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Building Traditional Minarets in Sana'a, Yemen

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Abstract: The apprenticeship as an anthropological method has enabled the researcher to merge the subject of the study with its object, and most importantly to learn about learning in a context in which formal technical training and the use of drawn plans are non-existent. The author had spent twelve months in Sana'a, where he contacted traditional builders who specialized in the construction of brick and stone minarets. This paper is part of a larger study. In particular, it aims at highlighting the architectural aspects of traditional minaret construction in Sana'a. The paper is divided into three main sections which correspond sequentially with the raising of the tower from the foundations and stone base, to assembling the brick shaft, and the dome. In each section, a description is given to the construction process, the division of labour, the technical innovations wrought by the builders. The goals are to provide insight into the design processes and the communication of expert trade knowledge.

Introduction

Minaret towers are prevalently referred to as *sauma'a* by both the builders and the general public in Sana'a, which is derived from a word meaning monk's cell or hermitage. The term was originally employed to describe the small cell built on the roof of the mosque at the top of the stairs to shelter the *muezzin* from poor weather conditions. Several mosques in the city survive with this arrangement, most notably the al-Mutawakkil mosque on Tahrir Square. Questions concerning the form of the minaret have historically been a subject of debate amongst some scholars in both Tabiristan and Yemen. Historical sources indicate that several prominent religious leaders have seemingly contested the towering form on the grounds that it represents an ostentatious display, not unlike conventional religious positions taken with regards to the decoration of the *mihrab*. In his treatise on *hisbah*, one Imam of Tabiristan "gave injunctions that the mosque must not be made like churches, contain pictures, be ornamented with gold, hung with curtains or decorated with plasterwork." He went on to state that "minarets must not be raised above the roof level of the mosque." [1, p. 321b] Jonathan Bloom maintains that during the course of history, the call to prayer became mistakenly conflated with the symbolic meaning of the minaret, but in fact the minaret's original purpose as a marker of Islam and its function as a place to perform the call to prayer are separate historical issues.[2, p. 175] He continues that "the minaret, a word ultimately derived from an Arabic word meaning 'sign' or 'marker', is still the most appropriate term for the universal architectural symbol of Islam."[2, p. 191] This hypothesis was supported by the general emphasis by both builders and public on the verticality and visibility of the towers built during the time of this study. Therefore, the more standard term 'minaret' is opted to be used throughout this paper.

The siting of a new minaret commissioned for the 'Addil mosque in the former Turkish quarter of Bir al-'Azab, west of old Sana'a, was, like all previous projects, selected strategically by Mohammad al-Maswari, the chief Master Builder and head of his family. His processes of site selection took into account several factors including existing soil conditions, the slope of the land, and the availability of space in the vicinity of the mosque, but most significantly he aimed to maximise the public visibility

of the tower. In the case of the ʻAddil minaret, a site was chosen in the mosque's forecourt and adjacent the street where it would be prominently viewed from a number of directions. The ground was then broken and excavated to a depth of five meters as prescribed by an engineer based on soil inspections and considerations of the intended height for the tower.

With the site chosen and excavated, the orientation of the foundation walls may then be aligned with either the axis of the *qibla* direction, which is slightly north-west in Sanaʻa, or, alternatively, in conjunction with the cardinal directions and thereby more approximately with the rising and the setting of the sun. It has been suggested by Lewcock, Serjeant & Smith that the true north orientation of the sixteenth century minaret of the al-Madrassah Mosque in an eastern quarter of old Sanaʻa was possibly set to correspond with its use for astronomical purposes. [1, p.361] The builders of the Bayt al-Maswari have subscribed to the latter orientation for the vast majority of the nearly twenty-five minarets they had built in and around the capital between 1980 and the time of my study, including that of the ʻAddil minaret. However, despite the extreme precision of their geometric constructions, there is absolutely no evidence of these new minarets serving astronomical purposes.

Subsequently, the excavated hole was filled-in with large pieces of stone rubble and concrete mortar, behaving like a large footing for the stone base & brick tower, which would be built above it. The rubble used in the foundation is called *ju'm*, a hard black basalt which is impermeable to the damp and salts which could potentially rise through the base of the edifice and corrode its structural integrity. Serjeant & Lewcock have suggested that the term *mawthar* is also used to describe this basalt stone, although I did not encounter this term on the building site. [1, p.468] This same method of constructing the foundation has been employed in Sanaʻa possibly since antiquity and is mentioned by Jamal al-Din in the mid eighteenth century text, *City of Divine & Earthly Joys*, in his description of the structural organisation of Sanaʻani tower houses. [3]

