Chapter 7
Shipshed Ramps and Side-passages in Phase 2 and Phase 3

7.1. Introduction

In previous research on shipsheds, the area between the load-bearing elements of superstructures (colonnades, side-walls, etc.) has been variously called a *ramp, slip* and *slipway*.[1] These terms are problematic in a detailed study of the architecture and function of the shipsheds in Area 1 at Zea because there are, in fact, two types of structures located here: the ramp itself, and the two adjacent side-passages. The functions of the side-passages and the ramp were interrelated, but their construction and purposes differed.

The primary function of the side-passages was to provide access and separating space for the people who worked in the shipsheds. The central ramp was designed to support the keel and upward curving stern of a warship during hauling, storing and slipping operations, and perhaps also to stabilise the ship laterally. Accordingly, ramps were always constructed on an inclination angled downward towards the sea. The function of the slope was to facilitate easier removal of the ship from the water and to assist in its launching. Ramps and side-passages have been found in a wide range of construction methods and materials: cut from bedrock (Figs. 44–45), constructed of earth (Figs. 38–41) or built partly in stone (Fig. 52). However, all ramps most likely had at least one construction trait in common: the presence of transverse timber sleepers. If more sophisticated ramp structures were built above these timber sleepers, their design can only be speculation at this point due to lack of extant evidence.

In basic terms, then, the ramp was designed to accommodate the stored ship, and the side-passages to accommodate people. Here the term 'slipway' is defined as this *entire area* between the load-bearing elements of the superstructure of a shipshed (see also Chapter 1.2).

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1. '*Ramp*': Hurst 1994: 34; '*Slip*': Flemming 1965: 172; Blackman 1968: 181, 184–185; Morrison, Coates & Rankov 2000: 193; Coates 2002: 266; '*Slipway*': Kenny 1947: 194; Flemming 1965: 170; Morrison, Coates & Rankov 2000: 132; Garland 2001: 156; Raban 2003: 93; Baika 2006a: 179; Blackman 2004: 78. The differences in terminology are best exemplified by the various uses of *ramp*, *slip* and *slipway* in Blackman 1968; 2003; 2004.

Relative Chronology

As demonstrated in Chapter 5, the ramps of the Phase 1 slipways in Area 1 of Zea Harbour are clearly not related to the later Phases 2 and 3 colonnade structures (see pp. 53–54). There is very little doubt that the ramps found centrally located in the upper ends of the well-defined Phase 3 colonnades belong to the same building phase (Pls. 15–16, 36a; see pp. 73–75). The ramps identified in this study as belonging to the Phase 2 colonnades, on the other hand, require a more detailed analysis of the available data:

1) The Phase 2 ramp features are clearly later than the Phase 1 slipways, as their construction cuts through the Phase 1 ramp features (see, for example, Fig. 169). Furthermore, the Phase 1 ramps did not extend as far landward (east) as the single identified ramp feature in Shipshed 12 (S12:R1) and the Phase 2 colonnade (C11/12:4). The most probable distances between the upper ends of the Phase 1 slipways and the two Phase 2 features are in all probability 14.34 and 11.45 m (*MoP*: 0.04 m; Pl. 43).

2) The eastern-most Phase 2 ramp feature (S12:R1) was identified in Shipshed 12 (see below) near the eastern-most identified Phase 2 colonnade features in the colonnade dividing Shipsheds 11 and 12 (C11/12:3–4; Pl. 13). No traces of later or earlier building phases were found in the 16.30 to 16.88 m-long area (*MoP*: 0.04 m) between the eastern-most possible Phase 2 block (C11/12:2(?)) and the identified Phase 2 ramp feature (S12:R1), and the Phase 3 back-wall (Pl. 43).[2]

3) In one instance the Phase 3 ramp of Shipshed 17(η) (S17:R7) cuts through the southern side of the Phase 2 ramp foundations of Shipshed 8 (S8:R1) (Fig. 167). Furthermore, the rock-cut Phase 2 ramp foundations in Shipshed 14 (S14:R1; Pl. 13) were most probably destroyed by the ramp of Shipshed 23(Π) further to the west (S23:R2; Pl. 16).

The Phase 2 colonnades are the earliest identifiable colonnade structures found in Area 1 (pp. 73–75), and in one instance these also cut through the Phase 1 slipways (Fig. 170), demonstrating that they belong to a later construction phase. The Phase 2 ramps are located centrally in the Phase 2 colonnades in Shipsheds 8–10, strongly indicating their relationship to each other (Pl. 13; Figs. 180, 187, 194). Seen in this light, it is highly unlikely that the Phase 2 ramps belong to a building phase earlier than the Phase 2 colonnades.

As mentioned above, the upper preserved parts of the Phase 2 ramps end 16.88 m (*MoP*: 0.04 m) west of the Phase 3 back-wall. Also, it should be noted that the well-defined ramps in the upper ends of the Phase 3 shipsheds are wider and have a different design compared to the Phase 2 ramps (see, for example, the ramp of Shipshed 9 (Phase 2; Fig. 187) compared to the ramp of Shipshed 17(η) (Phase 3; Pl. 6).

Therefore, there is a very high degree of certainty that the structures identified as Phase 2 ramps and the Phase 2 colonnades are related. In this study they are together identified as comprising the evidence for the Phase 2 shipsheds, and although earlier and later construction sequences cannot be ruled out entirely, they are most unlikely.

7.2. The Ramps of Phase 3

An analysis of the ramps of Phase 3 in Area 1 of Zea Harbour can naturally take as its starting point the evidence presented in Dragátsis' report, Dörpfeld's plans and sections (Pls. 17, 20), and the upper ramp ends of Shipsheds 21(Δ), 22(N) and 23(Π) visible in the photograph PIR 6 from March 1891 (Pl. 32b–32d).

The structure between the two standing colonnades in the left-hand (north) side of photograph PIR 6 has above been identified as the ramp of Shipshed 21(Δ) (Pl. 32b).[3] Evidently, the ramp was a frame construction (two rows of blocks with an internal fill), with one instance of a block on the left-hand side tying into the fill adding structural strength. Dragátsis reports that three column drums were found re-used in the ramp of Shipshed 21(Δ). As discussed earlier, these drums are most probably those illustrated in the northern part of the ramp, 16.44 to 20.94 m from the back-wall

2. See also pp. 112–113.
3. See p. 75.

Spot-height	Dörpfeld's spot-height (m)	Calibrated spot-height (m)	Distance from inside of back-wall (m)[7]
S17:R15(η1)	+1.68	+1.61	*ca* 26.22
S21:R1(Δ1)	+4.89	+4.82	*ca* 2.06
S21:R3(Δ2)	+3.17	+3.10	*ca* 16.66
S21:R7(Δ3)	+1.86	+1.79	*ca* 22.60
S12:R1(Δ4)	+1.90	+1.83	*ca* 17.92
S22:R1(N1)	+5.53	+5.46	*ca* 2.20
S23:R1(Π1)	+5.45	+5.38	*ca* 2.06
S23:R1(Π2)	+5.37	+5.30	*ca* 4.52
S23:R1(Π3)	+4.30	+4.23	*ca* 7.82

Table 7.1. Dörpfeld's spot-heights on the ramps of Shipsheds 12, 17(η), 21(Δ), 22(N) and 23(Π) (Dörpfeld 1885: pl. 2).

(*MoP*: 0.04 m; Pl. 17).[4] Although these column drums (S21:R3–R5) and two related features (S21:R6–R7) create a wider ramp compared to the upper end of Shipshed 21(Δ), they are assigned to Phase 3 based on the re-use of column drums in the structure; however, it is possible that they may be related to earlier and later construction sequences. Dörpfeld obtained three spot-heights, Δ1 (S21:R1), Δ2 (S21:R3) and Δ3 (S21:R7), on the Phase 3 ramp structure of this shipshed (Pl. 18; Table 7.1). Another spot-height, Δ4, was taken on feature S12:R1, which has subsequently been interpreted as belonging to the ramp structure of Shipshed 12 from Phase 2 (Pls. 13, 18; see below).

Shipshed 22(N), to the right (south) of Shipshed 21(Δ) in photograph PIR 6 (Pl. 32b–32c), is described by Dragátsis as totally destroyed. This is probably an exaggeration, since a well-preserved inclined rock-cutting is visible in the left-hand (northern) part of the ramp structure (Pl. 32c); additionally, the spot-height on the upper end of the ramp (S22:R1(N1) +5.53 m) represents the highest spot-height on the Phase 3 ramp structures (Pl. 17). To the right (south) of this follows the ramp of Shipshed 23(Π), which Dragátsis describes as being in better condition than the ramp of Shipshed 22(N). The ramp of Shipshed 23(Π) is perhaps the inclined structure visible on the far right of the photograph PIR 6 (Pl. 32d). Dörpfeld took three spot-heights on the upper end of this ramp, Π1, Π2 and Π3 (Pl. 18; Table 7.1); they represent important evidence of a stern-supporting ramp section in Phase 3, a feature that will be discussed in detail below (see pp. 134–137). Dragátsis reports that the ramp of Shipshed 24(Φ) was in good condition,[5] but no spot-heights were obtained from this structure (Pl. 17).

