	AD1356-AD1479	AD1481-1517
7	T1 north corner post	220 x 170	119	h/s+*10*	1.13	AD1352-AD1470	AD1480-1516
8	T2 north brace	200 x 90	83	-	2.37	AD1342-AD1424	after AD1434
9	T1 king post	220 x 110	89	-	1.68	AD1376-AD1464	after AD1474
10	T1 south corner post	200 x 160	63	19	1.47	AD1418-AD1480	AD1480-1507

T1 etc., truss numbers see Figure 3 for approximate origin of the samples, and Figure 4 for the nomenclature used to describe the timbers. h/s – core ends at the heartwood/sapwood boundary. *+10* detached section of sapwood includes a minimum of 10 additional rings.

*this post is also the central king post of the north side of pit 5, the timber has an L-shape section in order to double as both these elements of the structure, this demonstrates pit 5 is an integral feature

Table 2. Correlation *t*-values between the dated samples from the bellframe at St Bartholomew the Less, London EC1. Samples

	2	3	4	6	7	8	9	10
1	4.20	3.78	3.67	8.34	3.70	4.82	5.64	4.74
2		11.19	12.58	3.15	7.34	3.29	-	3.49
3			11.02	3.49	6.63	6.12	-	\
4				-	7.77	4.06	-	-
6					-	3.18	7.00	8.23
7						3.61	-	-
8							3.65	\
9								6.55

Table 3. Illustrative correlation *t*-values between the mean sequence constructed from the dated samples from the bellframe at St Bartholomew the Less, London EC1 and a number of independent oak reference chronologies.

Reference chronology	St Bartholomew the Less Bellframe AD1292-1480
Berkshire, Windsor Castle Kitchen (Tyers *et al* 1997)	6.91
Essex, Cressing Temple Wheat Barn (Tyers 1992)	8.04
Essex, Harlow Netteswellbury Barn (Tyers 1997)	7.53
Hampshire, Alton Johnson's Corner (Hillam 1983)	7.20
Kent, master sequence (Laxton and Litton 1989)	6.63
London, Hackney Sutton House (Tyers 1991)	7.13
London, Harrow Headstone Manor barn (Howard *et al* 2000)	7.58
London, Southwark Hays Wharf (Tyers 1996a; b)	10.40
Surrey, Newdigate Home Farm (Bridge 1998)	7.50
Sussex West, Ford, St Andrews Church (Bridge 2000)	8.41