Proceedings of the Danish Institute at Athens · II

Edited by Søren Dietz & Signe Isager

Aarhus Universitetsforlag
Langelandsgade 177
8200 Århus N

The publication was sponsored by:
The Danish Research Council for the Humanities.
Consul General Gösta Enbom's Foundation.
Konsul Georg Jorck og hustru Emma Jorck's Fond.

Proceedings of the Danish Institute at Athens

General Editor: *Søren Dietz* and *Signe Isager*
Graphic design and Production by: *Freddy Pedersen*

Printed in Denmark on permanent paper

ISBN 87 7288 722 2

Distributed by:
AARHUS UNIVERSITY PRESS
University of Aarhus
DK-8000 Århus C
Fax (+45) 8619 8433

73 Lime Walk
Headington, Oxford OX3 7AD
Fax (+44) 865 750 079

Box 511
Oakvill, Conn. 06779
Fax (+1) 203 945 94 9468

The drawing reproduced as cover illustration represents Kristian Jeppesen's proposal for the restoration of the Maussolleion, in particular of the colonnade (PTERON) in which portrait statues of members of the Hecatomnid dynasty said to have been carved by the famous artists Scopas, Bryaxis, Timotheos, and Leochares were exhibited. Drawing by the author, see p. 173, Abb. 5, C.

The Column Shafts of the Propylaia and Stoa in the Sanctuary of Athena at Lindos

Jari Pakkanen

Abstract

In this study it is demonstrated that the column shaft of the late third century BC Stoa in the sanctuary of Athena Lindia had a slight entasis. The mid third century BC Propylaia probably had higher columns than E. Dyggve has suggested; the height of the larger façade order is most likely ca. 4.9 m and the smaller courtyard order ca. 4.6 m, both ca. 0.3 m higher than Dyggve's suggestions. The study is based on the published measurements of the preserved column drums and the results are achieved by applying a method which combines computerised analysis with statistics. The new Propylaia column height is also supported by proportional comparison. The appendix of comparative material at the end of the paper presents previously unpublished dimensions on entasis in Hellenistic Doric buildings: in general the entasis proportions in Late Classical and Hellenistic buildings seem quite similar.

The Danish excavations in the sanctuary of Athena on the acropolis of Lindos in 1902-1905 were directed by Chr. Blinkenberg and K.-F. Kinch; their work was partially published in the first two volumes of *Lindos fouilles et recherches*.[1] E. Dyggve's publication of the architectural remains in the third volume of *Lindos* is based on the excavation notebooks and drawings of the Danish expedition as well as Dyggve's own fieldwork at the site in 1952,[2] by which time the appearance of the sanctuary had been radically changed by the Italian reconstruction work done in 1938-1940.[3]

The Hellenistic Buildings in the Sanctuary

The small amphiprostyle temple of Athena Lindia on top of the acropolis, built in the very beginning of the third century BC (building no. 1 in fig. 1), during the following hundred years was given an imposing entrance.[4] The building material used in the temple and the other Hellenistic buildings in the sanctuary is poros limestone coated with a layer of stucco.[5]
The Propylaia were built in the middle of the third century, probably in the second quarter (no. 2 in fig. 1).[6] The building is often called the 'upper stoa' because the core of the building is a wide Doric colonnade with projecting wings. A wide stairway leads up to the Propylaia and the courtyard is entered through gateways, probably five in number, in the wall behind the front colonnade. The temple court is surrounded by Doric colonnades on three sides, and the order is slightly smaller than the one used on the front exterior colonnade. The temple is at the back corner of the small court and it is not axially placed with respect to the Propylaia.[7]
At the end of the third century the Stoa was built below the Propylaia,[8] largely on an artificial terrace (no. 3 in fig. 1). It fairly closely repeats the plan of the Propylaia front colonnade, but at a larger scale and with wings projecting further. The architect found an ingenious solution to the problem of giving access to the stairs leading toward the temple without sacrificing the uniformity of the façade: the colonnade is extended across the entire façade, even in front of the stairs where it has no functional purpose.[9] Unlike the Propylaia columns, the bottom of the shaft is un-

NOTE 1
Blinkenberg 1931 and 1941.

NOTE 2
For an outline of the research done at Lindos until 1952, see Dyggve 1960, 13-28.

NOTE 3
Laurenzi 1938a and 1938b; Papadimitriou 1988.

NOTE 4
For a recent and very thorough study of the sanctuary, see Lippolis 1988-89; for the date of the temple, see *ibid.*, 127-133 and in general on the temple, see Dyggve 1960, 81-154.

NOTE 5
Dyggve 1960, 39-41, 94f. and 116.

NOTE 6
Lippolis 1988-89, 139f.

NOTE 7
On the building, see Dyggve 1960, 155-216.

NOTE 8
On the date, see Dyggve 1960, 247-253 and Lippolis 1988-89, 140-143.

NOTE 9
On the Stoa, see Dyggve 1960, 217-289. For an analysis of the architectural features of the Propylaia and Stoa, see also Coulton 1976, 61.

Fig. 1. View of the Lindos acropolis model from the north-east. The numbered buildings are the temple of Athena Lindia (1), the Propylaia (2), and the Stoa (3). National Museum, Copenhagen.

fluted for one third of the total column height.[10] This is a common practise in Hellenistic stoas, possibly spread into wider use by the third century BC Pergamene architects.[11]

The Column Drums at Lindos

E. Dyggve published a table of 109 column drums of poros stone discovered at the site during the excavations; he collected the data from H. Rasmussen's sketches with measurements and the additional notes that Kinch had occasionally written on them.[12] Since Dyggve gives also the sector where the drums were discovered,[13] it is possible to plot this information on a map: figure 2 presents the block codes imposed on a site plan.[14] The Stoa drums are printed with bold typeface and with prefix S, the drums from the Propylaia façade with italics and prefix P, and the drums whose provenience is unknown with normal typeface.