Turning to the northern part of Area 1, Dragátsis indicates that only the rock-cut foundations of Shipshed 16 are preserved. The ramp here is defined by a number of stepped, horizontal rock-cut foundation trenches, S16:R1–R6: (Pl. 6; Figs. 92–93, 173b). Ramp feature S16:R2 demonstrates that the upper end of this ramp had blocks placed within the ramp structure.

Like Shipshed 21(Δ), the ramp of Shipshed 17(η) to the south of Shipshed 16 was frame constructed (Pls. 6, 15). A column drum (S17:R11) was also re-used in this structure (Pl. 6). A number of blocks remain *in situ* in the inclined rock-cut foundations (Fig. 94).

To the south, two blocks (S18:R1–R2) form the upper-most end of Shipshed 18(χ)'s ramp (Pls. 6, 15). One (S18:R1) is fully exposed, and the adjoining block to the south (S18:R2) is just visible near the modern wall on the western side of the structure.[6] Compared to Dörpfeld's spot-heights on the upper-most part

4. Dragátsis 1885: 64; see this volume p. 90.
5. Dragátsis 1885: 64–65.
6. S18:R2 is not visible on the basement plan (Pl. 6).
7. *MoP*: 0.04 m. Measured to the centre of the spot-height.

of Shipshed 22's ramp (N1) (calibrated +5.46 m) and 23(Π1) (calibrated +5.38 m), the upper-most block in the ramp of Shipshed 18(χ) (S18:R2, +4.78 m) is preserved at a level which is 0.68 m and 0.60 m lower, respectively. According to Dörpfeld, the ramp of Shipshed 21(Δ1) is preserved to a height of +4.82 m (calibrated), which is almost the same level as S18:R2 (+4.78 m). The upper parts of the ramp structures of both Shipsheds 18(χ) and 21(Δ) are constructed of blocks (Pls. 6, 32b). It is safe to assume that the upper end ramp of Shipshed 21(Δ) was also preserved to a height of one course.

The ramp of Shipshed 21(Δ1) (calibrated +4.82 m) is preserved to an elevation 0.64 m below the top elevation of 22(N1) (calibrated +5.46 m) and 0.56 m below the top elevation of 23(Π1) (calibrated +5.38 m). The top elevation of the northern block in the ramp of Shipshed 18(χ) (S18:R2) is +4.78 m, and is located 0.68 and 0.60 m below the above-mentioned elevations on the ramp of Shipsheds 22(N) and 23(Π). The average difference in elevation between the ramps of Shipsheds 22(N) and 23(Π), and those of 18(χ) and 21(Δ) is 0.62 m. The second course stretched to approximately this height.

According to Dörpfeld's and the ZHP's measurements, the ramp width ranges from 3.03 to 3.24 m, averaging 3.12 m (Table 7.2). It should be emphasised that these measurements were taken at the upper end of the ramps, whereas the width of each may well have varied along its length; this is indicated on Dörpfeld's plan by the wider middle part of Shipshed 21(Δ)'s ramp (S21:R3–R7; Pls. 16–17). The foundations of the Phase 3 ramps have been followed for a maximum preserved length of 41.03 m (*MoP*: 0.01 m) in Shipshed 17(η) (S17:R7; Pl. 15), and for 52.22 m (*MoP*: 0.05 m) in Shipshed 23 (S23:R2; Pl. 16).

Except for the Phase 3 ramp features S17:R7, S23:R2, the now-missing ramp feature S17:R17, and to some extent S21:R3–R7 (Pls. 15–16), there is no evidence that the Phase 2 ramp foundations in Shipsheds 8–10, 12 and 14 (Pl. 13) were widened to accommodate the wider Phase 3 ramps. There are two possible explanations for this:

A) The builders of the Phase 3 ramps re-used the narrower Phase 2 ramp elements, which are also centred to the new building phase (see below). If this was the case, the middle lower parts (38.67 to 58.57 m)[8] of the Phase 3 ramps were narrower than the upper sections.

Shipshed	Width (m)
S16:R	*3.11*
S17:R(η)	3.24
S21:R(Δ)	3.03
S22:R(N)	3.12
S23:R(Π)	3.14
S24:R(Φ)	3.05
Average	**3.12**

Table 7.2. Average ramp widths in Phase 3. The rock-cut ramp foundations of Shipshed 16 are excluded from the average calculation due to poor preservation. MoP: 0.04 m.

B) Except for S17:R7, S23:R2 and S17:R17 (missing), there is little or no preserved evidence of the Phase 3 ramps in the interval that stretches between 38.67 to 58.57 m, from the modern quay to the dredging cut in the bedrock in the sea. This is due either to the natural shallow contours of bedrock in this area, or because the low inclination of the Phase 1 slipways had removed a considerable amount of bedrock, thus resulting in the need to build up substantial (yet now-missing) ramp foundations in Phase 3 (Pls. 12, 35b–35c, 36a, 43).

Especially the presence of S17:R7, S17:R17 (missing) and S23:R2 speaks against point A, so point B is considered the most likely explanation for the missing Phase 3 ramp foundations (Pl. 43).

Dimensions of the Ramp Blocks of Phase 3

The dimensions of S18:R2 located in the upper end of the ramp is evidently larger than the ramp blocks found in the ramp of Shipshed 17(η) (Pl. 6). In the ramp of Shipshed 17(η) the average dimensions are: L: 1.16 m, W: 0.42 m, and H: 0.40 m (Table 7.3).

8. Measured from the inside (west) of the back-wall (*MoP*: 0.01 m).

Feature	Length (m)	Width (top) (m)	Height (m)
S17:R8–R9	1.15	0.45	*0.14*
S17:R10	n/a	0.40	n/a
S17:R11	1.07	0.34	0.42
S17:R12	1.20	0.46	0.39
S17:R13	1.23	0.42	0.39
S17:R14	n/a	0.42	0.40
S18:R2	1.43	0.62	0.61

Table 7.3. Phase 3 ramp block dimensions.

Gradient of the Ramp Structures

According to Blackman, the gradient of Zea's slipways is 1:10, but also given elsewhere as "... just over 6°".[9] Graser, who investigated Zea in 1872 before Dragátsis' and Dörpfeld's excavation in 1885, was the first to document the gradient of a possible shipshed structure in the eastern part of Zea Harbour. Graser calculated the gradient of this structure at 1:9.[10] He reports:

> "Unfortunately, with the defectiveness of the tools [or aids] on hand, it was not possible for me to carry out the latter [calculate the height difference between the shipshed's upper and lower ends], except in the case of a single lateral structure on the eastern edge of Zea which, however, has an extraordinarily steep slope. In the case of this lateral structure, a large part (8 metres) lies on the dry (part of the) beach, and from this length, in comparison with the difference in height between its upper end and the part which goes into the water, the result is a gradient of 1:9, while nowadays the slope of the slipway is usually 1:12, so less steep".[11]

Blackman's 1:10 calculation of the gradient is generally accepted and used in subsequent research,[12] except by Garland who uses Graser's 1:9 gradient.[13]

The 1:10 gradient is inaccurate, as it is based on a misinterpretation of Dörpfeld's plan and sections of the colonnades dividing Shipsheds 17(η)/18(χ) and Shipsheds 20(π)/21(Δ). Blackman does not detail how he calculated the 1:10 *shipshed* gradient or the 6° *slipway* inclination, but it is possible to reconstruct the calculations from his 1968 article.[14] On Dörpfeld's sections of the colonnades dividing Shipsheds 17(η)/18(χ) and Shipsheds 20(π)/21(Δ) there is a double line running just below the top surfaces of the *in situ* and reconstructed column bases (Pl. 20). The double lines have the same inclination as the colonnades. Blackman misinterprets the double lines as the profile of the ramp,[15] and in all probability calculates the ramp gradient using the interaxial width and the spot-heights on the upper three column bases in the colonnades 17(η)/18(χ) (1:10) and 20(π)/21(Δ) (1:11).

Dragátsis reports a distance of 1.70 m between the upper end of Shipshed 21(Δ)'s ramp and the back-wall;[16] the figure corresponds with the space between the ramp and the raised rock-cut foundations on Dörpfeld's plan (Pl. 17). According to the ZHP survey, the rock-cut foundations of Shipshed 17(η)'s ramp actually end 1.61 m before the inside of the back-wall, and the preserved first course in the upper-most end of Shipshed 18(χ)'s ramp is located at a distance of 1.92 m from the back-wall. According to these data, the distance between the upper ends of the ramps ranged between 1.61–1.92 m. The double lines on Dörpfeld's sections run to the inner face of the back-wall (Pl. 20). As the ramp structure ceases before the back-wall, it is highly unlikely that Dörpfeld was illustrating the section of the ramps (see Pl. 20).

