GEOMETRIC OBSERVATIONS REGARDING EARLY IRON AGE LONGHOUSES IN SOUTHWEST NORWAY

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ABSTRACT

This paper presents a geometric model for the analysis of prehistoric longhouse ground plans. It is divided into three parts, starting with a description of the methodology. This will be followed by a presentation of the geometric model using several examples which date to the Early Iron Age. A brief discussion at the end of the article is meant to be read in concert with the first part of the article. The material for the case studies comes from excavations in Rogaland, Norway: Forsandmoen in 1991 and 2007, Myklebust in 2010, Høgevollen in 1991 and Ullandhaug in 1968-69. The author has taken part in the excavation of all buildings apart from Ullandhaug house 1, Høgevollen house II and Forsandmoen house 150.

INTRODUCTION

This article deals with the overall distribution of posts in prehistoric buildings with internal roof support; more specifically in those with structural arrangements composed by two parallel rows of internal posts. These constructions, commonly referred in archaeological literature as three-aisled longhouses, are common in much of the area defined as temperate Continental Europe during the Early Iron Age (EIA). Most of these houses share a common construction feature, a linear succession of transversal post frames called trestles constitute the principal element of the structure.

Some of the aspects of the geometric observations presented here originate from the necessity for a solid and scientifically valid method of identification of posthole patterns in field archaeology. To illustrate these observations, a handful of building remains are to be considered. These examples incorporate different types of constructions dating back to the Early Iron Age in Rogaland, (SW Norway), with special focus on some buildings excavated at Forsandmoen, (Forsand County). By examining the distribution of these specific structural remains, I hope to open new insights regarding the construction techniques that define the main form of these buildings.

Although there is a certain component of architectural understanding and reverse engineering involved in the process, the principle is very simple. Nevertheless, I strongly believe it has further implications regarding the understanding of sub scientific mathematics by EIA house builders. In addition, I believe there is a strong possibility in a future automatization of the process, in order to replicate the results in buildings with the same characteristics, using feature based pattern recognition algorithms through Geographic information system (GIS) software.

POSTHOLE RECOGNITION IN FIELD ARCHAEOLOGY

The identification and discussion of different types of building remains constitutes the starting point in a great deal of studies regarding settlement archaeology. Most of these discussions originate already during the process of excavation. In a mechanical topsoil excavation, large areas are stripped down to the natural subsoil. Within these areas, prehistoric building foundations in the form of posthole arrangements become easily identifiable in contrast to the mineralogical background. In Rogaland, the methods tested within this type of excavation have been implemented over time with the use of new recording techniques, but remain essentially the same as presented in Løken et al. 1996.

Although a posthole is relatively easy to identify in a stripped surface, relating it to other features may be difficult in some instances. These features, often truncated by later farming activity, are often not stratigraphically related to each other (Fig. 1).

Figure 1. Partial overview of the dwelling quarters of a AD 200–575 longhouse, house 1 in Myklebust, Sola municipality. Some of the identified structural features have been marked with blue plates, forming two parallel lines and disposed in consistent pairs. Part of this identification process was done during the first stages of excavation. The house interpretation, based on the initial hypothesis, was later validated by excavation results. Foto AM-UiS 2010.

We tend to rely on spatial observations such as shape, the identification of consistent pair arrangements or clear alignments in order to build up valid interpretations. This process is often based on a mixture of personal experience, *ad hoc* interpretations and a general familiarity as to what to look for. In other words, we often revert to the application of previous knowledge in order to validate and understand our own field observations. A pattern or posthole arrangement previously recorded in a similar site is most likely to be accepted as true, in some occasions without a full understanding of their structural function.

One of the tasks, both during excavation and in post-excavation analysis, is the identification of these buildings and the understanding of their different phases. As archaeologists, we are aware that differences, as well as similarities between different features are crucial in order to establish relationships and, eventually, puzzle-together the history of a building. Documentation of field observations, such as photography, drawings or digital measurements, help us in this task.

Time and financial limitations within rescue archaeology make it necessary to prioritize certain features over others. In some instances, the overwhelming number of features often results in the excavation of a mere fraction of what has been documented on the surface. This will influence the standards to which the excavation is conducted.

In cases where prioritization is necessary, we tend to excavate features that can be phased, that is; features that we understand and that can be related to each other. By proceeding in this manner, it becomes clear that knowledge of similar sites is a great advantage.

Depending on the site, the frequency and the state of preservation of the features defining a building, the assessment process can become rather complicated and difficult to verify. Posthole arrangements related to house foundations can appear in different states of preservation depending on how disturbed the site may be. Often only the deeper foundations survive. This has obvious implications for the legibility and understanding of the building remains (Trebsche 2009: 507).

Earlier attempts of computerized analysis applied to posthole assemblages can be defined as template based pattern recognition. As such, the identification of valid correlations is in relation to previously assumed templates such as straight angles, alignments and circular arrangements. (Litton and Restorick 1983; Fletcher and Lock 1984). Some of these pattern recognition algorithms can be implemented within modern archaeological GIS applications, but their utility is still in need of assessment. In fact, although the use of modern GIS methods of field recording has sped up the documentation process, spatial analysis is often allocated to the post excavation phase. As a result, the advantages of this type of analysis are not part of the onsite decision-making process, resulting in a potential information loss.

Ultimately, an adequate assessment of what is relevant to investigate is regarded as one of the most important stages in field archaeology. This aspect also affects the documentation of the site, often characterized by standard cross sections that offer little contextual information. Some authors have argued for an improvement of excavation techniques, from the common "objective" approach towards a more "interrogative" type of excavation (Millet 2008: 13; Trebsche 2009: 516). Leo Webley, in an extensive study of Iron Age houses in western Denmark, has noticed a decrease in detailed contextual evidence from rescue driven excavations (Webley 2008: 18). Parallels to this situation can be observed in Rogaland, as in many other areas of Norway.

GENERAL TRENDS REGARDING IA BUILDINGS IN ROGALAND, AN ARCHAEOLOGICAL PERSPECTIVE

In Rogaland, the research excavation program at Forsandmoen (1980-1990) resulted in the gradual adaptation of mechanical topsoil stripping as a systematic excavation method for farmed surfaces. This project represented a milestone for the professionalization of this method in Norway (Martens 2010: 243). It also enhanced our understanding of over 2000 years of building construction in Rogaland, through the end of Migration Period (AD 400–550) (Løken 1999b). Although several Late Roman Iron Age (AD 200–400) and Migration period houses had been excavated before Forsandmoen, few settlement remains dating back to Pre-Roman Iron Age (500–1 BC) and Bronze Age (BA) had been found.

The posthole arrangements representing the remains of three-aisled Iron Age longhouses are often the reflection of a very consistent architectural form, which originates in BA and disappears during the medieval period (Løken 1998: 169; Grindkåsa 2007: 15). In addition to the structural foundations, other evidence such as entrances or fireplaces contribute to our understanding of the function of different areas within the building. These remains are further illuminated by the recovery of quantifiable data such as ecofacts, artefacts or as the result of systematic botanic sampling. The analysis and comparison of these datasets often results in valid archaeological interpretations.