The first several course of stone resting directly upon the footing and extending slightly above grade were of a second type of hard dense basalt, *hajr aswad*, which is also resistant to damp rise and corrosive salts. The stone mason, or *muwaqqis*, cut these facing stones to size using a heavy iron hammer, or *zubrah*. He verified their dimensions with a measured section of steel reinforcing bar, and their square-ness with a steel ninety-degree angle, or *zāwīyah*. The face of each unit was left rough and unfinished, and each was cut to a rough pyramidal-shaped wedge on the backside in order to achieve a stronger and more penetrating bond between the facing elements and the infill of the base. If necessary, the Master Builder, or *usta*, would chisel the blocks to a more exact height and width with his adze-like hammer, *mitraqah* or *mifras*, before setting them in quicklime mortar. Above the final course of basalt the *usta* began setting more perfectly dimensioned and smooth-faced blocks of black *habash* stone. *Habash* stone is a hard, slightly porous volcanic stone quarried south of Sanaʻa in the region of Dhamar. Prior to the 1980's the stone was painstakingly cut to size by hand and dressed on site by the *muwaqqis*, but now the stones are machine-cut and delivered with need for only minor modifications. The stone mason bush-hammers a dense pattern of fine diagonal hash lines, *raqāmah*, in neat rows across the face of each stone in order to give the finished surface of the minaret's black stone base, or *murabbaʻa al-hajr*, a mildly rusticated, but controlled aesthetic.

In the initial stages of building a minaret, the stone courses making up the exterior faces of the foundation above grade must be made level in a systematic and rigorous manner. Any compromise to the perfect verticality of the structure may result in its failure, succumbing to the forces of gravity under its own unevenly distributed weight. Verifying the level-ness was achieved with a simple hydraulic system consisting of a long and narrow, clear plastic tube partially filled with water. Once the *habash* stones had been positioned at each corner of the square-planned base, the Master Builders verified that their vertical elevations were equal to one another (Figure 1). The senior *usta* held his end of the plastic tube upward at one corner, and his partner did likewise at a second corner, counter-clockwise in relation to the first, leaving the slag tube resting on the ground between them. Either end of the tube heights were adjusted in a dialectical fashion until it was determined that the water levels,

evidently marking the same vertical elevation in space, corresponded to the top heights of both corner stones. This procedure was repeated around all four faces of the base, proceeding in the counter-clockwise direction, using the first stone as a benchmark for all subsequent measures and making any necessary adjustments to the settings of the individual corner stones. Following the verification of the first five or so courses in this manner, subsequent courses were carefully levelled on the vertical plane using a plumb-line, *mizan*, which was lowered down along the face of the exterior walls from above.

The plan of the stone bases built by the al-Maswaris are of a standard 4.5 meters square, however the height of the base tends to be varied in proportion to the height of the minaret, and constitutes roughly one quarter of the structure's total verticality. The stone base of the 'Addil minaret reached fifteen meters and was constructed with inner and outer walls of faced stone and infilled with rubble masonry. During this early phase of construction, a team of twelve builders was co-ordinated, each with individual tasks. Two Master builders assisted by an apprentice set the exterior courses of cut stone which were prepared by the stone mason; meanwhile, the *thanā'a*, or second in command below the Master Builders, oversaw the in-filling of the base with the direct assistance of one labourer, and he also supervised the remainder of the labour corps. The corps included one labourer mixing the gravel mortar, three who systematically transported buckets-full to the base, one who carried large uncut stones, and another who collected smaller bits of rubble in order to complete pockets of the infill.

Once the based had risen several stone courses above grade, the circular interior space of the spiral stairwell was defined. This circulation shaft, roughly 2.4 meters in diameter, was centrally positioned within the plan, its empty space and spiralling staircase encompassed the solidity of a central masonry column. The convex-curved stones on the column's exterior face were cut by the stone mason with the aid of a bent steel bar serving as a template for the column's curvature. Approximately 65 centimetres in diameter, the column was infilled with mortar and rubble masonry, and within this, at the axial core, was a metal rod which rose through the entire height of the column, ultimately piercing the dome of the minaret some fifty-five meters above the foundation (Figs. 2-4).

Once the stone base had been completed, a large brass insignia, crafted in the *souk* of the old city and reading "*ma sha` Allah*" ("What God Wills") was hung from a chain over the doorway into the minaret, offering protection to all those who entered the work site. Above this black base, the transforming geometries of the multi-facetted forty-meter high brick tower would be erected. In the context of Sana'ani minaret design, geometric possibilities manifest in multiples of four, which are expressed in the bevelled geometries of the brick tower (Figure 5). Subsequently, the geometries of the tower serve to bridge the four sides of the earth-bound base and the dome, which caps the structure and echoes the celestial spheres above.

The Tower: fashioning from the inside out

With the completion of the minaret's stone base, the erection of the shaft proceeded in kiln-baked brick, or *ajurr*. Construction during all phases of the project, from beginning to end, was executed from the inside out, thereby eliminating any need for external scaffolding. In effect, the structure of the tower physically supported the processes of its own vertical extension. All components of the plan rose in tandem whereby the addition of steps and the rising height of the central column were co-ordinated with the rising height of the walls. In this manner all building assemblage was executed at the top of the structure, generating growth uniquely in the vertical plane. Variations in plan along the horizontal plane were minimal with the exception of the protruding balcony and the subsequent decrease in the width of the walls from four bricks thick to three. The diameter of the central column and the width of the staircase remained more or less constant throughout.

