TOWARDS UNDERSTANDING DORIC DESIGN: THE STYLOBATE AND INTERCOLUMNIATIONS

MOST of the efforts of students of Greek architecture have been devoted to two questions: what the buildings were like and when they were built, rather than to the manner of their design. This emphasis has obviously been justified, for those are the primary questions which must be reasonably well answered before the 'whys' and 'hows' can be approached. But our understanding of these primary questions has reached a stage where attention to the secondary questions is justified, not only because of their intrinsic interest, but also because a detailed study of proportion has become an established tool of stylistic dating. Some understanding of, or at least some hypothesis about, the way such proportions were envisaged and put into practice by ancient architects is necessary, in order to find out what proportions should most usefully be considered, and at what point small changes in them may represent a significant stylistic change.

Previous work in examining Greek design methods has usually been based on an investigation of a single building as a whole.[1] The method used here is to take just one feature—in this case the stylobate—and to trace the problems involved in its design through a whole series of buildings. This procedure is based on the assumptions, first, that Greek buildings were consciously designed, and, second, that the same methods of design are likely to have been used in a number of buildings. Neither of these assumptions can be proved, but both seem to be justified by such written evidence as there is[2] and by the sharply articulated and strongly conventional nature of Greek architectural forms. The chief advantage of proceeding in this way is that it provides us with another criterion for assessing the probability of any suggested system of design; and the problem of demonstrating the degree of probability has been one of the major stumbling-blocks to investigations in this field.[3] The three criteria for assessing the probability that a proposed rule was in fact used will be: that it can be simply expressed, that it fits existing remains with a reasonable degree of accuracy, and that it holds good for a number of buildings—preferably for a group of buildings from roughly the same place and period. While it may be difficult (and has proved impossible to the present author) to show in absolute terms the probability that a particular rule was used,[4] it should be easy to decide objectively, on the basis of these three criteria, which of a number of proposed rules is *most likely* to have been used. On this basis the rules proposed here are the most probable of the possibilities considered, but if they are not accepted, then at least they will form a point of departure for a more rigorous test of any other proposed rules.

In any study of Greek design it is necessary to make certain assumptions about the way

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[1] Even Bundgaard's pioneering study of Greek design methods is based on a study of the Propylaia (J. Bundgaard, *Mnesicles, A Greek Architect at Work* (1957)).

[2] Vitruvius (*De Arch.* vii. praef. 12) refers to accounts of their work by sixth-century architects, but such accounts *could* have dealt only with construction, not with design. On the second hypothesis it is to be noted how similar in nature is the design of Philo's Arsenal (*IG* ii² 1668) to that of Vitruvius' basilica (*De Arch.* v. 1. 6–10)—main measurements in round numbers of feet, with simple dimensions overriding simple proportions where necessary (virtually all dimensions expressible in quarter feet).

[3] Note Rhys Carpenter's criticism of Hambidge's principles of dynamic symmetry, which were intended to explain the basis of all Greek design (*AJA* xxv (1921) 16–36).

[4] The great recurring difficulty in any statistical assessment of probability is in finding sufficient buildings which one can reasonably assume to have been built according to the same rules of design.

architectural designs were formulated and executed. As far as possible no prior assumption has been made here on the fundamental question of whether or not the whole of a building was fully designed before construction began:[5] the choice of the feature selected for investigation is based on the fact that Vitruvius' rules for all kinds of temples derive the whole design from the stylobate width.[6] But on other matters a definite position has had to be adopted. There is a good deal of evidence supporting the working hypotheses used here,[7] but there is no space to discuss it in detail, so they will simply be stated briefly.

The two factors most likely to govern the size of any element in a Greek building are proportion and dimension;[8] within the limits of accuracy then in operation the size of any element should be expressible either as a simple proportion of some other part of the building, or as a whole number or simple fraction of the units of measurement used by the builders. Both the way in which rules of proportion were expressed and the way in which actual dimensions were calculated on the basis of them will have been affected by difficulties in handling fractions; these difficulties will limit the kind of fractions we should expect and lead to rounding off in calculations. The acrophonic numerals provided no easy way of expressing fractions,[9] and even with the alphabetic numerals there was a marked tendency to express fractions in submultiples only (i.e. $\frac{3}{5}$ is written as $\frac{1}{2}\ \frac{1}{10}$).[10] Eighty-four per cent of the fractional expressions in Vitruvius Bks. iii–vi have a numerator of 1, even if that involves using fractional denominators—that is, he writes one part in $12\frac{1}{2}$ rather than $\frac{2}{25}$.[11] The use of an abacus would also lead to the rounding off of many fractions.[12]

As far as measurement is concerned, the assumption that only two foot-standards were used throughout the Greek world[13] needs to be proved, not just accepted, and the chaotic situation in other branches of Greek metrology[14] suggests that it is unfounded. We cannot therefore simply assume the use of units of a certain length. In discussing measurements in feet, we should remember that not all measurements, both large and small, could be done with the same instrument, and that there is no reason to believe that Greek measuring-rods would be either very finely or very accurately subdivided.[15] All the tests of accuracy of measurement which can be applied to Greek buildings without presupposing the length of foot used, are tests of accuracy in repetition, not of accuracy in laying out a desired number of feet and dactyls. This may well make a difference, for there is less likelihood of error in repeating directly a given dimension, and also a strong aesthetic motive for accuracy. Thus the accuracy with which the full-scale model[16]

[5] On this, see J. Bundgaard, *Mnesicles* (1957). The conclusions of this paper tend to support Bundgaard's position, although I believe that many Greek architects had more interest in, and responsibility for, the aesthetic side of architecture than Bundgaard allows (ibid. 184).

[6] *De Arch.* iii. 3. 7 (Ionic); iv. 3. 3, iv. 3. 7 (Doric); iv. 7. 2 (Tuscan); iv. 8. 1, iv. 8. 2 (Circular).

[7] It is hoped to discuss these matters more fully in a later paper.

[8] On proportion, Vitruvius, *De Arch.* iii–vi, *passim*; on dimension, *De Arch.* v. 1. 6–10; *IG* ii.[2] 1668, and elsewhere.

[9] On this system: T. Heath, *A History of Greek Mathematics* i (1921) 30–1; *BSA* xviii (1911–12) 98–132; xxviii (1926–7) 141–57; xxxvii (1936–7) 236–57. Signs for fractions of a drachma or of an obol are not, of course, signs for fractions.

[10] Heath, op. cit. i (1921) 41–2; examples of rounding off in fractional calculations can be found in [Heron], *Geometrica*, *Stereometrica*, and *De Mensuris*.

[11] *De Arch.* iii. 5. 8.

[12] On the use of the abacus see Herodotos ii. 36; Aristophanes, *Vesp.* 656; *RE* Supp. iii. 4–13. For the Salamis Table as a gaming board not an abacus see *Hesperia* xxxiv (1965) 131–40.

[13] W. B. Dinsmoor, *The Architecture of Ancient Greece*, 2nd edn. (1960) 54 n. 4. Id. in *Atti del vii Congresso Internazionale di Archeologia Classica* (1961) i. 360.

[14] On changes in standard and variations from standard in Attic weights see M. Lang, M. Crosby, *The Athenian Agora* x, Weights, Measures, and Tokens (1964).

[15] None has survived. On the accuracy of calibration of measuring-rods from Egypt see F. Petrie, *Ancient Weights and Measures* (1926) 38–40. Most Roman foot rules are divided into 16 or 12 parts, some only into two (cf. op. cit. 48–9). The accuracy of official length standards cannot be taken as typical of that of the measuring rods in actual use.

[16] For ancient references to the use of models see A. Orlandos, *Ta Ilika Domes tōn archaiōn Ellēnōn* ii (1958) 268 n. 3; J. Bundgaard, *Mnesicles* (1957) 216–19, n. 217.

of a capital embodies the theoretical dimensions, whether those were whole numbers of feet or proportions of, for example, the lower column diameter, may be much less than the accuracy with which the capitals actually used in the building reproduce the measurements of the model.[17]

These then are the beliefs on the basis of which we shall be looking for the rules most likely to have governed the design of the krepis of a Doric temple, and it will be seen that they argue against a belief in the mathematical accuracy with which Greek architects have sometimes been credited.

The laying out of the krepis for a Doric peripteral temple has not normally been treated as a problem by students of Greek architecture. The fact that in many temples the intercolumniation on the flanks is different from that on the fronts is discussed in most handbooks on Greek architecture,[18] but little attention has been devoted to the question of why it was different. First of all, it must be realized that, in spite of the notorious triglyph problem, it should not be difficult to design a Doric temple with a regular frieze and with uniform front and flank intercolumniations and the correct amount of angle contraction. If one starts by deciding on a convenient triglyph width, T, then the width of the building at frieze level will be $T(5\ N_W+1)$ and the length $T(5N_L+1)$[19] where N_W and N_L are the desired number of intercolumniations along the front and flanks respectively;[20] for the intercolumniation is normally five times the triglyph width. Since the size at frieze level is also the size at architrave level, the addition of an amount equal to $(S-AW)$[21] to the frieze length and width thus obtained will give the correct size of the temple stylobate, provided that the columns are to be vertical and not inclined inward. All the intercolumniations can be made equal except those next to the angles, which will be reduced by the correct amount $(AW-T)/2$; the triglyphs and metopes will be uniform and regularly disposed, with the metopes just $1\frac{1}{2}$ times as wide as the triglyphs. If the columns were to be inclined, then the stylobate length and width would both have to be increased by an amount equal to $2 \times$ tilt factor $\times H/D$, where the tilt factor is the difference in level between the higher and lower edges of the bottom drum (FIG. 1), an amount which would almost certainly have to be specified in order to put the tilt into effect.[22] The stylobate size obtained in this way, whether with or without an allowance for tilting the columns, would still be valid if the architect wished to spread the angle contraction over two intercolumniations, provided that he wished to keep the frieze elements uniform and regularly spaced.

The fact that for at least one hundred years this effect was not regularly achieved in any part

[17] Measurements from the model would presumably be taken with dividers, not with a rule.

[18] e.g. W. B. Dinsmoor, op. cit. 73 n. 3, 76, 77, 80, 89, 93, 98, 99, 101; D. S. Robertson, *Greek and Roman Architecture* (2nd edn., 1943) 75; A. W. Lawrence, *Greek Architecture* (2nd edn., 1967) 120, 122, 123, 127.

[19] For this general rule cf. *Hesperia* ix (1940) 2 n. 7, 45.

[20] The following abbreviations for parts of buildings are used throughout this paper and the accompanying Tables:

- AW Architrave thickness from back to front.
- C Number of columns ($= N+1$).
- D Lower diameter of column on arrises.
- H Column height.
- I Axial intercolumniation.
- L Length over stylobate.
- N Number of intercolumniations ($= C-1$).
- OL Over-all length.
- OW Over-all width.
- S Stylobate breadth from back to front.
- T Triglyph width.
- W Width over stylobate.

Note that where the size of an element on the flank of a building differs from the size of the corresponding part on the front, the abbreviations referring to the front and flank are distinguished by W and L respectively, written as a *subscript*. Similarly where the size of an element near the corner of a building differs from that of the corresponding parts elsewhere, the part next to the corner is distinguished by A written as a *subscript*.

- I_L Axial intercolumniation on flanks.
- N_W Number of intercolumniations on fronts.
- D_A Lower diameter of columns at corners.
- I_{WA} Axial intercolumniation next to corners on fronts.

[21] Strictly this should be twice the distance from the front edge of the stylobate to the axis of the colonnade, since the axis of the colonnade does not always coincide with the centre of the stylobate.

[22] See J. Bundgaard, *Mnesicles* (1957) 134–6.

of the Greek world leaves us with three possible explanations: either the Greeks did not want regularity in column spacing and frieze arrangement; or they wanted it but wanted even more strongly something else which could with difficulty be combined with regularity; or they wanted regularity but could not obtain it.

Lawrence suggests[23] that the narrower spacing on the flanks of the Temple of Hera at Olympia was intentional; its purpose was to increase the rigidity of the long colonnade. Presumably this would also be the motive for the noticeably narrower flank spacing in other sixth-century temples—the temples of Athena at Assos, Apollo at Corinth, the Olympieion and temple

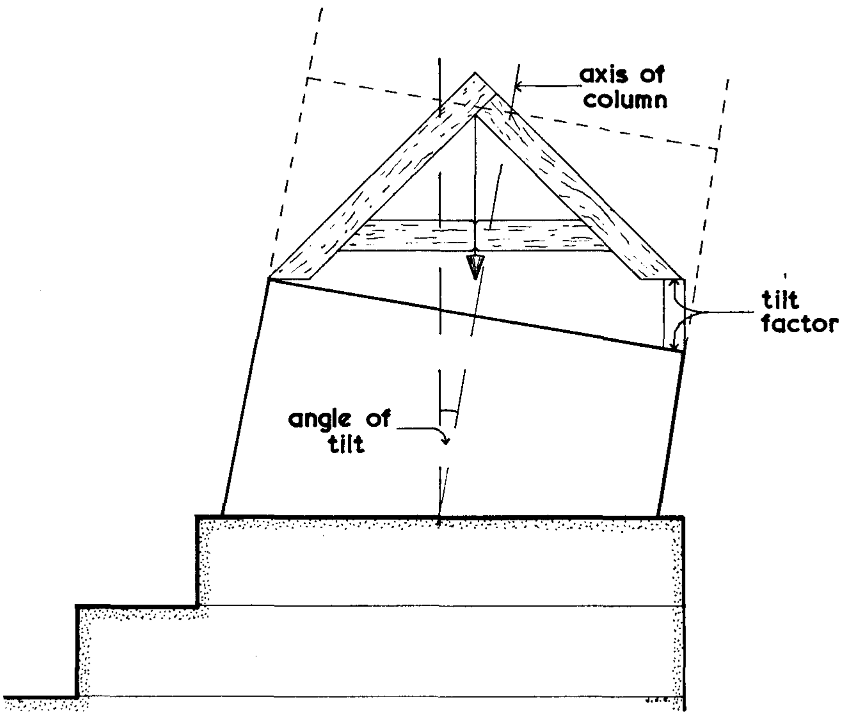

FIG. 1. THE INWARD TILT OF A COLUMN DEFINED BY A TILT FACTOR

of Apollo at Syracuse, and Temple C at Selinous, for instance; but how are we to explain the *wider* flank spacing of the 'Basilica' at Paestum? Simply as provincial blundering?[24] Here Lawrence suggests[25] an explanation of the second sort; the architect wanted regular spacing of the colonnades, but was unable to obtain it because he wanted to have a very deep pteron and at the same time to have twice as many columns on the flank as on the front. But in fact these two aims do not conflict with a regularly spaced colonnade. If we start with an intercolumniation of 3·0 m., then the width over the frieze of a temple with 9×18 columns will be $8\frac{1}{5} \times 3{\cdot}0 = 24{\cdot}60$ m. and the length over the frieze $17\frac{1}{5} \times 3{\cdot}0 = 51{\cdot}60$ m.; if we allow 0·40 m. for the difference between stylobate breadth and architrave breadth, the size over the stylobate will be $25{\cdot}00 \times 52{\cdot}00$ m. (comparable with the actual size of $24{\cdot}51 \times 54{\cdot}27$ m.); with a dipteral

[23] A. W. Lawrence, op. cit. 116.
[24] W. B. Dinsmoor, op. cit. 93 comments 'somewhat perversely'.
[25] A. W. Lawrence, op. cit., 127.

portico all round the width of the cella between wall axes it would be 4×3·0 = 12·0 m., and its length 13×3·0 = 39 m. (comparable with the actual size of 12·22×40·48 m.). Thus the three aims of regular spacing, dipteral portico, and flank colonnade with twice as many columns as on the front are not incompatible.