Dyggve's table is by no means complete: for example, L. Laurenzi gives in his article on the reconstruction work at Lindos the number of preserved Stoa bottom drums as 13 (Dyggve has only 3), second drums as 11 (Dyggve: 8), and third drums as 13 (Dyggve: 11).[15] Especially, all the seven Stoa bottom drums discovered *in situ* are omitted.[16] Likewise, it is very probable that

NOTE 10
In research literature the reason usually given for leaving the bottom of the shaft unfluted was to prevent the sharp arrises from breaking (see e.g. Dyggve 1960, 252 n. 103, Williams 1974, 406 and Coulton 1976, 112). Recently, D. Wannagat has demonstrated that the original function of this convention was to emphasise the connection of the half-columns with the wall: the height of the unfluted portion is equal to the height of the lower part of the wall. Especially, leaving the columns of stoas partially unfluted gives additional emphasis to the horizontality of the building (D. Wannagat 1995, 110-116, 127-129).

NOTE 11
Coulton 1976, 112. In general, the earliest known cases of partially unfluted columns in the Greek architecture are dated to ca. 300 BC. Due to wide geographical range of the phenomenon and to uncertainty in dating, the birthplace of the invention cannot be precisely defined; Wannagat 1995, 95.

NOTE 12
Dyggve 1960, 97-101.

NOTE 13
In figure 2 the excavations site is divided into a grid where each square is 10 × 10 m: in Dyggve's table the drum locations refer to these squares.

NOTE 14
The site plan was drawn by H. Rasmussen in 1905 (Dyggve 1960, pl. II A).

NOTE 15
Laurenzi 1938a, 18.

NOTE 16
The find spots of the three bottom drums in Dyggve's list are printed with a prefix S1 in fig. 2: none of them are *in situ*. On the bottom drums *in situ*, see Dyggve 1960, 219-223, pl. VI A.