Another argument against equating the double lines with the ramp is that the level points on Dörpfeld's plan clearly show that the upper ends of the ramps were constructed well above the top surface of

9. Blackman 1968: 181 (1:10); Blackman 1973a: 128 (6°).
10. Graser 1872: 20; Garland 2001: 156, following Graser. Graser reports that this structure had a particularly steep gradient.
11. Graser 1872: 20, "Leider war es mir bei der unvollkommenheit meiner hülfsmittel nicht möglich, letzteres auszuführen, ausgenommen bei einer einzigen wange om ostrande von Zea, welche aber eine aussergewöhnlich starke neigung besitzt. Bei dieser wange liegt ein grosser theil (8 meter) auf dem trockenen strande, und aus dieser länge im vergleich mit der höhendifferenz zwischen ihrem oberen ende und dem theile, welcher in das wasser tritt, ergiebt sich ein steigungsverhältniss von 1:9, während heutzutage die neigung des stapels gewöhnlich 1:12, also weniger steil is". Translation: S. Kennell.
12. See for example: Foley, Soedel & Doyle 1982: 305–318; Morrison, Coates & Rankov 2000: 133; Coates 2002: 265–278.
13. Garland 2001: 156.
14. Blackman 1968: 181; 1973a: 128.
15. Blackman 1973a: 128.
16. Dragátsis 1885: 64.

the column bases (Pl. 17). The best example on the plan is Shipshed 23(Π). Here the two spot-heights on the ramp – S23:R1(Π2) at +5.37 m and S23:R1(Π3) at +4.30 m – were taken roughly along the same alignment as the ones on column bases C23/24:3(Σ) and C23/24:6(Υ) (+4.14 m and +3.72 m). The ramp of Shipshed 23(Π) is preserved 1.23 m above C23/24:3(Σ) and 0.58 m above C23/24:6(Υ).

In the photograph PIR 6 from 1891, the colonnades dividing Shipsheds 20(π)/21(Δ) and Shipsheds 21(Δ)/22(N), and the side-passages of 21(Δ) and 22(N), have been backfilled (Pl. 32). As discussed earlier (see pp. 97–99), C20/21:2(H), 6(Θ) and 9(I) were clearly excavated *in situ* and can be identified as column bases. A spot-height was taken on each of them and they appear on both the plan and the section. The column bases are not visible in the photograph. The ramps of 21(Δ) and 22(N) were clearly constructed to a higher level than the covered bases.

The upper, southern part of Shipshed 17(η)'s ramp is not preserved to its original height, but is positioned at a higher level (0.13–0.31 m) than column bases C17/18:9(ε) and C17/18:11(ζ) in the colonnade dividing Shipsheds 17(η)/18(χ) (Figs. 175b, 176b).

It is possible to conclude, then, that the double lines on Dörpfeld's sections of Shipsheds 17(η) and 21(Δ) do not illustrate their respective ramps. Instead, they are lines that illustrate Dörpfeld's interpretation of the superstructure's inclination. Dörpfeld drew the section and reconstruction of the colonnades dividing Shipsheds 17(η)/18(χ) and 20(π)/21(Δ); the latter includes the reconstructed section of Colonnade 19(φ)/20(π) in outline. His main focus was to illustrate the section and reconstruction of the colonnades. Had he included a section of the ramp it would have lessened the clarity of the drawing. The inclinations of the keel- and stern-supporting ramp sections are discussed below.

7.3. Keel-supporting and Stern-supporting Ramp Structures

An analysis of ramps found outside the Piraeus that are relevant to the unroofed Phase 1 slipways at Zea are presented in Chapter 5. This present section deals with the comparative evidence that bears on the ramps of the shipsheds in Phases 2 and 3. A number of these ramps can be divided into two structural elements:

1) A keel-supporting ramp section. This main ramp element maintains a relatively linear gradient in order to support the keel during hauling, storage and slipping.

2) A stern-supporting ramp section. In some shipsheds the upper ends of the ramps curve more steeply upward to provide support for the upward curving sterns of warships in order to prevent them from sagging here during storage. It should be stressed that a structure may still be identified as a shipshed if it lacks this stern-supporting ramp feature, and of course there could be no such feature for the lower of the two ships accommodated in a double-unit shipshed. There is no evidence of unroofed slipways with this feature.

At Zea, evidence of shipsheds with upward-curving upper ends has only been found in Phase 3.

The Keel-supporting Ramp Section

Insufficient evidence precludes the possibility of calculating the gradient of the main portion of the ramps in Phase 3, but it was probably close in value to the mid-point (1:12.3/4.65°) of the most likely inclination range of the superstructure: SIT-1 (see pp. 107–108). It is clear that the inclination of the keel-supporting ramp section could not have deviated much from that of the superstructure, since this would have markedly reduced or increased the height between the underside of the roof and the top surface of the ramp (Pl. 37).

Evidence from Oiniadai (Fig. 43), Kos (Fig. 52; sections Λ–Λ, Δ–Δ), Mandraki (Fig. 49; sections S2, S3) and Carthage (Fig. 38; section A) lends weight to this observation. In all of these, the superstructure foundations (i.e. column bases, piers, and slots for wooden posts) and the side-passages are either just above or at the same elevation as the ramp, and both structures appear to follow the inclination of the keel-supporting ramp structure.

The Stern-supporting Ramp Section

Lehmann-Hartleben first suggested that the function of the upward-curving, upper ends of the ramps at Oiniadai were to support the sterns of ships during

Section	Gradient
A (uppermost *ca* 5.2 m)	*ca* 1:2.4 (22.6°)
B (following *ca* 2.0 m)	*ca* 1:3.9 (14.3°)
C (following *ca* 4.5 m)	*ca* 1:6.4 (8.9°)

Table 7.4. Oiniadai, inclination of ramp 3 on Powell's section (Sears 1904).

storage: "For this procedure has the aim of making the ramp fit the hull of the ship more closely whereby, in addition to facilitating the examination of the same [the hull], the wooden supports [or timber shores] required could be reduced to a minimum".[17] On Powell's reconstruction and profile, the upper *ca* 11.7 m of shipshed 3's ramp is increasingly steeper and changes gradient over three segments (Fig. 46; Table 7.4).[18]

As well as at Zea, clear evidence of a steeper upper ramp end has been demonstrated at the Phoenician site of Kition and at Punic Carthage, and is suggested at other sites, for example at Kos where the southwestern end of the well-preserved ramp curves upward on section E–E in Kantzia's report (Fig. 52c). At Kition, the upper-most 10 to 11 m of the phase I ramps (from the late 5th century BC) have a gradient of 13°, or 1:4.3.[19] On a photograph of a phase I shipshed, it is evident that the upper part of the ramp has a curvilinear construction similar to the Oiniadai ramps, and that the gradient changes sharply on the upper-most part of the ramp. The gradients on the following sections of the ramps belonging to phases II and III are not reported, but it is clear from the reconstructed section that it was probably less steep in phase I.[20]

On the Ilôt de l'Amirauté in Carthage, two of the excavated ramps have a steeper upper section. Ramp 16 has a gradient of about 1:15 (3.8°) over the first 25.0 m (Fig. 38). From 25.0 to 29.0 m the gradient changes to 1:10.0 (5.7°), and from 29.0 to 35.0 m it increases further to 1:6.3 (9.0°). Ramp 13 has a gradient of 1:6.9 (8.3°) between 25.5 to 29.5 m (Fig. 39). The gradient of the remaining part of the ramp must have been less steep. Ramp F762 on the north/northeastern perimeter of the Circular Harbour probably had a gradient of about 1:20 (2.9°) over the first 24.0 m. From 24.0 to 28.7 m the ramp has a gradient of *ca* 1:6 (9.5°) (Fig. 41). Hurst reasonably suggests that the ramp was adjusted to fit the shape of the hull.[21] The data from Oiniadai and Kition strongly support this interpretation.

The excavated upper ends of the three preserved ramps in the southern part of Mandraki harbour in Rhodes City have a linear gradient of between 1:4.0 (14.0°) and 1:4.4 (12.8°) (Fig. 49).[22] Coates suggested to Blackman that the steep upper ends of the Mandraki ramps were constructed to fit the stern of the ship, but Blackman stresses that this cannot be tested without new excavation towards the ancient shoreline.[23] Since the ramps at Sounion (1:3.5/15.8°) and Sitea (1:3.6/15.5°) had a comparably steep gradient along their entire preserved length, it cannot be ruled out that the excavated portion at Mandraki is in fact the keel-supporting section of the ramps.

