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Planning Method of B6 in Kaunos Design Methods of a Rock-Cut Tomb in Southeast of Karia

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Abstract

The aim of this study is to identify the planning method of B6 in Kaunos. Assuming proportional relationships of each part were applied in the construction, as in the ancient Greek temples and stoas, the planning of B6 was investigated, leading to a conclusion that rough calculation of the scale has been determined first as a scheme design, followed by dimensional adjustment of each part in the execution stage. Further, the study identified that the planning is based on a grid technique using 3 feet as a grid, with proportional design and dimensional adjustments employed in the façade.

Keywords: Ancient Greece; Karia; Rock-cut tomb; B6; Planning method

Introduction

It has been said that the ancient Greek architecture, as shown in the architectures of temples, stoas, etc., is highly formalized and consistent with predetermined style and structure according to the types of the buildings. However, Hellenistic tombs in the ancient Mediterranean world are so varied that it is said that there never existed the same form twice [1]. It is not hard to imagine that the varied architectural forms of tomb building during this period and a newly emerged value of accepting varieties have contributed greatly to Roman architecture that was to come later, in terms of, for example, the provision of the varied architectural languages and the universalization of freedom in choosing the languages. With 'the particularity among the ancient Greek architecture' and 'possibility of the contribution to the coming Roman architecture' of these Hellenistic tombs as the starting point, the author has been studying Hellenistic tombs, with the ultimate aim of systematically categorizing the tombs in order for them to be incorporated into the narrative of the history of architecture. However, as far as the author is aware, there is no study that dealt with Hellenistic tombs exhaustively other than those by Fedak [1] and the author himself. Comprehensive studies of Hellenistic tombs are at an early stage, and it is difficult to achieve the aim of system-atically categorizing the tombs in order for them to be incorporated into the narrative of the history of architecture. Therefore, based on the conclusion suggested by Fedak that 'a rich variety of appearance is the characteristic of Hellenistic tombs, however, clear tendencies and biases can be found in the forms, if chronological and geographical limits are imposed [1] the author has been investigating characteristics of the forms of Hellenistic tombs and the planning process of built-tombs [2-7].

In the previous paper the author investigated the rock-cut Greek temple style tombs [8] in southeast Karia (Figure 1). The dates of construction of most of these tombs are unclear, partly because these rock-cut tombs stand high on a cliff face conspicuously with very few

Figure 1: Rock-cut tombs, Kaunos B group.

Figure 2: B6 in Kaunus.

burial items remaining intact. Contrary to the general ancient Greek architecture that is ashlar masonry, these rock-cut tombs are cut out of cliff rocks usually at considerably elevated positions, using special construction methods. And knowing the architectural devices for con-structing a building at such a height or the knowledge on how the practical difficulties of constructing such rock-cut tombs affected the design decisions, even if the rock-cut tombs were built outside the Hellenistic era, may be useful in analyzing the rock-cut tombs of the Hellenistic era. With these points in mind, the constraint on estimated construction period as Hellenistic era was excluded from our discussion to focus on the rock-cut tombs that imitated ancient Greek temples and are situated in the southeast of Karia in the previous study, identifying a possibility that dimensional adjustment based on visual effect was carried out in these tombs.

Keeping the perspective, the present study mainly aims to analyze planning processes of the rock-cut tombs, and then, from the plan-ning point of view, discuss the possibility of having visual effect adjustment and the method of executing such planning. However, for want of space, this article focuses on Kaunos B6 in southeast of Karia (Figure 2), and aims to identify how the original ground planning was carried out. B6 was chosen since it is the best conserved ex-ample among the

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rock-cut Greek temple style tombs in southeast Karia, which makes it the preferred subject for the analysis, under the current situation where the planning method of these rock-cut tombs is still unknown. Fedak specified B6 as having been built in the Hellenistic era from its architectural form. Though it is risky to determine the date of construction purely by architectural form, if Fedak's judgment is to be believed, this present investigation can be positioned as a study into the planning method of Hellenistic tombs.

Materials and Methods

Multiple studies have been conducted on the planning methods of ancient Greek temples and stoas based on the Ten Books on Architecture by Vitruvius [8]. Though most of these studies are focused on individual buildings, Horiuchi [9] Hayashida [10-14] and Coulton [15-18] among others have studied the planning methods systematically with additional analysis of their own, and demonstrated that regular proportional relations between each dimension were used in temples and stoas in ancient Greek architecture. As far as the author is aware, no study has specifically examined planning methods of rock-cut tombs, however, the author's previous studies have found simple proportional relations between each dimension on the Lion Tomb at Amphipolis and the Nereid Monument at Xanthos, showing the possibility that planning methods using proportional relations were adopted for tombs in the Hellenistic period as well. So, in this study, the question whether a planning method using proportional relations was used in B6 is examined firstly by identifying any regular proportional relations between each dimension.