Generally speaking, these houses have an elongated, rectangular structure, which often combined a dwelling area and a stall area under the same roof (Webley 2008: 48). Although the main construction technique remains the same for the entire period, the size, function and longevity of these structures changes over time. This chronological development involves a progressive change in building materials, posthole foundation techniques, and use of internal space, resulting in identifiable and comparable remains between different sites. In archaeological literature, we find a wide variety of studies dealing with the identification of these general traits, later summarized in specific building types for a given period. In addition, the evolution in form, size and function of these constructions over time has been widely discussed in many investigations, dominated by a context of social paradigm explanations (Løken 1998: 169; Webley 2008: 68; Herschend 2009).

Towards the end of 500–1 BC, we witness newer types of building sharing the same construction principle. The houses show a consistent length over time, as well as a longer use span. This evolution culminates towards the end of EIA with longstanding, multi-functional buildings, frequently inhabited over several generations. In Rogaland, the remains of these later constructions are characterized by complex archaeological sequences that are difficult to analyze in detail (Myhre 1980; Løken 1992).

BEYOND THE FOUNDATIONS: HOUSE RECONSTRUCTION AND THE ARCHITECTONIC APPROACH

Some early architectonic reconstructions such as the one at Ullandhaug in the early 1970s have been defined by some as too primitive (Fig. 2a). These reconstructions showed the necessity of further archaeological investigation of prehistoric buildings with internal roof support. In spite of a large number of buildings having been excavated before Ullandhaug and the uniqueness of placing the reconstructions directly over the sites of the recently excavated houses, later research showed the limitations of the structural knowledge regarding these houses at the time the reconstructions took place (Fig. 2b) (Myhre 1992: 26; Møllerop 1992: 19; Løken 1992).

Modern reconstructions of archaeologically inspired wooden buildings, initiated in the 1980s, provided a different perspective from which to view the archaeological data (Komber 1987; Näsman 1987). The approach required a compromise between a framework dictated by the archaeological and the architectonic data, and the physical limitations of the material. This interchange of ideas had a positive effect on archaeological theory, as it necessarily involved an interpretative approach (Herschend 1987; Schelderup 2008: 43).

Much of the architectonic focus has used, as its primary data, ground plans from excavated buildings. Statistical analysis of large datasets (Herschend 1980; Hvass 1985; Løken 1994) helped to identify general characteristics that would constitute the groundwork towards more accurate reconstructions.

The work of J. Komber provides an insight into the advantages of multi-disciplinary studies, resulting in a variety of well-grounded conclusions, and subsequent new knowledge production. Komber, and later other authors such as Carter, are aware of the importance of the position of the roof bearing

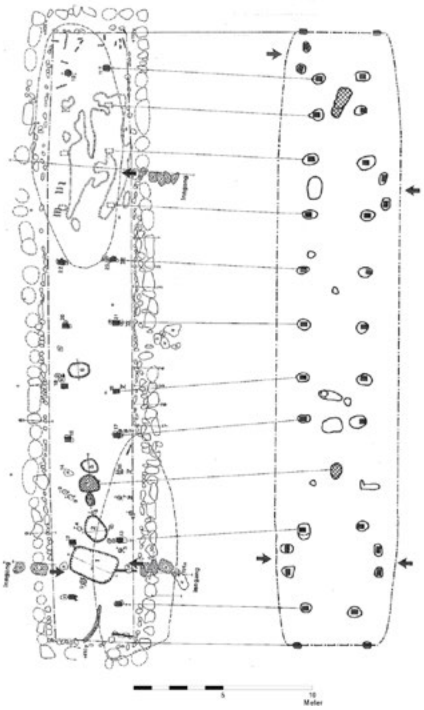

Figure 2a. Left: Ullandhaug reconstruction in Stavanger. Foto AM **Figure 2b. Right:** Comparison between House 1 in Ullandhaug and House169 at Forsandmoen (after Løken 1992).

posts in the building's ground plan and the trestle as a cohesive unit (Komber 1989; Carter 2008). These authors also pay attention to the different imposed loads and the requirement of a coherent structure in order to obtain the necessary stability. Komber`s valuable work regarding the structural performance of a trestle frame inferred from archaeological material has been very useful for modern day reconstructions of prehistoric buildings in Scandinavia.

His calculations regarding the implications of the trestle quotient, roofing materials and the foundation problems within prehistoric building technology have been utilized in a variety of posterior reconstructions and analysis (Schjelderup 2008). However, their use has been limited in archaeological field literature, partly because it does not have much effect on the process of excavation and many of his conclusions concentrate on the three-dimensional nature of archaeological reconstructions.

In general terms, EIA buildings are characterized by the use of an internal roof support construction technique based on post frames resulting in three-aisled constructions. It is generally accepted, through analogy with modern post frame constructions and experimental reconstruction work, what the structural elements of these houses would have looked like. In these constructions, roof bearing posts are placed in two clearly defined rows of paired foundation holes along the longitudinal axis of the house. Since the foundations are often shallow, the posts were stabilized by different means, both within the foundation and above the ground. Above the ground, each pair of posts was usually connected by a transversal tie beam, forming a trestle. Although the trestle constitutes the primary cohesive unit for the majority of these buildings, there are a few examples on which a purlin may have constituted the primary connection between the roof bearing posts. This type of roof must have been a gable roof with two equal sides. An internal framework formed by a cohesive construction of different wood elements supported the roof. Adjacent trestles were connected by two inner purlins running above the roof bearing posts, forming primary modules. The successive combination of these modules resulted in a continuous rectangular platform above the central aisle. Over this platform, the primary roof structure would rest. On some occasions, a ridge beam, supported by kingposts, would have run above the center of each trestle. This ridge represents the highest point of the roof and constitutes a straight line through the main longitudinal axis of the house. On either side of the ridge, a series of rafters would have connected the highest point of the roof with the walls, resting over the inner purlins connecting the trestles. On top of these rafters, battens covered by straw or turf would have comprised the roof.

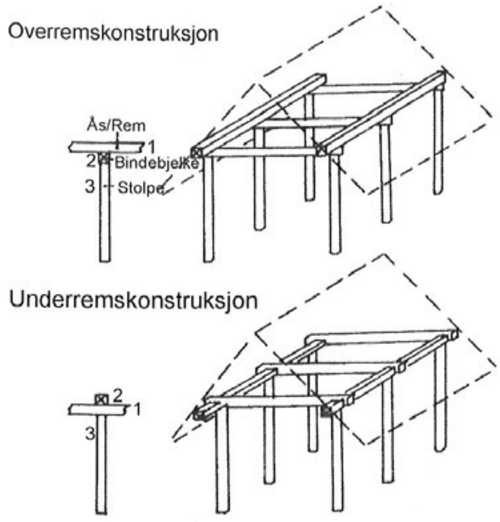

Figure 3. Two examples of three-aisled roof bearing systems, the trestle frame system (above) and inner purlins (below). This latter system does not necessarily need a pair correlation of the roof bearing posts in the plan and it is not further treated in this article. (after Näsman 1983, please notice that the original illustration has been clipped)

The structural principle that defines this construction creates an internal roof support system which functions satisfactorily. The vertical loads are successfully transferred from the point where they arise to the underground beneath the roof bearing posts, resulting in stable constructions capable of bearing their own weight and any loads imposed on them (Rosberg 2013: 5). The design of a structure capable of fulfilling this function is essential in architecture. It is the result of an understanding of the loading problems faced by a building of these characteristics (Macdonald 1994: 9).

