Ancient Monuments Laboratory
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Summary

The roof of the late-seventeenth century Samwell wing at the National Trust's Felbrigg Hall, Felbrigg, Norfolk, is currently undergoing repair, grant-aided by English Heritage. This report covers the dendrochronological analysis of a series of oak timbers within the roof which was undertaken to clarify the dating of the surviving timbers so as to inform repair decisions. The results indicate that the present structure is the product of a single phase of construction dated to AD 1684/5.

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Introduction

This document is a technical archive report on the tree-ring analysis of oak timbers from the roof of the Samwell wing of Felbrigg Hall, Felbrigg, Norfolk (NGR TG193394). It is beyond the dendrochronological brief to describe the building in detail or to undertake the production of detailed drawings. As part of a multifaceted and multidisciplinary study of the building, elements of this report may be combined with detailed descriptions, drawings, and other technical reports at some point in the future to form either a comprehensive publication or an archive deposition on the building. The conclusions may therefore have to be modified in the light of subsequent work.

The west wing of Felbrigg Hall was designed by William Samwell, for William Windham around AD 1675 as an extension of the earlier seventeenth-century south range (Fig 1; Maddison 1995, 12-17; Pevsner and Wilson 1997, 462-6). Samwell died *c* AD 1676, but building accounts indicate the structure was not started until AD 1681 and completed around AD 1686 (Maddison 1995, 15). The roof is currently undergoing grant-aided repair and many of the structural elements are currently accessible for the first time in several centuries. The roof is composed of six main roof trusses (Fig 2) of princess strut and collar type (Fig 3). The roof is floored throughout at tiebeam level, with walls and ceilings created by the struts, principals, and collars (Fig 3). Although the roof appears to be primarily single phase, there are clear areas of modification around the dormer windows.

A comprehensive tree-ring dating programme of the roof timbers of the Samwell wing at Felbrigg Hall was requested by Ian Harper from English Heritage primarily to provide a precise series of dates for the surviving structure and hence inform ongoing repair decisions, although with the secondary intention of producing a reference chronology from this area. The timbers of the first floor (Fig 3) are thought to be co-eval with the roof timbers but were specifically excluded from the sampling brief for practical reasons of access.

Methodology

The general methodology and working practises used at the Sheffield Dendrochronology Laboratory are described in English Heritage (1998). The methodology used for this building was as follows.

A brief survey identified those oak timbers with the most suitable ring sequences for analysis. Those with more than 50 annual rings and some survival of the original sapwood and bark-edge were sought. The dendrochronological sampling programme attempted to obtain cores from as broad a range of timbers, in terms of structural element types, scantling sizes, and carpentry features, as was possible within the terms of the request.

The most promising timbers were sampled using a 15mm diameter corer attached to an electric drill. The cores were taken as closely as possible along the radius of the timbers so that the maximum number of rings could be obtained for subsequent analysis. The core holes were left open. The ring sequences in the cores were revealed by sanding.

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 (Tyers 1997a). 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 visually 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 any found to cross-match were combined to form a site master curve. These, and any remaining unmatched ring sequences, were 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.

The tree-ring dates produced by this process initially only date the rings present in the timber. The interpretation of these dates 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 which are 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. The sapwood estimates applied throughout 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). Alternatively, if bark-edge survives, then a felling date can be directly utilised from the date of the last surviving ring. 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

Almost all the timbers in the roof are of oak (*Quercus* spp.), the only exceptions are from the most recent modifications which have introduced some softwood timbers, particularly around the dormers and the gutters.

The structural elements are noteworthy from a dendrochronological viewpoint in having extensive surviving sapwood and bark. During the coring it was noted that a remarkably diverse group of trees were being sampled, with a very fast growing group of young trees, and a much longer lived and slower growing group. These differences were apparent from inspection of the cores, and the timbers themselves during the assessment exercise. The sampling programme was arranged specifically to ensure that both groups were extensively sampled in case they turned out to be of differing date.

Timbers with surviving bark were selected for sampling. The remaining timbers in the structure were rejected for sampling because they contained too few rings, or because they did not have readily surviving bark, or because they were inaccessible. Although usually 'at least eight to ten timbers' per phase are required (English Heritage 1998, 21), in this case it was desirable to obtain more samples than this because of the apparent diversity of timbers utilised and the possibility that more than a single phase of timber was present.