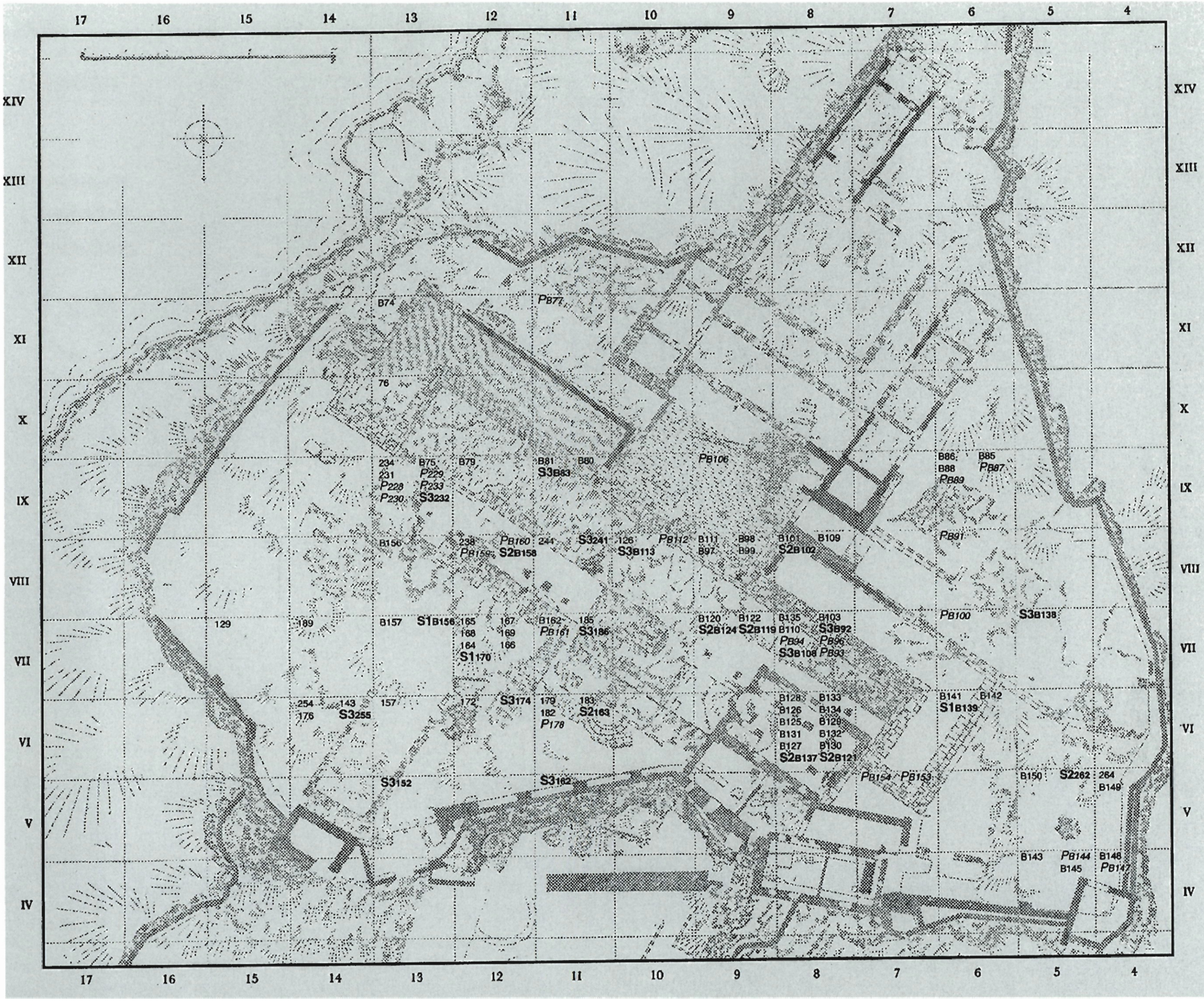

Fig. 2. The find-spots of the column drums. The **Stoa** drums are printed with **bold typeface** and with prefix **S**, the drums from the *Propylaia* façade with *italics* and prefix *P*, and the drums whose provenance is unknown with normal typeface (J. P., on a site plan by H. Rasmussen, 1905 published in Dyggve 1960, pl. II A).

the temple drums are missing. L. Laurenzi gives the position of the drum within the shaft and the block height for 14 original drums reused in the reconstruction,[17] and for only one of them it is possible to find a tentative match in Dyggve's table.[18] This observation is also verified by the distribution of the drums in figure 2: none of the listed drums was found near the temple. Even though Dyggve is sceptical about their reliability,[19] I believe that more information can be derived from the drum data by taking into consideration the additional data in L. Laurenzi's articles and by ap-

NOTE 17
Laurenzi 1938b, 29.

NOTE 18
It is possible to calculate approximate diameters for Laurenzi's drums based on their position in the shaft and then try to match the blocks with Dyggve's data. The single possible match is the eighth (top) drum of the second column with the height of 0.645 m (Laurenzi 1938b, 29): it could be drum B132 (Dyggve 1960, 99).

NOTE 19
"Les mesures prises de ces fûts, mis à part les dessins spéciaux de reconstruction, sont si sommaires qu'elles ne permettent pas de prononcer dans les détails, ni sur la disposition de ces fûts dans les divers bâtiments, ni sur les particularités éventuelles quant à leur forme. Les gros fûts à facettes proviennent de la grande Stoa, cela démontrable, mais à cette exception près, seul le diamètre des fûts peut nous guider dans une tentative de localisation." Dyggve 1960, 97. He is also very careful in drawing his conclusions; see *ibid.*, 97, 102, 160, 165 and 226f.

plying a method which combines computerised analysis with statistics. The diameter measurements reported by Dyggve are taken at the arrises, and these are indeed quite unreliable: taking accurate measurements of the weathered and broken poros blocks at this position is impossible. Unfortunately, the usually more accurate diameters measured between the recesses of two opposite flutes are not given, and therefore, the normal method of trying to match column drums according to their diameter measurements cannot be used in this case.[20] In one respect there is no reason to doubt the accuracy of the drum data, namely the height measurements: even if the bottom and top surfaces of the drums are partially broken, it is quite easy to get accurate results. Hence, I will use the drum height measurements extensively throughout this study.

The Stoa Columns

The Stoa is the best preserved of the three Hellenistic structures, and this is why I will first concentrate on that building, even though it is the latest. The excavators discovered large parts of the foundations preserved, in some places up to the stylobate level. The combined height of the columns and the entablature is known because in the south-east corner of the north-west wing the back wall retains its full height. Seven bottom drums of the colonnade were found *in situ* and enough of the other architectural elements remain for a reliable reconstruction.[21] Nevertheless, the column shaft profile has not been discussed in the previous studies on this building.

Figure 3 shows P. Baumann's reconstruction of the middle of the Stoa colonnade where it passes in front of the steps.[22] The two lowest drums and part of the third drum of the column are not fluted but faceted: the plan of these drums is a 20-sided polygon. The height of the unfluted part is 1.68 m and the total height of the column shaft ca. 4.66 m.[23] The column shaft consists of seven drums of approximately equal height. Baumann's drawing also carefully shows that the column had a slight entasis, even though this is not discussed by Dyggve.

In his publication on the reconstruction of the Stoa L. Laurenzi lists the diameters of the each class of drums at the site and

