

PLANNING METHOD OF THE NEREID MONUMENT AT XANTHOS

Design methods of Hellenistic tombs (2)

クサントスのネレイドモニュメントの平面の設計法に関する一考察
ヘレニズム期の墓の設計法に関する研究 (2)

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The purpose of this paper is to analyze the planning of the Nereid monument. Through the analysis of the dimensional proportion of the building, the following conclusions were given. In the planning of this building the proportional relationships between the dimensions are simple. The planning started from the decision of the internal dimensions of the naos as 9 feet by 11 feet (1 foot = 0.310m). Many dimensions are defined by the successive system of proportion. Many of the planning dimensions in the Nereid monument are complete figures, suggesting that the construction aspect was taken into account at the planning stage.

Keywords : *Ancient Greece, Hellenistic period, built tomb, Nereid monument, design method*

古代ギリシア、ヘレニズム期、家型墓、ネレイドモニュメント、設計法

1. Introduction

During the Hellenistic period in the ancient Mediterranean world, tombs in varied architectural forms were built of which it was once said, 'it is the characteristic of the Hellenistic tombs that there never existed the same form twice'¹⁾. There are studies on ancient Mediterranean architectural design methods, focusing on Greek temples and stoas²⁾, however, nothing similar is available for the Hellenistic tombs so far except the paper written by the author³⁾. Therefore it is not clear at all what kind of design methods or design philosophies were behind these tombs or indeed whether these design methods and philosophies were shared in the whole ancient Mediterranean world or were inherent to local areas. In this study an analysis of the design method of a Hellenistic tomb is attempted with the view of elucidating the whole picture of design methods and philosophies of Hellenistic tombs of the ancient Mediterranean world. As the precursor to this, an analysis of the design method of the Lion Tomb at Amphipolis in Macedonia was attempted in the previous paper. In this paper, an attempt is made to analyze the planning method of Nereid Monument at Xanthos.

The Nereid Monument is estimated to have been built later than the early 4th century BC⁴⁾, and is said to be the oldest of the Hellenistic tombs discovered so far. The upper part of the building was discovered deconstructed, how-

ever, since there are many parts excavated, sufficient data on dimensions are available for analyzing the design method. Also the architectural form is thought to be a Greek-style temple on a high podium, so it is possible to conduct the analysis referring to the planning method of the ancient Greek temple architectures.

2. Study method

Multiple studies are conducted on the design methods of ancient Greek temples and stoas based *The Ten Books on Architecture*⁵⁾ by Vitruvius. Though most of these studies are focused on individual buildings, Horiuchi⁶⁾, Hayashida⁷⁾, and Coulton⁸⁾ among others have studied the design methods systematically with additional analysis of their own, and demonstrated that regular proportional relations between each dimensions were used in temples and stoas in ancient Greek architecture. However, as previously mentioned, there are no such studies for Hellenistic tombs, leaving their design methods unknown as far as the author is aware. In the previous paper, an examination was made as to whether the design methods for the temples and the stoas proposed by Horiuchi, Hayashida or Coulton could be applied to the Hellenistic tombs. And simple proportional relations between each dimension were found on the Lion Tomb at Amphipolis, showing the possibility that design

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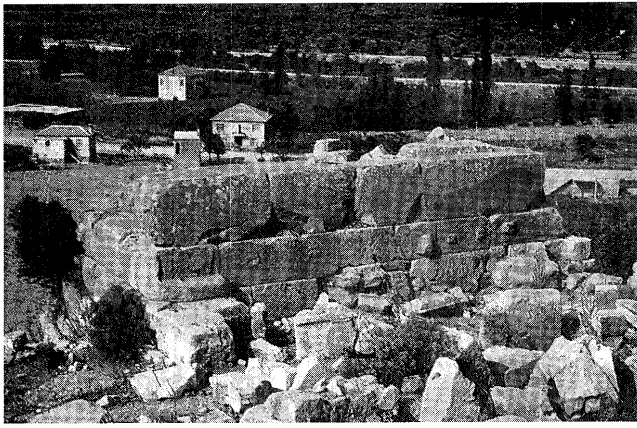