And of course, thinking of the time when the monument was act-ally built, each dimension must be expressed in the 'yardstick' of that time or the 'ancient measures'. After analysing the planning method using the identified proportional relations, design dimensions will be worked out by the planning method and the ancient measures, then the design dimensions and the actual measurements will be com-pared to verify the planning method suggested in the study. The an-cient measures is expressed in 'foot/feet'. In the past Dinsmoor reported that there were two kinds of 'ancient foot'; the Doric foot (1 foot=approximately 0.326m) and the Ionic foot (1 foot = approximately 0.294 m) [19]. However, in recent studies the ancient foot is not limited to these two measurements. Therefore, one foot in this study is assumed to be somewhere in the range of 0.294m to 0.330m as suggested in other studies. The smallest unit is called a dactyl, four times of a dactyl is called a palm and four times of a palm is a foot. Therefore dimensions of each part of the building need to be expressed as what fit into these units. Hayashida has also suggested the possibility that units of one third and one fifth also existed as well as dactyl, palm and foot. Since one third and one fifth are considered simple and basic divisional numbers, they are used in the analysis in this paper. In other words, the fractions are expressed with the denominators of 2, 3, 4, 5, 8, and 16 when converting into ancient feet. When analyzing, the dimensions of each part of the B6 tomb were taken from the Roos's report [20]. Roos's reported 'the aspect of facade', 'size and shape of each part', 'found artifacts', 'types and examples', etc. of rock-cut tombs in Kaunus in the southeast of Karia. Also included in the report are 1/100 and 1/50 scale drawings of the whole tombs as well as 1/10 and 1/5 scale detailed drawings of capitals and bases of the columns and the antae, for those tombs with exquisitely detailed designs or interesting features. Since the B6 tomb, a subject of interest, is quite large in scale, a 1/100 scale drawing of the whole tomb as well as 1/10 scale detailed drawings of the parts are avail-able. In this study, the 1/100 scale drawing and the 1/10 scale drawings created by Roos were scanned into CAD to obtain dimensions [21]. Some may wonder about the validity of the analysis of the planning method using the measurement data obtained from a 1/100 scale drawing; however, it is viable by the following reasons. Roos recorded several actual measurements in his report. For example, he reported the diameter of a small disc-shaped decoration under the capital of the antae as 21.5 cm. Meanwhile, when calculated using the afore-mentioned method suggested by the author, the diameter of the small disc-shaped decoration under the capital is 21.1 cm, showing a very small difference of 4mm from the 1/100 scale figure documented in Roos's report. Accordingly, this is thought to prove the highest accuracy of Roos's drawing, as well as the feasibility of acquiring good measurement data using the calculation method devised by the author. In addition, considering the characteristic of ancient Greek architecture of 'planning based on simple proportional relations' as mentioned in former studies [20], it is possible to analyze the planning method using data that allows a margin of a certain degree. In other words, 'proportional relations' in ancient Greek architecture usually refer to integer ratios, such as 1:2 and not 0.9:2.1. Above all, what must be presented here is a planning method based on a concept that is consistent throughout the whole plan, such as 'measurement of a part is used as the module to define all measurement' or 'dimensions of upper parts are all obtained as a result of the lower dimensions'. Therefore, even though there might be a slight discrepancy, it should not be a big problem, unless it is big enough to spoil the proportional relations which were supposed to be used in the original planning. Moreover, if the discrepancy is so big as to spoil the proportional relationship, we cannot deduce that a consistent and rational planning method was used. Further to this, the B6 tomb is relatively large in size, with larger parts. Therefore, for example, if a designer deter-mines a length of a part as 50 cm in relation to a 100 cm long part using a proportion of 2:1, and the measured length of the latter part constructed is 105 cm, we can get a proportion of 2:1 by calculating the ratio between 105 cm and 50 cm (105:50/2:1) where a discrepancy is 5 cm. The study concluded that the tomb was planned to use both proportional relations and a grid method, and a certain degree of discrepancy in measurement data is allowed also in the discussion regarding the grid method. When using the grid method, all parts, not just some part, must be determined in relation with the grid of equal intervals. In this case, it is unlikely that a discrepancy or discrepancies can accidentally place every part of the structure onto a grid with equal intervals. On the contrary, if all parts were deter-mined according to the grid method, even if some parts might have a certain degree of discrepancy, the overall structure would be placed on the grid, from which we can deduce the possibility of a planning process based on a grid method. Therefore, it can be said to be viable to use the 1/100 scale drawing to analyse the construction method even if the grid method planning had been conducted. As described above, in larger tombs such as B6, it is possible to explore whether proportional relations or the grid method were used or not, and if so, what their values were, even if there are some discrepancies in dimensional values, since the values themselves are rather large with minimal influence exerted by the discrepancy. Therefore, it is possible to analyse the planning method using the measurements taken from the 1/100 scale drawing.

