# EVIDENCE FOR WEST GREEK INFLUENCE ON MAINLAND GREEK ROOF CONSTRUCTION AND THE CREATION OF THE TRUSS IN THE ARCHAIC PERIOD

THE DETERMINATION OF REGIONAL STYLES is a recognized part of Greek architectural studies.[1] Such discussions have focused on ground plans, use of refinements, or ways in which architects solved specific problems common to all buildings.[2] This study introduces roof design as another means of recognizing regional building practices, as expressed in the form and function of the geison. Because of the geison's position at the top of the entablature and the edge of the roof, geison design reflects both the technical and the decorative aspects of the building and provides positive evidence concerning roof construction. Since wood from ancient Greek buildings is not commonly preserved, the woodwork of the ceiling and roof must be reconstructed from indirect evidence, such as the cuttings in stone members of the entablature and tympanum. In particular, the rafter beams generally came into contact with the lateral geison[3] (Fig. 1). The most thorough study of this subject is Trevor Hodge's book, *The Woodwork of Greek Roofs* (1960). On the basis of his own survey of extant geison blocks, Hodge recognized two basic forms, the flat-topped and the sloping-topped geison, each with several subtypes. But while Hodge acknowledged the diversity of forms, he maintained that the distribution of types of geison blocks revealed no chronological or geographical pattern.[4] The present study reexamines preserved geison forms from the Greek mainland and Sicily and brings new observations to bear on two specific areas of Greek architecture: the identification of a West Greek style of roof design and the role of Sicilian architects in the creation of a tie-beam truss.

## GREEK ROOF DESIGN

In Greek architecture the rectangular ground plan of most buildings allowed the roof to be designed with a double-pitch and a gable or hip at each end. As explained by Hodge, the woodwork of Greek roofs generally consists of primary timbers (ridge beam and purlins) and secondary timbers (rafters, battens, sheathing), where the ridge beam and purlins run parallel to the long axis of the building and provide the underlying frame for some or all of the secondary timbers just listed

[1] My dissertation (Klein 1991) focused on the development of the geison relative to the Doric order, while the present topic was only briefly addressed. Most of the mainland geisa were measured by me; dimensions of the Sicilian geisa are based on published drawings. An abbreviated version of this article was presented as a paper at the 92nd General Meeting of the Archaeological Institute of America, in December 1991 (Klein 1992). I would like to thank Barbara Barletta, Kevin T. Glowacki, Trevor Hodge, Margaret Miles, Brunilde S. Ridgway, Nancy K. Winter, and James C. Wright for their comments on earlier drafts of this paper. Any errors that remain are my own. All figures were drawn by me unless otherwise noted.

[2] Recent studies concerning regional architecture in the West are Mertens 1976; 1993; Barletta 1990. Barletta defines a regional architectural tradition as a "shared repertory of traits used within a limited geographical region."

[3] This is generally true of buildings in the Archaic period, but in later periods both the ceiling and the roof beams are placed lower, the latter eventually resting on top of the architrave: Coulton 1980, p. 165 and note 5; Martin 1951, pp. 452–453; Gruben 1986, p. 343. Gruben has postulated that the frieze was originally a Cycladic-Ionic invention intended to cover the ends of ceiling beams placed on top of the architrave. See also Mertens-Horn 1992. I thank Brunilde Ridgway for bringing these references to my attention.

[4] Hodge 1960, p. 77.