This architectural design creates a continuous free space, divided in three aisles, with a modular character for the areas between the trestles. Following its linear principle, the space is dynamic, allowing re-arrangements and future extensions in length if necessary. These modifications can be conducted without major changes in the building, predominantly because of the modularity of the trestle frames. In addition, the areas between the trestles can be shortened or enlarged depending of the need, creating or dividing the inner rooms between the trestles and allowing the multi-functional use of the space within these buildings (Webley 2008: 48-70; Herschend 2009: 236).

Although the previously mentioned elements help to explain the vertical and static load transmission, there are certain difficulties explaining the horizontal, dynamic load resistance of the building through the archaeological material. In Komber`s work, the overall horizontal distribution of the trestles and the subsequent need of equilibrium within a structural system have not received the same degree of attention. This is partially because, structurally speaking, there is a greater amount of strain in the postholes along the transverse axis of the house (Komber 1987: 56). In addition, few complete house plans with structural arrangements of posts had been published in Norway at the time his study took place (1989).

In the case of substantially long buildings, we must take into consideration a significant economic and social investment. During its construction, and even at a previous stage, a large amount of construction materials had to be gathered, transported and transformed, and the necessary manpower coordinated. The material inferred from different archaeological datasets shows some regional patterns (Løken 1999b; Herschend 2009). In addition, the consistent occurrence of different building types in different periods and regions show that there is a common idea of what these constructions should look like. This ideal layout may be encouraged by the fact that house building is a social activity with many actors involved. Webley has recently highlighted the implications of collective work affecting house type standardization (Webley 2008: 68). As many authors who deal with the tangible materiality inferred from the archaeological observations, I am interested in an ideal model, based on the same original material from a structural perspective.

THE GEOMETRIC MODEL

I believe that it was at the beginning of the construction process when a preliminary layout of the how and where of the building took place. During this process, a form of mathematical knowledge must have been used.

The regularity in the ground plans inferred from the archaeological remains gives reason to assume that a certain form of geometry must have been applied. Geometry, as a technique of spatial organization, enables the necessary calculations for planning, coordination and material transformation involved in the construction process. This process is still visible, to a certain extent, in the ground plan and by analyzing the location of the visible elements.

Earlier studies have considered the placement of these and other elements within a house plan as a way of obtaining information regarding the use of specific measurement units (Herschend 1987; 1991; Løken 1999a) and indirectly linking the construction techniques of the analyzed material with the classic Mediterranean world. Along the same lines, authors such as Meyer-Christian have recently shown clear indications related to the use of Pythagorean mathematics within the layout planning of the EIA longhouses in Federsen Wierde, northern Germany. The results of his analysis show proportional distances within the placement of the structural elements, as well as the use of Pythagorean triangles to obtain straight angles. His work is a good demonstration of the existence of a previous set of calculations for determining the best possible placement for each posthole (Meyer-Christian 2008).

Similar, symmetric arrangements are common in many longhouse plans. Regardless of the width of the trestles, the main axial line runs along the center of the main aisle and coincides with the peak of the roof. On either side of this line, both the roof bearing postholes and, in certain occasions, some of the wall postholes are placed in pairs, apparently mirroring each other. The length of this line is what we normally regard as the house length.

The axial line within this type of constructions deserves detailed attention. It has often been regarded as a way to determine the relative location of the fireplaces and other structures such as the roof bearing posts. However, this line may perhaps be more important than we have previously thought. In the following examples, I will try to demonstrate that those who built these houses were very preoccupied

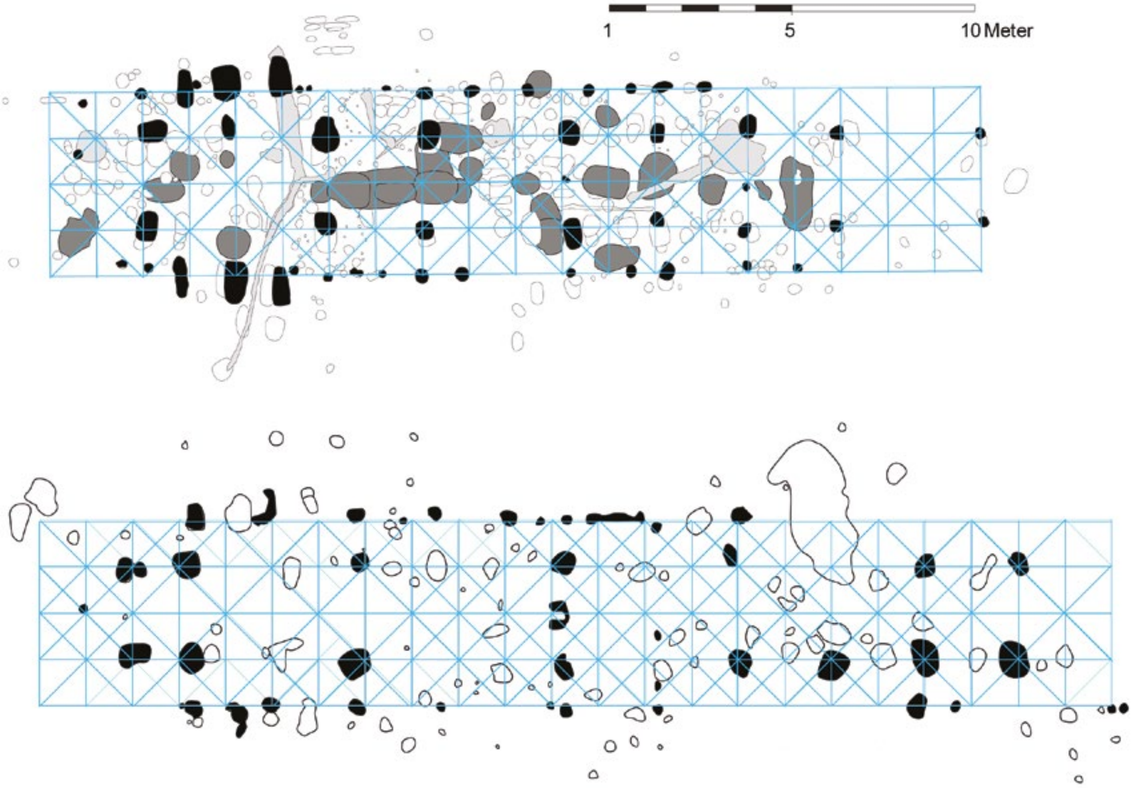

Figure 4. Two buildings from MP in Rogaland. House 1 from Myklebust in Sola County (above) and *Høgevollen in Egersund* (below). Notice the regular pattern of posts highlighted by an overlaid grid (blue).

with arranging the structural elements of the house in relation to this line.

