

RECONSTRUCTING THE GREAT HALL AT INKALLACTA

Vincent R. Lee, Architect
Institute of Andean Studies

Introduction

Preface

This paper is an attempt to reconstruct the Great Hall at Inkallacta, the ruined Inca provincial capital (Lee 1991:7-10) near the valley and village of Pocona in the Department of Cochabamba, Bolivia (Figure 1). Some of the masonry elements of the structure remain in remarkably good condition, while others are in various stages of ruin. Original construction components made of long-decomposed organic materials are absent altogether and must be inferred from the masonry or from what we know of both the mechanics and the spirit of Inca architecture and construction in general. In addition to analyzing the physical evidence at the site, therefore, I have revisited the design problems faced by the original builders in light of what Marcia and Robert Ascher have called Inca "insistence" in their study of the quipu (1981: Chapter 3).

Simply stated, insistence is the sum of those traits that repeatedly manifest themselves in the activities and artifacts of an individual or a culture. Properly understood, architecture is a form of language that tells as much about the speaker as it does of what is being spoken. As such, it is an especially rich repository of cultural insistence. Among the Incas, building was an important, perhaps primary, means of cultural expression. Whatever ends Inca builders sought to achieve, the means employed seem generally characterized by an insistent concern with organization, order and stability. In attempting to reconstruct their work, I have approached the task with these concepts, especially, in mind.

Inca Great Halls

The Great Halls, or *kallankas*, of the Incas were among the largest buildings of pre-Columbian America and certainly enclosed the largest interior spaces. They were important features of most Inca sites of consequence and one or more were often erected facing onto the main plaza. In addition to sheltering large public gatherings in foul weather (Garcilaso 1987 [1609]:320), they may have been used as hostels by travelers and passing military units. The Spaniards called them *galpones*, or dormitories, due to their similarity to the large structures in which slaves and farm workers were then housed in Spain.

According to Garcilaso de la Vega (1987 [1609]:320-321), the largest Inca halls were those of Cusco. He claimed that they were as much as 200 paces long, 50 or 60 wide and that one, the Casana, could accommodate a crowd of 3000 people. Nothing of these halls remains today and many scholars discount Garcilaso's report as exaggerated. The Great Hall at Inkallacta is the largest surviving example and covers an area 78 m long and 26 m wide. It is twice the size of its nearest rival, and the Statue of Liberty laid on its side would fit nicely inside. The three-to-one proportions of the plan at Inkallacta are also unusual. Most Inca halls were long and narrow, more on the order of six- or seven-to-one. The halls at Espíritu Pampa, Huánuco Pampa and Rosas Pata are typical examples (Figure 2).

We know little about the roof structures which once covered Inca buildings in general or Great Halls in particular. Virtually all observers reported that they were of thick, neatly trimmed thatch supported on frameworks of lashed poles (Markham 1862:193-4; Squier 1973 [1877]:395; Pizarro 1978 [1571]:161-2; Garcilaso 1987

[1609]:321). The drawings of Guaman Poma de Ayala (1936 [1615]) show various building types, but structural details are almost entirely lacking. His view of the royal palace of Cuyusmango in Cuzco (Figure 3) suggests only that the roof of that hall was rounded over the ridge, rather than rising to a sharp peak, an important point to which we will return later.

Huánuco Pampa

Craig Morris and Donald Thompson, in their excavations at Huánuco Pampa, uncovered a significant feature in one of the halls there, which they called *kallankas*. They found a row of seven stone-lined post holes running down the centerline of the largest and northern-most hall (1985:89). No record exists of the exact location of these holes, but Morris recalls that they did not appear to be related to the spacing of the doorways (personal communication). In a photograph of the same hall by Gasparini and Margolies (1980:204), the holes appear to be roughly equidistant apart. A reconstruction drawing (*ibid*:202) indicates how the authors thought posts set in the holes might have supported the roof. Other photographs of the building (*ibid*:200-204) also show the hall's partly destroyed gable ends, from the steep angles of which the authors surmised an apex height of about 8 m (26 ft.) above the eaves, or 12 m (40 ft.) overall. Finally, both gables were pierced by two man-sized openings above eave height (Figure 2, Cross Section XX).

Careful study of this building discloses several subtleties not noted by previous researchers that are also present at Inkallacta, and are therefore almost certainly intentional design features with some significant purpose. First, the two eave walls are of different heights, the rear side being nearly a meter higher than the front wall, facing onto the plaza. The building is on level ground and no external factors suggest a reason for the difference. Second, although they are equidistant from the centerline of the building, the two gable openings are set at different elevations vertically. The ones nearest the rear wall are about 30 cm (12 in) higher than

those toward the front. Finally, the distance between the post holes is roughly the same as the height of the posts, the width of the building and the length of each slope of the roof. All measure about 10 m (33 ft). Possibly this is an indication that trees available to frame the roof were limited to approximately this dimension, because there is no source of large timber in the vicinity of Huánuco Pampa.

Inkallacta

The Site and Previous Studies

Inkallacta was built by Topa Inca during his conquest of the region, probably in the 1470s, and underwent repairs by Huayna Capac about 50 years later (Cobo 1983 [1653]:154). It is a sprawling site, arranged above and below a large plaza spreading across a gently sloping bench at the confluence of two rivers flowing in deep *quebradas*. The perimeter of the bench is protected by a defensive parapet and 50 or more buildings of typical Inca design are scattered both within and beyond the fortified area. Of those structures inside the wall, one, called the Great Hall, stands out (Figure 4; Figure 5, Building 1). It is not mentioned specifically in any of the chronicles of the period. However, its enormous size and position of prominence facing onto the main plaza suggest both that it was an especially important building, designed to impress onlookers, as well as accommodate large crowds and serve its functional purposes, whatever they may have been.

Inkallacta was presumably abandoned at the time of the conquest and lay more or less undisturbed until 1913, when it was visited by Erland Nordenskiöld, a Swedish anthropologist then exploring the Inca frontier in southeastern Bolivia. His description of the ruins (1924) was the first by a European scientist, and was followed in 1927 by the account of a subsequent visit by Don Jesús Lara, a Bolivian from Cochabamba. An updated version of Lara's report was re-published in 1967 and again in 1988. In it, he reviewed various other assessments of the site published

in the four decades since his 1927 expedition. Among other things, Lara concluded that the efforts of some of his colleagues over the years to identify Inkallacta with the "lost" fortress of Cuzcotuyo (Sarmiento 1907 [1572]:165), and thereby endow the site with a bit of romantic history, were "in error" (Lara 1988: 61). The probable site of Cuzcotuyo is about 250 km southeast of Inkallacta, at a ruined hillfort now called Inkapirca (Lee 1992).

A detailed inventory of Inkallacta was done in 1976 by Gonzáles and Cravotto in connection with its designation as a World Heritage Site by UNESCO (Gonzáles and Cravotto 1977). In 1980, Gasparini and Margolies included a description of the Great Hall and a brief analysis of its roof structure in their comprehensive study of Inca architecture (1980:207-212). Aside from Santiago Agurto Calvo's generic speculations on large Inca roofs (1987:236-251), Gasparini and Margolies' was the first and, until now, only such study ever done. David Pereira, Director of the Archaeological Museum in Cochabamba, cleared the entire site, including the interior of the Great Hall, shortly before my own visit in the fall of 1990. It was fortunate timing, because we were able to see critical features in the building's fallen west gable end that had previously been obscured by brush.

Layout of the Great Hall

Before beginning an analysis of the roof and other missing elements of the Great Hall, a close look at its floor plan (Figure 6) and walls (both standing and fallen) is instructive. For descriptive purposes, the building will be assumed to be oriented with its long axis east-west and its doorways opening to the south, although they actually face about 20 degrees west of south. The site slopes gently to the south as well, such that the rear, or north, wall retains about 4 m (13 ft) of grade. The floor inside the building slopes a third of a meter toward the doorways, through which one steps down another half meter out onto the plaza (Figure 7).

The long dimension of the building was limited by the terrain. A narrow passage separates its east end from the parapet overlooking the eastern *quebrada* and the west end is cut into the base of a steep, rocky hillside. A large drainage gutter behind the north wall collected runoff from that slope of the roof and directed it down around the west end of the building and out onto the plaza, well away from the eastern bluff, which heavy runoff might otherwise have undermined. Twelve doorways with windows midway between them are arranged symmetrically on the south facade. No doorway stands on the centerline of the building, but a small platform outside the door just east of center may have signified the principal entrance, or may simply be related to two large boulders that occur there.

Lower Walls

Below the gables, the masonry throughout is well fitted and chinked *pirca*, or fieldstones set in clay mortar. With the possible exception of some roughly-shaped corner quoins and lintels, there is no cut stonework anywhere in the building. Nevertheless, it remains in remarkably good condition. The relative isolation of the site has no doubt saved it from the casual vandalism and pilfering of building materials common in more populated areas. Vestiges of a thick coat of hard, salmon-colored plaster remain in several niches (Figure 8) and inside the northwest corner (Figure 9). The many pebbles inserted into the wider joints to provide purchase for the plaster have incidentally served to retard weathering of the exposed mortar.

Except for the west gable end, which has collapsed completely, most structural damage to the lower walls has resulted from fallen lintels. They are missing from a number of the 44 equally spaced niches in the north wall, which is otherwise intact, and from all of the doorways and windows in the free-standing south wall (Figure 10), which has suffered badly as a result (Figure 11). The lack of long stones in the debris around the south doorways or elsewhere in the building suggests that

stones to cap the niches and windows were scarce and blocks long enough to span the doorways may have been unavailable. Wood poles, since decomposed, were probably used instead.

Another factor that may have contributed to the deterioration of the south wall is thrust from the south eave of the roof. Unlike the vertical surfaces elsewhere in the building, the south facade is battered noticeably back as if to resist lateral forces. Whether the battering commonly seen in Inca architecture was intended for this purpose is unknown, however examples exist that strongly suggest it sometimes was (Lee 1988b:10-11). In this case, thrust would have accelerated cracking and disintegration once the thatch began to rot and allow water into the top of the wall. On the north side, similar damage was resisted by the greater strength inherent in the design. Grade retained behind the wall offset the effects of thrust from the north eave and there were no doors or windows below to weaken the masonry.

Except on the south, all the walls retain (or retained, at the fallen west end) some amount of grade. Behind the north wall, it varies from about 4 m (13 ft) at the northeast corner to 3 m (10 ft) at the northwest end. Down the outside of the gable ends, these depths decrease to a bit more than 2 m (7 ft) at the southeast corner and zero at the southwest. All these walls would have been strengthened by being thicker at their bases than at their tops, yet none shows evidence of battering. Instead, the heights above floor level of the many interior niches vary approximately in proportion to the depth of retained grade behind the walls. The result is that the northern niches seem inconveniently high -- at or above eye-level -- and those near the south corners are less than half a meter above the floor (Figures 7, 9). Also, the pattern of the stonework sometimes shows a faint line in the joints connecting the base of one niche to that of those adjacent to it (Figure 12).

Susan Niles has shown that the Incas sometimes built niched walls that maintain full thickness up to the bases of the openings,

and then are stepped out to the plane of the niche-backs (1987). This allowed the builders to finish the niches at their leisure, meanwhile getting on with the rest of the work. This technique also provided a strong base for the wall from the outset. This was exactly the detail needed for the retaining walls of the Great Hall, and both the variable heights of its niches and the pattern of its stonework suggest that Niles' technique was used there (Figures 13, 14). In fact, the advantage of this system was especially important at Inkallacta, because the backfilling of earth around the outside of the building could have proceeded sooner in the process and simplified access to the walls by plasterers, roofers and other workers (Figure 15).