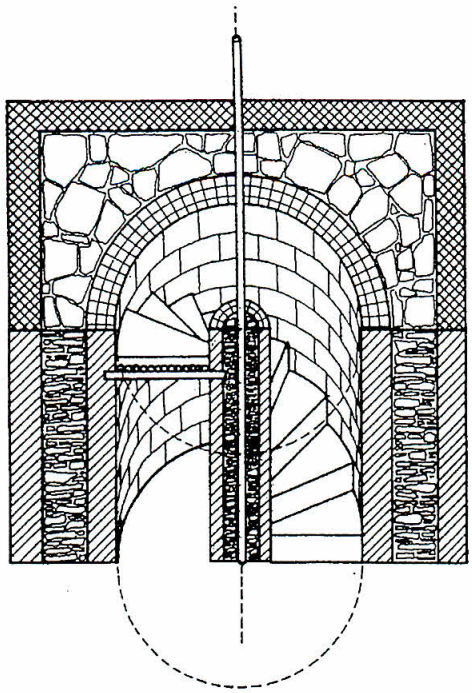


Fig. 1: Section through the minaret base.

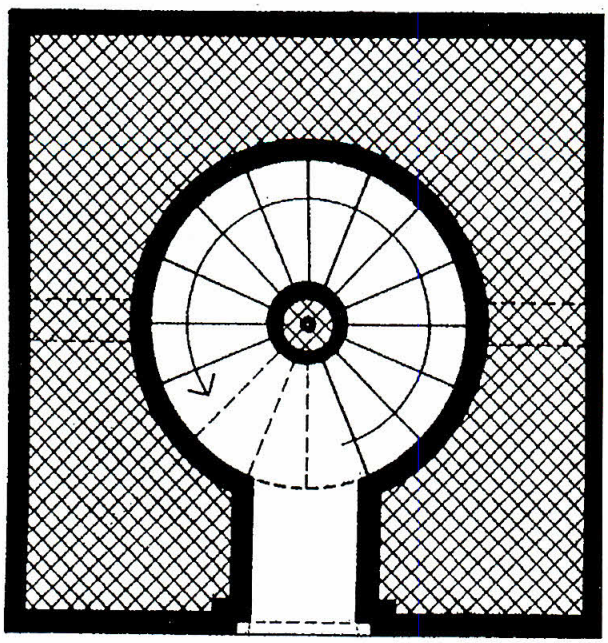


Fig. 2: Plan through the minaret base

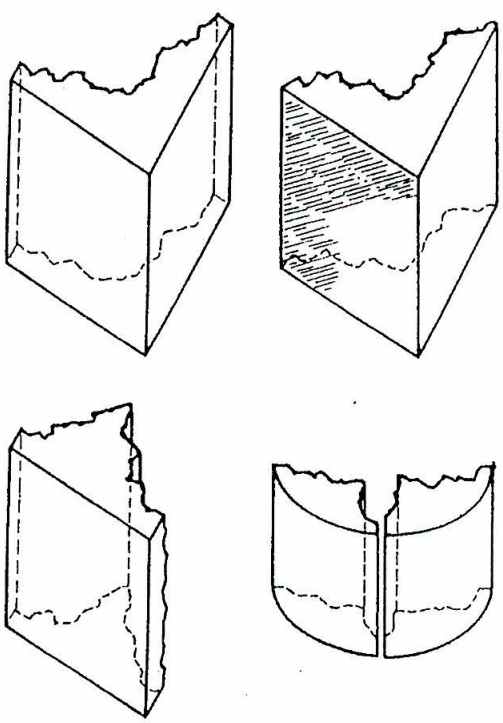


Fig. 3: *Habash* stone cuts for corners, sides and columns.

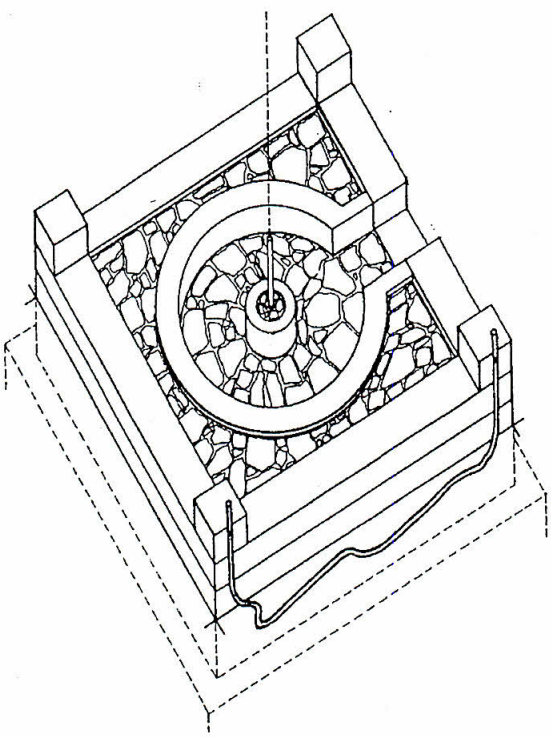


Fig. 4: Axonometric view of minaret base with hydraulic system for determining elevations.

The staircase, measuring between ninety centimetres and one meter in width, provided the main artery for the flow of men and materials to the top while the minaret was being constructed. Before the advent of electricity and loudspeakers in Yemen, and where the call was not made from the courtyard or forecourt of the mosque, the *muezzin* was required to climb the minaret five times daily to give the call to prayer from the balcony. Presently, the minaret stairs are rarely climbed except to service the loudspeakers or for maintenance of the structure. However, the author was informed by one *usta* that it is necessary to build a solid spiral staircase in order to ensure the tower's structural integrity. The staircase behaves as a continuous brace from bottom to top, spanning between the slender, but solid column and the outside walls, and thus rendering the tower more rigid as well as resistant to lateral forces.