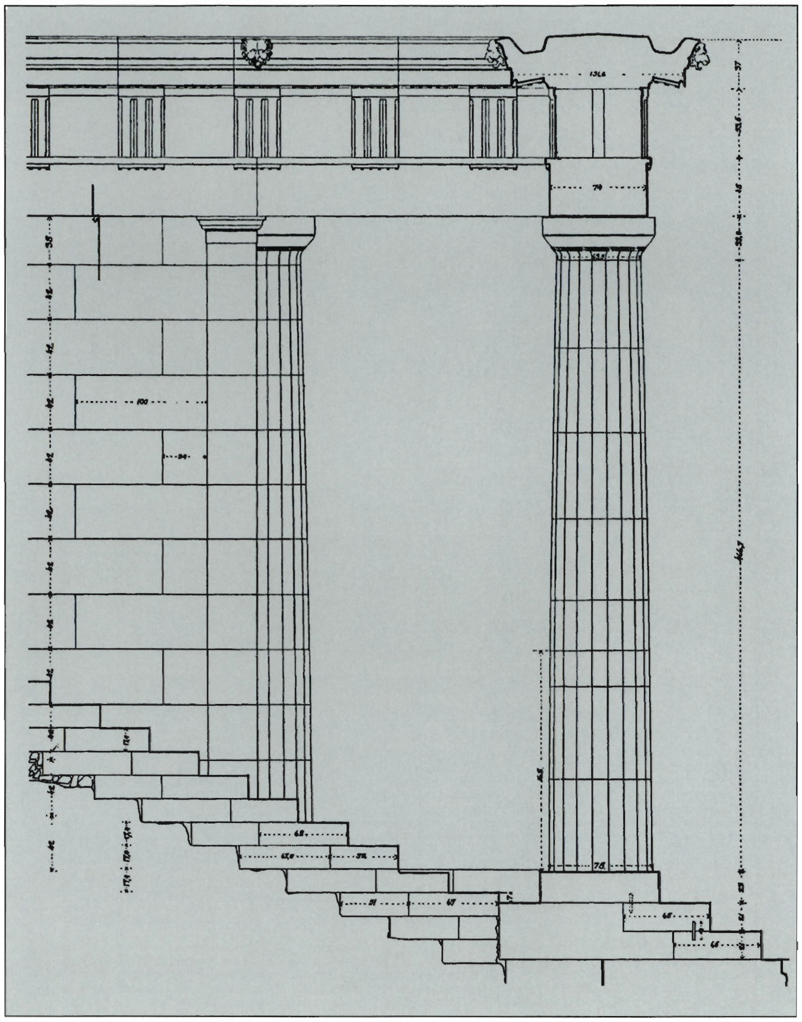

Fig. 3. Reconstruction of the section of the middle of the Stoa by P. Baumann (Dyggve 1960, pl. VI L).

NOTE 20
My interest in Lindos was partially aroused by the possibility to test with different material the computer programs I have developed in connection with my study on the late Classical temple of Athena Alea at Tegea; for the programs used in the analysis of shaft profiles, see Pakkanen 1996.

NOTE 21
See Dyggve 1960, 217-289.

NOTE 22
Dyggve 1960, pl.VI L.

NOTE 23
In Baumann's reconstruction the height is 4.667 m, but Dyggve 1960, 232 gives the height as 4.66 m.

NOTE 24
Laurenzi 1938a, 18.

NOTE 25
Dyggve 1960, 98-101. Block B145, "peut-être facetté", is not included within these 23 drums.

NOTE 26
Drums B156 and B139. The bottom drums are printed with bold typeface and have a prefix S1 before the drum code in fig. 2.

gives their quantity: for example, 13 of the lowest drums are preserved and their average lower diameter is 0.770 m and upper diameter 0.755 m. Unfortunately, he does not give any indication of their height,[24] but it is possible to look for clues on the average height of the different classes of drums in Dyggve's data.

In Dyggve's catalogue there are 23 faceted or partially faceted drums all of which can with certainty be attributed to the Stoa.[25] He gives the height of 16 of them: two of these are bottom drums,[26] six second,[27] and eight partially faceted third drums.[28] The average height of these preserved drums is 0.680 m.[29] Since the shaft height 4.66 m is certain – being derived from the preserved wall height – the average height of the seven drums can be calculated as 0.666 m. Even though the difference between these two figures is small, it is statistically significant.[30] Using the average height of the three lowest drums, the corresponding figure for the top four fully fluted drums can be calculated as 0.655 m.[31] This is actually very close to the mean height of the smaller drums, 0.653 m.[32] However, drawing conclusions from this fact is not easy: these fluted drums could equally likely be from the Propylaia front colonnade or the courtyard order as from the Stoa. I will return to this matter in the next section on the Propylaia columns.

In figure 4, a drawing of the Stoa shaft profile, I have combined L. Laurenzi's diameter data with the above calculated drum heights. In order to make it easier to observe the features of the profile the scale for x axis is ten times greater than for y axis. The dashed line is a straight line connecting the bottom and top points of the shaft; in figures 4 and 5 it serves as a reference to visually judge the shaft profile. Laurenzi's actual data are plotted as small circles. The resulting drawn profile is not very convincing: for the height of the two first drums it starts as a regular shaft curve with a slight entasis, but it very soon almost converges with the straight dashed line. The most likely explanation for this phenomenon is that the lower faceted

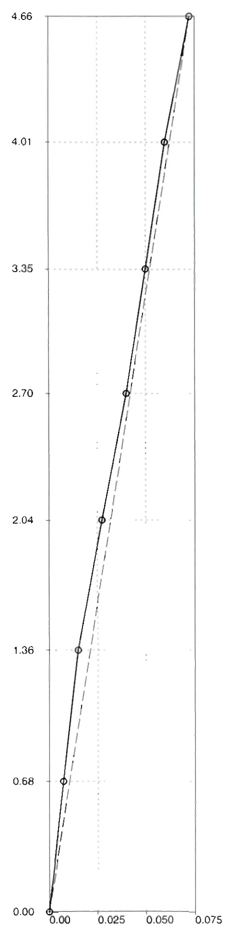

Fig. 4. Stoa column shaft profile according to L. Laurenzi (J. P.).

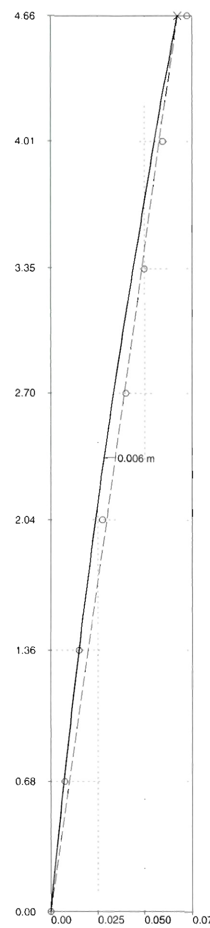

Fig. 5. Corrected stoa column shaft profile (solid line). Small circles represent L. Laurenzi's and the x E. Dyggve's data (J. P.).

