Chapter 15

Structural Strategies for Pithouses on the Keatley Creek Site

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Introduction

Of the multitude of housepits located at the Keatley Creek Site, a number have been subject to extensive examination. These include two housepits in the very small size range (HP 9 and HP 90), one in the small range (HP 12), a medium sized housepit (HP 3) and a large sized housepit (HP 7). These "study housepits" have been excavated so as to determine floor depths, wall slopes, rim heights and posthole locations as well as to investigate many non-structural concerns. With the information that was discovered, it appeared possible to start to piece together potential structural strategies employed by the builders of these ancient structures. The purpose of this article is to propose reasonable types of roof and support architecture that would have covered the pithouses at Keatley Creek based on architectural principles, ethnographic observations, and archaeological evidence. Reconstructing the basic structural designs of housepits of varying size was viewed as an important element in interpreting activity patterns within houses. Entrance locations, posts, and headroom considerations were particular factors that might affect the patterning of activities within the houses. As will become evident, there appear to have been a surprisingly diverse set of pithouse structures at Keatley Creek.

To begin to develop these proposed strategies, historical documentation was consulted to examine methods of pithouse construction described elsewhere in the British Columbia Interior. Most of this documentation was relatively limited in terms of the descriptions of physical structures. An example in the Thompson area though, has been elaborately described including drawings and photographs (Teit 1900:192–194), and has become the model generally used for depicting the typical pithouse. This typical model, however, does not respond to regional variations in climate, topography, materials, or to the local variations in household size, wealth, or permanency. In addition to these constraints, issues of convention should be considered. Techniques in response to physical concerns could become ethnic identifiers defining a particular group of people. The various uses of specific structures such as ritual houses would likely have physical manifestations as well. Social classes of dwellings may be indicated by size. Work or storage structures may be less carefully constructed. Some pithouses may be designed for occasional or temporary use as with women's seclusion houses.

Teit himself alludes to variations from the "typical" pithouse in his observations of the Interior Salish pithouse construction:

> In winter it was pitched over a few inches to a foot and a half in depth, and the excavated earth banked up around the base. Dry grass, dry pine needles, or pieces of bark were placed around the bottom of the mats to prevent decay. Double and treble layers of mats were used in wintertime. These lodges vary in diameter from about 5 to upward of 10 meters. It seems that the foundation was always made of three poles. (Teit 1904:58)

While the typical soil cover has been used on this structure, it is limited to the base only with mats acting as the main roofing component. Teit describes another variation of roofing in the Lillooet area where "mats were sometimes used . . . although old skins were perhaps more common" (Teit 1906:776).

A number of pithouse sizes and shapes have been documented from conical to flat and from round to square. In the Thompson area Teit also describes a smaller lodge:

> In building circular lodges, . . . a dozen or more long poles were placed some distance apart, with their butts upon the ground, outside the cleared space, forming a complete circle from 15 to 20 feet in diameter. The poles were placed with their small ends toward the center of the space, where they met and supported one another without being fastened together. (Teit 1900:196)

At a site near Squamish, Barnett records a deep, square, flat-roofed pithouse:

> A supporting post reaching to ground height was placed in the center of the excavation and two timbers traversing the excavation rested on top of this post at right angles. Planks were then radiated from this central point to the periphery of the excavation. Poles, mats, and finally earth were placed on top. The entrance hole was either at the center of the ceiling or at one corner, and the descent was made by means of a notched log ladder. The dimensions of the pit were fifteen feet by fifteen feet, by ten feet deep. (Barnett 1955:55)

At a site on Toba Creek (about 70 km northeast of Powell River), Barnett describes another flat-roofed and rectangular structure with a main entrance and escape tunnel:

> Describing the situation as it existed in the days of his great-great-grandfather, a Klahuse informant asserted in 1936 that the winter houses of his people at the head of Toba Inlet were all underground. The Village was about ten miles up the Toba River, and the informant claimed to have seen the remains of the pits. Originally, they were about ten feet deep, and rectangular, with a pole lying on the midline across the excavation. Two or three posts supported this member, which in turn supported cross pieces reaching it from two sides of the pit. Poles, brush, and bark were added for the roof and the whole was covered with earth. There was no top entrance; a gangway sloped down to the main level for entry, and for flight in case of attack a tunnel led out the back way. (Barnett 1944:266)

An example by Teit (1906:236) of Lillooet winter village pithouses that "were sometimes equipped with underground escape tunnels leading from the pit houses to the bank of a stream or nearby gulch," begins to suggest alternate entries. He further documents a case where the side entrance replaces the typical top access.

> It seems that they [Columbia Salish pithouses] were constructed in the same way as among the Thompson, only a majority had the entrance on one side . . . Ascent and descent were by a short ladder or notched log. A few had entrance only through the smoke-hole, and a long ladder like the common kind among the Thompson. (Teit 1908:114)

Another area of potential variation is in the use of support posts. Some structures appear to have made little or no use of interior supports. Others seemed to employ many, either angled or vertical in orientation. Other than in the rim locations, there was no evidence of angled posts on any of the study housepits at Keatley Creek. Some structures seemed to be without posts. Hayden and Spafford (1993:119) address this issue in their study of the small housepits:

> . . . all such structures excavated to date appear to be characterized by a scarcity or absolute lack of interior structural postholes. This seems to indicate that any interior posts were simply set on the surface of the floor (which seems unlikely given the risk of knocking such posts out of position), or that all structural posts were set on the rim of the pithouses. . . . This is a considerably different type of architecture than Teit (1900) illustrates as being the typical pithouse.

An informant for Duff (1952:47) describing the Stalo Indian pithouses in the Fraser Valley "denied the existence of any posts in the floor other than the ladder . . . [but instead used a system] in which four rafter-struts holding up the main rafters were against the wall of the pit." An example of a pithouse with a single central support post has been included in a publication of archaeology in Washington State (Kirk and Daugherty 1978:69) and seems to have been employed at the Bear River Site in Utah (Shields and Dalley 1968:62). The potential for variation in structure due to its size for pithouses in the Chilcotin Plateau has been described by an informant:

> There were either four or six center-posts, fourteen to sixteen feet tall, which formed the corners of a square or hexagonal opening three to five feet in diameter. The rafters, poles peeled to prevent rotting, radiated from plates on top of the center-posts. If the house was small, or had six center-posts, the rafters rested over the posts. . . . If the house were large, with four center-posts, as many rafters as were needed were used and they did not necessarily rest over the center-posts. (Lane 1953:157)

Roof slopes were another source of variation. It would seem likely that in desert conditions rain penetration or excessive snow loads would not have been a problem and the roof slopes could have been more shallow. Cultural preferences and the use of the roof top for entry may also have played a part in determining roof angles. Kennedy and Bouchard (1978:36) cite an account of a pithouse roof slope that varies from that described by Teit (1900:192–194):

> Present-day Fraser River Lillooet informants' statements concerning construction of the superstructure appear to be in agreement with the Thompson pit house construction so thoroughly described and illustrated by Teit (1900:192–194, Figs. 135, 136). However, it is believed that the pitch of the roof was not as severe as illustrated by Teit and that the distance between the floor and the entranceway of the Lillooet pit house was approximately 2.5 m.

Given these various accounts, it seems reasonable to suggest that many different styles of pithouses were employed, and that these varieties could even occur within the same settlement. Each variant would be subject of course to certain physical limits inherent in its structural type. By analyzing a small number of basic structural options and their roof slope possibilities, the appropriateness of certain schemes for the different study housepits can be determined. Using the study housepit floor plans with the locations of existing postholes established, these structural options can be "overlaid" and evaluated for their suitability. At this point, possible structural schemes can be further detailed and critiqued on their performance as residential structures.

Structural Strategies

While there may be numerous possibilities for constructing frameworks over the study housepit excavations, it seems reasonable to focus on four basic physically and perhaps culturally viable structural strategies. These selected schemes relate to documented accounts of pithouse construction around British Columbia and in areas immediately to the south. Through a brief analysis of these different schemes without the burden of contextual issues, the rationale of individual structural moves may become clearer.

Type A: Post, Girder, and Beam (Fig. 1)

This structural strategy appears to be somewhat similar to the well documented Thompson pithouse (Teit 1900:192–194). The main girders rest on vertical posts and continue inwards with a cantilever to form a central opening. Stabilizing lateral beams rest on each girder near the post location. Their purpose is twofold. They act to brace the girders in position and to cut down the long purlin spans between the girders. Variations