Individual steps were constructed one by one as the height of the external walls was raised in brick. Beams, each comprising a pair of thick tamarisk branches, were spanned between the central column and the external wall. On average seven of these beams were positioned per revolution of the spiral stair at equidistant intervals, ascending vertically in correspondence to the required slope of the staircase. Between these beams, longer, thinner, more flexible branches of tamarisk, known as *al-sāb'*, or 'fingers', were laid closely packed together, bent in conformity to the curved space between the two beams. This wooden superstructure supported sixteen stone stair treads per 360° rotation of the wind. The stair treads of roughly hewn stone were set in mortar, and the spaces between them and the underlying support of tamarisk branches was filled in with mortar and rubble.

In the lower half of the shaft, tamarisk sticks are also laid flat within the walls every fifteenth or so brick course in order to strengthen the structure's lateral resistance. The sticks are cut to short lengths and arranged radially pointing outwards, set one next to the other between an exterior and interior facing of half-bricks. Tamarisk, or in Arabic *athl*, is the wood most commonly used in construction in Sana'a, growing abundantly in several *wadis* outside the city and in those fingering their way down from the highlands to the Tihama Plain.[1, p. 481] Several literary sources allude to the employment of star lore for judging the most appropriate season for harvesting woods so as to avoid worm infestations.[3] Nowadays, however, it seems highly improbable that these ancient prescriptions are heeded by the enterprising harvesters of Yemen's scarce wood supplies.

The consistent diameter of the interior face of the brick wall wrapping the radial staircase, and the dimensions of the transforming geometries of the wall's exterior face and projecting balcony were all measured from the centre point of the minaret's plan, marked by the metal rod that rises through the entire height of the structure. This hollow metal pipe, approximately four centimetres in diameter, is called *qasabah* in Arabic, and is also the word used to refer to the human trachea. It is manufactured in manageable lengths of a few meters, and threaded at the ends so that individual sections may be screwed together. Consequently, the pipe may be conveniently lengthened in co-ordination with the rising height of the walls. This pipe was maintained in a perfectly vertical position, and rigidly encased within the central stone column of the stairwell.

Interestingly, the column itself is called the *qutub* by the builders, which appropriately translates to axis or axle as all dimensions are measured and verified radially from the metal post at its centre. In contrast, the general word to describe a column such as that supporting an arch in the mosque is *'amūd* (plural *a'midah*) derived from the verb *'amada*, 'to support'. Rather than supporting a roof or structure above it, the central column of the minaret ties the various structural components together laterally. A similar role is played by the square-planned stone pillar at the core of the stairway in a Sana'ani tower house, and which is said to shoulder the integrity of the edifice: if it fails, so too does the house.

All geometries of the minaret plan were measured from the centre using a nylon rope attached to the metal post and marked along its length with knots or nails representing the dimensions of the plan's geometries. For example, the geometries of the sixteen flutes expressed on the lower elevations of the brick shaft were constructed using two points along the rope, the first corresponding to the fillets on

either side of a flute, and the second to the trough of the flute itself. Half bricks were used to fill in the remainder of the curve by eye between two fillets and the trough of a flute, following the pattern as initially set by the head *usta*. A third knot in the rope marked the diameter of the interior stair wall. Verticality was verified continually on either side of the rising brick wall using a plumb line, and the building process proceeded in the counter-clockwise direction, like the ascent of the stairs.

Crucial elements in the geometry, such as the eight corners of an octagonal section of the tower, were set out by the head builder who began at one point on the horizontal plan and continued, almost without exception, to complete the circle in a counter-clockwise direction. He constructed each corner of the octagonal plan with a single square *ajurr* brick by adjusting it with his adze, or *mitraqah*, to accommodate the necessary 135° obtuse angle between faces. His assistant passed wetted bricks unto him, which had been soaked in a basin fed via a rubber water hose that spiralled around the column, following the stairs, to the top. The kiln-baked bricks were highly absorbent and thus easier to carve, as well as amenable to better cohesion with the clay and lime mortar. Squatting on top of the wall, the *usta* clasped the brick firmly in one hand, standing it in a soldier-course formation and directing it length-wise in toward himself. With his adze in his other hand, he lopped off the corner nearest him usually with a single clean blow, and producing a nearly perfect 45° notch. He then laid the brick in position at the corner to verify the angle by eye, making any further alterations and smoothing the cut face with the edge of his adze before setting it in mortar.

