The Knowledge of Carpenters from the Early Medieval Period to the 18th Century in Setting Out Roofs and Buildings without Geometry and Numerical Measurement

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The question of how medieval carpenters set out their work is an under investigated topic of research. Advanced craft knowledge is needed for a study of this kind and, in that regard, this article is written from a craftsman's point of view. Domestic medieval roofs have consistently common roof pitches of 43°, 48º, 52º, 55º[1], and 58º, and roofs were being pitched long before the early scholars brought knowledge from the ancient world to England in the mid-twelfth century. Moreover, it is unlikely that master carpenters and masons had access to this knowledge until the early to mid-thirteenth century, and equally unlikely that the domestic carpenter had any knowledge of geometry until the seventeenth or eighteenth century. Instead, this article argues that medieval carpenters used a simple method of setting out using cord, which would obviate the need for measurement and geometry and whose common divisions correspond to the common pitches found in medieval buildings.
KEYWORDS: crown post, rafter holes, roof pitch, setting out, medieval carpenters

INTRODUCTION

Throughout history, cord or string has been an important part of the craftsman's kit. Whilst one immediately thinks of bricklayers and stonemasons working to a line, most building crafts need a length of string for one use or another.

Apart from its importance as an aid to setting out in constructing buildings as diverse as the ancient pyramids, Stonehenge and our impressive cathedrals, the simple line has also been responsible for achieving a vertical plumb line and for drawing an ellipse.

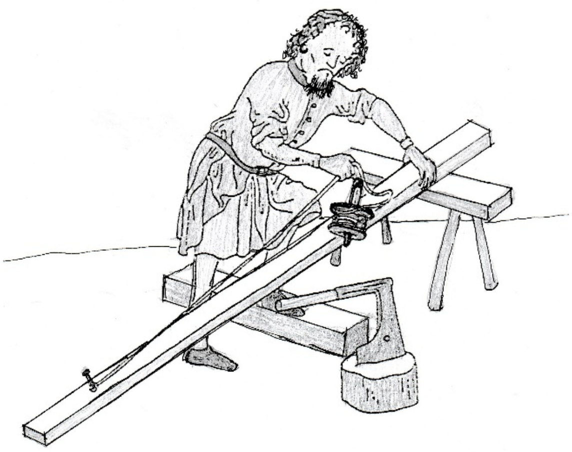

Figure 1. measuring a plank, Catherine of Cleves' Book of Hours, MS 917, fol. 105, traced from Illustration No.358, p120, Günther Binding, 2004, Medieval building Techniques

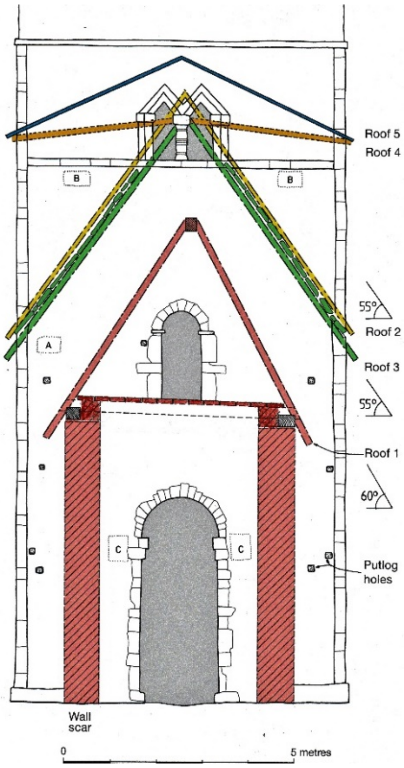

*Figure 2. East face of the tower at Barton-upon-Humber showing five successive roof lines that have abutted it. **1** Late 10th c. 60^0, **2** 11th c. **3** 13th c. 55^0, **4** 15th c. & **5** 19th c. Drawn by Rodwell 2011, amended by PR*

Modern-day technology has dispensed with the many uses of the handy string line. The laser is now found in the modern workman's toolkit to level, plumb and set out buildings. The historic use of the string line has almost been forgotten.

This article discusses how the early medieval craftsmen were almost certain to have used string or cord to measure and set out their buildings (Fig. 1). Villard de Honnecourt in his notebook (circa 1250)[2] shows illustrations using string for setting out examples and solving problems. Salzman[3] mentions carpenters using lines or rods for measuring. Medieval master craftsmen would have met regularly in their lodges or guilds to discuss methods of construction, problem-solving and how to use practical geometry, dividing up a circle and creating angles, not necessarily attributing it to Pythagoras or Euclid. This knowledge, while closely guarded by the guild, would be passed down from master to apprentice; when the apprentice was qualified, he became a master craftsman, keeping the knowledge secret in the same way to protect the craft.[4] Euclid's *Elements* was translated into Latin by Adelard of Bath in the mid-twelfth century, most likely from the Arabic of the Moors in Spain.[5] The Roman foot, $11^{5}/_{8}$in. (296mm), may have been used by Anglo-Saxon builders. The Saxon foot has been studied by Fernie[1], Huggins[6], Marshall and Marshall and Bettess[7] with inconclusive results.

Regulating measurement originated with Henry III or his son Edward I sometime between 1216 and 1307. The original yard was a length devised by one of these monarchs, based apparently on a rod of iron. However, not only is there no record of this early yard, crucially, it also seems not to have been widely used. It was only with the Tudors that two important Acts of Parliament set out standard measurements of length and area: the yard, the rod and the acre.[8] Henry VII in 1497 produced a fixed yard called the Exchequer Standard, which in 1588 was slightly revised by Elizabeth I. Moreover, to cement acceptance of the official weights and measures, Elizabeth appointed inspectors to enforce their use. These measurements, the Exchequer Standard first established by Henry III or Edward I,[9] were calculated as follows:

3	Dry barleycorns laid end to end	= 1 Inch
12	Inches	= 1 Foot
3	Feet	= 1 Yard
5½	Yards (16½ft)	= 1 Rod
40	Rods in length and 4 in breadth	= 1 Acre (4,840 sq. yds. or 43,560 sq. ft.)

Elizabeth's yard, a rod made of bronze divided into feet and inches, could be accurately measured and reproduced,[10] allowing her officials to secure in every borough in England the adoption of the new standard measures: yards, feet, inches, pounds and ounces, gallons and pints. Before Elizabeth's decree, old measures were still being used. This made it very difficult for merchants and craftsmen working in different towns to trade with those from outside their immediate area. Thus, builders would agree the 'rod' measure within their lodge or guild and all the craftsmen working on a particular building would use that same local measure.[11] The rod of 16½ft (5.03m) is still used today for setting out a cricket pitch, which is 4 rods long = 22yds (or 1 chain), the modern acre is still 4,840 sq. yds. Garden allotments in England are still measured in rods and it was not until the eighteenth century that the 10ft (3.05m) rod came into common use.[22] The yard that Henry III established, copied by Henry VII and Elizabeth I, is only 0.037in (0.094mm) shorter than the modern yard today.[13] The medieval master craftsman was likely to have been a master carpenter or may also have been a master stonemason, or else they worked alongside one another. The Master would have had a basic knowledge of geometry, of how to use dividers and compasses to bisect angles and circles; and he would have had to use a straight edge and setsquare. He was capable of drawing full-size plans and elevations (there is evidence in the form of full-size drawings traced on the floors of Wells and York cathedrals) and especially of working-out proportions, having sufficient knowledge to build cathedrals and castles, structures where we know geometry was essential[14]

This knowledge of geometry held by the master craftsman/architect in the thirteenth century was secret knowledge known only to them, as noted by authors such as Harvey,[15] Salzman[16] and Gimpel.[17] But in the case of most buildings, this knowledge did not supersede the cord method for setting out which, as I will show, had been established since Saxon times. Supporting my argument, the late Arnold Pacey in his book *Medieval Architectural Drawings*, published in 2007, states that there are no surviving medieval working drawings produced by craftsmen. Indeed, in private correspondence with the author, Pacey has said that he finds the basic argument of this article convincing – namely, that the medieval carpenters didn't need working drawings to set out roofs and buildings because they had a much simpler method that served them very well. Such practical geometry, as we could describe it, would have been used, for example, to make a right-angled triangle with sides in the ratio of 3:4:5 (as in Pythagoras's Theorem), which would have been applied to the setting out of right angles for buildings.[18] In this instance, they would have used a cord with 12 fixed units long with a knot at 3 units, another knot at 4 units and a final knot at 5 units; these three lengths, when joined together with a total perimeter of 12 units, make a right-angled triangle.[19] This practical application is still used today deploying two tape measures for the purpose. However, though in England this practical knowledge of Pythagoras was used for making right angles, there is no evidence that the same formula was applied for obtaining common roof pitches, as the earlier, established cord method continued to be used in most buildings up to the eighteenth century, as this article will show.

It is very unlikely that a form of standard measurement was used by Anglo-Saxon builders, as we see from papers by Marshall & Marshall and others.[20] These authors carried out surveys and analysis of Saxon building plans to see if there was a common length and width, but the summing-up of their findings was inconclusive. However, there was a common denominator of spans being around either 15ft 3in. (4.65m) or 16ft 6in. (5.03m), the latter equivalent to the Elizabeth rod.

At the VAG winter conference at Leicester in January 2017, in this instance on timber and trees, the resident master carpenter of the Weald and Downland Museum, Joe Thompson, gave a presentation in which he showed how the circumference of a tree can be measured with a piece of string, which is then folded twice to determine how much timber can be retrieved from a felled log.[21] It was a brilliant practical demonstration of the use of a piece of string and my research in Anglo-Saxon woodworking which set off the train of thought which has led to this article. This ancient method was formalised by Edward Hoppus in the eighteenth century into tables measured in feet, providing easy references taken from a girth tape. Tables and tape, used together, were published as *Hoppus's Practical Measurer* in 1736.[22] This method is still used by woodmen today to calculate the amount of timber obtainable from a standing or a felled tree.

This article takes the same simple procedure and applies it to the task of setting out historic buildings. This method of setting out does not require any form of numerical measurement, a protractor for angles, or any form of geometry. The main factors controlling the design of a medieval building were the length of the available timbers required for tie-beams (giving the maximum width of the building) along with the length of the posts (giving the height of the building) and the available size of building plot, as well as what the owner could afford. Tie-beam lengths are usually between 16 and 23ft (roughly 5 to 7m), as in the Weald and Downland Museum's Pendean Farmhouse, where the span is 16ft 6in (5.03m), and in the same museum's Bayleaf Wealden Hall House, which is 21ft 6in (6.55m) wide (Fig. 9). Widths depended on the available sizes and quality of local timber, as stated by Rackham in his studies on Prittlewell Priory[23] and Grundle House.[24]

Given these natural restrictions, how was the medieval building designed? How did the medieval carpenters manage to maintain common roof pitches of 43, 48, 52, 55 and 60°? (Fig. 3) Take, for example, the 110 roof pitches used on medieval domestic roofs in Kent, examined as part of the Royal Commission on the Historic Monuments of England (RCHME) survey conducted from 1968 to 1992.[25] The angles of these different roof pitches were consistent throughout this period. The choice of pitch was down to the carpenter pitching the roof as well as the materials he intended to use: thatch and shingles required a steeper pitch, say 55°, than tiles or slate roofs, which were usually 48°. The results of a survey in the Midlands by Nat Alcock and Dan Miles, *The Medieval Peasant House in Midland*

England, including 134 cruck and box-frame buildings, which again all have these same five constant pitches.

With many medieval buildings having stood for over 800 years, it must be borne in mind that most will have suffered from distortion arising from wear and tear, structural changes, general alterations, and decayed sole plates, posts and the like. It is therefore inevitable that tie-beams will have become out of level and wall plates distorted, resulting in an original pitch of, say, 52° ending up anywhere in the range of 50–53°. These discrepancies of perhaps several degrees are somewhat misleading. It is true that the historian, the archaeologist and the surveyor can only record what is there. However, to ascertain the true pitch of a roof, it has to be measured as accurately as possible, by measuring the rafter length, the span of the tie-beam or the height of the apex using sine, cosine or tangent. Assuming an original rafter and a tie-beam survive, will take into account any historic distortions that may have occurred.