One point to note is the difference between ashlar masonry buildings and the rock-face masonry buildings. Whether it is a temple, stoa or built-tomb, the ruins of an ashlar masonry building are usually buried underground and only exposed by excavation. In those circumstances, the condition of the ruin and components are generally good without much erosion by the weather. With this in mind, when the planning method of these ruins is analysed, the acceptable tolerance value between the design dimensions calculated using the planning method and the actual measurements is usually set rather small. On the other hand, rock-cut tombs have been exposed to the weather for a long time, resulting in more deterioration compared to a temple, stoa or built-tomb built in ashlar masonry. Further, with the technical difficulties of carving directly onto a rock face, accuracy in execution may have been reduced. These factors can cause larger discrepancy between the design dimensions derived from the planning method and the actual measurements. With the above consideration in mind, a yardstick value for such discrepancy was set using comparisons of measurements of a pair of theoretically same parts, such as right and left antae as well as data of existing discrepancy on the rock-cut tombs.

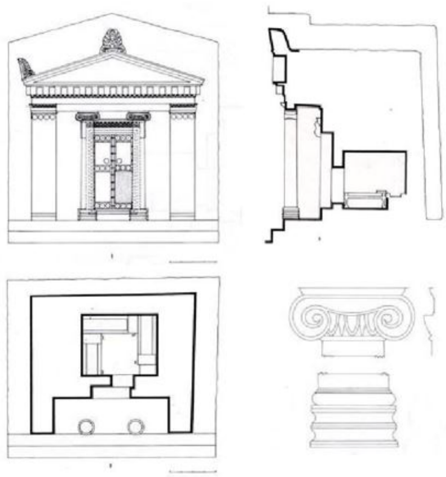

Figure 3: Elevation, plan, section, capital and base of B6.

General Description of B6

The ancient city of Kaunos situated in the modern day city of Dalyan in southwest Turkey, across the river that runs at the west side of the city. B6 is carved out on the rock cliff facing the river and can be seen from the city of Dalyan on the other side. As stated ear-lier, a ruin of ashlar masonry buildings is usually buried underground and only exposed upon excavation. Rock-cut tombs, on the other hand, we have been exposed to the weather since ancient times, resulting in more erosion and deterioration. Considering this, B6 is in relatively good shape without many parts missing, except the acroteria (Figure 3).

The tomb and its surroundings are separated from the rest of the rock face. The ground is rectangular, approximately 6.8×10.2m and the height from the foundation platform to the top of the acroterion is approximately 9.3m. The order is Ionian. The façade consists of 2 bands of foundation platform supporting 2 columns, flanked by a pair of anta, and which, in turn, support the architrave and the pediment on top. In other words, B6 is a rock-cut tomb that imitates an in-antis style Greek temple. However, the tops of the antae go through the lower fascia of the architrave, showing another difference from the formal in-antis prototype.

The sepulcher is located behind the pronaos and contains 3 catafalques positioned in three-pointed-star layout, not side by side. The catafalques are part of the tomb, not separate pieces. If equal-sized catafalques are positioned in a three-pointed-star layout, the floor

(A)	(B)	(C)		(D)	(E)	(F)	(G)		(H)	
Element	Symbol	Measurement (m)		Scheme Design	Execution Planning	Ancient foot (ft)	Deference (m)		Rate of Deference (%)	
		Left	Right				Left	Right	Left	Right
Width of Whole Tomb	W・WT	9.075*		9G	9G+ (1/4) W・A	27 3/4	0.029		0.32	
Depth of Whole Tomb	D・WT	7.870	8.033	8G	8G	24	- 0.046	0.209	0.58	2.63
Width of Side Passage	W・SP	0.992	0.995	1G	1G	3	0.014	0.017	1.43	1.73
Width of Back Passage	W・BP	0.660	0.673	1G	1G-1foot	2	0.008	0.021	1.23	3.22
Width of Tomb	W・T	7.088*		7G	7G+(1/4) W・A	21 3/4	- 0.003		0.04	
Depth of Tomb	D・T	6.169	6.301	6G	6G+1foot	19	- 0.025	0.107	0.40	1.73
Thickness of Front Wall	T・FW	1.056		1G	1G+ {(1/16) T・FW**}	3 3/16	0.017		1.64	
Thickness of Back Wall	T・BW	0.941	0.998	1G	1G	3	- 0.037	0.020	3.78	2.04
Width of Pronaos	W・P	4.925		5G	5G	15	0.035		0.72	
Depth of Pronaos	D・P	1.573		2G	2G-1foot-{(1/16) T・FW**}	4 13/16	0.004		0.25	
Width of Upper Platform	W・UP	0.505		(1/2) G	(1/2) G	1 1/2	0.016		3.27	
Width of Lower Platform	W・LP	0.500		(1/2) G	(1/2) G	1 1/2	0.011		2.25	
Width of Sepulcher	W・S	3.210		3G	3G+1foot	10	- 0.050		1.53	
Depth of Sepulcher	D・S	2.640		2G	2G+2feet	8	0.032		1.23	
Width of Anta	W・A	1.075	1.088	1G	1G+(1/8) W・A**	3 3/8	- 0.025	- 0.012	2.27	1.09
Width of Opening	W・O	1.610		(1/3) W・P	(1/3) W・P	5	- 0.020		1.23	
Axial Intercolumniation	I	2.160		(6/16) C・DA**	(6/16) C・DA**	6 3/4	- 0.041		1.86	
Lower Diameter of Column	LD・C	0.570	0.565	(1/4) I	(1/4) I	1 11/16	0.020	0.015	3.64	2.73
Width of Plinth	W・Pl	0.721		LD・C+(1/3) LD・C	LD・C+(1/3) LD・C	2 1/4	- 0.013		1.77	
Center-to-center Distance of Anta	C・DA	6.007		6G	6G+(1/8) W・A**	18 3/8	0.017		0.28	