By plotting Dörpfeld's spot-heights on the ramps of Shipsheds 17:R(η1), 21:R(Δ1–Δ3), 22:R(N1) and 23:R (Π1–Π3) at Zea (Pl. 18; see Table 7.1 for the data used), it becomes clear that there is evidence of a rising, stern-supporting ramp section in the Phase 3 shipsheds. In Plate 36a the traced and scaled section of the stern-supporting ramp section of shipshed 3 at Oiniadai (Fig. 45) is inserted and aligned to the upper end of the ramp of Shipshed 23(Π); the distance from the ramp end to the inside of the back-wall is *ca* 1.88 m (*MoP*: 0.04 m; Pl. 17). It should be noted that the distance to the spur-wall directly behind the ramp of shipshed 3 is much shorter at Oiniadai, *ca* 0.42 m,

17. Lehmann-Hartleben 1963: 117, "Denn dies Verfahren hat den Zweck die Bahn dem Schiffskörper stärker anzupassen, wodurch man neben der erleichterten Untersuchung desselben das erforderliche Stützwerk aus Holz auf ein Minimum reduzieren konnte." Translation: S. Kennell.
18. Sears 1904: pl. X. The profile appears to have been based on four spot-heights, as it is drawn in three sections. The inclinations are scaled from the section.
19. Callot 1997: 72, fig. 6; Yon 2006: 137. The gradient is listed as 13°, which equals 1:4.3.
20. Yon 2000: figs. 6, 11; Callot 1997: fig. 3.
21. Hurst 1994: 33–35; see this volume pp. 65–66.
22. Blackman, Knoblauch & Yiannikouri 1996: 380–384, figs. 6–7. Shipshed BC is 1:4.36; CD, 1:4.23 and DE, 1:4.00.
23. Blackman 1990b: 42. Blackman refers to a discussion with Coates: "John Coates feels that this would have suited the after keel, say 10 m long from the after cut up of the keel to the after end of the ship, and would go well with a keel lying lower on the slip on a slope of 1 in 10; this idea cannot be tested without excavation."

Section	Distance (m)	Gradient
S23:R1(Π2) to S23:R1(Π3)	*ca* 3.30	1:3/18°
S23:R1(Π3) to S21:R3(Δ2)	*ca* 8.84	1:8/7°

Table 7.5. Inclination between Dörpfeld's 1885 spot-heights on the ramps of Shipsheds 21(Δ) and 23(Π) in Group 1 at Zea.

demonstrating that the stern of the slipped ship was positioned very close to the spur-wall.[24]

The structure lines connecting spot-heights S21:R3(Δ2), S23:R1(Π3) and S23:R1(Π2) create a ramp with roughly the same shape and inclination as the three sections Sears surveyed on the stern-supporting ramp section of shipshed 3 at Oiniadai (Pl. 36a; Fig. 45; Tables 7.4–7.5). The spot-heights S23:R1(Π1) and S22:R1(N1) form a flat platform with S23:R1(Π2) (Pls. 18, 36a). Ramp features S17:R15(η1) and S21:R7(Δ3) are unlikely to be preserved to their original height, as the gradient between the two spot-heights is simply too low (1:20/2.9°), but they and S23:R2 are most likely Phase 3 ramp foundations (Pl. 36a). On the other hand, spot-height S21:R3(Δ2) may represent a near-original ramp surface.

Possible Ramp Blocks from the Stern-supporting Ramp Section

Before reconstruction work was carried out inside the basement of Sirangiou 1 in 2000–2001 by the 26th Ephorate of Prehistoric and Classical Antiquities, possible ramp blocks AE:1, 11 and 12 (Figs. 95, 103–104) were located in a tumble atop Wall 16/26(λ) and the northern side-passage of Shipshed 16. The blocks are not visible in the Meletopoulos photographs (Figs. 61–62), and although it is likely they were found during the construction of Sirangiou 1, it is not certain that they belong to the Phase 3 shipsheds.[25] The stepped rock-cut foundations for the ramp in Shipshed 16 are level (Figs. 93, 173b). If the blocks belong to a ramp with a similar design their gradient can be calculated from these cuttings. However, if they are from a ramp with a sloping foundation trench for the ramp blocks, like those of Shipshed 17(η) (Figs. 175a–175b), then the gradient of the foundations must be taken into account (an analysis that will not be undertaken here). Moreover, there are no cuttings capable of accommodating these blocks in the side-passages, so it is unlikely that they belong here (Figs. 174b, 176a; Pl. 6). The blocks were in all probability from the stern-supporting ramp section, as the gradients of AE:1 (1:5.7/9.0°), AE:11 (1:7.3/7.8°) and AE:12 (1:4.1/13.7°) are too steep to belong to the ramp section that supported the keel (which is reconstructed at the mid-range of the SIT-1 inclination of the Phase 3 colonnades: 1:12.3 [4.65°]); for a discussion of the SIT-1 inclination, pp. 107–108).

Blocks AE:1 and AE:11 are well preserved. The variation in their gradient measurement supports the evidence of a stern-supporting ramp section in Shipshed 23(Π), and also strengthens the assumption that the gradient of the upper part of the ramp varied, increasing towards the end to mirror and support the curve of the stern. Indeed, a block similar in design to blocks AE:1, AE:11 and AE:12 appears to stand at the rear of Shipshed 21(Δ) in the 1891 photograph PIR 6 (Pl. 32p). Further, the southern (right) side of Ramp 21 appears to be steeper to the left of column drum C20/21:10 in the foreground than on the right side of this column (Pl. 32b, 32j). As discussed above, the Oiniadai ramps become increasingly steep at their upper ends, and the same is true of the Kition and Carthage ramps (see above). The ramp blocks at Zea may have been built into the ramp from west to east: AE:11 (1:7.3/7.8°), AE:1 (1:5.7/9.0°) and AE:12 (1:4.1/13.7°). If this was the case, they appear to have been situated at various positions, not adjacent, in the line of upward-curving blocks. The upper end of the ramp could well have had an inclination steeper than 1:4.1 (13.7°), as the inclination between levelling points S23:R1(Π3) to S23:R1(Π2) is 1:3 (18°).

At Oiniadai, the upper-most section A of the ramp of shipshed 3 has a gradient of 1:2.4 (22.6°; Fig. 46), but it must be kept in mind that this section is located closer to the back-wall than section S23:R1(Π3) to

24. Sears 1904: scaled from pl. IX.

25. Two other blocks (AE:4–5) possibly belonging to a ramp structure have been re-used in Wall 16/26(λ) at a point after it went out of use as a side-wall in the shipsheds. AE:4–5 (Figs. 97–99) are visible in the Meletopoulos photographs (Figs. 61–62; Pl. 6).

S23:R1(Π2) at Zea (Pl. 36a). The curves of both ramp structures are defined by very few spot-heights, and the ramps at Oiniadai exhibit a continuous curve and are not built in linear sections, as Powell shows (Fig. 45). The same appears to be true of the Kition ramps, although they should be re-surveyed with a higher number of point measurements in order to document the true shape of these important features.[26]

Length of Stern-supporting Ramp Section

The lengths of the stern-supporting ramp section at Oiniadai (*ca* 11.7 m), Kition, phase I (*ca* 10.5 m), Carthage, ramp 16 (*ca* 10.0 m) and Zea, Area 1, Phase 3 (*ca* 12.14, *MoP*: 0.04 m) fall within a close range of *ca* 10.0 to 12.14 m, averaging 11.1 m. The lengths and shapes of these structures are essential for understanding the dimensions and forms of the upward-curving sterns of ancient warships.

The Phase 2 and most probably the Phase 3 shipsheds at Zea are the only positively-identified *trireme* shipsheds yet known. Although the data are sparse, Dörpfeld's spot-heights on the upper end of the Phase 3 ramps represent the only solid evidence of the stern dimensions and shape of a *trireme* of the 4th century BC (Pl. 36a; see also p. 173).

The stern-supporting ramp section is first seen in the Kition phase I shipsheds of the late 5th BC; it is possible that this design was invented in the Phoenician/Punic cultural sphere, and was used at least until 146 BC, when Carthage's shipsheds were destroyed.

Summary

The Phase 3 ramps can be divided into two structural parts: a keel-supporting ramp section and a stern-supporting ramp section (Pl. 36a). The former maintains a linear gradient in order to support the keel during hauling, storage and slipping, and is reconstructed based on the 1:12.3 (4.65°) mid-point of the SIT-1 inclination range (1:12.9/4.5° to 1:11.9/4.8°). The latter in all probability curved more steeply upward to mirror and support the upward-curving stern of the upper warship (Pl. 36a) in the Phase 3 double-unit shipsheds.