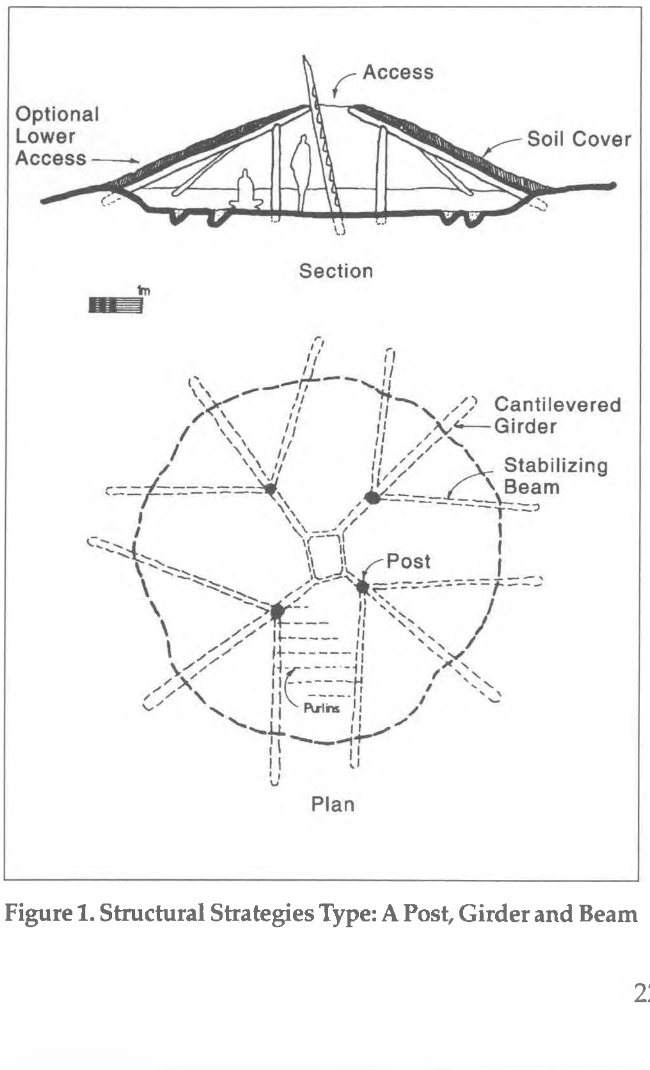


Figure 1. Structural Strategies Type: A Post, Girder and Beam

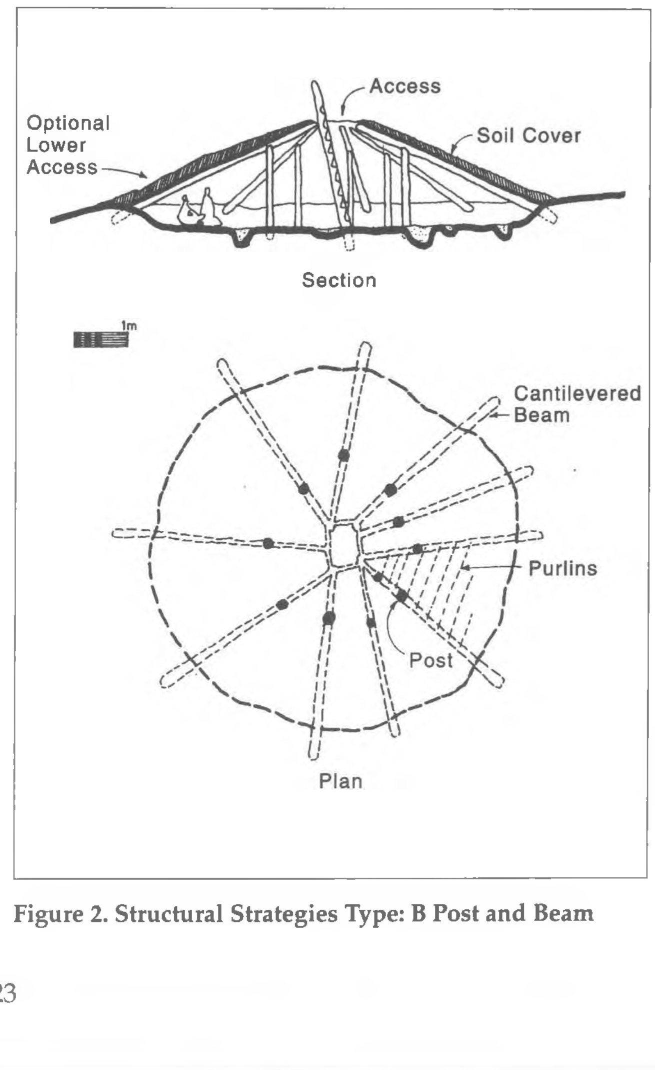


Figure 2. Structural Strategies Type: B Post and Beam

on this theme may include additional post-girder-beam elements from four to six or more. Alternatively, a three post-girder-beam configuration could also be possible.

By increasing the depth of the excavation to provide sufficient headroom, there would be no minimum size for a structure of this type. The maximum size would only be limited to the length and diameter of local trees and a sufficient number of workers for the erection of the superstructure. On a very large scale, the introduction of a second set of posts between the rim and the first set may be required to support the extra weight carried by the girders. The stabilizing beams may also require intermediate posts on very large structures.

In his description of the Chilcotin Indian pithouses, Lane refers to some of the components of what appears to be a Type A structure:

> The rafters were lashed to the central frame with spruce roots. The rafter butts rested on a step inside the edge of the pit. The pitch of the roof was steep, between thirty and forty degrees. Rafter sheathing was laid rafter to rafter. (Lane 1953:158)

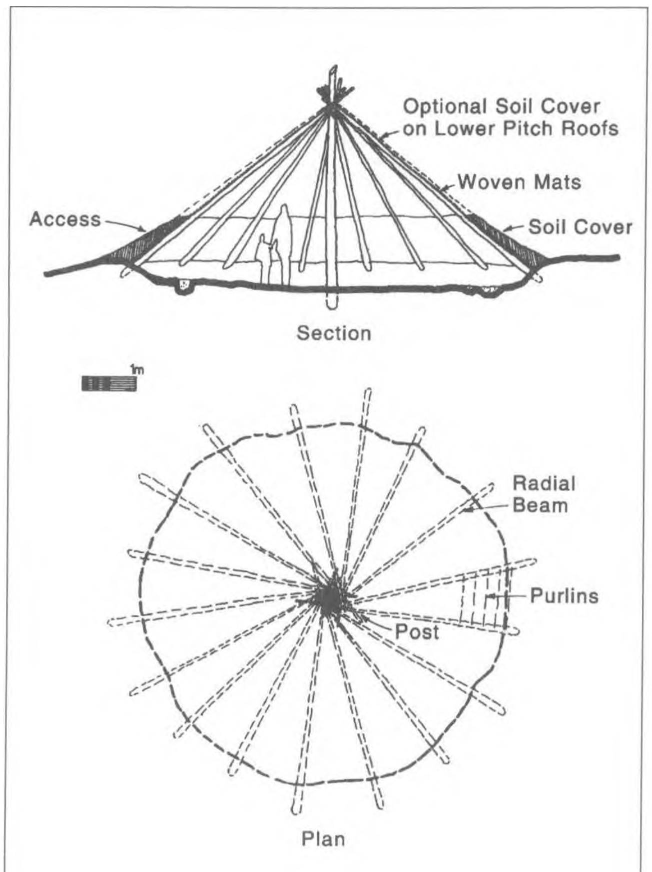


Figure 3. Structural Strategies Type: C Radial Beams and Post

Type B: Post and Beam (Fig. 2)

Similar to the Type A structure but without the stabilizing beams, this next system employs lighter supported members (cantilevered beams) in place of the heavy girders. The elimination of heavier girders demands a closer beam spacing to avoid overloading and to keep the purlin spans to a minimum. There are several possible benefits to using a system of this nature. The lighter members would be easier to handle and small segments could be repaired without having to remove large sections. Aside from the clutter of posts near the center of the floor, the major drawback to this system is one of stability. The posts would need to be buried deeply and all the beam connections would have to be extremely rigid to maintain structural integrity.

With an additional set of support posts nearer the rim, there would likely be no maximum size limits (other than material sizes) for a Type B pithouse. The smaller size structures, however, would suffer from the dense cluster of posts in an area where the headroom is the most usable.

Type C: Radial Beams and Post (Fig. 3)

While there appears to be minimal concrete documentation for a structure of this type, an illustration of a housepit using one center post does appear in one publication (Kirk and Daugherty 1978:69) and is titled a "Columbia Plateau Pithouse." At the Bear River No. 3 site (Sheilds and Dalley 1968:63), another probable example of this type of structure exists, although with two central posts rather than one. The roof slope employed on this example (Structure 5) appears to be about 45 degrees over a floor size of about 3 m in diameter.

In the Type C system, a large number of moderately slender beams radiate about a large central post. The top ends of these beams are lashed to each other and to the post itself to form a rigid assembly. The lighter the beams, the greater number that would be required to carry the load. This increase in beam numbers would act to reduce the span and therefore the size of the purlins. Without the central post the structure would still be viable (as shown in Type D, Fig. 4), but only by incorporating a steeper pitch. With the addition of the post however, the roof pitch could be reduced to that of housepit Type A.

While this Type C system affords a reasonably clear floor space, it suggests the requirement for a side entrance only due to the steepness of the roof. The maximum size limit imposed by this method would depend on the roof slope and the type of cover (soil or mats), but would likely be limited to small or perhaps medium sized structures due to the tremendous weight that would be bearing on the top lashing connections at the larger size. Unlike housepit Types A and B, a post does not rest below each beam and if the lashing were to decay and fail, the entire structure could collapse. This system would therefore be most successful when employed on the smaller structures with the least weight on the top lashed beam connections.

Type D: Radial Beams (Fig. 4)

While similar to the Type C housepit described above, this structure has no central post but relies on the rigid top lashed connections for its stability. The light radial beams are located closely together on the rim and overlap at the top to form a conical shape. This connection is lashed together to make the entire structure rigid. Without any posts the roof slope would have to be reasonably steep so that the weight of the structure would be efficiently transferred down to the base of each beam. This type of system would likely be satisfactory only for the smallest pithouses due to the difficulty of erecting large timbers at a steep pitch and lashing them all together. The floor diameters for this type of structure in the Thompson Area has been documented as ranging from about 3–6 m (Teit 1900:196). Although there would be no minimum size for a structure of this type, it would appear that an upper size limit would be reached with a floor diameter of about 9 m.

Slope Comparisons

Each of the above pithouse types have inherent limitations in their roof slopes. These limitations affect the maximum and minimum slopes of each structure type and involve issues such as access, water penetration, headroom and loading. To isolate these issues effectively the slope studies are examined independently of any contextual constraints (such as the sloping nature of the site) so their effects might be more clearly understood.

Types A and B (Fig. 5)

Both the Type A and Type B pithouses are grouped together for this analysis because they share very similar concerns with regard to roof slopes. The roofing strategies would likely have been limited to sod roofs similar to those described in the Shuswap area (Boas 1891:81–82). These sod roofs consisted of soil over bark and grass or pine needles, placed on tightly spaced lathing.