- Ancient foot (F) is obtained using 1G as 3 feet applied to the equation of Execution Planning (E). Difference (G) is calculated as; Measurement (C) - (Ancient foot (F) × 0.326 (m)). Ratio of Difference (H) is calculated as; (Difference/actual measurements) × 100. When actual measurements are different between the right and left sides, the average is used.
- A symbol '*' indicates the dimension for a façade part. Places with this mark have different dimensions on the façade side and the backside. The façade side dimension is used in the study since it is natural to assume that more attention must have been paid on the façade side that was intended to be seen.
- A symbol '**' indicates the scheme design dimension.

Table 1: Measurements, scheme design, execution planning, ancient feet and difference.

shape of the sepulcher should be square. However, in B6, the catafalque at the left side of the entrance (in this article, left and right are always seen facing the façade.) is smaller than the rest, which makes the floor shape of the sepulcher a rectangle of approximately 3.2 × 2.6 m. The dimensions of each part are shown in the (C) column of the Table 1.

Results

Setting the yardstick value for tolerance

As mentioned earlier, taking the technical difficulties of the construction on a cliff face as well as the severe erosion into consideration, it was decided to set yardstick values for tolerance. Rock-cut tombs are carved out of a cliff face at an elevated position and an observer cannot see the back, sides and inside of a tomb. Because of

this, there is a possibility that less accurate works might have been carried out at such places. In fact, in the B6 tomb, the back wall and the right-side wall do not make a right angle, which makes the depths widely different on the right and the left, as well as the widths of the tombs at the front and the back. Therefore, this study set two separate yardstick values for tolerance, one for the facade side which was intended to be seen, and another for the rest, including the back, the sides and the interior, which were not intended to be seen. For those parts which were not intended to be seen such as the back, the sides and the interior, the yardstick tolerance was set as follows using the values of the 'back wall thickness' of both on the right and left side; that is, (0.998-0.941)/{(0.998+0.941)/2}×100=5.88 (%). For the fa-cade side, which was intended to be seen, the yardstick tolerance was set as follows using the 'distance between the inward-facing side of anta and the outward-facing side of the column'; that is, (1.076-1.036)/{(1.076+1.036)/2} = 3.79 (%).

Investigation into the planning method

In this study, each part of B6 is expressed simply with initials. For example, the width of anta is expressed as 'W・A'. The positions of each symbol are shown in Figure 4 and the (A) and (B) columns in Table 1.

Reconstruction of the designing method: As a result of examining proportional relations among dimensions of various parts, many parts were found which contained a ratio of dimensions that cannot be expressed simply by integers. This revealed that Tomb B6 cannot be designed only by a designing method using simple integer ratios. On the other hand, it was confirmed that the thickness of front and back walls, the width of the anta, and the width of side passage have relatively similar dimensions. Equi-interval grid lines were thus drawn on the plan of Tomb B6 using dimensions of those parts, and it was found that the planar shape of Tomb B6 is defined approximately by those grid lines. In light of the above facts, assuming that an ancient foot used for Tomb B6 was between 0.294 m and 0.330 m, a method such as this, which is further described below, can be proposed as the designing method of Tomb B6: per-form basic design by using the grid method with 1 grid ("grid" is hereinafter abbreviated as "G") stipulated to be equivalent to 3 feet and then adjust dimensions of each part in detailed design.