A total of 19 timbers were selected as most suitable for sampling (Table 1 and 2; Fig 4). The samples were numbered **1-19** inclusive. In two cases, a second core was taken from the same timber because the first core broke with the loss of the critical bark edge; these cores were labelled **4A**, **4B**, **12A**, and **12B**. The samples can be grouped into seven types according to the structural element represented:

All 21 samples when examined in the laboratory were found to include enough rings for reliable analysis (Table 1). The duplicate cores from two timbers were combined to make single composite sequences, labelled **4** and **12**. The resultant 19 series were initially compared with each other. 16 sequences were found that matched together to form an internally consistent group (Table 3). A 149-year site mean chronology was calculated, named FELBRIGG (Fig 5). The site mean was then compared with dated reference chronologies from throughout British Isles and northern Europe. Table 4 shows the correlation of the mean sequences at the dating position identified for the sequence, AD 1536-1684 inclusive. Table 5 lists the site mean chronology.

The three samples which did not match the rest of the material to form the FELBRIGG sequence were compared with dated reference chronologies from throughout British Isles and northern Europe without any dating being obtained.

Interpretation

The 149-year chronology FELBRIGG is dated AD 1536 to AD 1684 inclusive. It was created from 16 timbers, 15 of which were complete to bark-edge (Fig 5). All the timbers with clear bark-edge, except one exhibit no signs of the spring growth for AD 1685 and thus the felling of this material appears to have taken place between summer AD 1684 and the early spring of AD 1685. The exception is **15** which clearly has spring vessels for AD 1685 indicating this tree had at least started growing in the spring of that year, and was possibly felled as late as early summer of AD 1685.

Although groups of neighbouring trees can be observed to exhibit differences of several weeks in leaf bud each spring the anatomical difference in outermost ring between sample **15** and the other fourteen bark-edge samples is sufficient to suggest that they were felled at different times, although this difference could be as little as a few weeks in the early spring AD 1685. Since timbers were usually felled as required and used green (Rackham 1990, 69), a construction date in spring or early summer of AD 1685 is indicated. It is perhaps possible that the timber originally intended to become the east principal rafter on truss 5 was found to be rotten or unsuitable, or a mistake was made during the fabrication of the frame and a substitute had to be cut.

Discussion

The sampling programme undertaken on the building was commissioned 'to inform the forthcoming programme of grant aided repairs including timber repair/replacement' (Harper pers comm). The sampling was extensive due to the diversity of timbers observed within the building, and in the knowledge that there was a lack of suitable local reference material with which to correlate the data. The results clearly confirm that the principal structural elements of the roof are survivals of the documented construction work of William Windham completed by 1685. No other dating evidence was obtained, and thus it seems likely that the roof structure is a complete survival of William Windham's building. There is no reason to suspect that the three undated samples are different from the dated material, since they appear identical in all other respects.

There is a surviving Windham document (the '*Green Book*', NNRO, WKC 5) ordering the felling of trees in AD 1685 for completion of the building (Maddison 1995, 15). It seems clear that the timbers in the roof are part of those felled at that time. The Green Book may provide details such as dates and possibly location of these fellings (Maddison pers comm). It is tempting to suggest but impossible to prove that the faster grown material was derived from parkland areas, with the slower grown material from the woodland.

The seventeenth century has the least well replicated and least geographically diverse data set of any in the British Isles after the fourth century AD. Although the data from Felbrigg matches to a number of chronologies some distance from the area, there is no East Anglian data to compare with it and no especially good correlation with reference data. This probably serves to emphasise the importance of the data to future work in Norfolk and the rest of East Anglia. There is significant diversity within the data, there are several very slow growing samples (eg **9**, **11**, and **14**), as are several very fast growing samples (eg **3**, **7**, and **15**). Although it is possible to construct several different chronologies from such data in this case the very good internal correlation between the entire sampled assemblage suggests the tree-ring sequence should be combined and used as a single data set (Table 2).

Conclusion

The dendrochronological analysis of timbers from the roof of the Samwell wing at Felbrigg has revealed the extensive presence of timbers throughout the structure felled in winter AD 1684/5, with one timber definitely felled in early summer AD 1685. The analysis has produced a well replicated seventeenth-century data set.