An important aspect of geometry in architecture is symmetry. A construction that allows a division in two equal parts is defined in structural design as bilaterally symmetric, and represents one of the most common ground plan forms in architecture (Williams 1999). In a bilateral symmetrical arrangement, the relation between a structural element and its counterpart must be the same in relation to the main axial line.

Since the foundations are not deep enough to take lateral thrusts, the stability of the building is dependent on other factors. A systematic placement of the posts would have resulted in a much more stable structure, with a subsequent arrangement of the different components in a very regular manner. In other words, the posts would have been arranged in a perfect square. This method would have resulted on ground plans such as the ones in Federsen Wierde, that can be analyzed by overlaying a grid and establishing secure relations between the foundations (Fig. 4). In fact, there is a general tendency towards regularity in most ground plans, especially in AD 200–550 buildings. However, it is common to notice a few postholes that appear slightly misplaced.

In a building where a considerable number of posthole foundations need to be dug, turning an

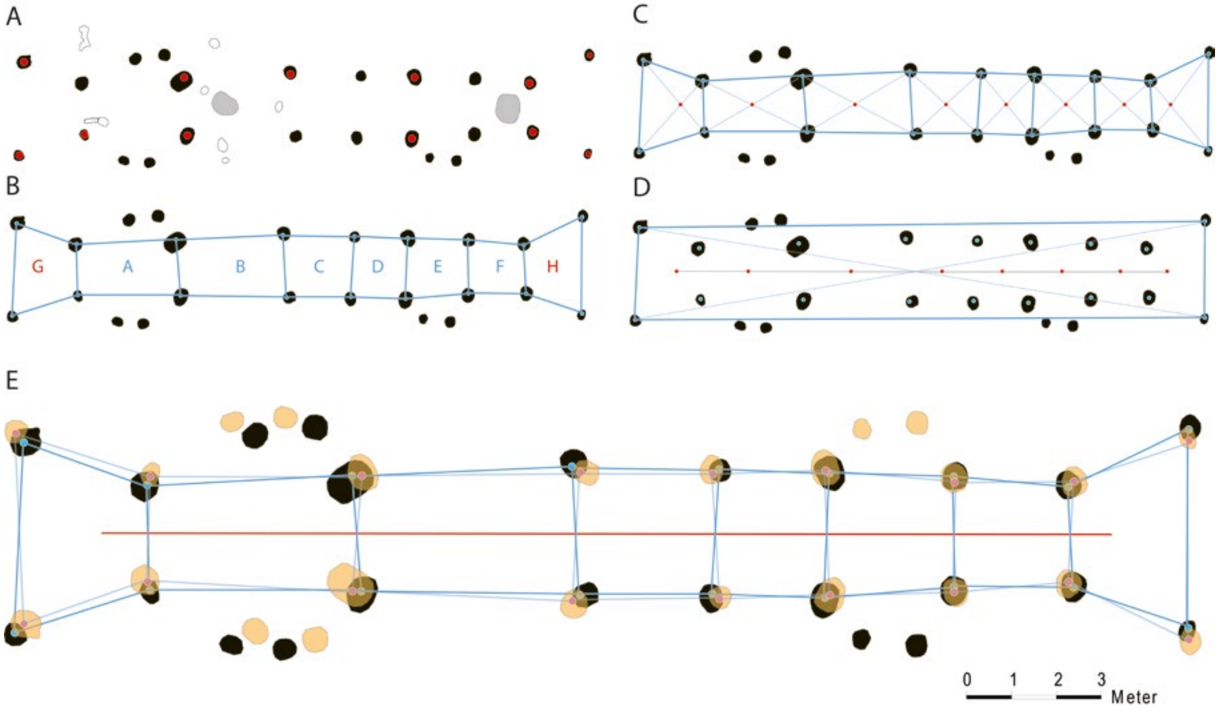

Figure 5. Geometric principle exemplified in house 248 from Forsandmoen. See text for a detailed explanation.

idealized post layout into reality is difficult. The main problem resides in the nature of a posthole itself. In Rogaland, it is common to come across a glacier moraine sub-soil layer, characterized in many occasions by the presence of large boulders. This may, for example, prevent a more regular posthole distribution. Thus, we do not expect these posthole arrangements to be perfectly symmetric, that is, bilaterally symmetric.

Some authors, when working with wooden constructions, have considered these misalignments to be within an acceptable tolerance level (Jensenius 2010: 158). On other occasions, some of the stability problems caused by irregular or shallow foundations could have been corrected by the use of reinforcements above the ground (Komber 1987: 56). These assumptions are difficult to prove through the archaeological data.

But the arrangement is, in fact, much more precise than we think, a point I will illustrate using a series of buildings from different periods at Forsandmoen. The building numbers presented here coincide with those given to the houses during the excavation.

House 248 from Forsandmoen (Fig. 5) was excavated in 2007 and represents a typical example of a main longhouse from AD 200–550 (Dahl 2009). The house consists of seven pairs of roof bearing posts and three entrances. The ground plan shows no indication of the walls, which is typical for buildings within truncated sequences. On the other hand, two pairs of corner posts on both ends of the building provide clear indications of its dimensions.

Many of the foundations bear traces of the original post location, marked as a red circle (Fig. 5a). Taking into consideration the original placement of the posts when possible, adjacent posts are connected by lines (blue) creating eight polygons (A-H). These polygons represent eight linear modules along the longitudinal axis of the house forming the basic roof bearing structure (A-H, Fig. 5b). Notice that these modules are apparently not completely regular.

By tracing diagonal lines between the opposite corners of these polygons, we will obtain a point representing its center. (red dots, Fig. 5c). These points are perfectly arranged in a line. In addition, the point formed by the diagonals between opposite corner posts also falls on this line. (Fig. 5d). In a bilateral symmetric arrangement, paired elements should be equidistant from the mid-axis. This fact can be seen exemplified by reflecting the ground plan around the symmetric axis we have established. Figure 5e illustrates this by overlaying both plans, the original (black) and its reflection (transparent yellow). The impression of bilateral symmetry is manifest.

This simple visual analysis shows that the placement of the posts, although not regular, fulfill the requirements of structural equilibrium exemplified by bilateral symmetry. I believe that this was the solution of the Iron Age house builders for accommodating the structural layout required by such a building regardless the position of the postholes (Fig. 6).