A curious detail occasionally seen in well preserved, but smaller Inca buildings elsewhere is also present in the Great Hall. Empty pockets still evident in the stonework indicate that meter-long, 20 cm (8 in) diameter wooden poles once spanned diagonally across each interior corner, about 4 m (13 ft) above the floor on the north (Figure 9) and 3 m (10 ft) in the south. The purpose of these poles has never been proven, but it has been suggested that they strengthened the masonry, provided points of anchorage for the roof or were for hanging interior appointments of some sort. In small buildings, any of these ideas might be feasible. At Inkallacta, however, the size of the walls, roof structure and interior space seems to render the poles insignificant for any of those purposes. Instead, the fact that their height above floor level inside roughly mirrors finished grade outside suggests they had some function related to the construction of the building rather than to the finished product.

We know from buildings abandoned during construction elsewhere (there is a clear example among the *chullpas* at the site of Sillustani on Lake Umayo) that Andean stoneworkers, like masons today, built their corners first and then filled in between. Nowadays, batter boards are first erected outside the building perimeter from which lines are strung to establish perfectly square corners with straight walls between them. The

walls of the Great Hall are straight, but as with Inca buildings elsewhere, the corners are only roughly square. A layout method that would account for this might also explain the corner poles. If the corners were laid up first and fitted with the poles near their tops, then string-lines connecting the poles would establish perfectly straight interior wall faces between only approximately square corners. Such lines might also have been used to assist in laying out niches and other openings by the use of sliding, quipu-like plumb lines to establish their locations for the finish masons (Figure 14).

Upper Gable Ends

The cross section of a building's roof, and thus the configuration of its roof structure, are usually reflected in the shape of its gable ends. For this reason, most speculation to date has focused on the gable walls of the Great Hall. Although most of the west end has collapsed, the east end still stands more than 8 m (25 ft) high (Figure 19) and portions remain of all four gable corners (Figures 16, 17). By projecting the steep, finished corners upward to their intersections in space, the original height of the apex would have been about 20 m, or 66 ft (Figure 7). By comparison, the still intact ridge of the slightly larger Temple of Wiraqocha at Raqchi rises to only about 12 m (40 ft). Because it is clear from the standing east gable that the stonework gave way to adobe above the 7.5 m (25 ft) level, researchers have wondered whether such a high, largely adobe wall was structurally feasible. Gasparini and Margolies solved the problem by disregarding the standing corners and projecting instead a low-pitched gable of modest height. In addition, they abstracted the layout of the niches and upper gable openings, projecting a symmetry not found in the building itself (compare Figures 7 and 18).

The actual layout of the east gable wall recalls the design of the *kallankas* at Huánuco Pampa (Figure 2, Cross Section XX). At Inkallacta, four man-sized openings pierce the stonework just above eave level. As at Huánuco Pampa, they are horizontally symmetrical about the centerline of the

building, but they are progressively lower towards the front or south side. In the Great Hall, their slope approximately matches that of a line connecting the corner poles discussed earlier, as well as the grade outside the building and the bases of the niches inside (Figure 7). Possibly Gasparini and Margolies assumed the visual "sag" of this wall to the south was the result of uneven settling beneath the structure's foundations, but the lack of any cracking or other damage to the masonry (Figure 19) suggests rather that the slope of all these features toward the front of the building was intentional.

Of the four gable corners, the southeast stands tallest and shows about 3 m (10 ft) of intact wall above eave height. In typical Inca fashion, four stone pegs protrude from the exterior face of the wall about a meter apart and almost a meter below the top (Figure 17). For the first two m (6-1/2 ft), the top of the wall rises at a uniformly steep angle matching the smaller remnant still visible at the southwest corner (Figure 16), as would be expected. Above 2 m, however, the southeast corner lays back to an angle slightly less steep. The fourth and highest of the stone pegs reflects this subtle change, as may be seen from its shadow in Figure 17. None of the other corners being high enough to confirm whether the subtle change was an intentional feature or just the result of uneven building, this detail was not previously thought significant.

After walking over the west end of the building for several days, we suddenly realized that the west gable end had fallen almost entirely intact (Figures 6, 20). The stones extended the same distance out from the original base of the wall as the stonework did above the base of the standing east end, so it was clear that the west gable had not only collapsed in one piece, it had not been distorted by the fall. Even the four openings may be seen in roughly their correct positions (Figure 6). Beyond the fallen stones, a distinct mound of dirt still shows where the adobe upper part of the wall fell. Unlike the east end, where the adobe has melted into a formless pile, the fallen west end retains an

even, rounded shape out to an apex about 7.5 m (25 ft) beyond the stonework. This suggests that the original gables were about 15 m (50 ft) high and were made of adobe in their upper halves. Viewed together with the subtle reduction in the steepness of the southeast gable corner, the rounded profile of the fallen west gable confirms that both became progressively less steep toward the apex of the roof. For the first time, we have a good idea of the design and height of the Great Hall's original gable ends. Assuming that they reflect the shape of the building's roof structure, we are now better able than ever before to analyze how it was framed.

Roof Framing

It is theoretically possible that the roof was framed by some sort of trusswork spanning from eave wall to eave wall, without interior supports, as suggested by Agurto Calvo (1987:241), but there are good reasons to think otherwise. We have seen that less than half the width of the Great Hall required a line of posts at Huánuco Pampa and there is no mention of a knowledge of truss design in any of the chronicles. Finally, a clear-span system is most easily supported by eave walls of equal height and would impart no outward thrust at its bearing points, yet the eave walls at Inkallacta differ nearly two m (6 ft) in height and the south wall is battered inward, seemingly against thrust.

Assuming, then, that posts were used, their layout remains open to question until excavations uncover firm evidence. Gasparini and Margolies proposed a system with three rows of columns completely unrelated to even their stylized version of the gable ends (Figure 18). From what we now suspect is the true shape and design of the gable ends, it is possible to make a better informed guess. At Huánuco Pampa, the posts were placed along the centerline of the building with aisles about 6 m (20 ft) wide to either side (Gasparini and Margolies 1980:204-205). The openings in the upper gables are roughly centered in these aisles (Figure 2, Cross Section XX). If a similar layout was used at Inkallacta, there would be five rows of posts, with one down

the centerline, beneath the ridge, and the others at the third points to each side. The aisles between the rows would be about 4.5 m (15 ft) wide, except at the front and back, where the thickness of the eave walls would reduce aisle width by more than half. The gable openings would appear approximately centered in the four middle bays, as would the pairs of niches in the end walls below (Figure 21).

Horizontal poles, or purlins, attached to the tops of each line of posts could have been set to reflect the profile of the gable ends by adjusting the post heights accordingly. As if to confirm this idea, the southern-most row of posts would line up with the slight reduction in the slope of the southeast gable corner noted earlier (Figure 22). If a similarly small reduction occurred in line with the second row of posts, the resulting apex at the centerline would have been about 15 m (50 ft) above the floor (Figure 21), exactly where the fallen west gable suggests that it was. Indeed, using straight framing members like poles, there would be no other non-trussed way to frame a roof of progressively decreasing pitch.

Similar to the "Dutch" or gambrel barn roofs common in rural America, the system proposed here not only resembles the profile of the Cuyusmango recorded by Guaman Poma (Figure 3), but would have been a good design on several counts. The steep pitch at the eaves reduces thrust onto the tops of the eave walls and creates headroom for the outer-most gable openings, while the lower pitch in the center allows for lower gable walls and eliminates unnecessary interior volume, framing materials and thatch. Even so, 12 and 15 m (40-50 ft) high posts would have been required in the inner rows, although they might have been spliced from shorter members the way tall, wooden ship's masts were a century ago. In any case, lateral bracing would have been needed to prevent failure by buckling, especially at the splices, if any. Again, the masonry suggests how this might have been accomplished.

The four upper gable openings have been assumed to be windows by most authorities to

date (Gasparini and Margolies 1980:208). Like those at Huánuco Pampa, however, they were large enough to have been small doors, and if so, the stepping downward of their sills makes sense. In so doing, the sill heights reflect the sloping grade outside the building and are between 4 and 5 m (13-16 ft) above the floor inside, about the right height for the first level of bracing between the posts. To be effective, such bracing would have to steady the posts both laterally (N-S) and longitudinally (E-W). If post-to-post braces running N-S were covered with a continuous layer of smaller poles laid E-W at the level of the door sills (Figure 21), the posts would be supported in both directions and an easily accessible layer of scaffolding would result inside the gable ends, simplifying construction of both the high gable walls and upper level pole and roof work (Figure 15).

To be strong enough to act as floor beams without becoming excessively thick and to provide bearing for butt joints in the layer of scaffolding poles above, the N-S braces would likely have been double logs, about 30 cm (12 in) in diameter, with one on either side of the posts (Figure 15). To avoid excessive length, these beams would have spanned only from one post to the next, a distance requiring 6 m (20 ft) poles. This means that they would have necessarily been offset vertically at least one log thickness at each post. This offset could take several forms, but the proposed scheme is suggested by the fact that each door sill steps down about 30 cm, or one beam thickness, from the door to its north. Scaffolding poles bearing on beams offset as shown would therefore exactly match the descending elevations of the door sills (Figure 21). Assuming such scaffolding was used, there is no way to tell whether it extended the full length of the building or, whatever its extent, whether it was retained in the finished building as a permanent loft or removed once construction was complete. If full length and left in place, it would have increased usable floor space by more than 40%--an attractive feature, one would think.

Next is an estimate of the longitudinal (E-W) spacing of the posts. Two factors suggest

the layout proposed here. The entire weight of the roof was almost certainly carried by horizontal purlins spanning longitudinally (E-W) between the tops of the posts. As with the logs supporting the loft described above, the diameter and length of these purlins were limited by practical considerations such as availability, weight and manageability. Also, there is a direct relationship between their size, strength, span and load. Any one is given by fixing the other three. Garcilaso claimed that the best Inca thatchwork was typically heavy, sometimes as much "a fathom" thick and extended "a yard" beyond the exterior walls (1987 [1609]:321). Based upon this and other similar reports in the chronicles, I have conservatively assumed about a meter of dry *ichu* grass over a pole framework, which gives a load of about 50 lbs/ft². At Huánuco Pampa (Figure 2), the ridge purlins spanned a bit less than 10 m (30 ft) and if similarly loaded and done with an average grade (1200 psi) of structural timber, would have been about 35 cm (14 in) in diameter. The same sized logs used at Inkallacta would have spanned only about 6 m (20 ft) due to heavier effective loading resulting from the lower pitch of the roof. With this in mind, we might expect that the posts in the Great Hall were somewhat closer together than those at Huánuco Pampa.

Another difference between the halls of Huánuco Pampa and the Great Hall may have influenced longitudinal spacing as well. At Huánuco Pampa the posts bear no relationship to the spacing of the doors, but are nearly 5 m (16 ft) inside the building and well out of the way of people entering and leaving. At Inkallacta, the southern-most row of proposed posts is only 2 m (6-1/2 ft) inside the south wall and the E-W post spacing may therefore have been coordinated with the doorways to avoid interference with traffic. Because the doors are 5.5 m (18 ft) apart and this spacing is close to the 6 m purlin span suggested above, the layout proposed here places the posts 5.5 m apart, midway between the doors (Figure 23). At first glance, this seems to create a forest of posts, but the large scale of the building is deceptive. To get a better feel for the space between the posts, refer instead

to the sketches with people in them (Figures 15, 21, 22).

Before turning to the roof covering, there is another important, if largely conjectural, aspect of the framing to be noted. The upper portions of the three tallest rows of posts would have required bracing above the loft level. The lateral X-bracing suggested here (Figure 21) would have been needed longitudinally as well. It is simple, effective and utilizes relatively lightweight poles of manageable length, but there is no way to know what method the Incas actually used.