Acknowledgements

The sampling and analysis programme was funded by English Heritage. David Bryden, National Trust Property Manager at Felbrigg Hall, Tom Ground from Purcell Miller Tritton and Partners, Norwich, Adrian Woods site manager for Bullens, and John Maddison, retired Historical Buildings Representative for Felbrigg provided practical help and valuable discussion. My colleagues Cathy Groves and Nigel Nayling provided much useful discussion and encouragement.

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Figure 1 Plan of Felbrigg Hall, showing the Samwell wing (after Maddison 1995)

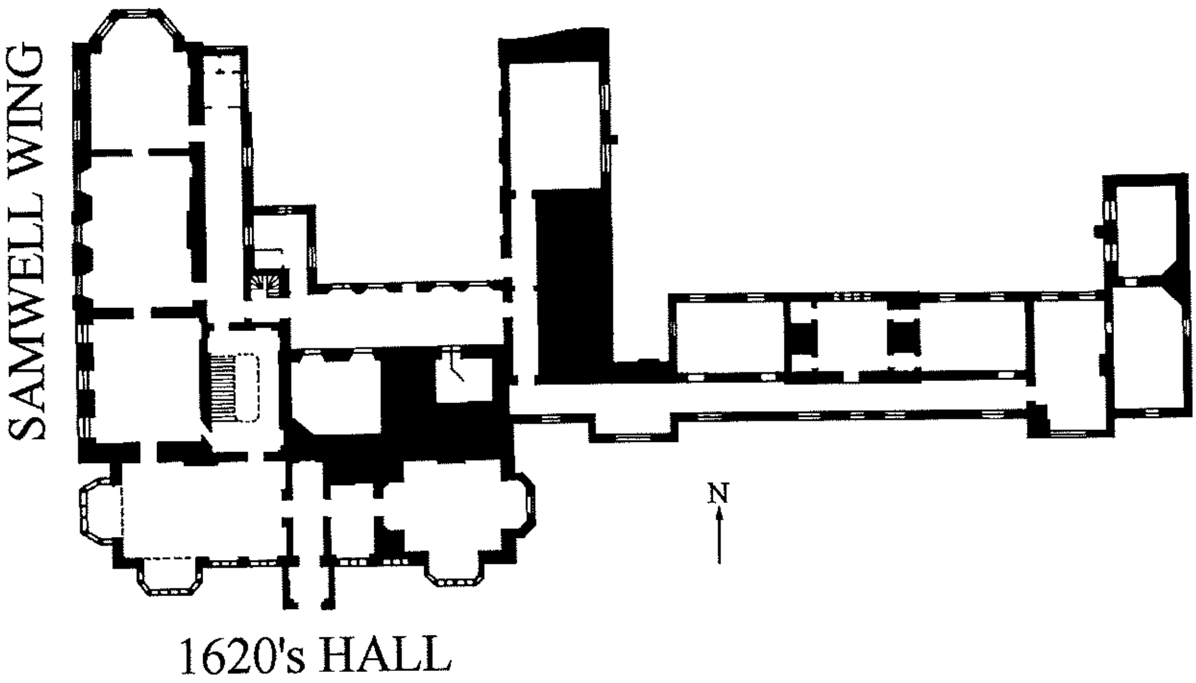

Figure 2 Roof layout showing truss numbering scheme adopted during the sampling (after Purcell Miller Tritton and Partners diagram)