HOW PITCHES WERE ESTABLISHED

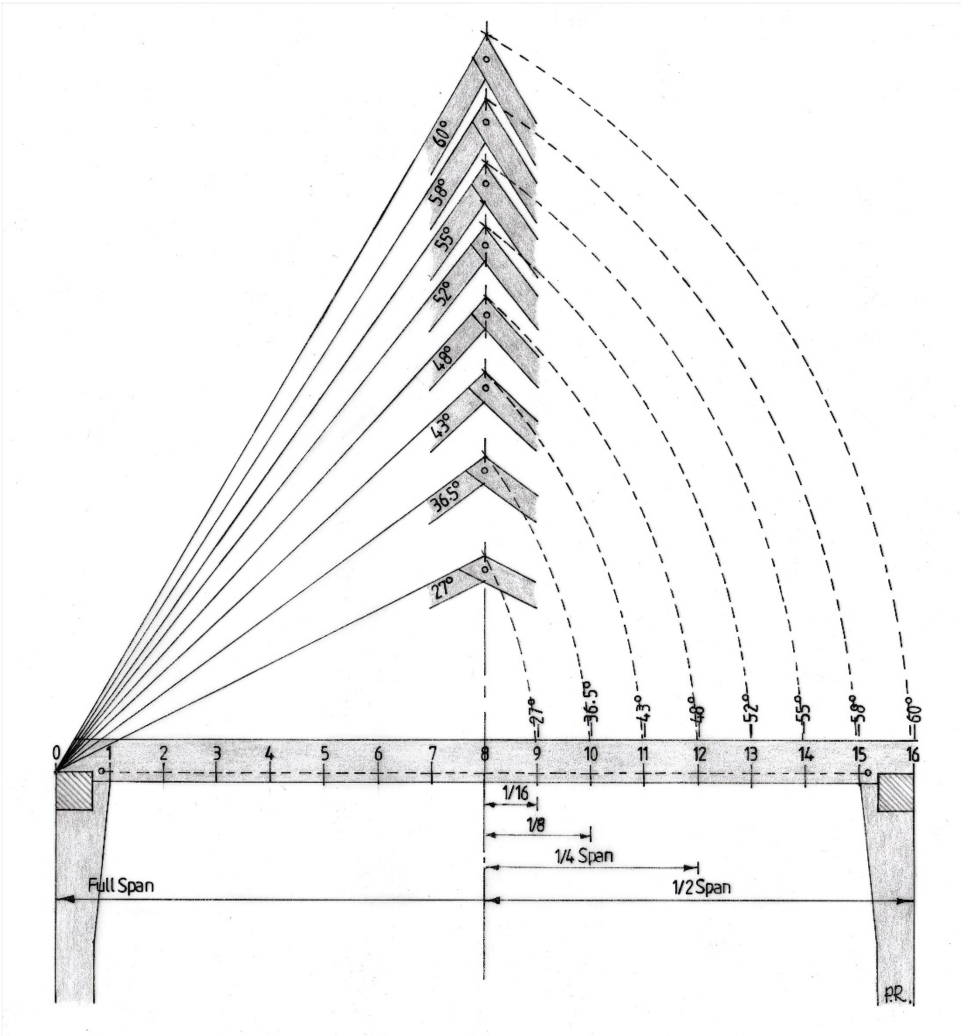

Figure 3. Different roof pitches set out by proportions of the half span

The following argument will set out how, having chosen a particular roof covering, either due to availability of local materials or the preference of the client, the medieval carpenter set out his roof pitch without using a protractor, bisecting angles or using numerical measurement. shows the different pitches carpenters could produce just by dividing up the half span of a building into eight equal portions by simply folding a piece of cord (Fig. 3). First the span is divided into two to find the centre of the tie-beam at **0**. Then the half span is again divided into two by folding the cord again to find the quarter span at **4** (commonly referred to as the three-quarter span), which will give a pitch of 48°. Then divide the quarter span again into one eighth at **6** and **2,** and this will give a pitch of 55° at **6** and 36° at **2**. Divide again into one sixteenth, giving pitches of 43° at **3**, 52° at **5** and 58° at **7**, all by folding the cord four times or using dividers and marking the tie-beam at the appropriate place with chalk or charcoal. A 60º pitch is obtained by using the full span of the tie-beam, making an equilateral triangle.

The buildings selected as examples for this article are some of those at the Weald and Downland Museum near Chichester, West Sussex as well as other buildings in East Sussex. This will make for easy reference for the reader to visit the buildings and to check the evidence. Bayleaf is a medieval Wealden Hall house at the western end of the museum site. The example shown in stages 1–5 will be based on the tie-beam in this house (Fig. 9); this is easy to see in the chamber above the cross passage and the service rooms. Other buildings at the museum for instance, North Cray House will also be used in this article as examples for checking and confirming the evidence.

Joe Thompson explains the roof geometry in his article published in the museum's magazine.[26] He shows how the roof pitch is worked out by using templates based on ratios and proportions. For example, equilateral triangles having a ratio of 1:1 give an angle of 60º, while a pitch of 45º (common pitch, 2:1) is the diagonal of a square. Three-quarter pitch is the rafter length, which is three quarters of the span, giving 48º, as I will show in Figures 13 & 15. Thompson also mentions Pythagorean and Euclidean geometry, but this would have been unknown to medieval vernacular carpenters, making his findings an unlikely basis for any method that would have been widely used by practical carpenters during this period. My article, on the other hand, will show a practical application for achieving roof pitches without the need for geometry, which is backed up by the physical evidence of numerous roofs extant from this time. Indeed, it is most likely that this practical method of setting out was common practice throughout England among carpenters even as recently as the eighteenth century (see Figure 14 and 15, Monkings Barn, 1783; and Figures 16, The White Barn at Great Dixter).

PREVIOUS THEORIES FOR SETTING OUT CROWN-POST ROOFS USING THE JIG METHOD

Before going on to describe the method I believe was used for setting out crown-post and other roofs in medieval vernacular buildings, it is important to consider existing theories put forward in well-known publications by different authors over many years. One of these is Bernard H. Johnson's work in *The Archaeological Journal* in 1987.[27] Johnson proposes a base board rather than the tie-beam as the basis for setting out. He also describes having metal or timber pegs driven into the ground to form the jig. But, as these can move about very easily when using heavy green oak timbers when trying to line up a rafter hole on the underside of the rafter with the top of the peg, this would be very problematic in practice. The setting out of the crown post from a base board and not from the tie-beam could be a bit hit and miss, as the carpenter would need to allow for natural variations in the straightness of each tie-beam; most tie-beams have a camber. Johnson's method assumes that the carpenters had measures over a foot (30cm) long, but as we have seen, these did not exist until after 1588.

F.W.B. Charles in *Vernacular Architecture*, 1974,[28] explains that the rafter holes were used by the carpenter to secure the rafter feet while erecting and fixing the rafter by a bent iron that fitted into the hole and clamped to the underside of the wall plate, but the figure 3C he mentions in his article was not published, so there is no way of verifying his contention. Charles characterises R.T. Mason's jig theory[29] as dubious because the holes would be on the side of the rafter, impossible for the carpenter to drill. But, as described in my subsequent discussion, the hole is augered before it is to be used (See author's video 3. https://www.youtube.com/channel/UCW0SIClt4iHlM1HfpsWlarA). Charles also refers to a Vernacular Architecture Group presentation, given at the winter conference in 1969 by E.W. Perkins, suggesting the rafter holes are for fixing sprockets, as Perkins had seen sprockets fixed in this way on a barn at Salwarpe Court in Worcestershire. Charles believed this barn was a one-off, being a purlin roof, not a crown-post roof where sprockets are common.

In response to Charles's article, a letter was published in *Vernacular Architecture*. by K.W.E. Gravett[30] supporting Perkins's observations, with Gravett confirming that he has seen a number of houses in Kent where sprockets have been fixed in this way. But, as I will show, to fix sprockets to rafters using a peg, the hole in the rafter would need to go right through to secure it. A stub peg would not give enough support to a sprocket, which is designed to support battens and tiles. Most rafter holes are stub holes about 2–2⅜in (50–60mm) deep, though there are some instances where the rafter hole goes right through the rafter with no evidence of sprockets. In his paper,[31] the late John McCann questioned Perkins and Gravett's sprocket theory by saying that rafter holes are found in cross wings where sprockets are not required and are not found on jack rafters where sprockets would be required!

McCann spent many years studying rafter holes and theories, publishing them in *Vernacular Architecture*[32] and *The British Archaeological Reports*.[33] It also appears he did not think about the protruding peg on the tie-beam acting as a jig for the common rafters, and nor did he take up Mason and Joe Thompson's suggestion of using a jig. It seems that he also did not consider the simple method of setting out a roof without using dimensions and a protractor. However, a letter was published in the Vernacular Architecture newsletter 75[34] shortly after John's death, where John states that he accepts Joe Thompson's results. Finally, Mennim's article in *Vernacular Architecture*,[35] following on from Charles, Gravett and McCann, mentions rafter holes he noticed on a church butt-purlin, hammer-beam roof in the same location, in the side of the rafters, 3 and 5in. (75 and 125mm) above the wall plate. He is suggesting that they were there to set out a temporary tie-beam and in this he gets closer than any previous author to the actual method. Since this article was published in 2020 Joe Thompson has responded with an article in Vernacular Architecture 52, 2021 63-70 explaining his method in using a jig to cut rafters for a crown post roof very similar to my description on the following pages.

THE PRACTICAL METHOD FOR SETTING OUT ROOFS

It is my assertion, based on the common pitches that are found in buildings of the period that the practical method widely used among medieval carpenters for setting roofs involved the cord method already described. The following example of the Bayleaf house shows how a crown-post roof was set out using this method. To make the assembly of this roof easy to follow, and to avoid confusion, the rafters, which in this case are tenoned into the top of the tie-beam, are called the tie-beam rafters, with the intermediate rafters known as common rafters (Fig. 6). In the following examples, the tie-beam used in the Bayleaf house is situated over the chamber above the service rooms and the cross passage; it is accessible and can be clearly seen from the chamber floor.

STAGE 1: SELECTING THE TIE-BEAMS

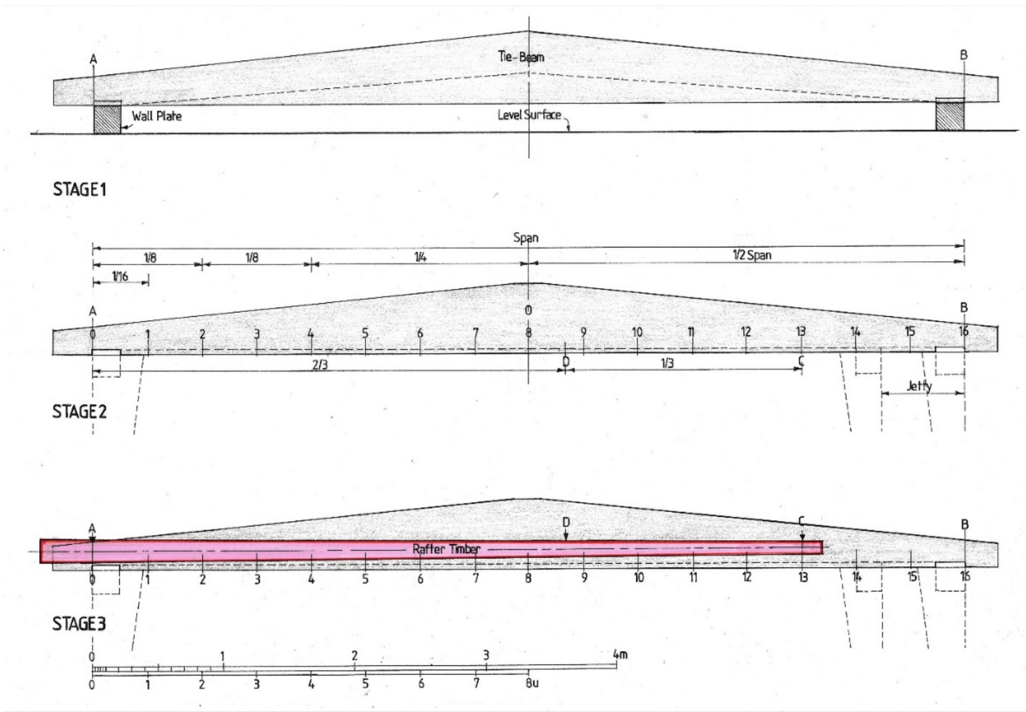

Figure 4. Stages in setting out the pitch of a roof

The carpenter, having decided how many bays his building was to have, selected the required number of tie-beams and laid them out on the framing floor. The carpenter selects a tie-beam to use for setting out the building and levelled it up on blocks. The position of the wall plates was decided at each end of the tie-beam and marked by plumbing down to set out the dovetail joint, points **A** and **B**, on the top of the tie-beam, (stage 1, Fig. 4). The tie-beam was rolled over onto its side remaining in this position during the setting out and the wall-plate marks were squared across for the dovetail joint. Once the wall-plate positions have been ascertained, the wall plates are assembled and levelled on the framing floor, giving the floor area of the uppermost floor of the building.