NOTE 27
Drums B137, B158, 262, 163, B119, and B121. The second drums are printed with bold typeface and have a prefix S2 before the drum code in fig. 2.

NOTE 28
Drums B92, B138, 255, 162, 174, B113, B108, and 241. The third drums are printed with bold typeface and have a prefix S3 before the drum code in fig. 2.

NOTE 29
The range of heights is 0.659-0.728 m.

NOTE 30
The sample mean of the 16 preserved drums ($\bar{X}$) is 0.680 m, the 95% confidence interval t-value corresponding to 15 degrees of freedom (t_{n-1}) 2.131, the sample standard deviation (S) 0.0158, and the sample size (n) 16. Substituting these into the formula $\bar{X}\pm(t_{n-1})\,S/\sqrt{n}$, we get the following 95% confidence interval: 0.672-0.688 m. In other words we can be 95% sure that the mean drum height of the three lowest drums is between 0.672 and 0.688 m, and therefore significantly higher than the average drum height of 0.666 m calculated from the shaft height (on confidence intervals, see e.g. Siegel & Morgan 1996, 321-330).

NOTE 31
(4.66 m - 3 × 0.680 m) / 4 = 0.655 m.

NOTE 32
The average height is calculated on the basis of the 49 fluted drums which have an upper diameter of 0.70 m or less in Dyggve's table. The height range is large, 0.54-0.806 m, but the extremely short and tall drums are very infrequent.

drums are better preserved and easier to measure than the upper fluted drums. The corners of a 20-sided polygon do not break as easily as the sharp Doric arrises and even if the corner is broken, it is easier to extrapolate its position from the straight sides of the polygon than the position of the arris from the curving flutes.[33] The error in Laurenzi's drum diameters for the top five data points seems fairly consistent.[34]

In figure 5 the error is corrected by taking as points of departure Laurenzi's diameters of the faceted drums,[35] Dyggve's diameter of the top of the shaft measured from the preserved Stoa capitals[36] and the fact that in Late Classical and Hellenistic Doric buildings it is customary to place the point of maximum entasis approximately in the middle of the column shaft.[37] In figure 5 the plotted third degree curve passes through the co-ordinates determined by the bottom drums, reaches its maximum projection from the straight line at the middle of the shaft and at the top converges with the straight dotted line.[38] The entasis continues also through the unfluted section of the shaft.[39] The proportional emphasis of the maximum entasis (the maximum entasis divided by the shaft height) of this curve is 0.13%[40] which fits well to the architectural comparanda.[41]

The Propylaia Columns

The Propylaia are the worst preserved of the three Hellenistic buildings on the acropolis, and this is also the probable reason why E. Dyggve's information on the Propylaia columns is imprecise and not thoroughly argued. For example, he gives two different figures for the upper diameter of the façade shaft, 0.625 and 0.61m.[42] The height of the columns and the lower diameters of both the façade and the smaller courtyard orders are calculated, but Dyggve gives neither the formulas used in the calculations nor the reasoning behind them.[43]

Again, the upper diameter of the shaft is known on the basis of the preserved capitals: H. Rasmussen gives the diameter for three capitals in his sketches as 0.63, 0.61, and 0.623 m; in P. Baumann's reconstruction drawing the diameter is 0.625 m.[44] On the basis of this information I would accept this last figure as at least fairly accurate for the upper diameter of the Propylaia large order shaft. Baumann reconstructs the diameter of the small order capital as 0.56 m.[45] The large order

NOTE 33
An alternative explanation for the appearance of Laurenzi's shaft profile is that the measurements are taken between the centers of the facets of the unfluted drums and between insides of the flutes of the fluted ones. However, this is not likely: the taper of the partially faceted third drum should in this case be much stronger than the 25 mm reported by Laurenzi.

NOTE 34
Comparing Laurenzi's data points with the curve in fig. 5 we get an error of ca. 5 mm; therefore, Laurenzi's drum diameters are ca. 10 mm too small.

NOTE 35
Laurenzi 1938a, 18 gives as the diameters of the bottom drum 0.770 and 0.755 m and the second drum 0.755 and 0.740 m. In Dyggve 1960, 101 the corresponding measurements for the bottom drum are 0.776-0.784 m and 0.76-0.761 m and the second 0.732-0.765 m and 0.722-0.746 m, but these are based on only 3 bottom and 7 second drums where as Laurenzi has 13 bottom and 11 second drums.

NOTE 36
Dyggve 1960, 227 and pl. VI D gives the measurement as 0.635 m and Laurenzi 1938a, 18 as 0.625 m. The reason for accepting Dyggve's figure is Laurenzi's consistent error in the top drum diameter measurements.

NOTE 37
See Pakkanen 1997 and the Appendix below.

NOTE 38
The formula of the drawn curve is $y = 100x - 704x^2 + 3614x^3$ when y is between 0 and 4.66.

