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THE VAULTING SYSTEM OF UKHEIDAR.

[PLATES X., XI.]

THE vaulting system of a Persian palace may seem to be a subject remote from the province of the Hellenic Society. It is not perhaps so remote as it appears. The history of Hellenistic art is closely interwoven with the problems of the Orient, and all evidence is welcome which will help to elucidate a period so obscure, yet of so far-reaching an influence, as that which saw the fusion of Greece with the East after the conquests of Alexander. From the age of the Diadochi the arts emerged profoundly modified. To instance architecture alone, we find the builders in the Greek coast-lands preoccupied with Asiatic structural methods, bringing forth new solutions, modifying, with their quick sense of proportion² and of beauty, ancient oriental themes, and giving back to inner Asia as much as they had derived from her. Not one of the great cities of the Diadochi in Mesopotamia or Syria has yet been excavated, and the importance of such fragmentary knowledge of the succeeding civilizations as can be gathered together lies in the fact that they indicate the changes that had taken place during a time of rapid development about which we have no direct information. In this development Greece and Asia bore an equal part, and the lines of interaction are everywhere to be traced. I am not, however, concerned here to disentangle these complex questions, but merely to furnish a few more details that bear upon their oriental aspect.

The fortified palace of Ukheidar lies seven hours to the west of Kerbela, and three hours to the south-east of the oasis of Shefätha, which I believe to occupy the pre-Mohammedan site of 'Ain et Tamr. When I reached Ukheidar in March, 1909, it had already been visited a year earlier (though I was not aware of the fact) by M. Louis Massignon.¹ The buildings consist of an outer wall set with towers, enclosing an area of 161·00 m. × 153·50 m. In the interior is a palace covering a rectangular space 110·80 m. × 77·60 m.; it adjoins the northern enclosing wall,

FIG. 1.—BATH.

¹ He published a plan of part of the castle in the *Bulletin de l'Acad. des Inscr. et Belles Lettres* for March of the same year.
² the *Gazette des Beaux Arts* for April, 1909, and

and is surrounded on the other three sides by an open court. In the east part of the court there is an annex which is fitted clumsily on to one of the round bastions of the main block of the palace, and on to one of the pilasters which form a blind arcade round the interior of the enclosing wall. Though it is not materially different in style from the rest of the castle, it must be regarded as an addition to the original scheme, and I believe that to

FIG. 2.—FIRST FLOOR OF PALACE.

FIG. 3.—SECOND FLOOR OF PALACE.

the same period may be assigned a detached building which lies outside the walls to the north. A few hundred yards further to the north-east is a small structure known to the Arabs as the bath (Fig. 1), and near it there are some low mounds which may cover ruins. Otherwise I saw no trace of construction outside the castle walls save a few fragments of masonry, half

buried in the sand, between the northern annex and the adjacent Wādy Lebay'a, possibly the remains of a water-conduit.

Ukheidar is almost exactly oriented to the cardinal points of the compass. The disposition of the courts and chambers can be realised from the accompanying ground-plan (Plate X.). Most of the palace is one storey high, but in the northern part, immediately within the enclosing wall, there are two upper floors, of which I give the plan (Figs. 2 and 3).² The second floor, which is considerably ruined towards its eastern end, is on the same level as the *chemin de ronde* of the outer walls. Access could be obtained to this vaulted gallery along the top of the walls from the uppermost floor by four staircases, one in each interior angle of the court. The

FIG. 4.—INTERIOR OF HALL, LOOKING NORTH.

ground-plan shows marked affinities with the plan of other Sassanian palaces and fortresses already known, notably with that of Qasr-i-Shirīn, published by M. de Morgan,³ and Ukheidar can be attributed without hesitation to Persian architects. The perfect state of its preservation makes it an exceptionally favourable field for the study of their methods.

All the corridors and chambers are vaulted. The masonry of the castle is of uncut stones laid in a thick bed of mortar, but some of the finer vaults are built of brick tiles. In this respect it resembles the Sassanian

² These plans, in order to correspond in position with the ground-plan on Pl. X., are printed with the northern point of the compass to the left.