In order to illustrate these results in a more general perspective, I will apply this principle to other buildings from the same site. The following example (Fig. 7) encompasses nine construction sequences from the same period as house 248, excavated in 2007. The results must be considered in the light of

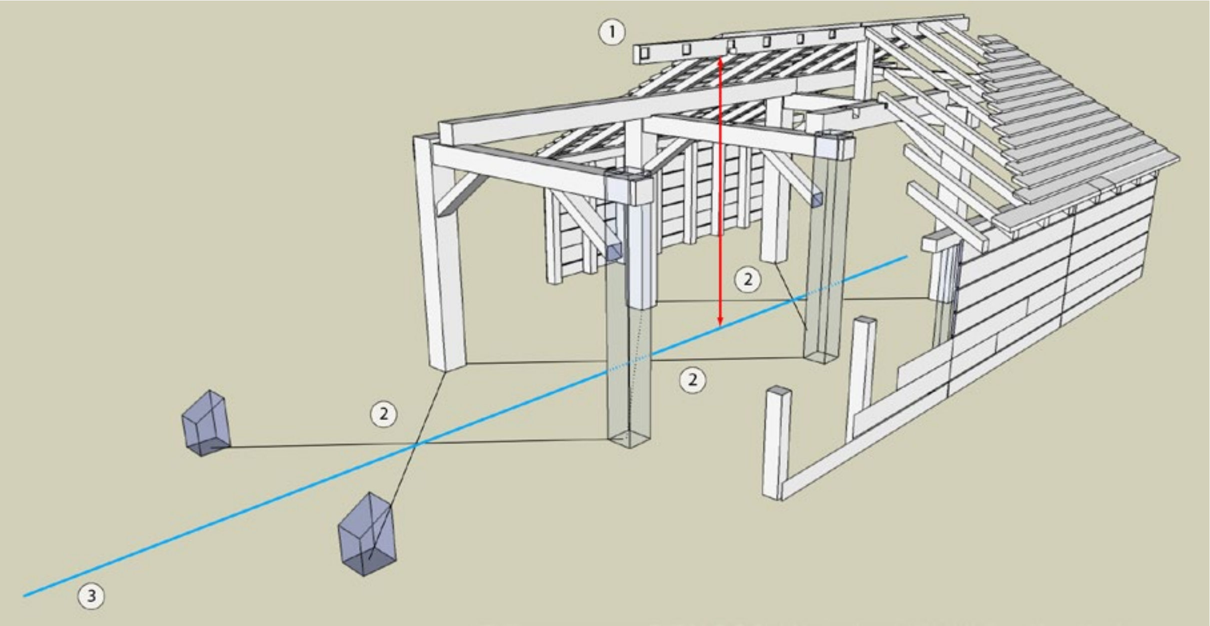

Figure 6. Three dimensional representation of the geometric principle. The main axis line (3) coincides with the uppermost part of the roof (1). The roof supporting pairs are located in diagonal relation to this line (2).

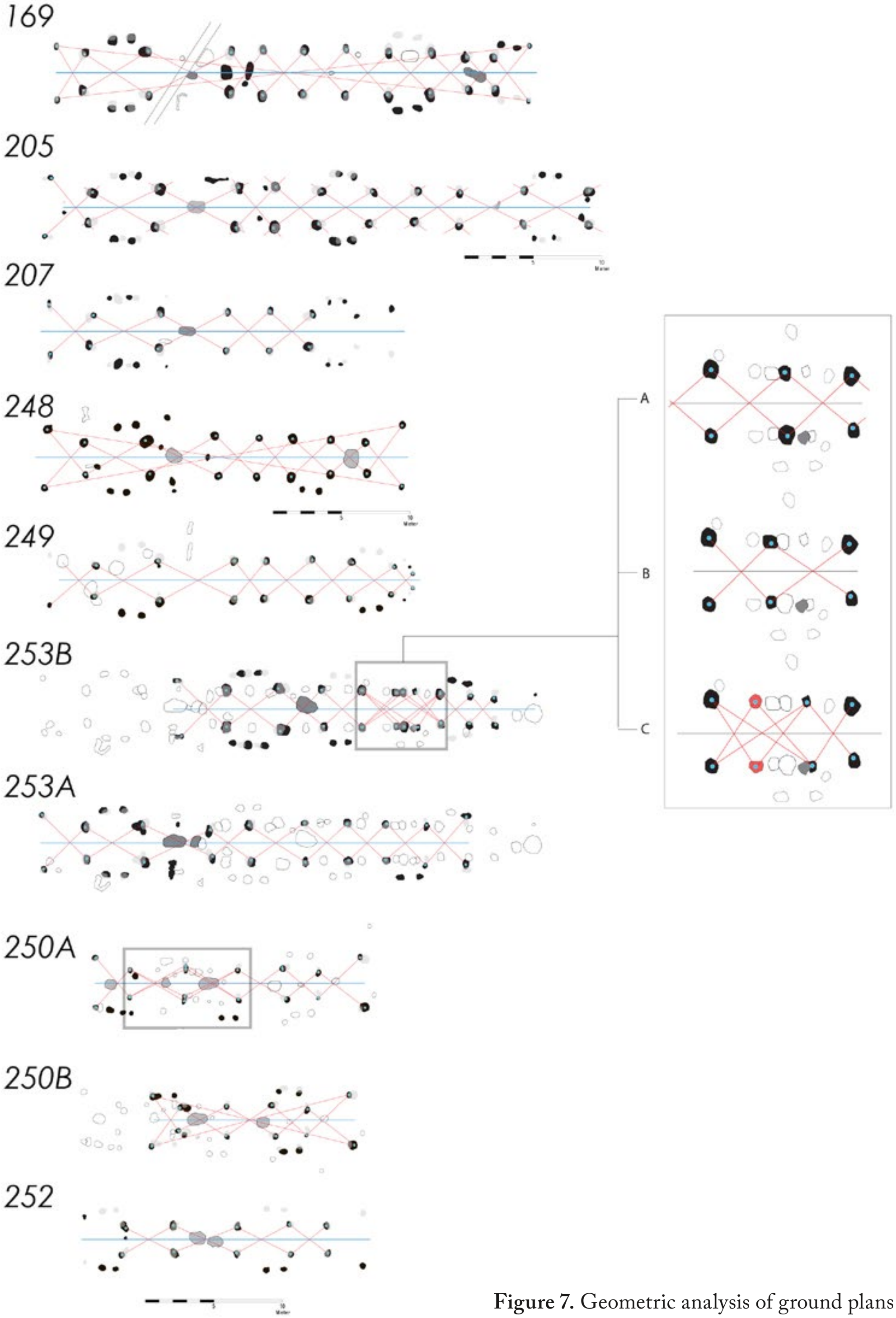

Figure 7. Geometric analysis of ground plans from RA-MP buildings dug in 2007 at Forsandmoen discussed in the text.