The Phase 3 ramps were primarily frame constructed (two rows of blocks with an internal fill), best exemplified by Shipsheds 17(η) and 21(Δ). Shipshed 16 is the exception, as it had an internal block (S16:R2) in the upper ramp structure (Pls. 6, 32b). Where topography permitted, bedrock was used in the ramp structure (i.e. Shipshed 23(Π)) to save labour and resources. Since there is no clear evidence of a wooden ramp structure, the Phase 3 ramps have been re-constructed (Pls. 36a, 37) based on the dimensions of the transverse timber slots found in the frame-constructed ramps at Kos (Fig. 52). It must be noted, however, that the Kos ramps date to the 3rd century BC, and that the frame construction here is wider (*ca* 4.30 m) compared to the average of the Phase 3 ramps of Zea, Area 1 (3.12 m), *terminus post quem* 375–350 BC.

7.4. The Ramps of Phase 2

Identification of the Ramp Structure in Phase 2

The ramps in Phase 2, including their rock-cut foundations and built features, are not as clearly delineated as those of Phase 3. Even so, careful observation reveals a number of diagnostic features and problem areas.

The 6.48 m interaxial spacing between the colonnades dividing Shipsheds 9/10 and C10/11 in Area 1 at Zea is based on the calculated centres of C9/10:2 and C10/11:3 (Pl. 28; p. 116). The mid-point of this interaxial space defines the longitudinal centre axis of the shipshed as illustrated by the *dash-dot-dash* line on Plate 13. In the ramp foundations of Shipshed 10, the bottom of the rock-cut step (the southern bottom side of S10:R1) between S10:R1 and S10:R2 runs parallel to the centre axis – exactly on top of or very near to it. The two features form a central rock-cut foundation trench 1.61 m wide. The northern edge of S10:R2 is eroded; it may originally have formed a vertical step to the southern bottom of structure S10:R1. This would account for the difference in width between S10:R2 (0.75–0.78 m) and S10:R1 (0.83 m) and would bring the northern edge of S10:R2 nearer to the centre axis.

As established in the analysis of the slipways of Phase 1, it is absolutely clear that the rock-cut ramp foundations in Shipshed 10 (S10:R1–R2) are later than the Phase 1 ramp features of Slipway 3 (see pp. 53–54). S10:R1 and S10:R2 are level and cut through

26. Callot 1997: fig. 3.

the inclined Phase 1 ramp features (SW3:R1–R7) at various points (Figs. 169, 226). One could speculate that S10:R1 and S10:R2 accommodated stone blocks with rock-cut slots related to the continuation of the Phase 1 rock-cut slot, but this would not explain why SW3:R4–R7 were partially removed by the construction of S10:R2, and completely removed by S10:R1.

S10:R1 was excavated for a total length of 4.59 m. The top surface of S10:R1 is nearly horizontal (Figs. 198a, 226a) and varies between -0.92 to -0.93 m. To the west the transition between S10:R1 and S10:R2 is damaged, so the height between the two features and the width of S10:R1 were measured on the eastern half. The step down between S10:R1 and S10:R2 is 0.07–0.10 m. The maximum bottom width of S10:R1 is 0.83 m. S10:R2 was excavated for a total length of 5.30 m. The top surface of S10:R2 is nearly horizontal (Figs. 198b, 226b) and varies between -0.82 to -0.86 m.[27] S10:R2 was hewn through Slipway 3; in this area it destroyed SW3:R1–R3 and shaved off the upper parts of SW3:R4–R7 (Fig. 111). The step down between the top surface of Slipway 3's ramp structure and S10:R2 slopes from a height of 0.20 m (east) to 0.06 m (west). In the western part, the northern side of the structure is severely damaged, so the bottom width was measured on the eastern half at 0.75–0.78 m. The northern top edge is eroded but may originally have formed a vertical side with the southern bottom edge of S10:R2.

Using the same method, other ramp structures from Phase 2 were identified in Shipsheds 8–9, 12 and 14 (Pl. 13). The width of the rock-cut ramp foundations of Shipshed 8 is estimated at *ca* 1.90 m between the southern side of S8:R2 and the northern side of S8:R1 (Fig. 180). The foundation of the ramp of Shipshed 10 is *ca* 1.61 m wide (Fig. 194). The width of Shipshed 14's ramp foundations (Fig. 207) is reconstructed at *ca* 1.60 m.[28] In Shipshed 9, only the northern side of the built ramp structure is fully preserved (Fig. 187), so the ramp width is reconstructed at *ca* 1.52 m based on the average distance (0.76 m) between the centre of the interaxial spacing of the colonnades (the *dash-dot-dash* line) and the the northern side of ramp blocks S9:R6–R8 representing roughly half the width of the ramp (Pl. 13). Note that this reconstructed centre line aligns with the transition (rock-cut step) between S9:R2 and S9:R4. In the reconstructed plan and cross-section of the Phase 2 shipsheds the reconstructed ramp width of Shipshed 9 is used (Pls. 14, 29). In Plate 13 the widths of the other Phase 2 ramps are based on their rock-cut foundations. It is important to note that the built ramp would be narrower than its foundations.

Feature	Length (m)	Width (m)	Height (m)
S9:R6–R9	1.21 (range: 1.13–1.28)	0.63 (range: 0.57–0.72)	0.36 (range: 0.34–0.37)

Table 7.6. Shipshed 9: ramp block dimensions.

In both Shipsheds 8 and 14 the foundations continue up (eastwards) under the modern quay. On Dörpfeld's plan a feature (S12:R1; Pls. 13, 17) is interpreted as a Phase 2 ramp block in Shipshed 12 based on its relation to the Phase 2 colonnade. It is positioned 2.02 m (*MoP*: 0.04 m) from the side of colonnade block C11/12:4, a measurement that is comparable to: (1) the distance between colonnade block C10/11:3 and the bottom edge of the ramp foundations S10:R2 at *ca* 1.96 m; and (2) the distance of *ca* 2.05 m between C9/10:2 and the reconstructed southern side of Shipshed 9's ramp structure (with the reservation that the ramp width is reconstructed). The ramp width of Shipshed 12 is reconstructed at *ca* 1.54 m (*MoP*: 0.04 m) based on the 6.48 m Phase 2 interaxial spacing between adjacent colonnades, and the distance (2.47 m) from the centre of C11/12:4 to the northern side of S12:R1. This measurement is very close to the built ramp structure of Shipshed 9 (*ca* 1.52 m). The Phase 2 ramps have been followed for a length of 33.21 m (*MoP*: 0.05 m; Pl. 13), measured from the east side of S12:R1 to the western-most part of S10:R1.

Ramp Blocks of Phase 2

Only a small section of a built-up Phase 2 ramp is preserved in Shipshed 9 (Figs. 187, 191b). Two rectangular

27. The level difference between the eastern (-0.82 m) and western (-0.86 m) parts of S10:R2 is 0.04 m over 4.53 m (1:113/0.5°). It is unlikely that this minimal inclination is intentional; it has probably been caused by wave erosion.

28. Based on the distance (2.44 m) between S14:R1 and the calculated centre of C14/15:1, and the 6.48 m interaxial width between the Phase 2 colonnades: 6.48 m - (2 x 2.44 m) = 1.60 m.

blocks and parts of a third are aligned longitudinally to the ramp (S9:R7–R9), and a fourth block is aligned across the ramp structure (S9:R6). Their average dimensions are shown in Table 7.6.

The Phase 2 blocks (ave. 1.21 x 0.63 x 0.36 m) are wider than the Phase 3 ramp blocks, whereas their lengths and heights are comparable (ave. 1.16 x 0.42 x 0.40 m).

Summary

These rock-cut and built features clearly served as foundations for ramps. However, they retain no evidence that would indicate the inclination or position of the original ramp surface. A calculation of the Phase 2 ramp inclination therefore cannot be made.

7.5. The Side-passages of Phase 2 and Phase 3

The grooves (*Rillen*) that Graser identifies on a submerged rock-cut structure in Mounichia Harbour were interpreted by Wachsmuth as features designed to give hauling crews secure footing.[29] Although the grooves may simply have been cuttings for transverse timbers on a ramp, or some other feature, Wachsmuth is to be credited for first touching on the architecture and function of the side-passages in this building type.

The side-passages are an integral and ubiquitous architectural feature of the Phase 3 shipsheds at Zea (Figs. 73, 81, 94; Pl. 6). Their layout provides clues not only of the general arrangement of architectural features, but also the practical role they served in slipping and hauling operations.

The Open Width of the Side-passages of Phase 3

In shipsheds the *open widths* of the side-passages at ground level are measured in two different spans:

1) Open width from the side of the ramp to the nearest side of a column base (or pier).

2) Open width from the side of the ramp to the bottom of a column shaft/or side of a side-wall.

These measurements depend on what are determined as the linear boundaries between the side-passage and the load-bearing elements of the superstructure on the one hand, and those boundaries between the ramp and the side-passages on the other.