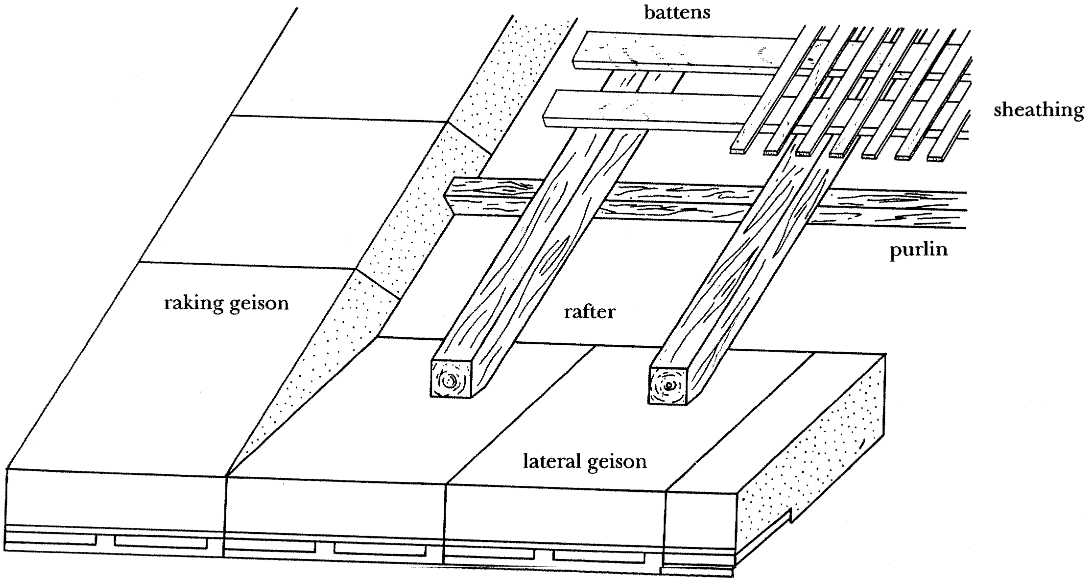



FIG. 1. Roof design and terminology

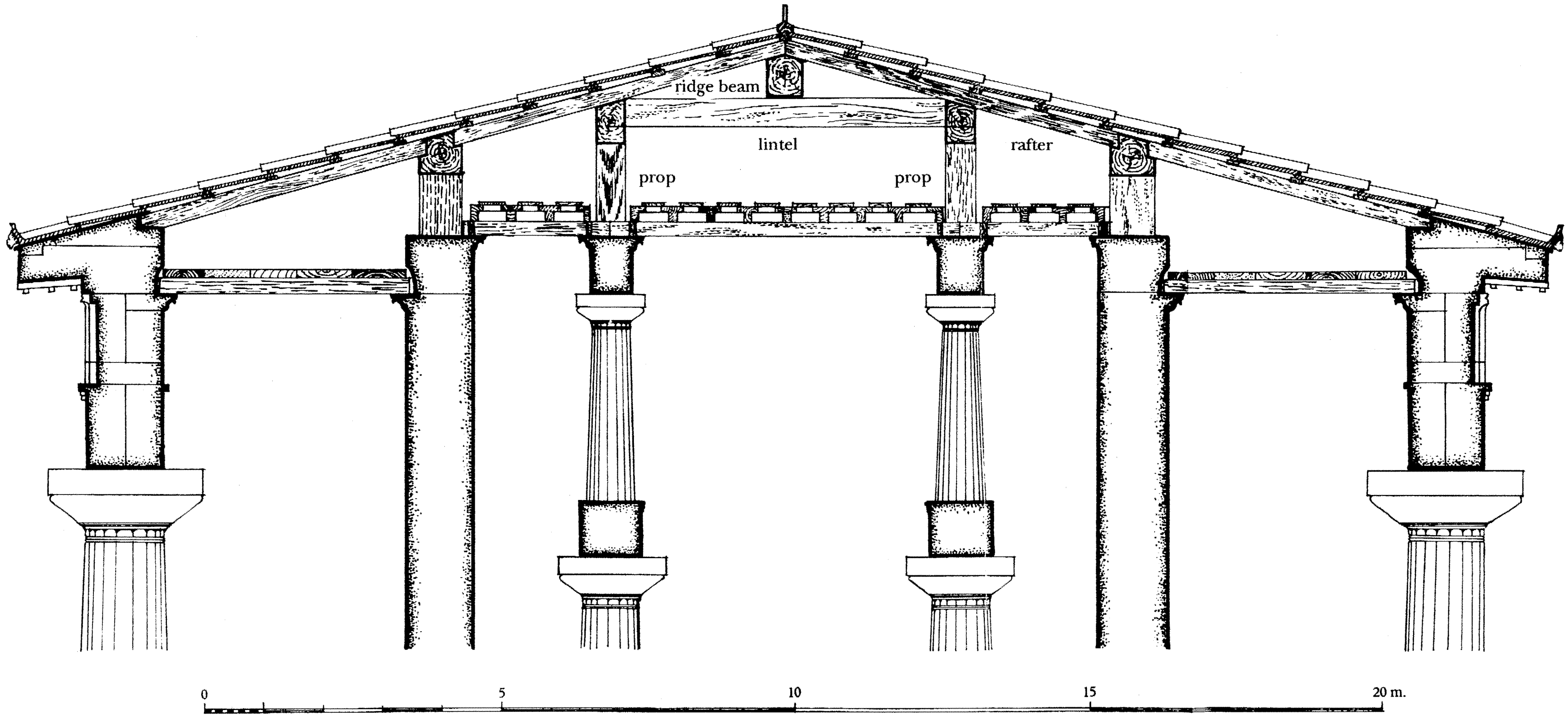
(Fig. 1). Together, the timbers support a roof of terracotta or marble tile. The primary timbers must be long enough to span the length of the building or be divided into smaller sections supported at regular intervals. In a small building they may rest on the end walls and span the interior without additional support, but in larger structures both the purlins and the ridge beam must be supported from below. This is commonly done by spanning the width of the cella with a horizontal beam (lintel), from which vertical elements (props) support the primary timbers (Fig. 2).[5] For the cella of a Greek temple (in general the longest and widest area to be roofed), the ridge beam and purlins run parallel to the walls and are supported by a vertical beam (prop) that in turn rests upon a horizontal member spanning the distance between the cella walls. As the width of the cella increases, the distance to be spanned by horizontal beams can be shortened by dividing the interior with a single or double colonnade. This produces a prop and lintel arrangement of timbers in which the weight of the roof is carried in a series of direct forces.