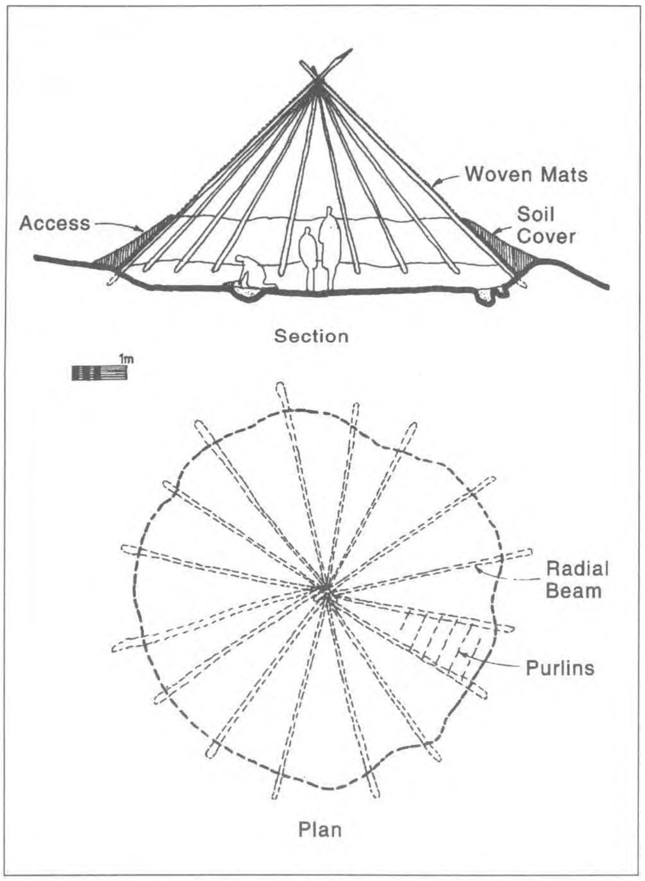


Figure 4. Structural Strategies Type: D Radial Beams

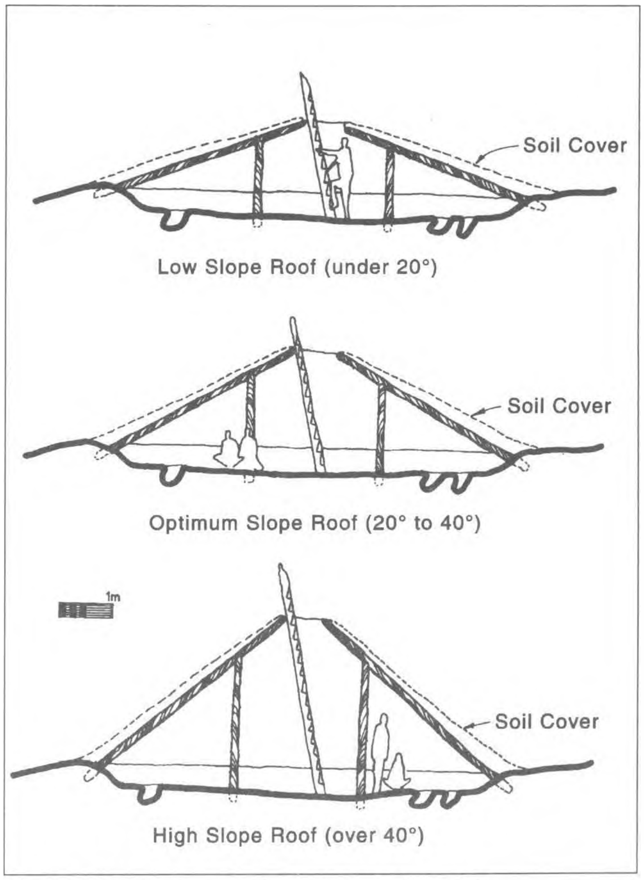


Figure 5. Slope Comparisons Types A and B

Low Slope Roofs: While there are benefits to having a roof slope under 20 degrees (such as easy access, lower volume to heat and shorter length of structural components and ladder), there are important drawbacks. The base of the girders or beams would have insufficient underpinning to support much of a cantilever at the top end and would require extra ballast (rocks or soil) to be placed over the girders at the base. Water would likely penetrate the roofing at a slope of less than 20 degrees, which would cause damage to the structure and make living conditions uncomfortable during times of heavy rainfall. At lower slopes, the girders and beams begin to approach the horizontal and their loads act predominately in a vertical direction. Additional snow loads, which would build up on the leeward side, could add to these loads causing severe deflections of the beams and purlins. Another concern would be headroom, especially on the smaller pithouses. During the course of a long winter it would seem necessary to have some room to carry out activities in a standing position.

Optimum Slope Roofs: A roof slope between 20 and 40 degrees begins to address the drawbacks of the low slope roof without compromising the benefits. Access is reasonable and the structure volume is not excessive. The structural components and ladder are marginally longer but manageable. The angle of the girders and beams at the base provides satisfactory underpinning. Water would tend to run off before it could penetrate even the outermost roofing materials. Snow may still build up at the lower slope ranges (20 to 30 degrees), but there is a greater vertical load component carrying more of the load to the base of each member, hence, minimizing deflection of the roof components. Headroom, even on the smaller structures, is much more reasonable.

High Slope Roofs: A roof slope of beyond 40 degrees begins to develop a new set of problems. Issues of headroom, snow load, water penetration and roof member deflection all but disappear. The top access would now be problematic, both because of the steepness of the pathway up the structure, and the dangerous height of the ladder. More critical is the issue of soil stability. Water runoff would carry away soil and roofing materials. Even when dry, 40 degrees is approaching the limit for angle of repose of earth. The larger volume created by the increased slope is located mainly in the upper areas inside the structures where the heat would migrate and be of little use to the occupants. The physical size and weights of the structural elements also become difficult to handle. As the posts become longer they must increase in diameter to resist buckling (slenderness ratio). The post to beam connection angle becomes more acute to a point where the post may tend to kick out from under the beam.

It would appear from these studies that an optimum roof slope for a Type A or Type B pithouse would fall within the 20 to 40 degree range. Documentation of a pithouse in the Chilcotin Plateau supports this range with an example of a roof slope (for a Type A pithouse) between 30 and 40 degrees (Lane 1953:158). On a sloping house site (most of the Keatley Creek site is situated on slopes of various magnitude), the roof slope would vary side to side to compensate for the ground slope. In this case a single structure may have a roof slope that varies 15 or 20 degrees and may border on the upper and lower limits mentioned above.

Type C (Fig. 6)

Inherently, with this type of structure, an upper roof access seems unlikely. By using a side entrance, the problems of a steep climb up and a dangerous ladder descent can be avoided. Since there is limited documentation for this type of structure, little evidence of the choice of roofing that would have been used exists. On the Bear River No. 3 site there was no evidence of any earth cover over the Structure 5 housepit (Shields and

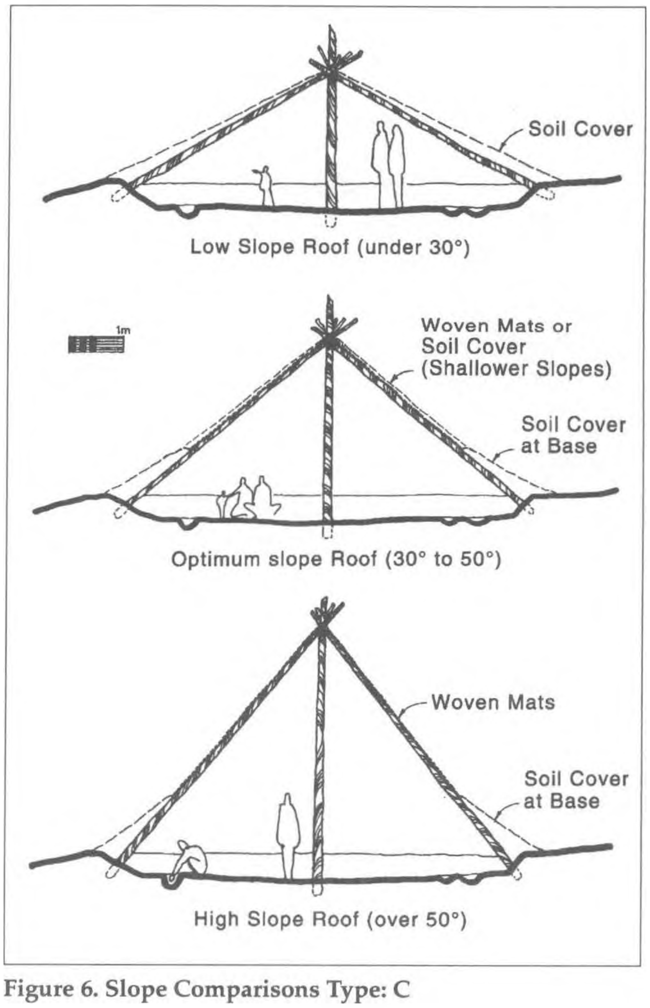


Figure 6. Slope Comparisons Type: C

Dalley 1968:63). It would appear that for very low Type C roof slopes, soil cover could have been possible. For steeper structures this would not have been an option and woven mats or possibly animal skins would have been required for winter occupation cover.

Low Slope Roofs: With a roof slope of less than 30 degrees woven mats would probably be insufficient to provide adequate rain protection for the occupants. With a soil cover, the minimum roof slope could be reduced to about 20 degrees (as discussed in Types A and B Low Slope Roofs). The combination of low slope and the increased weight of the soil cover would demand large sized roof members which would be difficult to lift into place. A structure built in this way would therefore have to be very small (probably under 5 m) or have some additional posts installed to support sagging members at times of high snow loads. Building this type of structure at a very small scale with a low slope roof would provide little area of adequate headroom.

Optimum Slope Roofs: With a roof slope between 30 and 50 degrees, woven mats or animal skins would likely provide adequate rain protection. The combination of increased roof slope and light loading (no soil cover) would make deflection problems negligible, even with extremely small roof members. Headroom in smaller pithouses, including those with shallow floors and low rims would appear to be reasonable.

High Slope Roofs: Beyond 50 degrees the structure becomes more difficult to erect. The materials are longer and consequently heavier and harder to manage. While headroom is definitely not an issue, the large upper level volume that has been created would cause heat stratification and adversely effect any heating strategies.

Considering the above criteria, it would appear that with a Type C structure, an optimum roof slope of between 30 and 50 degrees would be the most appropriate. The example on the Bear River Site (Shields and Dalley 1968:63) of Structure 5 seems to support this. With the floor diameter and height above floor at which the roof members would meet (as derived from the post hole angles recovered in excavations), the roof slope can be calculated to be about 38 degrees.

Type D (Fig. 7)

This type of structure is very similar to that of Type C but without the center post. By comparing Figures 6 and 7 it can be seen that much the same conditions apply to both types, including the requirement of soil cover at the lower roof slopes. The omission of a central support, however, does have certain ramifications.