Whatever the explanation of these large differences between front and flank intercolumniations, the much smaller differences to be found in later temples cannot be explained either on structural or on aesthetic grounds. They are too small to affect the structure, and while we may expect Sicilian architects to have had different views on aesthetic matters from those of the mainland Greek architects, it would be odd if they consistently held to *diametrically* opposed views, when both were building temples of closely similar design. When we find that the flank intercolumniations are consistently smaller than the front ones in mainland Greece, but consistently larger or equal to them in Sicily and south Italy, it is hard to believe that mainland architects found slightly smaller flank intercolumniations aesthetically desirable while those in the West thought the exact opposite.

Perhaps the greatest problem in explanations of this sort, however, is that there appears to be no system in the lengthening or shortening of the flank intercolumniations. If there was an explicit rule that the flank intercolumniations should be made shorter or longer, then the rule would presumably have said by how much they should be decreased or increased. The difference between front and flank intercolumniations should therefore be reasonably stable either when expressed as an absolute length—for instance, flank intercolumniation to be one palm or one dactyl shorter or longer—or when expressed as a proportion of the front intercolumniation—for instance, flank intercolumniation to be decreased or increased by one-fiftieth. In Table 3 Column 2 the difference is given in absolute terms, and in Column 3 the flank intercolumniation is given as a proportion of the front intercolumniation. It might also be supposed that the difference was based not on the front intercolumniation but on some more fundamental module, so Columns 4 and 5 give the difference expressed as a proportion of the lower diameter and the triglyph width. It will be seen, however, that none of these suggestions provides a basis for a simple rule governing the relation of front and flank intercolumniations of a whole group of buildings.

The absolute differences vary considerably, even between buildings of the same place and period—0·136 m. in Temple FS at Selinous, 0·08 m. in the original design of Temple GT, which was begun only slightly later. Only a small proportion of the buildings constitute groups sharing approximately the same difference, and those that do—e.g. the temple of Aphaia at Aigina (0·0575 m.), the Older Parthenon at Athens (0·054 m.), and the temple of 'Juno Lacinia' at Akragas (0·054 m.)—do not form particularly close groups in time, place, or style. The same is true of the proportional differences. A rule that the flank intercolumniation should be less by $\frac{1}{64}$ than the front intercolumniation (that is, $I_W = 1{\cdot}015625\ I_L$) might account for the design of the temples of Athena Pronaia at Delphi ($I_W = 1{\cdot}0264\ I_L$), Aphaia at Aigina ($I_W = 1{\cdot}0225\ I_L$), 'Juno Lacinia' at Akragas ($I_W = 1{\cdot}0176\ I_L$), Apollo at Bassai ($I_W = 1{\cdot}0153\ I_L$), and the Older Parthenon at Athens ($I_W = 1{\cdot}0124\ I_L$). But what of the others? How are they to be fitted into a series to which $\frac{63}{64}$ naturally belongs? Of course any decimal fraction between 0·0 and 0·1 can be expressed reasonably accurately as a vulgar fraction of the type $1/n$, but unless some consistent principle can be suggested by which the relevant fraction was chosen, it is unconvincing to suggest that the relation of flank to front intercolumniation was in fact designed as a fraction of this sort. There are of course other elements of the temple to which the difference in intercolumniation might be related, but those tested here seem the most obvious ones, given what we know of Greek architecture; those who are interested will try others.

We can compare all these results with those based on other assumptions; for instance, the assumption that the difference between front and flank intercolumniations was not intentional.

Dinsmoor, in discussing the Parthenon,[26] suggests three possible reasons why Iktinos may have arranged the colonnade of the Parthenon with excessive angle contraction and consequent irregularity in the frieze; that it was intended to create a perspectival illusion in the frieze, since the metopes nearer the corners would be narrower; that it was intended to improve the proportions of the otherwise excessively wide octostyle façade; and that it allowed the stylobate to have the desirable proportion of 4:9, which occurs elsewhere in the building. The first explanation is based on the doubtful hypothesis that the Parthenon was designed to be viewed from a point on the long axis of the building, for it is only from such a point that the illusion could work; when the Parthenon was seen from an angle, as it would be seen by a visitor,[27] the smaller metopes near that corner of the building would be nearer the observer, not further from him. Let us look at the other two explanations. The proportion $\frac{\text{stylobate width}}{\text{column height}}$ of the Parthenon as it stands is about 2·96; if the angle contraction had been normal, the stylobate width would have been increased by about 0·30 m., making the proportion $\frac{\text{stylobate width}}{\text{column height}}$ equal to about 3·01. The effect of the excessive angle contraction on the proportions of the façade is therefore small, and the same effect could have been achieved by slightly increasing the column height.[28]

The third explanation is perhaps the most interesting from the present point of view: the proportion 4:9 is indeed a nice simple one, which seems to have been favoured by Iktinos. But one might have expected to find the desirable proportion at frieze level, for the architrave and frieze (which share the same dimensions in plan) together occupy about five times as much of the total façade height as the stylobate does, and it is at least as easy for an observer to assess the ratio of length to width at frieze level as at stylobate level. Besides, a proportion of 4:9 at frieze level is precisely what is needed in a temple of 8×17 columns to produce equal flank and front intercolumniations with normal angle contraction and a regular frieze, for $7\frac{1}{5}:16\frac{1}{5} = 36:81 = 4:9$.[29] Unless the stylobate has these proportions simply by chance, therefore, it suggests that Iktinos regarded the proportions of the stylobate as a significant element of the design, and that he did not derive the stylobate dimensions from the frieze, but vice versa.

In the present study it is suggested that this was normal procedure, and that the differences which we find between the front and flank intercolumniations, and the irregularities in the frieze, particularly at the corners, were the result of the way in which the stylobate dimensions were derived, not by reference to the frieze length with allowance for angle contraction and column tilt, nor by calculation from a module such as the lower diameter of the column or the triglyph width, but by the application of gradually refined rules which had no theoretical basis, but which were known to work. It appears that whatever design process was involved, once the stylobate dimensions had been defined, they were regarded as fixed dimensions to which the rest of the design must be adjusted.

Surprisingly Vitruvius, whose design methods are in some ways quite sophisticated, provides some further evidence to support this suggestion. Although he talks knowledgeably of plans and

[26] W. B. Dinsmoor, op. cit. 161–2.

[27] *Hesperia* Suppl. iii (1940) 4; the entrance to most Greek sanctuaries was placed so that visitors got first an angle view of the temple, although that may have been for functional rather than aesthetic reasons; (B. Bergqvist, *The Archaic Greek Temenos* (*Opusc. Ath.* iv (1967) 13).

[28] The increase necessary, *c.* 0·10 m., would give the Parthenon columns a height of about 5·54 lower diameters, midway between the proportions of the east and the west porticoes of the Propylaia.

[29] See above, p. 63.

elevations drawn to scale, and also of some form of three-dimensional drawing, as a preliminary to building,[30] his instructions for designing a temple in all cases start firmly with the stylobate width, from which all the other dimensions of the façade are then derived.[31] (Unfortunately he gives no instructions for finding the length of the stylobate, given its width.)[32] Furthermore the words used by Vitruvius in describing the Ionic temple suggest that each stage of the building was actually executed before the design of the next need be attended to—'The shafts of the columns having been erected, the rule for the capitals will be as follows. . . . The capitals having been finished and set up in due proportion to the columns, the rule for the architrave is to be as follows.'[33] Apart from the base, which is designed in terms of the lower diameter of the column it is to carry (but the lower diameter is equal to the module which has already been derived from the stylobate width in order to lay out the intercolumniations), each stage of the construction could be executed quite satisfactorily without any calculations having been made about the parts that were to occur higher up in the building. The idea that much earlier Greek architects may have decided on the size of the stylobate without reference to what it was to carry is not, therefore, as unreasonable as it might appear.[34]

The method used in analysing the design of the Doric krepis is of the sort outlined earlier.[35] A representative sample of temples for which sufficient information is available, is examined; hypothetical rules of design, as simple and reasonable as possible, are formulated and tested against the data to see whether they apply with sufficient accuracy to a number of buildings. The more buildings which appear to conform to a rule, the more likely it is considered that this rule was actually employed. And if the buildings which appear to conform to the rule constitute a fairly coherent chronological and/or local group, then the possibility that the 'rule' is simply due to coincidence is held to be even more remote. The most convenient source of data for this purpose is that provided by W. B. Dinsmoor in his *Architecture of Ancient Greece* (2nd edn., 1950), 337–9. This is probably the most accurate series of measurements of this kind, but more important, it is also the most consistent, the majority of the measurements having been retaken by Dinsmoor himself.[36] The sample thus consists of forty-nine buildings ranging in space from Assos to Segesta and in time from *c.* 590 B.C. to *c.* A.D. 125.

The tables which contain the data, the analysis, and the detailed working out of the proposed rules are organized as follows. The buildings are arranged in three local groups: Sicilian, south Italian, and mainland Greek (including Asia Minor); within these three groups buildings are approximately in chronological order, with some adjustments to preserve local or stylistic groups. The data on which the analysis is based are given in Columns 2–14 of Table 1.[37]

[30] *De Arch.* i. 1. 4; i. 2. 2.

[31] See note 6 above.

[32] The interior of a basilica presents a different problem from the pteron of a temple, of course, but it is interesting that the central space of Vitruvius' basilica at Fano is surrounded by 4×8 columns, while the ratio of its width to its length is 60:120 = 4:8; i.e. the length is related to the width by Rule 1 proposed below (p. 69).

[33] *De Arch.* iii. 5. 5; iii. 5. 8. (trans. M. H. Morgan).

[34] On the probability of a general lack of detailed preliminary planning in Greek architecture see J. Bundgaard, *Mnesicles* (1957), but the procedure adopted in this investigation does not demand such an assumption.

[35] See above, p. 61.

[36] For the exceptions: W. B. Dinsmoor, *The Architecture of Ancient Greece* (2nd edn., 1950) 337 n. 1. For the Temple of Asklepios at Epidauros, which was one of the exceptions, the figures are all taken from the recent study by G. Roux (see n. 37). It is unfortunate that in his most recent study of Greek temple design (*Atti del vii Congresso Internazionale di Archeologia Classica* (1961) i 355–68), Dinsmoor gives without explanation figures differing significantly from those given in *The Architecture of Ancient Greece* (2nd edn., 1950), which are used here.

[37] The data given by Dinsmoor is supplemented from the following sources: for the temples of Sicily and south Italy, R. Koldewey, O. Puchstein, *Die griechischen Tempel in Unteritalien und Sicilien* (1899); P. Marconi, *Himera* (1931); for Aigina, A. Furtwaengler, *Aegina: Das Heiligtum der Aphaia* (1906); for the Argive Heraion, C. Waldstein, *The Argive Heraeum* (1902–5); for Assos, F. H. Bacon, J. T. Clark, R. Koldewey, *Investigations at Assos 1881–3* (1902–21); for Athens, T. Wiegand, *Die archaische Poros-Architektur der Akropolis zu Athen* (1904); B. H. Hill, *AJA* xvi (1912) 535–58; F. C. Penrose, *An Investigation of the Principles of Athenian Architecture* (2nd edn., 1888); R. Bohn, *Die Propyläen der Akropolis zu Athen* (1882); H. Koch, *Studien zum Theseus-*

Columns 15–26 give the proportions stylobate width to length, over-all width to length, stylobate width and length to intercolumniations, and over-all width and length to intercolumniations. The figures in these columns which suggest the application of simple rules are printed in bold type and these can be followed up in Table 2. Each set of columns in Table 2 gives the proposed rule, followed by the measurement which application of that rule would produce (the heading to each column shows in which direction the rule is being worked; thus Columns 9 and 14 are based on the same rule but are worked from opposite ends). The last column in each set gives the difference between the figure produced by strict application of the rule and the measurement given in the data, i.e. the discrepancy between rule and reality. No allowance is made in Table 2 for calculations in feet; where such calculations are suggested in the text, they may be followed up in Columns 11–23 of Table 3. Here the size of the proposed foot is given in Column 11, followed by a few main dimensions of the buildings concerned, expressed in terms of that foot. In each pair of columns, the first gives the equivalent number of feet, while the second gives the difference between the number of feet multiplied by the size of the foot and the actual dimensions given in the data. Thus the Tables can be used as a check on all the suggestions made in the text.

Columns 2–5 of Table 3 deal with the suggestion that the difference between flank and front intercolumniations was planned, and Columns 6 to 10 compare the actual amount of angle contraction with the 'correct' amount given by the modern formula $(AW-T)/2$ and by the Vitruvian rule $T/2$.

The first step in analysing the stylobate sizes is obviously to calculate the proportion of length to breadth in the simplest terms. This is done in Column 15 of Table 1. Some of the proportions turn out to be fairly simple ones—1:2·5 (= 2:5), 1:2·67 (= 3:8), 1:2·25 (= 4:9), etc.; but many do not. Clearly this was not the only criterion for most temple architects, and in any case, how were they to decide which simple proportion to choose? It will be seen that the proportion is not the same for all the temples with the same number of front and flank columns, so that this too must be counted out as a sole criterion for stylobate proportion. Nevertheless, the architect must have decided at an early stage how many columns a temple was to have. At any particular time and place, temples with various different numbers of flank columns could be designed, as for example at Selinous, where Temple C (*c.* 550–530 B.C.) has 17 flank columns, Temple D (*c.* 535 B.C.) has 13, Temple FS (*c.* 525 B.C.) has 14, and Temple GT (*c.* 520–450 B.C.) has 17 flank columns and 8 front ones; so that there is no question of the architect simply using the number of columns that was conventional at the time. Nor was it just a case of putting on the flanks as many columns as there was room for, using intercolumniations as nearly as possible equal to those on the fronts, for the Temple of Apollo at Syracuse and Temple C at Selinous would have more nearly uniform intercolumniations if there were two columns fewer on the flanks, while the colonnades of the Temples of Hera at Olympia, Apollo at Corinth, and Athena at Assos would all be more regular with one fewer flank column. The desired number of columns was therefore erected in spite of the size of the stylobate, rather than because of it, and when we find that in later temples the front and flank intercolumniations

tempel (1955); W. B. Dinsmoor, *Hesperia* ix (1940) 1–52; for Bassai, C. R. Cockerel, *The Temples of Jupiter Panhellenius at Aegina and of Apollo Epicurius at Bassae* . . . (1860); for Delos, *Délos* xii (1931); for Delphi, *FdD* (1915, 1923, 1933); for Eleusis, Society of Dilettanti, *Unedited Antiquities of Attica* (1817); for Epidauros, G. Roux, *L'Architecture de l'Argolide aux iv^{e} et iii^{e} siècles av. J.-C.* (1961); for Nemea, B. H. Hill, C. K. Williams, *The Temple of Zeus at Nemea* (1966); for Olympia, E. Curtius, F. Adler, *Olympia: die Ergebnisse* . . . 2 (1892); for Pergamon, *Altertümer von Pergamon* ii and iii. 1 (1885, 1906); for Rhamnous and Sounion, W. Doerpfeld, *AM* ix (1884) 329–37, W. H. Plommer, *BSA* xlv (1950) 78–109; for Stratos, C. Picard, F. Courby, *Recherches archéologiques à Stratos d'Acarnanie* (1924); and for Tegea, C. Dugas, J. Berchmanns, M. Clemmensen, *Le Sanctuaire d'Aléa Athéna à Tégée* (1924).

are more nearly equal, it is reasonable to suppose that their architects had found more effective ways of designing a stylobate to hold the number of columns they wished.

If the number of front and flank columns was among the earliest features to be decided, apparently preceding the design of the stylobate, then it is likely that the stylobate was designed in terms either of the number of columns or of the number of intercolumniations. These possibilities are tested in Columns 16 and 17 of Table 1. Surprisingly perhaps, it is the first alternative which best explains the dimensions of the three earliest temples in the sample which lies east of the Adriatic; the stylobate proportions of the Temple of Hera at Olympia are almost exactly $1:2\frac{2}{3}$ or 6:16, which is the number of columns on the fronts and flanks; similarly those of the temple of Apollo at Corinth (with 6×15 columns) are about $1:2\frac{1}{2}$ or 6:15, and those of the Temple of Athena at Assos (with 6×13 columns) are $1:2\frac{1}{6}$ or 6:13. The rule involved can be expressed generally as $W:L = C_W:C_L$.[38] As the results show, this rule does not produce a flank spacing which is very close to the front spacing, and it is not surprising that it was dropped by the end of the sixth century B.C.