³ *Mission scientifique en Perse*, vol. iv. second part.

palace of Sarvistān,⁴ where the walls are of stone, better cut and coursed than at Ukheidār, while all the vaults and domes are of brick. The largest of the brick vaults is that which covers the hall that lies between the north gate and the central court; the hall is the largest chamber in the palace, and the vault spans exactly seven metres (Fig. 4). From the earliest period the problem which the Mesopotamian vault builder set himself to solve was how to construct his roof over space without using centering beams to support it while it was in progress of erection, and the hall at Ukheidār is a typical example of this system (Fig. 5).⁵ The stone wall is corbelled inwards on either side so as to reduce the space;⁶ the first few courses of bricks are laid lengthways, each course with a slight inclination forward; when it is no longer possible to continue the curve in this fashion, the bricks are set upright in concentric courses. The first of these upright courses,

FIG. 5.—INTERIOR OF HALL, LOOKING SOUTH.

or slices, as Choisy calls them, is laid with a slight backward inclination against the head-wall at the back of the hall, and each subsequent course adheres with mortar to the one behind. The result is a vault of ovoid curve. Exactly the same process can be observed in the great vault at Ctesiphon, which spans 25·80 m.; it was the solution which had been adopted by the masons of Assyria, and it was handed down by the Persians to the builders of the Mohammedan period.

⁴ For Sarvistān, Firūzabād, and Ctesiphon, see Dieulafoy, *L'Art Ancien de la Perse*, vol. iv.

⁵ The process is minutely described by Choisy, *L'Art de bâtir chez les Byzantins*, p. 31. See, too, Dieulafoy, *L'Art Ancien de la Perse*, vol. iv, p. 13. The same construction has been

found in Egypt: Perrot et Chipiez, *Histoire de l'Art dans l'Antiquité*, p. 534.

⁶ This does not seem to be the case at Sarvistān (Dieulafoy, *loc. cit.*, section of chamber F), but the brick walls of Ctesiphon are treated as at Ukheidār.

The smaller vaults are constructed on the same principles, but most of them are of stone, not brick, the stones being cut into narrow slabs so as to resemble brick tiles as nearly as possible (Fig. 6). The vaults and domes of Firūzabād, another palace of the Sassanian kings, are built in precisely this manner with stones shaped like bricks. At Ukheidar the details of the vaults are generally hidden under the plaster which covers wall and roof alike, but where the passages are partly ruined the backward slope of the slices of stone bricks against each other, and ultimately against the head-wall, is strongly marked, and I do not doubt that centering beams were dispensed with here as they were in the brick vaults.

To cover a series of parallel chambers with parallel barrel vaults of exactly the same height, surmounted by a flat roof, implies the existence

FIG. 6.—VAULTED PASSAGE.

of a heavy mass of masonry filling the convex sides of the triangular space between the vaults; this was obviated by running tubes through the masonry (Fig. 7). In the chambers on either side of the small courtyards of the palace the outer end of these tubes appears like the narrow slit of a window in the upper part of the wall; where the outer wall has fallen the shape of the tube is clearly apparent—it is itself a small vaulted gallery in the thickness of the roof. The tubes are used not only between two barrel vaults, but between the barrel vault and a straight wall, and thus applied they appear round all the interior of the wall that separates the palace from the court, *i.e.* between that wall and the vault of the cloister

that occupied one side of the courts; indeed, so far as I was able to observe, every vault was accompanied by tubes. This system was new to me, but I subsequently saw it in a ruined Khān which lies on the Tigris a day's ride to the north of Tekrit. I judge Khān el Khernīna to belong to the thirteenth century, and it is interesting to observe that the traditions of an earlier time were so closely followed by later Mohammedan builders. It is not impossible that the tubes of Ukheidār helped to keep the rooms cool by laying a belt of unheated air along the vaults; it is certain that the builders were much preoccupied with the necessity of making their rooms habitable during the burning months of the summer, and they succeeded so well that they were able to dispense with underground chambers, serdabs, of which there are only a very limited number. The serdabs were placed, as I shall show in a fuller account of the palace, in the upper chambers

FIG. 7.—PARALLEL VAULTED CHAMBERS, SHOWING TUBES.

themselves. In the east annex, and also in the north annex outside the walls, the rooms are provided with a false roof consisting of narrow parallel spaces covered with slabs of stone (Fig. 8) which form a cushion of air between the rays of the sun and the top of the vault.