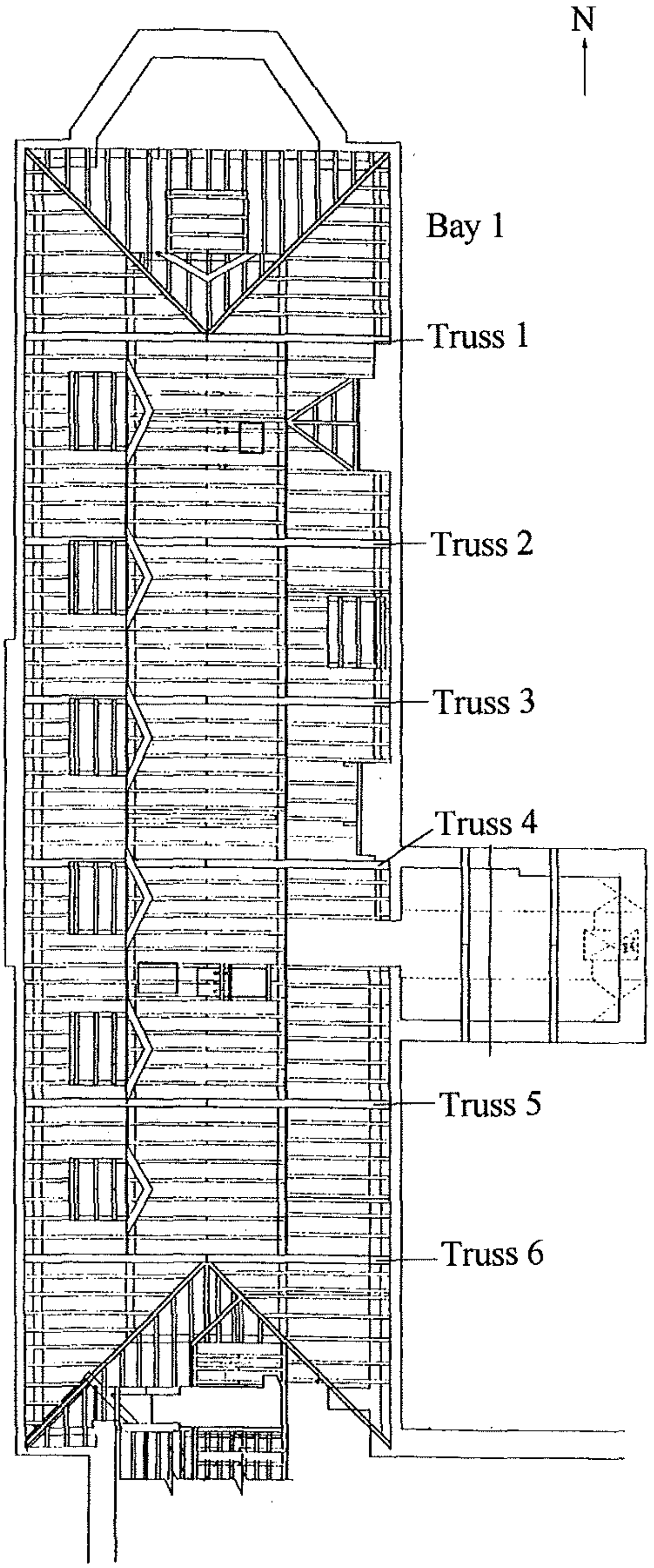

Figure 3 Typical truss showing nomenclature used during sampling (after Purcell Miller Tritton and Partners diagram)