NOTE 39
D. Wannagat has argued that the lower unfluted section of the shaft is often "cylindrical" (more proper term would be conical), but his notion is based on relatively few and not completely preserved cases; see Wannagat 1995, 116, esp. n. 554. Anyhow, the difference between a conical drum and a drum with a curving side profile is very small. Richard Anderson has informed me of the work he has done on the columns of the Stoa of Attalos at Athens: The individual drums appear to be conical, but the taper of the drums increases from bottom to top. In other words, the shaft profile has entasis, but it is made up of line segments, it is not a continues curve. As the Appendix below shows, the entasis used in Hellenistic Doric buildings is quite similar to entasis in Late Classical architecture.

NOTE 40
0.006 m / 4.66 m ≈ 0.13%.

NOTE 41
In the 4th cent. Doric buildings in the Peloponnese and Delphi the range of the proportional emphasis of the maximum entasis is 0.08-0.22%; see Table 3 in Pakkanen 1997. In Hellenistic buildings the range is wider, 0.11-0.35%; see the Appendix below.

NOTE 42
Dyggve 1960, 97 and 160.

NOTE 43
Dyggve 1960, 160 and 165f.

NOTE 44
Dyggve 1960, pls. V C4 and V D1.

NOTE 45
Dyggve 1960, pl. V J4.

columns are ca. 0.32 m higher than the small order: in Rasmussen's and Dyggve's reconstruction the architrave level is the same for both orders while the columns rise from different floor levels.[46]

Clues for the lower diameter and the column height of the façade can be searched for in Dyggve's list of column drums. As I have shown above, it is very likely that none of the temple drums is included in the list. Since all the bottom drums of the Stoa are faceted and the Propylaia court order is considerably smaller than the large order, the large fluted drums are necessarily from the Propylaia façade. The difficulty lies in where to draw the line: I have chosen to accept as large-order Propylaia drums all the fluted drums whose upper diameter in Dyggve's list is at least 0.705 m. The grounds for this limit is Dyggve's suggestion of 0.70 m for the lower diameter of the small order and the fact that the second smallest partially faceted Stoa drum has an upper diameter of 0.704 m.[47]

The 16 drums from the lower part of the shaft whose height is known have an average height of 0.674 m.[48] Interestingly, this is virtually the same as the mean height of the Stoa bottom drums, 0.680 m.[49] The similarity of the Stoa and Propylaia columns does not end in the height of the bottom drums: the capitals of the two buildings are so alike that when the Italians reconstructed the Stoa one of the Propylaia capitals was placed on top of the re-erected columns.[50] As we saw above, the average height of the smaller fluted drums at the site is almost the same as the calculated average height of the Stoa top drums. This fact could be explained if the top drums of the Propylaia façade were approximately the same height as the Stoa drums and if the number of preserved Propylaia small-order drums is few enough not to have a great effect on the mean height. The shaft height of the Propylaia large-order could in this case be calculated as ca. 4.6 m and the total column height as ca. 4.9 m.[51]

This column height is also supported by the comparison of column proportions of the buildings in the sanctuary. Even though the lower diameter of the Propylaia column is not known, it can be approximated fairly accurately. The lower diameter of the largest fluted drum B147 in Dyggve's list is 0.771 m. With the diameter of ca. 0.77 m the column height is 6.4 lower diameters, the same proportion as in the temple and only a fraction less than in the Stoa.[52] The taper of the shaft is in between the temple and Stoa proportions and the proportional height of capital is slightly less than in these two buildings.[53] Since the height difference of the large and small Propylaia orders is known, the height of the courtyard column can be calculated as ca. 4.6 m. With a lower diameter of ca. 0.71 m the column proportions of the two Propylaia orders are consistent.[54]

Conclusion

The results I have obtained in this paper are perhaps slightly less significant than I anticipated at the beginning of my study. This is due to the fact that the published column drum diameter measurements are not very reliable. Without stretching the

NOTE 46
Dyggve 1960, 166, pl.V L.

NOTE 47
For the small order diameter, see Dyggve 1960, 165. For the smallest partially faceted drum (B83) the upper diameter is not accurately known. The Propylaia drums are printed with italics and have a prefix P before the drum code in fig. 2.

NOTE 48
The range of heights is 0.625-0.695 m.

NOTE 49
Comparison by Mann-Whitney U test confirms that there is no height difference between the two groups of drums: the critical level of the two-sided test is $p = 0.665$ (for a conclusion that the samples are from different distributions probability p should be less than 0.05). On the Mann-Whitney test, see e.g. Siegel & Morgan 1996, 403-405.

NOTE 50
See Dyggve 1960, pl.V D2. For illustrations of the two capitals, see pls.V D1 and VI D2. The main difference is the capital height: the Propylaia capitals are ca. 0.276 m and the Stoa capitals ca. 0.34 m (Dyggve 1960, 161, 227).

NOTE 51
Shaft height: 3×0.680 m + 4×0.653 m ≈ 4.6 m; column height: 4.63 m + 0.276 m ≈ 4.9 m.

NOTE 52
See column G in table 1.

NOTE 53
See columns H and I in table 1.

NOTE 54
See table 1.

limits of the original data too far I have been able to put forward a drawing of the Stoa column shaft profile and to suggest a new height for the Propylaia columns. The comparative material on Hellenistic architecture in the Appendix demonstrates that the entasis in Hellenistic Doric columns is quite similar to the entasis used in the fourth century BC buildings.

In this study I have emphasised the similarity of the Propylaia façade and Stoa columns. This correspondence supports E. Lippolis' recent suggestion that the buildings were designed as a single project but completed in two separate phases.[55] The unknown architect made a design for the Propylaia which besides solving the problems created by the difficult terrain also gives an exciting architectural frame for the top of the acropolis. When the next architect took up the Stoa half a century later he left his own fingerprints on the design. He used the same proportions and even the same size drums as in the Propylaia columns, but he left the Stoa columns unfluted for one third of their height.[56]

NOTE 55
Lippolis 1988-89, 148-153.

