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Summary

Dendrochronological analysis of elements of the bellframe in the spire of St Andrews, Sutton-in-the-Isle, has shown that this large well-preserved bellframe is of early seventeenth century date. This represents one of the first successful applications of dendrochronological techniques to a bellframe from East Anglia. In previous studies, difficulty in obtaining suitable samples from such structures has prevented the direct dating of timber bellframes. None of the later modifications to this frame has been successfully dated.

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Introduction

The purpose of the study was to carry out dendrochronological analyses of timber elements of the bellframe of St Andrews, Sutton-in-the-Isle, Cambridgeshire (NGR TL44847896). The spire has been the subject of a major programme of restoration. During this programme provision was made for a survey of the bellframe and this analysis was commissioned as part of this survey.

The bellframe originally consisted of four bell pits of equal size symetrically arranged around a central space (Figure 1) using four basically similar inner and outer trusses (Figures 2 and 3). A number of later modifications enabled six bells to be hung in the frame. The frame is the subject of a separate survey (Watkin in prep) and extensive discussion is beyond the scope of this report. Note however that using the modern classification scheme (Pickford 1993) the frame is a long-headed wooden frame with scissor braces (Group 5, sub-type R) and the original layout is type 4.2.

Methodology

The bellframe was visited and all the timbers were assessed for suitablility for analysis. Those timbers which had less than 50 rings were rejected as unsuitable for analysis. As is all too common from bellframes examined in Essex the majority of the timbers contained too few rings (author unpubd), at Sutton however the original four bottom bearers and majority of the top heads did include plenty of rings. In addition one of the floor beams was also accessible and appeared, from external examination, to possibly contain enough rings. Samples were taken using a 15mm diameter hollow corer attached to an electric drill. The cores were taken within the beams at positions which maximised the numbers of rings obtained and, where possible, included sapwood or the outer-most heartwood rings. The ring sequences in the cores were revealed by sanding the cores in the original horizontal plane of the parent tree.

The complete sequences of growth rings in the samples that were selected for dating purposes 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 (Baillie and Pilcher 1973; Munro 1984) were employed to search for positions where the ring sequences were highly correlated. 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.

All the measured sequences from this assemblage were compared with each other and those that were found to cross-match were combined to form a site master curve. This master curve and the remaining unmatched ring sequences were then tested against a range of reference chronologies, using the same matching criteria: high *t*-values, replicated values against a range of chronologies at the same position, and satisfactory visual matching. Where such positions are found these provide calendar dates for the ring-sequence.

These tree-ring dates can initially only date the rings present in the timber. Their interpretation relies upon the nature of the final rings in the sequence. 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 through-out this report are a minimum of 10 and maximum of 55 annual rings, where these figures indicate the 95% confidence limits of the range. These figures are applicable to oaks from the British Isles (Hillam *et al* 1987). 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 re-use of timbers and the repairs of structures before the dendrochronological dates given here can be reliably interpreted as reflecting the construction date of phases within the structure.

Results

The entire frame was of oak (*Quercus* spp.) but, as usual, the headstocks were elm (*Ulmus* spp.). Eight samples were obtained (Table 1), six of which proved to contain enough rings to be suitable for the technique. Samples **2** and **5** contained too few rings.

The measured sequences were compared with each other and of these five were matched together to form a single sequence (Table 2 and Figure 4). The average growth rates and quality of the cross-matching demonstrate the material is fairly similar but the sample size is too small to be sure if they were derived from a single woodland area. This sequence was found to match to an extensive range of chronologies (Table 3), and is dated AD 1508 to AD 1615

inclusive. The remaining measured sample has failed to produce a visually and statistically acceptable match and is thus undated by the technique. The site master chronology SUTTON, dating from AD 1508 to AD 1615 inclusive is listed in Table 4.