In the first case (1) the boundary between the side-passage and the superstructure elements alternates due to the non-uniform placement of the latter and their foundations (see for example the boundary between the southern side-passage in Shipshed 17(η) and the colonnade dividing Shipsheds 17(η) and 18(χ) (Pl. 6). The foundation trenches that were opened to accommodate the column bases and their foundation blocks would have been levelled with fill in order to prevent tripping on the part of the hauling crews (Fig. 73). Consequently, the width of the side-passage cannot be measured from the ramp to the inner edge of the foundation trench because it does not take into account the functional area between the column bases and the side of the foundation trench closest to the ramp structure.

Furthermore, some of the top surfaces of identified column bases are at an elevation below that of the rock-cut bottom of the side-passages (Figs. 229a–229b), thus indicating that the infilling would have buried the base and created even wider spaces between the ramp and the side of the column shaft. Shipsheds 16, 17(η) and 18(χ) are representative of this fact. The top surfaces of the three upper-most column bases in the colonnade dividing Shipsheds 17(η)/18(χ) lie at 0.04 m below to 0.25 m above the southern side-passage of Shipshed 17(η) (Figs. 81, 229b). In the colonnade that divides Shipshed 16/17(η), the top surfaces of column bases C16/17:2(θ) and C16/17:4(ι) lie at about 0.02 m above to 0.09 m below the northern side-passage of Shipshed 17(η) (Fig. 229a). Assuming that the foundation trenches were topped up with fill, there was about 0.09 m more functional space to the side of the column on each side-passage at locations where the tops of the column bases were at the same level or lower than the side-passages.[30] Side-passages, then, were constructed at about the same level – in some places higher, in others lower – as the top surfaces of the column bases.

29. Graser 1872: 40; Wachsmuth 1890: 68, n.2.

30. The calculation is as follows: 0.81 m (ave. column base width) – 0.64 m (ave. bottom diameter of the base column drum)/2 = 0.09 m.

As *in-situ* column drums (and piers) have been found only at Oiniadai, Carthage, Kition, and in the Phase 3 shipsheds at Zea Harbour, the clearest general boundary between the colonnade (in some instances a side-wall) and the side-passage must be the side of the column base. However, the span between the ramp and the column shaft remains an important measurement for reconstructing the three-dimensional *space* between the columns and the hull of the warship. The spaces between the columns in the individual colonnades were probably also used as general working areas.

Next is the boundary between the ramp and the side-passages. In the upper parts of Shipsheds 16, 17(η), 18(χ), 20(π), 21(Δ), 22(N) and 23(Π), the upward-curving ramps in all likelihood were built to mirror and support the sterns of the ships, and are constructed to a height well above the side-passages, clearly defined as the side of the raised ramp structure (Figs. 91, 94; Pl. 6).

In the area of the 1885 excavations in Area 1 of Zea, there is very little evidence of the side-passages, as they have been covered by modern structures (min. covered area from 10.07 to 39.40 m).[31] In the submerged areas that have been excavated to date only four rock-cut features, S16:SSP2(?)–3(?), S23:SSP1(?) and S24: NSP1(?), can possibly be related to the Phase 3 side-passages, but no original surfaces can be identified and they offer no clear delineation of the side-passages near the ramps (Pls. 15–16). This could be due to the natural shallow contours of bedrock, or because the low inclination of the Phase 1 slipways had removed a considerable amount of bedrock, thus resulting in the need to build up substantial (now-missing) side-passage foundations in this area (Pl. 43). In the case of the Phase 1 slipways, the boundary to the open-passage is defined by the ends of the rock-cut slots for transverse timber sleepers (Pl. 11; Figs. 186, 193). The open widths of the side-passages found in Area 1 at Zea are excluded from the catalogue in Vol. I.2, Chapter 3, because they are not directly measurable in the empirical material. According to the ZHP measurements (Table 7.7), the average open width of the upper end of the side-passages to the column base is 1.31 m (range: 1.25 to 1.39 m), and the average open width to the bottom of the column shaft is *ca* 1.40 m (range: 1.34 to 1.48 m).

The Open Width of the Side-passages on Dörpfeld's Plan

On Dörpfeld's plan the side-passages are generally shown as blank spaces on each side of the ramp structures. The one exception to this is an unexplained feature in the southern side-passage of Shipshed 20(π) (Pl. 17).

The reconstructed open width of the side-passages to the column base can be calculated by deducting half the average column base width (0.41 m) from the printed measurement running from the axis lines of the individual colonnades to the side of the ramps. The reconstructed open width of the side-passage to the bottom of the column shaft is calculated by subtracting half the average lower diameter of a bottom column drum (0.32 m; see pp. 96–97).

The estimated average of the open width of the side-passages to the column base on Dörpfeld's plan is 1.30 m, and the estimated average open width to the bottom of column shaft is 1.39 m (Table 7.8). Only the southern side-passages of Shipsheds 21(Δ) and 24(Φ) vary markedly. In the upper end of the Phase 3 shipsheds, the ZHP survey average open width to the column base (1.31 m) and to the bottom of the column shaft (1.40 m) varies only 0.01 m from those of Dörpfeld (Tables 7.7–7.8).

The maximum preserved length of the Phase 3 side-passages is estimated at 55.87 m (*MoP:* 0.05 m, from inside of the back-wall preserved in the basement of Sirangiou 1 to S23:SSP1(?); Pls. 15–16).

The Side-passages of Phase 2

It is not possible to identify any Phase 2 side-passage features. However, the open width of the Phase 2 side-passages can be estimated based on the 6.48 m interaxial spacing between the Phase 2 colonnades, the average width of their colonnade foundation blocks (0.87 m) and the reconstructed width of the built ramp of Shipshed 9 (*ca* 1.52 m; Pl. 13). The open space between the ramp and the colonnade blocks would be *ca* 2.05 m. This measurements is augmented by: (1) the distance between the colonnade block C11/12:4 and

31. Measured from the inside face of the back-wall to the inside face of the western wall of the Sirangiou 1 apartment block, and from this point to the sea (Pl. 15).

Side-passage	Phase 3: Open width to column base (m)	Phase 3: Reconstructed open width to bottom of column shaft (m)
S16:NSP[32]	*ca 1.42*	*ca 1.42*
S16:SSP	1.30	*ca* 1.39
S17(η):NSP	1.26	*ca* 1.35
S17(η):SSP	1.25–1.29	*ca* 1.34–1.38
S18(χ):NSP	1.39	*ca* 1.48
Average	**1.31**	*ca* **1.40**

Table 7.7. Phase 3 side-passages. A comparison of open widths between the ramp and (1) the column base and (2) the bottom of the column shaft.

Side-passage	Centre line of colonnade to side of ramp (m)	Reconstructed clear width to column base (m)	Reconstructed clear width to bottom of column shaft (m)
S21(Δ):NSP	1.69	*ca* 1.28	*ca* 1.37
S21(Δ):SSP	1.80	*ca* 1.39	*ca* 1.48
S22(N):NSP	1.70	*ca* 1.29	*ca* 1.38
S22(N):SSP	1.68	*ca* 1.27	*ca* 1.36
S23(Π):NSP	1.66	*ca* 1.25	*ca* 1.34
S23(Π):SSP	1.69	*ca* 1.28	*ca* 1.37
S24(Φ):SSP	1.79	*ca* 1.38	*ca* 1.47
S24(Φ):SSP	1.63	*ca* 1.22	*ca* 1.31
Average	**1.71**	*ca* **1.30**	*ca* **1.39**

Table 7.8. Reconstructed open widths of the Phase 3 side-passages in Group 1 shipsheds of Zea in Dörpfeld's 1885 plan (MoP: 0.04 m). Measurements taken between the ramp and (1) a column base and (2) the bottom of a column shaft (based on the 0.64 m lower diameter).

ramp feature S12:R1: 2.02 m (*MoP*: 0.04 m; Pls. 13, 16–17); and (2) the distance between colonnade block C10/11:3 and the bottom edge of the ramp foundations S10:R2 at *ca* 1.96 m (as the built ramp would be narrower than its foundations; Fig. 194).

As the Phase 2 ramps are narrower than those of Phase 3, it is logical to expect correspondingly wider side-passages. But as the measurement (*ca* 2.05 m) is based on the reconstructed ramp width of Shipshed 9 it must be used with caution.

7.6. Comparative Side-passages from Other Shipshed Sites

Published evidence from other sites offers little information on side-passages. Researchers have generally

32. Measurement to the south face of the wall dividing Shipshed 16 and possible Shipshed 26. This measurement is based on severely damaged ramp feature S16:R1 and is not included in the average width calculation.

Shipshed	South/southwestern side-passage (m)	North/northeastern side-passage (m)
1	*ca 1.48*	n/a
2	n/a	*ca* 1.46 (ave.)
3	*ca* 1.29 (ave.)	*ca* 1.48 (ave.)
4	*ca* 1.41 (ave.)	*ca* 1.41
5	*ca* 1.34	*ca* 1.46
6	n/a	n/a

Table 7.9. Oiniadai, width of side-passages (Sears 1904).

focused on ramp structures and the load-bearing elements of the superstructure, with little or no documentation on side-passages. Although cross-sections are often published, most lack spot-heights and relevant longitudinal-sections.