The three earliest Sicilian temples in the sample (the Temple of Apollo and the Olympieion at Syracuse and Temple C at Selinous) were all built with 6×17 columns, but in none of them is the stylobate laid out as 6:17. As we have seen, even this would have made the flank intercolumniations noticeably shorter than those on the fronts, but in each of these three temples the stylobate is shorter still. The simplest expression of the ratio of stylobate width to length in the Temple of Apollo at Syracuse is 7:18,[38] which may be an experiment with a rule $W:L = (C_W+1):(C_L+1)$. It is noteworthy, however, that the stylobate and the step below it are here cut from the same course of huge blocks, the jointing of which coincides with the position of the columns. It may be, therefore, that it was the size of this course as a whole (i.e. the size of the temple along the step below the stylobate) which the architect planned as a significant proportion and that the stylobate size was simply obtained by cutting back the top part of the course by a suitable amount to form another step. In fact the size of this course as a whole is $22{\cdot}50\times56{\cdot}30$ m., which makes a proportion of almost exactly $1:2\frac{1}{2}$.[39] But if this was the only factor controlling the stylobate size, it is hard to understand why, if the architect wanted a temple with 6×17 columns, he chose a proportion of $1:2\frac{1}{2} = 6:15$, or alternatively why, if he wanted the proportion of $1:2\frac{1}{2}$ in the platform, he chose to put 6×17 columns on it rather than 6×15.

The architect of the Olympieion at Syracuse (also with 6×17 columns) made the temple platform rather longer than that of the Temple of Apollo, presumably in order to reduce the difference between the front and flank intercolumniations. The stylobate proportions are $6\frac{1}{2}:18$ rather than 7:18, but here again the stylobate and the step below it are cut from the same course of blocks. The size of this course as a whole cannot be measured or estimated with great precision, but it appears to have been about $23{\cdot}60\times63{\cdot}25$ m.;[40] the proportion of width to length was therefore approximately $1:2\frac{2}{3} = 6:16$ ($63{\cdot}25/16\times6 = 23{\cdot}72$ m.), which forms a natural progression from the corresponding proportion of the Temple of Apollo. The stylobate proportions of Temple C at Selinous come half-way between those of the two temples at Syracuse—$6\frac{3}{4}:18$ as opposed to 7:18 and $6\frac{1}{2}:18$—which is perhaps surprising if Temple C is later

[38] For the accuracy of fit of this rule see Table 2, Cols. 2–4. The rule $W:L = C_W:C_L$ seems to be implied by F. Krauss, *Paestum, Die Griechischen Tempel* (2nd edn., 1943) 34, but the idea is not followed up.

[39] *MA* xli (1951) 813: $22{\cdot}50\times2\frac{1}{2} = 56{\cdot}25$; error $= 0{\cdot}05$ m. The significance of this step is also suggested by the fact that the flank intercolumniation equals $\frac{1}{17}$ of the length of the temple at this level ($56{\cdot}30/17 = 3{\cdot}312$ m.; $I_L = 3{\cdot}331$ m.), while the normal front intercolumniation equals $\frac{1}{6}$ of the width at the same level ($22{\cdot}50/6 = 3{\cdot}75$; $I_W = 3{\cdot}772$ m.). These are much simpler proportions than those relating intercolumniation and stylobate size (cf. Table 1, Col. 21, 24).

[40] See also *MA* xiii (1902) pl. 18.

than the Olympieion, as it appears to involve a retrogression. But if we regard as significant not the strict stylobate but the course of large blocks on which the columns stand, we find the same proportion used in both buildings—$1:2\frac{2}{3}$. The difference is that in Temple C this course of large blocks forms only the stylobate, while in the Olympieion it contains both the stylobate and the step below it. The stylobate proportion of the Olympieion is therefore necessarily slightly longer and narrower, and as a result there is rather less difference between the front and flank intercolumniations. It is possible therefore to see some logical connection between these three early Sicilian temples in the way the stylobate size was obtained, although it is difficult to see why proportions of $1:2\frac{1}{2} = 6:15$ and $1:2\frac{2}{3} = 6:16$ should have been used for temples with 6×17 columns.

The stylobate size was not necessarily the first dimension that had to be decided. In the actual construction of a temple, the over-all size of the foundations would have to be pegged out at an early stage, so that the foundation trench for the krepis could be dug and the foundations begun. The over-all size could easily be obtained from the stylobate size, if that were already known, by adding a suitable number of feet to the length and to the width of the stylobate to allow for the treads of the two or more steps below the stylobate. Since the tread width of the steps did not have to be in a precise relation to any upper part of the building, and even the number of steps varied in some cases, this allowance for the step treads would not involve pursuing the upper part of the design of the temple any further at this stage; and even the stylobate size could be modified slightly after the krepis foundations had been begun, for the step treads are not always of precisely the same width on all four sides of a temple.

Nevertheless, since the over-all size was probably the first dimension that would be measured out on the ground, it is obviously worth considering the possibility that the over-all size, rather than the stylobate size, was decided first, and that the stylobate size was derived from that and not vice versa. If this were so, we should expect the relationship of over-all length to over-all width to be a simple, recognizable, and repeated proportion. The figures[41] are given in Table 1, Columns 18 to 20, first the proportion width to length in the simplest terms, then the proportion in terms of the number of columns and the number of intercolumniations in the façades. It should be noted that the figures for the over-all sizes of the temples have had to be drawn from a variety of sources; the proportion width to length should not be affected by this, but in other columns the over-all width and length are related to the stylobate width and to the intercolumniation, the figures given by Dinsmoor being used for these latter dimensions. This has seemed the lesser evil in the present circumstances, but greater inaccuracies are likely to occur in the proportions which involve figures drawn from different sources.

It will be seen that in many cases the proportion relating over-all width to over-all length does not seem to be very simple, but there are some cases which may be significant. Although the Peisistratid temple on the Acropolis at Athens has flank intercolumniations substantially smaller than the front ones, its stylobate size does not conform to the rule $W:L = C_W:C_L$ which we have suggested for the three earlier eastern temples.[42] If the proportions of the stylobate were related to the number of columns it carried, the width should be to the length as 6:12, that is as 1:2 not as 1:2·026. In this case the over-all size conforms more closely than the stylobate size to the number of columns; the over-all width is to the over-all length as 1:2·011, the length being 0·25 m. more than twice the width.

The stylobate proportions of the two giant temples in Sicily, Temple GT at Selinous and the

[41] For the sources of these figures see p. 67 n. 37.

[42] It has been often suggested that the colonnade of the Peisistratid Temple was constructed around a pre-existing cella (*JHS* lxxx (1960) 129–34). If so, the architect will not have been entirely free in his choice of stylobate proportions.

Olympieion at Akragas, also conform to no obvious rule; their over-all proportions come nearer to it. The over-all size of Temple GT, 53·31 × 113·36 m., is almost exactly in the proportion 8:17, the number of columns its stylobate carried. The Olympieion at Akragas (7 × 14 columns) conforms less accurately to the same rule, $OW{:}OL = C_W{:}C_L$. The over-all proportions are 7:14·1, so that the length is again too great, this time by 0·85 m., an error of 0·705 per cent. This is too much to be accounted for simply by inaccuracy in measurement, but much of the difference between rule and reality *could* be accounted for by the way the dimensions were calculated. If we assume that the Olympieion was intended to rival its neighbour Temple GT, then presumably its design started off from the length. The over-all length of the Olympieion is, according to Koldewey and Puchstein, 113·45 m., about 0·09 m. more than that of Temple GT. If we convert that into feet using an equation of 0·326006 m. = 1 ft., the over-all length will be 348 ft.;[43] $348/14 = 24\frac{12}{14}$—say $24\frac{3}{4}$;[44] $24\frac{3}{4} \times 7 = 173\frac{1}{4}$ ft.—say 173 ft.; 173 × 0·326006 = 56·399 m., which is reasonably close to the figure of 56·30 m. given by Koldewey and Puchstein (error = 0·19 per cent). We should notice that this explanation will only work if we divide and multiply by the intended number of columns as such; if instead of calculating 348/14 × 7 in two stages (with appropriate approximations) we reduce 7:14 to 1:2 and calculate 348/2, we get a result of 174 ft., not 173 ft. as required. The explanation will also only work for certain values of the foot. If the length of 113·45 m. is equated with 350 feet of 0·32414 m., then 350/14 = 25, and 25 × 7 = 175, which is exactly half of 350.

So far we have been working mainly with an assumed rule that the proportions of the krepis—measured either on the stylobate or over all—were derived directly from the number of columns which the krepis was intended to carry; that is, $W{:}L$ or $OW{:}OL = C_W{:}C_L$. But when we turn to the Sicilian temples from the middle of the sixth century onwards, a different rule seems to apply. The original rule, having been found to give too short a flank stylobate, has been modified so that the stylobate width is to the stylobate length as the number of columns across the fronts is to the number of columns along the flanks *plus one*, that is, $W{:}L = C_W{:}(C_L+1)$. This rule may seem perverse, and it is of course just a rule of thumb, but in fact it produces flank intercolumniations much closer to the front ones than the previous rule, provided that the length of the temple is between two and three times its width. Thus the intercolumniations of the Temple of 'Hercules' at Akragas, which obeys the second rule, are uniform, while those of the early mainland temples, which follow the first, vary substantially.

Temples D (6 × 13 columns) and FS (6 × 14 columns) at Selinous are the somewhat doubtful first examples of the application of the rule $W{:}L = C_W{:}(C_L+1)$, with stylobate proportions of 6:14·1 and 6:15·2 respectively, instead of 6:14·0 and 6:15·0. Again, however, an explanation is possible on the basis of a calculation in feet. With an equation of 0·3279 m. = 1 ft., the stylobate size of Temple D comes out as 72 × 170 ft., which could be explained by the following calculation; 72/6 = 12; 12 × 14 = 168; take this to the nearest decade of feet—170 ft. Similarly with an equation of 0·326 m. = 1 ft., the stylobate size of Temple FS would be 75 × 190 ft.; $75/6 = 12\frac{1}{2}$; $12\frac{1}{2} \times 15 = 187\frac{1}{2}$; take this to the nearest decade of feet—190 ft.[45] Obviously these foot equations need more rigorous testing before they can be accepted with full confidence, but they show how Temples D and FS could have been designed in accordance with the proposed rule, and none of the other possible rules examined here fits them any better.

Apart from the two colossal temples which we have looked at already, almost all the later

[43] For other dimensions of this temple expressed in terms of this foot see Table 3, Cols. 12–23.

[44] $24\frac{7}{8}$ ft. would be a closer approximation, but both Philo and Vitruvius liked to have dimensions expressible in quarter feet, not smaller fractions. See p. 61 n. 2 above.

[45] Both these calculations can also be worked in reverse. If the length of the temple rather than the width was decided first: $L = 170$ ft.; $170/14 = 12\frac{1}{7}$—say 12; 12 × 6 = 72; $W = 72$ ft.; $L = 190$ ft.; $190/15 = 12\frac{2}{3}$—say $12\frac{1}{2}$; $12\frac{1}{2} \times 6 = 75$; $W = 75$ ft.

Sicilian temples seem to fit the rule $W{:}L = C_W{:}(C_L+1)$ fairly accurately. Column 4 of Table 2 shows the difference in metres between the actual stylobate lengths and the lengths predicted by the application of this rule. In the Temple of 'Hercules' at Akragas, the next earliest example after Temples D and FS at Selinous, the difference is 0·384 m., but in the Temple of Athena at Syracuse and Temple A at Selinous it is less than 0·05 m.; in these two cases, and perhaps also in the Temple of 'Concord' at Akragas (difference = 0·071 m.), the differences can probably be explained simply as the result of inaccuracy in measurement. In the other cases the difference amounts to about 0·20 m., and some other explanation is needed. Rounding off at some stage in the calculation of the length could easily account for such a difference, amounting as it does to less than a foot.

It is important, in assessing the probability that this rule was actually used by Sicilian architects, to notice first that it applies to temples with different numbers of columns—6×15, 6×14, and 6×13—so that we are not just dealing with a single proportion of, say, $1{:}2\frac{1}{2}$ $(= 6{:}15)$, which should be explained in some quite different terms; second, that it applies to almost all the later Sicilian temples but to virtually none of the mainland ones,[46] so that we have a tight local and chronological group; and third, that the proposed rule forms a fairly logical progression from the rule $W{:}L = C_W{:}(C_L+1)$, which was found to make the stylobate length substantially too small. The first of these points is important because the proportion $1{:}2\frac{1}{2}$ is equivalent not only to $6{:}15$ but also to $5\frac{1}{3}{:}13\frac{1}{3}$; if a temple with 6×14 columns has a stylobate length $2\frac{1}{2}$ times its width, the stylobate proportions could either be expressed in the terms given here—$C_W{:}(C_L+1)$—or as $(N_W+\frac{1}{3}){:}\,(N_L+\frac{1}{3})$, an expression which, as we shall see, appears to have been used in later mainland temples. But these two ways of formulating the stylobate proportions are only identical for a 6×14 temple; the existence of temples with 6×15 and 6×13 columns within the group allows us to choose between the two formulations and to see that $C_W{:}(C_L+1)$ is to be preferred.

The odd man out among the later Sicilian temples is that of 'Juno Lacinia' at Akragas; although it is a temple with 6×13 columns, its stylobate proportions are $6{:}13\frac{1}{2}$ $(= 1{:}2\frac{1}{4})$, not $6{:}14$ $(= 1{:}2\frac{1}{3})$. This is probably to be understood as a compromise between the old mainland rule of $W{:}L = C_W{:}\,C_L$, which produced too short a flank stylobate, and the current Sicilian rule of $W{:}L = C_W{:}\,(C_L+1)$, which tended to produce too long a flank stylobate. It is interesting that the Temple of 'Juno Lacinia' is almost alone among Sicilian temples in having on both fronts and flanks the single angle contraction common in mainland temples,[47] even though this resulted in flank intercolumniations smaller than the front ones (as in earlier mainland temples). As we shall see, the so-called 'Tavole Paladine' at Metapontion[48] also follows this compromise rule of $W{:}L = C_W{:}(C_L+\frac{1}{2})$ but has no angle contraction, and as a result the difference between front and flank intercolumniations is much less. It is also worth noting that if the architect of the Temple of 'Juno' wished to introduce angle contraction, he employed a formula for the stylobate proportions which is found elsewhere only about forty years earlier, and which had already been replaced on the mainland by a more sophisticated formula.

The close relation between the existence of angle contraction and equality or inequality of front and flank intercolumniations can be seen from the comparison of the Temple of 'Juno Lacinia' with the 'Tavole Paladine'. It will perhaps be clearer from a hypothetical example. Let us suppose a stylobate of the right size to take a temple with 6×13 columns spaced so as to have the front and flank intercolumniations equal, with the correct amount of angle contraction

[46] Possible cases are the Older and later Parthenon (see below pp. 75–6).

[47] It is also unusual for Sicily in having enlarged front columns, although that was the normal mainland practice (Table 1, Cols. 10–11).

[48] See below, p. 80.

on both fronts and flanks. The amount of the angle contraction on the fronts will be the same as on the flanks, so that if we place on this stylobate the same number of columns but *without* any angle contraction, a given amount of angle contraction will have to spread over five front intercolumniations, but over twelve flank intercolumniations. Clearly this given amount will have more effect on the five front intercolumniations than it will on the twelve flank ones, so that the front intercolumniations will be shorter than the flank ones. Hence the absence of angle contraction in Sicilian temples will be part of the explanation of their 'perversely' wider flank intercolumniations.