Low Slope Roofs: Without the center post this scheme becomes problematic at a roof slope of under 35 degrees. With this low slope, the roof loading including both dead and live loads (loads from the structure itself and introduced loads such as snow or people) acts primarily to drive the opposing beams apart at the base. At the same time the smaller lashed beam tops are being forced to slide through the lashed joints. The shallower the roof pitch, the easier it would be for the structural members to move slightly and cause the assembly as a whole to collapse while still remaining intact. This would be similar to flipping a shallow woven basket inside out. The requirement for soil cover to provide rain protection (as discussed in the Type C Low Slope Roofs) adds further complications. Along with this, the additional drawbacks as discussed in Type C Low Slope Roofs still apply.

Optimum Slope Roofs: With a roof slope ranging from between 35 and 60 degrees, the structure becomes much more stable. More of the structural load is acting as a vertical component and is therefore effectively transferred down to the base of the beams. Again, as with the Type C Moderate Roof Slope, light woven mats would have been used instead of soil to provide rain protection. With this, the radial beam framework could be quite light and easy to erect. Sufficient headroom

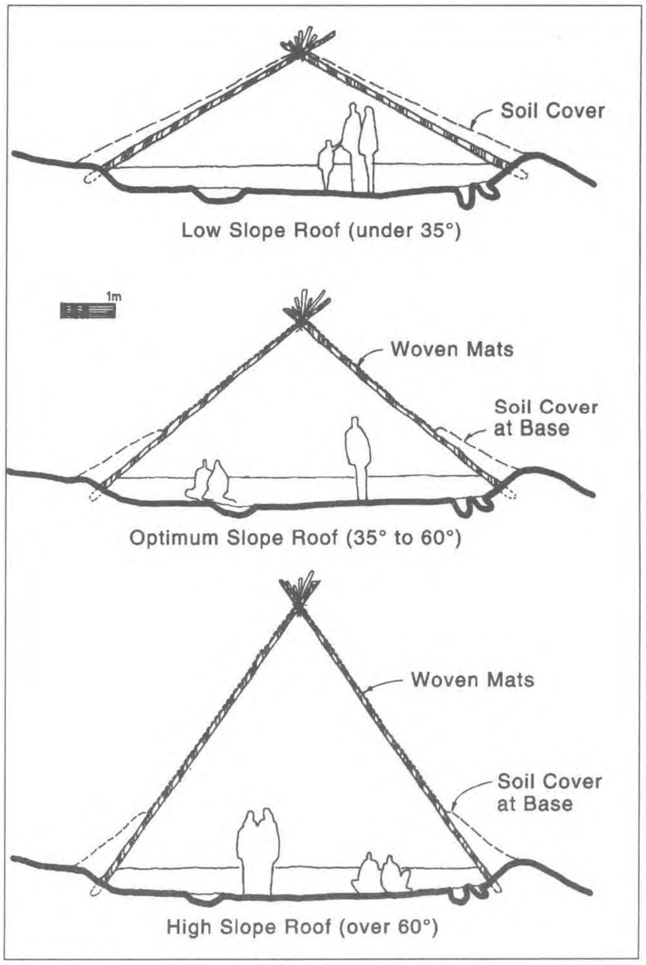


Figure 7. Slope Comparisons Type: D

could be achieved without creating a large volume overhead that would draw the heat.

High Slope Roofs: Roof slopes beyond 60 degrees would become heavier and unwieldy making them difficult to erect. As with Type C pithouses, heat stratification combined with a large radiating surface area would adversely affect the heating strategies during the winter.

Considering the above arguments, it seems probable that a roof slope in the optimum range would have been employed on a Type D pithouse.

Structural Options

Four structural options have been selected for each study housepit location. It is important to note that none of these options are meant to represent the exact structures used, but instead, are used to examine the implications of a number of possible strategies. All "last occupation" postholes that were found have been shown, with those corresponding to post positions of specific structural models being darkened (Figs. 8–12). Much of the rim area was unexcavated and, as a consequence, very few girder emplacements or postholes have been located outside the floor area. Locating the positions of postholes in the rim would have been very useful in determining the exact locations of the main girders and beams and perhaps the slope of the roof, although in most cases this was a difficult endeavour.

HP 3 Floor Plan (Fig. 8)

While there are a profusion of post locations scattered throughout HP 3, it remains among the most clear structurally. While there seems to be a particular pattern for interior main support posts, it is interesting to see the variety of options still available within this pattern for this 10 m floor diameter structure.

Option 1: This Type A system represents a variation of the type well documented by Teit (1900:192–194) in his study on the Thompson. Four main girders each rest on posts fairly evenly spaced from the center roof access. For the most part, the stabilizing beams rest over these main posts. The spans between the support members are relatively equal and certainly not excessive (under 3 m at the worst).

Option 2: Although the radial beams of this Type B system produce a viable structural scheme, there are certain weak elements. The purlin spans between the beams have become excessive (up to 4 m). The cantilevered sections of some beams are probably beyond reasonable limits as well.

Option 3: This structural strategy is actually a hybrid of a Type A and Type B system. There are girders on posts with span-reducing stabilizing beams typical of Type A schemes and cantilevered beams typical of Type B schemes side by side. This mix seems like a logical one to employ on larger pithouses in that additional beams can be added if required during construction to achieve short purlin spans and reasonable stability. Although this option may not look as tidy as that of option 1, it is probably just as effective.

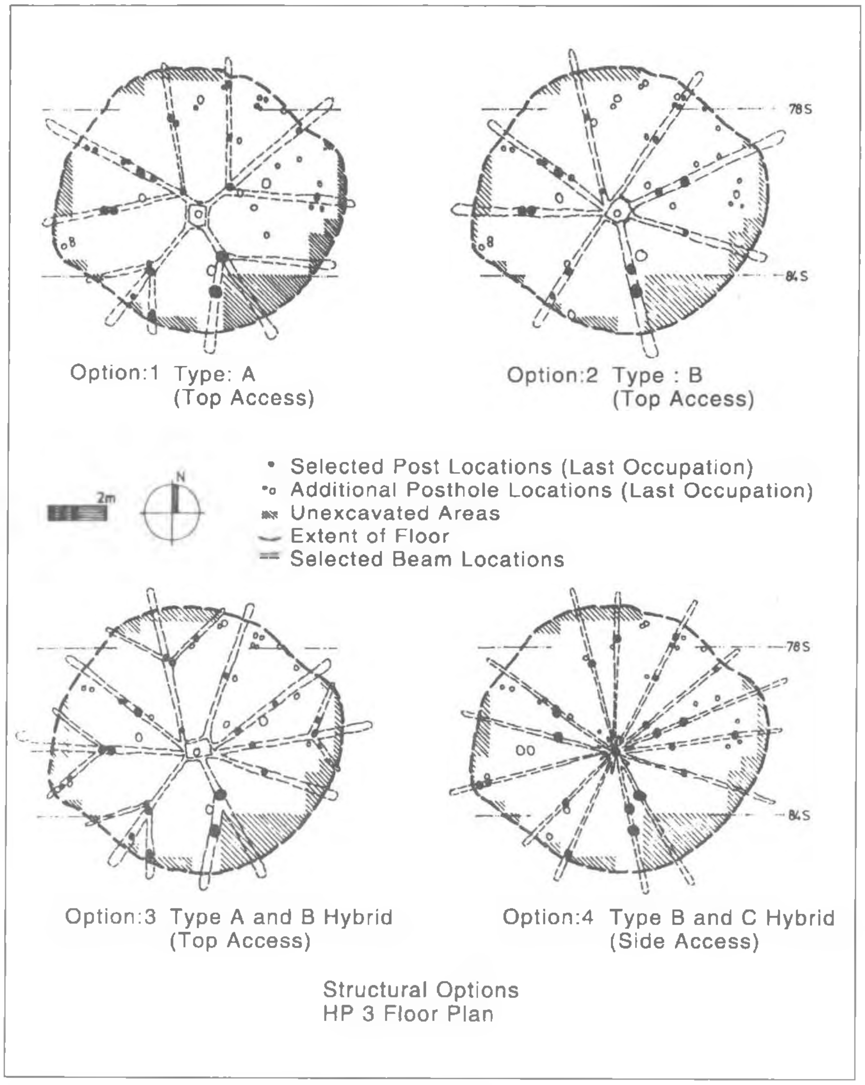


Figure 8. Structural Options HP 3 Floor Plan

Option 4: By mixing structure Types B and C, many of the posthole locations have been utilized which would reduce the beam sizes to a minimum. Access here would probably be limited to a side entrance for which there was no evidence during the excavation.

While both options 1 and 3 appear reasonable, the former seems more logical and has been chosen for a more detailed study in the following section of this article. A Type D structure was not included due to the large size of the floor and the abundance of posthole locations.

HP 7 Floor Plan (Fig. 9)

HP 7, the largest of the study housepits with a 12 m diameter floor, is very similar to, but larger than HP 3. It also has an abundance of postholes throughout most of the floor areas, although they do not read as clearly as those of HP 3. It is interesting that many of the last occupation posthole locations (shown on Fig. 9) and those of the prior occupations were very similar. This tends to suggest that earlier structural systems were repeated when the structure was rebuilt, perhaps indicating that there was a clearly understood system for the construction of this size of pithouse.

Option 1: As in HP 3, option 1 represents a clear Type A structural system, although the spans and structural members are all slightly larger. The increased spans of the purlins (upwards of 4 m) would necessitate that the purlins be quite large in diameter, making the roof extremely heavy and hard to build.

Option 2: The radial beams of this scheme are similar to those of HP 3, option 2 although a key posthole is missing. Even if this missing posthole could be assumed to have been present, the purlin spans would still be considered excessive (almost 5 m in the worst case).