After setting each corner brick, the builder mechanically verified the verticality by dropping his plumb line down the face of the wall. Two courses were laid before the *usta* proceeded to the next corner. Once two corners had been constructed, a thin white cord was fastened tautly between them, running over their outer faces and demarcating the outer boundary of the linear wall to be constructed between them. A second *usta*, normally of lower rank, followed in counter-clockwise direction, filling in the outer face of the wall with alternating courses of full and half bricks to secure a solid bond, and possibly advancing a decorative pattern initiated by the head *usta*. A third *usta* was responsible for simultaneously laying the brick courses of the plain interior wall face, also in alternating courses of full and half bricks, and the *thanā'a*, below the level of *usta* and derived from *ath-thānī*, 'the second', was accountable for infilling the wall space between the faces. Because the geometry of the round wall was not conducive to the perfect fit of rectilinear building units, infilling was effected with an odd assortment of triangular and trapezoidal brick shapes and pieces of rubble set in mortar, with the principal aim being to create strong bonds between courses and to eliminate any air pockets. The extent of the visibility of the craftsmanship was directly correlated with the builders' hierarchy: from the exterior facade executed by the senior *usta*s, to the rarely viewed interior wall surface built by a lower ranking *usta*, to the hidden workmanship of the wall's infill performed by the *thanā'a*.

The bricks produced for all construction were of two standard dimensions, a whole brick measuring about sixteen centimetres square by five centimetres thick, and a half brick, called *ansāf* (derived from the verb *nassafa*, meaning 'to halve'), measuring sixteen by eight centimetres, also with a thickness of five centimetre.s [4, p.317-321, 5] The inspiration for the decorative brickwork on the al-Maswari's minarets was derived from the abundance and variation of decorative patterns on Sana'ani houses and the minarets of the old city, a prominent hallmark of the region's architectural character (Figure 6). It was normally the head *usta* who 'designed' the decoration, or *naqsh*, but the other Master Builders also indulged in this creative activity and made occasional contributions to the final configurations. Each of the minarets displayed a unique decorative pattern achieved by subtle variations and manipulations of the limited palette of highly geometric motifs. They firmly maintained that there was no symbolic significance to the patterns they chose, but rather they were simply a part of the decorative heritage of their city.[1] Because the bricks produced were of a standard rectilinear dimension, as well as being fairly uniform in their colour, decoration was almost exclusively reliant upon three-dimensional relief

[1] This is opposed to what the author contend to be Bonnenfant's over-extended symbolic analysis of Sana'ani architectural decorative motifs. [5, p.188 & p.196]

dimension, as well as being fairly uniform in their colour, decoration was almost exclusively reliant upon three-dimensional relief arrangements. A fixed number of carved brick types had been developed which could be easily shaped on site with the chisel-like-adze, and which facilitated permutations of the raised geometric arrangements. [1, p.472]

In comparison with the builder's eyed judgements in determining the quantity and angle to be removed from an individual brick with his adze, his judgement of spatial relations of greater magnitude was generally reliant on more precise, numerical systems of measurement. For instance, the gauging of the vertical progress of the structure was qualified in metres as measured with a tape, or by the number of brick courses, where sixteen bricks was known to roughly equate to one metre. On the other hand, at the project's scale of greatest magnitude, when the parts of the minaret were to be adjusted in relation to the whole, the proportions of the overall structure were judged without the use of mathematical ratios. The experienced senior builders judged the proportionality 'by eye', and made any adjustments accordingly.

As the walls rose, the outer-most surface of the brick was rubbed smooth by the apprentice who applied daubs of wet, runny mortar to the surface and scrubbed it into the brick facing with another brick which he held like a shoe-shine brush. In effect, the patina of the brick was removed by the abrasive rubbing action, and replaced by a thin, even layer of earth-red plaster produced by the mixing of the mortar and the pulverised brick. The resultant outer surface of the structure was smooth and uniform in colour, rendering the seams between individual bricks nearly undetectable. However, the long-term consequences of removing the kiln-baked patina are highly questionable, and will likely induce premature erosion of the brick.

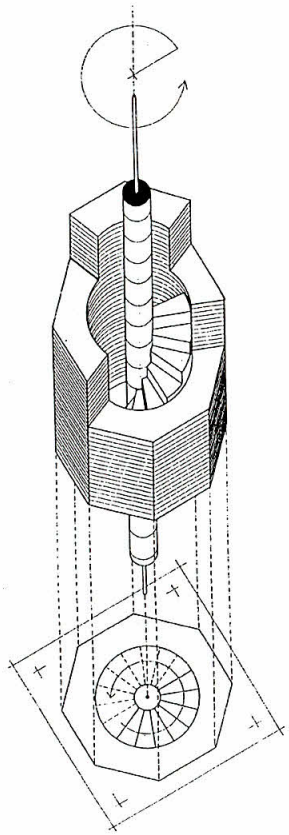


Fig. 5: Axonometric of the octagonal brick tower with the axial metal rod passing from the bottom to the top.

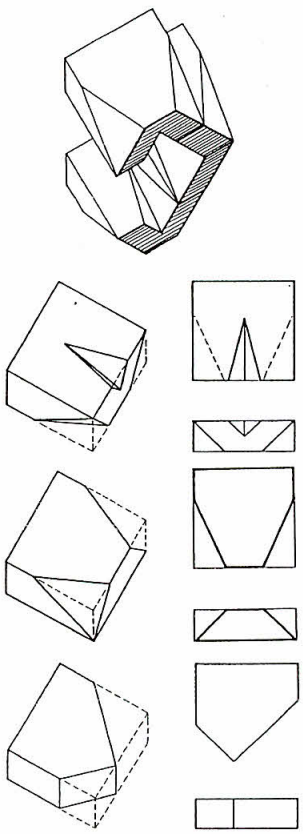


Fig. 6: Decorative assembly of cuts bricks in a diamond shape or diblah.