Fig.1 Nereid monument, Ruin

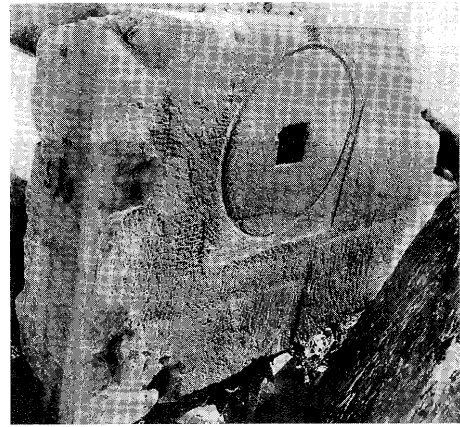


Fig.4 Stylobate block with the setting line

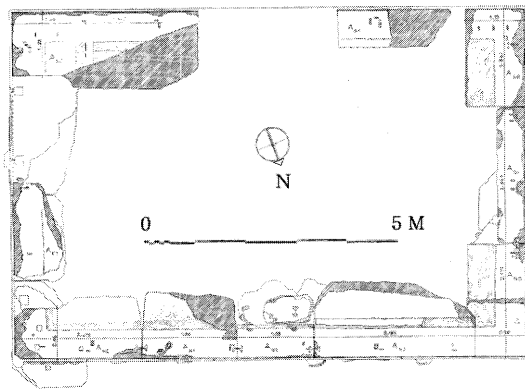


Fig.2 Nereid monument, Plan

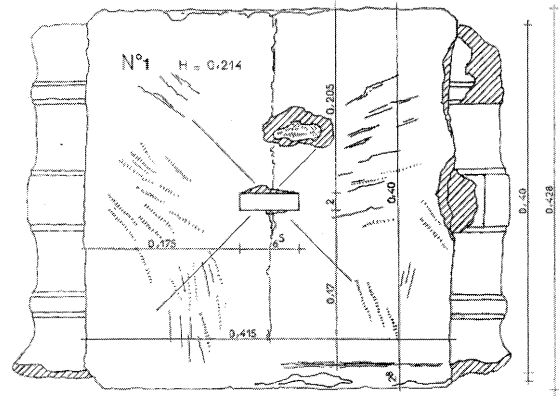


Fig.5 Ionic capital block

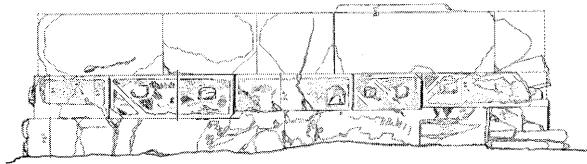


Fig.3 Nereid monument, North Elevation

methods using proportional relations were adopted for tombs in the Hellenistic period. So in this study, the question whether a design method using proportional relations was used in the Nereid monument at Xanthos is examined firstly by identifying any regular proportional relations between each dimension.

Also thinking of the time when the monument was actually built, each dimension must be expressed in the 'yardstick' of that time or the 'ancient foot'. Therefore, as in the previous paper, the proportional relations and the planning process will be validated by first determining the design dimension using the identified proportional relations and the ancient foot, then comparing the design dimension and the actual measurement. 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 0.294m)⁹⁾. However in recent studies the ancient foot is not limited to these two measurements¹⁰⁾. Therefore one foot in this study is assumed to be somewhere in the range of 0.294m to 0.330m which are suggested in other studies. Another point to consider is the relation of units in the ancient foot. The smallest unit is

called a dactyl, four times of a dactyl is called a palm and four times of a palm is a foot¹¹⁾. Therefore dimensions of each part of the building need to be expressed which fit into these units. Hayashida¹²⁾ has 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 were 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.

For the purpose of the analysis in this paper, the dimensions reported in the Coupel's paper¹³⁾ are used. The ground plan¹⁴⁾ in the report shows the dimensions up to three decimal places, a digit short of the unit of mm. Therefore in this study the measurements are picked up from the text of the report, converting each dimension into values with three decimal places, then used for the examination of the planning method. The reason for this manipulation is the known highly technical standard of the construction in the ancient Mediterranean architectures. For example, inward inclination as small as mm unit is observed in the outer wall of the Treasury of Massilians at Delphi¹⁵⁾ showing the construction technique at that time was capable of achieving the level which is called the mm in present days. Therefore the analysis in this paper adopted the mm level of miniscule.

3. General description of the Nereid Monument

The ancient city of Xanthos is situated on a hilltop in the mountains. Both sides of the city gate are steep cliffs. Stone-built city walls, the height is 13.5m¹⁶⁾,

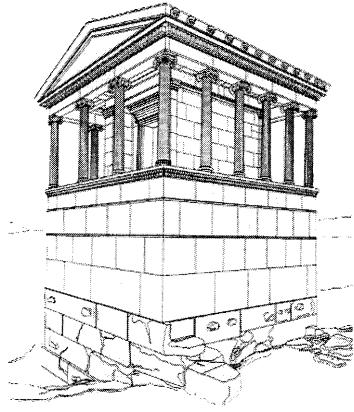


Fig.6 Nereid monument, View reconstructed

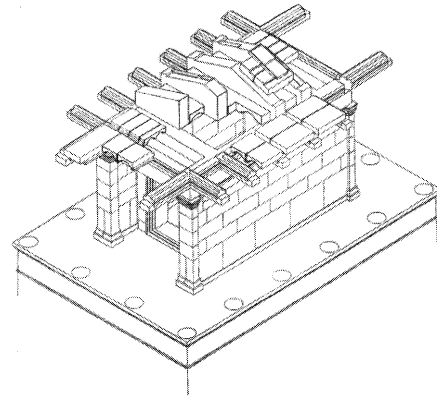


Fig.8 Nereid monument, Structure of the roof

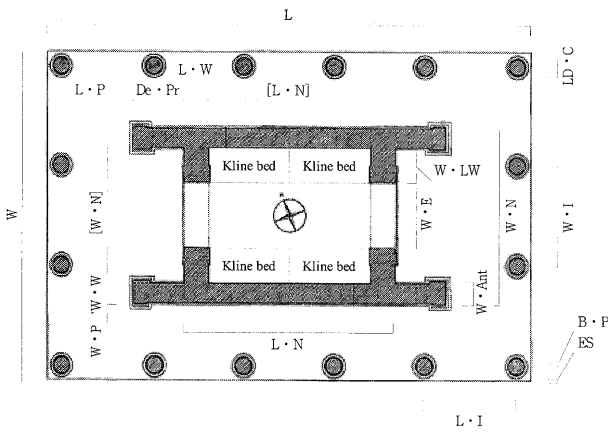


Fig.7 Nereid monument, Plan reconstructed

run along the cliff and the Nereid monument stands just within the city wall. A present day visitor to the city would see the ruin of the monument in front of the wall on his right. Most of the upper structure has fallen, leaving only a part of the podium on site (Fig.1, 2, 3). For a first time visitor it will be difficult to see which part belongs to the Nereid Monument. However many parts which used to comprise the upper structure from the podium up to the roof had been discovered (Fig.4, 5). Since most of them are made of marble stone, detailed and high quality reconstructions were drawn based on them by Coupel and his group who conducted the investigation (Fig.6, 7).