In the assumed basic design of Tomb B6, let the "width of the whole tomb (W・WT)" including passage around the tomb be 9G [21,22], the "depth of the whole tomb (D・WT)" likewise including passage around the tomb be "8G", and the "width of the side passage (W・ SP)" and the "width of the back passage (W・BP)" be respectively 1G. The width of the sepulcher (W・S) and the depth of the sepulcher (D・S) are determined to be 3G and 2G, respectively. The width of the anta (W・A) and the thickness of the back wall (T・BW) and the front wall (T・FW) are each determined to be 1 G. Let the width of the foundation platform covering upper and lower levels be 1 G, with the width at each level determined to be (1/2) G. As a result, the "width of the tomb (W・T)," the "depth of the tomb (D・T)," the "width of the pronaos (W・P)," and the "depth of the pronaos (D・P)" are 7G, 6G, 5G, and 2G, respectively (Column (D) of Table 1 and Figure 4). On the other hand, the "axial intercolumniation (I)," the "lower diameter of the column (LD・C)," the "width of the plinth (W・PI)," and the "width of the opening," are determined on the basis of proportional relations. That is, the "axial intercolumniation (I)" is deter-mined as (6/16) C・DA by dividing the "center-to-center distance between antae (C・DA)" into the ratio of "5:6:5" (Figure 5). The "lower diameter of the column" is determined as (1/4) I based on "axial intercolumniation (I)" by using the ratio of "1:4." The "width of the plinth (W・PI)" is determined as "LD・C + (1/3) LD・C" by adding (1/6) LD・C, derived from the "lower diameter of a column (LD・C)" by using the ratio of "1:6," to both left and right sides of the lower diameter of the column. The "width of the opening (W・ O)" is considered to have been determined as (1/3) W・P on the ba-sis of the "width of a pronaos" by using the ratio of "1:3."

It is considered that dimensions of certain parts were adjusted in consideration of the functionality of the tomb and construction constraints after finishing the above basic design (Column (E) of Table 1). For instance, let us take a look at the tomb in the direction of its depth. The "depth of the sepulcher (D・S)," which was planned to be 2 G, has the value increased by 2 feet. As a reason why the depth of the sepulcher had to be increased, it is conceivable, for instance, that it was required to place a sarcophagus of an appropriate size in the sepulcher. For, without this expansion of the sepulcher, the length and width of a sarcophagus that could have been placed there would have been 60 cm smaller than those of the one actually placed, and such a sarcophagus

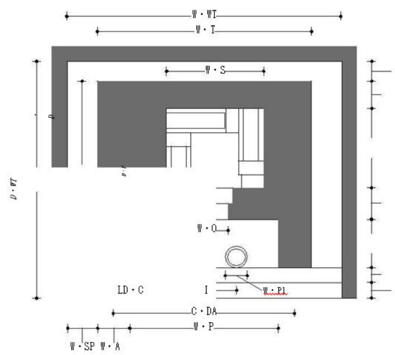

Figure 4: Part names.

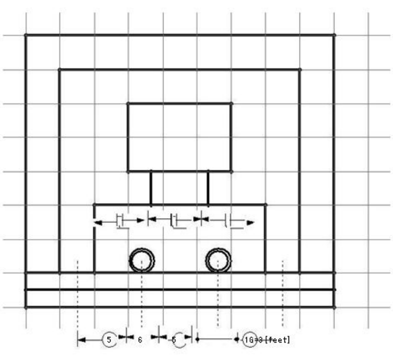

Figure 5: Scheme design using grids.