Roof Covering

With the timber frame erected, the next step in construction was the thatchwork. Based upon analysis of the unique and well-preserved masonry detailing of the Incahuasi at Puncuyoc, in the Cordillera Vilcabamba (Lee 1988a), the thatch was applied over a layer of small, horizontal poles supported on vertical rafters lashed to the horizontal purlins spanning between the posts (Figures 15, 21, 22, 24, 25). Being about 7 m (23 ft) long, the rafters would have been spaced to reduce the span of the polework above and to keep their own size and weight within manageable limits. The only other clue we have as to their probable layout is the configuration of the south eave wall. It was penetrated by numerous doorways, windows and niches (Figures 10, 11) that reduced its strength and resistance to loading from above, especially directly above the lintels. The safest place for the rafters to bear would have been between the openings, where the wall was strongest (Figure 15, arrows), or about 1.4 m (4-1/2 ft) apart. Loaded to 50 lbs/ft², they would have been about 20 cm (8 in) in diameter. Horizontal poles about 5 cm (2 in) thick lashed atop the rafters every 30 cm (12 in) would have been needed to support the thatch. If installed progressively as the supporting structure underneath was erected, the poles would also have turned the entire roof into a giant ladder, facilitating the movement of men and materials up onto its higher reaches (Figure 22).

The only example of Inca thatchwork known to have survived into relatively recent times was the dome-shaped roof of the Suntorhuasi at Azángaro, Peru. During his visit there in 1864, George Squier observed a decorative, woven ceiling mat between the polework and the underside of the thatch (1973 [1877]:394). His photograph and drawings of the exterior show heavy, multi-layered thatch and neither they nor his sketch of the interior indicate any attachment between the roof and masonry, despite what appear to be two projecting "pegs" high on the inside wall (McElroy 1986:102). The features Squier reported were probably also typical of other important Inca buildings. Assuming this, the mat would have been fastened to the polework at the eaves, as it appears to have been at Azángaro. On buildings with pitched roofs, however, the gables at Puncuyoc suggest that the mat extended flush out onto the tops of the gable walls, secured to the recessed "eye bonders" sometimes found there (Lee 1988a).

This implies that the top of the polework was flush with the tops of the gables, as shown here (Figure 22). Contrary to the speculations of Bingham (1979 [1930]:78) and others, the polework was not typically attached to the gable walls (Puncuyoc is an exception, due to its exposure to high winds). At Inkallacta, the upper gables were mostly adobe, a material able to support little more than its own weight in simple compression and ill-suited to attachment of anything applying lateral forces. Significantly, there are no eye bonders atop the gables of the Great Hall. Probably, there was no woven ceiling mat above the polework—an understandable omission, given that the building would have been quite dark inside, a loft might have obscured view of the underside of the roof from most of the ground floor, and a mat would have been nearly as large as a football field.

Squier also observed that the thatch of the Suntorhuasi was composed of alternating layers of ichu grass and a coarser, net-like lathwork used to hold it together (1973 [1877]:395). Analysis of Puncuyoc suggests

that this mass extended out over the tops of the gable walls and down to the stone pegs protruding from the exterior face of the gables, where it was secured (Lee 1988a). The pegs at the Great Hall are almost a meter (3 ft) down from the tops of the gables, probably to insure sufficient anchorage into the adobe, a material inherently less secure than well fitted stonework.

Finally, consistent with the observations of various writers (Markham 1862:193-194; Squier 1973 [1877]:395; Pizarro 1978 [1571]:161-2; Garcilaso 1987 [1609]:321) both the weather surface and the eaves of the finished thatch would have been neatly trimmed, with the latter providing a generous, sheltering overhang above the south doorways (Figures 21, 22).

Construction Sequencing and Coordination

As with any large, complicated construction project, building the Great Hall involved the efforts of numerous trades peripheral to the work already described, but equally important to the finished product. Based upon their prolific output, Inca builders must have been particularly good at organizing these trades and coordinating their work efficiently. Presumably, work progressed simultaneously on as many fronts as possible, as long as the various trades did not interfere with one another. Activities which took place off-site, such as stone gathering, pole and grass cutting and rope making, needed only to be scheduled for proper support of the work at the building.

Other trades, however, such as earth movers, plasterers, painters and general laborers had to be coordinated with the masons, carpenters, lashers, and thatchers working within the structure itself. In the discussion of the lower walls, for example, it was suggested that the retaining walls were built first without niches so that earth movers could backfill outside the building while the masons completed the niches inside. This also provided for earlier and easier access to the upper parts of the work than was otherwise possible. Four crews of masons probably started at the corners and increased to eight or

more as they worked toward the centers of all four walls. A gap may have been left at the center of the south façade to facilitate erection of the interior posts. Otherwise, the large timbers required would have necessarily been lifted over the completed south wall or threaded through its narrow doorways.

Just as the masons worked inward from the corners, other trades probably did the same. Once walls were up, the carpenters, lashers and thatchers could have started from each corner of the roof and built inwards and upwards toward the center, such that four crews for each trade were always working concurrently. Meanwhile, as masons completed the interior niches, plasterers and painters (if any) could have begun finishing the masonry walls.

Finally, one of the most troublesome aspects of construction high above the ground is the time, material and energy consumed in moving men and materials up and down the structure and providing, moving and eventually removing the scaffolds necessary to their work. Great savings are achieved if these operations are simplified, minimized or eliminated. At the Great Hall, the building itself was probably designed at least partly with this in mind. The loft, with direct access through the gable doorways is one example. The lowering of the upper roof pitch and use of the polework as a giant ladder are others. None of these features required otherwise unnecessary work during construction or the removal of extraneous work afterwards.

Conclusion

The interior space of the Great Hall was large by any standard, then or now. The ground floor (Figure 23) contained 1737 m² (18,574 ft²), about the same as a large super-market or chain store. To this, the loft might have added an additional 1263 m² (13,505 ft²) of upper level storage or dormitory space. Probably, large public gatherings were reserved for the ground floor because of the heavy loadings involved and because access to the loft was so limited by comparison. How many people might the ground floor have

accommodated? A lot, probably, depending on how daunting were the conditions outside and how attractive were the activities inside. Absent safety rules limiting occupancy, people can and do crowd very closely on occasion. To prevent this, most modern (US) Building Codes set a limit of 15 ft² per person in an assembly hall without fixed seating. By that standard, the Great Hall would have had a capacity of 1238 people, with little space left over for whatever activity they were there to witness or participate in. From this we might assume that crowds numbering in the hundreds were not uncommon.

As with much of Inca architecture in general, the aesthetic appeal of the Great Hall as reconstructed here is more akin to that of present-day engineering or industrial building than to architecture in the Western sense. Like the Golden Gate bridge or any good New England barn, the Great Hall was true to its purpose (sheltered assembly, for whatever reason) and to the materials from which it was made, and its designers had the good sense and restraint to let it go at that. Nothing extraneous appears to have been added for decorative effect. The appeal of the design lay not so much in how it looked, though it was undoubtedly a handsome structure (Figures 26, 27), but in the clear and honest relationship between how it looked and what it was. In these plethoric times of pre-occupation with appearance before substance and fascination with guile and glitter, is it any wonder that the simple integrity of Inca architecture is often dismissed as the work of skilled dullards? Upon whom does that assessment ultimately shed the most revealing light?

References Cited

- Agurto Calvo, Santiago
1987 *Construcción, arquitectura y planimiento incas*. Lima: CAPECO.
- Ascher, Marcia and Robert Ascher
1981 *Code of the Quipu*. Ann Arbor: University of Michigan Press.
- Bingham, Hiram
1979 *Machu Picchu - Citadel of the Incas*. New York: Hacker Art Books. Originally published in 1930 for the National Geographic Society by Yale University Press, New Haven, and issued as No.1 of *Memoirs of the National Geographic Society*.
- Cobo, Bernabé
1983 [1653] *History of the Inca Empire*, translated by Rowland Hamilton. Austin: University of Texas Press.
- Garcilaso de la Vega, El Inca
1987 [1609] *Royal Commentaries of the Incas and General History of Peru*. Austin: University of Texas Press.
- Gasparini, Graziano and Luise Margolies
1980 *Inca Architecture*, translated by Patricia J. Lyon. Bloomington: University of Indiana Press.
- González, Alberto Rex and Antonio Cravotto
1977 *Estudio arqueológico y inventario de las ruinas de Inkallajta*. Paris: UNESCO.
- Guaman Poma de Ayala, Felipe
1936 [1615] *Nueva corónica y buen gobierno (del Perú)*. Facsimile edition. Paris: Institut d'Ethnologie.
- Lara, Jesús
1988 *Inkallajta/Inkaraqay*. La Paz and Cochabamba: Los Amigos del Libro.
- Lee, Vincent R.
1988a *The Lost Half of Inca Architecture*. Wilson, Wyoming: privately published.
1988b *Function, Form and Method in Inca Architecture*. Wilson, Wyoming: privately published.
- 1991 *Seven "Inca Pucaras" on the Bolivian Frontier*. Wilson, Wyoming: the author.
- 1992 Cuzco-tuyo -- the Search for a Lost Inca Fortress. *The Explorers Journal* 70(4):118-123.
- Markham, Sir Clements
1862 *Travels in Peru and India*. London: J. Murray.
- McElroy, Keith
1986 Ephraim George Squier: Photography and the Illustration of Peruvian Antiquities. *History of Photography* 10(2):99-129.
- Morris, Craig and Donald Thompson
1985 *Huánuco Pampa -- An Inca City and its Hinterland*. London and New York: Thames and Hudson.
- Niles, Susan
1987 Niche Walls in Inca Design. *The Journal of the Society of Architectural Historians* 46(3):277-285.
- Nordenskiöld, Erland
1924 *Forschungen Und Abenteur in Sudamerika*. Stuttgart: Strecker und Schroder.
- Pizarro, Pedro
1978 [1571] *Relación del descubrimiento y conquista de los reinos del Perú*. Lima: Pontificia Universidad Católica del Perú.
- Sarmiento de Gamboa, Pedro
1907 [1572] *History of the Incas*. London: Hakluyt Society, Second Series 22.
- Squier, Ephraim George
1973 [1877] *Peru: Incidents of Travel and Exploration in the Land of the Incas*. Reprint. New York: AMS Press.



Figure 1. Location of Inkallacta.

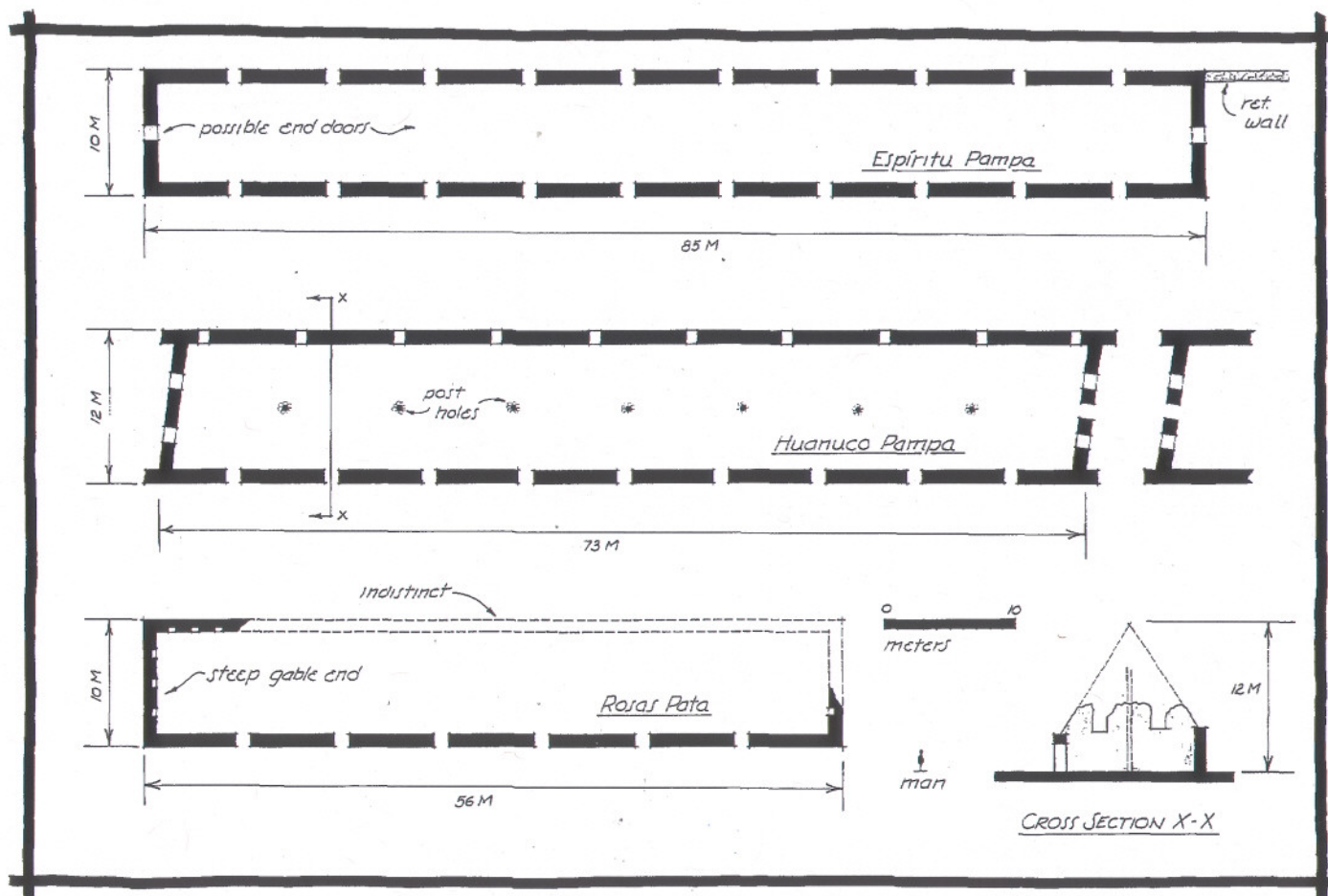


Figure 2. Plans of kallankas from different Inca sites.