The relationship between angle contraction and front/flank intercolumniations can also be seen in those temples which have only partial angle contraction. Thus in Temple GT at Selinous angle contraction was introduced in the later west façade to an extent that allowed the normal intercolumniations of that façade to be made equal to those on the flanks, while the intercolumniations on the (earlier) east façade, which had no angle contraction, were narrower than those on the flanks. This effect was applied more whole-heartedly in the Temple of 'Hercules' at Akragas, where there is angle contraction on both façades but on neither flank, with the result that the normal intercolumniations of the front, which would otherwise have been smaller than those on the flank, can be made equal to them. In Temple A at Selinous the equality of front and flank intercolumniations is produced in a similar way by making the angle contraction on the fronts twice as great as that on the flanks.

Normally the angle contraction of a Doric colonnade is discussed in terms of $AW-T/2$,[49] the amount by which the intercolumniation nearest the angle should be reduced if the frieze elements are to be uniform and regularly spaced. It is doubtful, however, if this way of calculating angle contraction was used in antiquity. Column 8 of Table 3 gives the value of $AW-T/2$, and Columns 6 and 7 the amount of angle contraction actually found in each temple. It will be seen that the figures rarely coincide exactly. Only in the fourth-century temples of the Peloponnese do we find a group of related buildings to which the rule applies at all accurately, and it is notable that in these buildings the architrave width is almost exactly twice the triglyph width, so that $AW-T/2 = T/2$. Since $T/2$ is the rule given by Vitruvius for angle contraction,[50] it is more likely that his simpler formula was used in these buildings. But in the earlier temples the angle contraction does not correspond any more regularly with Vitruvius' formula than with the modern one (compare Column 9 of Table 3 with Columns 6 and 7).

From the point of view of the architect, it would probably be more helpful to know how the normal intercolumniation should be related to the size of the stylobate (or vice versa), rather than to know the amount of the contraction. If the formulae involving the frieze were not used then there must have been some other way in which normal intercolumniation and stylobate size were related. In the temple of Hera at Olympia the intercolumniations are so irregular and the stylobate jointing so unrelated to them that some form of trial and error is the most likely method of deciding the positions of the columns. But in the Temple of Apollo at Corinth we seem to find the first instance of a procedure which was to have great importance later on. The stylobate width is equal to $5\frac{1}{3}$ normal front intercolumniations, or, to reverse the relationship, the normal front intercolumniations are $\frac{3}{16}$ of the stylobate width—a comparatively easy proportion to calculate, provided that the stylobate width was a whole number of feet. No such formula would be necessary for the Temple of Athena at Assos, for there was no angle contraction, so that once the position of the corner columns was decided, the others could be located simply by dividing up the distance between the corner columns into the required number of

49 See, for instance, D. S. Robertson, op. cit. 106–9. *AW* is used for the thickness of the architrave from back to front here, to avoid confusion with the architrave height.

50 *De Arch.* iv. 3. 2.

spaces. In the Peisistratid Temple at Athens a slightly different proportion seems to have been used—$I_W = W/5\frac{1}{4}$ (or $I_W = 4/21\ W$). One or other of these two proportions relates the stylobate width and front intercolumniations of almost all the later mainland temples in the sample with a few others grouping around $W = 5{\cdot}3\ I_W$ and $W = 5{\cdot}2\ I_W$. In the Temple of Apollo at Corinth and the Peisistratid Temple at Athens it seems probable that the intercolumniation was calculated from the stylobate width and not vice versa, for if the intercolumniation had been decided first and used to calculate the stylobate width, the same intercolumniation would presumably have been used to calculate the stylobate length, and we should find uniform flank and front spacing. In fact we do not find that. Instead the flank intercolumniation seems to have been obtained by dividing up the stylobate length, already determined by some other means, in much the same way as the front intercolumniation was derived from the stylobate width. In the Peisistratid Temple (6×12 columns) the flank intercolumniations are almost exactly equal to 1 part in $11\frac{1}{4}$ of the stylobate length, while those of the Temple of Apollo (6×15 columns) are slightly less than 1 part in $14\frac{1}{3}$ of the stylobate length, the difference being perhaps due to the greater difficulty in carrying out this division, whether arithmetically or directly.

When we look on to the fifth century B.C., however, it seems clear that the stylobate size *was* calculated from the intercolumniation. The formulae used earlier to find the intercolumniation were reversed; the intercolumniation was first decided on and the length and width of the stylobate were calculated by the formulae $W = I(N_W+k)$ and $L = I(N_L+k)$, where k is the fraction which allows for angle contraction, usually $\frac{1}{3}$ or $\frac{1}{4}$. The new procedure can be seen most obviously in the Temple of Zeus at Olympia (6×13 columns), where the intercolumniation of 16 ft. looks like a consciously chosen number. The stylobate size can then be calculated as $5\frac{1}{3}\ I$ by $12\frac{1}{3}\ I$ ($= I/3\times 16$ by $I/3\times 37$); $16/3 = 5$ ft. $5\frac{1}{3}$ dact.—say 5 ft. 5 dact.; 5 ft. 5 dact. × 16 = 85 ft. = W; 5 ft. 5 dact. × 37 = 196 ft. 9 dact. = L. Using the equation 0·326048 m. = 1 ft., this calculation gives the width as 27·714 m. (actually 27·68 m.) and the length as 64·089 m. (actually 64·12 m.). It will be seen that the calculation is perhaps not so easy to carry out when the formula is reversed in this way, for although no awkward fractions will occur when the intercolumniation is derived from a stylobate width which is a whole number of feet, awkward fractions are liable to occur when the process is reversed. Thus the division of 16 ft. by 3 produces fractions of a dactyl and the disregard of the fractions in the present case means that the stylobate width is $5\frac{5}{16}\ I$ rather than $5\frac{1}{3}\ I$. Some of the other variations from the formula $W = I(N_W+\frac{1}{3})$, $L = I(N_L+\frac{1}{3})$ are probably to be explained on similar lines.

The reversal of the formula which seems to have taken place by the middle of the fifth century B.C. reflects quite an important change in the architect's attitude to the design. Instead of working strictly from the larger to the smaller and from the bottom to the top of the building, he works from an intermediate point, so that at least one further step in the design is necessary before the construction can begin. The change of procedure seems also to reflect a change of interest, from the over-all proportions of the building to the proportional relationships between the constituent parts. The new formula may mean uniform front and flank intercolumniations, but it also means that in most cases there is no simple proportion between stylobate length and width. It is of some interest to see when this change took place.

The same rule as that suggested for the Temple of Zeus at Olympia seems also to apply to the Old Temple of Poseidon at Sounion (6×13 columns). If we take 0·326497 m. as 1 ft., we can start from an intercolumniation of $7\frac{1}{2}$ ft., and calculate the stylobate width and length as $5\frac{1}{3}\ I$ and $12\frac{1}{3}\ I$ as follows: $7\frac{1}{2}/3 = 2\frac{1}{2}$; $2\frac{1}{2}\times 16 = 40$ ft. $= W =$ 13·060 m. (actually *c.* 13·06 m.); $2\frac{1}{2}\times 37 = 92\frac{1}{2}$ ft. $= L =$ 30·201 m. (actually *c.* 30·20 m.). But with the nearly contemporary temples of Aphaia at Aigina and Athena at Delphi (both with 6×12 columns) we are on more doubtful ground. In fact these two temples seem to represent a compromise position. It is possible that they follow the rule suggested for the Temple of 'Juno Lacinia' at Akragas, that is, $W{:}L = C_W{:}(C_L+\frac{1}{2})$.[51] For the Temple of Athena we should then have $W = 13{\cdot}25$ m.; $13{\cdot}25/6 = 2{\cdot}2083$; $2{\cdot}2083\times 12\frac{1}{2} = L = 27{\cdot}6017$ m. (actually 27·464 m.); and for the Temple of Aphaia we would have $W = 13{\cdot}77$ m.; $13{\cdot}77/6 = 2{\cdot}295$; $2{\cdot}295\times 12\frac{1}{2} = L = 28{\cdot}687$ m. (actually 28·815 m.). However, there is another possible way in which the dimensions could have been worked out: the front intercolumniation of the Temple of Aphaia seems to have been equal to 8 ft. and the column height 16 ft. The choice of these numbers, powers of 2, is suspiciously similar to the choice of intercolumniation = 16 ft. and column height = 32 ft. for the Temple of Zeus at Olympia. It suggests that the intercolumniation may have been chosen first rather than derived from the stylobate width, and it is in fact true that in both temples the stylobate length is about equal to eleven times the front intercolumniation, so that both width and length of the stylobate could have been derived from a previously decided intercolumniation by the formulae $W = I_W(N_W+k)$, $L = N_L\times I_W$. We could calculate for the Temple of Athena $W = 5\frac{1}{3}\times I_W = 5\frac{1}{3}\times 2{\cdot}485$ m. $= 13{\cdot}2523$ m. (actually 13·25 m.), and $L = 11\times 2{\cdot}485$ m. $= 27{\cdot}335$ m. (actually 27·464 m.). For the Temple of Aphaia we could calculate similarly $W = 5\frac{1}{4}\times I_W = 5\frac{1}{4}\times 2{\cdot}618$ m. $= 13{\cdot}7445$ m. (actually 13·77 m.), and $L = 11\times 2{\cdot}618$ m. $=28{\cdot}798$ m. (actually 28·815 m.).

It may be worth looking again at the effect of doing these calculations in feet. In particular it will be found that although the relation of stylobate width to front intercolumniation in the Temple of Aphaia is in fact $W = 5\frac{1}{4}\ I_W$, this result could be arrived at by the application of the formula $W = 5\frac{1}{3}\ I_W$ if approximations took place in the calculation (the relevant figures are given in brackets). We can with some confidence take the foot used in the Temple of Aphaia as *c.* 0·327751 m., giving $W = 42$ ft., $L = 88$ ft., and $I_W = 8$ ft. Using the two alternative formulae suggested above we can calculate *either*: $W = 42$ ft.; $42/5\frac{1}{4} = 8$ ft. $= I_W$ ($42/16 = 2\frac{5}{8}$; $2\frac{5}{8}\times 3 = 7\frac{7}{8}$—say 8 ft. $= I_W$); $L = W/6\times 12\frac{1}{2} = 7\times 12\frac{1}{2} = 87\frac{1}{2}$ ft.—say 88 ft.; *or*: $I = 8$ ft.; $W = 8\times 5\frac{1}{4} = 42$ ft. (*or* $8/3 = 2$ ft. $10\frac{2}{3}$ dact.—say $2\frac{5}{8}$ ft.; $2\frac{5}{8}\times 16 = 42$ ft. $= W$); $L = I_W\times 11 = 8\times 11 = 88$ ft. With less confidence we may take the foot used in the Temple of Athena as 0·331069 m., giving $W = 40$ ft., $L = 83$ ft., and $I_W = 7\frac{1}{2}$ ft. Using the two alternative formulae suggested above we can then calculate *either*: $W = 40$ ft.; $40/16 = 2\frac{1}{2}$; $2\frac{1}{2}\times 3 = 7\frac{1}{2}$ ft. $= I_W$; $L = W/6\times 12\frac{1}{2}$; $40/6 = 6$ ft. $10\frac{2}{3}$ dact.—say $6\frac{5}{8}$ ft.; $6\frac{5}{8}\times 12\frac{1}{2} = 82$ ft. 13 dact.—say 83 ft. $= L$; *or*: $I_W = 7\frac{1}{2}$ ft.; $W = 7\frac{1}{2}/3\times 16 = 2\frac{1}{2}\times 16 = 40$ ft.; $L = I_W\times 11 = 7\frac{1}{2}\times 11 = 82\frac{1}{2}$—say 83 ft. Thus the existing data seem to be explicable either by the rules $I_W = \frac{3}{16}W$, $W{:}L = C_W{:}\,(C_L+\frac{1}{2})$, or by the rules $W = I_W(N_W+\frac{1}{3})$; $L = N_L\times I_W$: there seems to be little to choose between the alternatives. In either case the flank intercolumniation of the two temples seems to have been derived from the stylobate length by dividing it into N_L+k parts—$11\frac{1}{3}$ parts for the Temple of Athena and $11\frac{1}{4}$ parts (perhaps by approximation for $11\frac{1}{3}$ parts) in the Temple of Aphaia.

The Older Parthenon (6×16 columns) is also something of a problem. The front intercolumniation is related to the stylobate width in the usual way: $W = I_W/3\times 16$ or $I_W = W/16 \times 3$, but the stylobate length was made neither $N_L\times I_W$ (as perhaps at Delphi and Aigina) nor $(N_L+\frac{1}{3})I_W$ (as at Sounion and Olympia). Nor was the alternative rule for Delphi and Aigina used: $W{:}L = C_W{:}(C_L+\frac{1}{2})$. Instead the stylobate length is equal to about $15\frac{1}{3}\ I_W$, which seems hard to account for seeing that the flank intercolumniation was obtained in the usual way by dividing the stylobate length into $15\frac{1}{3}$ parts. The only other possibilities that occur to the

[51] See above, p. 72.

writer are these. It may have been the over-all size that was decided on, and the stylobate size was derived from that by subtraction of the step treads. The size over the bottom step of the krepis is given by Hill as 26·19 m. × 69·616 m.,[52] so that the proportion is 1:2·65 or 6:15·9. The Older Parthenon would then have followed the rule apparently used for the Peisistratid Temple—$OW:OL = C_W:C_L$: in this case 26·19 m./6 = 4·365 m.; 4·365 m. × 16 = 69·84 m., which is 0·224 m. more than the actual length. The other possibility is that the stylobate length was related to the width by the Sicilian rule of $W:L = C_W:(C_L+1)$. So 23·533/6 = 3·922; 3·922 m. × 17 = 66·674 m., which is 0·266 m. less than the actual stylobate length. Again there does not seem to be much to choose between these two alternatives, and indeed both of them could have been applied at once. If either is correct, the difference between the theoretical and the actual length could result from approximations in the calculation when done in feet. Whatever formula related stylobate length and width it would appear that the intercolumniations were derived from the stylobate size, not vice versa, and that the rules $I_W = W/(N_W+\frac{1}{3})$, $I_L = L/(N_L+\frac{1}{3})$ were used.

It may be worth noticing at this point that the stylobate proportions of the later Parthenon (8 × 17 columns), whether intentionally or not, do conform to the Sicilian rule for $W:L = 4:9 = 8:18 = C_W:(C_L+1)$. But in this case the angle contraction is so managed that the front and flank intercolumniations are equal, so that the later mainland rule $W = I(N_W+k)$, $L = I(N_L+k)$ also applies, in the form $W = 7\frac{1}{5}\,I$, $L = 16\frac{1}{5}\,I$: for as we have seen, $7\frac{1}{5}:16\frac{1}{5} = \frac{36}{5}:\frac{81}{5} = 4:9 = 8:18$. This convenient result, which allowed the later insistence on uniform column spacing to be combined with simple stylobate proportions which conformed to one of the accepted rules relating stylobate length to width, may explain to a considerable extent the excessive angle contraction of the Parthenon. If at the same time it reduced the usual width of the octostyle façade, so much the better.[53]

The later mainland temples in the sample seem with three exceptions to derive the stylobate length and width from a previously decided intercolumniation by the rule $W = I(N_W+k)$, $L = I(N_L+k)$, where k is most commonly $\frac{1}{3}$, less often $\frac{1}{4}$ or $\frac{1}{5}$. The variations from these simple fractions are probably to be explained by the way in which the calculations in feet were made—as we have already seen that at Aigina $W = 5\frac{1}{4}\,I$ can be explained as another occurrence of the more common $W = 5\frac{1}{3}\,I$ with approximations in the calculations. It does not seem worth while to try to suggest in detail the way all these calculations ran, for suggestions of foot length made in the context of this inquiry are necessarily made without any real attempt at proof. It is hoped, however, that the calculations suggested above will show how discrepancies between rule and reality which appear quite substantial when the calculations are done in metres can often be removed if the calculations are done in feet, with some allowance made for the simplification of fractions.

The over-all size of a temple, which would need to be decided before construction could begin, could be calculated directly and easily from the stylobate size by adding on to both length and width an allowance for the step treads all round. But when the stylobate size was calculated from the intercolumniation, two stages of calculation would be needed to obtain the over-all size of the foundations, and it might be convenient to have a way of deciding on the

[52] *AJA* xvi (1912) pl. 9. The over-all size of the whole platform was 31·39 × 76·816 m.—approximately 7:17 or $(C_W+1):(C_L+1)$.