In the construction of barrel vaults the builders of Ukheidār employed methods already well known in Mesopotamia; of far greater significance are the groined vaults, of which there are no less than eight examples in the castle, one covering a chamber which measures 5.40×5.00 m. in the eastern annex, two at the angles of the big corridors (3.60 m. wide) in the main block of the palace, and five in the length of the corridors, where they are marked off by transverse ribs from the vault on either side. The groined

vault is unknown to Sassanian architecture so far as it has yet been recorded, though it must be borne in mind that the great palaces found by de Morgan on the western frontiers of Persia are very insufficiently published. It occurs in Syria during the pre-Christian period, and becomes universal in that country from the seventh to the eleventh centuries.⁷ The groin was translated into brick and adapted to the oriental system of building without centering.⁸ In this shape it appears in Constantinople in the sixth century, or perhaps as early as the fifth, and Choisy has pointed out how clearly it foreshadows the earliest form of the dome on pendentives.⁹ Thus constructed we have it at Ukheidar. Plate XI. Fig. A gives a detail of

FIG. 8.—VAULT SURMOUNTED BY FALSE ROOF.

the ruined groin in the east annex. The lower part of the salient angle is composed of a corbel, such as that which is known in French Gothic work

⁷ I am not here concerned with the Roman aspects of the question, but it may be well to note that the groin occurs in Rome during the Republican period and is used in the *Tabularium*. See Delbrück, *Hellenistische Bauten in Latium*. This example of the groin is the earliest known to me.

⁸ Choisy, *L'Art de bâtir chez les Byzantins*,

p. 51.

⁹ *Architecture*, ii. p. 10. Choisy talks of brick groins in Constantinople dating from the time of Constantine, but that is probably because he places some of the existing cisterns too early. See Strzygowski and Forchheimer, *Die Byz. Wasserbehaltung*, pp. 173 *et seq.*

as the solid springer (*tas de charge*); above it the stone bricks are laid in slices against the head-walls, the courses being glued to the wall and to one another with mortar. They show a slight inclination backwards against the wall, which is produced by placing thicker stones at the bottom of the course and narrower slabs above them. I doubt whether this groin could be built entirely without centering, and the putlog holes in the wall towards the base of the solid springer seem to indicate that beams were placed across the chamber during the course of construction, but in any case only a centering of the lightest description would have been required. Plate XI. Fig. B represents a perfect groin at one of the angles of the corridor. The masonry is partly concealed by plaster, but enough is visible to prove that the system is the same as in the east annex. The presence of the groin leads me to the conclusion that Ukheidar cannot be dated within what may strictly be called the Sassanian period, but that it was built by Persian workmen for one of the early khalifs. It is thus more easy to explain a certain amount of Syrian influence which might result in the adoption of the Hellenistic groin in countries where it had hitherto been unknown. There is a growing body of literary evidence to show that the Umayyad khalifs were accustomed regularly to visit the desert, where they could throw off, remote from critical eyes, the galling restraints of Islam. One of their hunting lodges, Qseir 'Amra, has recently been discovered by Musil on the western side of the Syrian desert; I believe that Ukheidar is but a larger and a more splendid example of these desert palaces. It must be remembered that the Mohammedan invaders brought no arts with them. On the western borders of the desert they had recourse to Syrian builders; on the Mesopotamian frontiers they would naturally employ the skilled Sassanian artificers who had already served their predecessors, the Arab princes of the Beni Lakhmid.¹⁰ Choisy notices that the groin must have come into universal use in Syria during the period of the Damascus khalifate, for it does not exist in Justinian's buildings at Jerusalem, whereas the Crusaders found it firmly established, and the groined vault that covers one of the chambers at Qseir 'Amra¹¹ furnishes an interesting comment on his words. It would be of importance to compare the method of construction there with that of the Ukheidar vaults, but unfortunately the Viennese publication of the Syrian palace is singularly lacking in architectural detail, and no attempt has been made to clear up important points such as the method of building vault and dome. There is another question which can be answered by accepting a post-Islamic date for Ukheidar. At the western end of the three-storeyed block that forms the northern part of the palace, the sequence of vaulted chambers is interrupted by an open court. On the east, south, and west