According to the Coupel's report¹⁷⁾, six courses below the podium are of limestone while everything above is made of marble stone. The monument is rectangular with the dimensions of approximately 6.80m × 10.17m. On the podium, an Ionian style peripteral temple used to stand. The temple itself does not have a foundation platform, just a projecting decorative band attached to the top of the podium separating the podium and the temple. The podium consists of 9 courses of cut stone masonry, however the courses up to the fifth course are closer to rubble work which seems to suggest they are part of the earth work in order to create the level ground rather than a part of the building's construction. The upper four courses are of the range ashlar masonry construction with smooth surface finish. The bottom course among these four is made of tall members like orthostats, giving the impression that these four upper courses were planned as a part of the building. The Ionian temple has four columns on the east-west façade, six columns on the sides. A column is

made of one piece of rock with 12 flutings, has an Ionic capital and Asiatic-Ionic type base¹⁸⁾ without column foundation, with double scotia and torus above. The gable roof is a rare construction with stone covering (Fig.8). There are two sepulchers; one in the cella and another in the podium. Four Kline beds have been identified in sepulcher in the cella. The sepulcher inside the podium has a rectangular shape and is situated three meters above the ground. The dimensions of each part are shown in the (C) column of the Table 1.

4. Investigation into the planning method

In this study, a long side of the building is expressed as 'L side' while a short side is expressed as 'W side'. Each part of the Nereid monument is expressed simply with initials. For example the external dimension of the 'Width of naos' is expressed as 'W · N'. When it refers exclusively to the internal width, brackets are used such as '[W · N]'. The positions of each symbol are shown in the (A) and (B) columns in Table 1 and Fig.7.

4-1. Examination of the planning process

Having examined the proportional relationships between each dimension, simple and accurate proportional relationships were found at several places (Table 1 (D) and (E)). However the thickness of the L side walls and the depth of the pronaos (the depth of the opisthodomos) have no relationship with any other parts. To solve this problem it is assumed, in this paper, that an outline scheme had existed. In other words, at the Nereid monument, it is assumed that the width and length of the stylobate have been set first at 20 feet and 30 feet respectively making the relationship between W and L as 2 to 3 ratio. Then the proportional relationship of the dimensions of the width of the pteron and the width of the naos were set to a 1 to 2 ratio, the dimensions of the length of the pteron and the length of the cella at a 1 to 4 ratio and the dimensions of the length of the naos and the depth of the pronaos (the depth of the opisthodomos) at a 2 to 1 ratio (Fig.9). In this way it could be assumed that the proportions of the whole structure, the rooms and the passages were set first, then dimensions for each part were adjusted and re-planned. (In this paper the word 'PLAN' refers to the process later than the outline scheme). Allowing the existence of the outline scheme, the thickness of the L side wall and the depth of the pronaos (the depth of the opisthodomos) can be determined. In fact there are reports that this method, where an outline scheme was first determined then in the planning stage the dimensions of each parts were recal-

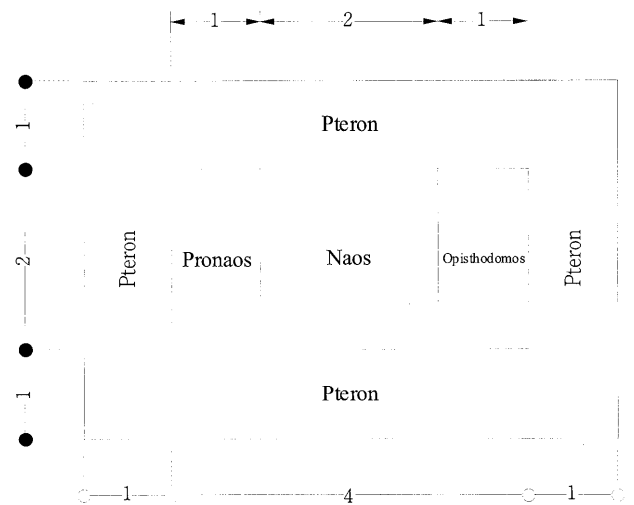
Table 1 Measurements, Proportional relationships, Ancient feet and Difference

1foot=0.310m

	(A)	(B)	(C)	(D)	(E)	(F)	(G)
	Element	Symbol	Measurement (m)	Proportional relationship	Deference (m)	Ancient foot (ft)	Deference (m)
W side	Width of Styrobate	W	6.795	$W \cdot N + 2W \cdot P$	0.000	22	- 0.025
	Width of Pteron	$W \cdot P$	1.550	$(5/12) W \cdot N$	0.010	5	0.000
	External Width of Naos	$W \cdot N$	3.695	$[W \cdot N] + 2W \cdot W$	0.000	12	- 0.025
	Internal Width of Naos	$[W \cdot N]$	2.785	*	*	9	0.005
	Width of L side Wall	$W \cdot LW$	0.701	*	*	2 1/4	0.003
	Width of Entrance	$W \cdot E$	1.383	$2W \cdot LW$	- 0.019	4 1/2	- 0.012
	Width of Anta	$W \cdot Ant$	0.545	$(1/5) [W \cdot N]$	- 0.012	1 4/5	- 0.013
	Thickness of W side Wall	$W \cdot W$	0.455	$(5/6) W \cdot Ant$	0.001	1 1/2	- 0.010
L side	Length of Styrobate	L	10.170	$(3/2) W$	- 0.023	33	- 0.060
	Length of Pteron	$L \cdot P$	1.845	$(5/12) L \cdot N$	- 0.008	5 35/36 → 6	- 0.015
	External Length of Naos	$L \cdot N$	4.446	$[L \cdot N] + 2L \cdot W$	0.000	14 1/3	0.003
	Internal Length of Naos	$[L \cdot N]$	3.406	*	*	11	- 0.004
	Thickness of L side Wall	$L \cdot W$	0.520	$(1/13) L \cdot N'$	- 0.005	1 9/13 → 1 2/3	0.003
	Virtual Length of Cella	$L \cdot Ce'$	6.820	$2[L \cdot N]$	0.008	22	0.000
	Depth of Pronaos (Depth of Opisthodomos)	$De \cdot Pr$	1.017	$(L - L \cdot N - 2L \cdot P) / 2$	0.000	3 1/3	- 0.016
Others	Axial Intercoluniation on the W side	$W \cdot I$	2.065	$(W - B \cdot B - 2ES) / 3$	0.000	6 2/3	- 0.002
	Axial Intercoluniation on the L side	$L \cdot I$	1.914	$(3/16) L$	0.007	6 3/16	- 0.004
	Lower Diameter of Column	$LD \cdot C$	0.362	$(3/16) L \cdot I$	0.003	1 41/256 → 1 3/16	- 0.006
	Breadth of Plinth	$B \cdot P$	0.500	$LD \cdot C \{1 + (1/4 + 1/8)\}$	0.002	1 81/128 → 1 5/8	- 0.004
	External End Space	ES	0.050	$[L - (5L \cdot I + B \cdot B)] / 2$	0.000	7/32 → 3/16	- 0.008