[53] See above, p. 66. The Temple of Zeus at Kyrene, also with 8 × 17 columns, has a stylobate with the same proportions (30·40 × 68·35 m.; 30·40 × 18/8 = 68·20 m.), but the angle contraction is here not so strong, and as a result the front and flank intercolumniations are different: W. B. Dinsmoor, *The Architecture of Ancient Greece* (2nd edn., 1960), 86; but according to Pesce (*BCH* lxxi–lxxii (1947–8) 319 pl. 56) although the columns are rather irregularly spaced there is no systematic difference between front and flank intercolumniations.

over-all size more directly. We have already seen that in three, and perhaps four, archaic temples the over-all size seems to have been obtained by $OW{:}OL = C_W{:}C_L$. This relationship seems to have been taken up by the 'Theseion' architect, but he based the calculation on the intercolumniation, and combined it with the later mainland rule for the stylobate size, so that we have $OW = C_W \times I$, $OL = C_L \times I$, and $W = (N_W + \frac{1}{3})\, I$, $L = (N_L + \frac{1}{3})\, I$. The projection of the krepis outside the stylobate would thus be equal to $\frac{1}{3}\, I$. So at Sounion, where a Doric temple with 6×13 columns and an intercolumniation of $7\frac{3}{4}$ ft. was to be built, he could at once extend the foundations of the older temple to take a krepis $6 \times 7\frac{3}{4}$ ft. by $13 \times 7\frac{3}{4}$ ft., that is $46\frac{1}{2}$ ft. by $100\frac{3}{4}$ ft., over all. This convenient rule was used by some other architects too, but many preferred proportionately smaller step treads, and in some cases there seems to be no simple relationship between over-all size and intercolumniation.

The three exceptions to this later mainland rule relating stylobate width and length to normal intercolumniation are the Temples of Apollo at Delphi and Bassai and the Temple of Athena at Tegea. At Delphi the stylobate width and length of the fourth-century Temple of Apollo (6×15 columns) are related in the way we should expect—$W{:}L = (N_W + \frac{1}{3}){:}(N_L + \frac{1}{3})$; but in spite of that there is no uniform intercolumniation equal to $W/5\frac{1}{3}$ and $L/14\frac{1}{3}$. Instead, $I_W = W/5\frac{1}{4}$, $I_L = L/14\frac{1}{4}$ (producing stronger angle contraction), so that the flank intercolumniation is slightly less than that on the fronts. The situation here is clearly complicated by the fact that the fourth-century temple was built on the platform of the Alkmaionid temple and reused some of the old columns.[54] The over-all size of the Alkmaionid temple ($23{\cdot}80 \times 59{\cdot}50$ m.) had been laid out to the rule $OW{:}OL = C_W{:}C_L$ ($23{\cdot}80 \times 15/6 = 59{\cdot}50$), just as the sixth-century Temple of Athena Pronaia had been. This, however, did not produce uniform intercolumniations, so when the Temple of Apollo was rebuilt in the fourth century B.C., the platform was lengthened by a few feet so that the stylobate could conform to the later mainland rule of $W{:}L = (N_W + \frac{1}{3}){:}(N_L + \frac{1}{3})$. But in the event, as we have seen, the intercolumniations were made equal to $W/5\frac{1}{4}$ and $L/14\frac{1}{4}$, spoiling the effect of the improvement. A possible reason for this change of intercolumniation might have been the decision to reuse the columns from the Alkmaionid temple, assuming that the intercolumniations of that temple had been related to its stylobate size by the same formulae.[55] Unfortunately there are not enough accurately known data to be sure whether this was the case or not, although the assumption that these formulae were used does not conflict with the probable dimensions of the temple.[56]

At Bassai (also with 6×15 columns) the stylobate width equals $5\frac{1}{3}\, I_W$ and the length equals about $14\frac{1}{3}\, I_L$, in the usual way, but I_W and I_L are not equal. This suggests that the stylobate size was not derived from the intercolumniation, but vice versa. The nearest simple expression relating stylobate width to length with reasonable accuracy is $W{:}L = (N_W + \frac{1}{2}){:}(N_L + \frac{1}{2}) = 5\frac{1}{2}{:}14\frac{1}{2} = 1{:}2{\cdot}639$. Using this formula to calculate the stylobate length from the width we

[54] W. B. Dinsmoor, op. cit., 2nd ed., 217.

[55] The effectiveness of the rule $W = I_W(N_W + \frac{1}{3})$ in producing approximately the right amount of angle contraction depends very much on the relation of the stylobate breadth (S) to the axial intercolumniation (see p. 83 n. 64 below). If the stylobate is too narrow the angle contraction will be too little, or even non-existent. Since the lower column diameter must be closely tied to S, columns designed for a temple where $I_W = W/(N_W + \frac{1}{4})$ could not be used in a temple of virtually the same size where $I_W = W/(N_W + \frac{1}{3})$. We must assume that the decision to reuse the old columns was taken after the lengthening of the foundations, but before the detailed setting out of the stylobate and column positions, i.e. before the construction of the visible krepis.

[56] The stylobate width of the Alkmaionid Temple was was probably much the same as that of the fourth-century temple, c. 21·68 m., since the over-all width is virtually the same in both buildings; and if the stylobate was set back from the ends of the foundation by the same amount as at the sides, the stylobate length would be c. 57·38 m. Using the formulae $I_W = W/(N_W + \frac{1}{4})$, $I_L = L/(N_L + \frac{1}{4})$, we get $I_W = 4{\cdot}130$ m., $I_L = 4{\cdot}027$ m. Using the formulae $I_W = W/(N_W + \frac{1}{3})$, $IL = L/(N_L + \frac{1}{3})$, we get $I_W = 4{\cdot}065$ m., $I_L = 4{\cdot}003$ m. The estimate of the French publication, based on other evidence, is $I_W = c.\ 4{\cdot}104$ m., $I_L = 3{\cdot}95$–$4{\cdot}00$ m. (*FdD* ii, F. Courby, *La Terrace du Temple* i (1915) 96–7).

get $14{\cdot}478/5\frac{1}{2}\times14\frac{1}{2} = 38{\cdot}1698$ m., 0·074 m. less than the actual stylobate length. But why should the width have been related to the length in this way, if the intercolumniations were then to be derived by $I_W = W/5\frac{1}{3}$, $I_L = L/14\frac{1}{3}$? It is perhaps more likely that the stylobate size was derived from the over-all size by the deduction of a suitable amount for the step treads all round. For $OW{:}OL = C_W{:}C_L = 6{:}15$ with an error of only 0·03 m. This explanation is made the more likely by the fact that it applies also to the only other Arkadian temple in the sample, that of Athena at Tegea (6×14 columns). Here the stylobate width $= 5\frac{3}{10}\, I_W$ and the length $13\frac{1}{4}\, I_L$, but I_W and I_L are not equal: so here too the intercolumniations were presumably derived from the stylobate size rather than vice versa. But here also it looks as if the stylobate size was itself derived by just subtracting suitable tread widths from the over-all size, for it is hard to formulate a simple rule connecting the stylobate length and width, but the over-all width is related to the over-all length by the same formula as at Bassai; $OW{:}OL = C_W{:}C_L$, which in this case equals 6:14. The error is only 0·09 m.

When considering the stylobates of the Sicilian temples, we looked simply at the relation of stylobate length to width. So long as there was no angle contraction, no special rule would be needed to establish the positions of the columns. The position of the corner columns could easily be found, either on the stylobate or within a line equivalent to the stylobate laid down on the euthynteria or on a drawing; and then the distance between their axes could be divided up into the required number of equal intercolumniations for each front and flank. And when in the Temple of 'Hercules' at Akragas angle contraction was used only on the fronts so as to equalize the normal front and flank inter-columniations, the flank columns could have been located in just the same way, and then three intercolumniations of the same size could have been set out in the middle of each front, the remainder of the space available making up the contracted intercolumniations next to each corner.

When, however, a more elaborate system of angle contraction was adopted, from about 480 B.C. onwards, something similar to the mainland rule of $I_W = W/(N_W+\frac{1}{3})$ $I_L = L/(N_L+\frac{1}{3})$ must have been required. We have seen that the most probable explanation of the Sicilian stylobate sizes is that the length was derived from the width, not from the intercolumniation, by the rule $W{:}L = C_W{:}(C_L+1)$. As mentioned above, however, in the case of a temple with 6×14 columns $C_W{:}(C_L+1) = 6{:}15 = 1{:}2\frac{1}{2} = \frac{16}{3}{:}\frac{40}{3} = 5\frac{1}{3}{:}13\frac{1}{3} = (N_W+\frac{1}{3}){:}(N_L+\frac{1}{3})$. That is, a temple with 6×14 columns can obey both the Sicilian rule and the later mainland rule for stylobate size simultaneously. That may explain why, of the seven Sicilian temples in the sample which were begun after *c.* 490 B.C., there are two with 6×13 columns, one with 6×15 columns, but *four* with 6×14 columns, a number which is very rare in mainland Greece.

In a number of Sicilian temples the mainland rule relating intercolumniation to stylobate size seems to apply directly. At Segesta $I_W = W/5\frac{1}{3}$ ($= W/16\times3$) and $I_L = L/13\frac{1}{3}$; the fact that I_W and I_L are here not quite equal, although this is a temple with 6×14 columns, is due to the stylobate length not being exactly $2\frac{1}{2}$ times its width. In the Temple of 'Concord' at Akragas $I_W = W/5\frac{3}{10}$, and $I_L = L/12\frac{3}{10}$, but again I_W and I_L are not quite equal. This time it is because the Sicilian rule for stylobate length is used (since this is a temple with 6×13 columns the Sicilian and mainland rules do not apply simultaneously) and makes the stylobate length slightly too great.

In the Temples of Athena at Syracuse and 'Victory' at Himera, both with 6×14 columns, the front and flank inter-columniations could have been made equal; if the normal front inter-columniation had been repeated on the flanks, the angle contraction on the flanks would have been the same as that on the fronts. Instead of that, however, the normal flank intercolumniations were made *c.* 0·02 m. greater than the front ones, so that the intercolumniations near the corner had to be much more strongly contracted than the corresponding ones on the fronts. The total amount of contraction at each end of the flank colonnades of the Temple of Athena is 0·535 m. compared with 0·35 m. on the fronts, and in the Temple of 'Victory' it is 0·342 m. on the flanks compared with 0·243 m. on the fronts.

This looks like a deliberate preference for flank intercolumniations slightly larger than those on the fronts. It may be so, but another explanation is possible. The normal front intercolumniation was derived from the stylobate width by a formula of the type $I_W = W/(N_W+k)$, but this may well have given a dimension which was not very simple when expressed in feet. The inconvenience could be accepted on the fronts, where only one normal intercolumniation had to be set out, but for the flanks, where nine normal intercolumniations were needed, it may have been decided to round off the dimension to a more convenient figure in feet. For instance, if we take 1 ft = 0·329128 m. for the Temple of 'Victory', we get $W = 68\frac{1}{4}$ ft., $L = 170$ ft. W would have been worked out from L by the Sicilian rule as follows: $L = 170$; $170/15 =$ 11 ft. $5\frac{1}{3}$ dact.—say $11\frac{3}{8}$ ft.; $11\frac{3}{8}\times 6 = 68\frac{1}{4}$ ft. $= W$. The normal front intercolumniation would be about 71 ft. 11 dact. in terms of this foot, while the flank intercolumniation would have been increased by one dactyl to the more convenient figure of $12\frac{3}{4}$ ft.[57]

A similar explanation may account for the rather surprising occurrence of wider flank intercolumniations together with angle contraction on the flanks of the Olympieion at Akragas, although without angle contraction the flank intercolumniations would have been rather closer to the front ones. Without angle contraction the flank intercolumniations would have been 8·123 m. rather than 8·185 m. The increase of 0·062 m. may well have been intended to produce a more convenient figure in feet (8·185 m. is approximately equal to 25 ft. of the size proposed on p. 71), but such an increase would necessarily involve the introduction of angle contraction on the flanks.

The normal front intercolumniation of the Temple of Athena at Syracuse is equal to $W/5\frac{3}{10}$, as in the Temple of 'Concord' at Akragas. But in the Temple of 'Victory' at Himera it is equal to about $W/5\frac{3}{8}$, and in general it is true that the fraction k in the expression $I_W = W/(N_W+k)$ is larger in Sicily than in mainland Greece, so that there is less allowance for angle contraction than in the mainland. Of the Sicilian temples which have angle contraction of any sort, we have already looked at Temple GT at Selinous, the Olympieion, the Temple of 'Hercules' and the Temple of 'Concord' at Akragas, the Temple at Segesta, the Temple of Athena at Syracuse and the Temple of 'Victory' at Himera. Of the other three, Temples ER and A at Selinous have $k = \frac{3}{8}$ as at Himera. In Temple A this is used only to obtain the normal front intercolumniation. The normal flank intercolumniation which, if it had been derived by $I_L = L/13\frac{3}{8}$, would have been slightly more than the front one, was simply made equal to the front intercolumniation. The result is that the contraction on the flanks is less strong (0·0945 m.) than on the fronts (0·19 m.). In Temple ER, however, $I_W = W/5\frac{3}{8} = I_L = L/14\frac{3}{8}$. This is a temple with 6×15 columns, and just as both the Sicilian rule for stylobate size $W{:}L = C_W{:}(C_L+1)$ and the mainland rule $W = (N_W+\frac{1}{3})I$, $L = (N_L+\frac{1}{3})I$ can apply simultaneously to a temple with 6×14 columns, so the rules $W{:}L = C_W{:}(C_L+1)$ and $W = (N_W+\frac{3}{8})I$, $L = (N_L+\frac{3}{8})I$ can both apply almost exactly in a temple with 6×15 columns, for $5\frac{3}{8}{:}14\frac{3}{8} = 43{:}115 = 1{:}2{\cdot}6744$, while $6{:}16 = 42{:}112 = 1{:}2{\cdot}6667$. In the Temple of 'Juno Lacinia' at Akragas the allowance

[57] Dinsmoor suggests (*The Architecture of Ancient Greece* (2nd edn., 1950) 108–9) that the discrepancy arose from a last-minute decision to give the flanks double rather than single contraction. However, that does not explain why the total angle contraction on the flanks was increased, instead of the same amount being spread over two intercolumniations. For if the two intercolumniations nearest each corner on the flanks had been made equal to the two nearest each corner on the fronts, the discrepancy between the normal front and flank intercolumniations would have been only 0·011 m., rather than the actual 0·023 m.

for angle contraction is even smaller, with $I_W = W/5\frac{7}{16}$, $I_L = L/12\frac{7}{16}$, and the actual angle contraction is only *c.* 0·08 m. The reason in this case is presumably that any greater angle contraction would have increased the difference between front and flank intercolumniations (here equal to 0·05 m.).