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would have caused problems in the burial of a corpse. The "thickness of the front wall (T・FW)" became "1 G + (1/16) T・FW**," expanded by the value calculated from the "thickness of the front wall (T・FW)" in the basic design by using the ratio of "1:16." This adjustment in dimension is considered to have been made in order to decorate the jambs of the door on the lateral surface of the front wall with reliefs without decreasing the thickness of the front wall. As the value of this amount of dimensional adjustment, (1/16) T・FW**, resultantly coincides with a mark on an ancient measure, namely 3/16 foot, it can be said to be possible that it was not calculated by using the said ratio as described above but determined as 3/16 foot directly in accordance with an ancient measure from the beginning. If, however, this amount of dimensional adjustment is assumed to have been derived by using ratios, the designing method proposed by the author is the one based on a consistent concept as a measure was used in designing those parts that were not conspicuous to those who would look at the tomb in consideration of construction constraints and ratios were used in designing those parts that were conspicuous to them. As noted above, this dimensional adjustment is considered to have been made in order to decorate the jambs of the door with reliefs. In this case, it seems natural to think that the amount of dimensional adjustment was derived from the thickness of the front wall using a ratio by considering how thick the decorating reliefs should be relative to the original thickness of the wall to strike a good balance. Therefore, in this paper, the amount of dimensional adjustment for the thickness of the front wall is considered to have been derived using a ratio. Returning to the subject of dimensional adjustment, the "depth of a pronaos (D・P)" has a value slightly reduced, by 1 foot. In light of this, 1 foot out of 2 feet added to the depth of the sepulcher mentioned above and (1/16) T・FW** added to the thickness of the front wall are considered to have been subtracted from the "depth of a pronaos (D・P)." In light of the fact that the "width of the back passage" has a value reduced by 1 foot, the remaining 1 foot out of 2 feet added to the depth of the sepulcher is considered to have been subtracted from the "the width of the back passage (W・BP)." It should be noted that length added by the "depth of the sepulcher (D・S)" and the "thickness of the front wall (T・ FW)" could have been handled by increasing the "depth of the whole tomb (D・WT)" instead of subtracting it from the "depth of a pronaos (D・P)" and the "width of the back wall." That was not the case with Tomb B6, however. The following reason is conceivable for this. If the "depth of the whole tomb" was increased, the volume of rock that had to be excavated in order to construct Tomb B6 had to be increased for the amount obtained by "the increment of the depth of the whole tomb × the width of the whole tomb × the height of the whole tomb." Therefore, only a slight increase in the "depth of the whole tomb" would have significantly increased the work for con-structing the tomb. On the other hand, since human eyes are not so sensitive to depth wise changes compared with lateral changes, the impact of some change in the "depth of a pronaos (D・P)" on the appearance of the tomb is considered to be small. In addition, since the back passage of the tomb is out of the sight of those who see the tomb, a change in the "width of the back passage" does not affect the appearance of the tomb at all. Therefore, the amount of dimensional adjustment generated in the "depth of the sepulcher" and the "thick-ness of the front wall" is considered to have been handled by subtracting it from such parts as the "depth of a pronaos" and the "width of the back passage." Such an approach of adjusting dimensions in parts that are unlikely to affect the appearance of the tomb is one found in the designing method of the Nereid Monument at Xanthos.

With regard to the width direction, the "width of the sepulcher (W・S)" was expanded by 1 foot to 10 feet. While the actual opening serving as an entrance to the sepulcher was established in the lower right corner of the apparent door (Figure 3), the sepulcher was shifted to the right so that the central axis of the actual opening and that of the sepulcher coincide (Figure 6). If the sepulcher had not been shifted right to align with the actual opening, the sarcophagus would have been pushed out to the position of the actual opening, which would have caused problems in carrying a corpse into the sepulcher. Therefore, it can be said that the sepulcher needed to be shifted to the right to align with the position of the actual opening. While the "width of the sepulcher (W・S)" was expanded by 1 foot, as noted above, even if the width of the sepulcher had remained 9 feet, the original size, it would still have been possible to place a sarcophagus having a sufficient size to put a corpse into. Therefore, it is difficult to think that the reason for expanding the "width of the sepulcher" was to accommodate a sarcophagus large enough. While several reasons for expanding the "width of the sepulcher" are conceivable, we can think of the following reason for instance. That is, the ratio of the length to the width of the sarcophagus was 1:3 except for the small one placed on the left of the entrance (Figure 7). If the "width of the sepulcher" is divided using this ratio, if the "width of the sepulcher" is 10 feet, the length of the sarcophagus is 7.5 feet and its width is 2.5 feet, resulting in proportional dimensions. Therefore, it can be in-ferred as a reason to have increased the "width of the sepulcher" by 1 feet to improve the workability of the sarcophagus. Alternatively, the interval between sarcophagi placed on the right and left of the sepulcher is 5 feet in the clear, which is a well-rounded number (Figure 7). This part of the sepulcher is considered to require a certain amount of space for conducting the burial of a corpse and rituals such as flower offering. Thus, assuming that the designer of Tomb B6 gave priority to keeping the width of this part 5 feet, if the width of the sepulcher had remained 9 feet, the width of each sarcophagus would have been 2 feet. If the width of each sarcophagus had been 2 feet, the width of space in which a corpse is actually placed would have

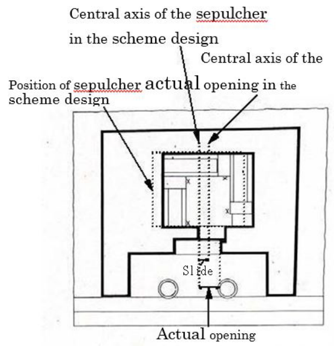

Figure 6: Concept of moving the position of the sepulchre.