STAGE 2: SETTING OUT ON THE SIDE OF THE TIE-BEAM

The carpenter then lightly stretched the cord line between **A** and **B**, and folded the cord in half to find the centre span at **O** (stage 2, Fig. 4). At this stage the carpenter flicked a chalk line as a reference line (shown on the drawings as a dotted line). Folding the cord line again divided the half span into ¼ and marked the side of the tie-beam at **4** as described in Figure 3, then repeat the folding of the cord line until all sixteen positions were marked on the tie-beam **A0-16**. The carpenter checks the spacing of each unit and adjust accordingly with large dividers to produce a rod or set the dividers to 1 unit as demonstrated in Part 1 Video (https://www.youtube.com/channel/UCW0SIClt4iHlM1HfpsWlarA).

With these positions clearly marked, with chalk or charcoal, the carpenter can transfer these unit marks onto a rod or set the dividers to 1 unit. With the rod or dividers can set out the height of the building by using **A**, on top of the wall plate to 10.5 units. This would have given the required height of the jowl posts. While the tie-beam was still in this position on the wall plates, the jowl posts would also have been set out for the mortices and teasel tenons. The first-floor height was established by measuring on the jowl post the distance between the top of the sole plate and the wall plate by folding the cord string once to find the underside of the floor joist and the top of the side rails. Bayleaf being a jettied building, the jetty was set out from the inside face of the sole plate (jowl post) and the outside of the wall plate, points **14-16** will be the distance of the jetty overhang (stage 2, Fig. 4). This can be observed in the tie-beam in the Bayleaf bedchamber next to the tie-beam described in this article, the tie beam in the solid wall dividing the open hall from the bedchamber. Thus, the whole building was set out from the proportion marks on the side of the tie-beam. No drawings were required. Set dividers or a Rod (lengths of timber) could be taken from these marks on the tie-beam to assist the carpenter in setting out the remainder of the building, including bay lengths, window positions, etc. The setting out of the whole truss frame is shown in (Fig. 10).

STAGE 3: SETTING OUT THE PITCH OF THE ROOF AND THE TIE-BEAM RAFTERS

With the correct marks on the tie-beam, all the carpenter now needed to do was to lay the rafter timber on top of the tie-beam along the setting-out line **A–B (**stage 3, Fig. 4). So, the rafter timber shaded red in the diagram reached beyond the chosen pitch point **C13** (52°), and extended beyond point **A** with sufficient timber to make a tenon joint to fit into the tie-beam and a bridle or halving joint at the apex. With the top of the rafter at point **A** on the tie-beam, the carpenter marked the rafter at point **A**. He also marked the rafter at **D**, one-third span, which became the location for the collar. This measurement was taken by folding the cord string into three. Finally, he marked the rafter at **C13**, giving him the length of the rafter. The same procedure was then repeated with another rafter, as described above, to form a pair that met at the apex. Note where the rafter extends beyond the wall plate the rafter is set out on the centre line of the side of the rafter. Where the rafters have sprockets (Fig. 17) the setting out of the rafter is done on the back of the rafter, this is clearly shown on the appropriate drawings in this article.

STAGE 4: FIXING THE TIE-BEAM RAFTERS AND COLLAR

With the tie-beam still resting on the wall plates, the carpenter then laid out the two rafters with the birdsmouths cut so that the centre apex lined up at point **CC** and the centre of the rafter feet lined up at points **A0** and **B16** (Fig. 5). Once the apex was set out in this manner, he would have cut the apex joint using either a bridle or halving joint (stage 4, Fig. 5). To keep the paired rafters together he augered through the apex joint and secured it with a temporary peg or iron pin.

The jointed, paired rafters were again laid level on top of the tie-beam at points **A0** and **B16** and the joints for the rafter feet are set out by plumbing up from the tie-beam before being morticed and tenoned into the top of the tie-beam and secured with temporary pegs or iron pins (stage 4, Fig. 5). The collars were laid out on top of the rafters and marked by plumbing up from point **D**. The collars could then be set out for either a dovetail halving joint or a mortice and tenon joint. Some carpenters prefer to do a dovetail halving joint because it is quicker to execute and does not require the rafters to be taken apart. The illustration (stage 4, Fig. 5) shows the tie-beam, rafters and collar assembled and temporary-fixed. The temporary peg securing the tie-beam rafter into the tie-beam is left proud by about 2in. (50mm) to become the jig peg (Fig. 6). At this stage the remaining tie-beams can be set out from this tie-beam by laying it on top and plumbing up from points **A0** and **B16**, continuing to set out the tie-beam rafters and collars as previously explained above. In the case of the Bayleaf only one tie-beam was used with tie-beam rafters, all the other rafters were common.

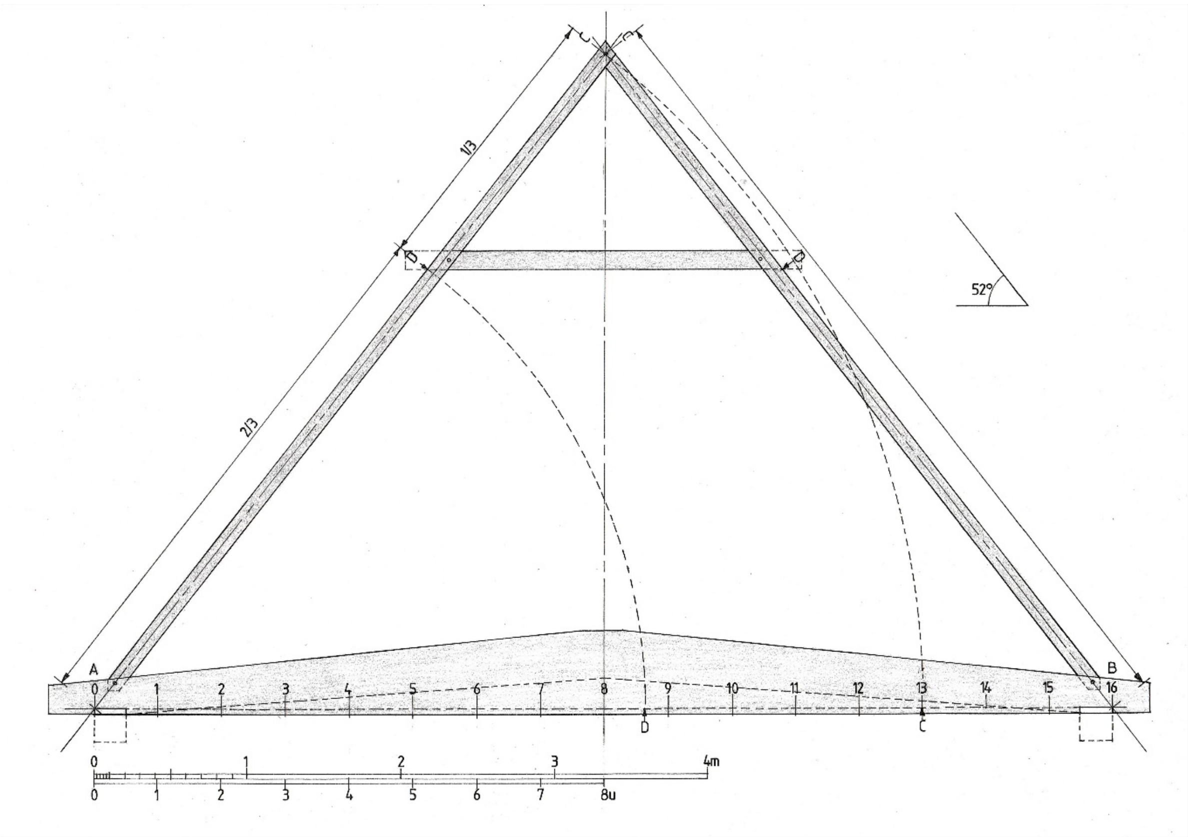

Figure 5. Stage 4: Assembling the rafters and collar

STAGE 5: SETTING OUT COMMON RAFTERS AND COLLAR

The next stage was setting out the common rafters and collars, using stage 5 (Fig. 6). The common rafter was selected with the best or straight side to the top, and a hole is bored halfway into the side of it, centre of the thickness of the rafter or using a template, leaving sufficient length to reach the apex and enough rafter to form the eaves. The template consisted of a small piece of wooden board with a hole bored right through it. A jig hole is bored into the side of the common rafter using the template and laid on top of the tie-beam, one at a time, and the tie-beam rafter assembly, with the newly augered hole (the rafter hole) in the side of the common rafters, placed over the protruding jig pegs securing the tie-beam rafters on the side of the tie-beam. The tops of the common rafters were flush with the tops of the tie-beam rafters, as they are still today. While the common rafter sits on top of the tie-beam rafter, it can be set out by marking the common rafter at the apex joint by plumbing up point **C**. This was repeated for the paired rafter, and again the apex joint was cut and temporarily pegged. The fixed, paired common rafters were offered again on the top of the framed-up tie-beam rafters and temporarily held in place by the rafter holes engaged on the protruding jig pegs (stage 5, Fig. 6). The apex of the common rafters matched the apex of the paired tie-beam rafters underneath.

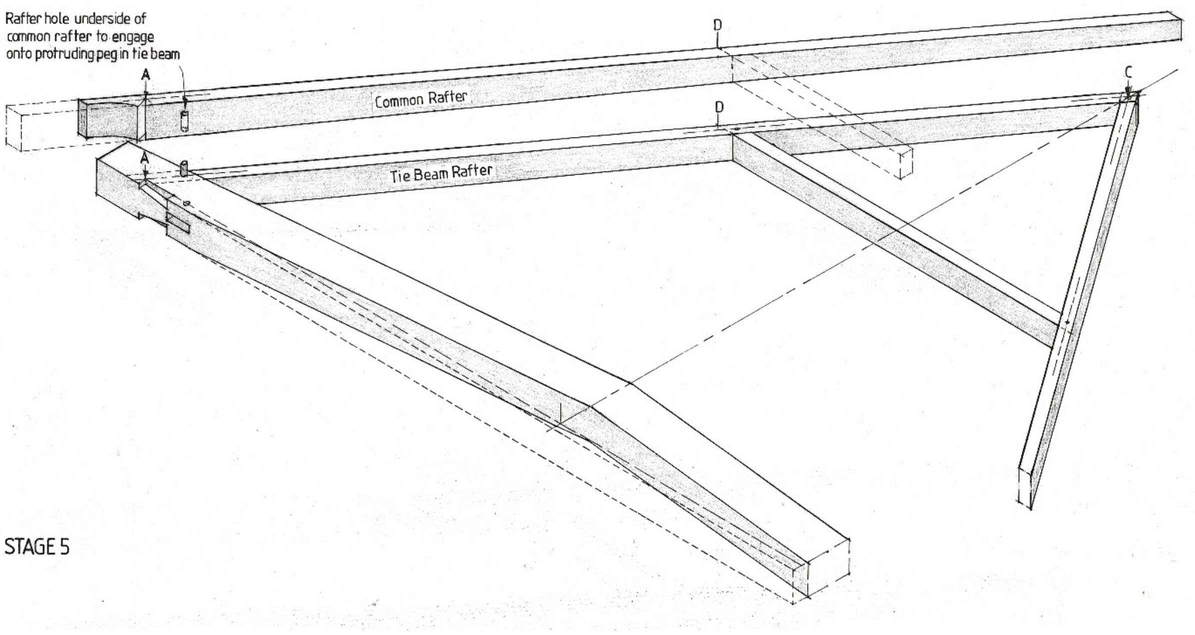

Figure 6. Stage 5: Setting out the common rafter using a jig

The collars were set out by laying a collar timber on top of the paired common rafters and by plumbing up to the collar below at point **D**. As long as the undersides of the collars were consistent, they would always sit on the collar purlin, no matter if there is a difference in thickness of the common rafters or the collars. The gablet collars would have been set out and fixed at this stage.
(See video 3 https://www.youtube.com/channel/UCW0SIClt4iHlM1HfpsWlarA)