As far as the actual laying out was concerned, Sicilian double contraction would be almost as easy to deal with as single contraction. Two-thirds of the total amount of the contraction was normally given to the intercolumniation next to the angle and the remaining one-third to the intercolumniation second from the angle. Thus once the stylobate size and normal intercolumniation had been decided, and the position of the corner columns was established, then

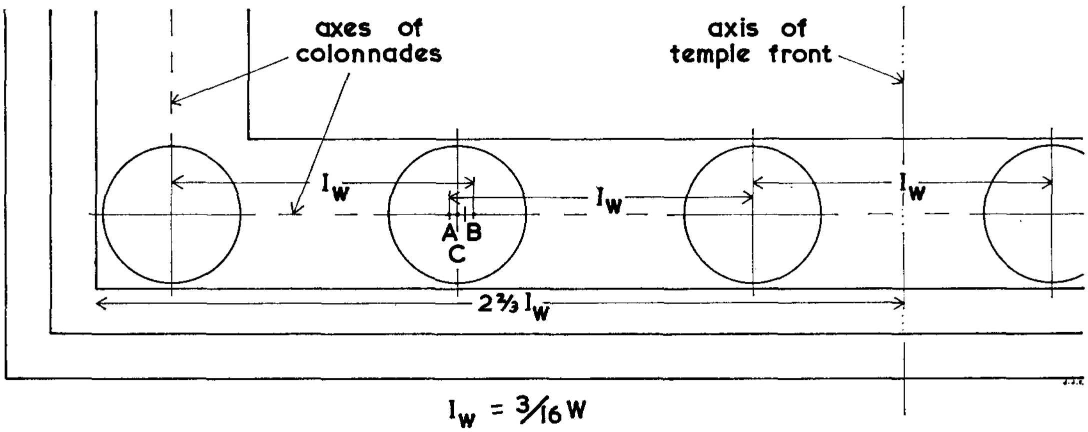

FIG. 2. A METHOD OF SETTING OUT DOUBLE ANGLE CONTRACTION

for the fronts it would simply be necessary to lay out (either on a drawing or on the ground) one normal intercolumniation in the middle of the stylobate, measure from the end of it a distance of the same length, and make a mark *A*; the same length would then be measured out again from the axis of the corner columns and a mark made at *B*. If *AB* was then divided into three equal parts, the second column from the corner should be centred at the point *C*, one third of the distance from *A* to *B* (FIG. 2). For the flanks N_L-4 normal intercolumniations would be laid out in the middle of each flank, and then the procedure described above could be used for the two intercolumniations nearest each corner.

We have not yet considered the four Italian temples in our sample, and they are in fact among the most problematic. One difficulty is that they are few in number and very different from each other in design—that much is clear even without an examination of the way in which they were set out. The simplest to deal with is the 'Tavole Paladine' at Metapontion (6 × 12 columns). There the ratio of width to length is $6:12\frac{1}{2}$ (width = 16·06 m.; $16{\cdot}06/6 \times 12\frac{1}{2} = 33{\cdot}4587$ m.; actual stylobate length = 33·46 m.), so that the rule implied, $W:L = C_W:(C_L+\frac{1}{2})$, is the same as that used in the Temple of 'Juno Lakinia' at Akragas, and perhaps also in the Temples of Aphaia at Aigina and Athena at Delphi. But at Metapontion there is no angle contraction, so that there is less difference between the front and flank intercolumniations; and without angle contraction there is no need for any rule to derive the intercolumniations from the stylobate size. The Temple of 'Ceres' at Paestum (6 × 13 columns) also lacks angle contraction, but here the front and flank intercolumniations are virtually equal, which suggests that the design was built up from the size of the intercolumniation: $W = 5\frac{1}{2} I$ ($5\frac{1}{2} I_W = 14{\cdot}459$ m., actual stylobate width $= 14{\cdot}541$ m.), $L = 12\frac{1}{2} I$ ($12\frac{1}{2} I_W = 32{\cdot}861$, actual stylobate length $= 32{\cdot}880$ m.). This, however, may be another example of the same rule as at Metapontion. The stylobate length of the Temple of 'Ceres' was probably 100 ft. (if 1 ft. $= 0{\cdot}3288$ m.) If we divide this by $13\frac{1}{2}$ (the number of flank columns plus a half) we get 7 ft. $6\frac{14}{27}$ dact.—say $7\frac{3}{8}$ ft.—$7\frac{3}{8} \times 6 = 44\frac{1}{4}$ ft.,[58] $44\frac{1}{4} \times 0{\cdot}3288$ m. $= 14{\cdot}549$ (the actual stylobate width $= 14{\cdot}541$ m.). The justification for calculating the width from the length in this instance is that 100 ft. was a consciously chosen length.

In the 'Basilica' at Paestum (9×18 columns) the flank and front intercolumniations are widely different, so that the question of the stylobate size being derived from the intercolumniation probably does not arise. The ratio of stylobate width to length is $1:2{\cdot}219$, which is nearly $9:20$: $24{\cdot}51/9 \times 20 = 54{\cdot}466$ m.; (the actual length $= 54{\cdot}27$ m.).[59] This could be an experiment with a rule $W:L = C_W:(C_L+2)$ as an emendation of the early mainland rule of $W:L = C_W:C_L$, just as we have suggested that the Sicilian rule of $W:L = C_W:(C_L+1)$ was an improvement of this sort.[60] The Sicilian rule works much better of course, and it is not surprising that the over-correction $W:L = C_W:(C_L+2)$, if it was in fact so visualized, was dropped immediately. Nevertheless, since there is no other temple on which this rule can be tested, the suggestion that it was used in the 'Basilica' must remain tentative.[61]

The Temple of 'Poseidon' at Paestum, built in the middle of the fifth century B.C., ought to be less peculiar than the 'Basilica', but it is even more difficult to see the way in which it was laid out. Since the front and flank intercolumniations are substantially different, we should expect the length of the stylobate to have been derived from the width, rather than both from the intercolumniation; but the ratio of width to length is $1:2{\cdot}47$ or $6:14{\cdot}83$—not a very simple expression. The ratio $1:2{\cdot}50$, of course, corresponds, for a temple with 6×14 columns, both to the Sicilian and the later mainland rules. If the width and length are related to each other, not to the intercolumniation, the mainland rule can hardly have been used; but if we make the maximum use of rounding off in the calculation, we can perhaps apply the Sicilian rule of $W:L = C_W:(C_L+1)$. Then taking 1 ft. $= 0{\cdot}327697$ m., we get $W = 74$ ft., $L = 183$ ft., and could derive L from W as follows: $74/6 = 12$ ft. $5\frac{1}{3}$ dact.—say $12\frac{1}{4}$ ft.; $12\frac{1}{4} \times 15 = 183\frac{3}{4}$ ft., omitting fractions say 183 ft. This seems rather a forced calculation, but the over-all measurements are not much more helpful. Koldewey and Puchstein give the over-all size as $26{\cdot}06 \times 61{\cdot}70$ m., which gives a ratio of $1:2{\cdot}37$ or $6:14{\cdot}2$.

The situation is clearly complicated by the way the angle contraction is handled: not only is there double contraction on the flanks and single contraction on the fronts, but the total contraction is twice as great on the flanks as well. If a single contracted intercolumniation of $4{\cdot}295$ m. (as on the fronts) had been used at each end of the flank colonnades, then the normal flank intercolumniation would have been very near the normal front intercolumniation ($4{\cdot}464$ m., as against $4{\cdot}471$ m.). The treatment of the angle contraction is thus varied here, not as in Temple A at Selinous and the Temple of 'Hercules' at Akragas in order to make the normal intercolumniations of front and flank equal, but apparently to make them unequal.[62] The

[58] The advantage of the second formulation is that it explains the odd $\frac{1}{4}$ foot in the stylobate width, which must otherwise be put down to error in measurement. For by the first formulation, with $I = 8$ ft., the stylobate size ought to be $5\frac{1}{2} \times 8$ by $12\frac{1}{2} \times 8$ ft., that is 44×100 ft.

[59] The discrepancy could be reduced by calculating in feet of $0{\cdot}326846$ m. as follows: $W = 75$ ft.; $75/9 = 8\frac{1}{3}$—say $8\frac{5}{16}$; $8\frac{5}{16} \times 20 = 166\frac{1}{4}$—say 166; $L = 166$ ft.

[60] See above, p. 71.

[61] F. Krauss, *Paestum, Die GriechischenTempel* (2nd edn., 1943) 62–3, suggests that the aim was to give the temple the proportion $1:2\frac{1}{2}$ at the level of the architrave taenia. This seems rather a strange place to embody such a proportion if it was meant to be appreciated by the onlooker. If the plan of a Doric temple is taken at every possible level, it will produce so many concentric rectangles of slightly varying proportion, that this result could easily be due to chance.

[62] Cf. the Temples of Athena at Syracuse and 'Victory' at Himera and the Olympieion at Akragas, pp. 78–9 above.

most likely explanation is perhaps this: the stylobate width was divided into $5\frac{7}{16}$ parts to obtain the normal front intercolumniation ($24{\cdot}264/5\frac{7}{16} = 4{\cdot}462$ m.—actually 4·471 m.), but this was found to be very awkward when expressed in feet, so that the flank intercolumniations were laid out to the nearest convenient fraction of a foot, which was slightly more ($13\frac{3}{4}$ ft. of the size proposed above equals 4·506 m.; the actual flank intercolumniation = 4·503 m.). This lengthening of the normal intercolumniation on the flanks involved stronger contraction near the angles, and so it was decided to spread the total contraction over two intercolumniations on the flanks to prevent too harsh a contrast between the front and flank intercolumniations adjoining the angle.

CONCLUSIONS

It is perhaps as well to have finished with a temple which cannot be easily understood. It is worth saying again that the aim of this paper is not to explain *all* the workings of *every* Greek architect, but to try to see the way in which *most* architects *normally* worked. There are bound to be some buildings where factors unknown to us operated, or where the architect used a different procedure from his fellows. Some of the explanations suggested above may well be wrong in detail, therefore: this particularly applies to the foot units. But it is much more unlikely that the basic rules which seem to apply to substantial groups of related buildings are simply the product of chance. Those proposed here seem to conform reasonably to the theoretical requirements for such rules: that they be simple, repeated, and accurate. They are as simple as rules could well be, considering that they have to allow for temples with different numbers of columns, and they form a reasonable progression one from another. The buildings to which each rule applies form a fairly close local and chronological group, but one which includes buildings with different numbers of columns. It is perhaps in the matter of accuracy of fit that these rules may seem to be most deficient. Some of the proposed explanations may appear too much like special pleading. But rules of some sort there must surely have been, and although it is beyond the powers of the author to calculate the absolute probability that these rules were used, it should be a fairly straightforward matter to compare the likelihood that they were used with the likelihood that any other set of rules was used. It is with this in mind that I have tried to set out as clearly and fully as possible the discrepancies between fact and theory in the rather lengthy tables which accompany this paper.

It may be convenient at this point to summarize the general conclusions which seem at least the most likely answers to questions that must be asked. The difference between front and flank intercolumniations in archaic Doric temples was probably not the result of a detailed design intended to produce precisely this result. Whether the effect was disliked, ignored, or even perhaps in some cases desired, it was the result of the application of rules relating the length to the width of the stylobate which did not allow a regular spacing of columns. The decrease in the difference was due to the improvement of these rules.

Three main rules seem to have been used, with some related variations.

Rule 1. The early mainland rule. Let the stylobate width be to the length as the number of columns across the front of the temple is to the number of columns along the flanks ($W{:}L = C_W{:}C_L$).[63] This rule was current in mainland Greece through most, perhaps all, of the sixth century B.C. It produces flank intercolumniations considerably shorter than the front ones.

Variation 1*a*. This rule may be applied to the over-all dimensions of a temple rather than to those of the stylobate, and in that case it may be combined with other rules for the stylobate. In this form the rule continues in use until the late fourth century B.C.

[63] For the abbreviations used here and throughout this paper see n. 20.

Rule 2. Sicilian rule. Let the stylobate width be to its length as the number of columns across the front is to the number of columns along the flanks *plus one* ($W{:}L = C_W{:}(C_L+1)$. This rule is clearly a modification of Rule 1, and it was current in Sicily, probably from the middle of the sixth century through the fifth century B.C. In a temple without angle contraction this rule will give flank intercolumniations slightly longer than the front ones. Other modifications of Rules 1 and 2 were used as follows:

Variation 2a. Width is to length as number of front columns is to number of flank columns *plus two* ($W{:}L = C_W{:}(C_L+2)$). This rule may have been used in the 'Basilica' at Paestum.

Variation 2b. Width is to length as number of front columns *plus one* is to number of flank columns *plus one* ($W{:}L = (C_W+1){:}(C_L+1)$). This rule fits the Temple of Apollo at Syracuse, but seems unlikely to have been the one used.

Variation 2c. Width is to length as number of front columns is to number of flank columns *plus a half* ($W{:}L = C_W{:}(C_L+\frac{1}{2})$). This rule was probably used in the 'Tavole Paladine', the Temple of 'Ceres' at Paestum, and the Temple of 'Juno Lacinia' at Akragas, and perhaps also in the Temples of Athena at Delphi and Aphaia at Aigina.

The problems of angle contraction and non-uniform column-spacing appear to be closely connected. Where angle contraction was used, some means would be needed to calculate the normal intercolumniation, which could not be derived simply by subdividing the stylobate. Neither the modern formula (angle contraction $= (AW-T)/2$) nor the Vitruvian rule (angle contraction $= T/2$) appears to have been used. Instead the normal intercolumniation was derived directly from the stylobate size by dividing it into the required number of intercolumniations plus a fraction, which was usually one-third ($I_W = W/(N_W+\frac{1}{3})$; $I_L = L/(N_L+\frac{1}{3})$,[64] but might be some other fraction. Where the stylobate width and length were directly related to each other by Rule 1 or 2 above, these formulae were used to derive the front and flank intercolumniations from the stylobate size, and the spacing was rarely uniform. However, at some time around 500 B.C. architects began to use the rule in reverse. They decided first the size of the intercolumniation and then derived the stylobate size from that. Thus we have a third rule governing stylobate size.

Rule 3. The later mainland rule. The stylobate width should be equal to the desired number of front intercolumniations *plus a third*, and the stylobate length should be equal to the desired number of flank intercolumniations *plus a third* ($W = I(N_W+\frac{1}{3})$, $L = I(N_L+\frac{1}{3})$). This rule or a variation of it was apparently used in almost all mainland temples after the Persian Wars. Since both the length and the width of the stylobate are now derived from a previously decided intercolumniation, front and flank intercolumniations are now almost exactly equal; but the simple relationship between the length and the width of the stylobate in most cases disappears, and this state of affairs was not accepted in Sicily. The variations on Rule 3 are variations in the fraction which increases or decreases the amount of angle contraction.

Variation 3a. $W = I(N_W+\frac{3}{10})$, $L = I(N_L+\frac{3}{10})$.

Variation 3b. $W = I(N_W+\frac{1}{4})$, $L = I(N_L+\frac{1}{4})$.

Variation 3c. $W = I(N_L+\frac{1}{5})$, $L = I(N_L+\frac{1}{5})$. This variation gives the excessive angle contraction in the Parthenon.

[64] With no allowance for tilting the columns, this rule will give the correct angle contraction ($I-I_A = AW-T/2$) when $S = I/3+AW-T$; that is, if $AW = 2T$ and $T = I/5$, then I must equal about $2D$. The use of the same rule with three-metope spans, and therefore much smaller columns, in the Stoa at Brauron ($I = c.\ 4{\cdot}0$ D) means that the angle intercolumniations are enlarged not contracted—conveniently, since the angles are re-entrant not external ones.

Variation 3d. $W = I(N_W + \frac{3}{16})$, $L = I(N_L + \frac{3}{16})$. This variation is used to give angle contraction for three-metope intercolumniations in the Temple of Athena at Pergamon.[65]

Variation 3e. $W = I(N_W + \frac{3}{8})$, $L = I(N_L + \frac{3}{8})$.

Variation 3f. $W = I(N_W + \frac{7}{16})$, $L = I(N_L + \frac{7}{16})$.

Variation 3g. $W = I(N_W + \frac{1}{2})$, $L = I(N_L + \frac{1}{2})$. This variation was perhaps used in the Temple of 'Ceres' at Paestum, rather than Variation 2*c* above.[66]

If we leave aside Variation 3*d*, which is only found in the one temple in the sample which has three-metope intercolumniations, then the variations on Rule 3 fall into two groups: Variations 3*a* to 3*c*, which give stronger angle contraction than Rule 3, are found chiefly in mainland Greece, while variations 3*e* to 3*g*, which give less angle contraction than Rule 3, or none at all, are found only west of the Adriatic, and they are used to derive the normal intercolumniation from the stylobate size, not vice versa.