Figure 3. Royal palace at Cuyusmango in Cusco, after Guaman Poma de Ayala (1936 [1615]: 329 [331]).



Figure 4. Great Hall at Inkallacta from the west.

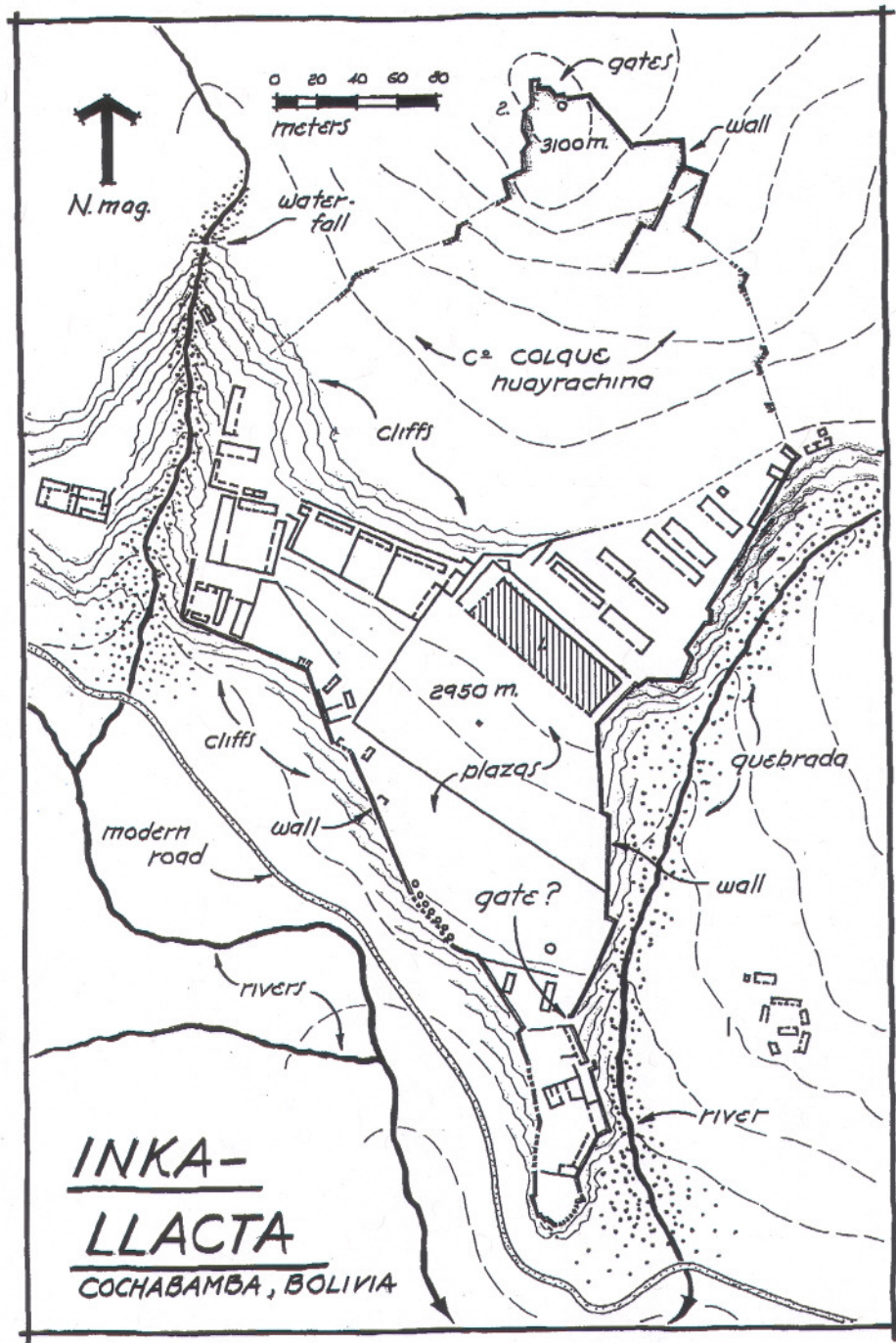


Figure 5. Plan of Inkallacta, with Great Hall shaded.

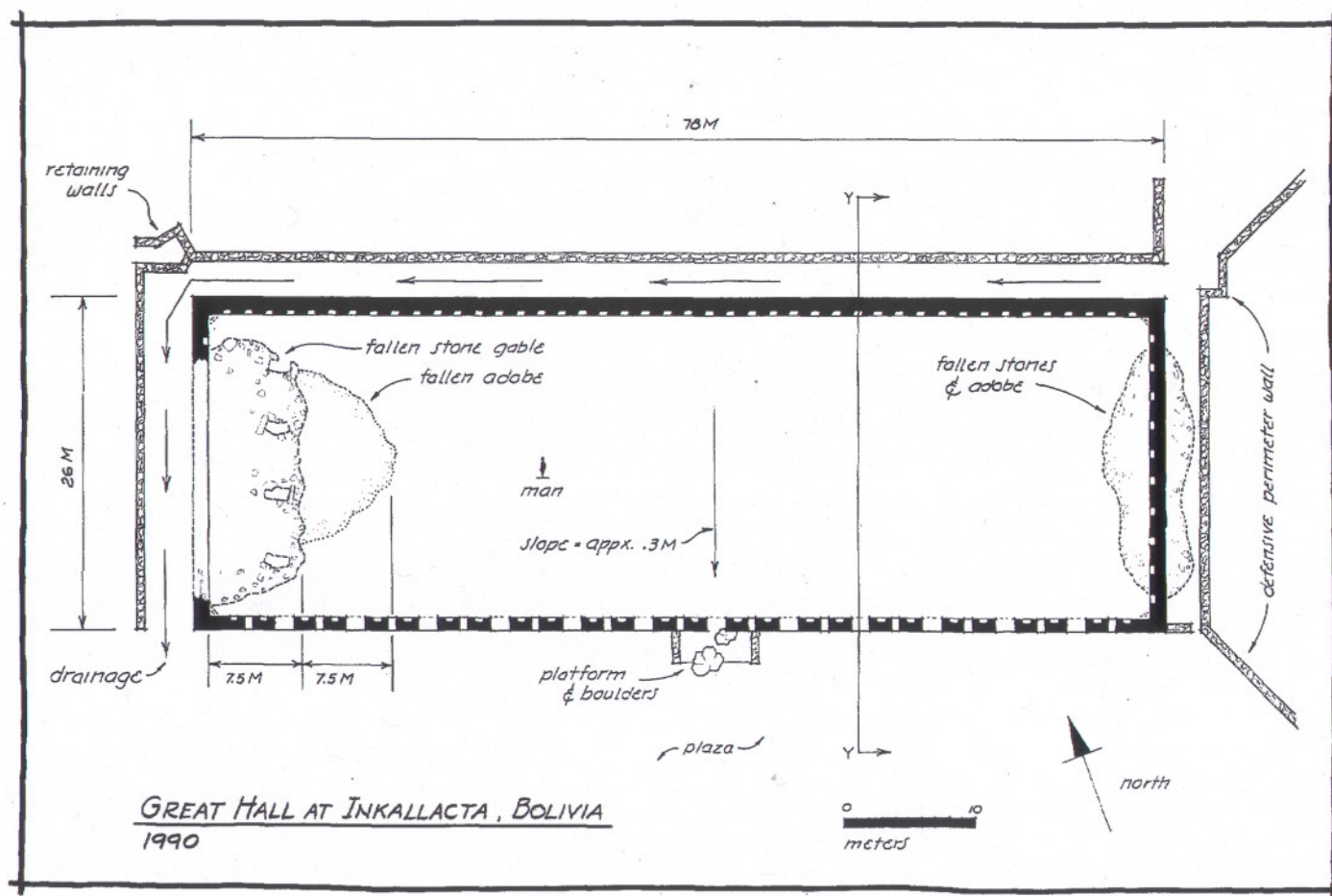


Figure 6. Existing floor plan of Great Hall at Inkallacta.

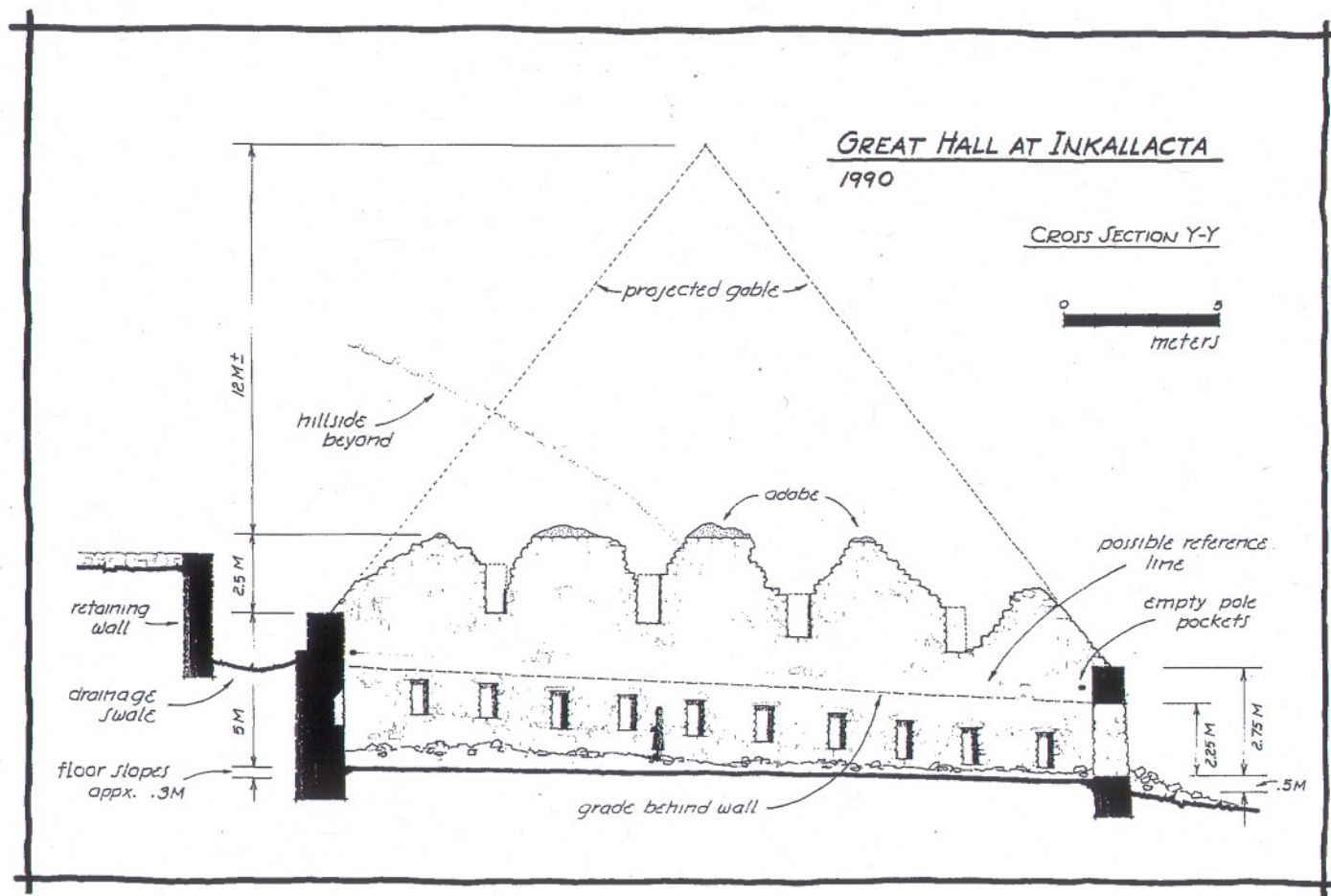


Figure 7. Existing section through Great Hall at Inkallacta, looking east.