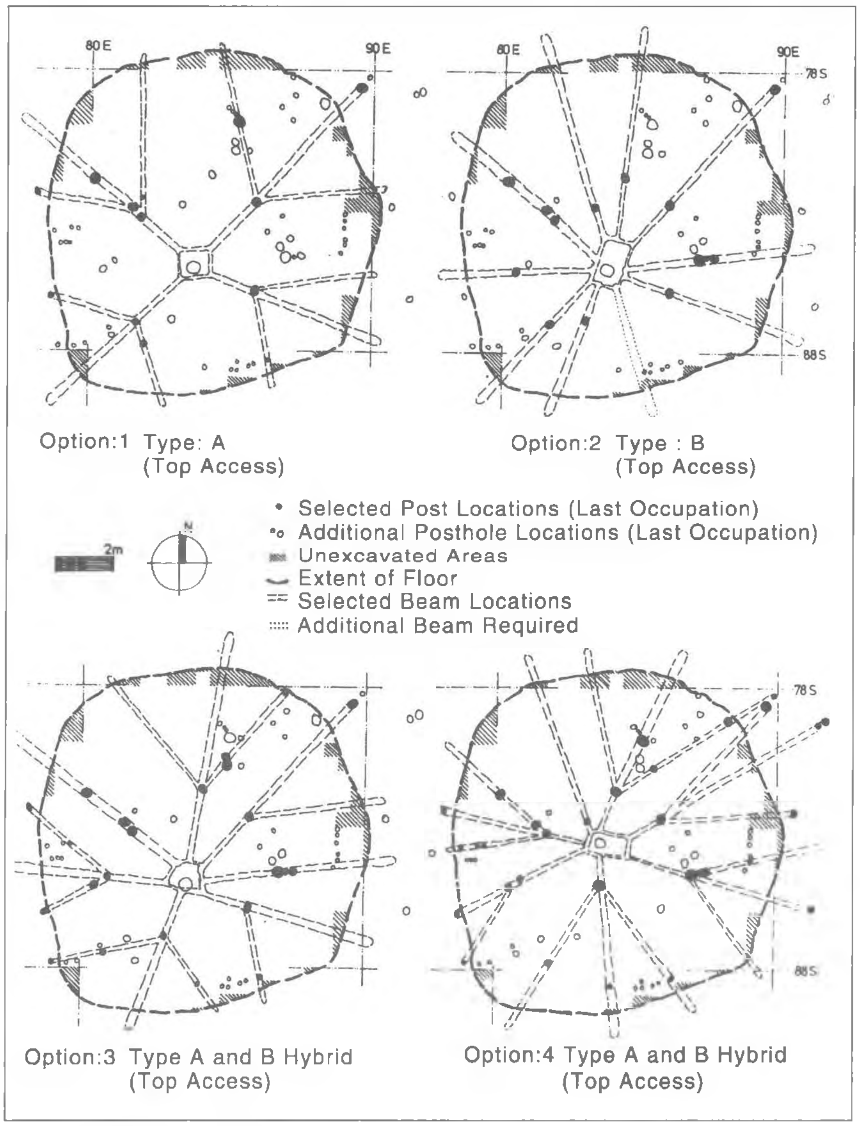


Figure 9. Structural Options HP 7 Floor Plan

Option 3: This Type A and B hybrid utilizes several unstabilized or semi-stabilized cantilevered beams to dramatically reduce the span of the purlins (just under 3 m in the worst case). Many of the smaller unused posts could have served for non-bearing partitioning purposes.

Option 4: By utilizing the posthole locations on the uphill rim for girder and brace supports, a Type A and B hybrid scheme with very short purlin spans has been developed. Similar to option 3, a mix of cantilevered beams and stabilized girders have been employed, although unlike option 3, the entrance on this scheme is placed squarely in the center of the structure.

Although the structural system employed in the option 1 scheme appears to provide the simplest fit with the archaeological floor plans, the hybrid scheme of option 4, with its shorter purlin spans, is more structurally sound, and therefore, more likely to have been used. This option has been chosen for more detailed study in the following section. As in the case of HP 3, a Type D configuration would not be viable at this scale.

HP 9 Floor Plan (Fig. 10)

During the course of HP 9 excavations, only four small posthole locations were found. It is quite possible that these postholes contained non-bearing posts for racks, partitions, or other types of furniture given their relatively small size. It is also possible that the posts were added later to repair sagging support members of this relatively small (5 m floor diameter) house.

Option 1: This hybrid option could perhaps be described as a Type C (central post) structure that has had several posts added over time. It would appear unlikely that on such a small structure the builders would have chosen to locate the central post so far from the center of the floor unless it served the purpose of allowing for a side access.

Option 2: With several support posts but without the main central post, this scheme could be described as a Type B and D hybrid. It may also have been constructed as a Type D structure and had repair posts added over time as required. If there was snow accumulation on the south-east side of the structure, the addition of three posts may have been sufficient to bolster a sagging section of roof.

Option 3: By moving the peak of the roof towards the north, the spans of the south beams increase. This may account for the requirement of extra support posts. On a small structure like HP 9, however, it would seem reasonably easy to design a structure that would not require any additional posts, especially with a steeply sloped roof.

Option 4: This appears to be the most obvious option. Here the posthole locations serve partitioning or other non-structural uses. With the small size of HP 9, spans between beams would not be excessive (1.5 m maximum). It would also be easy to add additional beams to further reduce these spans if required.

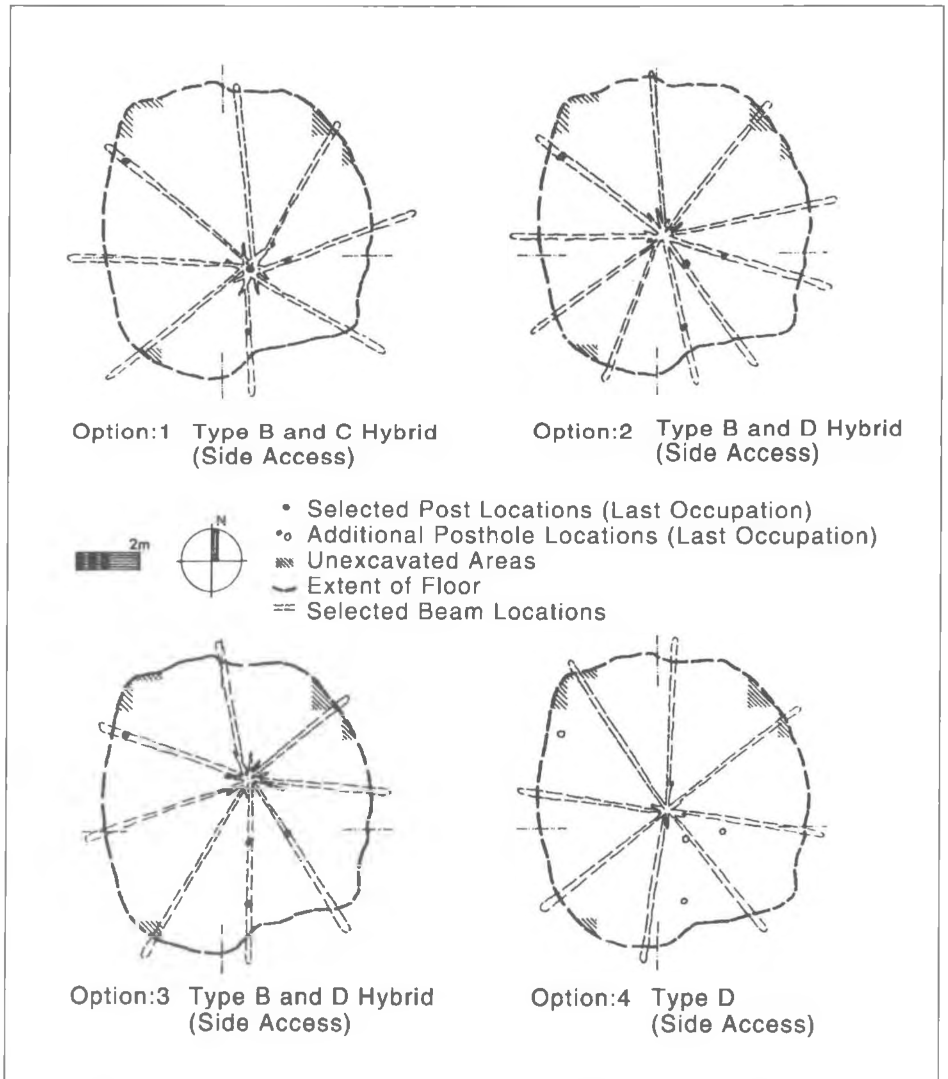


Figure 10. Structural Options HP 9 Floor Plan

Given the lack of evidence for bearing post supports, neither Type A nor Type B models are appropriate to consider. While option 4 appears to be the most logical to choose for a more detailed study, a similar scheme will be elaborated for HP 90. Given this, it may be useful to look more closely at option 1 in order to broaden the detailed analysis for heuristic purposes.

HP 12 Floor Plan (Fig. 11)

Structurally, HP 12 seems most closely related to HP 3 and 7, but at just over 6 m in floor diameter it is much smaller. There are a number of large and small posts scattered apparently at random throughout the floor area. As with the other study housepits, rim posthole locations would have been very useful in determining the actual structural system used.

Option 1: While options 1 and 2 both share the Type A strategy, option 1 places the access closer to the center of the structure creating a more even roof slope. Except for one 3 m span, the purlin spans are generally small. With the inclusion of another central post to support the longest north beam, this scheme would appear much more rational.

Option 2: Although this scheme displays most of the typical Type A components, their arrangement is somewhat problematic. The south side slope of the roof would have to be very steep and the north side quite shallow. The eastern girder is not a standard cantilever and its stabilizing beams are located too close to the rim to be of much use either in bracing the girder or reducing the purlin spans.

Option 3: By mixing Type A and B systems the spans are minimized and the structure appears quite orderly. With the absence of a key central posthole, the possibility of a roof entrance seems unlikely. From the abundance of unexcavated outer floor and rim areas that appear on Figure 11, it is possible that evidence of a side entry could exist at the north part of the rim and still remains to be discovered.

Option 4: With a housepit of this size, it would seem logical to use either a Type C or Type D system; however it is hard to explain the profusion of large postholes. Many look too large to have been introduced at a later time for the purposes of repair. Given this, it is possible that a single center post or perhaps several center posts were used to support the roof beams with several additional mid-beam supports added later.