Side-passages that have been identified on plans and sections include those found at Oiniadai, Kos, Mandraki (Rhodes), Sounion, Apollonia, Sicilian Naxos, Punic Carthage and Phoenician Kition. Unless there is additional or contrary evidence one may assume that all the side-passages described therein were accessible from the open ends of the shipsheds facing the sea (see also Chapter 8.1.3).

Oiniadai, Western Greece

The sloping side-passages of Oiniadai's six shipsheds were hewn out of bedrock (Fig. 44). In each shipshed, the side-passages appear to follow the gradient of the ramp, curving more steeply upwards alongside the upper end forming a U shape (seen in plan view) that connected the two behind the upper end of the ramp, directly under the stern of the stored warship.[33] This design would have allowed the crew to work around and under the stern of the ship. The widths of the side-passages were measured from the edges of the ramps to the edges of the column bases (Table 7.9).[34]

The side-passages have an average open width to the column base of about 1.41 m. Based on the 0.80 m width of the column bases and the average lower column diameter of 0.73 m, the open width to the bottom of the column shaft can be estimated at 1.45 m. At the eighth column position from the back-wall the side-passages are 0.75 m higher than the bottom of the ramp foundations (Fig. 43).[35]

Sears followed the south/southwestern side-wall for a distance of 48 m until he reached groundwater level.[36] Except for the distance from the top end of the ramp and side-passages (*ca* 3 m) to the back-wall, the side-passages are probably as long, or longer, but excavation of the submerged part of the complex is required for clarification.

Kos City, Kos

The northwest shipshed has relatively well-defined side-passages (Fig. 52).[37] The two parallel rows of blocks with rock-cut slots for transverse timbers are elements of one ramp structure. The gap between these and the load-bearing elements of the superstructure appears to be too narrow (*ca* 0.35 to 0.73 m) to have functioned as a side-passage (Fig. 52), even if there had been a narrower superstructure (colonnade, side-wall, etc.).[38]

The preserved foundations of the load-bearing elements of the superstructure are constructed at a slightly lower elevation than the top surface of the two rows of blocks making up the ramp and the inner sides of side-passages (Fig. 52; cross-sections: Λ–Λ, Δ–Δ). The gap between the two structures was

33. Sears 1904: 227–237, pls. IX–XI; Kolonas 1996: pl. 74β.
34. Sears 1904: scaled off pl. IX.
35. Sears 1904: 233, pl. XI.
36. Sears 1904: 227.
37. Kantzia 1992: 632–635, pl. 12; Lianos 1999: fig. 6.
38. Lianos 1999: scaled off fig. 6.

in all probability filled with earth. The open widths of the side-passages are therefore to be measured from the outer end of the slots that delineate between the ramp and the side-passage to the closest edge of the foundations of the superstructure; it is unclear whether the load-bearing elements were narrower at the top level of the side-passages and ramp. The northwestern side-passage is *ca* 0.77 to 1.24 m wide, and the southeastern side-passage is *ca* 1.02 to 1.34 m wide.[39]

Perhaps the narrower dimensions of the northwestern side-passage signify that the continuation of the southeastern foundations of the load-bearing elements supported a wall, and that the foundation blocks supported a narrower superstructure of columns or piers. The side-passages likely had an inclination close to that of the blocks forming the delineation between the ramp and the side-passages (Fig. 52).[40] No cuts suggestive of foot-holds were found. The ramp and side-passages were excavated for a length of *ca* 15.12 m.

Mandraki, Rhodes City, Rhodes

The excavators interpret the preserved side-passages of shipsheds BC, CD and DE (Period 4) as a part of the ramp structure (Fig. 49).[41] The good quality of Knoblauch's 1:200 plans, sections and cross-sections allows for a re-definition and examination of the architectural structures in question.

The sides of the ramps are identified as the course of blocks with rock-cut slots that probably held transverse timber sleepers. The fill (now missing) and the timbers in the slots would have made up the ramp structure. The side-passages were defined by a row of blocks arranged one course above the preserved ramp features and the fill between them and the foundations that carried the load-bearing elements of the superstructure. No features related to foot-holds were found in the side-passages. The wooden ramp structure could have been built up to a higher level than the side-passages, but since working space was needed for the hauling and maintenance crews, the side-passages were probably not incorporated into the ramp area.

Shipshed BC (narrow). The eastern side-passage was excavated for a length of *ca* 8.18 m. The structure consists of a row of seven blocks with a gradient of 1:4.36 (12.9°); except for the northern-most block, they alternate between roughly square and roughly rectangular (Fig. 49). This construction method strengthened the structure by locking the projecting square blocks into the fill between the course of blocks and the foundation piers of the colonnade (Fig. 49). There is no visible delineation between the row of blocks forming the eastern edge of the western side-passage and the colonnade dividing shipsheds BC/CD. The width of the side-passage is not reported.

Shipshed CD (narrow) & Shipshed DE (wide). The tops of features D2 and D3, both of which have cuttings that probably supported wooden posts, appear to be at the same level as the two side-passages (Fig. 49). The top surface of the now-missing fill between the two rows of blocks and the foundations for D2 and D3 is considered a part of the side-passages. As a result, the widths of shipshed CD's western and shipshed DE's eastern side-passages are measured from the outer edge of the row of blocks to the side of the slots for the possible wooden posts in D2 and D3. The two side-passages were built at an elevation *ca* 0.35–0.50 m higher than the top of the ramp.[42]

Shipshed CD (narrow). The western side-passage was excavated for a length of *ca* 7.40 m and is *ca* 1.15 to 1.25 m wide. The structure consists of five blocks with a gradient of 1:4.23 (13.3°) (Fig. 49).[43]

Shipshed DE (wide). The western side-passage was excavated for a length of *ca* 5.30 m and is *ca* 1.20 to 1.35 m wide. The western edge of the structure consists of four blocks with a gradient of 1:4.00 (14.0°) (Fig. 49).[44]

It is interesting that the widths of the side-passages of shipsheds CD (narrow) and DE (wide) are comparable. The similarity in width strongly suggests that the width of the side-passage was primarily determined by

39. Lianos 1999: scaled off fig. 6.
40. No valid gradient has been published: see p. 62.
41. Blackman, Knoblauch & Yiannikouri 1996: 371–426.
42. Blackman, Knoblauch & Yiannikouri 1996: scaled off fig. 7.
43. Blackman, Knoblauch & Yiannikouri 1996: scaled off fig. 6.
44. Blackman, Knoblauch & Yiannikouri 1996: measurements scaled off fig. 6.

the space needed for the hauling crew, and not by the size of the shipshed.

Although the ramp and the side-passages appear to have similar gradients in the section drawings (Fig. 49b), it must be stressed that the ramp gradients recorded were calculated from levelling points taken on the side-passage, and not on the ramp. The open width of the side-passages range from *ca* 1.15 to 1.35 m, and the gradient varies between 1:4.00 (14.0°) and 1:4.36 (12.9°). No features that could be related to wooden structures on the side-passages were found.

Sounion, Mainland Greece

The side-passages of the two shipsheds are cut out of the bedrock and appear to have the same gradient as the ramps (1:3.5/15.8°) (Fig. 48).[45] The probable remains of a bollard were found between the upper ends of the two ramps (Fig. 47), and no evidence was found of load-carrying elements between them. This central area is roughly twice as wide (*ca* 2.7 m) as the two outer side-passages: both the south/southwestern and north/northeastern side-passages are *ca* 1.3 m wide (Fig. 42).[46] The double side-passage in the centre was probably designed to accommodate two hauling crews simultaneously for coordinated operations, or perhaps just for more working space when two ships were standing side-by-side. The side-passages were also accessible from a staircase in the north/northeastern side-wall (on access points, see Chapter 8.1.3).

Apollonia, Libya

The side-passages are hewn out of the bedrock, and no evidence of rock-cut features for wooden structures was found (Figs. 50–51). The two side-passages of shipshed 2 are *ca* 2.4–2.5 m wide. In longitudinal cross-section the side-passages slope downward and match the level and gradient of the ramp (1:14.3/4.0°; Fig. 51).[47] The inclination would allow water to drain off the side-passage and flow down along the ramp structure and into the sea. The ramp structure of this shipshed is very narrow (*ca* 1.0 m) compared to other sites; a hull would have obstructed parts of the side-passages that could not have been used by a standing person. On the other hand, maintenance work could have been carried out on the bilge and keel areas of the hull by a person lying down.