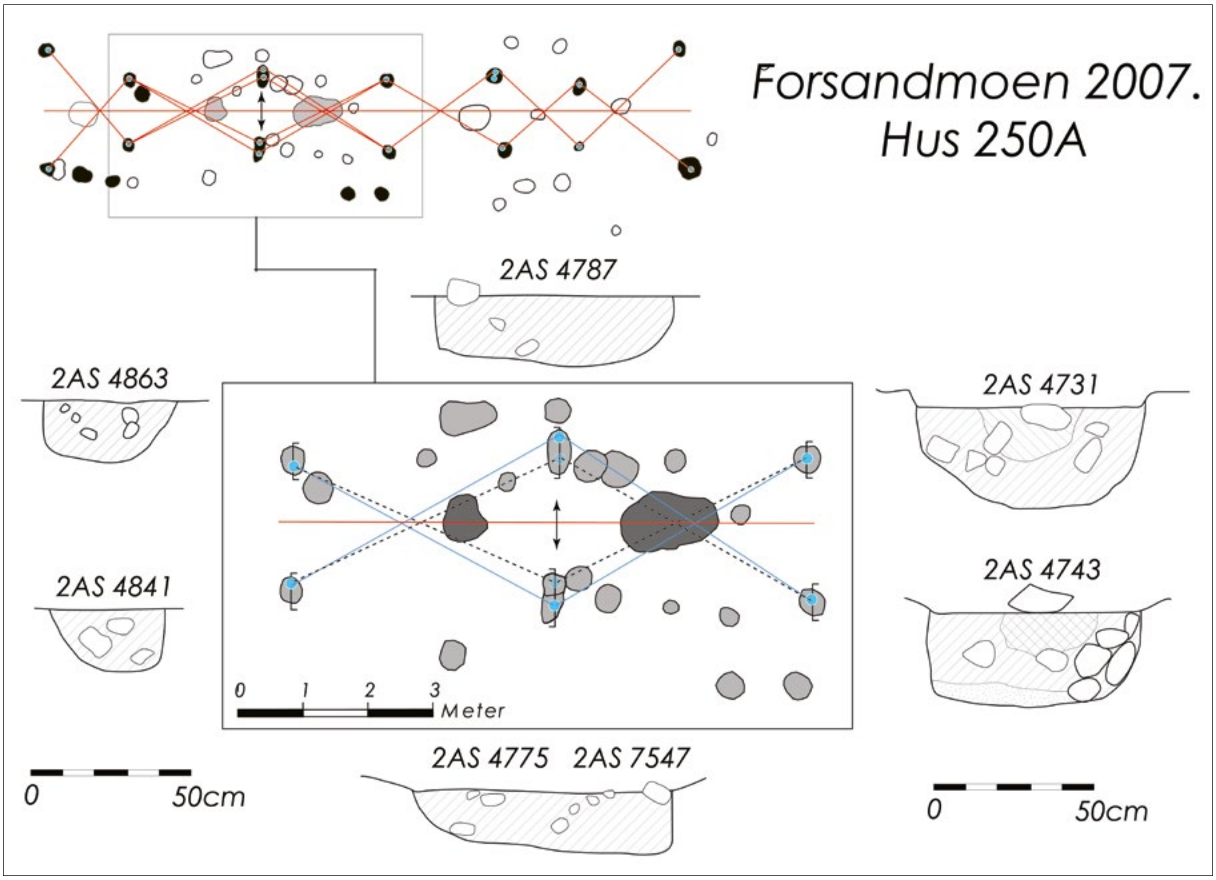

Figure 8. Analysis of house 250A at Forsandmoen discussed in the text.

the limited size of the dataset and the fact that all the buildings are from the same site. Most of the houses represent one phase with the exception of 253 and 250, which consist of two sequences each in addition to several structural adjustments. The analysis has special relevance for these multi-phased buildings since it offers a visual understanding of the phase divisions which is both logical and easily defendable. The phasing of the repair sequences in buildings 250A and 253B may also be described through this visual principle.

The analysis shows that an axis of symmetry is present in all of the buildings. This result is especially interesting in sequences with a large number of roof bearing posts, and thus a large number of diagonal crossings and longer axis lines, such as houses 169, 205 and 253A. The adherence to a longer axis of symmetry should have been more difficult in such buildings since it involves a large number of perfectly aligned points. This indicate that those results consistent with the model are not accidental.

In the case of house 249, the diagonal combination between three known posts helps to pinpoint the location of a missing corner post (on the far left end of the house in Fig. 7). In this case, there is a possibility that the missing post had been destroyed by a later cooking pit structure. This example shows how such visual analysis could help in the location of missing or otherwise unrecorded structures.

The ground plan of three of the analyzed houses show corner pairs in both ends, (houses 250A-B and 253A). Only in one of these (250B) can we produce the same results as in house 248. In the other two, the point at which the diagonals between the end pairs cross falls off of the inferred axis of symmetry (not illustrated). This preliminary result may indicate that the placement of the corner post pairs in these houses is not dependent on bilateral symmetry. A symmetry analysis of multi-phased buildings can help in defining of which postholes paired with each other (Fig. 8). In addition, it could assist in the subdivision of the structural adjustment sequence. House 250A-B constitutes an example of a repair that has maintained the same symmetric axis, probably as the result of a structural rearrangement of a still standing building with a complete roof structure. The resulting ground plan (250A) is the consequence of an extension of an original building (250B) involving the shifting of a roof bearing pair.

The ground plan for houses 253A-B (Fig. 7, Fig. 9a-c) shows a complete reconstruction process that has retained the same symmetric axis. Over a first, considerably shorter building, a second, larger structure was raised. The ground plan shows that the original house was probably dismantled during the construction of the second building and that, most likely, the structural elements from the first phase were utilized for the second.

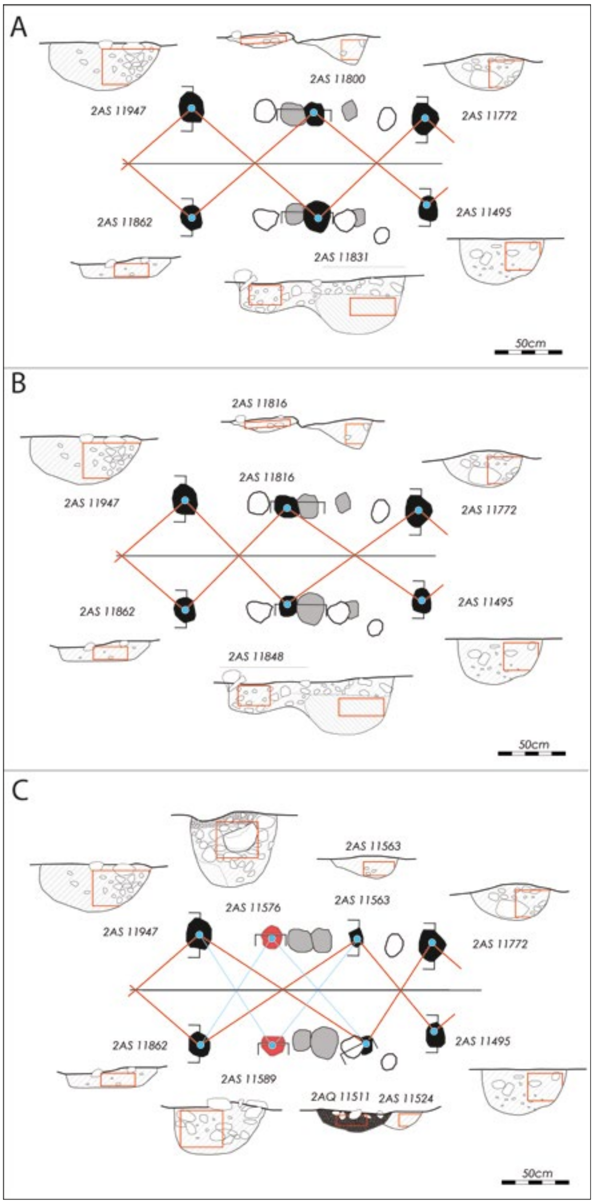

Figure 9. Analysis of house 253 from Forsandmoen, discussed in the text. See also figure 7 for a complete overview of the overlapping building plans.