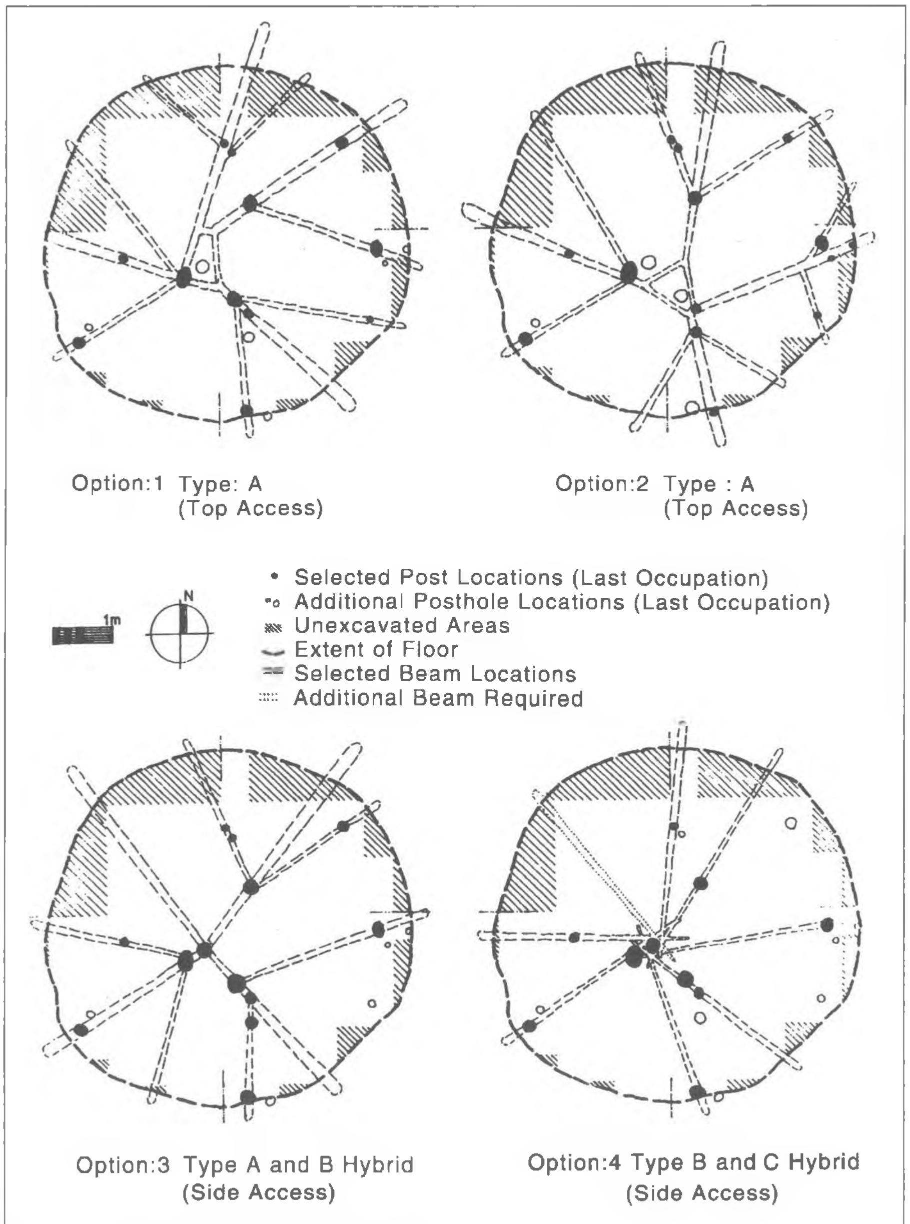


Figure 11. Structural Options HP 12 Floor Plan

Given the possibility of a side entrance, option 1 could be amended slightly to eliminate the top access without changing the general structural layout. It is also possible that this structure (and others as well) may have employed both a top and side entrance. Either way, option 1 appears the most logical and has been selected for a more detailed study in the following section.

HP 90 Floor Plan (Fig. 12)

HP 90 is strikingly similar to HP 9 in the size of the floor (5 m in diameter) and the quantity and distribution of postholes. This is the only housepit of the five study housepits in which a side entrance was uncovered. Given the small size, lack of evidence for substantial posts, and obvious entry location, it would seem unlikely that this structure would have employed either the Type A or Type B system.

Option 1: This scheme seems to represent a Type C roof system that has had additional support posts added to some of the beams. Using the posthole location closest to the

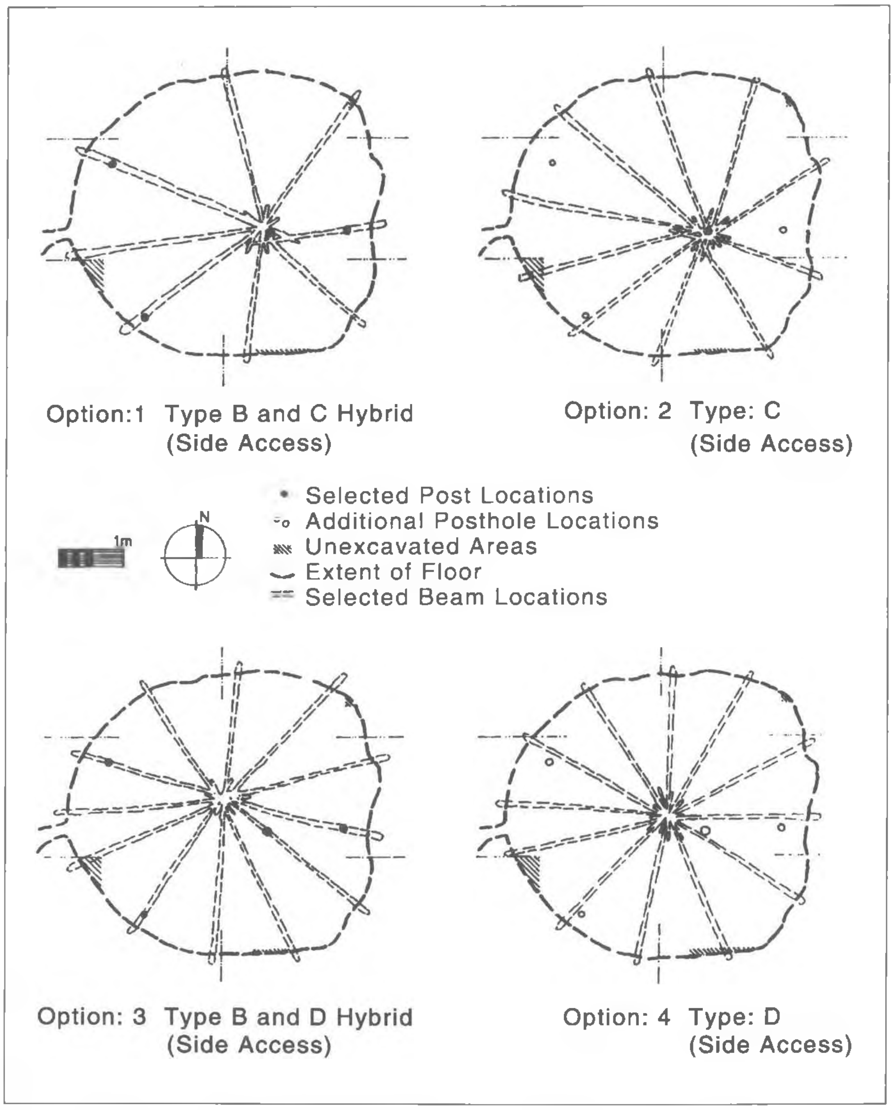


Figure 12. Structural Options HP 90 Floor Plan

center for the main support, a roof is produced that is shallowest over the entry and very steep on the opposite side. This seems contrary to the logical requirement of having sufficient headroom immediately inside the entrance. The additional posts have not been located at the points of maximum deflection and there fore may serve other than structural functions.

Option 2: Assuming, as mentioned in option 1 above, that the additional posts were not required structurally, the radiating beams are free to move and be spaced closer together. While the beam spacings now seem more reasonable, the drawback of the low slope over the entry is still unresolved.

Option 3: By moving the apex of the structure nearer to the center of the floor, the entry headroom would improve somewhat. Given the depth of the entry floor, the clearance of the roof structure would not be a problem. Most of the posts in this scheme appear to be non-structural given their more peripheral locations below the beams.

Option 4: Considering the locations of the postholes in the floor of HP 90, it would be logical to explore a Type D roof strategy that does not use structural posts. This structure employs relatively even, short spans and a uniform roof slope.

Given the drawbacks to options 1 through 3, and the clear documentation for this type of structure (Teit 1900: 196), it would seem reasonable to select option 4 for further study in the following section.

Selected Layouts

A structural layout and roof slope has been selected for each study housepit location from the preceding housepit options. This selection is not meant to imply that any layout exactly represents the roof which was built prehistorically. A number of points make that task difficult. Some posthole locations may have been from prior occupations rather than from the latest occupation. Postholes may have been missed or misinterpreted during excavation. Important postholes may lie in unexcavated areas. Some posts undoubtedly served purposes other than structural. It is also possible that some support posts sat directly on the floor and therefore left no remaining holes. A number of postholes (especially the smaller ones) may have been from posts added later in the life of the structure to repair or bolster sagging sections including purlins and roof lathing.

In spite of these qualifications, the selection and analysis of possible structural layouts may prove valuable in better understanding the problems encountered by their early builders, and some of the more likely solutions.