The birds-mouth joints were set out by marking the underside of the common rafter with a knife or a fine race knife where the tie-beam has been notched out for the dovetail joint on the top of the wall plate at **A** (Fig. 6). At this stage, with the whole assembly still on the framing floor, the surplus end timber of the tie-beam would have been marked and removed. The distance between the tie-beams along the wall plate determined how many common rafter pairs were needed. This was where the cord was again stretched between the centres of tie-beams and folded according to the number of pairs required; the wall plate was set out and the trenches cut to receive the birds-mouth joints (see Video 4 https://www.youtube.com/channel/UCW0SIClt4iHlM1HfpsWlarA). Because every pair of common rafters were identical it would not matter in which order they were fixed. The evidence proving the peg on the tie-beam matches the rafter hole can be seen in photographs (Figs 7 and 8) taken inside the roof of Bayleaf. The photograph shows the rafter holes lined up with the peg in the side of the tie-beam securing the tie-beam rafters. A surveyor's rolled-up orange line, inserted into the rafter hole in the side of the common rafter, lines up perfectly with the peg in the side of the tie-beam and is visible at both ends of the tie-beam. Before each of the roof members was separated from the corresponding tie-beam rafter and common rafters on the ground, was marked with assembly numbers, usually Roman numerals or a variation of knife, race or chisel marks; this explains why carpenters' marks are seen on historic timbers. Most crown-post roofs have rafter holes in this location, though they may not always be in the position described above. (See heading below, TIE-BEAMS WITHOUT TIE-BEAM RAFTERS.)

In those cases where rafter holes are not visible on the side of the common rafters, the rafters have not been set out with a jig, using points **A0** and **B16** marked on the tie-beam as shown at stage 4. Without the means to secure the feet of the rafters onto a protruding jig peg, it would have been necessary to rely on visual assistance to line up **A0** and **B16**. This would have been troublesome when using irregular-shaped rafters and handling heavy green-oak timbers.

Figure 7. Rafter peg hole in line with the peg securing the tie-beam rafter on the west end of the Bayleaf tie-beam

Figure 8. Rafter peg hole in line with the peg securing the tie-beam rafter on the east end of the Bayleaf tie-beam

SETTING OUT THE CROWN POST

While the tie-beam, tie-beam rafters and collar were still assembled on the framing floor, the centre line of the collar was marked by taking the cord along the collar from **D** to **D** and folding it in half to find the centre of the collar (Fig. 9). A suitable, selected timber for the crown post was laid on top of the tie-beam between the central point **8** and the centre of the collar. An offcut of the collar purlin was placed beside the collar, and the top of the crown post was plumbed and marked out, allowing for scribing. Tenons were set out on each end of the crown post and the mortice set out on the top of the tie-beam. Because the crown post was being set out from the collar, it would not have mattered if the top of the tie-beam had an irregular camber.

Up-braces could now be set out to spring from the sides of the crown post to the collar; shoulders were cut on the barefaced tenons on the braces, and the brace mortices were set out on the collars and temporarily pegged. It was common to find twin down-braces coming from the crown post onto the tie-beam in closed trusses; the braces stabilised the crown post when set up on the tie-beam. Open trusses, on the other hand, do not usually have down-braces, as in the case of the Bayleaf tie-beam, whereas down-braces are common in barns. When the setting out of the braces was complete, the crown post was decorated with rebates, stop chamfers and mouldings, as can still be seen today.

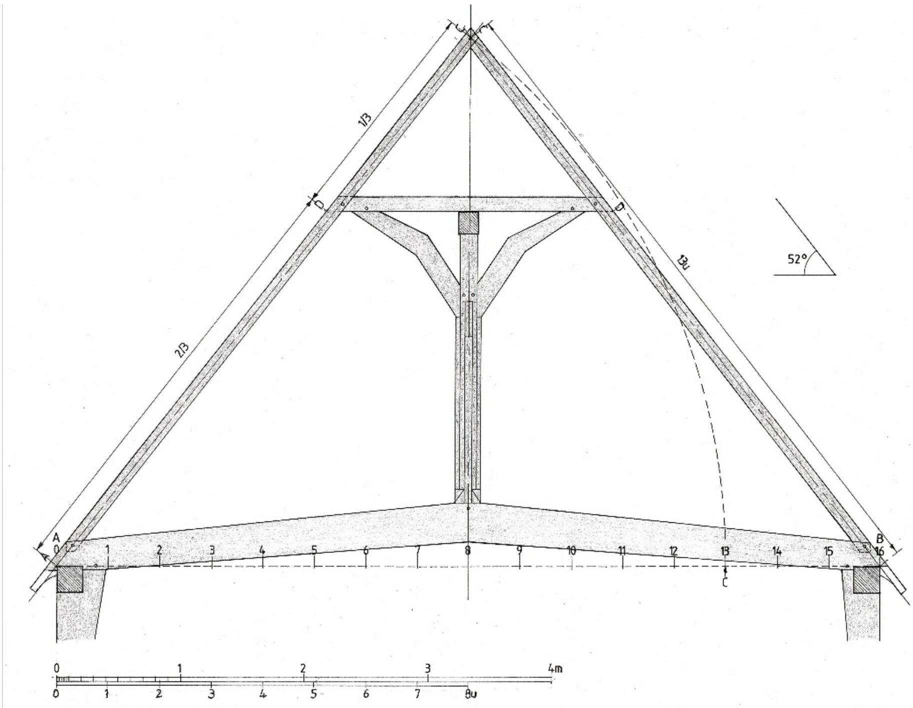

Figure 9. Bayleaf Farm House, truss frame J over the cross passage

When all the tie-beam trusses had been completed, they were set up temporarily on the wall plates at ground level, and the crown posts were temporary-fixed into the tops of the tie-beams with up-braces or down-braces where required. The collar purlin was set out by laying the purlin on top of the tie-beams so that the mortices for the crown posts could be set out. The collar purlin was scribed and fitted to the tops of the crown posts. When the collar purlin was in place the up-braces from the crown post to the collar purlin were set out, scribed and fitted. At the hipped end the first pair of rafters was set up with the gablet collar and held in place with the centre rafter on the hipped end. The collar purlin was set out and fitted to this central rafter and temporary-secured with pegs. With the collar purlin rigid and stable, the up-braces could now be set out from the crown posts. With this stage completed, the carpenter then adds the assembly marks. Then he dismantles and reassembles again on top of the wall plates of the building and the collar purlin would act as a scaffold to fix the common rafters.

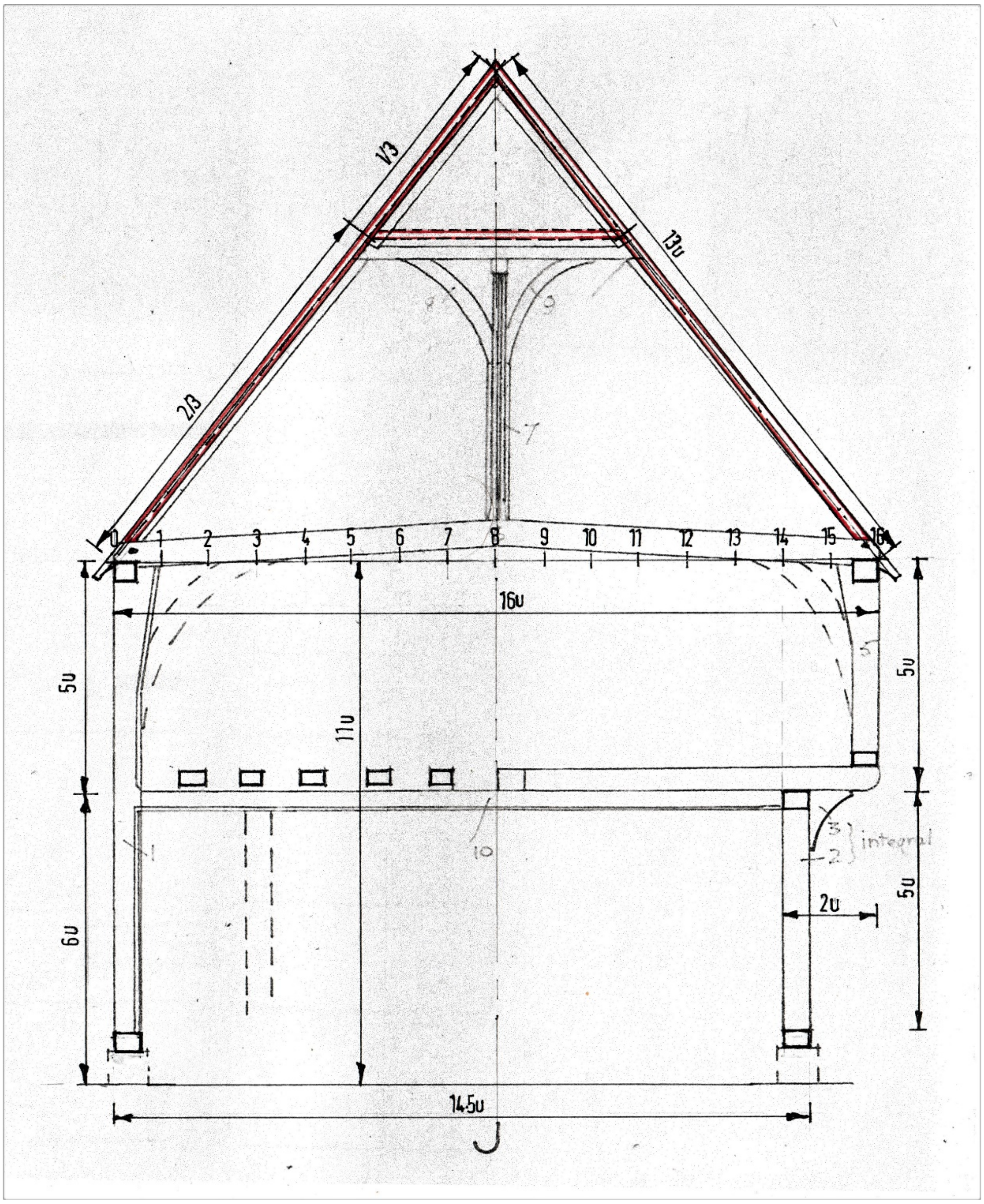

Figure 10. Survey drawing of the Bayleaf showing section J, drawing produced by the Weald and Downland Museum with added unit dimensions by the author.