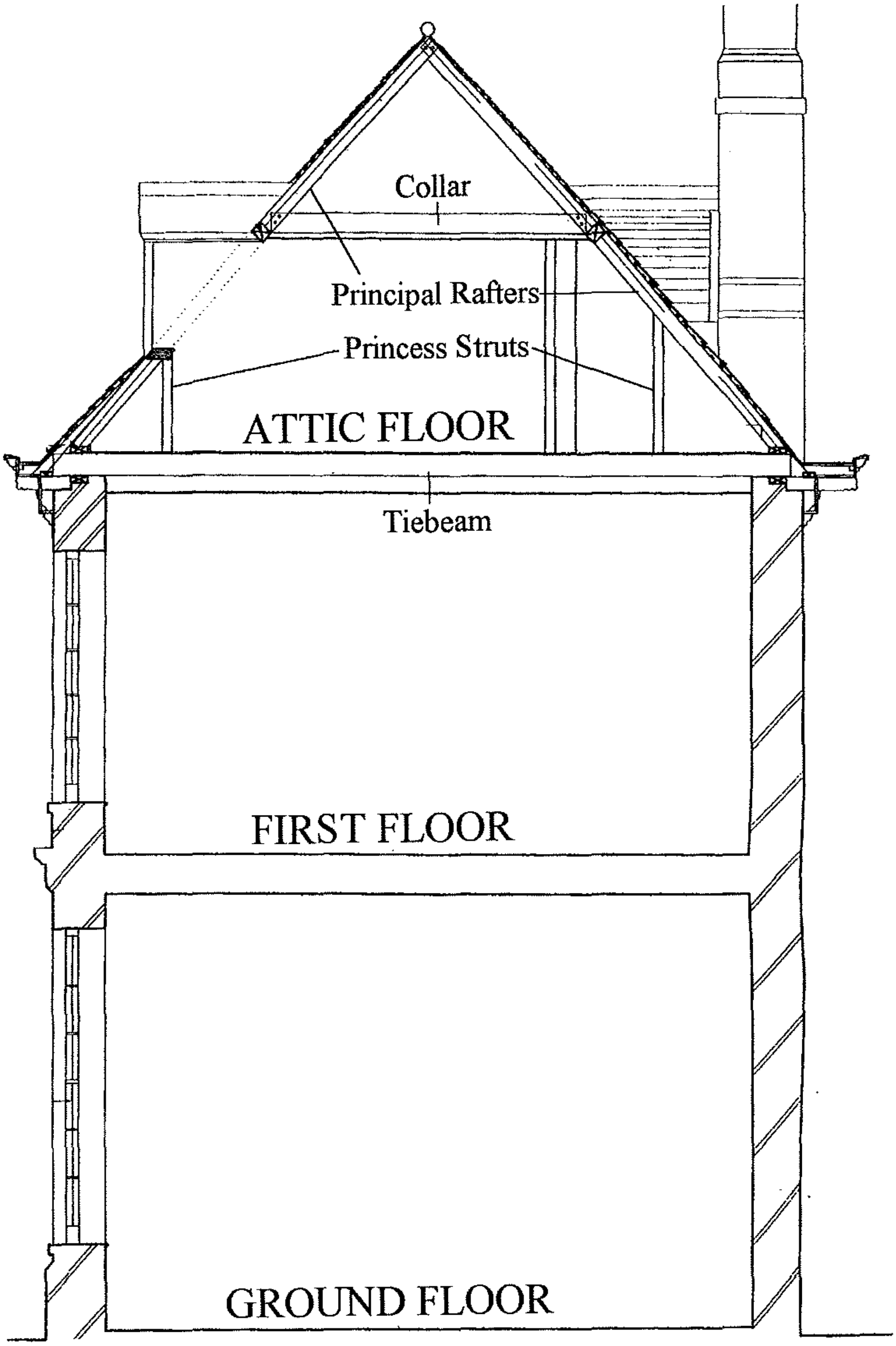

Figure 4 Plan of roof timbers showing sample locations (after Purcell Miller Tritton and Partners diagram)