Fig. 3 shows graphically how the actual proportions of the stylobates dealt with in this study compare with the proportions predicted by the three main rules proposed. It will be seen that the early mainland temples conform more closely to Rule 1 than to any other, and that the early Sicilian temples stand well away from any of the Rules. The majority of the later Sicilian temples fall closer to Rule 2 than to Rule 3 (except where the two coincide), while the majority of the later mainland temples conform more closely to Rule 3 than to Rule 2. A small group, falling half-way between the lines for Rules 1 and 2 (i.e. conforming roughly to Variation 2*c*), consists mainly of buildings in south Italy and mainland Greece built around 500 B.C. Thus groups of buildings based on conformity to the rules proposed here coincide to a great extent with groups based on the obvious criteria of place and time.

Finally we should perhaps consider the effect of these probable conclusions on ideas of Greek design procedure. If the rules suggested above were used, then the operations required to dimension the stylobate for a temple with a given number of columns, and to set out the foundations to carry it and the position of the columns on the stylobate, could all be done without any preliminary drawing, and without making any detailed decisions about the design of the upper part of the building. That, of course, does not prove that no detailed scale-drawing was done, but it is something of a hint. In any case, as far as the design of the krepis is concerned it was calculation rather than drawing that was required, and since the columns of a temple must inevitably occupy the stylobate that has been built for them, the intercolumniations will have to take up any irregularities that may have arisen, whether as a result of inaccurate measurement or of approximations in the course of calculation. Thus, even if the size of the stylobate has been calculated by Rule 3 from the intended intercolumniation, the calculation may produce a stylobate slightly different from that required, and the actual intercolumniation may not be precisely the same as the intended one. Factors of this sort probably explain the slight differences between front and flank intercolumniations in later temples.

It has been suggested several times above that the way in which the proposed rules (or indeed any others) worked in detail can only be seen by following through the calculations in feet. Various foot units have been proposed, largely for the sake of argument, but such equations can only be rigorously tested by a detailed examination of individual buildings. This, however, in its turn raises problems, since it is necessary to make some sort of assumption about the dimensions which are likely to have been planned in round numbers

65 This rule will give the correct angle contraction ($I - I_A = AW - T)/2$) when $S = \frac{3}{16}I + AW - T$; that is, if $AW = 2T$ and $T = I/7\frac{1}{2}$, then I must equal about $3\frac{1}{10}D$.

66 See p. 81 and n. 58 above.

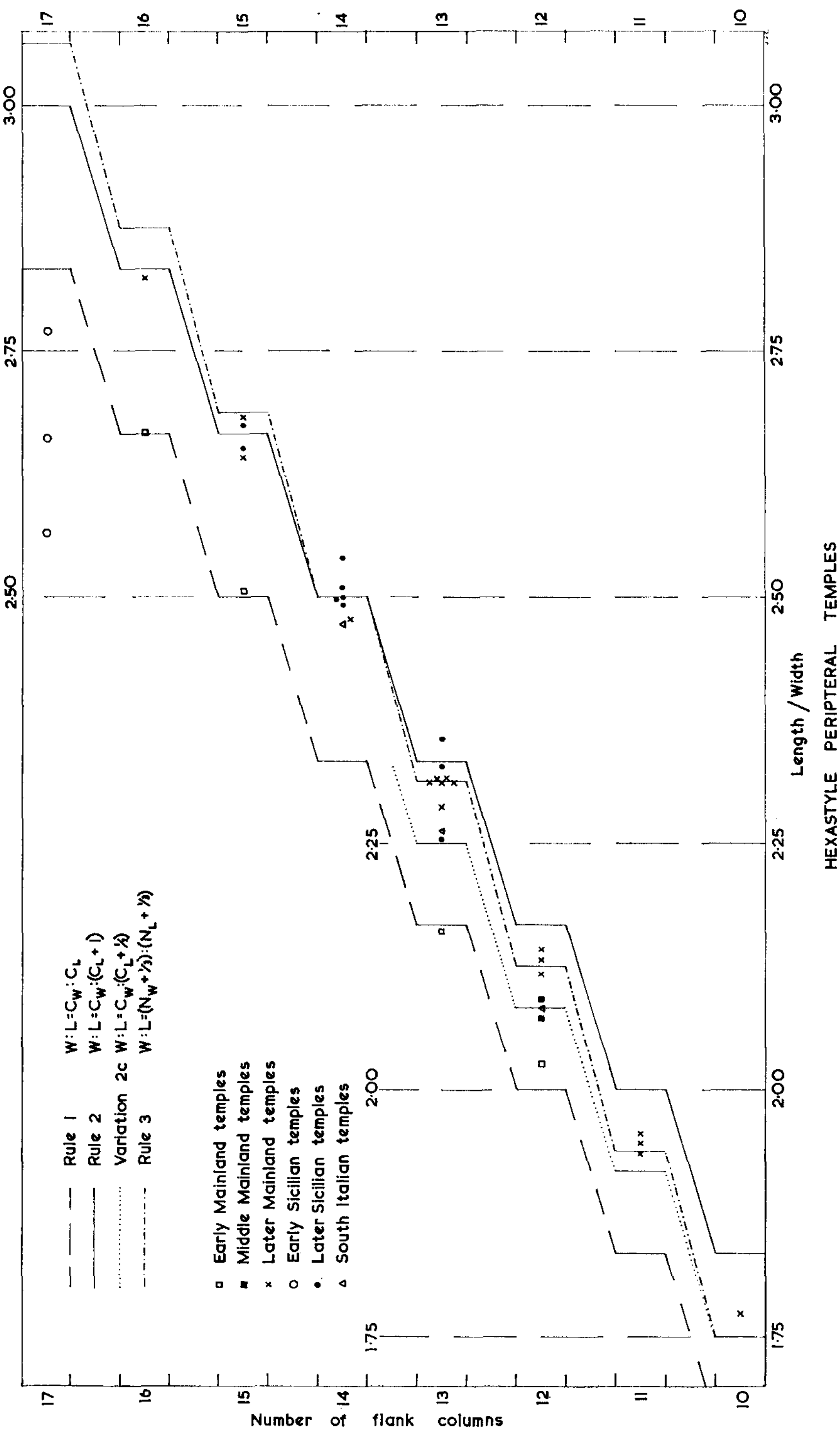

FIG. 3. STYLOBATE PROPORTIONS OF HEXASTYLE DORIC TEMPLES

of feet: for instance whether the intercolumniations or the stylobate length are likely to be more significant.[67]

The present study may help to resolve these problems to some extent. Where the stylobate length and width are directly related by Rule 1 or 2 one may reasonably expect both width and length to be expressible as a whole number of feet, although even here, as we have seen, Variation 2*c* will produce a stylobate width of $44\frac{1}{4}$ ft. from a stylobate length of 100 ft. In temples based on rules like these, particularly those without angle contraction, the architect will, however, have very little control over the size of the intercolumniations, and although they may sometimes be expressible as a whole number of feet, we must be prepared for them to require dactyls or even fractions of dactyls for accurate expression. On the other hand, where the stylobate size is derived from the intercolumniation by Rule 3 or one of its variants, we should expect the intercolumniation to be expressible as a whole number of feet or a simple fraction. The stylobate width and length may also be expressible as a whole number of feet, but they may very well not be. Thus we find that the Temple of Zeus at Olympia has an intercolumniation of 16 ft. and a stylobate width of 85 ft. The stylobate length of $196\frac{9}{16}$ ft. is at first sight peculiar, but in fact it is derived from the accurate application of a rule which appears to have had quite widespread use. Indeed it is precisely because the rule is applied accurately that the stylobate length is not a whole number of feet. For it is true to say that it is where, from the point of view of rules of proportion, there appears to be an anomalous situation, that the process of rounding off to a more convenient expression in feet is most likely to have taken place, and it is at such points that the search for the unit used by the architect can most confidently begin.

The difficulties in tracing in detail the way Greek architects worked should not, however, be allowed to obscure the fact that their methods of design appear to have been remarkably simple, and initially crude. It may be hard to accept that the architectural masterpieces of Periclean Athens were achieved by the application of rules of thumb; but it is at least as hard to imagine that the architect of the Temple of Hera at Olympia or the Temple of Artemis at Kerkyra sat down at his drawing-board with his T-square and his scale-ruler, and did accurate scale drawings of the plan, elevations, and sections before beginning to build. It is not just that the instruments would not be available. Such a man is unlikely to have been aware of the need for detailed planning or in possession of the intellectual concepts that would make it possible. If early temples could be built without preliminary drawing, there is no reason why the system should have been changed, for the basic temple type remains unchanged. Since by the Periclean period there would be at least a century and a half of experience in designing Doric temples without drawing, and a body of increasingly sophisticated rules for doing so, it is not so surprising that brilliant results could be achieved. Certainly the implications of the present study are that there was no major change in the *procedure* for designing a peripteral temple between the erection of the Temple of Hera at Olympia and the time of Vitruvius.

J. J. COULTON

[67] See, for example, the differences of opinion between the reviewer and authors in O. Broneer's review of B. H. Hill, C. K. Williams, *The Temple of Zeus at Nemea* (1966) in *AJA* lxxii (1968) 188–9.

TABLE 2

1 Name of Building	2 Rule for $W:L$	3 L by Rule 2 from W	4 3–L	5 Rule for $OW:OL$	6 OL by Rule 5 from OW	7 6–OL	8 Rule for $W:I_W$	9 I_W by Rule 8 from W	10 9–I_W	11 Rule for $L:I_L$	12 I_L by Rule 11 from L	13 12–I_L
Syracuse, T. of Apollo	7:18	55·466	+0·136	$(C_W+2):(C_L+2)$	58·093	−0·227						
Syracuse, Olympieion	$6\frac{1}{2}:18$	62·031	−0·019	$(C_W+1):(C_L+1)$	65·314	+0·264						
Selinous, Temple C	$6\frac{3}{4}:18$	63·832	+0·112	$(C_W+\frac{1}{2}):(C_L+\frac{1}{2})$	70·961	−0·189						
Selinous, Temple D	$C_W:(C_L+1)$	55·127	−0·552	$(C_W+1):(C_L+2)$	60·206	+0·327						
Selinous, Temple FS	$C_W:(C_L+1)$	60·925	−0·955	$C_W:C_L$	66·243	+0·343						
Selinous, Temple GT				$C_W:C_L$	113·284	−0·076						
Akragas, Olympieion				$C_W:C_L$	112·600	0·850						
Akragas, T. of 'Hercules'	$C_W:(C_L+1)$	67·424	+0·384									
Syracuse, T. of Athena	$C_W:(C_L+1)$	55·00	−0·02				$W = I_W\ (N_W+\frac{3}{10})$	4·151	+0·001			
Himera, T. of 'Victory'	$C_W:(C_L+1)$	56·138	+0·183	$C_W:C_L$	58·543	−0·067	$W = I_W(N_W+\frac{3}{8})$	4·178	+0·003			
Selinous, Temple ER	$C_W:(C_L+1)$	67·531	−0·204				$W = I_W(N_W+\frac{3}{8})$	4·711	−0·001	$L = I_L(N_L+\frac{3}{8})$	4·712	000
Selinous, Temple A	$C_W:(C_L+1)$	40·323	+0·020				$W = I_W(N_W+\frac{3}{8})$	3·001	+0·004			
Akragas, T. of 'Juno Lac.'	$C_W\ (C_L+\frac{1}{2})$	38·048	−0·052				$W = I_W(N_W+\frac{7}{16})$	3·110	−0·008	$L = I_L(N_L+\frac{7}{16})$	3·063	−0·001
Akragas, T. of 'Concord'	$C_W:(C_L+1)$	39·492	+0·072				$W = I_W(N_W+\frac{3}{10})$	3·193	−0·002	$L = I_L(N_L+\frac{3}{10})$	3·205	−0·001
Segesta, Temple	$C_W:(C_L+1)$	57·800	−0·235	$C_W:C_L$	61·273	+0·103	$W = I_W(N_W+\frac{1}{3})$	4·335	+0·001	$W = I_L(N_L+\frac{1}{3})$	4·353	−0·0065
Paestum, Basilica	$C_W:(C_L+2)$	54·467	+0·197									
Paestum, T. of 'Ceres'	$C_W:(C_L+\frac{1}{2})$	32·717	−0·163				$W = I_W(N_W+\frac{1}{2})$	2·644	+0·015	$L = I_W(N_L+\frac{1}{2})$	2·630	+0·005
Metapontion, 'Tavole Pal.'	$C_W:(C_L+\frac{1}{2})$	33·458	−0·002	$C_W:C_L$	34·8	+0·060						
Paestum, T. of Poseidon	$C_W:(C_L+1)$	60·660	+0·685									
Olympia, T. of Hera	$C_W:C_L$	50·00	−0·010	$(C_W+\frac{1}{2}):(C_L+\frac{1}{2})$	51·150	+0·040						
Corinth, T. of Apollo	$C_W:C_L$	53·710	−0·114				$W = I_W(N_W+\frac{1}{3})$	4·028	000	$L = I_L(N_L+\frac{1}{3})$	3·755	−0·003
Assos, T. of Athena	$C_W:C_L$	30·398	−0·088	$(C_W+\frac{1}{2}):(C_L+\frac{1}{2})$	30·842	+0·102						
Athens, T. of Peisistratids				$C_W:C_L$	43·700	−0·25	$W = I_W(N_W+\frac{1}{4})$	4·057	+0·015	$L = I_L(N_L+\frac{1}{4})$	3·836	+0·002
Delphi, Treas. of Athenians							$W = I_W\times N_W$	2·207	+0·032			
Delphi, T. of Athena Pronaia	$C_W:(C_L+\frac{1}{2})$	27·604	+0·140	$C_W:C_L$	28·50	+0·05	$W = I_W(N_W+\frac{1}{3})$	2·484	−0·001	$L = I_L(N_L+\frac{1}{3})$	2·423	+0·002
Aigina, T. of Aphaia	$C_W:(C_L+\frac{1}{2})$	28·688	−0·127				$W = I_W(N_W+\frac{1}{4})$	2·623	+0·005	$L = I_L(N_L+\frac{1}{4})$	2·561	+0·0005
Sounion, Old T. of Poseidon							$W = I_W(N_W+\frac{1}{3})$	2·449	000	$L = I_L(N_L+\frac{1}{3})$	2·449	000
Athens, Older Parthenon	$C_W:(C_L+1)$	66·677	−0·263	$C_W:C_L$	69·840	+0·224	$W = I_W(N_W+\frac{1}{3})$	4·412	−0·001	$L = I_L(N_L+\frac{1}{3})$	4·366	+0·007
Olympia, T. of Zeus							$W = I_W(N_W+\frac{1}{3})$	5·190	−0·0365	$L = I_L(N_L+\frac{1}{3})$	5·198	−0·023
Bassai, T. of Apollo	$(N_W+\frac{1}{2}):(N_L+\frac{1}{2})$	38·170	−0·074	$C_W:C_L$	39·600	+0·030	$W = I_W(N_W+\frac{1}{3})$	2·715	+0·001	$L = I_L(N_L+\frac{1}{3})$	2·668	−0·005
Argive Heraion, T. of Hera							$W = I_W(N_W+\frac{3}{10})$	3·265	−0·001	$L = I_L(N_L+\frac{3}{10})$	3·265	−0·001
Athens, T. of Hephaistos				$C_W:C_L$	33·410	−0·070	$W = I_W(N_W+\frac{3}{10})$	2·586	+0·003	$L = I_L(N_L+\frac{3}{10})$	2·583	+0·002
Sounion, T. of Poseidon				$C_W:C_L$	32·933	+0·133	$W = I_W(N_W+\frac{1}{3})$	2·526	+0·004	$L = I_L(N_L+\frac{1}{3})$	2·524	+0·002
Athens, T. of Ares				$C_W:C_L$	35·104	+0·072	$W = I_W(N_W+\frac{1}{3})$	2·690	000	$L = I_L(N_L+\frac{1}{3})$	2·690	000
Rhamnous, T. of Nemesis				$C_W:C_L$	23·160	+0·400	$W = I_W(N_W+\frac{1}{4})$	1·904	000	$L = I_L(N_L+\frac{1}{4})$	1·904	000
Athens, Parthenon	$C_W:(C_L+1)$	69·480	−0·023				$W = I_W(N_W+\frac{1}{8})$	4·289	−0·0075	$L = I_L(N_L+\frac{1}{8})$	4·290	−0·0015
Athens, Propylaia							$W = I_W(5\frac{1}{2}+\frac{1}{3})$	3·621	−0·007			
Delos, T. of Athenians				$C_W:10$	18·817	−0·003	$W = I_W(N_W+\frac{3}{10})$	1·828	−0·004	—	—	—
Epidauros, T. of Asklepios							$W = I_W(N_W+\frac{1}{3})$	2·256	−0·004	$L = I_L(N_L+\frac{1}{3})$	2·253	−0·007
Delphi, T. of Apollo	$(N_W+\frac{1}{3}):(N_L+\frac{1}{3})$	58·265	+0·085				$W = I_W(N_W+\frac{1}{4})$	4·130	−0·008	$L = I_L(N_L+\frac{1}{4})$	4·083	000
Tegea, T. of Athena				$C_W:C_L$	49·467	−0·093						
Nemea, T. of Zeus							$W = I_W(N_W+\frac{1}{3})$	3·767	+0·017	$L = I_L(N_L+\frac{1}{3})$	3·755	+0·009
Stratos, T. of Zeus							$W = I_W(N_W+\frac{1}{4})$	3·156	−0·014	$L = I_L(N_L+\frac{1}{4})$	3·163	−0·007
Olympia, Metroön				$C_W:C_L$	22·055	+0·175	$W = I_W(N_W+\frac{3}{10})$	2·004	−0·006	$L = I_L(N_L+\frac{3}{10})$	2·007	−0·003
Athens, Nikias Monument							$W = I_W(N_W+\frac{3}{10})$	2·093	−0·001			
Delos, Great Temple				$C_W:C_L$	29·727	−0·053						
Pergamon, T. of Athena				$(N_W+\frac{1}{2}):(N_L+\frac{1}{2})$	22·445	−0·090	$W = I_W(N_W+\frac{3}{16})$	2·365	−0·002	$L = I_L(N_L+\frac{3}{16})$	2·370	−0·001
Pergamon, T. on Market							$W = I_W(N_W+\frac{1}{3})$	2·029	+0·007			
Eleusis, T. of Artemis							$W = I_W(N_W+\frac{1}{4})$	1·981	+0·005			