Interpretation

The presence of sapwood on two of the dated samples enables a felling date range to be calculated for the timbers in the bellframe. Samples **1** and **8** both included 13 sapwood rings, sample **1** ends at AD 1615 whilst sample **8** ends at AD 1611. Combining the felling date ranges for both timbers indicates felling in the period AD 1615 to *c* AD 1650. The interpretation of sample **3** which ends at the heartwood/sapwood boundary at AD 1600 and samples **6** and **7** which end at AD 1596 and AD 1588 respectively, both in the heartwood, are entirely compatible with this date range. These results support the overall impression of the structure that it is basically complete, with the exception of the obvious modifications.

The AD 1615 to *c* AD 1650 date range can however be further refined. Although sample **1** does not include the bark edge, the timber from which it came does. Unfortunately the outermost surface of the core disintegrated during sampling. Careful notes taken at the time indicate 6-8 mm of the core was lost, but that the bark-edge identification is sound because small fragments of bark still survived upon this beam's outer surface (lower north side). Since the core shows the tree was growing at an average growth rate of 2.4mm/year, it seems likely that a maximum of 10 but a minimum of 2 rings have been lost. This would indicate that the beam was felled between AD 1617 and *c* AD 1625.

If the material is used green, which appears to be normal practice, this interpretation indicates construction of the bellframe was after AD 1615 and probably around AD 1620.

Discussion

The provision of a fairly tight tree-ring date for an important East Anglian bellframe is useful evidence for survival of early bellframes in this area. The success of this analysis can be attributed to some extent to the massive trees utilised for the bottom bearers and the quartered trees used for the top heads. This is in marked contrast to the Essex pilot survey where five bellframes have so far failed to provide a single dated sample (author unpubd).

One notable aspect of the analysis is the remarkable quality of the matches obtained between the bellframe timbers and those from the Granary and Farmhouse at Cressing Temple, Essex. These are structures dating from AD1623 and *c* AD1603 respectively (Table 3). The chronology from St Andrew's may therefore be of significant value for future studies in north Essex as well as south Cambridgeshire.

Conclusion

The present bellframe at St Andrew's is early seventeenth-century in date, most probably around AD 1620. This is important evidence of East Anglian bellframe construction systems.

Acknowledgements

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Figure 1 Plan of bellframe (Derived from survey by Mr E Watkin)