NOTE 56
Even though the earliest instances of partially unfluted columns can be dated to ca. 300 BC, the practise became into wider use in stoas only in the second half of third century BC. For a catalogue of buildings with partially unfluted columns, see Wannagat 1995, 137-145.

Appendix

Comparative Material on Columns in Hellenistic Doric Buildings

Table 1 gives the column dimensions and proportions for a selection of Hellenistic Doric buildings: they all are from the Aegean islands and Pergamon, except for the South Stoa at Corinth, and their time span is from early Hellenistic to the middle of the second century BC. I have calculated the entasis data in cols. E and F by fitting a curve to the shaft profile points derived from the publications listed in table 1.[57]

In the proportional height of the column (col. G) no general trend can be observed, and the range is from 5.9 to 7.2 lower diameters. The taper of the column shaft (col. H) is in most cases ca. 3.0%: the exceptions are the Shrine of the Royal Cult at Pergamon and the Hieron on Samothrace with less tapering columns and the temple of Athena Lindia with more. In Late Classical buildings the taper is usually stronger, ca. 3.5%, than in these Hellenistic buildings.[58] Col. I in the table gives the proportional height of the capital of the whole column height: no trend is visible and the range is fairly large, 4.6-7.2%.

The range of the proportional emphasis of the maximum entasis (col. J) is fairly wide, 0.11-0.35%, but on the average it is stronger than in the fourth century BC buildings (0.20% v. 0.13%). The maximum entasis is approximately in the middle of the column shaft (col. K), but the two slight exceptions at Pergamon are interesting: in these late third and early second century buildings the entasis is more emphasised and also slightly higher in the shaft than in the other buildings. Very close parallel for this entasis can be found in the fourth century treasury of Kyrene at Delphi, which is clearly different from the other Late Classical buildings. In general there seems to be no great break in the entasis design between the Late Classical and Hellenistic periods.

NOTE 57
For the method, see Pakkanen 1997. The entasis of the shafts of the Dodekatheon on Delos is quite clear, even though Will 1955, 26 denies its existence (see also Vallois 1966, 112): a large number of the two bottom drums are at least fairly well preserved (the shaft consisted of four drums), and since both the upper diameter and the height of the shaft are certain (Will 1955, 26-29), there is enough data to reconstruct the shaft profile with certainty.

NOTE 58
For the Late Classical buildings, see Pakkanen 1997, esp. Table 3.

Table 1. Column dimensions and proportions. Dimensions in cols. A-F are given in meters.

	A	B	C	D	E	F	G	H	I	J	K
Temple of Athena Polias, Pergamon (late 4th/ early 3rd cent. BC)[59]	5.25	4.95	0.754	0.605	0.008	2.60	6.96	3.01	5.71	0.16	0.525
South Stoa, Corinth (ca. 300 BC)[60]	5.71	5.31	0.754	0.794	-	-	5.9	3.1	7.01	-	-
Temple of Athena Lindia, Lindos (early 3rd cent. BC)[61]	5.60	5.24	0.87	0.685	-	-	6.4	3.5	6.43	-	-
Dodekatheon, Delos (early 3rd cent. BC)[62]	4.62	4.37	0.69	0.566	0.005	2.22	6.7	2.8	5.41	0.11	0.508
Propylaia of the Athena Lindia sanctuary, large order (mid 3rd cent. BC)[63]	ca. 4.9	ca. 4.6	ca. 0.77	0.625	-	-	6.4	3.2	5.6	-	-
Propylaia of the Athena Lindia sanctuary, small order (mid 3rd cent. BC)[64]	ca. 4.6	ca. 4.3	ca. 0.71	0.56	-	-	6.5	3.3	6.1	-	-

A. Column height
B. Column shaft height
C. Lower diameter of the shaft at the arrises
D. Upper diameter of the shaft at the arrises
E. Maximum entasis
F. Height of maximum entasis
G. Proportional height of the column: A / C
H. Taper of column shaft (%): 100 × (C - D) / B
I. Proportional height of the capital / column height (%): 100 × (A - B) / A
J. Proportional emphasis of the maximum entasis (%): 100 × E / B
K. Proportional position of the maximum entasis in the shaft: F / B

NOTE 59
Source for dimensions in cols. A-D: Bohn 1885, 11. Radt 1988, 22 and 179 dates the building to ca. 330-320 BC on historical reasons, but traditionally it has been dated to 3rd century (see e.g. Gruben 1986, 425).

NOTE 60
Source for dimensions in cols. A-D: Broneer 1954, 30-32. For the date, see Williams & Fischer 1972, 171.

NOTE 61
Source for dimensions in cols. A-D: Dyggve 1960, 87, 110.

NOTE 62
Source for dimensions in cols. A-D: Will 1955, 26-28. For the date, see *ibid.*, 167-177.

NOTE 63
In the calculation for the value in column I the known height of the capital, ca. 0.276 m, is used (Dyggve 1960, 161).

NOTE 64
In the calculation for the value in column I the known height of the capital, ca. 0.28 m, is used (Dyggve 1960, 165).