CROWN-POST ROOFS WITHOUT TIE-BEAM RAFTERS

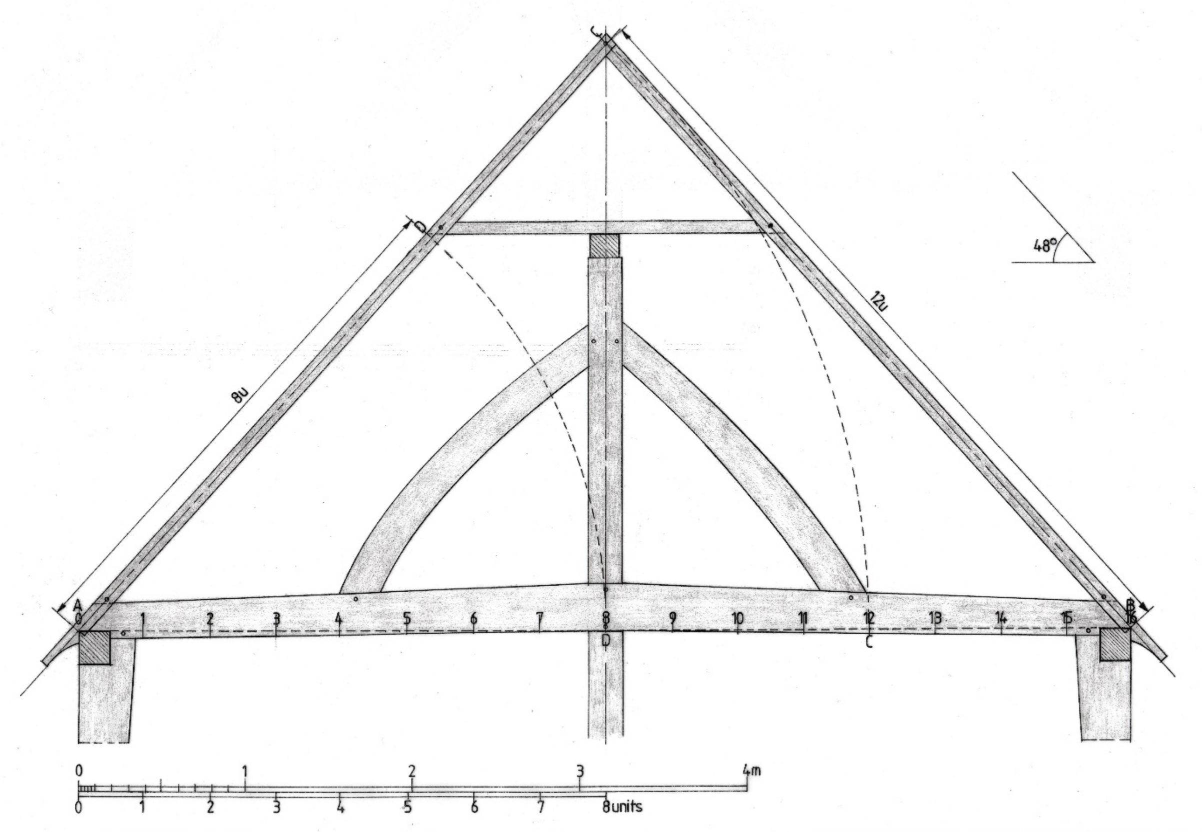

Figure 11. North Cray House truss above the cross passage

There are several examples of this type of medieval roof at the Weald and Downland Museum; for example, North Cray House, Cowford Barn and Sole Street. To construct a roof which does not have tie-beam rafters morticed on top of the tie-beam, in other words where all the rafters are common rafters, a different method is required to set out the crown-post roof. I will use North Cray House at the museum to explain this method. The tie-beam described in the following examples is in the chamber over the service room next to the cross passage, where it is easy to see close up. In this case the rafters had to be set out differently, using a jig as described by R.T. Mason[36] and as in Figure 12 similar to the description by Joe Thompson, Master Carpenter at the Weald and Downland Museum.[37] The rafters used on this type of roof still have rafter holes, which work with a jig rather than the protruding peg on the tie-beam described in the example based on the tie-beam in the Bayleaf house and as demonstrated in the author's video (Part 3 https://www.youtube.com/channel/UCW0SIClt4iHlM1HfpsWlarA) . The tie-beam was still used to set out the pitch of the roof (see stages 1–3 above), employing the same method of setting out as for the Bayleaf roof except the roof pitch is 48° (fig. 10).

As the tie-beam rafters were not fixed into the top of the tie-beam, the A-frame assembly was laid on top of the tie-beam, and the birds-mouth joint, point **A,** was set out as described for the common rafter (stage 5A, Fig. 11). Again, the crown post could be set out while the A-frame assembly was still in position (stage 5, Fig. 6). Up-braces to the collar cannot be used in this type of roof, but they can be used in the collar purlin and collar.

STAGE 5A: SETTING OUT THE COMMON RAFTER AND COLLAR

Stage 5A (Fig. 11) is different from stage 5 above. In this method tie-beam rafters are not used. In North Cray, the common rafter was laid along the tie-beam, as in stage 3, and marked at **A**. The length of the rafter was marked at point **12C** on the tie-beam 48° and the collar height at **D** allowing extra length of

timber for eaves and for the joint at the apex. This was repeated for the paired rafter, with the apex peg holes augered and secured with a temporary peg or iron pin. The paired rafters with the birds-mouths already cut were laid onto the tie-beam and the marks **A** and **B** on the centre line top face of the rafters were lined up with the marks **A0** and **B16** on the tie-beam. On sprocket roofs and barns with isles the setting out of the rafter would be the back of the rafter not on a centre line.
``

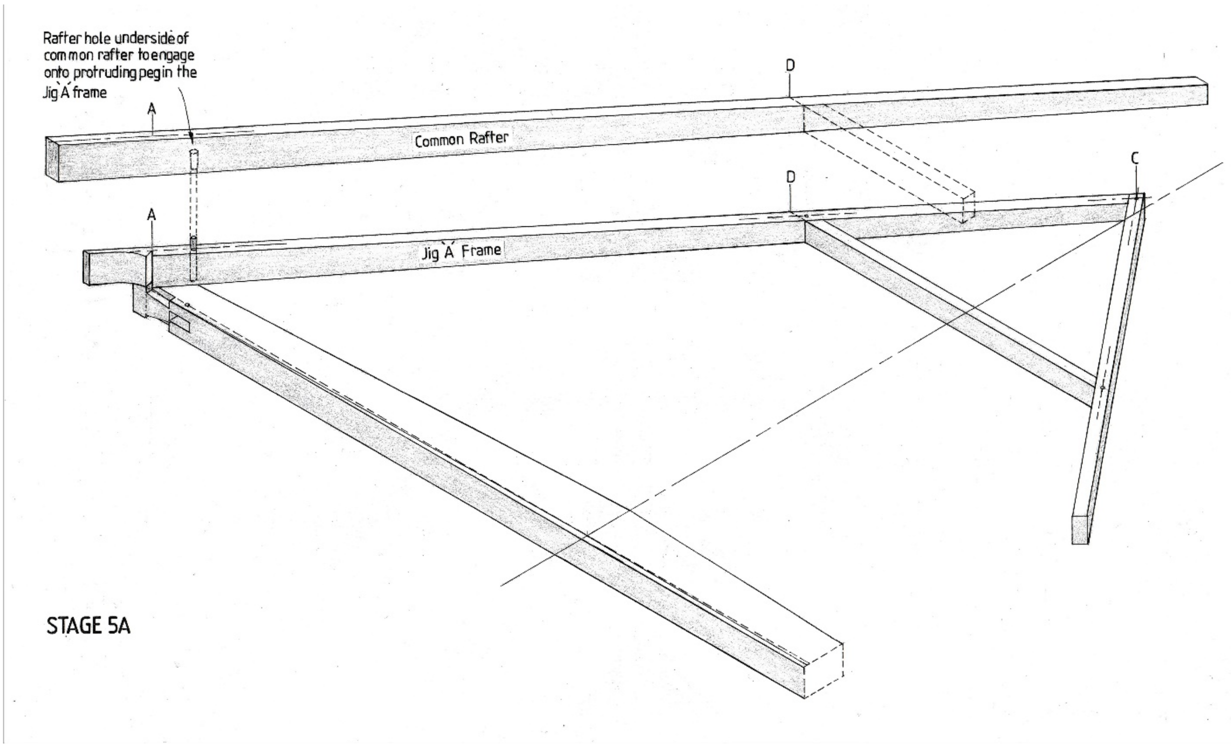

Figure 12. Setting out the common rafter using the A-frame rafter jig

HOW IS THE A-FRAME JIG MADE?

The paired rafters were again laid out level on the side of the tie-beam, on the framing floor as previously described, with **A** lined up with **A0** on one side, while on the other side **B** was lined up with **B16** on the tie-beam (stage 5A, Fig. 11). The collar timber was laid across the paired rafters from points **D** to **D** and marked by plumbing up from point **D** on both rafters so that the joint for the collar could be set out. The collar was fitted and pegged to the paired rafters, now assembled forming an A-frame, and was again laid on top of the tie-beam so that points **A0** and **B16** lined up.

The top of the tie-beam was marked on the top of both A frame rafters, and the birds-mouth joints for the rafter feet were also marked on the underside of the rafters at **A** with a sharp fine race knife where the top of the wall plate is visible by the dovetail joint. The birds-mouths were cut on both rafters and a peg hole was augered right through the side of the rafter above the mark made above the tie-beam, using a simple template giving the centre distance of the peg hole from the external face of the rafter (see stage 5 above). A peg was inserted into this hole and the same process was repeated on the other paired rafter. The jig was now complete and the remaining paired rafters could be laid on top of the jig and set out. The rafters were all the same length and the collars were all at the same height. As in stage 5A above, the common rafters had pre-augered holes which fitted over the protruding pegs on the jig A-frame, so that the common rafters could be marked off for the collar, the apex joint and the birds-mouth joints (Figs. 11 and 12). The peg hole in the North Cray rafter is just above the tie-beam, indicated by a red pencil in the photograph (Fig. 13). In the event the jig peg had been snapped off when the common rafter was being removed from the jig. The snapped peg can easily be removed from the back of the jig rafter and a new jig peg can be inserted. Through rafter holes are often found and also broken pegs in rafter holes.

Figure 13. Rafter hole shown by a red pencil above the tie-beam and the rafter hole is seen in the foreground rafter. Photo taken in North Cray House, Weald and Downland Museum

SETTING OUT THE CROWN POST

The paired rafter jig A-frame remained lying on the tie-beam so that points **AA** and **AB** were lined up, with the tie-beam on its side. The crown post centred at **0,** was marked out on the side of the tie-beam. The crown post was set out as described for the Bayleaf house. Note that braces were not set out from the collar. The centre of the collar was set out by stretching the cord from **D** to **D** and folding it in half to give centre point of the collar. On this tie-beam was taken from the centre of the crown post is usual with crown-post roofs. The braces were set out using the quarter-span marks, point **4 and 12** on the tie beam (Fig. 11).

QUEEN-STRUT ROOFS AND OTHER PRINCIPAL RAFTER ROOF VARIATIONS

MONKINGS BARN, STAPLECROSS, EAST SUSSEX

This barn is in the yard of Chalk Down Lime Ltd, Gate Farm, Northiam Road, Staplecross. The owner has given consent for access during normal working hours. The barn was removed from Monkings Farm at Horns Cross, two miles east of the yard. This aisled barn was built in 1783 with a purlin-collar roof at a pitch of 48°. The rafter length has been set out from **A** on the tie-beam to point **C12** as explained in stages 1–4 above. Halve the rafter length at **6D** will be the mark on the rafter for the location of the collar (Fig. 14). The aisle wall plate in this case is 5 units below the wall plate. This would also be the location of the sole plate on the framing floor. In the survey plan and elevations (Fig. 15) shows all the setting out dimensions in units very precisely. It is clear the carpenter was using a rod or dividers to set out this building in units in the late 18th century.