culated, was used in the planning of the temples and stoas¹⁹⁾. In construction generally, a rough idea of the size of the building is always envisaged first, before the construction commences, taking consideration of the size of the site and the building as well as the cost; it is also quite natural to assume that such an outline scheme existed. Therefore the planning method of the Nereid monument is investigated in this paper on the assumption that this outline scheme existed.

Now PLAN based on the aforementioned outline scheme will be examined. The dimension most probably determined first must be internal width of the naos which can not be calculated from comparison with other parts of the building. It seems natural to assume that the internal dimensions of the naos were first determined since it has to contain the Kline beds and a Kline bed had to be the right size, not too small or too big, for a human body (0.701m × 1.703m). To be more precise, using the width of catafalque, the width of the L side wall is determined by the ratio of 1 to 1 so that the width of catafalque may not protrude the width of the L side wall. After this, using the width of the L side wall, the width of the entrance is determined by the ratio of 1 to 2. As a result the internal width of naos is four times the width of the catafalque. Once the internal width of the naos are determined, the dimension of the internal width of the naos is used to determine the width of the anta as the ratio of 5 to 1. Using the width of the anta, the thickness of the W side wall is determined by the ratio of 6 to 5. Then double the thicknesses of the W side wall and add the internal width of the W side the naos to make the external width of the naos. This width of the naos is then used to determine the width of the pteron by ratio of 12 to 5. Finally double the width of the pteron and add the external width of the naos makes the width of the stylobate. This calculation process can be expressed as follows:


Fig.9 Nereid monument, Outline scheme

[Outline scheme]

$$W : L = 2 : 3 = 20 : 30 \text{ [feet]}$$

$$\text{Width of naos} : \text{Width of pteron} = 2 : 1 = 10 : 5 \text{ [feet]}$$

$$\text{Length of cella} : \text{Length of pteron} = 4 : 1 = 20 : 5 \text{ [feet]}$$

$$\text{Length of naos} : \text{depth of pronaos} = 2 : 1 = 10 : 5 \text{ [feet]}$$

[PLAN]

$[W \cdot N] = 9$ [feet] (Determined as the width a catafalque × 4. The reason why 9 feet was chosen will be explained in the next section.)

$$W \cdot Ant = (1/5)[W \cdot N]$$

$$W \cdot W = (5/6)W \cdot Ant$$

$$W \cdot N = [W \cdot N] + 2W \cdot W$$

$$W \cdot P = (5/12)W \cdot N$$

$$W = W \cdot N + 2W \cdot P$$

As for the L side, the aforementioned width of the stylobate is used to determine the length of the stylobate first by the ratio of 2 to 3. Then using the dimensions of the catafalques, the internal length of the naos is determined as 11 feet (The internal length of the naos might have been already decided while setting the internal width of the naos). Then based on the outline scheme, the internal length of the naos is used to calculate the virtual length of the cella by the ratio of 1 to 2. Using this virtual length of the cella, the thickness of the L side wall is determined by the ratio of 13 to 1. The external length of the naos is calculated by adding the internal length of the naos onto the double thickness of the L side wall, then the external length of the naos is used to determine the length of the pteron by the ratio of 12 to 5. After this, double length of pteron and the external length of the naos are subtracted from the length of the stylobate which was determined earlier, leaving the sum of the depths of the pronaos and the opisthodomos. In this calculation of the L side, only the thickness of the wall is determined based on the outline scheme. The reason for that is, though admittedly only guesswork, based on the intention of the architect. In other words, the architect must have thought that 'the length of the pteron should be determined using the relationship with the external length of the naos, as was done in the W side calculation'. However to determine the external length of the naos, the thickness of the L side wall has to be decided. The architect also must have thought that the thickness of the L side wall should be decided taking the structural stability into account, based on the idea that 'the thickness of the wall needs to be appropriate for the size of cella (the length of the cella)'. However unless the length of the cella is determined, the planning process after the determination of the internal length of the naos cannot proceed. It is assumed here that the architect then devised the virtual external length of the cella based on the outline scheme. The planning process of the dimensions of the L side parts is expressed as follows:

$$L = (3/2)W$$

$[L \cdot N] = 11$ [feet] (Determined as the length a catafalque $\times 2$. The reason why 11 feet was chosen will be explained in the next section.)

$$L \cdot Ce' = 2[L \cdot N]$$

$$L \cdot W = (1/13)L \cdot Ce'$$

$$L \cdot N = [L \cdot N] + 2L \cdot W$$

$$L \cdot P = (5/12)L \cdot N$$

$$De \cdot Pr = (L - L \cdot N - 2L \cdot P)/2$$

As shown so far, the planning process for the Nereid monument starts from the naos, since the naos is used as the sepulcher which contains the Kline beds. Adjustment of the dimension is devised at the depth of the pronaos in order not to distract the L and W proportion of 3 to 2 set at the outline scheme stage. Looking at the building from outside, the depth of the pronaos is the least noticeable for overall appearance. This example shows the intention of the architect to combine the functionality of a tomb and the aesthetics of architecture. It also demonstrates the challenge of planning a small to medium size temple style tomb, the naos of which has a sepulcher, compared with

planning a pure temple. In addition, the dimensions like 8 feet by 12 feet to which a clear-cut solution can be given may be more desirable as the first dimension of the design than 9 feet by 11 feet. However, the external dimensions of the naos were planned into 10 feet by 10 feet in the outline scheme. Therefore, taking into consideration making the internal dimensions of the naos close to the dimensions of this outline scheme and that, of course, the catafalques are put on the naos it is assumed that 9 feet by 11 feet were chosen as the internal dimension of the naos.