Figure 8. Plastered niche in Great Hall at Inkallacta.



Figure 9. Plastered northwest corner in Great Hall at Inkallacta.

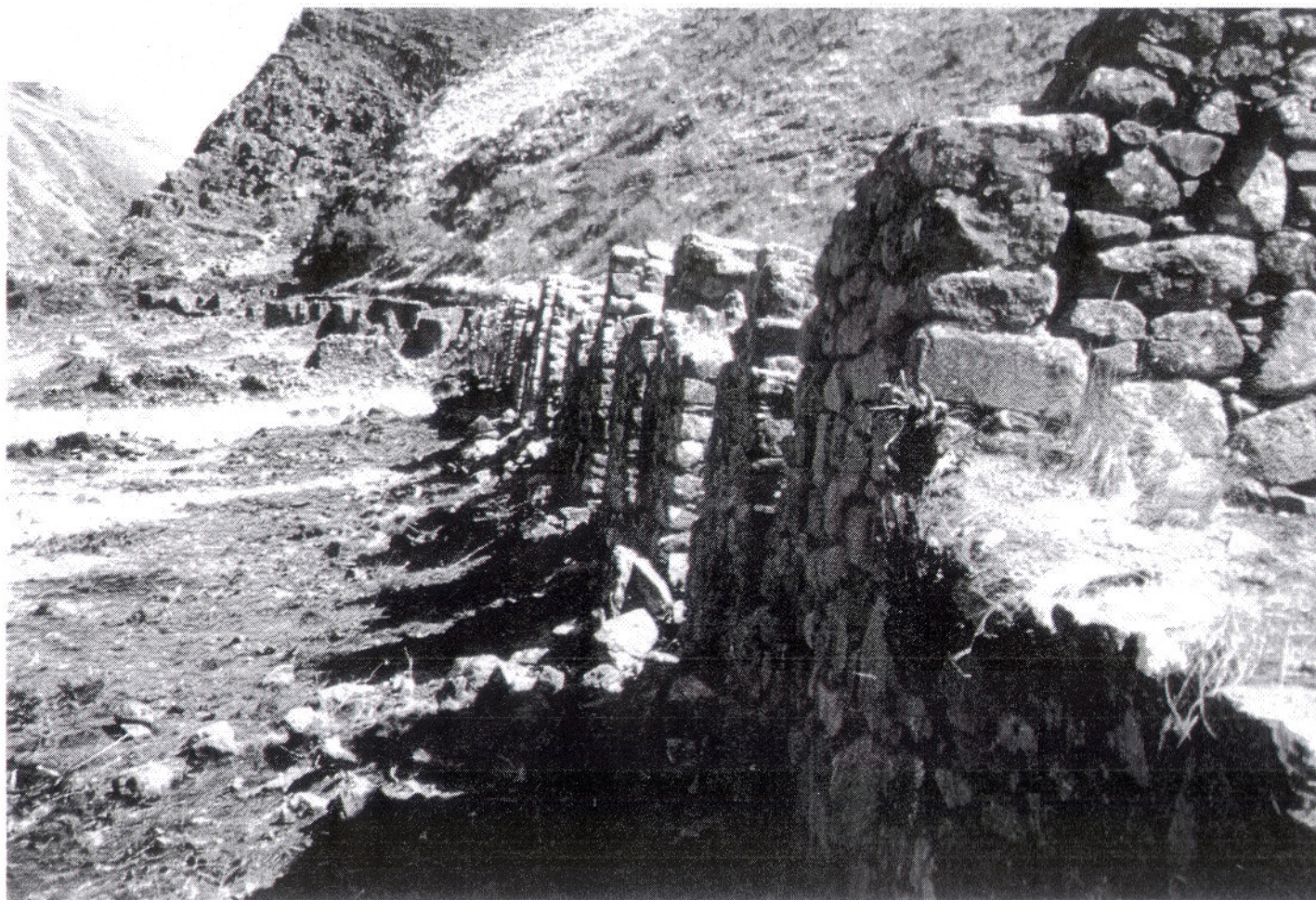


Figure 10. Free-standing south wall of Great Hall, Inkallacta.



Figure 11. Damage to the south wall of Great Hall, Inkallacta.



Figure 12. Niches in the north wall of the Great Hall at Inkallacta.

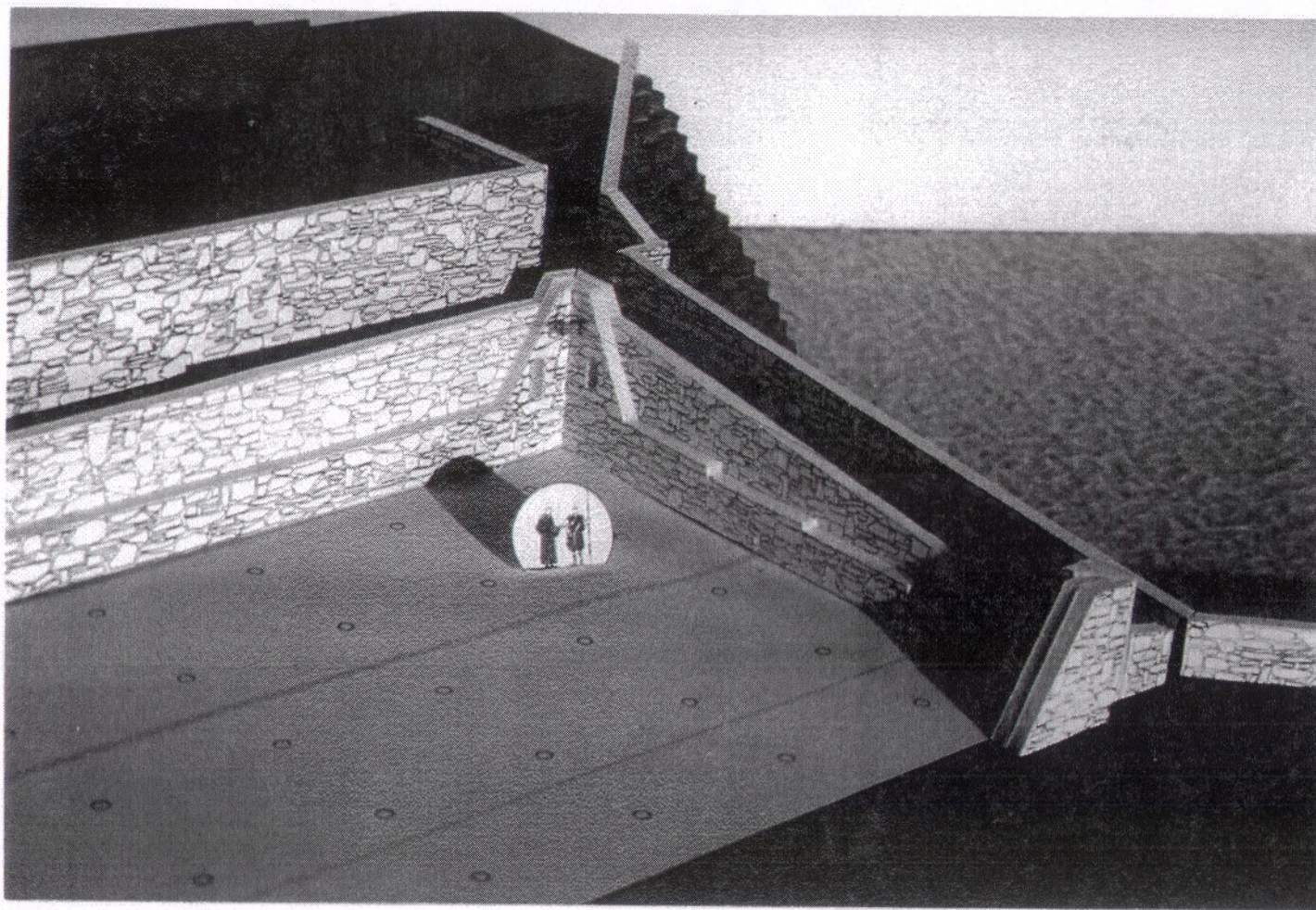


Figure 13. Stepped construction of Great Hall walls (model).

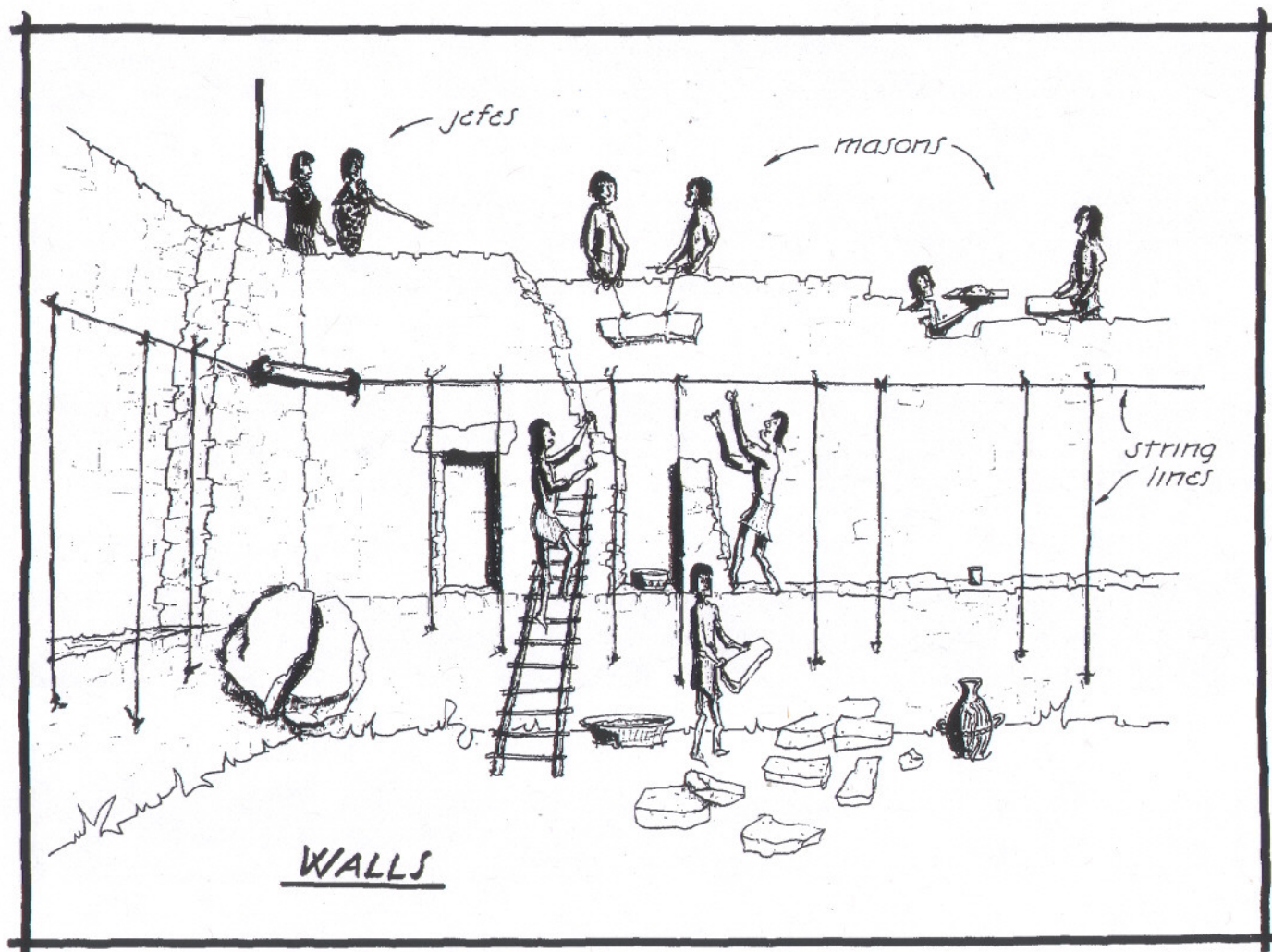


Figure 14. Suggested wall construction techniques using string lines.