¹⁰ It is worth noticing that legend gave to one of these princes a 'Roman,' i.e. Greek, architect (Rothstein, *Die Dynastie der Lakhmidien in al-Hira*, p. 15). Their civilization

was, however, derived from their Persian over-lords.

¹¹ *Kuseir 'Amra*, published by the K. Akademie der Wissenschaften.

sides, this court has once been surrounded by a cloister. The angle piers and the returns in the north wall are shown in the plan; the springing-stones of the barrel vault that covered the cloister can still be seen adhering to the walls, but the intermediate columns that supported it are ruined and buried under masses of fallen masonry. They were probably built of small stones and mortar like the existing columns in the central chambers of the palace. The vault that formed the cloister on the south side of the court was elaborately decorated with stucco ornaments, a barred motive upon the space between the transverse ribs, a series of diamonds upon the ribs

FIG. 9.—STUCCO DECORATION IN COURT.

themselves and a flute in the angles of the vault (Fig. 9). I believe this court to have been a mosque of a primitive type, a translation into the terms of Mesopotamian architecture of the earliest sanctuaries erected in Arabia by the Prophet and his followers.

There is at Ukheidar but one example of the dome. A small chamber (2·8 m. × 3·20 m.) between the north gate and the great hall is covered by a fluted dome accommodated to the rectangular substructure by means of slabs set across the corners (Fig. 10). A very early date has been assigned

to the Mesopotamian dome, chiefly on the authority of a bas relief found by Layard at Kuyunjik.¹² The evidence which can be derived from this relief is very slender. The buildings represented therein appear to be closely akin to the modern mud-built villages of North Syria and Northern Mesopotamia, where the houses are covered with conical dome-like roofs like the two on the relief. The modern roof is not a true dome, but is constructed of horizontal rings of sun-dried brick, each ring oversailing the one below it so that the roof narrows up to an apex. It is true that upon the relief three spherical domes appear to be depicted, but the

FIG. 10.—DOME.

indications given are so insufficient that it would be unwise to base a comprehensive theory upon them. The analogy with the modern village suggests that the houses here shown were of insignificant dimensions, and no trace of the dome has yet been found in Assyrian palaces or temples. Choisy hazarded the opinion that the domes in the relief were set upon pendentives, but all subsequent research goes to prove that this view would

¹² Frequently published. See Perrot and Chipiez, ii. p. 146.

be in any case untenable. The pendentive, so far as its history is known at present, was, like the groin from which it perhaps arose, a creation due to the genius of the West. It appears in the Hermus and Maeander valleys in buildings of the pre-Christian period, and the brick construction there illustrated was generally used by the Christian architects of Constantinople and the coast-lands.¹³ In Syria, which is a stone-building country, the continuous sphere of the coast-lands, *i.e.* the calotte continuous with the pendentives,¹⁴ was erected in stone. It is customary to cite a well-known dome at Jerash as a pre-Christian example of the stone pendentive,¹⁵ but I am inclined to place it nearer the period of similar edifices raised by Justinian at Constantinople. Certain it is that Syrian domes of the fourth and fifth centuries are almost invariably adapted to the rectangular base by means of slabs over the corners, as at Ukheidar, and as this is the simplest as well as the earliest method of setting a dome over a small square chamber, it was probably universally known and used. I have found it, for example, in early Christian churches on the Anatolian plateau, where the architecture, especially in respect of the roofing systems, is strongly orientalisèd; whereas I have never come across the pendentive in districts removed from the influence of the coast. If the Greek solution of the problem of the larger dome was the pendentive, the Asiatic solution was the Persian squinch, which may roughly be described as an arched niche set over the corners. The best known examples of the squinch are at Firūzabād and Sarvistān under domes that have a diameter of some sixteen metres. I have published a fine instance of its use in Central Anatolia,¹⁶ and recently I found a yet more instructive example of the dome on squinches in a church at Khakh, south-east of Diarbekr.¹⁷ I see no reason to believe that the true dome appeared in Mesopotamia before the Sassanian period, though it may have been foreshadowed in the conical dome-like roofs, set on corner slabs, of ancient villages like those depicted in Layard's relief. The complete absence of the dome in the Parthian palace of Hatra, where the small square chambers were eminently well adapted for it, is extremely significant, and the fact that it appears only once at Ukheidar, and then in so primitive a form, is not without importance.