Returning to the investigation of the planning process, the next step is to decide the axial intercolumniation on the L side using the dimension of L by making the distance the ration of 16 to 3. Using the dimension of the axial intercolumniation on the L side, the lower diameter of the column is then determined by the ratio 16 to 3. From this lower diameter, the breadth of the plinth is determined using the ratio of $(1 + (1/4 + 1/8)) = 11/8$. The sum of 5 times the dimension of the axial intercolumniation of the L side and a breadth of the plinth is subtracted from the length of the stylobate, then the resulting value is divided in two to work out the dimension of the external end space. Then turning to the W side. The dimension of the axial intercolumniation of the W side is determined by subtracting the sum of double the dimension of the external end space and a breadth of the plinth from the width of the stylobate, and dividing the result by 3. The lower diameter of the column was calculated based on the axial intercolumniation of the L side, which is the longer side of the building with more columns. To avoid a tight appearance, it was assumed in this paper that the architect had chosen the L side for this reason. The calculation behind the axial intercolumniation, the lower diameter of the column, the breadth of the plinth and the external end space is expressed as follows:

$$L \cdot I = (3/16)L$$

$$LD \cdot C = (3/16)L \cdot I$$

$$B \cdot P = (1 + (1/4 + 1/8))LD \cdot C$$

$$ES = \{L - (5L \cdot I + B \cdot P)\} / 2$$

$$W \cdot I = (W - B \cdot P - 2ES)/3$$

The formula used for the calculation of the breadth of the plinth here is the same formula described as the Ionian column in the Ten Books on Architecture by Vitruvius²⁰. The ratio of 3/16, which was used to work out the axial intercolumniation of the L side, seems hardly a simple one however it is not difficult to come up with this ratio using the following logic. Having six columns with 5 intercolumniations, the dimension of the axial intercolumniation should come close to one fifth of the length of the stylobate. However taking into consideration the dimensions of the external end space as well as the thickness of column, the dimension of the axial intercolumniation needs to be adjusted to slightly less than one fifth of the length of the stylobate. From this requirement that 'the axial intercolumniation has to be as close as possible to but less than one fifth of stylobate', it is not difficult to come up with the integer ratios such as 1/5 to 1/6, 2/10 to 2/11, 3/15 to 3/16 and 4/20 to 4/21 and so on. If 1/6 is chosen, unless the lower diameter of the column is designed rather wide, the external end space becomes too large. If 2/11 is chosen, it makes the external end space narrower and spacing of the columns wider than

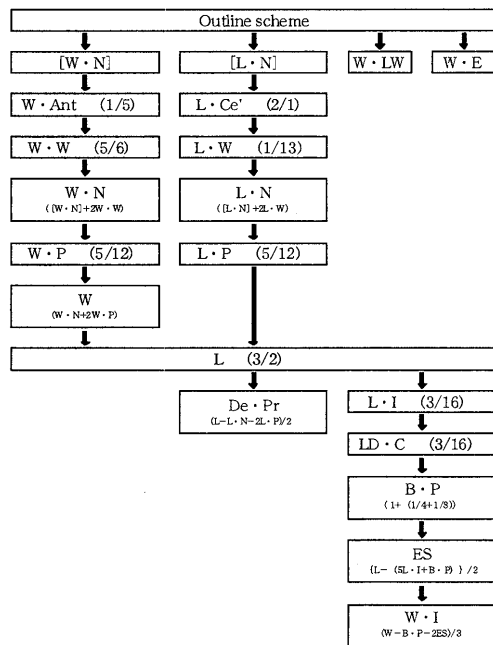


Fig.10 Flowchart of the planning process

1/6 ratio, it still needs wider columns. By considering the relationships between the external end space, the axial intercolumniation and the lower diameter of the column, it is assumed that 5/16 was chosen for its best balance. As reported in the previous investigation, the axial intercolumniation was likely to be calculated from the dimension of the stylobate at the Lion Tomb at Amphipolis. This is, as in the case of the Nereid monument, probably based on the same requirement that it has to be slightly shorter than the value resulting from dividing the dimension of stylobate by the number of the intercolumniation²¹⁾.

Fig.10 is the flowchart of the planning process of the Nereid monument, showing all the floor plan dimensions are successively determined from the internal dimension of the naos using simple ratios. Therefore the planning of the Nereid monument falls into the category that Vitruvius proposed as ‘the successive system of proportion’²²⁾ in his Ten Books on Architecture.

As for the numbers used in the ratios in deciding the dimensions of each part, it is interesting to notice that there are several closely related part which use the same ratio in the floor plan of the Nereid monument. For example, the dimensions of the pteron for both L side and W side were determined using the same ratio of 5/12 from both L and W side external dimensions of the naos. Further, the dimension of the axial intercolumniation was decided as the ratio of 3/16 of the length of the stylobate and the lower diameter of the column was also determined as the ratio of 3/16 against the dimension of the axial intercolumniation. These examples show that the same ratios are used in the conceptually related parts, such as the axial intercolumniation which involve dividing the length of the stylobate as well as the lower diameter of the column which involve dividing the axial intercolumniation. They might be pure coincidence, but there is a possibility that the same ratios were used in the related areas deliberately in order to create a good balance or express some symbolic meaning. This repetition of the same ratios was not found in the Lion Tomb investigated in the previous paper. Of course it is difficult to come to a conclusion studying just two tombs, but architects’ intentions of

choosing ratios in designing tombs need to be looked at when analyzing the design method of other tombs in future.