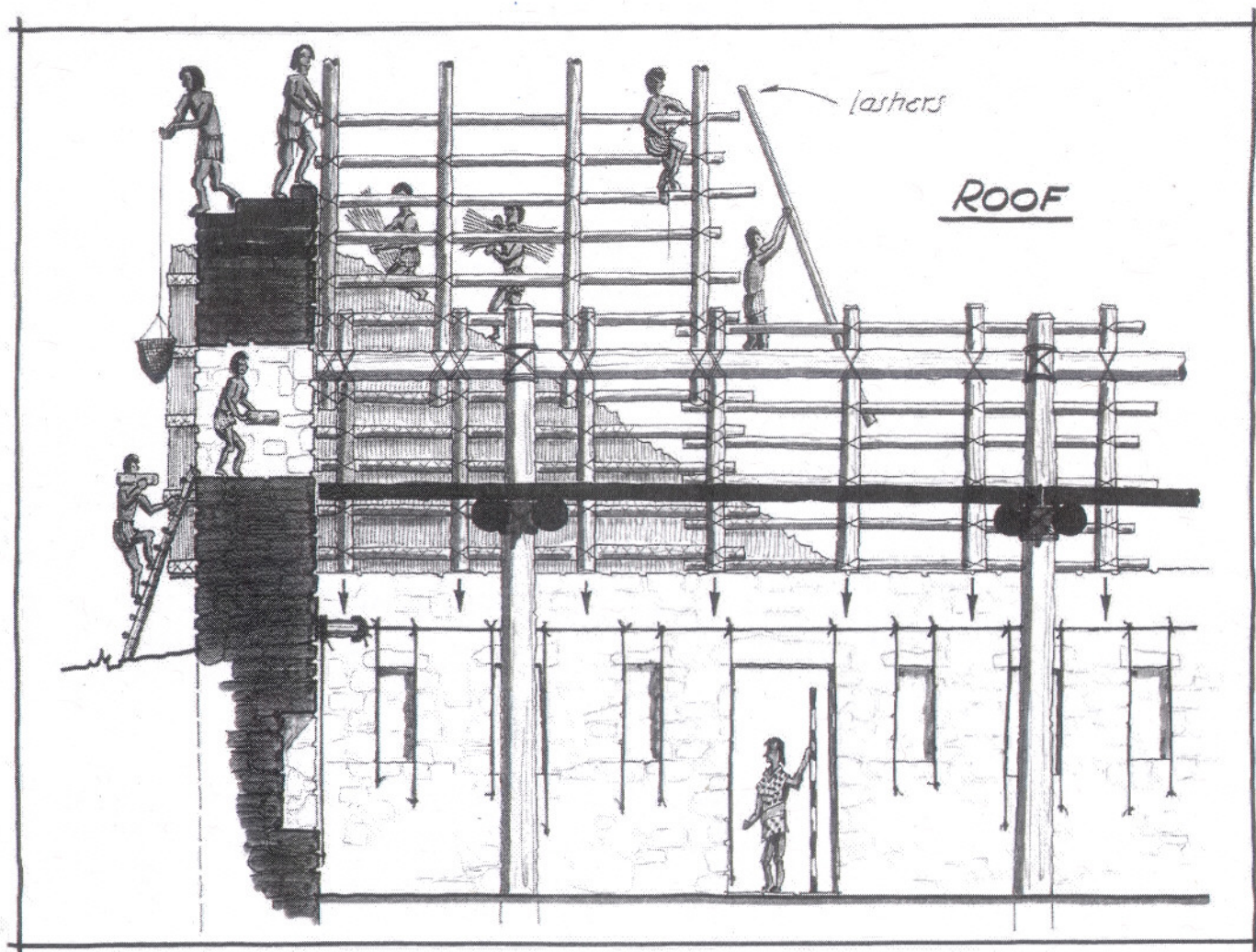


Figure 15. Suggested roof and loft framing at east end of the Great Hall, Inkallacta.



Figure 16. Southwest gable corner, Great Hall, Inkallacta.



Figure 17. Southeast gable corner, Great Hall, Inkallacta.

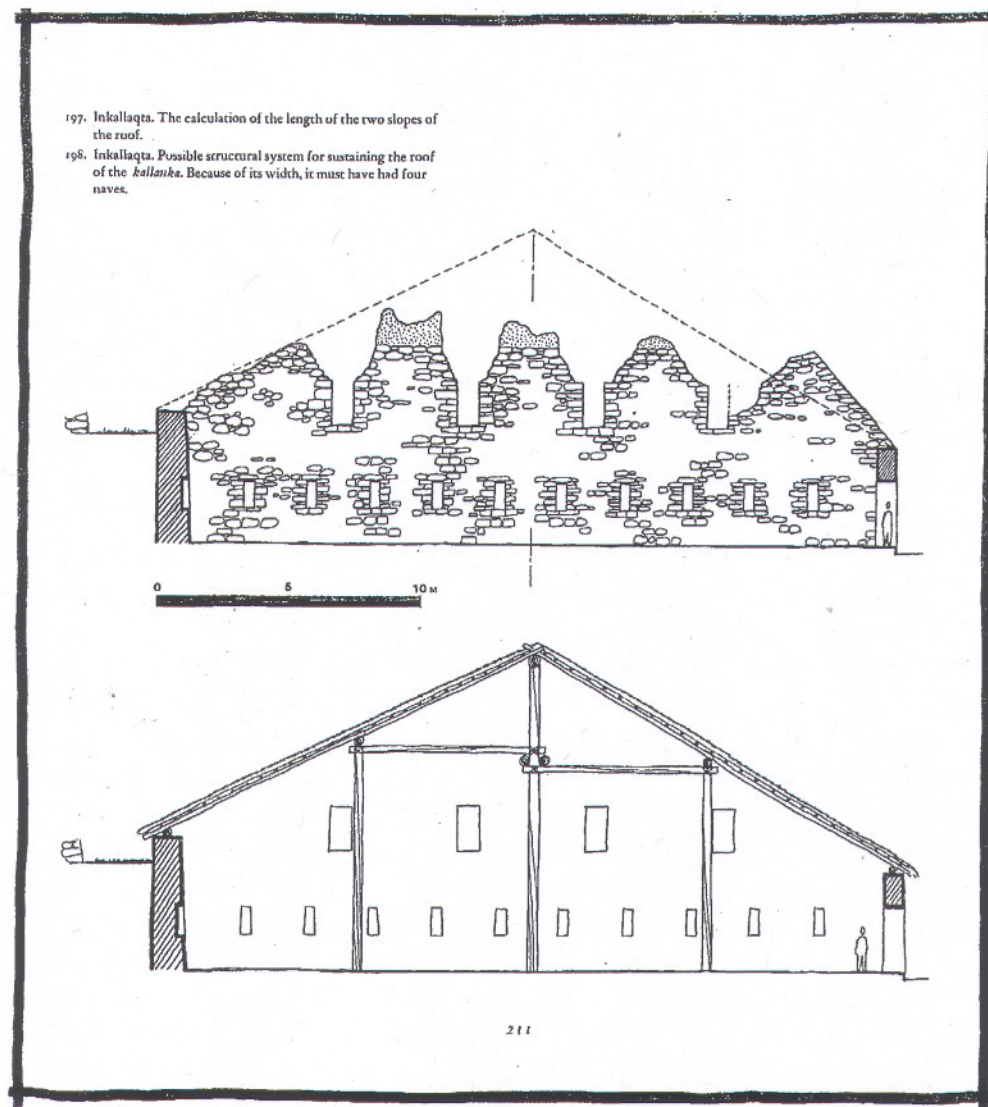


Figure 18. Reconstructions of gables at Inkallacta (from Gasparini and Margolies 1980:211).



Figure 19. East gable end of Great Hall at Inkallacta.

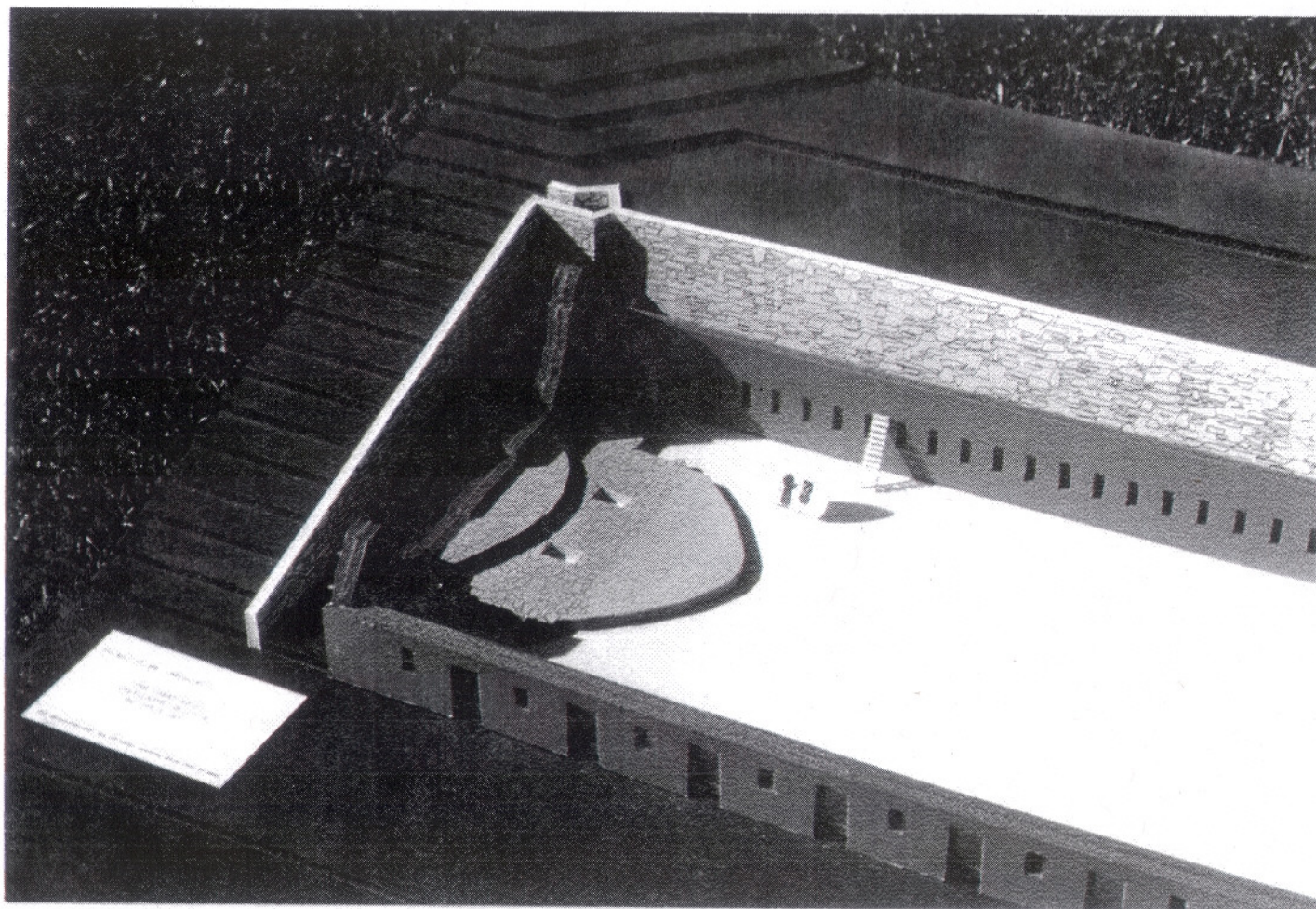


Figure 20. Fallen west gable end of Great Hall at Inkallacta (model).