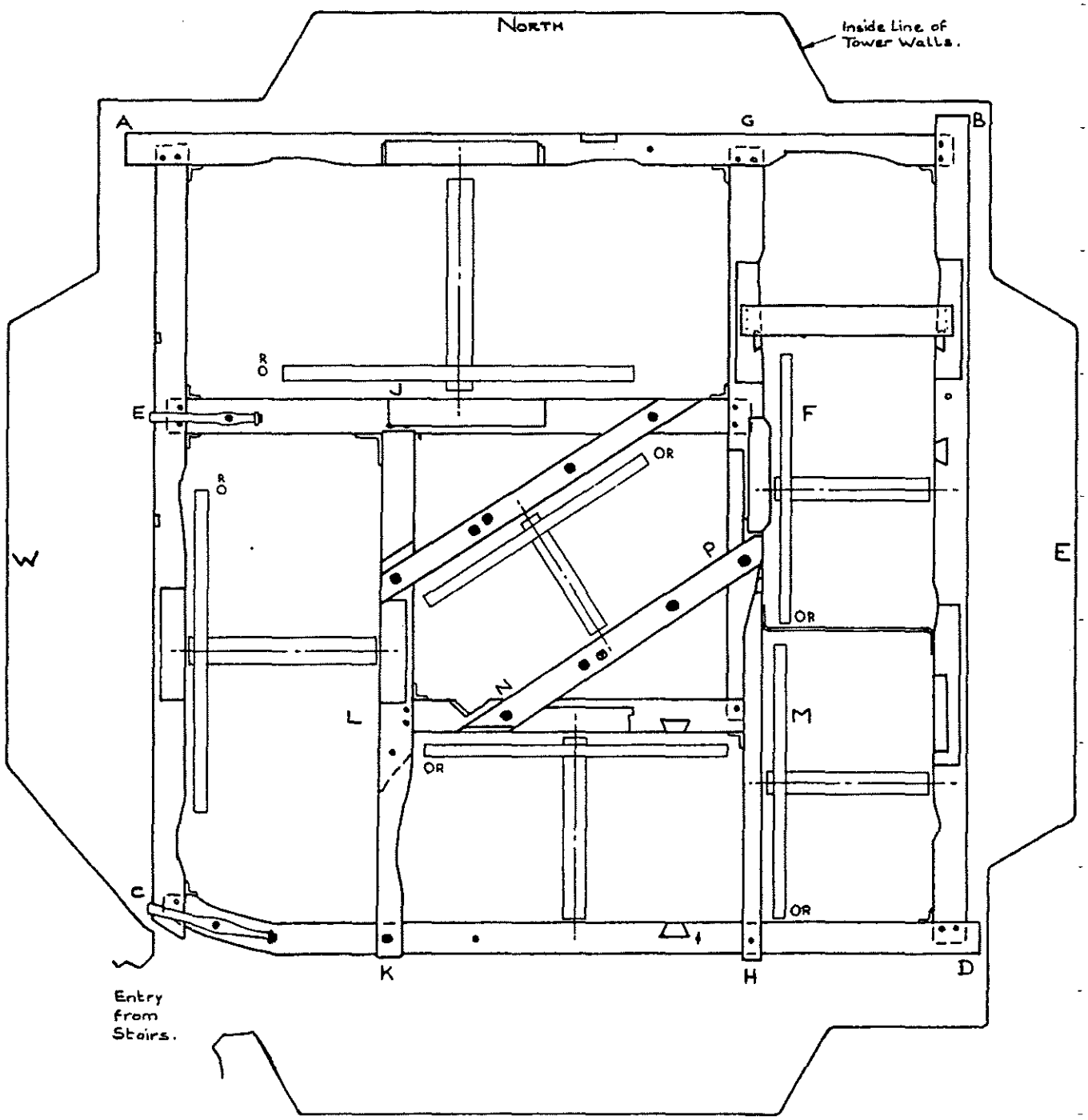

Figure 2 Typical outer truss of bellframe (Derived from survey by Mr E Watkin)

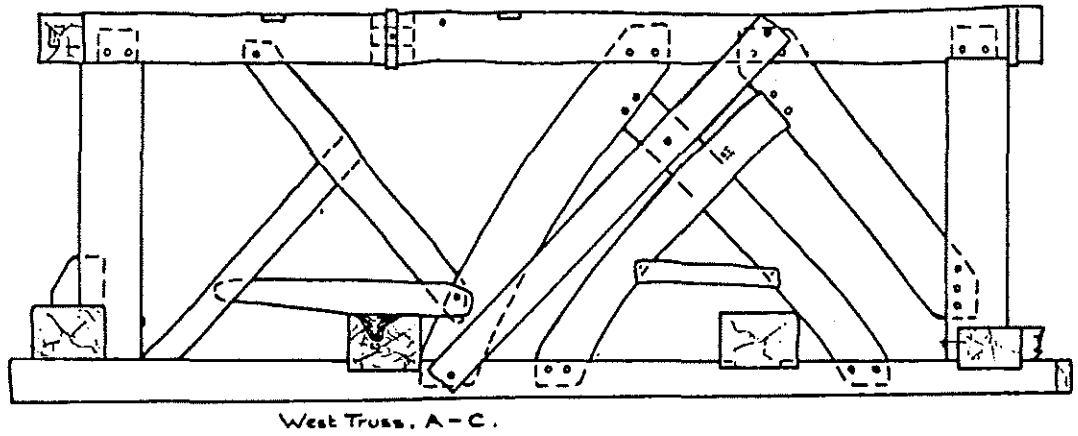

Figure 3 Typical inner truss of bellframe (Derived from survey by Mr E Watkin)