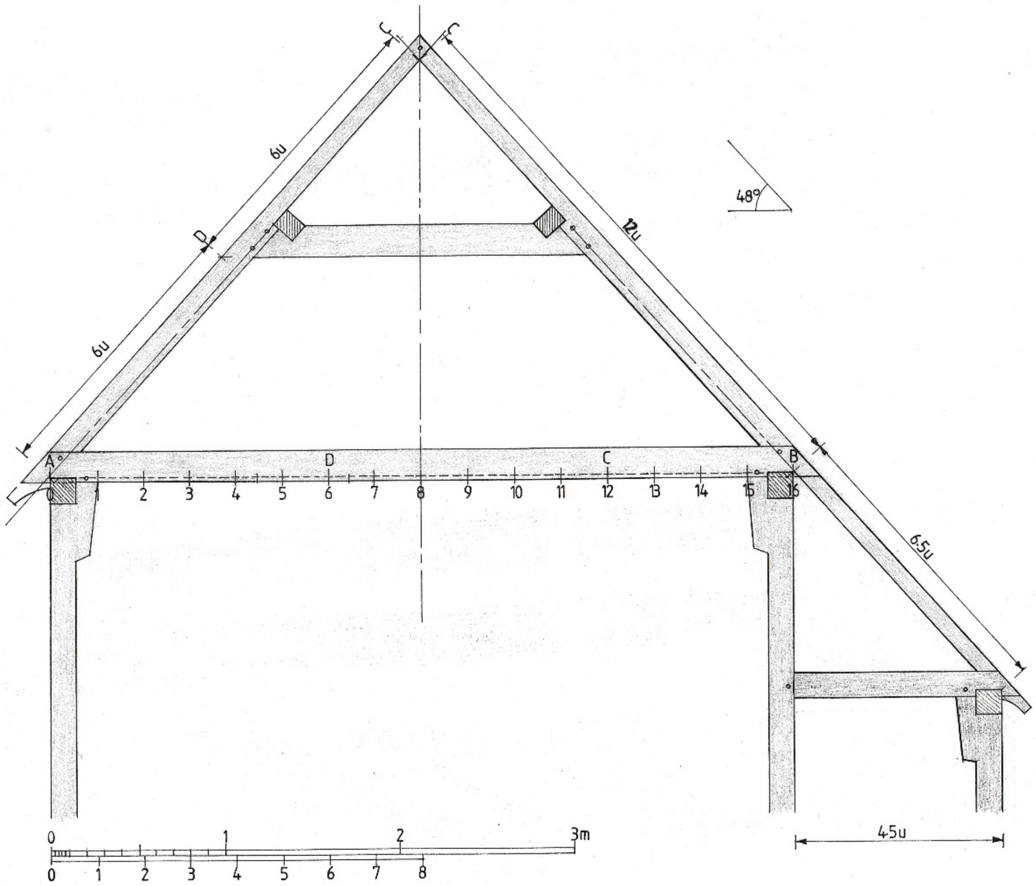

Figure 14. Monkings Barn, Roof Detail, Staplecross, East Sussex

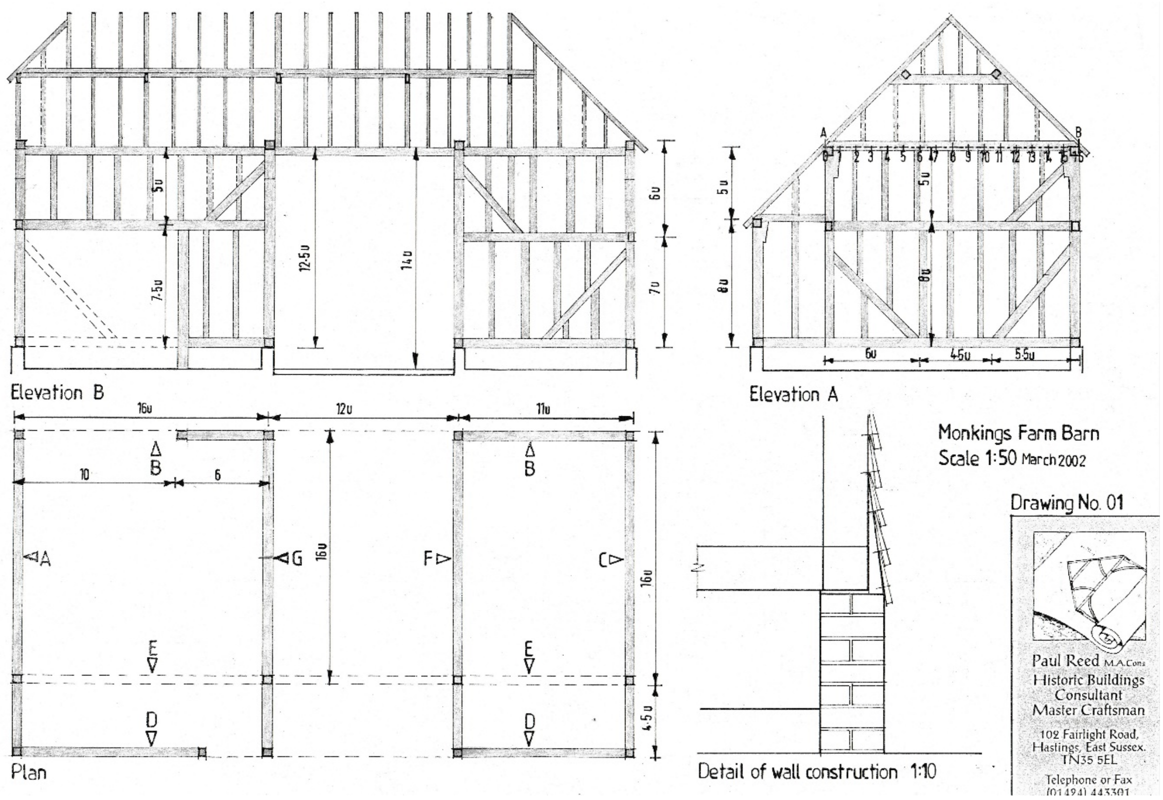

Figure 15. Monkings Barn, Plan and Elevations showing the setting out in units. Drawn by Paul Reed

WHITE BARN, GREAT DIXTER, NORTHIAM, EAST SUSSEX

This building is thatched with hip ends, partly two stories, with 6 bays. It is part of the Great Dixter estate and is connected to the great medieval barn. The building was probably used for wagons and as a coach house with stabling, in the 1900s it was used by the Loyds as a garage. Great Dixter, both house and grounds, is open to the public. The roof of this property can be inspected by appointment with the Property and Administrative Director during normal opening hours. The barn, which is early eighteenth century, was the subject of a detailed report by Archaeology South East in 2012.[38] The roof is a collar-purlin roof with strut supports from the tie-beam. The roof pitch is 52° which is taken from point **C13**. The collar is set out from point **D7** on the tie-beam. The struts spring from the tie-beam at **7** and **9** and the braces down from the tie beam to the jowl post is set out at **3.5** and **12.5** units. (Fig. 16).

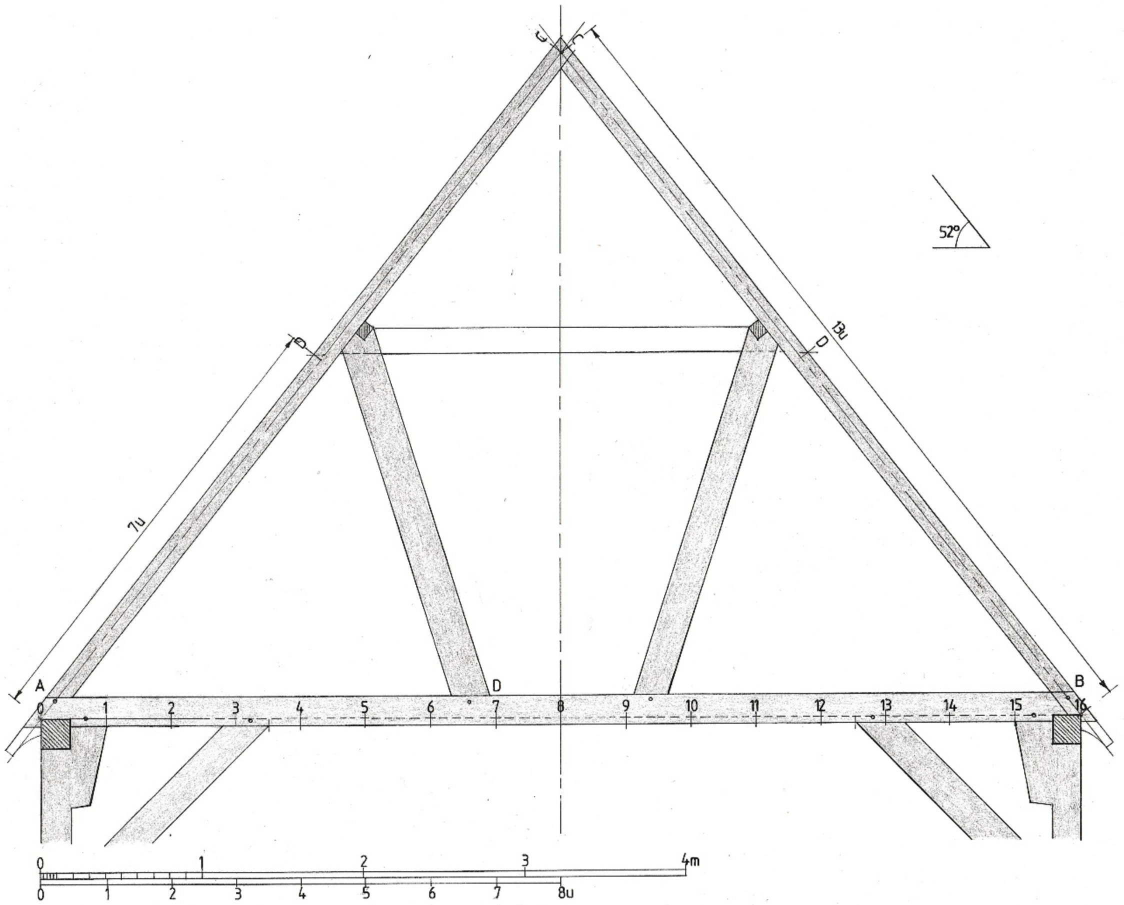

Figure 16. Frame E (third frame from the east) The White Barn Great Dixter, Northiam, East Sussex

SPROCKET ROOF

These roofs are fairly common, especially in Kent. The setting out is straightforward following stages 1–4 described above. This type of roof has sprockets, which are fixed on top of the rafters at the eaves to provide an attractive bell shape. The sprocket will also give the eaves a bigger overhang to protect the walls of the building.

Comparing this type of roof to the standard rafter eaves, there is extra labour needed in making the sprockets and there is extra expense of the nails to secure them. The setting out of the sprocket roof is taken from the outside face of the wall plate at **A** (Fig. 17). This example has a pitch of 48°. The rafter length is taken from **A** to point **C12**, and usually on medieval buildings the collar is taken from the centre point of the tie-beam at **D**, as shown in this example. The point **D** on the rafter also divides up into one third and two thirds respectively, where the collar is set out at **D 8** though this will only happen on 48° pitch roofs. A similar roof has been recorded by the RCHME survey of the fifteenth-century Ivy Cottage, Hartlip, Kent.[39] The survey found a total of 40 per cent of roofs in Kent with sprockets.