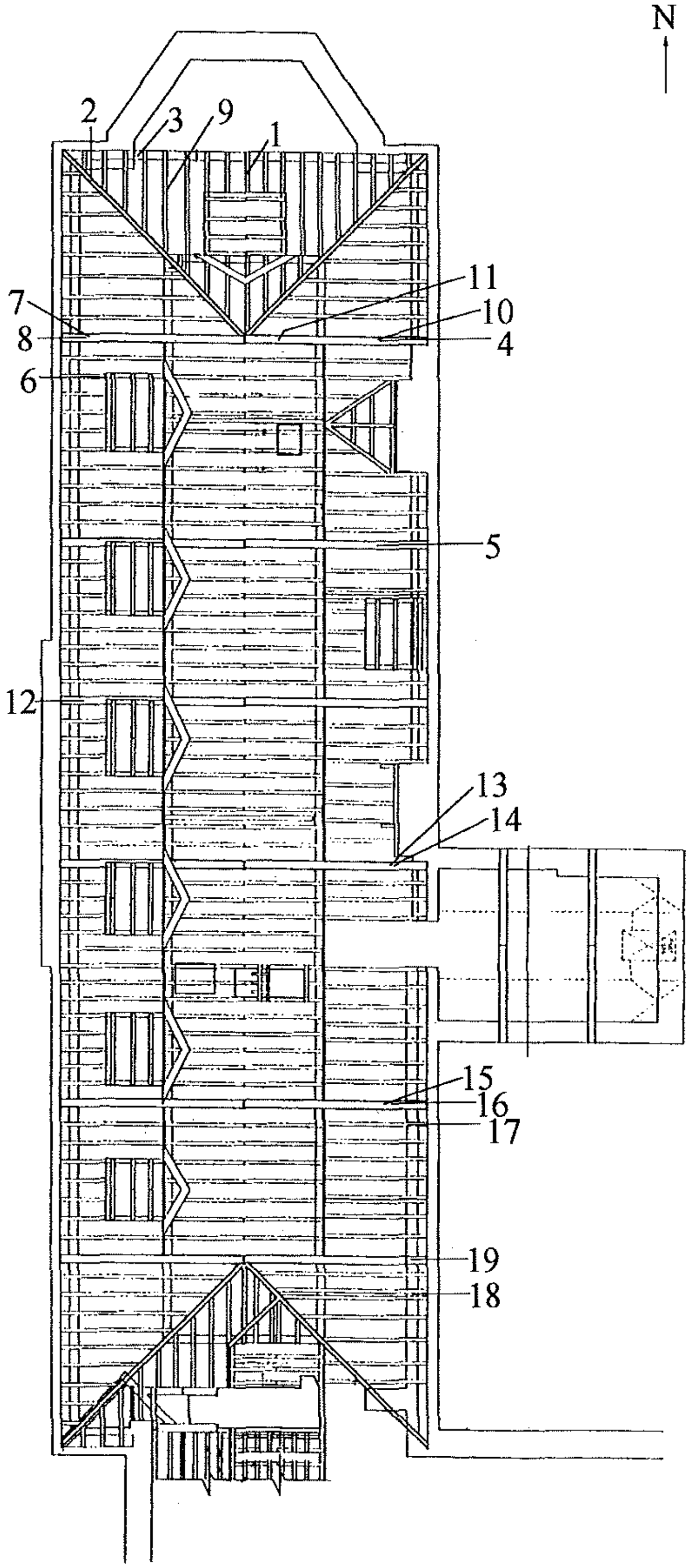

Figure 5

Bar diagram showing the chronological positions of the 16 dated timbers. The felling period for each sequence is also shown