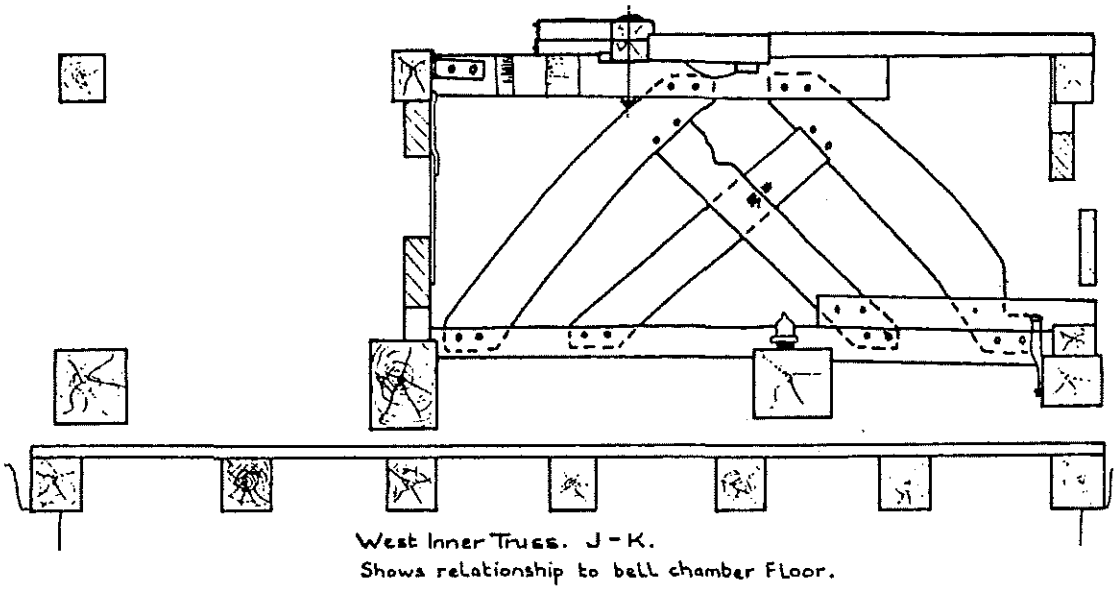

Figure 4. Bar diagram showing the relative positions of the dated ring sequences from the bellframe at St Andrews Church, Sutton-in-the-Isle, Cambridgeshire.