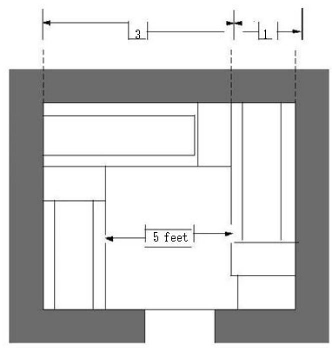

Figure 7: Floor plan of sepulchre.

been approximately 40 cm, subtracting the width of the two sidewalls, 12 cm wide each, constituting a sarcophagus. As this approximate value of 40 cm is smaller than the shoulder width of a typical adult, it would have been impossible to place a corpse in the sarcophagus appropriately. The width of the sepulcher may have been increased in order to avoid this. Returning to the subject of dimensional adjustment, the "width of an anta (W・A)" was also somewhat increased to decorate the side of an anta with reliefs. This increment is (1/8) W・A*, which is derived from the "width of the anta (W ・ A*)" in the basic design by using the ratio of 1:8. In accordance with this increase in the width of an anta, the "width of the tomb (W・T)" is considered to have been changed to "8 G + (1/4) W・A*" by Adding the increment in the width of antae on the right and left. The "width of the whole tomb (W・WT)" is also considered to have been changed to "9 G + (1/4) W・A*" by adding the increment in the width of antae on the right and left. As the value of this increment in the width of antae resultantly coincides with a mark on an ancient measure, namely 3/8 foot, it can be said to be possible that it was not calculated by using a ratio but determined as 3/8 foot directly in accordance with an ancient measure from the beginning. If, however, this increment in the width of antae is assumed to have been determined by using ratios, the designing method proposed by the author is the one based on a consistent concept as a measure was used in adjusting dimensions of those parts that were not conspicuous to those who would look at the tomb in consideration of construction constraints and ratios were used in designing those parts that were conspicuous to them. In addition, antae are components of a façade, and it needs to be considered how much adjustment to the original anta width re-sults in the balanced anta width relative to a façade. Therefore, it seems natural to conceive that this increment in anta width was de-rived by using a ratio for the purpose of proportional adjustment rather than adjusted by using a measure in one way or the other. Therefore, in this paper, the increment in the width of antae is considered to have been derived from the width of antae itself by using a ratio. This kind of planning process in which a scheme design is adjusted at the execution planning stage was observed in other temples and stoas as well as the Nereid Monument in Xanthos.

In light of the above design process, for parts where dimensional adjustments using ratios were made, numbers coinciding with marks on an ancient measure were used in ratios applied, for instance, 1:2 (=1/2), 1:3 (=1/3), 1:8 (=1/8), 1:16 (=1/16) (Table 1, Column E). On the other hand, the dimension of each part of Tomb B6 in the basic design was determined on a 3-foot grid. Therefore, the value of a dimensional adjustment calculated by using the ratio of numbers mentioned above is necessarily a well-rounded number coinciding with a mark on an ancient measure (Table 1, Column (F)). For in-stance, the width of an anta was considered to have been planned on a 3-foot grid in the basic design, as noted above, and a value derived from itself using the ratio of 1:8 was considered to have been added in the detailed design. In this case, the increment in anta width is 3/8 foot, which coincides with a mark on an ancient measure. It is difficult to be considered as accidental that ratios used in dimensional adjustment all coincide with numbers found on marks on an ancient measure as found above. Therefore, this fact can be conceived as one piece of evidence that supports that the designing method proposed in this paper is appropriate. In addition, under the designing method proposed in this study ratios are used in executing design and dimensional adjustment for the façade, which is conspicuous, namely with regard to such lengths as axial intercolumniation, the diameter of a lower column, the width of a plinth, the width of an anta, and the width of an opening. On the other hand, inconspicuous parts are de-signed by the grid method, and dimensional adjustment is made in multiples of an ancient foot. This can be interpreted as follows. Ratios were used in designing the façade, which is conspicuous, in giving priority to design, and the designing method using the grid method was basically used, with adjustment made in dimensions easily measured by a measuring stick, in designing other parts, giving priority to construction constraints. Namely, the designing method proposed in this paper is based on a consistent concept, and a possibility is considered small that a designing method with such a consistent concept was accidentally devised.

Some may wonder that, in light of the above result, there is a possibility that dimensional adjustments were made after executing basic design by using ratios instead of using the grid method. Design using proportional relations, however, is considered to have been used to create harmonious architectural appearance, to begin with, as Vitruvius said. Therefore, it is difficult to think that, if design was executed using proportional relations, a dimensional adjustment was made that broke those proportional relations. As a matter of fact, as indicated in preceding studies on ancient Greek designing methods, even if design was executed using proportional relations, when it came to overall dimensions such as the width and depth of a building, for instance, some revisions were made by later detailed adjustment even if proportional relations were used in the early stage of design. Except for such situations, however, it was rarely found that an adjustment is easily made to dimensions derived by using proportional relations. On the other hand, as shown by the preceding study by Horiuchi, under the grid method, instances are found where the overall shape is determined by reference to grid lines with dimensions of each part being adjusted later. Therefore, in light of the results of preceding studies, it seems appropriate to think that basic design by the grid method was executed in the case of Tomb B6.