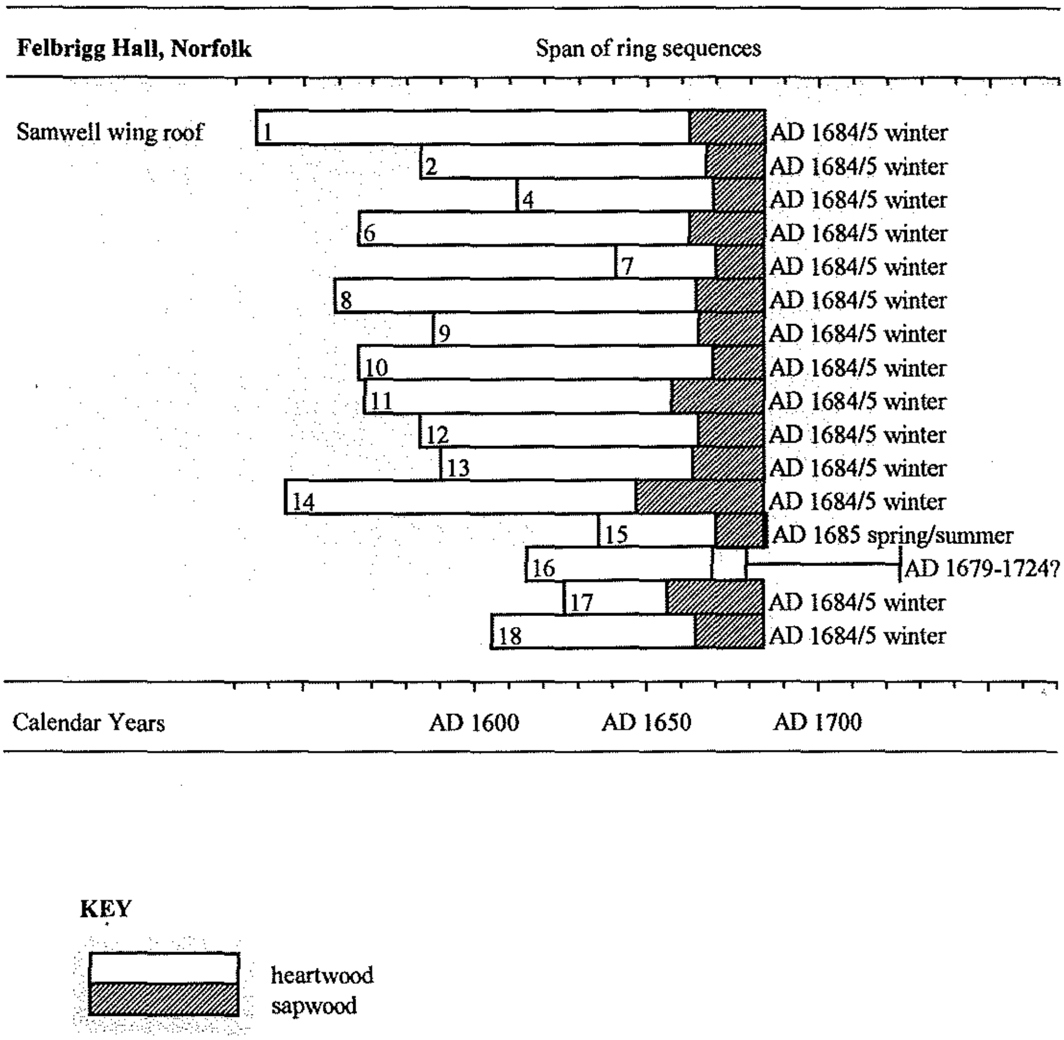

Table 1

List of samples

Core No.	Origin of core	Cross-section size (mm)	Cross-section of tree	Total rings	Sapwood rings	ARW mm/year	Date of sequence	Felling period
1	Binding joist bay 1	290 x 260	Whole	149	22+bw	1.40	AD 1536-1684	AD 1684/5
2	Dragon beam north-west hip	235 x 185	Quartered	101	17+bw	1.51	AD 1584-1684	AD 1684/5
3	North end wall plate	300 x 240	Whole	69	14+bw	3.91	Undated	
4	Truss 1 tiebeam (2 cores)	315 x 260	Whole	73	15+bw	2.70	AD 1612-1684	AD 1684/5
5	Truss 2 tiebeam	330 x 260	Whole	59+?h/s		1.85	Undated	
6	Rafter 2 south of truss 1, west side	165 x 100	Quartered	119	22+bw	1.46	AD 1566-1684	AD 1684/5
7	Truss 1 west principal rafter	200 x 170	Quartered	44	14+bw	4.11	AD 1641-1684	AD 1684/5
8	Truss 1 west princess strut	200 x 125	Quartered	126	20+bw	1.63	AD 1559-1684	AD 1684/5
9	Rafter 5 east of jack rafter, north side	120 x 80	Quartered	97	19+bw	1.28	AD 1588-1684	AD 1684/5
10	Truss 1 east princess strut	200 x 125	Quartered	119	15+bw	1.67	AD 1566-1684	AD 1684/5
11	Truss 1 collar	219 x 95	Quartered	117	27+bw	1.17	AD 1568-1684	AD 1684/5
12	Truss 3 tiebeam (2 cores)	330 x 280	Whole	101	19+bw	1.27	AD 1584-1684	AD 1684/5
13	Truss 4 east principal rafter	190 x 165	Quartered	95	21+bw	1.97	AD 1590-1684	AD 1684/5
14	Truss 4 tiebeam	330 x 260	Whole	140	37+bw	1.25	AD 1545-1684	AD 1684/5
15	Truss 5 east principal rafter	200 x 170	Quartered	49	14+bs	4.52	AD 1636-1684	AD 1685 late spring
16	Truss 5 tiebeam	330 x 310	Whole	55+?h/s		2.95	AD 1615-1669	AD 1679-1724
17	Rafter 1 south of truss 5, east side	120 x 90	Quartered	59	28+bw	1.87	AD 1626-1684	AD 1684/5
18	Truss 6 tiebeam	330 x 280	Whole	80	20+bw	2.68	AD 1605-1684	AD 1684/5
19	Truss 6 east principal rafter	200 x 180	Quartered	84+5+h/s		2.91	Undated	

Key:
Total rings = all measured rings, +value means additional rings were only counted, the felling period column is calculated using these additional rings.
sapwood rings: h/s heartwood/sapwood boundary, ?h/s possible heartwood/sapwood boundary, +bw = bark-edge winter felled, +bs = unmeasured spring growth also present
ARW = average ring width of the measured rings

Table 2

Summary showing the structural function of the sampled timbers

Structural element	Sample numbers	Description
Truss tiebeams	**4**, **5** ,**12**, **14**, **16**, and **18**	Each truss tiebeam was sampled (Figs 3 and 4)
Principal rafters	**7**, **13**, **15**, and **19**	Four cores from four principal rafters (Figs 3 and 4)
Rafters	**6**, **9**, and **17**	Three other rafters were sampled (Fig 4)
Princess struts	**8** and **10**	Two cores from two of the princess struts (Figs 3 and 4)
Plates	**3**	A lower wall plate was accessible at the north end (Fig 4)
Floor beams	**1** and **2**	Two timbers connected to the tiebeams forming the supports of the attic floor (Fig 3 and 4)
Collars	**11**	One collar (Fig 3 and 4)