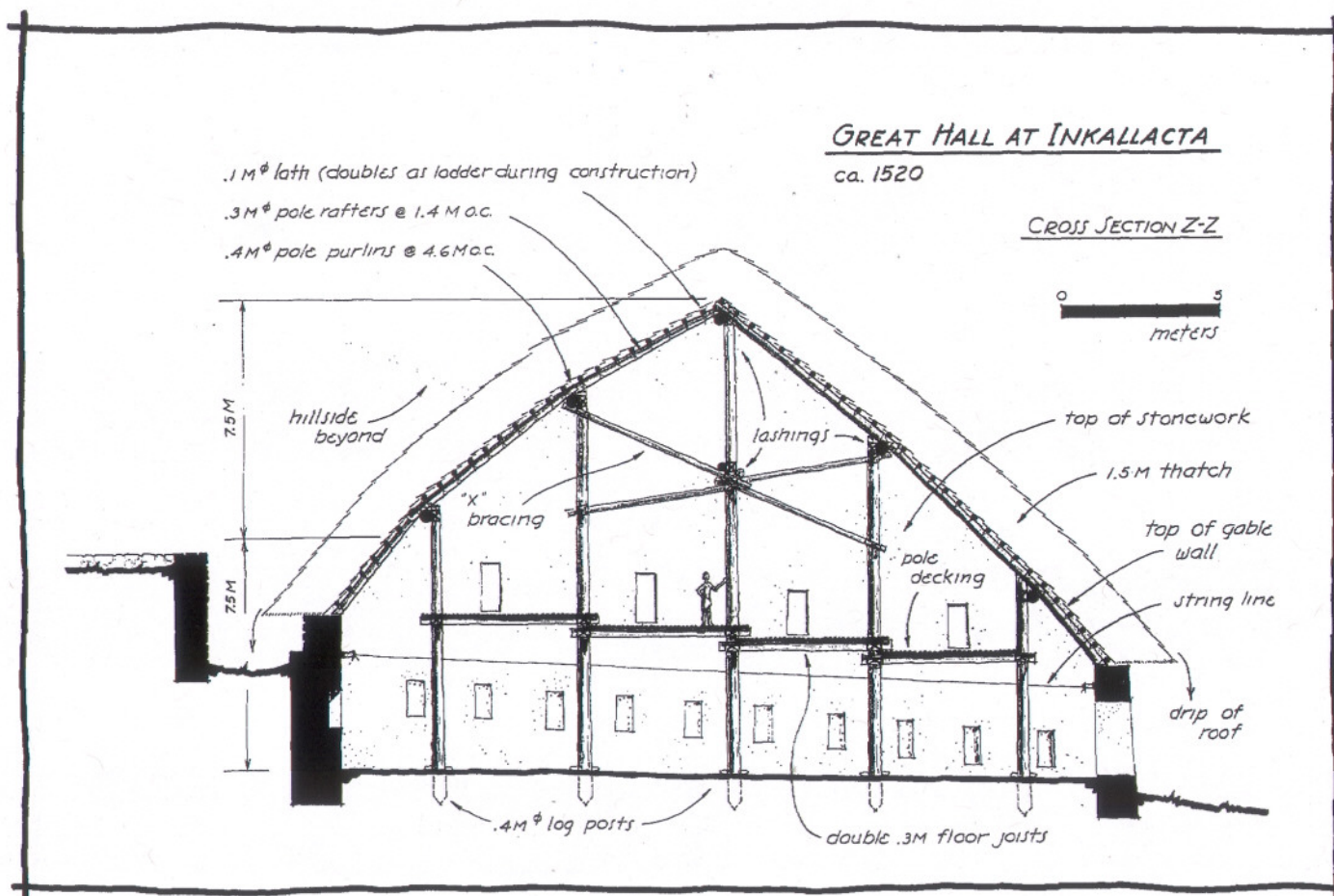


Figure 21. Proposed section through Great Hall, Inkallacta, looking east.

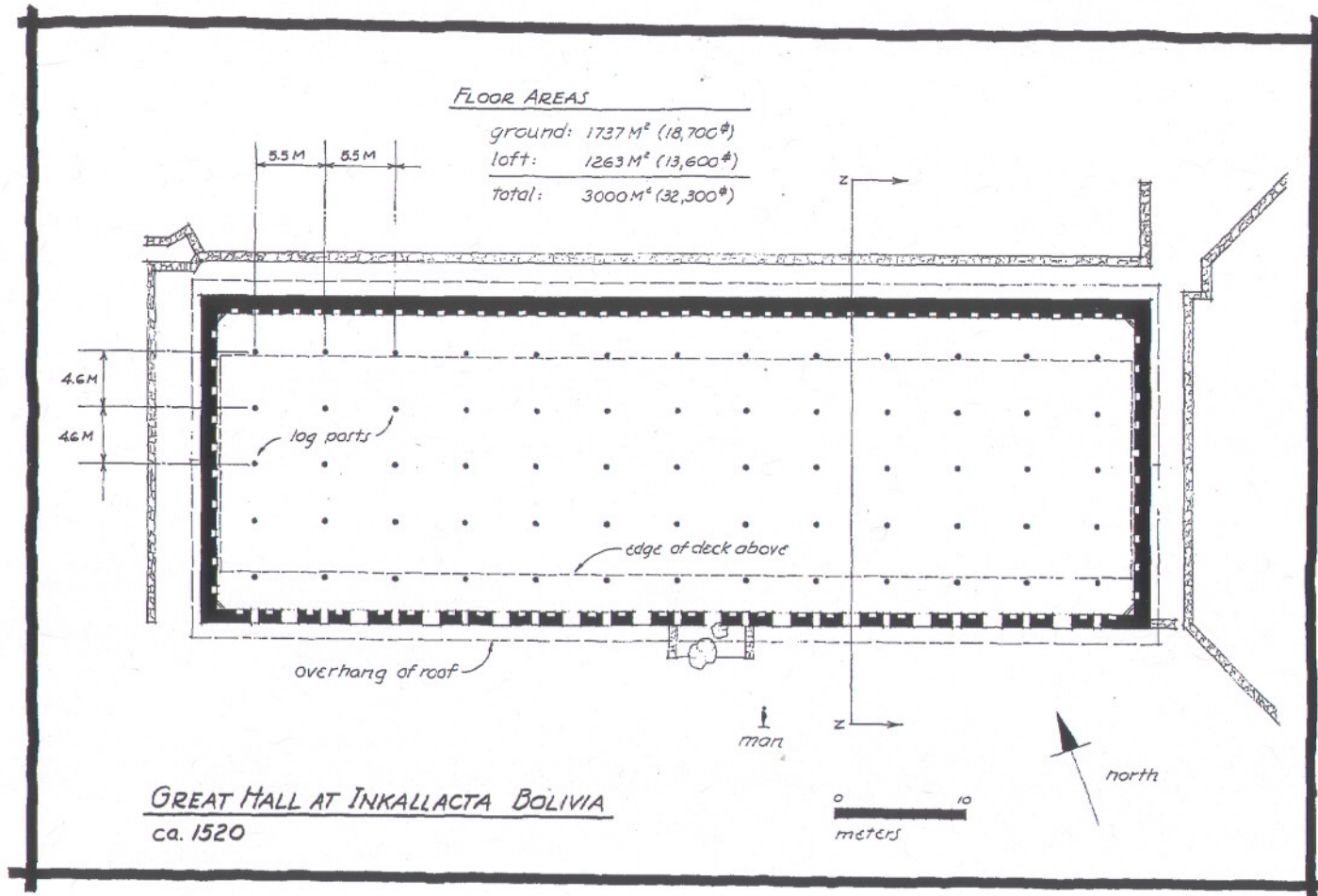


Figure 23. Proposed floor plan of the Great Hall, Inkallacta, showing suggested post locations

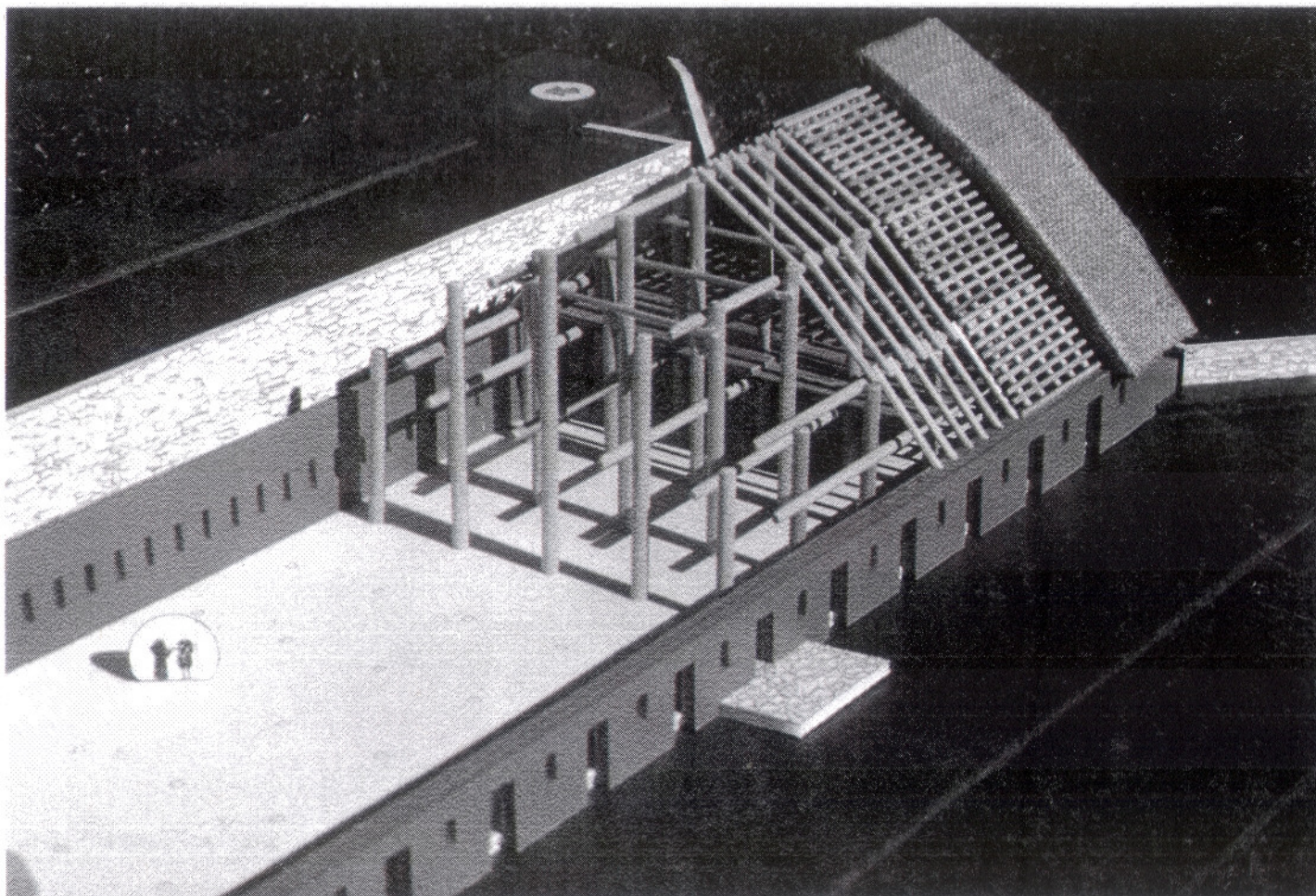


Figure 24. Proposed roof construction of the Great Hall, Inkallacta (model).