4-2. Calculation of planning dimensions

The dimensions calculated using the aforementioned proportional relations must have been expressed in ‘ancient foot’, which was the yardstick used at the time of the construction. In this section, the planning dimensions will be calculated using the proportional relationships worked out in the previous section and the ancient foot, then the proposed planning procedure will be verified by comparing the resulting planning dimensions and the actual measurements.

Firstly, it is necessary to estimate how long was a foot used in the Nereid monument. As stated earlier, it was assumed the ancient foot used in the Nereid monument would be in the range of 0.294m to 0.330m. Using this assumption, the internal dimensions of the naos determined first will be 8.439 to 9.473 feet on the W side and 10.321 to 11.585 feet on the L side. Referring to the architectural specifications of that time²³⁾, it is likely that the basic dimension which is used as the start of the planning to decide the size of the whole building must be a rounded or even number without any complicated fractions. Therefore in this study 0.310m was chosen as a foot, assuming that the planning was started from the naos with 9 feet on the W side and 11 feet on the L side. The resulting dimensions for each part was calculated using this foot and the proportional relationships described in the previous section as well as the difference between the actual measurements are shown in the (F)²⁴⁾ and (G) columns of Table 1. The difference between the calculated figures and the actual measurements are very small demonstrating that the planning method proposed in this paper is valid. Also as shown in the (F) column in Table 1, many of the planning dimensions in the Nereid monument are complete figures, suggesting that the construction aspect was taken into account when planned. At the same time it is unlikely that such complete figures were derived using only the proportional planning method, again suggesting the validity of the planning method proposed in this paper.

5. Conclusion

By analyzing the proportional relationships of each part, the planning method of the Nereid monument was elucidated. The characteristics of the planning method of the Nereid monument are as follows:

1) In this paper, the analysis was conducted on the assumption that the planning was based on proportional relations and indeed a theory for the planning process was elucidated. Since the difference between the planning dimensions, which were derived from the proportional calculation, and actual measurements are small as well as the frequent occurrence of complete figures which cannot be pure coincidence, there is a high possibility that the planning based proportion similar to the ones used for the ancient Greek temples and stoas was conducted at the Nereid monument as well.

2) It is highly possible that, at the Nereid monument, the rough planning of the size and the layout of the rooms was conducted in the outline scheme stage before the planning of the building.

3) It is highly possible that the planning started from the decision of the

internal dimensions of the naos as 9 feet by 11 feet, using the ancient foot which is 0.310m in the present measurement.

4) It is highly possible that the floor was planned using the successive system of proportion.

5) Many of the planning dimensions in the Nereid monument are complete figures, suggesting that the construction aspect was taken into account at the planning stage. At the same time, the dimensional adjustment was conducted upon the depth of the pronaos, which was unlikely to affect the external appearance of the building, in order not to disturb the proportional relation of the width and the length of the building as 2 to 3.

As stated before the same ratios are used in the conceptually related parts, such as the 5/12 ratio for determining the dimensions of the pteron on both L and W side or the 3/16 ratio for determining the L side axial intercolumniation and the lower diameter of the column. It is difficult to assert at this moment whether these are intentional or not. Therefore it is the author's intention that attention will be paid to the proportion selecting methods and the intention behind the selection in further analysis of design methods of other buildings. In next paper, the author will investigate the design method of the elevation of the Nereid monument with an examination of the proportional choice made by the architect.

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Notes

- 1) Fedak J.: *Momumental Tombs of the Hellenistic Age*, Toronto, 1990, p.3; Fedak sums up the characteristics of the Hellenistic tombs, one of which being their varied forms.
- 2) 堀内清治: ドリス式周柱神殿平面設計法の研究 地中海建築の設計技法の研究—全体と部分の対応—, 平成元年~3年度科学研究費補助金 総合研究 (A) 研究成果報告書 (課題番号 01302051), 1992. 3, pp.1-142、林田義伸: アテナのゼウスのストアの設計法, 日本建築学会計画系論文集, 第523号, 1999. 9, pp.293-300、林田義伸: メガロポリスのフィリップのストアの平面計画, 日本建築学会九州支部研究報告, 第33号 (計画系), 1992. 3, pp.321-324、伊藤重剛, 林田義伸, 松尾直樹: 地中海古代都市の研究 (88) リンドスのアテナ神域の翼付きストアの平面計画, 日本建築学会中国・九州支部研究報告, 第10号 (計画系), 1996. 3, pp.685-688、林田義伸: タソスとデロスの翼付きストアの設計過程—中央部柱間とトリグリフについて—, 日本建築学会九州支部研究報告, 第31号 (計画系), 1989. 3, pp.257-260、林田義伸, 伊藤重剛: デルフィのマッシリア人の宝庫の設計法 古代ギリシア建築調査1994 (2), 日本建築学会計画系論文集, 第506号, 1998. 5, pp.185-190、Coulton J. J.: *The Treatment of Re-entrant Angles*, BSA 61, 1966, pp.142-146; Coulton J. J.: *The Columns and Roof of the South Stoa at the Argive Heraion*, BSA 68, 1973, pp.65-85; Coulton J. J.: *Toward Understanding Doric Design: The Stylobate and Intercolumniations*, BSA 69, 1974, pp.61-86; Coulton J. J.: *Toward Understanding Doric Design: General Considerations*, BSA 70, 1975, pp.61-99 etc.
- 3) 武田明純: アンフィポリスのライオン墓の設計法に関する一考察 ヘレニズム期の墓の設計法に関する研究 (1), 日本建築学会計画系論文集, 第613号, 2007. 3, pp.235-241
- 4) Dinsmoor W. B.: *The Architecture of Ancient Greece*, New York, 1928, p.256; Coupel P. & Demargne P.: *Fouilles de Xanthos III, Le Monument des Nereides, Texte et Planches photographiques*, Paris, 1969, p.157; Fedak: op. cit. 1990, p.68; As for the construction date

of the Nereid monument, there are several estimates. Dinsmoor stated that it could be as old as mid 5th century BC but quite possibly built in later 4th century BC. Coupel stated that it was built around 400 BC based on Dinsmoor's estimate. Fedak estimated it to be later than the early 4th century BC referring to Borchhardt's calculation which was based on the style of the sculptures. Since it is the latest hypothesis, Fedak's estimate is used in this paper.