White bars - heartwood rings; Shaded bars - sapwood rings

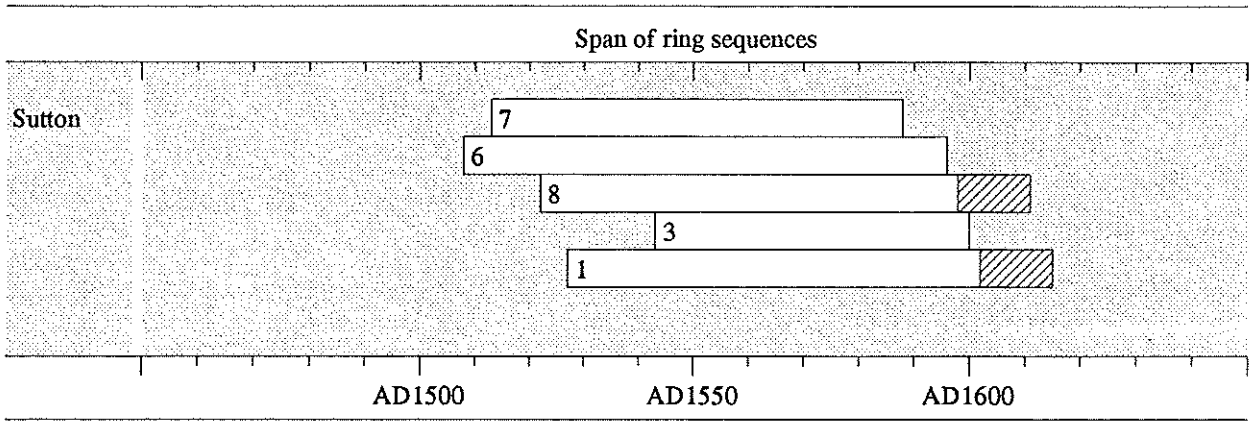

Table 1

St Andrews Sutton-in-the-Isle; Bellframe Cambridgeshire TL44847896

Sample	*Description*	*Species*	*Pith*	*RingNo*	*SapNo*	*Bark*	*ARW*	*Result*	*StartDate*	*EndDate*
1	EW bottom bearer inner south	Quercus spp. (Oak)	V	89	13	N	2.38	Measured and dated	AD1527	AD1615
2	EW bottom bearer outer south	Quercus spp. (Oak)						Not measured		
3	EW bottom bearer inner north	Quercus spp. (Oak)	V	58	0	B	2.05	Measured and dated	AD1543	AD1600
4	EW bottom bearer outer north	Quercus spp. (Oak)	G	56	0	N	2.05	Measured but undated		
5	EW floor beam inner north	Quercus spp. (Oak)						Not measured		
6	North Outer Truss Head	Quercus spp. (Oak)	F	89	0	N	2.49	Measured and dated	AD1508	AD1596
7	East Outer Truss Head	Quercus spp. (Oak)	C	76	0	N	2.89	Measured and dated	AD1513	AD1588
8	East Inner Truss Head	Quercus spp. (Oak)	C	90	13	N	2.16	Measured and dated	AD1522	AD1611

Key to Table 1

Sample	sample identification number
Comment	description of sample
Species	Latin and common name of timber type
Pith	C = centre
	V = <5 years from centre
	F = 5-10 years from centre
	G = > 10 years from centre
RingNo	Number of Rings
SapNo	Number of sapwood rings
Edge	N = no bark or heartwood/sapwood boundary
	B = heartwood/sapwood boundary
	? = ?heartwood/sapwood boundary
	Y = bark
	! = ?bark
ARW	average ring width (mm/year)
Result	description of analysis and result for the sample
StartDate	date of first ring in sequence for dated samples
EndDate	date of last ring in sequence for dated samples

Table 2

Correlation between the dated material from the bellframe at St Andrews, Sutton-in-the-Isle, Cambridgeshire. (- = *t*-values less than 3.5)

	***t*-values**			
sample			**samples**	
	3	*6*	*7*	*8*
1	4.7	4.0	4.1	6.0
3		5.7	4.2	3.6
6			5.3	4.1
7				-

Table 3

Dating of the master curve from the bellframe at St Andrews, Sutton-in-the-Isle, Cambridgeshire. *t*-values with dated reference chronologies. All the reference curves are independent.

Area	**Reference chronology**	***t*-values**
Essex	Cressing Farmhouse (Tyers unpubd)	5.7
Essex	Cressing Granary (Andrews *et al* 1994)	8.6
England/Wales	Welsh Border (Siebenlist-Kerner 1978)	7.1
Gtr Manchester	Sefton Fold (Hillam pers comm)	5.8
Berkshire	Windsor Castle Kitchen (Hillam and Groves pers comm)	4.2
Derbyshire	Ridgeway (Groves pers comm)	4.5
Oxfordshire	Corpus Christi College (Tyers unpubd)	5.5

Table 4

Ring-width data of the site master curve for oaks from the bellframe at St Andrews, Sutton-in-the-Isle, Cambridgeshire, dated AD1508-AD1615 inclusive.

year	ring widths (0.01mm).										number of trees per year									
AD 1508								473	497	538								1	1	1
	571	476	433	285	344	417	332	429	537	381	1	1	2	2	2	2	2	2	2	2
	368	389	377	404	351	367	353	268	276	197	2	3	3	3	3	3	4	4	4	4
	335	250	332	353	439	261	326	304	385	425	4	4	4	4	4	4	4	4	4	4
	354	343	274	289	304	252	291	309	364	263	4	4	5	5	5	5	5	5	5	5
AD 1551	319	249	310	271	278	170	154	182	196	237	5	5	5	5	5	5	5	5	5	5
	209	214	178	166	158	167	179	213	184	222	5	5	5	5	5	5	5	5	5	5
	190	138	168	187	155	148	144	131	142	209	5	5	5	5	5	5	5	5	5	5
	130	145	134	164	199	224	197	221	248	128	5	5	5	5	5	5	5	5	4	4
	140	150	203	199	200	201	207	228	183	178	4	4	4	4	4	4	3	3	3	3
AD 1601	145	140	165	164	143	198	209	194	165	184	2	2	2	2	2	2	2	2	2	2
	150	200	256	193	152						2	1	1	1	1					