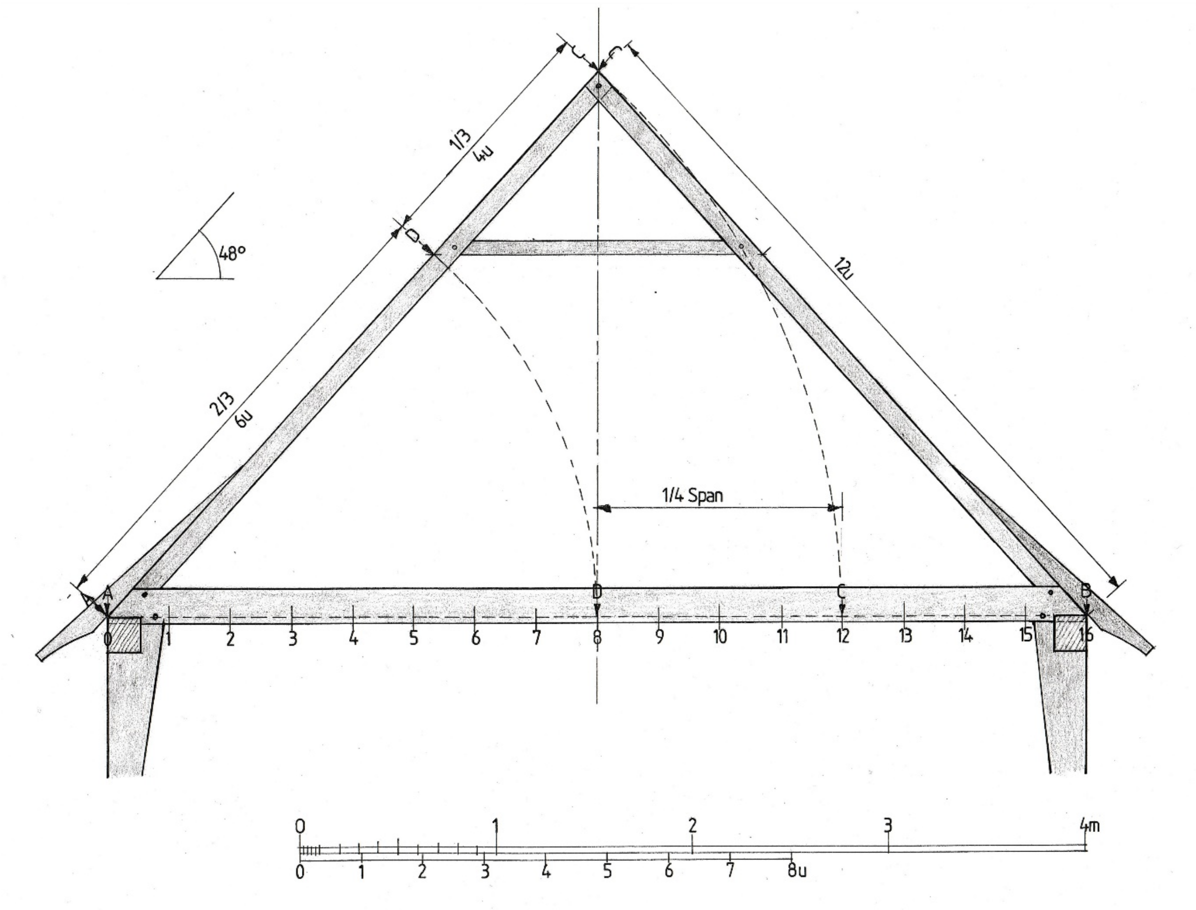

Figure 17. Sprocket Roof

SUMMARY AND CONCLUSIONS

This article is intended to bring knowledge of early carpentry to the attention of scholars, making them aware of how intelligent medieval carpenters were able to design buildings and roofs on a tie-beam timber without the need to do drawings, or the use of numeric measurements or geometry. This method of setting out using a cord, which is very accurate, could also be used today by archaeologists and architectural historians in piecing together a timber building where the structure is fragmented, where there is a limited number of historical roof timbers, and where they need to determine the pitch of the roof and the original design. Stages 1–5 described at the beginning of this article can be used to set out any type of roof accurately, as demonstrated in the above examples, with a piece of cord, applying knowledge handed down from Saxon times.

Ever since roofs have been pitched off wall plates, which are restrained with tie-beams, this use of cord or string has made it easy for carpenters to build roofs and set out their buildings. For example, the Saxon roof AD 980 at Barton-upon-Humber (Fig. 2) shows an outline roof pitch of 60°, also the scars of later roofs of the late 11th and the 13th century being 55°[40], two of these angles are in the diagram shown in (Fig. 3). Similarly, the now-demolished 11th century hall at Lurk Lane, Beverley had a roof pitch of 55°.[41]

It is very probable that when the medieval carpenter had established a one-eighth proportion of the half-span of the tie-beam, as illustrated in (Fig. 3), he would have used a pair of large dividers to make repeated divisions on the tie-beam, making a total of eight equal divisions. Once the carpenter had established these divisions, he would have known that if he chose division 4, he would have a pitch of 48°, suitable for tiles. If he chose divisions 5 or 6, he would have a pitch of 52 or 55°, suitable for thatch or shingles. The carpenter would have remembered this rule and applied it accordingly. For example, the roof of the hall at Great Dixter, Northiam, East Sussex, built in 1480, has a pitch of 43° and was clad with Horsham slates. The carpenters were also capable of advancing their skills by making jigs for accuracy and easy working, especially when using green oak, their principal building material, which was very heavy to handle. The setting out, working the timber and making the joints were all done at ground level.

The evidence is convincing that all early timber structures were set out by this cord method, using the tie-beam or a rod board to represent a tie-beam to establish the width of buildings, the size of bays, and where to put the cross passage and window positions, as all the structural elements were proportions of the span of the building. People always ask why vernacular cottages look pleasing to the eye. They were not designed by architects but by craftsmen using their lengths of cord or string, which gave pleasing proportions. By the eighteenth/nineteenth century, not only were there far fewer newly built timber-framed buildings, but architects were designing buildings using protractors and scale drawings on paper, then handing these over to the builder to do the construction. For these reasons the carpenter no longer needed his piece of cord to set out roofs and buildings, just a measuring rule and a square, and as a result the age-old cord method fell out of use. However, the setting-out rod, a thin board or piece of plywood, is still used today in the carpenter's and joiner's workshop to set out joinery, such as windows and stairs, at full size. But if this is the sole evidence extant of the old cord method, it is my belief that until the eighteenth century this ancient technique would have been widely known among English carpenters. Until now, the lack of documentary evidence, as confirmed to me by Arnold Pacey,[42] has led to a blind spot among scholars. Though as I have shown, to someone schooled in the practical methods of working carpenters, the evidence is copious and conclusive. As the numerous examples in this article make clear, from the tenth to the eighteenth century, the setting-out method described, using just a piece of cord or a rod suggests a continuity of the English school of carpentry unbroken since Anglo-Saxon times.

During this research I have proved that my theory of this method of setting-out works perfectly on crucks and box-frame buildings found in the Midlands of England and on iconic buildings such as Westminster Hall, St Marys Church Kempley, Gloucestershire (the oldest non-tie-beam roof in Europe), the Cressing barns in Essex and many churches and cathedrals. I also plan to conduct further research to see if European roofs may have used the same setting-out method.

I would like to encourage readers to make a clear transparent copy of Figure 3 of this article, so they can check the pitches of historic surveyed roofs for themselves.

ACKNOWLEDGEMENTS

I am very grateful to Julian Bell, Curator of the Weald and Downland Museum, allowing me to use Bayleaf, North Cray for my study, Joe Thompson, Master Carpenter, and the late Roger Champion, retired Master Carpenter, of the Weald and Downland Museum; without their assistance I would not have been able to do this research. Thanks also to Victoria Williams, Project & Administrative Director at Great Dixter, Dr Mark Gardiner of Lincoln University has been a constant mentor in encouraging me in this research. Thanks to Warwick Rodwell for allowing me to use his drawing of the Saxon roof St Peters Church, Barton upon Humber, image figure 2. The History Press (Tempus) for allowing me to trace image in figure 1. David Ellwood and Des Pawson confirmed to me the quality of the medieval cord; Des kindly sold me some spun cord for my research. Rupert Austin of the Canterbury Archaeological Trust confirmed my observation about rafter holes in Kent. The late Arnold Pacey was generous in sharing his knowledge on Medieval Drawings. My wife Christine has patiently acted as surveyor's assistant, holding the other end of the tape, ladder and line on freezing-cold days and spending many hours extracting the data from the RCHME Kent survey, and producing spreadsheets and charts. Thanks to the staff of the Kent Archives, History and Library Centre in Maidstone Kent, for allowing me to study the 11 volumes of the RCHME medieval house survey of Kent. Nat Alcock and Dan Miles have graciously allowed me to use their material and data on cruck and box-frame buildings. Grateful thanks are also due to Roger Bunney, structural engineer specialising in timber-framed buildings, for the technical editing of this paper and to Peter Massey, master craftsman specialising in historic carpentry, for his constructive comments and support with my research. Finally, Julian Beecroft

has spent many careful hours editing this text. Unless otherwise stated all of the figures in this article are copyright of the author.

Notes

1. Drawing by Warwick Rodwell, figure 276, p 283, St Peters church Barton-upon-Humber, in W. Rodwell, *The Archaeology of churches*, 2012, showing roof pitches of 60º and 55º
2. Barnes, *The Portfolio of Villard de Honnecourt*, *A New Critical Edition,* 2009
3. Salzman*, Buildings in England Down to 1540*, 1957, p339–40
4. Harvey, *Medieval Craftsmen*, p87. Batsford, 1975
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6. Huggins, *Anglo-Saxon Timber Buildings Measurements: Recent Results*, Soc. of Med. Arch 35, 1991, 6–28.
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10. Science Museum, London, ref. 1931–985
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14. Barnes, *The Portfolio of Villard De Honnecourt*, c1260 folios 14, 15, 16 and 17
15. Harvey. *Medieval Craftsmen*. Batsford
16. Salzman, *Building in England down to 1540*, 1976, Oxford Pess
17. Gimpel, *The Cathedral Builders* 1983)
18. Harvey, *Medieval Craftsmen*, p107. Batsford
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20. Marshall and Marshall, *Survey and Analysis of the Building of Early and Middle Anglo-Saxon England*, Med. Archaeology 35, 1991 29–43. Huggins, *Anglo-Saxon Timber Measurement,* Med. Archaeology and Bettess, *The Anglo-Saxon foot: A computerised Assessment*, Med. Arch. 35, 1991
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25. RCHME, *Medieval Houses of Kent*, vols 1–3, 1996. The complete survey can be found in 11 volumes at Kent Archives, Maidstone. Catalogue reference XK 728 ROY
26. Thompson, J., Master Carpenter at The Weald and Downland Museum, Singleton, East Sussex, 'Lining out the Rafters: 1300–1900 AD, Raising the Roof Conference', 2012. Published i *Weald & Downland Open Air Museum* magazine, Autumn 2013, 9–11. He has done extensive research on the subject of rafter holes and has spoken about them at the following conferences: Essex Historic Building Group, May 2005; Weald and Downland Museum conference, 1000 Years of Roofing in September 2012; Vernacular Architecture Group, January 2014; Weald Building Group, January 2015.
27. Johnson, "*Further Thoughts on Rafter Holes"*, 144.
28. Charles, '*Scotches, leavers sockets and rafter-holes'*, 22–4. Mason's jig theory in *Framed buildings of England,* 56-57 explaining the use of the rafter holes and the procedure how the carpenters assembled the roof in stages. The rafters were cut in pairs using a jig but Mason did not explain why they needed to use a jig.
29. Mason's jig theory in *Framed buildings of England,* 56-57 explaining the use of the rafter holes and the procedure how the carpenters assembled the roof in stages. The rafters were cut in pairs using a jig but Mason did not explain why they needed to use a jig.
30. Gravett, "On Rafter Holes," 840
31. McCann, "*The Purpose of Rafter Holes,"* 9.26-9.31
32. Ibid.
33. McCann, *A Guide used for the Alignment of Medieval Roofs*, BAR, 129, 1982, 357-365
34. John McCann's letter in the News Letter 75, July 2018, 32-33
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38. Martin, *Survey of the Minor Barn, Great Dixter, Northiam, East Sussex.*
39. RCHME Survey of Kent, Ivy Cottage, Hartlip. Kent, NMR file number 40151, 1996.

40. Drawing showing roof pitches of 60° and 55°, by Warwick Rodwell, "St Peter's Church Barton-upon-Humber" figure 276, 283.
41. Forman and Hall, *Excavations at Lurk Lane Beverley*, ref. 971 A&M timbers, 178 illustration, timber 971A on 179, both timbers on display in Hull Archaeological Museum.
42. Pacey, *Medieval Archaeological Drawing*

APPENDIX

The Royal Commission on the Historic Monuments of England Survey of Kent 1994 Vols. 1-3. Extracts from the survey giving the property, location, the different roof constructions and their pitches.