In addition, the first building, 253B shows a repair sequence prior to the second phase. A closer look comparing the posthole cross sections shows further details within this sequence. Figure 9a shows the original placement of the trestle foundations, regularly placed at equal distances. Due to a first modification, the central pair has been shifted, as the cross section of postholes 11848/11831 clearly illustrates (Fig. 9b). Notice that the placement of the new pair is still consequent with the axis line.

At a later stage, the same area has undergone a new repair in which possibly two extra pairs have been included (Fig. 9c). In the last repair sequence, the geometric analysis provides two possible structural combinations, both arrangements could have functioned satisfactorily. In addition, there is reason to believe that the two new trestles could have remained when the new house (253A) phase was constructed. Although the later sequence offers multiple interpretations, the overall repair sequence appears clear and maintains a certain structural logic. This example shows how this visual analysis can provide useful information when attempting to clarify the construction sequences in buildings with multiple phases and repairs. In the case of building 253A-B there is a strong indication that the later phase (253A) constitutes an enlargement of the building.

The potential of this type of geometric analysis as an aid for defining the different construction sequences is exemplified in the dwelling area of house I from Myklebust, Sola (Fig. 10). This building, excavated in 2010, also dates from AD 200–550 and is comprised of two main phases with several structural adjustments each (Dahl 2014). The type of complex archaeological sequence represented by this building is quite common for many large farm buildings from this period in Rogaland, where the central building has been standing in the same place for over 250 years, in some examples even longer. In addition, it was considered a possibility that this house may have been surrounded by an outer, protective stone wall. This structure would have been removed later as a result of modern farming, without leaving any traces.

The number of possible combinations for house I at Myklebust would have been difficult to analyze in detail without digital visualization tools. Usually, these buildings are regarded as multi-phased, and a detailed analysis of their elements and phases is often not completed under the limitations of present day rescue archaeology.

In this case, the different diagonal combinations clarify both which posts are more likely to form a pair and which pairs could have belonged together, defining two main construction phases and a large number of repairs. Both construction phases share the same axis line, which indicates that they are likely not the result of a complete dismantlement of the house structure, although this coincidence could be a result of the limitations set by the previously mentioned outer stonewall.

The scope of this article does not allow for a detailed discussion of the different phases and structural adjustments of the house. This case is merely intended to illustrate possibilities when dealing with complex sequences.

We have seen many examples related to later periods within EIA. The buildings within this period are characterized as more regular than the buildings from earlier periods. On the other hand, the placement of wall posts is not regular and in many instances they are not present at all. This has been considered a general characteristic these buildings and has been seen as an indication of the introduction of wall paneling (Løken 1998). In 500 BC–AD 200 the buildings are characterized by a regular amount of wallposts, providing a series of examples suitable for a further analysis, such as house 150 from Forsandmoen (Fig. 11 a-c).

House 150 from Forsandmoen, excavated in 1991, constitutes the main building of an opulent farm from AD 1–200 (Løken 1994: 337-341). A closer look to the ground plan indicates that this building is closely related to what has been later defined as the Central Scandinavian house type (Herschend 2009: 14). In addition, the wide trestle in the middle room and other characteristics within the building have been seen as evidence of a hall room within the building, enhancing the prominent nature of

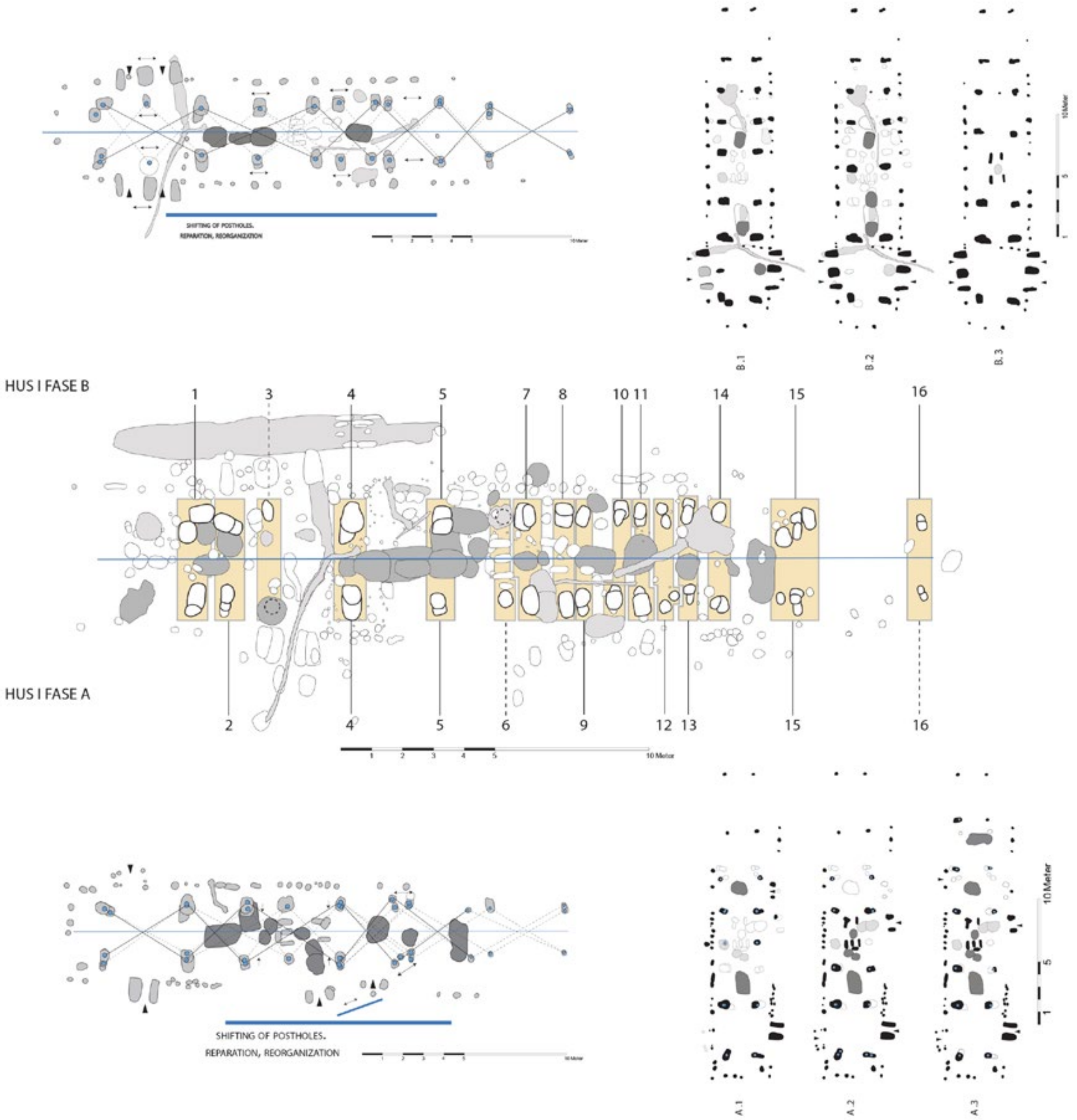

Figure 10. Different phases and options within each phase for house 1 at Myklebust.

the structure (Løken 2001: 68). The building plan does not show clear indications of several phases, possibly indicating that this building has not had the long lifespan that characterizes house I from Myklebust. In fact there are some slight indications that the building may have burned down (Løken 1994: 339). House 150 may constitute a building occupied by the upper spheres of Forsandmoen`s society sometime around the first century AD.