- 5) Vitruvius, 森田慶一訳注: *ウィトルーウィウス建築書*, 東海大学出版会, 1969, pp.131-309; *Ten Books on Architecture* is said to be written by Vitruvius between the late Roman Republic era and the early Imperial era. This is a ten volume series and contained detailed description of ancient Greek architectural methods. Design methods of temples and theaters are described in volume 3 to volume 6.
- 6) 堀内: op. cit. 1992, pp.1-142
- 7) 林田: op. cit. 1999, pp.293-300; 林田: op. cit. 1992, pp.321-324; 伊藤, 林田, 松尾: op. cit. 1996, pp.685-688; 林田: op. cit. 1989, pp.257-260; 林田, 伊藤: op. cit. 1998, pp.185-190
- 8) Coulton: op. cit. 1966, pp.142-146; Coulton: op. cit. 1973, pp.65-85; Coulton: op. cit. 1974, pp.61-86; Coulton: op. cit. 1975, pp.61-99
- 9) Dinsmoor W. B.: *The Architecture of Ancient Greece*, New York, 1975, p.152, 222, 229
- 10) 堀内: op. cit. 1992, p.16; Coulton: op. cit. 1975, p.87; 林田: op. cit.; Horiuchi, Coulton and Hayashida all conducted their analysis based on the hypothesis that there existed several 'ancient foot's.
- 11) Vitruvius: op. cit. 1969, pp.131-137
- 12) 林田, 伊藤: op. cit. 1998
- 13) Coupel: op. cit. 1969, Texte; Coupel P. & Demargne P.: *Fouilles de Xanthos III, Le Monument des Nereides, Texte et Planches photographiques*, Paris, 1969
- 14) Coupel: op. cit. 1969, Restitutions, Pl. XLIII
- 15) 伊藤重剛, 林田義伸: デルフィのマッシリア人の宝庫の現況 古代ギリシア建築調査1994 (1), 日本建築学会計画系論文集, 第496号, 1997. 6, p.218
- 16) Fedak: op. cit. 1990, p.66; The height of the wall at Xanthos in this paper is quoted from Fedak.
- 17) Coupel: op. cit. 1969, Texte; Coupel: op. cit. 1969, Restitutions
- 18) A variety of the Ionic column base that is said to be developed in Asia minor. A column with a disc decorated with horizontal groove or scotia at the bottom of the plinth. The large chaplet at the top has horizontal relief of round beading.
- 19) 堀内: op. cit. 1992; 林田: op. cit. 1999, 1996.3, 1992.3, 1989.3
- 20) Vitruvius: op. cit. 1969, p.155
- 21) 武田: op. cit. 2007, p.238
- 22) Coulton: op. cit. 1975, pp.68-69; Coulton coined the names 'the modular system of proportion' and 'the successive system of proportion' for which Vitruvius had called, for temple designing, the Doric order of proportion and the Ionic order of proportion respectively. In the modular system, dimensions of each part derive from one standard dimension in the form of either multiples of fractions. In the successive system, all the dimensions derive from the one immediately before them in successive manner.
- 23) Jeppese K.: *Paradeigmata*, Aarhus University Press, 1958, p.72; Coulton J. J.: *The Ancient Greek Architect at Work*, New York, 1977, p.18; On the epitaph (the architectural specification) regarding the Navy storage built 4th century BC in Piraeus, it is stated that 'the storage of 400 feet × 55 feet including the thickness of the wall to be built'. Also there is a description saying that a Syrian prince Antiochus had offered the donation of a stoa 600 feet in length to Miletos in the 3rd century BC.
- 24) The descriptions such as '5 35/36 → 6' in the (F) column in Table 1 show that adjustments were made in order to fit the ancient feet when calculating the planning dimensions. As stated in '2. Study method' the ancient foot consisted of fractions such as the palm (1/4 of a foot) and the dactyl (1/4 of a palm), suggesting the fractions of 2, 3, 4, 5, 8, 16 have existed. Since such a number as 5.2 dactyls cannot be expressed in ancient feet, it needed to be converted to the nearest value such 5 dactyls i.e. 5/16 foot.

Source of Figures

- Fig.1; Fedak: op. cit. 1990, p.295, fig.59
 Fig.2; Coupel: op. cit. 1969, Restitutions, Pl. VI
 Fig.3; Coupel: op. cit. 1969, Restitutions, Pl. IV
 Fig.4; Coupel: op. cit. 1969, Texte, Planche 26
 Fig.5; Coupel: op. cit. 1969, Restitutions, Pl. C
 Fig.6; Coupel: op. cit. 1969, Restitutions, Pl. XLIII (section lines were added by author).
 Fig.7; Coupel: op. cit. 1969, Restitutions, Pl. XCI
 Fig.8; Author's own drawings
 Fig.9; Author's own drawings

和文要約

1. はじめに

ヘレニズム期の古代地中海世界では、豊富な建築形態を持つ墓が建設されるようになる。しかしながら、ヘレニズム期の墓の設計法に関する研究は、今のところ筆者が執筆した前稿以外にはない。そのため、このヘレニズム期の墓の豊富な建築形態が如何なる設計法や造形理念に基づいて造られたのかは全くわかっておらず、ヘレニズム期の墓の設計法や造形理念が古代地中海世界全体に共通するものであったのか、あるいは各地域毎に固有の特徴を持つものであったのかについても明らかにされていない。