Phase	Ramp width (m)	Side-passage width (m)
Phase 1	1.80 (south)	*ca* 1.70
Phases 2–3	4.10 (north)	*ca* 0.55
Phases 2–3	3.00 (south)	*ca* 1.10

Table 7.10. Kition, ramp width of phases 1–3 (Callot 1997).

Naxos, Sicily

Lentini and Blackman excavated paved side-passages at Sicilian Naxos. In the southeastern-most shipshed of the site, the widths of the side-passages range between *ca* 1.35 to 1.95 m. The side-passage width in the adjacent shipshed range between *ca* 1.05 to 1.75 m.[48] These dimensions must be used cautiously, however, as the ramp structures found in both shipsheds are off-set to the south-east, strongly indicating that these ramps and side-passages may not belong to the same building phase as the side-walls delineating them.

Ilôt de l'Amirauté & the Circular Harbour (North/North-east), Carthage, Tunisia

Remains of side-passages were excavated on the island in the middle of the harbour (Figs. 37–38). Like the ramps, the side-passages were made of a fill consisting of clay-sand with a concentration of marine shells.[49] No features suggestive of footholds were found.

On Ilôt de l'Amirauté the two transverse timbers making up the ramp structure of shipshed 13 average *ca* 2.10 m long. According to Hurst, 22 out of 30 shipsheds on Ilôt de l'Amirauté are more than 45 m long, and shipshed 13 belongs to this group.[50] The intercolumniation between the colonnades of these shipsheds widens towards the sea from *ca* 4.9 to 5.8 m+,

45. Kenny 1947: 194–200, pls. 31–34.
46. Kenny 1947: width measurements scaled from pl. 34.
47. Flemming 1965: 170–173, figs. 69–70; 1971: 103–105, figs. 14–15 (width measurements scaled off plan).
48. Blackman & Lentini 2004: scaled off fig. 5 (poster image resolution is 300 dpi).
49. Hurst 1994: 34–35.
50. Hurst 1994: 35.

Site	Open width of side-passages (m)
Zea, Phase 2, ZHP	*ca* 2.05
Zea, Phase 3, ZHP	1.31 (ave.)/1.40 (ave.)
Zea, Phase 3, Dörpfeld	1.30 (ave.)/1.39 (ave.)
Apollonia	*ca* 2.4–2.5
Sicilian Naxos	*ca 1.05–1.95*
Carthage, ramp 13	*ca* 1.65
Carthage, ramp F762	*ca* 1.83
Kition, phase 1	*ca* 1.70 (south)
Kition, phases 2–3	*ca* 0.55 (north) to *ca* 1.10 (south)
Kos	*ca* 0.77–1.24/ *ca* 1.02–1.34
Mandraki (shipshed CD, narrow)	*ca* 1.15–1.25
Mandraki (shipshed DE, wide)	*ca* 1.20–1.35
Oiniadai	*ca* 1.41 (ave.)/1.45 (ave.)
Sounion	*ca* 1.35 (ave.)

Table 7.11. Open widths of comparative side-passages (for references see notes on pp. 141–145).

and has a mid-range of *ca* 5.4 m (see Table 6.32). The width of the side-passages of ramp 13 is estimated from the mid-range intercolumniation between the colonnades (5.4 m) to be about 1.65 m.

In the north/northeastern part of the Circular Harbour at Carthage, two well-defined transverse timbers with an average length of *ca* 1.75 m delineate the width of ramp F762. Like the ramp, the side-passages are also constructed of clay-sand with a high concentration of marine shells. Their cross-sections resemble a shallow U (Figs. 38, 41).[51] The side-passages can be reconstructed at *ca* 1.83 m wide using the same estimated mid-range intercolumniation between the colonnades (*ca* 5.4 m) as the long shipsheds at Ilôt de l'Amirauté.

Kition, Cyprus

Behind the ramps at Kition runs a 1.20 m-wide passage that gives access to each side-passage via three stepped stairs.[52] The width of the side-passages of phases 1–3 were estimated based on the ramp width and the open space (intercolumniation) between the wall/piers colonnades (5.20 m; Table 7.10).[53]

7.7. Discussion

The open width of the majority of side-passages falls within the range of 1.20 to 1.50 m. At Mandraki, comparisons of measurements between the *wide* and *narrow* shipsheds indicate that the width of each side-passage was determined by the functional needs of the space, and not by the size of the shipsheds (Table 7.11). This is also clear when we compare the *narrow* shipsheds at Sounion and Mandraki with the *wider* shipsheds at Zea (Phase 3), Oiniadai, Kos and Carthage (ramp 13).[54]

Construction Methods

The Phase 3 side-passages found in Area 1 at Zea are mostly hewn out of bedrock, for example in the upper

51. Hurst 1994: 33.
52. Callot 1997: 74, fig. 2a; Yon 2000: fig. 7a.
53. Callot 1997: figs. 2a–2b.
54. See Table 6.32 for the interaxial spacings and intercolumniation of these shipsheds.

part of Shipsheds 16 and 17(η) (Figs. 73, 81, 91–92, 94, 174b, 176a; Pl. 6). In the areas of Zea where the contours and quality of the natural bedrock did not allow the side-passages to be shaped directly, they must have been constructed to the required height by means of foundation fills and/or architectural elements, such as blocks and perhaps timber. Some features in Area 1 are possibly related to such construction methods.

Rock-cut features in the area of the side-passages of the Phase 3 Shipshed 16 (S16:SSP2(?)–3(?)), Shipshed 23(Π) (S23:SSP1(?)) and Shipshed 24(Φ) (S24:NSP1(?)) could have served as foundations for blocks or (less likely) for a timber construction on the side-passages (Pls. 15–16). On the other hand, it is remotely possible that the features in Shipsheds 23(Π) and 24(Φ) may be the actual top surfaces of the side-passages.

In the southern side-passage area of Phase 4 Shipshed 27(?) were found two blocks (S27:SSP:1(?)–2(?)) in the same structural orientation as the colonnade dividing possible Shipsheds 26(?) and 27(?) (Pls. 10, 15, 41). South of these features a related foundation cutting (S26:SSP2(?)) was found in the southern side-passage area of Shipshed 26(?). Perhaps these features are the remains of built side-passages. Alexandri excavated what may be the remains of a side-passage next to a side-wall in Group 5 at Zea; here the blocks are resting on fill (see section A-A in Fig. 19).

A combination of blocks and foundation fill is documented at Kos, Mandraki and at Sicilian Naxos. Side-passages constructed by means of a foundation fill are found in Kition, and at both sites in Carthage, Ilôt de l'Amirauté and the north/northeastern part of the Circular Harbour. Rock-cut side-passages are found in Oiniadai, Apollonia and Sounion.

Side-passages and their Relationship to Ramps

In photograph PIR 6 the upper end of the ramp in Shipshed 21(Δ) in Group 1 at Zea (calibrated +4.82 m) is clearly constructed at a higher level than the side-passages, since the latter are not visible (Pl. 32b). The northern side-passage of Shipshed 18(χ) is not well defined near ramp block S18:R2 (+4.78 m); its level above the side-passage is calculated at 0.62 m on the basis of Shipshed 17(η)'s relatively well-preserved northern side-passage (+4.16 m). This figure is very close to the height of block S18:R2 (0.63 m).

When calibrated to the ZHP spot-heights, the upper ends of the best-preserved ramps of Shipsheds 22(N) (calibrated +5.46 m) and 23(Π) (calibrated +5.38 m) are constructed to a height of *ca* 1.30 and 1.22 m, respectively, above the northern side-passage of Shipshed 17(η). Taking the uniformity of the Phase 3 shipsheds into consideration, these measurements are probably close to the elevation of the ramp above the side-passages in the upper ends of Shipsheds 22(N) and 23(Π).

At Kition the ramps are also constructed well above the side-passages in the upper end of the shipsheds. The publications, however, make no mention of their height, nor were sections of these structures published that would enable it to be calculated. At Oiniadai, the side-passages follow the gradient of the ramps and match their upward slope (Fig. 45). As discussed above, along the keel-supporting ramp section the side-passages are positioned at the same level or just above the ramp.

Function and Three-dimensional Space of the Side-passages

The northern side-passage of Shipshed 16 at Zea runs parallel to Wall 16/26(λ) and is *ca* 1.42 m wide (Pl. 6). This is comparable to the average width recorded in Area 1 (1.31 m/1.40 m) and the open widths calculated from Dörpfeld's plan (1.30 m/1.39 m). The uninterrupted wall W16/26(λ) was in all probability constructed to the same height as the colonnades. The width of the northern side-passage clearly defines the maximum functional working space. If the extra work spaces available between the columns in the individual colonnades had been essential for the hauling and slipping operations, this side-passage would have been designed wider in order to compensate. It is clear from these considerations that the extra spaces between the colonnades were not necessary for hauling and slipping operations, or for repair and maintenance work. Even so, those engaged in these arduous tasks probably found it more convenient to work alongside a colonnade rather than a wall.