The squinch arch is frequently used at Ukheidar in the angles under barrel vaults, that is to say, where the vault does not end against a head-wall but against a portion of barrel vault springing from the narrow end of the chamber (Fig. 11). The effect produced by this arrangement is almost that of a semi-dome terminating a long barrel vault, especially if the termination is marked off from the barrel vault by a transverse rib,

¹³ Choisy, *L'Art de bâtir chez les Byzantins*, p. 90.

¹⁴ I have given a fuller definition of this term in *The Thousand and One Churches*, p. 439.

¹⁵ Choisy, *L'Art de bâtir chez les Byzantins*, p. 88.

¹⁶ *The Thousand and One Churches*, Fig. 308.

¹⁷ I am publishing it in a forthcoming work on Amida by Strzygowski and von Berchem.

as is the case in the cloister of the mosque (Fig. 9). Here the semi-domes are more than usually complicated in structure. They are divided down the centre into two concave triangles by another rib which springs from the back wall and joins the transverse rib at the summit and at right angles to it. A small fluted squinch is used in setting the concave triangle over the corner of the wall. The squinch is found in the angles of barrel vaulted chambers at Firūzabād.

There is another significant deduction to be drawn from the roofing system of Ukheidar. Towards the centre of the palace there are two

FIG. 11.—SQUINCH ARCH AT ANGLE OF BARREL VAULT.

chambers each containing four masonry columns. It would be natural to conclude that these columns were intended to carry domes, but such is not the case: the chambers are roofed with three parallel barrel vaults (Fig. 12). There is no sure example of a Sassanian dome resting on columns, the nearest approach to this type being the little monument of Ferāshabād,¹⁸ where the four supporting walls are broken by wide arches; but the anxious care of an architect engaged on a new problem is shown by the strength of the angle piers, and no attempt is made to transfer the thrust of the

¹⁸ Dieulafoy, *L'Art Ancien de la Perse*, iv. p. 77.

dome through collaterals on to an outer wall. The mastery of the difficulties connected with weight and thrust—a mastery which enabled the builder to cut down the supports directly under his dome to the dimension of slender columns—was in all likelihood never acquired by the Sassanians, and it will be necessary to revise, on the evidence supplied by Ukheidar, de Morgan's suggestion that domes existed in the columned chambers of Qasr-i-Shirīn.¹⁹

It is perhaps not superfluous to lay stress upon the cardinal importance of these questions of construction or upon the need of detailed photographs for their study. Choisy's work, invaluable as it is, does not cover the ground revealed by recent discoveries, and it will be necessary for some skilled

FIG. 12.—BARREL VAULTS ON COLUMNS.

architect, thoroughly conversant both with the Greek and with the Oriental aspects of the problem, to take up the subject where he left it. But before this can be done a more complete body of evidence must be collected. Accurate reproduction of detail is of the highest value, and one good photograph of a dome that stands is worth a thousand conjectures after it has fallen. It is therefore essential that those who have the opportunity of visiting ancient monuments should spare no pains in making a careful record of structural methods, and, judging from my own experience, however lavish they may be in the taking of photographs, they will always have subsequent occasion to wish that they had been more lavish still.

GERTRUDE LOWTHIAN BELL.

¹⁹ *Op. cit.* p. 344.

GROUND-PLAN OF PALACE AT UKHEIDAR.

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Fig. A. GROIN IN EAST ANNEX.

Fig. B GROIN IN CORRIDOR.

PALACE AT UKHEIDAR.