	A	B	C	D	E	F	G	H	I	J	K
1	**Location**	**House name**	**Date**	**Tie beam**	**Sprocket**	**Crown post**	**Queen post**	**High collar**	**Base cruck**	**Roof pitch**	**Comments**
2	Aldington	Court Lodge Farm House	15C	•						55°	
3	Aldington	Parsonage Farm House	14C	•						52°	
4	Alkham	Hog Brook	15C	•						55-58°	Roof repitched
5	Appledore	Hornes Place	14C	•	•					52°	Public
6	Ash *	Chequers Inn	15C	•			•			55°	Corbelled flying plate
7	Ash	Uphousden Farm	1400	•	•	•				52°	
8	Ashford	Worgers	14C	•	•	•				52°	
9	Aylesham	Ratling	1450	•	•	•				55°	
10	Benenden	Manor House	15C	•		•				52°	Double wealden
11	Bethersden	Pimphurst Farm House	16C	•				•		58°	
12	Biddenden	Vane Court	15C	•		•				52°	
13	Brenchley	Old Cryals	13C	•	•					52°	
14	Brenchley	Old Palace	15C	•	•					45-50°	45 at front *
15	Capel	Wenhams and Thistles	15C	•		•				52°	
16	Charing Heath	Brockton Manor	15C	•		•				55°	
17	Charing	Hunger Hatch Cottage	15C?	•				•		52°	
18	Charing	Old Vicarage	14C							52°	
19	Pett	Plcae Farm tithe barn	15C	•		•				52°	
20	Chart Sutton	Chart Hall Farm House	1400-30	•		•				52-55°	
21	Chart Sutton	Old Moat Farm House	1382D	•		•				52°	
22	Chiddingstone	Old Gilwyns	14C	•		•				52°	
23	Chiddingstone	Old Manor House	15C	•				•		52°	
24	Bough Beech	Somerden Oast	16C	•	•		•			48°	Barn
25	Chilham	Hurst Farm	16C	•	•		•			55°	Cross wing
26	Chilham	Tudor Lodge	14C	•	•	•				52°	
27	Chislet	Port Farm House	15C	•	•	•				48°	
28	Chislet	Tudor House	15C	•	•	•				48°	
29	Cliff at Hoo	Allens Hill Farm House	15C	•	•			•		48°	
30	Hadlow	Barns Place	14C	•		•			•	55°	
31	Golden Green Hadlow	Old Farm House	15C	•	•	•				55°	
32	Hartlip	Ivy Cottage	16C	•	•			•		48°	
33	Hastingsleigh	Coombe Manor	1400	•		•			•	52°	
34	Headcorn	Wick Farm House	15C	•		•		•		52°	
35	Hever	Hever Brocas	16C	•		•				48°	

Figure 18. Table showing roof types and their pitches

	A	B	C	D	E	F	G	H	I	J	K
36		Rectory Park	16C?	•						48°	Arch braced
37	Kenardington	Place Farm House	16C	•		•				48°	
38	Fawkham	Court Lodge	14C	•				•		55°	Aisled
39	Goudhurst	Riseden Hall	15C?	•	•	•				48°	
40	Goudhurst	Star and Eagle pub	1500	•	•	•				52°	
41		Old Rectory House	16C	•			•			48°	
42	Great Chart	Court Lodge	14C	•						52-55°	Ashlars with soulace
43	Great Chart	Godinton Park	1400	•		•				55°	
44	Detling	Well Cottage	16C	•		•				48°	
45	East Farleigh	Gallants Manor	14C	•	•	•				55°	
46	Eastling	Eastling Manor	14C	•				•		48°	Passing braces
47	Eastling *	Tong House	14C	•		•				48°	With side hangers
48	East Malling	The Barrack	15C	•		•				52°	
49	East Malling	Derbies	400	•				•		52°	Collar with soulace
50	East Malling	Rocks	16C	•				•		55°	Straight high collar onto side purlins
51	East Peckham	Court Lodge Farm House	15C	•		•				52°	
52	East Peckham	Old Well House	15C	•				•		52°	High collar with post
53	Eastry	Eastry Court	14C	•				•		48°	High collar with passing braces
54	Eastry	Old Selson House	15C	•	•			•		52°	Notched purlin
55	East Sutton	Barling Farm House	1500	•		•				55°	
56	East Sutton	Divers Farm House	1440-70	•		•				48°	
57	East Sutton	Luckhurst	1500	•		•				52°	
58	East Sutton	Noah's Ark Farm House	15C	•		•				55°	
59	East Sutton	Street Farm House	1500	•		•				52°	Crown post with soulace
60	East Sutton	Walnut Tree Cottage	14C	•		•				52°	Crown post with isle
61	Edenbridge	Church House	1400	•	•	•				48°	Short crown post
62	Edenbridge	94&96 High Street	1420	•		•				48°	
63	Edenbridge	75,77&79 High Street	1590	•	•		•			48°	Butt purlins
64	Edenbridge	Old Stanford's End	15C	•		•				48°	
65	Elham	Boyke Manor	1500	•		•				52°	
66	Elmstead	Dean Farm	1500	•		•				52°	
67	Elmstead	Spong Farm House	1580	•		•				52°	
68	Otham	Belks	15C	•				•		55°	High collar but no crown post
69	Otham	Stoneacre	15C	•		•				48°	Low crown post
70	Petham	Dormer Cottage	15C	•				•		58°	Thatched

Figure 19. Table showing roof types and their pitches

	A	B	C	D	E	F	G	H	I	J	K
71	Petham	Old Hall	1450	•	•	•				55°	
72	Petham	Yew Tree Farm House	1500	•	•	•				48°	
73	Plaxtol	Clakkers Hall	1500	•	•	•				58°	
74	Plaxtol	Ducks Farm	1340	•	•	•				55°	Straight tie beam
75	Plaxtol	Nut Tree Hall	1480	•	•	•				52°	
76	Plaxtol	Old Graingers		•		•				43°	Straight tie beam
77	Plaxtol	Old Soar	13C	•		•				52°	Crown post with rafter struts
78	Pluckley	Chambers Green Farm	1450	•	•	•				55°	
79	Pluckley	Coopers Farm House	15C	•	•	•				55°	
80	Pluckley	Jennings Farm House	1500	•		•				55°	Tall crown post
81	Pluckley	Lambden Cottage	1450	•				•		52°	
82	Pluckley	Rose Farm House	1480	•	•			•		55°	
83	Rodmersham	Bakers Cottage	1500	•	•	•				52°	Cambered tie beam
84	Margate	Selmestone Grange	13C	•		•				52°	Straight tie beam,Soulaces
85	Meopham	Dene Manor	14C	•	•	•				52°	
86	Meopham	Nurstead Court	14C	•	•	•				55°	Arch braced tie beams
87	Mereworth	Laurel Cottage 87&89 St.	1480	•		•				52°	
88	Mersham	Mersham Manor	1375		•					52°	No TB,scissor brace Ashlar sprockets
89	Minster	Minster Abbey	1400	•	•					48°	Straight TB,as above with tie
90	Molash	Harts Farm House	1490	•	•	•				55°	
91	Newington	Church Farm House	1400	•		•				48&52°	Range & Hall
92	Luddesdown	Luddesdown Court	13C					•		52°	No TB,scissor brace with collar
93	Lydd	13,15&17 New Street	1480	•	•	•				55°	Straight tie beam
94	Lydd	31&53 Manor Road	1480	•				•		55°	No crown post, isled
95	Lynsted	Lynsted Court	14C?	•		•				52°	Scissor brace with crown post
96	Selling	Southenay Cottage	14C	•				•		52°	South Range 48°
97	Selling	Well House	1450	•	•	•				55°	Straight tie beam, tall crown post
98	Sevenoaks	21-25 London Road	1500	•	•	•				52°	Straight tie beam, tall crown post
99	Sheldwich	Copton Manor	1300							55°	Scissor truss Ashlar
100	Sheldwich	Oast Cottage	1500	•	•	•				48°	Crown post and struts
101	Sheldwich	Yew Tree Cottage	1450	•		•				52°	
102	Shepherds Well	West Court	1400	•		•				52°	Tall crown post
103	Smarden	Biddenden Green Fm Hs	1490	•	•	•				52°	Tall crown post
104	Smarden	Fleete House	1450	•	•	•				55°	Straight tie beam
105	Smarden	Romden	1450	•		•				55°	Tall crown post

Figure 20. Tables showing roof types and their pitches

	A	B	C	D	E	F	G	H	I	J	K
1	Location	House name	Date	Tie beam	Sprocket	Crown post	Queen post	High collar	Base cruck	Roof pitch	Comments
107	Smeeth	Evegate Manor	1500	•	•			•		55°	No crown post
108	Southfleet	Court Lodge Farm House	1550	•			•			*	52 up to collar,55 from collar to apex
109											Queen post/purlins
110	Southfleet	Friary Court	1350	•	•	•		•		52°	Braced rafter collar
111	Southfleet	The Limes	1400	•	•	•				60°	Tall crown post
112	Speldhurst	Holly Cottage	1540	•		•				55°	Tall crown post
113	Staple	Gander Court Farm Hse	1540	•	•	•				52°	
114				107	44	73	6	22	2	↓	
115				97.3%	40.0%	66.4%	5.5%	20.0%	1.8%		
116									43	1	0.9%
117									48	23	20.9%
118									52	47	42.7%
119									55	30	27.3%
120									58	3	2.7%
121									60	1	0.9%
122									55-58°	1	0.9%
123									45-50	1	0.9%
124									52-55	2	1.8%
125									48&52	1	0.9%
126										110	
127											
128										0.0%	
129											
130									48	23	20.9%
131									52	47	42.7%
132									55	30	27.3%
133									58+60	4	3.6%
134									Others	6	5.5%

Figure 21. Table showing roof types and their pitches

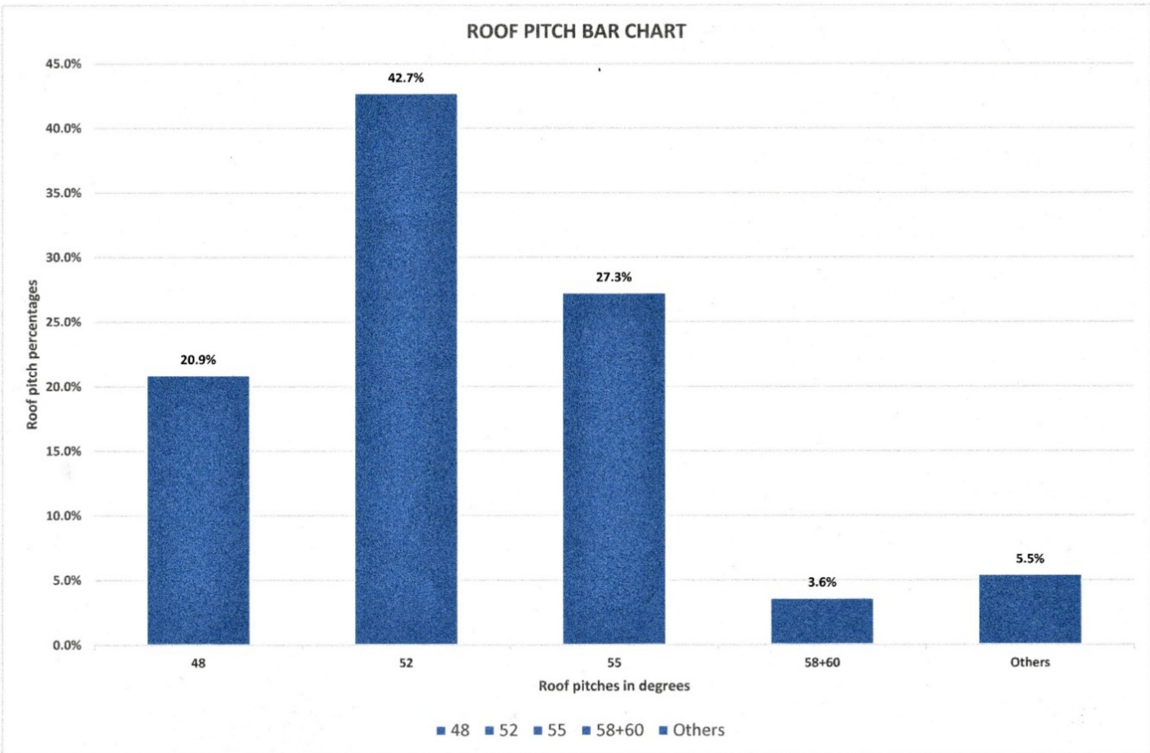

Figure 22. Bar chart showing the percentages vertical, pitch horizontal of the different types of roof pitches in the RCHME Kent Survey. It is interesting to see the majority of roof pitches are 52 and 55°

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