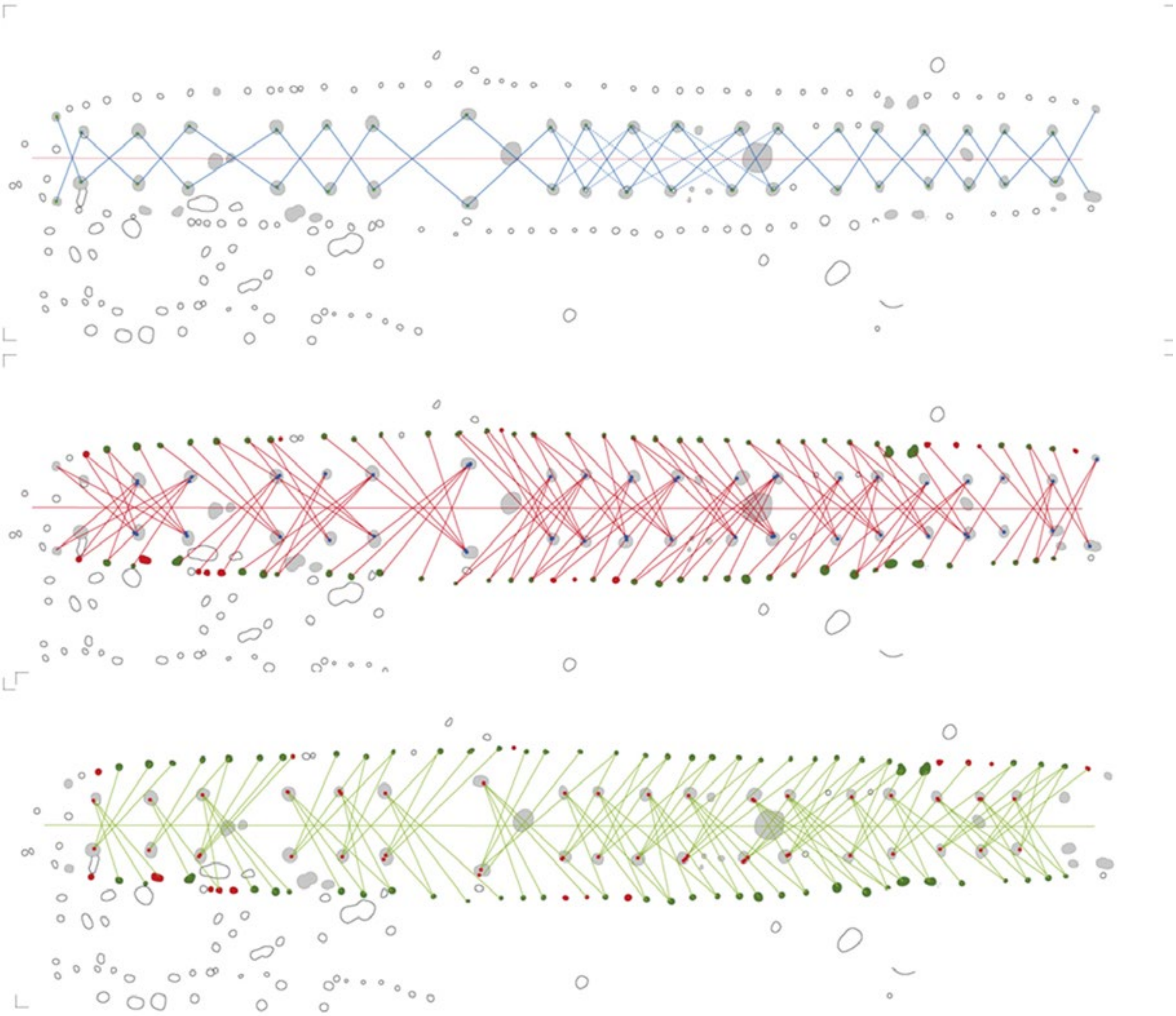

Figure 11. House 150, Forsandmoen. Fig 11a (above) the geometric principle applied to the roof bearing elements and the walls Fig b-c (middle and below).

A closer look at the placement of the roof bearing posts (Fig 11b-c) shows that these are consistent with the previously described geometric principles. The closely placed trestles in the middle section of the building, interpreted as part of a stall and a storage room could be the result of a repair. When it comes to the wall postholes in relation to the main axis, we can deduce that most of these were carefully placed in relation to this line. The result of the analysis shows that most of the wall posts, as well as the roof bearing posts, have a distinct placement that creates a clearly equilibrated and structurally robust construction. This pattern is not the result of pure chance, but a rare example of early architectural planning where a very distinct and complex form of geometry has been applied. The implications of these types of results are that use of geometric principles precede AD 200–550houses and are possibly a common characteristic of three-aisled longhouse architecture. Examples of this type should help us understand the complex planning processes involved in the construction of these houses.

CONCLUSION

The different examples presented in this paper point towards the existence of a clearly defined pattern in the distribution of the roof bearing postholes in Iron Age houses. I believe this organization is related to the necessity of an equilibrated distribution of the structural elements as a prerequisite for a successful construction. A geometric analysis of the archaeological remains presented here illustrates a carefully worked-out strategy for achieving this, repeating over several centuries and in different types of buildings. The approach presented here could be defined as a type of reverse engineering (RE), resulting in a new understanding of these constructions. The purpose of this exercise has been to examine the "repetitivity" of collective action and the degree of regularity of the material consequences of such activities (Barcelo 2009: 179). In this context RE is understood as the process of discovering the technological principles of a building through the analysis of its structure (Nazidizaji et al. 2013: 515).

Some of these ideas have a clear and specific application within field archaeology while others may have a more general value. The primary goal was to contribute to the process of posthole pattern recognition by establishing a feature based systematic approach, using architectural necessity rather than the previous templates. The examples here presented deal with this aspect and a replication of this model may contribute to a better praxis, especially when combined with more deductive ways of excavation (Trebsche 2009). The geometric configurations here presented, as graphic representations of a reproducible mathematical pattern, could be automated within a GIS program. Other authors, within the fields of both architecture (Nazidizaji et al. 2013: 514) and archaeology (Barcelo et al. 2011: 53), have highlighted the advantages of different forms of the computational study of geometry. Field interpretations and decision making within large sites would benefit by applications grounded in these observations.

Although not within the scope of this article, there are other implications of a more general significance regarding Iron Age architecture. The inference of geometric patterns within the analyzed buildings constitutes an example of the practical application of sub-scientific mathematics in their construction (Høyrup, 1989: 66). This type of knowledge, understood as acquired and transmitted in view of its applicability, is witness of a specialized type of work with distinct ways of proceeding. A type work from which, until now, we grasp only a little more than its large scale; houses had been planned and constructed.

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