Table 3
t-value matrix for the timbers forming the chronology FELBRIGG.
KEY: - = *t*-values under 3.0, \ = no overlap

	2	**4**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	-	-	4.93	-	-	4.14	-	4.42	5.41	5.58	3.01	4.10	-	4.21	4.19
2		-	-	-	8.66	3.98	11.13	4.60	3.65	3.32	7.87	3.06	-	-	4.86
4			3.16	4.92	-	4.95	-	3.65	5.32	5.86	-	4.44	-	4.81	5.22
6				-	-	3.05	3.37	3.12	3.46	4.17	4.03	4.66	-	-	5.04
7					-	-	3.48	-	3.71	5.02	-	5.13	-	7.33	3.52
8						-	10.88	5.13	4.53	3.40	7.98	3.76	-	3.74	4.45
9							-	-	4.94	5.83	4.56	-	-	-	4.02
10								5.61	3.77	3.66	8.07	3.43	-	3.59	5.46
11									4.61	3.49	4.54	3.18	4.75	3.28	5.57
12										6.22	3.46	5.04	3.07	3.85	4.47
13											6.09	5.96	5.60	6.70	6.45
14												4.65	-	3.11	5.40
15													-	5.63	5.45
16														3.20	6.42
17															6.07

Table 4

Dating the mean sequence FELBRIGG, AD 1536-1684 inclusive. *t*-values with independent reference chronologies

Area	Reference chronology	*t*-values
Cambridgeshire	Ely (Howard *et al* 1992)	4.10
Derbyshire	Ridgeway (Groves and Hillam 1990)	4.59
East Midlands	East Midlands master (Laxton and Litton 1988)	4.26
Hampshire	Beaulieu Abbey (Hillam and Groves 1992)	3.09
N Ireland	Belfast (Baillie 1977a)	3.28
Scotland	South central Scotland (Baillie 1977b)	3.74
Shropshire	Brookgate Farm, Plealy (Miles and Haddon-Reece 1993)	3.12
Staffordshire	Sinai Park (Tyers 1997b)	4.60
Wales	Hafoty, Anglesey (Hillam and Groves 1992)	3.84
Wiltshire	4-5 St John's Alley, Devizes (Haddon-Reece *et al* 1990)	3.04
Yorkshire	Finthorpe Barn, Huddersfield (Boswijk 1997)	3.86
Yorkshire	Kings Manor, York (Stefan King pers comm)	3.58

Table 5

Ring-width data from site master FELBRIGG, dated AD 1536-1684 inclusive

Date	Ring widths (0.01mm)										No of samples									
AD 1536						315	364	301	480	432						1	1	1	1	1
	365	246	379	415	271	322	306	307	301	277	1	1	1	1	2	2	2	2	2	2
AD 1551	237	157	132	97	118	122	116	79	207	280	2	2	2	2	2	2	2	2	3	3
	291	298	279	245	255	290	252	253	291	288	3	3	3	3	3	5	5	6	6	6
	174	188	222	268	234	204	171	213	195	203	6	6	6	6	6	6	6	6	6	6
	134	157	197	219	203	206	168	170	210	152	6	6	6	8	8	8	8	9	9	10
	184	142	222	152	228	171	166	180	179	201	10	10	10	10	10	10	10	10	10	10
AD 1601	169	161	218	158	160	135	136	138	116	145	10	10	10	10	11	11	11	11	11	11
	148	160	174	172	217	164	158	157	139	148	11	12	12	12	13	13	13	13	13	13
	125	135	150	197	152	183	174	162	222	180	13	13	13	13	13	14	14	14	14	14
	163	166	124	137	147	205	217	273	195	164	14	14	14	14	14	15	15	15	15	15
	214	153	182	183	217	223	217	208	177	138	16	16	16	16	16	16	16	16	16	16
AD 1651	183	140	135	199	207	221	169	192	193	189	16	16	16	16	16	16	16	16	16	16
	176	173	197	212	236	205	153	140	197	249	16	16	16	16	16	16	16	16	16	15
	223	179	141	149	102	106	152	171	199	160	15	15	15	15	15	15	15	15	15	15
	142	229	141	139							15	15	15	15						