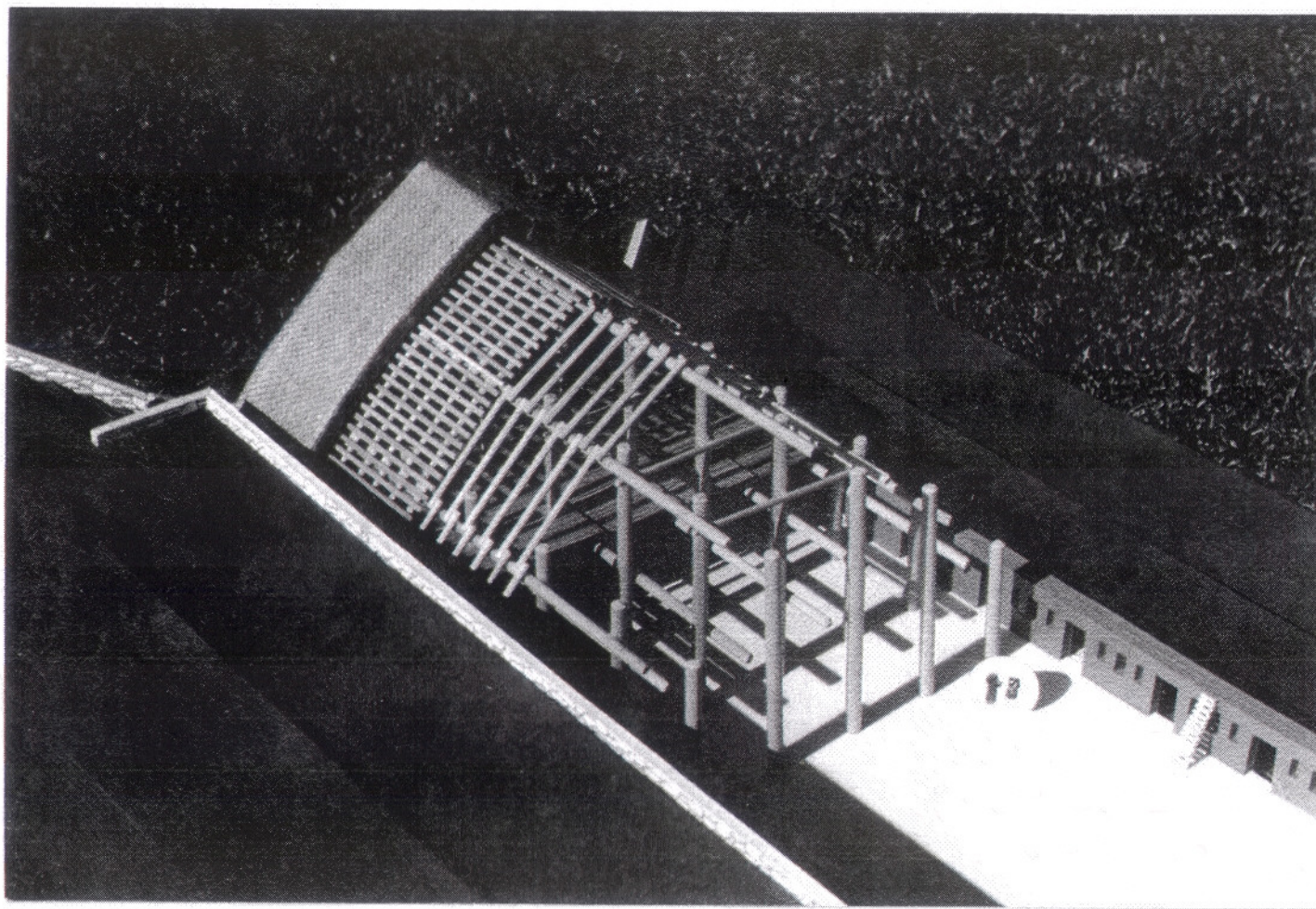


Figure 25. Proposed roof construction of the Great Hall, Inkallacta (model).

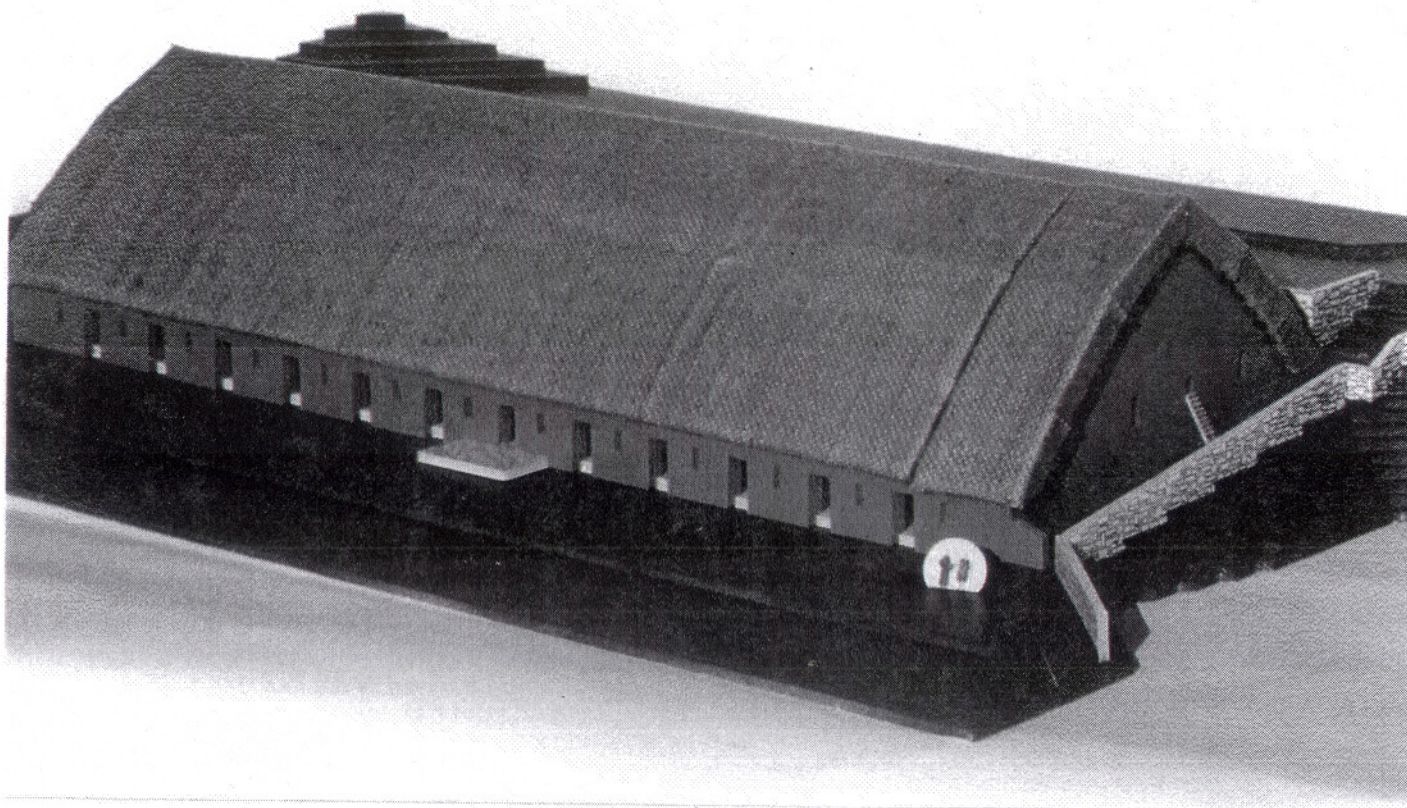


Figure 26. Reconstructed external appearance of the Great Hall, Inkallacta, from the southeast (model).

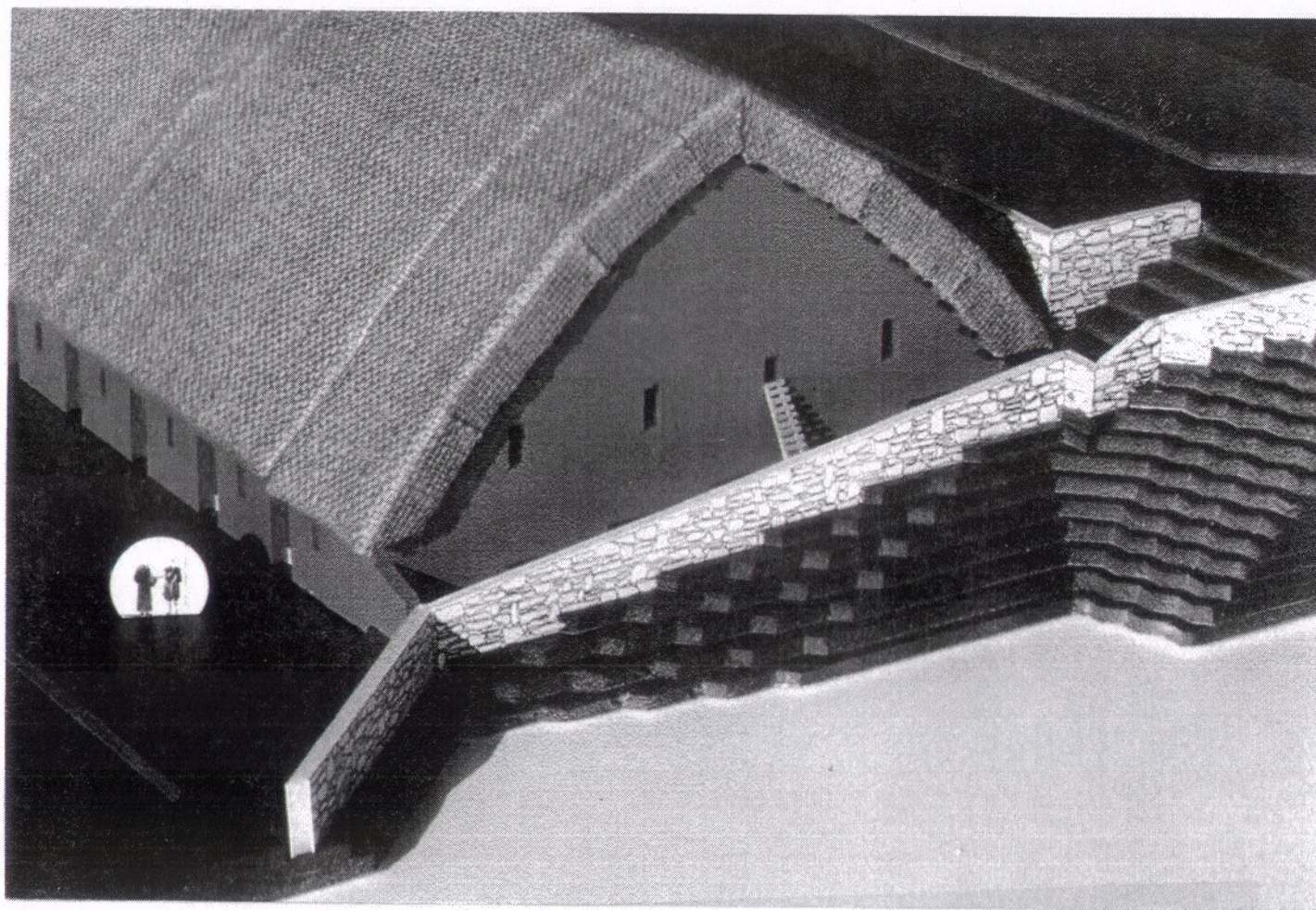


Figure 27. Reconstructed external appearance of the east gable end of the Great Hall, Inkallacta (model).