Throughout the construction, narrow slit windows were inserted in the minaret walls at every half turn of the staircase, alternately aligning with the east and west cardinal directions, and supplying natural light to the passage. After nine complete rotations of the staircase in the minaret of the ʿAddil Mosque, or 144 steps from the ground level, an exit was provided onto the calling platform. The platform itself was slender in width, about seventy-five centimetres at its widest point, ringing the shaft, and protected by a low brick wall. The platform was assembled by progressively cantilevering the courses of bricks out over each other, setting the individual square bricks diagonally in a tooth-like arrangement. A strong quicklime mortar (in Arabic *jiss* and pronounced *guss* on the site) was used exclusively at this stage to bond the courses of the projecting platform. The subsequent railing-wall with its eighteen decorative panels would only be constructed at the end of the project, as it served no pressing structural purpose for the continuation of the tower.

Completing the Dome

From the balcony level, thirty-one more steps were joined to the staircase whose spiral boasted a total of one hundred and seventy-five risers upon reaching the final interior prayer-calling platform. The minaret's outer brick shell, reduced in thickness from four bricks to three from the balcony upwards, maintained its steady inner circumference hugging the stair shaft, and an octagonal exterior plan built without any further geometric transformations. From the level of the final stair, it was to take one more month to complete the nearly eight meters of vertical construction required to reach the crest of the dome. The termination of the staircase, which had previously provided an important means of access to the top of the walls, meant that the construction process itself became more complicated. Alternative forms of interior scaffolding were required in order for the builders to reach their stations on the ever-rising walls. The central stone column, like the stairs, was terminated at the level of the last calling platform. On top of it was built a narrow brick wall, on one *ajurr* brick wide and the length of the column radius, located to the east side of the axial metal post, or *qasabah*. This brick wall, effectively a small pier built on top of the larger column, was built upward to a point below the inner surface of the dome, and served primarily to support a series of working platforms which were built as needed.

Eight large apertures, about two meters in height, were introduced into the eight planes of the shaft at the level of the highest calling platform. Upon completion, four giant bell-shaped loudspeakers were hoisted to the top by ropes and installed in four of the eight apertures. The eight planes of the exterior wall were terminated one meter above the apertures with a decorative cornice in brick relief. The eight corners of the planes were each vertically accentuated with decorative finials built in carved bricks, like jewelled points crowning the base of the high dome.

There are two prevalent types of domes used to cap traditional Sanaʿani minarets: a smooth-surfaced dome which may be either spherical, like that of the recently reconstructed Masjid al-Shahidayn, or slightly bulbous like those of the city's Great Mosque; or fluted, like that of the Masjid al-Abhar (1374-75 AD) or the al-Madrassah Mosque built in the first half of the 16th century, which look rather like the ribbed bulbous element in the centre of a typical glass orange-juicer. [6] These ribbed domes are referred to locally as *muthallajah*. The Bayt al-Maswari was experienced in constructing both types during the course of their numerous past commissions.

Typically, the *muthallajah* domes constructed by the Bayt al-Maswari have sixteen fillets, or ribs, governed by the 'multiple-of-four' geometries of the transforming structure: two flutings incised above each of the eight planar faces of the wall below, and aligned with the sixteen scallops situated further down the shaft below the level of the balcony (Figs. 7, 8). The dome of the ʿAddil minaret was constructed entirely in *ajurr* brick, and the consistency of its inner spherical surface and the contours of the fluted exterior were regulated once again by points fixed on a radial rope attached to the *qasabah*, or axial metal post (Figs. 9, 10). It can be recalled that for the construction of the walls, the rope, with fixed radial points measuring out contours on the horizontal plane, was slid up along the

post in accordance with the rising height of the tower. In constructing the curvature of the dome the rope was fixed vertically at a point on the *qasabah* and was used to measure the hemispherical contours in all three dimensions.

By experience, the al-Maswaris have learned the merits of vertically elevating the base of the dome before introducing the curvature in order that the cupola be adequately viewed from the street below. The dome of their first minaret, commissioned for the Masjid al-Husseini around 1980, was built without an elevated base and is therefore barely perceptible from the street level. Once the curvature of the 'Addil minaret dome began, a maximum of four brick courses could be laid in a single day as there was no scaffolding system to support the inward sloping sides of the dome. It was erected as a self-supporting structure, and a stronger, faster drying mix of quicklime mortar, or *guss*, was used to bond the bricks rather than the normal mortar, *khalta*, used in the walls. The *guss* was applied to the brick surface by hand, and the builders were required to wear rubber gloves and a full-length overall in order to protect their skin from the acidity of the lime. As the dome proceeded, the quicklime mixture was also generously applied on both the inner and outer surfaces to bolster the homogeneity of the structure and, very importantly, to provide an impervious protective coating.