	A	B	C	D	E	F	G	H	I	J	K
NW Stoa, Thasos (early 3rd cent. BC)[65]	5.16	4.85	0.74	0.595	-	-	7.0	3.03	6.01	-	-
Shrine of the Royal Cult, peristyle column, Pergamon (ca. 230 BC)[66]	4.66	4.44	0.666	0.558	0.010	2.50	7.00	2.43	4.72	0.23	0.563
Stoa of Philip, Delos (216-200 BC)[67]	5.91	5.58	0.905	0.735	-	-	6.53	3.05	5.58	-	-
Stoa in Athena Lindia sanctuary, Lindos (late 3rd cent. BC)	5.00	4.66	0.77	0.635	0.006	2.36	6.5	2.9	6.80	0.13	0.506
NE Stoa in the sanctuary of Athena, Pergamon (190-180 BC)[68]	4.99	4.76	0.69	0.545	0.017	2.64	7.2	3.0	4.61	0.35	0.555
Hieron, Samothrace (mid 2nd cent. BC)[69]	5.66	5.25	0.901	0.783	0.011	2.73	6.28	2.25	7.24	0.21	0.518

NOTE 65
Source for dimensions in cols. A-D: Martin 1959, 14-17, 47. For the date, see *ibid.*, 44-50.

NOTE 66
Source for dimensions in cols. A-D: Boehringer & Krauss 1937, 60-64, figs. 7, 13. For the date, see Radt 1988, 275.

NOTE 67
Source for dimensions in cols. A-D: Vallois 1923, 34-37. For the date, see *ibid.*, 154-166 and Coulton 1976, 233f.

NOTE 68
Source for dimensions in cols. A-D: Bohn 1885, 34f. For the date, see Coulton 1976, 275f.

NOTE 69
Source for dimensions in cols. A-D: Lehmann 1969, 96f. and pl. 114 (central column). For the date, see *ibid.*, 234. The entasis measurements and proportions are calculated from the second column from the left in fig. 445 (shaft height 5.27 m). This column is thicker than the central columns, but its shaft profile is the most consistent of the five reconstructed columns.

Bibliography

For the abbreviations used in the bibliography, see the American Journal of Archaeology 95 (1991), 4-16.

Blinkenberg, Chr. 1931
Les petits objets. Lindos fouilles et recherches I. Berlin & Copenhague.

Blinkenberg, Chr. 1941
Inscriptions. Lindos fouilles et recherches II. Berlin & Copenhague.

Boehringer, E. & Krauss, Fr. 1937
Der Temenos für den Herrscherkult. AvP 9. Berlin.

Bohn, R. 1885
Das Heiligtum der Athena Polias Nikephoros. AvP 2. Berlin.

Broneer, O. 1954
The South Stoa and Its Roman Successors. Corinth 1.4. Princeton.

Coulton, J. J. 1976
The Architectural Development of the Greek Stoa. Oxford.

Dyggve, E. 1960
Le sanctuaire d'Athana Lindia et l'architecture lindienne. Lindos fouilles et recherches III. Berlin & Copenhague.

Gruben, G. 1986[4]
Die Tempel der Griechen. München.

Laurenzi, L. 1938a
"I restauri sull'Acropoli di Lindo (Parte prima: Il restauro del tempio di Atena Lindia e del portico maggiore)", Memorie pubblicate a cura dell'instituto storico-archeologico F.E.R.T. e della deputazione di storia patria per Rodi 2, 9-21.

Laurenzi, L. 1938b
"I restauri del Santuario di Atena Lindia (II relazioni preliminare)", Memorie pubblicate a cura dell'instituto storico-archeologico F.E.R.T. e della deputazione di storia patria per Rodi 3, 27-30.

Lehmann, P.W. 1969
The Hieron. Samothrace 3. Princeton.

Lippolis, E. 1988-89 [1993]
"Il santuario di *Athana* a Lindo", ASAtene 66-67, 97-157.

Martin, R. 1959
L'Agora. Études Thasiennes 6. Paris.

Pakkanen, J. 1996
"The Entasis of Greek Doric Columns and Curve Fitting. A Case Study Based on the Peristyle Column of the Temple of Athena Alea at Tegea", Archeologia e Calcolatori 7, 693-702.

Pakkanen, J. 1997
"Entasis in the Fourth Century BC Doric Buildings in the Peloponnese and Delphi", forthcoming in BSA 92.

Papadimitriou, V. 1988
"The Anastylosis of the Ancient Monuments on the Acropolis of Lindos. Past and Present Attempts", in S. Dietz & I. Papachristodoulou (eds.), Archaeology in the Dodecanese, 169-171. Copenhagen.

Radt, W. 1988
Pergamon. Geschichte und Bauten, Funde und Erforshung einer antiken Metropole. Köln.

Siegel, A. F. & Morgan C. J., 1996[2]
Statistics and Data Analysis. An Introduction. New York.

Vallois, R. 1923
Le portique de Philippe. Délos 7.1. Paris.

Vallois, R. 1966
L'Architecture hellénique et hellénistique à Délos jusqu'à l'éviction des Déliens (166 Av. J.-C.), vol. 2.1. BEFAR 157. Paris.

Wannagat, D. 1995
Säule und Kontext. Piedestale und Teilkannelierung in der griechischen Architektur. München.

Will, E. 1955
Le Dôdékathéon. Délos 22. Paris.

Williams, C. 1974
"The Corinthian Temple of Zeus Olbios at Uzuncaburç: A Reconsideration of the Date", AJA 78, 405-414.

Williams, II, C. K. & Fischer, J. E. 1972
"Corinth, 1971: Forum Area", Hesperia 41, 143-184.