14 W by Rule 8 from I	15 14–W	16 L by Rule 11 from I	17 16–L	18 Rule for $L:I_W$	19 L by Rule 18 from I_W	20 19–L	21 Rule for $OW:I_W$	22 OW by Rule 21 from I_W	23 22–OW	24 Name of Building
										Syracuse, T. of Apollo
										Syracuse, Olympieion
										Selinous, Temple C
										Selinous, Temple D
										Selinous, Temple FS
										Selinous, Temple GT
							$OW = I_W\times C_W$	56·294	−0·006	Akragas, Olympieion
										Akragas, T. of 'Hercules'
										Syracuse, T. of Athena
							$OW = I_W\times C_W$	25·050	−0·040	Himera, T. of 'Victory'
										Selinous, Temple ER
							$OW = I_W\times C_W$	17·982	+0·067	Selinous, Temple A
										Akragas, T. of 'Juno Lac.'
										Akragas, T. of 'Concord'
							$OW = I_W\times C_W$	26·004	−0·256	Segesta, Temple
							$OW = I_W\times C_W$	25·839	−0·161	Paestum, Basilica
14·460	−0·081	32·863	−0·017							Paestum, T. of 'Ceres'
										Metapontion, 'Tavole Pal.'
										Paestum, T. of Poseidon
										Olympia, T. of Hera
										Corinth, T. of Apollo
										Assos, T. of Athena
										Athens, T. of Peisistratids
										Delphi, Treas. of Athenians
				$L = N_L\times I_W$	27·335	−0·129				Delphi, T. of Athena Pronaia
				$L = N_L\times I_W$	28·798	−0·017				Aigina, T. of Aphaia
13·061	+0·001	30·204	+0·004							Sounion, Old T. of Poseidon
										Athens, Older Parthenon
27·839	+0·159	64·379	+0·259				$OW = I_W(N_W+\frac{3}{4})$	30·052	−0·148	Olympia, T. of Zeus
				$L = N_L\times I_W$	37·996	−0·248				Bassai, T. of Apollo
17·310	+0·005	36·906	+0·006							Argive Heraion, T. of Hera
13·685	−0·023	31·759	−0·010				$OW = I_W\times C_W$	15·498	+0·078	Athens, T. of Hephaistos
13·451	−0·019	31·105	−0·019				$OW = I_W\times C_W$	15·132	−0·068	Sounion, T. of Poseidon
14·346	+0·002	33·177	+0·003				$OW = I_W\times C_W$	16·140	−0·062	Athens, T. of Ares
9·996	000	21·420	000				$OW=I_W\times C_W$	11·424	−0·156	Rhamnous, T. of Nemesis
30·899	+0·019	69·522	+0·019							Athens, Parthenon
21·163	+0·038									Athens, Propylaia
9·710	+0·024	—	—	$L = 9\frac{3}{10}\times I_W$	17·038	+0·024				Delos, T. of Athenians
12·053	+0·023	23·350	+0·070							Epidauros, T. of Asklepios
										Delphi, T. of Apollo
										Tegea, T. of Athena
20·000	−0·090	42·50	−0·055							Nemea, T. of Zeus
16·643	+0·073	32·493	+0·073							Stratos, T. of Zeus
10·653	+0·033	20·703	+0·033				$OW = I_W\times C_W$	12·060	+0·030	Olympia, Metroön
11·098	+0·003			$L = 7\frac{3}{10}\times I_W$	15·286	+0·066				Athens, Nikias Monument
							$OW = I_W\times C_W$	13·743	+0·023	Delos, Great Temple
12·284	+0·014	21·756	−0·014				$OW = I_W(N_W+\frac{1}{2})$	13·018	−0·002	Pergamon, T. of Athena
6·739	−0·026			$L = 5I_W$	10·110	−0·025				Pergamon, T. on Market
6·422	−0·018			$L = 6\frac{1}{4}I_W$	12·350	+0·020				Eleusis, T. of Artemis

TABLE 3

1 Name of Building	2 $I_W - I_L$	3 I_W/I_L	4 $\frac{D_W}{I_W-I_L}$	5 $\frac{T_W}{I_W/I_L}$	6 Total contraction on fronts	7 Total contraction on flanks	8 $\frac{AW-T}{2}$	9 $\frac{T_W}{2}$	10 6–8
Syracuse, T. of Apollo	0·441	1·1324	4·558	?	—	—	?	?	?
Syracuse, Olympieion	0·327	1·0871	?	?	—	—	?	?	?
Selinous, Temple C	0·539	1·1396	3·544	varies	—	—	0·17	0·435–0·54	—c. 0·17
Selinous, Temple D	−0·123	0·9726	13·829	8·537	—	—	0·033	0·525	−0·033
Selinous, Temple FS	−0·136	0·9705	13·162	7·574	—	—	0·15	0·515	−0·15
Selinous, Temple GT	−0·080	0·9879	40·750	16·75	0·32(W)	0·04 (NW) (SW)	0·465	0·670	−0·145
Akragas, Olympieion	−0·143	0·9825	28·322	12·517	—	0·400	0·765	0·895	−0·765
Akragas, T. of 'Hercules'	000	1·0000	—	—	0·113	—	0·38	0·445	−0·267
Syracuse, T. of Athena	−0·015	0·9964	128·0	56·0	0·35	0·535	0·49	0·42	−0·140
Himera, T. of 'Victory'	−0·023	0·9945	81·522	36·61	0·243	0·342	?	0·421	?
Selinous, Temple ER	000	1·000	—	—	0·307	0·307	0·452	0·475	−0·145
Selinous, Temple A	−0·0005	0·9998	2640·0	1280·0	0·19	0·0945	0·242	0·32	−0·052
Akragas, T. of 'Juno Lac.'	0·054	1·0176	25·685	11·389	0·085	0·079	0·34	0·307	−0·307
Akragas, T. of 'Concord'	−0·011	0·9966	132·0	58·182	0·285	0·286	0·32	0·32	−0·035
Segesta, Temple	−0·0255	0·9942	78·235	33·333	0·325	0·394	0·445	0·425	−0·120
Paestum, Basilica	−0·231	0·9255	6·242	?	—	—	?	?	?
Paestum, T. of 'Ceres'	0·004	1·0015	316·75	137·5	—	—	0·223	0·275	−0·223
Metapontion, 'Tavole Pal.'	0·031	1·0104	34·194	21·630	—	—	?	?	?
Paestum, T. of Poseidon	−0·032	0·9929	66·00	28·125	0·176	0·421	0·321	0·45	0·145
Olympia, T. of Hera	0·30	1·0920	varies	?	0·235	0·14	?	?	?
Corinth, T. of Apollo	0·284	1·0759	6·141	2·923	0·27	0·238	0·41	0·415	−0·14
Assos, T. of Athena	0·160	1·0653	5·719	3·50	—	—	0·135	0·28	−0·135
Athens, T. of Peisistratids	0·208	1·0543	7·837	3·952	0·31	0·367	0·239	0·411	−0·071
Delphi, Treas. of Athenians	—	—	—	—	—	—	0·162	0·208	—
Delphi, T. of Athena Pronaia	0·064	1·0264	15·703	7·984	0·16	0·136	0·229	0·255	−0·069
Aigina, T. of Aphaia	0·0575	1·0225	17·200	8·783	0·218	0·2335	0·232	0·252	−0·014
Sounion, Old T. of Poseidon	000	1·000	—	—	0·143	0·143	?	?	?
Athens, Older Parthenon	0·054	1·0124	35·241	?	0·338	0·2945	?	?	?
Olympia, T. of Zeus	0·0055	1·0011	409·09	192·73	0·4335	0·473	0·47	0·53	−0·0365
Bassai, T. of Apollo	0·041	1·0153	28·317	13·07	0·208(N) 0·188(S)	0·241	0·221	0·268	−0·013
Argive Heraion, T. of Hera	000	1·000	—	—	0·225	0·225	?	0·325	?
Athens, T. of Hephaistos	0·002	1·0008	509·0	257·5	0·170	0·168	0·242	0·257	−0·072
Sounion, T. of Poseidon	000	1·000	—	—	0·148	0·148	0·22	0·255	−0·072
Athens, T. of Ares	000	1·000	—	—	c. 0·16	c. 0·16	?	0·277	?
Rhamnous, T. of Nemesis	000	1·000	—	—	c. 0·174	c. 0·174	0·148	0·188	−0·046
Athens, Parthenon	0·005	1·0012	381·0	168·0	0·6150	0·6025	0·469	0·420	+0·146
Athens, Propylaia	—	—	—	—	0·246	—	0·368	0·354	−0·122
Delos, T. of Athenians	—	—	—	—	0·185	—	?	0·185	?
Epidauros, T. of Asklepios	000	1·0000	—	—	0·26	0·26	?·208	0·220	+0·052
Delphi, T. of Apollo	0·055	1·0135	32·83	14·91	0·43	0·416	0·41	0·41	+0·020
Tegea, T. of Athena	0·028	1·0078	55·36	25·36	0·271	0·36	0·363	0·355	−0·084
Nemea, T. of Zeus	0·004	1·0011	407·5	132·5	0·297	0·294	0·395	0·355	−0·098
Stratos, T. of Zeus	000	1·000	—	—	0·335	0·335	0·337	0·312	−0·002
Olympia, Metroön	000	1·000	—	—	0·29	0·29	?	0·202	?
Athens, Nikias Monument	—	—	—	—	0·15	0·15	0·176	0·211	−0·026
Delos, Great Temple	000	1·000	188·5	78·0	—	—	0·225	0·24	−0·225
Pergamon, T. of Athena	−0·004	0·9983	188·5	78·0	0·192	0·196	0·184	0·156	+0·008
Pergamon, T. on Market	—	—	—	—	0·131	—	0·106	0·161	+0·025
Eleusis, T. of Artemis	—	—	—	—	0·196	—	0·197	0·193	−0·001

24 Name of Building	11 Size of proposed foot	12 W in feet	13 $(11\times12)-W$	14 L in feet	15 $(11\times14)-L$	16 I in feet	17 $(11\times16)-I$	18 D in feet	19 $(11\times18)-D$	20 H in feet	21 $(11\times20)-H$	22 T in feet	23 $(11\times22)-T$
Syracuse, T. of Apollo													
Syracuse, Olympieion													
Selinous, Temple C													
Selinous, Temple D	0·327781	72	−0·026	170	0·044	I_W13 5/16	−0·004	5 3/16	−0·001	25 5/16	−0·013	3 1/4	+0·015
Selinous, Temple FS	0·325438	75	+0·038	190	−0·047	I_W13 3/4	+0·007	5 1/2	000	28	+0·002	3 3/8	−0·013
Selinous, Temple GT													
Akragas, Olympieion	0·326006	(OW) 173	+0·099	(OL) 348	000	I_L 25	−0·035	12 7/16	+0·005	53	+0·013	5 1/8	+0·003
Akragas, T. of 'Hercules'													
Syracuse, T. of Athena													
Himera, T. of 'Victory'	0·329128	68 1/4	+0·008	170	−0·003	I_L12 3/4	−0·002	5 11/16	−0·003			2 9/16	+0·001
Selinous, Temple ER													
Selinous, Temple A													
Akragas, T. of 'Juno Lac.'													
Akragas, T. of 'Concord'													
Segesta, Temple													
Paestum, Basilica	0·326846	75	+0·003	166	−0·014	I_W8 3/4 I_L9 1/2	−0·011 +0·003	4 7/16	+0·008	19 3/4	+0·010		
Paestum, T. of 'Ceres'	0·328721	44 1/4	+0·005	100	−0·008	8	+0·001	3 7/8	+0·007	18 5/8	−0·005	1 11/16	+0·005
Metapontion, 'Tavole Pal.'													
Paestum, T. of Poseidon	0·327697	74	−0·014	183	−0·006	I_L13 3/4	+0·003	D_W6 1/2	+0·019	27 1/8	+0·009	2 3/4	+0·001
Olympia, T. of Hera													
Corinth, T. of Apollo													
Assos, T. of Athena													
Athens, T. of Peisistratids													
Delphi, Treas. of Athenians													
Delphi, T. of Athena Pronaia	0·331069	40	−0·007	83	+0·015	I_W7 1/2	−0·002	3	−0·002	14	+0·035	1 9/16	+0·002
Aigina, T. of Aphaia	0·327751	42	−0·004	88	+0·027	8	+0·004	3	−0·006	16	−0·028	1 9/16	+0·007
Sounion, Old T. of Poseidon	0·326497	40	000	92 1/2	+0·001	7 1/2	000	3	−0·001				
Athens, Older Parthenon													
Olympia, T. of Zeus	0·326048	85	+0·034	196 9/16	−0·031	I_L16	−0·004	6 7/8 6 3/4	−0·008 −0·009	32	+0·004	3 1/4	−0·000
Bassai, T. of Apollo													
Argive Heraion, T. of Hera													
Athens, T. of Hephaistos	0·328000	41 13/16 (OW)47	+0·006 −0·004	96 7/8 (OL)102	+0·006 −0·024	7 7/8	000			17 1/2	+0·027	1 9/16	−0·002
Sounion, T. of Poseidon	0·325918	41 5/16 (OW)46 1/2	−0·006 −0·045	95 1/2 (OL)100 3/4	+0·001 +0·036	7 3/4	+0·004			18 1/2	+0·005	1 9/16	−0·001
Athens, T. of Ares													
Rhamnous, T. of Nemesis													
Athens, Parthenon													
Athens, Propylaia													
Delos, T. of Athenians													
Epidauros, T. of Asklepios													
Delphi, T. of Apollo													
Tegea, T. of Athena													
Nemea, T. of Zeus													
Stratos, T. of Zeus													
Olympia, Metroön													
Athens, Nikias Monument													
Delos, Great Temple													
Pergamon, T. of Athena													
Pergamon, T. on Market													
Eleusis, T. of Artemis													