HP 3 Floor Plan and Section (Fig. 13)

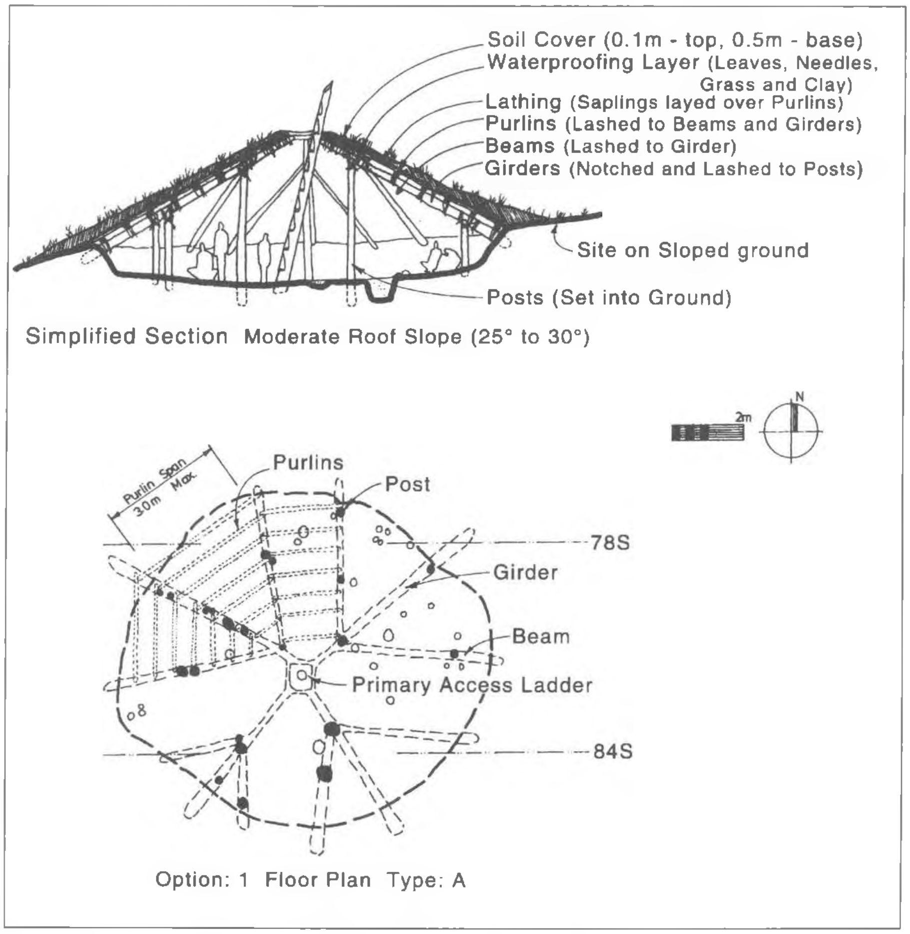


Figure 13. Selected Layout HP 3 Floor Plan and Section

HP 3 is located on a slight slope which would necessitate having an off-center top access to achieve a uniform roof slope. Conversely, if the roof slope varied slightly around the structure, the access could be located in the center of the floor. The selected scheme, option 4, places the entrance near the center of the floor and is considered to be the most likely basic type of roof to have been used prehistorically on this pithouse. A moderate roof slope was chosen in the slope comparison section. Given the slight grade of the site, a required roof slope variation within the 25 to 30 degree range would likely optimize the roof slope physical requirements and keep the access in the center of the structure. Some of the structural posts indicated on the floor plan may be shoring applied some time after the construction of HP 3. It is also possible that some of these posts may be acting as partitions only and do not have structural functions. Three bays of purlins have been located on the floor plan to give an indication of the probable direction and spacing of these members.

The complete roofing and structural assembly has been detailed on the simplified section. The thickness of the soil cover is based on excavations at HP 7 and may have varied slightly. The lathing appears to have been laid at 90 degrees to the purlins which would make sense from a structural point of view. The locations of charred structural remains excavated in HP 3 tend to support the locations, spacings and directions of the purlins.

It would seem likely that as the structure aged and sections of the roof began to sag, additional posts and perhaps beams as well, would have been brought into the structure and wedged into place to make the structure last another few years with minimal work. This repair process, in fact, could have carried on to the point where the floor was cluttered with posts. At this point posthole locations would appear quite confused, perhaps much in the way they do on the detailed archaeological floor plans.

HP 7 Floor Plan and Section (Fig. 14)

This housepit is located at the base of a hill and is graded quite steeply. The roof pitch would change as the girders radiate from an uphill position to a downhill position. Since the downhill girders would require a steeper slope to maintain adequate underpinning, the slope of the uphill girders must gradually decrease to provide a uniform opening elevation.

The central posts forming the cantilevers on the girders are roughly equidistant from the top access hatch. The lengths of these cantilevers do not exceed a distance of roughly half the backspan (1/3 cantilever) which seems to be quite sound. A top end supported, unstabilized beam cuts the purlin span down to the size of the other purlin spans around the structure. Mixing stabilized girders with unstabilized beams seems an appropriate way to minimize long purlin spans and to create a more even superstructure over a slightly asymmetrical floor.

There are a number of small post groupings whose placements appear highly organized. These do not appear to serve any structural purposes and are likely

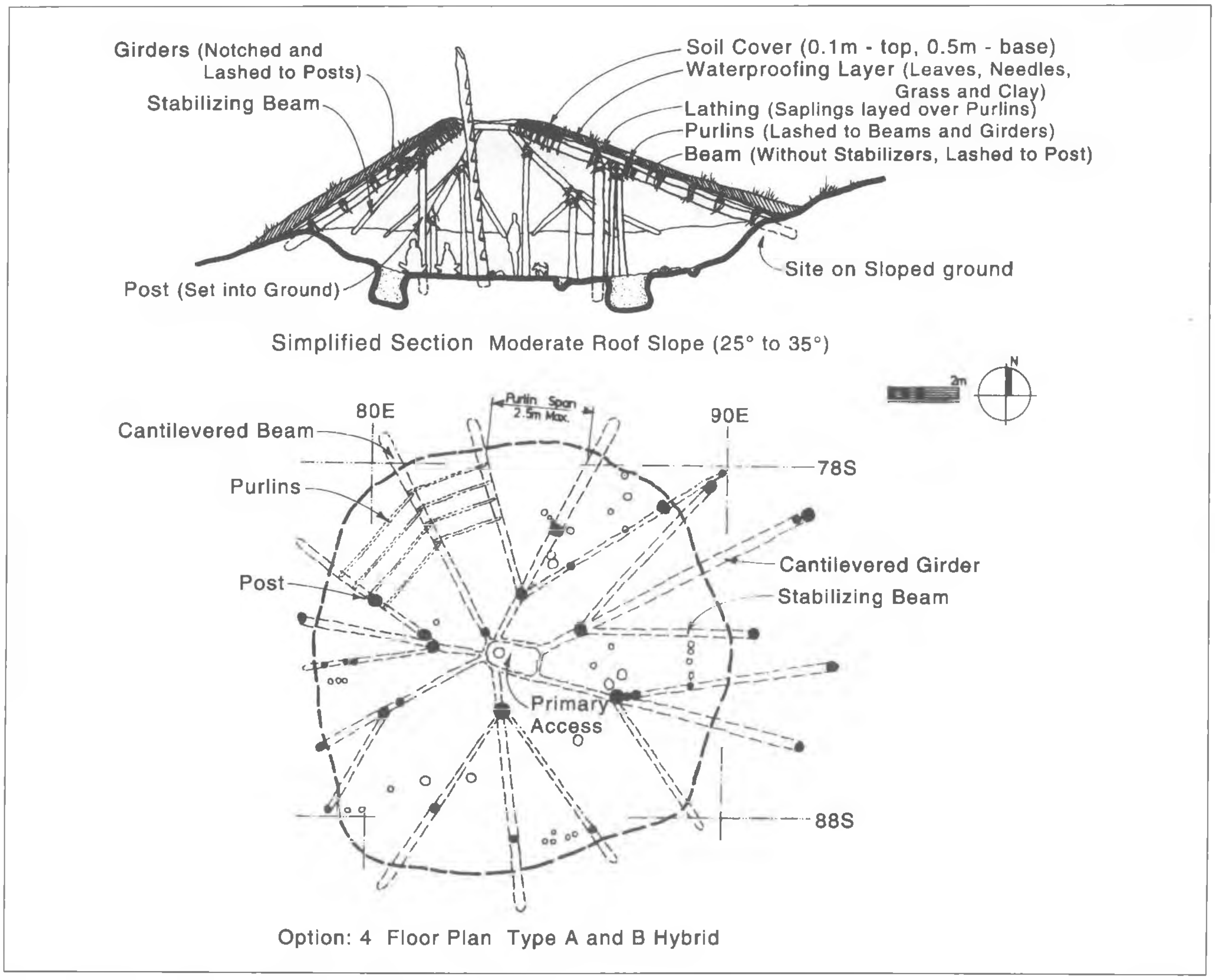


Figure 14. Selected Layout HP 7 Floor Plan and Section

partitions separating different activities. The simplified section indicates a reasonably accurate floor profile and the inclusion of people in the sketch serve to illustrate the large relative size of this structure.

The relative thickness of soil cover indicated on the section represents amounts actually recovered in excavations.

HP 9 Floor Plan and Section (Fig. 15)

The grade around HP 9 is nearly level. The off-center location for the main support post would act to increase the southeast side roof slope. A possible side access has been located at this steep sloped section to provide adequate headroom upon entering the structure. If subsequent excavation indicates that a side entrance was located elsewhere (e.g., in the northeast where excavators think it may occur), then this reconstruction will be much less attractive than option 4, which, as previously discussed, probably is most realistic for this housepit in any event. The direction and extent of the purlins supporting the soil cover have been located on the floor plan. The simplified section illustrates that the soil cover, roofing and roofing support structure carried part way up the base of the housepit and is similar in construction to that shown on HP 3 and HP 7. Above this point, woven mats or perhaps animal skins act as the roofing system.

The roof slope chosen (ranging anywhere from 35 to 50 degrees) provides sufficient headroom while keeping the volume of the structure to a minimum for sufficient heating. The additional posts under the beams may have been used to shore up undersized members or provide a framework to fix partitioning to.