Examination of design dimensions: In light of the fact that Tomb B6 was constructed in the ancient time, design dimensions of each part derived by using the above de-signing method must, of course, be represented in "ancient measures," yardsticks used at the time. Here, the validity of the designing method proposed in this paper is verified by calculating design dimensions using the designing method introduced in the preceding section and ancient measures and examining errors against measured dimensions.

For this purpose, the length of an ancient foot used for Tomb B6 needs to be estimated first. As noted in the preceding section, the "width of the tomb (W・T)" is considered to have been planned to be 21 3/4 feet. Therefore, by dividing the measured dimension of the "width of the tomb" at 7.088 m by 21 3/4 feet, 1 foot is obtained as 0.326 m. The reason why the ancient foot is calculated on the basis of the "width of the tomb" is as follows. The dimension such as the "width of a tomb" that defines the overall shape of a tomb has a large impact on its visual impression. If this dimension deviates from the design dimension, the visual impression of the tomb will be different from what has been assumed at the time of design. If the construction of a tomb starts from detailed parts, errors resulting from work on each part can accumulate, making it more possible that the width of the tomb differs from the design dimension. Therefore, it seems natural to think that, in constructing a tomb, the width of the tomb was precisely established first and then work on detailed parts started. Therefore, in this paper, assuming that the builder of Tomb B6 also paid a minute attention to ensuring the width of the tomb, an ancient foot is calculated on the basis of the width of the tomb. Let me add, however, that taking an average of lengths of an ancient foot calculated on the basis of parts on the façade yields the same value of one ancient foot at 0.326 m.

Columns (F), (G), and (H) in Table 1 list values of the design dimension of each part calculated on the basis of the designing method introduced in the preceding section using this ancient measure with one foot = 0.326 m as well as errors between the design and measured dimensions. As shown in Table 1, except for the depth of the right side of the tomb, which was obviously deformed in work, an error between the design and measured dimensions is small with every part. As indicated above, the designing method proposed in this paper is based on a consistent concept. In addition, under the designing method proposed in this paper, every ratio used in dimensional adjustment is expressible as a fraction found in marks on the ancient measure. As a result, the amounts of dimensional adjustment are necessarily calculated as values coinciding with marks on an ancient measure (Columns (E) and (F) of Table 1). Of course, reasonable grounds leading to a dimensional adjustment can be inferred for each part where the adjustment was made. Since a probability is considered low that these state of affairs occur simultaneously by accident, there can be said to be a sufficient possibility that the designing method presented in this paper was used for Tomb B6.

It should be noted that, while, under the designing method pro-posed in this paper, dimensional adjustments are made in detailed design after basic design, as indicated by Column (F) of Table 1, a wall thickness was never decreased by dimensional adjustment even if it was increased. A wall thickness of at least 1G or 3 feet was secured. Perhaps, the designer of Tomb B6 may have thought, in executing design, that it was necessary to ensure a wall thickness of at least 1G or 3 feet in constructing a rock-cut tomb of the scale of Tomb B6. An attention is intended to be paid to the relationship between wall thickness and the scale of a tomb in analyzing the design-ing methods of other rock-cut tombs in Kaunos.

Conclusions

This paper thus analyzed the plan designing method of Tomb B6. The designing method proposed in this paper are characterized as follows.

1) It is possible that, in designing the plan of Tomb B6, after the approximate scale of the tomb and the layout of chambers were determined in the basic design, dimensions of parts were adjusted in the detailed design.

2) While the basic design basically used the grid method with 1 grid equivalent to 3 feet, ratios were considered to have been used in designing the façade. In the detailed design, dimensional adjustments based on ratios were made in the façade, and dimensional adjustment based on a measure were made elsewhere. This can be interpreted as follows. The designer of Tomb B6 gave priority on design in designing the façade, which was conspicuous, and on construction constraints in designing other parts.

3) In dimensional adjustments regarding wall thickness, no adjustment was made that resulted in a wall thickness below 3 feet or 1 G while some adjustments resulted in a wall thickness above 3 feet. This suggests a possibility that the designer of Tomb B6 thought, in executing design, that it was necessary to ensure a wall thick-ness of at least 1 G or 3 feet in constructing a rock-cut tomb of the scale of Tomb B6.

As indicated above, this study showed a series of designing methods that have a possibility of having been used for Tomb B6 and clarified several characteristics of those designing methods. In the future, it will be necessary to analyze the designing methods of other rock-cut tombs adjacent to Tomb B6 and further examine whether the designing methods proposed in this paper and their characteristics are products of chance or not. The next paper, however, will continue to focus on Tomb B6 to clarify the designing method for its elevation surface. It is intended to examine the presence or absence and the methodology of visual compensation reported by the author in the preceding study from the perspective of a designing method.

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