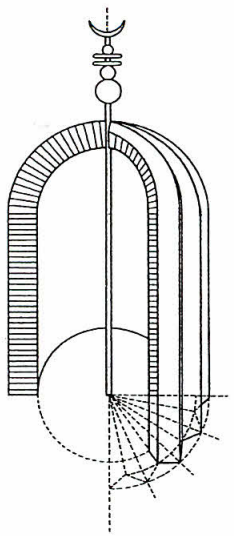


Fig. 7: Section through a *Muthallajah*

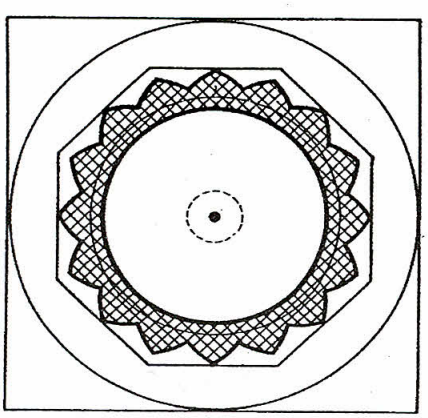


Fig. 8: Plan through a *Muthallajah* dome.

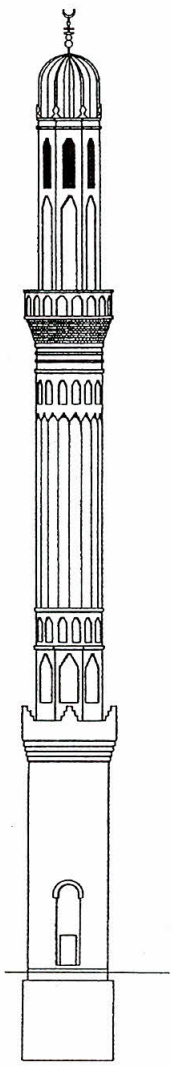


Fig. 9: Elevation through the minaret.

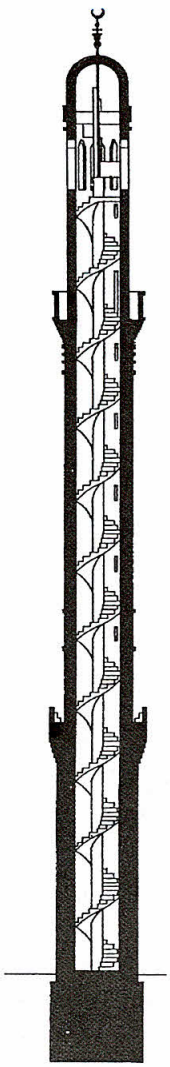


Fig. 10: Section through the minaret.

The shell of the dome, like the walls below from which it sprang, was three *ajurr* bricks thick from the base to the apex. In the trough of each fluting, where the dome's shell was thinnest, a series of small perforations about fifteen centimetres in diameter were introduced in vertical arrangements. These served a number of interesting functions. Firstly, during the construction itself, narrow wooden beams could be inserted into these perforations which in turn supported temporary latforms for the builders. They also provided a sourcep of natural light to the interior of the dome, reminiscent of the star-like vaults of a Turkish bath. Perhaps most importantly, the perforations provided grips for the hands and feet of the builder who undertook the daring task of scaling the exterior surface to install the brass crescent moon, or *hilāl*, or for those commissioned to apply the decorative lime plaster on the exterior or to perform future maintenance work. A small slit opening along one of the flutes was made halfway up the height of the dome and just large enough for a worker to pass through in order to gain access to the exterior.

Progressively there was less and less room at the top, and the number of Master Builders constructing the dome was reduced to two. They were assisted by an apprentice who prepared the quicklime mortar and bricks, and distributed any necessary tools. Below the apprentice, between where he was located on a platform in the dome and the top of the stairs, were two other labourers responsible for passing on heavy bags of lime and bricks from the stockpiles on the last calling platform. The task of moving materials upward was made more difficult by the steep and awkward series of platforms that had now replaced the staircase. Once a sufficient reserve of bricks was secured at the top, there was no need to employ a large battery of labourers to man the winding staircase or to prepare materials in the mosque forecourt, and their total numbers were reduced to five.

The sides of the dome were steadily closed in upon themselves, and finally only one Master Builder and an apprentice remained working in the confined space at the top. The axial metal post had been extended to the exterior beyond the vertex of the dome, and it would eventually support the brass *hilāl*. An occuli of about one meter in diameter was left around the *qasabah*, and from this point onwards the *usta* worked from the exterior, climbing onto the dome through the top and setting the shell's innermost layer of bricks. He was no longer setting entire courses around the circumference, but rather was bridging small sections between the completed edge of the ring and the central post. Progressively, as the *guss* dried and the bonds hardened, he set the weight of the outer two layers of brick upon the first. After each small section was completed, he re-entered the interior space of the cupola and applied a coating of the quicklime mixture to the inner surface by hand.

As the sixteen fillets and flutes closed in toward the apex, it became impossible to maintain their perfect geometries, and the arrangement of bricks, now at a point on the curvature which would be imperceptible from the street below, were set in more haphazard arrangements with the main aim of completing a solid hemispherical structure. In the final stages, the top of the dome could only be accessed via the slit opening on the south side, and wetted bricks and quicklime mortar were carefully passed up from here to the builder on top completing the process. Finally, with the dome structure complete, all that remained was the installation of the *hilāl* and the highlighting of the relief brickwork with *guss* by a team of specialists in this notoriously dangerous trade.