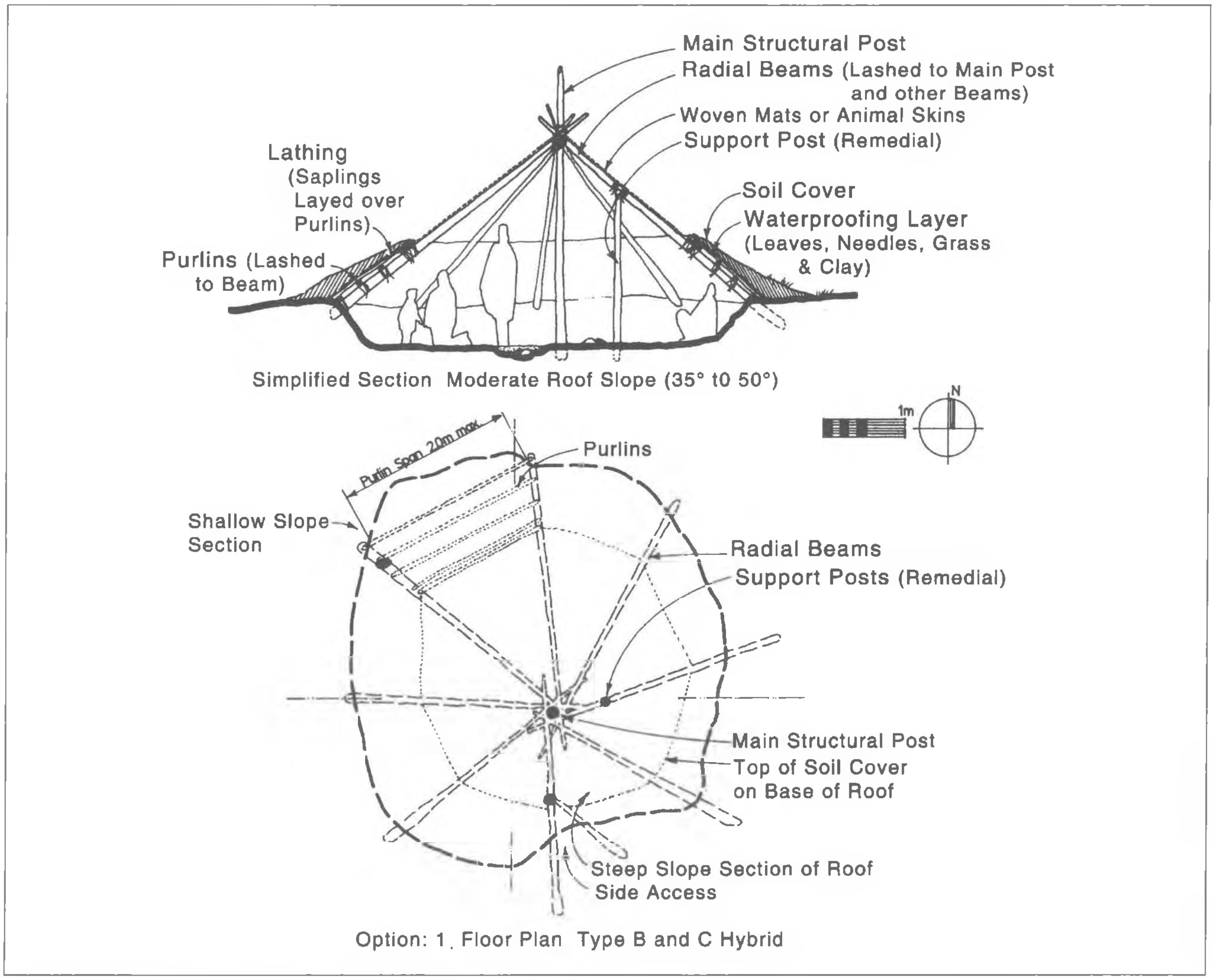


Figure 15. Selected Layout HP 9 Floor Plan and Section

HP 12 Floor Plan and Section (Fig. 16)

This structural system is essentially the same as those employed on the selected layouts of HP 3 and HP 7 (Figs. 13 & 14). The gently sloping grade of the natural ground surface could be accommodated with a minimal variation in roof slope. A moderate roof slope has been utilized, possibly ranging from 30 to 35 degrees. With the depth of the excavation indicated on the simplified section and the roof slope chosen, much of the central floor area would have sufficient headroom. The interior volume to be heated would not be excessive in this scheme. Most purlin spans are just over 2 m in length and the one long span on the southwest section could be halved with the addition of another light beam at the mid-span point. As mentioned in the previous section, even if a side entrance was actually used in this housepit (which might be determined by future excavations), the roofing strategy would require only minimal change.

HP 90 Floor Plan and Section (Fig. 17)

The system of radial beams employed on this Type D scheme responds to "frame in" the side entrance. Similar to HP 9 (Fig. 15) but without the center post, the roof slope is probably less arbitrary, requiring a steeper roof slope to achieve structural stability. With a 45 degree roof, the excavation depth can be kept to a minimum without affecting the headroom. The steep roof effectively transfers the load to the base of the beams causing minimal deflection. With this argument, the beams therefore can be quite small and light. The purlin spans supporting the lower soil cover are minimal (1.5 m maximum at the lowest point and 1 m at the highest point) and would also be small and light. This would be an easy structure to build, but due to the small sized structural members, the lifespan would likely be quite short.

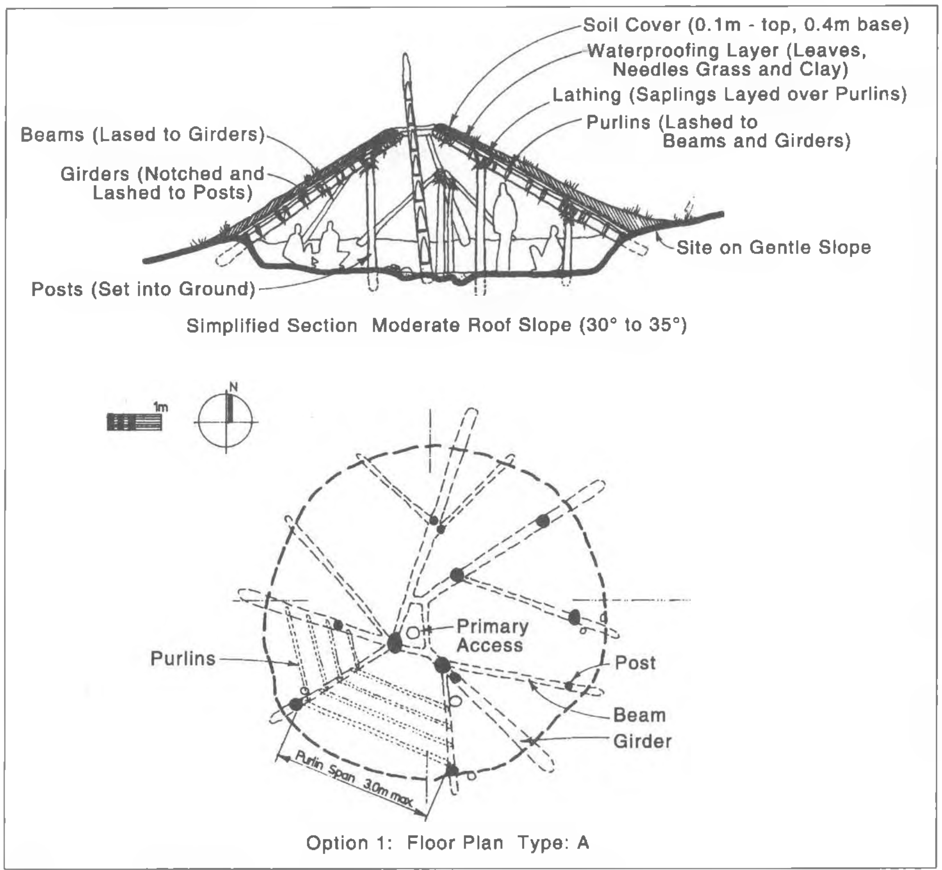
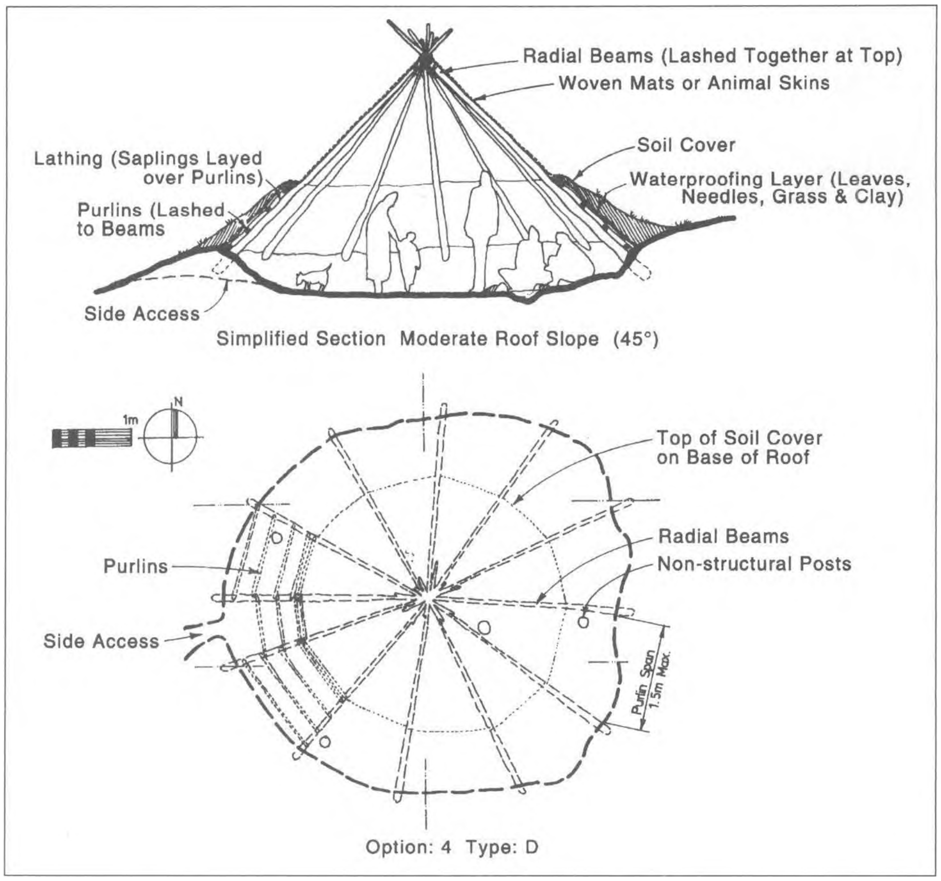


Figure 16. Selected Layout HP 12 Floor Plan and Section

Figure 17. Selected Layout HP 90 Floor Plan and Section



Conclusions

Without the complete rim posthole locations it is impossible to determine the definite structural layout that would have been employed at each studied location. Some housepit floor plans are much clearer and more highly patterned than others and the selected layouts look very plausible. For those that are less clear, the general type of system that was used can still probably be deduced. By analyzing the various layout options for the five study housepits, it can be determined that there was likely a much wider variety of building types used at the Keatley Creek Site than is generally assumed by archaeologists or in popular portrayals of prehistoric Plateau cultures. In fact, all but one of the structures dealt with here appears to have varied greatly from the "typical" pithouse described by Teit.

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