そこで、本研究では、古代地中海世界におけるヘレニズム期の墓の設計法のあり方や古代地中海世界の人々のヘレニズム期の墓に対する造型理念の解明にまで踏み込むことを想定しながら、まずは古代都市クサントスにあるネレイドモニュメントの設計法の分析を行うこととする。なお、クサントスのネレイドモニュメントは、現在報告されているヘレニズム期の墓の内では最古のもので位置づけられている。

2. 研究方法

前述の通り、今のところヘレニズム期の墓の設計法に関する研究は殆どなく、ヘレニズム期の墓の設計法は正確にはわかっていない。そこで、本稿では、まずは堀内や林田、クールトンの提唱する古代ギリシアの神殿やストアで使われている設計法が、ヘレニズム期の墓にも適用されている可能性があるのか否かから検討を行うこととする。

また、実際に当時建物が施工された時のことを考えれば、比例関係によって導き出された建物各部の寸法は、当時の「ものさし」、つまり「古代尺」によって表現されなければならない。よって、選出された比例関係と古代尺を用いて設計寸法を導き、設計寸法と実測寸法との誤差の大小を検討することで、選出された比例関係や設計過程の正当性を検証することとする。なお、既往研究に従って、古代尺の寸法は0.294～0.330 mの範囲内の何れかに該当すると仮定し、尺度の端数を表記する際には、端数の分母が「2、3、4、5、8、16」となるよう留意して分析を進めることとした。

3. ネレイドモニュメントの概要

現在のネレイドモニュメントは、その上部構造の殆どが倒壊しており、ポディウムの一部だけしか残っていない。だが、本来上部構造を構成していた部材は、ポディウムから屋根部材に至るまで多数発見されている。また、それらの多くが大理石製であったため、調査を担当したクーペル達によって、精度の高い復元図が描かれている。

クーペルの復元に拠れば、ネレイドモニュメントの建築形態は、ポディウムの上にペリプテラル周柱式のイオニア式神殿を冠するといったもので、そのイオニア式神殿は、東西に向けられたファサード側に4本の円柱を持ち、側面に6本の円柱を持つものである。なお、墓室はケラの内部とポディウムの内部の2箇所に分けられており、ケラ内部の墓室では4つの寝台が確認されている。

4. 設計法の検討

以降、長辺方向をL方向、短辺方向をW方向と呼称する。

4-1. 設計手順の算出

各部寸法相互の比例関係を計算した結果、単純で正確な比例関係を

複数の箇所で見出すことが出来た。その結果、ネレイドモニュメントでは、基本構想として全体の規模や部屋、通路の割付を想定した後、細かい部分を調整しながら各部寸法を設計し直すといった設計方法が採られていた可能性が高いことがわかった（以下、基本構想後の設計を「本設計」と呼ぶ）。

また、本設計では、最初に「ナオス内法寸法」が決定された後、比例を用いてW方向アンタ幅、W方向壁厚、W方向ナオス外法、W方向プテロン幅、W方向全長の順番に寸法が決定される。L方向も、以上で算出されたW方向全長からL方向全長が決定した後、W方向と同様にナオス内法から外側に向かって連鎖的に各部寸法を決定される。また、柱間心々間距離は、L方向から、やはり連鎖的に円柱下部直径、柱礎幅、外法エンドスペースの順で求められる。従って、ネレイドモニュメントの平面設計は、ウィトルーウィウスが建築十書に記している「連鎖方式」によるものだといえる。

なお、ネレイドモニュメントの本設計では、基本構想時に想定したL方向全長とW方向全長の3対2の比例関係を崩さないよう、プロナオスの奥行き部分で寸法が調整されている。プロナオスの奥行きは、建物を外から見ている限り、特にデザインに対する影響が少ない箇所だといえる。よって、このような設計方法からは、墓としての機能性と建築としてのデザイン性を両立させようとした設計者の姿勢が伺えると共に、中小規模でナオスに墓室を構える神殿形式の墓の設計における、神殿の設計とは異なる難しさを見て取ることができる。

4-2. 設計寸法の算出

前項で導き出した比例関係と古代尺を使って設計寸法を算出し、実測寸法との誤差を検討することで提案した設計手順の正当性を検証した結果、設計寸法と実測寸法との誤差は非常に小さく、本稿で提示した設計手順の正当性を示すことができた。加えて、ネレイドモニュメントでは、1尺が0.310 mの古代尺を使用し、ナオス内法を9尺×11尺とすることから設計が始められた可能性が高いことがわかった。

また、ネレイドモニュメントの設計寸法には完尺が多く、施工性を考慮した設計が行われたといえることも把握された。

5. 結論

- 1) 本稿では、比例を用いた設計が行われたと仮定して分析を進めたが、一連の設計過程を見出すことができた。ネレイドモニュメントでも、古代ギリシアの神殿やストア等と同様に比例を用いた設計がなされていたと考えることができる。
- 2) ネレイドモニュメントでは、基本構想で大凡の規模や部屋の割付を決定した後、本設計が行われた可能性が高い。
- 3) 本設計は、1尺が0.310 mの古代尺を用いて、ナオス内法を9×11尺と決定することから開始された可能性が高い。
- 4) ネレイドモニュメントの平面の設計は、連鎖方式で行われていた可能性が高い。
- 5) ネレイドモニュメントの設計寸法には完尺が多く、施工性を考慮した設計が行われていたといえる。一方で、建物全体の幅と奥行きにおける2対3の比例関係を崩さないよう、建物の外観に影響しにくいプロナオス奥行きで寸法の調整を行っており、施工性のみならず、建物外観のプロポーシオンにも配慮された設計であったといえる。

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