Initially the author had been informed that the brass crescent moon to be placed on the pinnacle of the ʻAddil minaret would be imported from a workshop in Damascus at a price of 250,000 Yemeni riyals (approximately two thousand American dollars). Although a*hālīl* (plural of *hilāl*) are locally manufactured in the *souk*, the indigenous models are considered to be of lower quality than those produced in Cairo, Damascus, or India. The imported quality also served as a status marker for the patron of the religious endowment. In all their minaret constructions to date, the Bayt al-Maswari had employed the more standard and traditional crescent moon motif. However, there is also a tradition in Sanaʻa of employing a finial surmounted by a brass pigeon, such as on the minarets of the al-Madrassah and the Salah al-Din Mosques, two of the earliest prayer calling towers of the Old City. After a

period of several months, the *hilāl* was finally imported from India, not Damascus, and a garish flashing pink light was installed on the top of a metal pole in the interim to visually designate the presence and functionality of the tower.

In June of the following year, more than six months after the completion of works by the builders, a small team of plaster workers specialising in the white washing of decorative brick relief and interior surfaces arrived to execute the final stages of the 'Addil minaret project. In any expert manner they plastered the interior face of the masonry wall lining the stairwell from bottom to top, leaving the stonework of the central column exposed, and plastering the underside of the winding staircase in an organically sculptural way. All of the decorative brick relief elements were picked out in white, the junctions between planes were highlighted, and the contours of doors and apertures were framed with lime plaster in typical Sana'ani fashion. When finally completed later that summer, the 'Addil minaret was highly praised by local residents and by Sana'anis of other quarters alike. Many claimed that it was the most elegant minaret of the city, and Mohammad al-Maswari proudly agreed that it was possibly his family's best work yet.

Concluding Remarks

In this paper I have described the construction of a fifty-five meter high minaret for the 'Addil Mosque in Sana'a, Yemen. The minaret was designed and built by members of the Bayt al-Maswari, a family of Master Builders who have employed traditional methods and materials in their constructions including locally quarried stone, kiln-baked clay brick, tamarisk branches, and quicklime mortar. The existing hierarchy between the Master Builder, or *usta*, the *thanā'a*, the apprentice, and the labourers, as well as the division of labour that characterises the various phases of the project has been described. The most significant technical innovations wrought by the builders are those which have enabled them to raise these towering structures without the use of exterior scaffolding or any modern machinery. The exquisite craftsmanship displayed in an edifice like the 'Addil minaret represents the complex intersection of various concerns including those for the physical forces acting upon the structure; a project budget; the satisfaction and reputation of the patron; the impact on the local community; and the production and reproduction of the builders' reputation as Masters of their trade.

The stylistic precedent of the al-Maswari's minarets can be traced locally to the minaret of the al-Madrassah Mosque built in the first half of the 16th century, and such early examples are though to have be derived from the earlier patterned brick minarets of Central Asia and Persia. [1, p.362] or from Anatolia or the Jazira. [7, p.132] North Yemen's sudden economic prosperity in the 1970's and the resultant importation of 'modern' building materials, designs, and technologies threatened to eradicate Sana'a's unique architectural heritage and traditional building trade. Several reinforced concrete minarets appeared on the skyline in the city's rapidly expanding newer quarters. However, the since weakened national economy has been coupled with a marked decrease in the pace of change and development in the country. Fortunately, a forced re-evaluation of indigenous resources has coincided with burgeoning international and local interests in 'traditional' Yemeni architecture, largely initiated by UNESCO's inclusion of Sana'a on the list of World Heritage Cities. Wealthy Yemenis are once again appropriating 'traditional' architecture as a signifier of their status, and the current flourishing of minaret building in the capital marks a significant public display of pious patronage.

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تشييد المآذن التقليدية في صنعاء، اليمن

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ملخص البحث: مكن أسلوب التعلم وطرق دراسات علوم الإنسان الباحث من المزج بين موضوع الدراسة وهدف الدراسة وذلك بـــالاطلاع على طريقة التدرب على صنعة بناء المآذن التقليدية في مدينة صنعاء باليمن تحت إشراف البناء المتخصص (المعلم) ، وذلك في حالة غياب منهجيـــة رسمية للتدريب المهني وفي غياب المخططات التنفيذية. لقد أمضى الباحث قرابة الإثنى عشر شهرا في صنعاء حيـــث اتصـــل بالبنـــاءين التقليديـــن المتخصصين في بناء المآذن من الطوب والحجر. يشكل هذا البحث جزء من دراسة واسعة، ويستهدف البحث توضيح الجوانب المعمارية لأساليب الإنشاء التقليدية للمآذن في صنعاء. تم تقسيم الدراسة إلى ثلاثة أجزاء رئيسية تقابل تماما مراحل بناء المئذنة من الأساسات والقاعدة الصخريـة، إلى مرحلة بناء جدار المئذنة وقبتها. وتم وصف عملية التشييد لكل مرحلة، وتوزيع البنائين، والإبتكارات الفنية من قبلهم. كما يستهدف البحـــث إيضاح مسار طرق التصميم والاتصال بعلوم الصناعات المحترفة.