[6] The horizontal beam (lintel) is supported at each end by two vertical supports (props), usually walls or colonnades. When a load is placed on the lintel from above, the beam bends downward. As the load increases, the height of the beam must also increase.[7] For this reason, the horizontal beams must have a large cross section in order to resist bending downward beneath their load.

In contrast to the system described above, in which the primary timbers support the secondary, some builders reverse this order of support by using a truss. The truss can be defined simply as

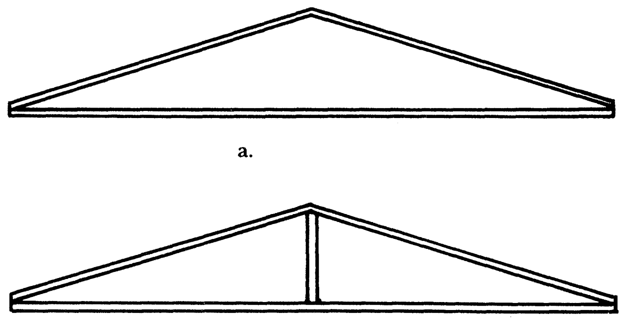
[5] Bankel 1989; 1993, pp. 102–103. In his study of the Late Archaic Temple of Aphaia on Aigina, Bankel discovered stone pillars with cuttings to support the purlins. He suggests that wooden props were used only when they could be doweled to another wooden member. Similar stone pillars have been restored in the Parthenon on the basis of cuttings in the epikranitis.

[6] The structural problems of a double-pitched roof are presented in Liebhart 1988, p. 12. The ridge beam and rafters are pulled down by gravity, creating a lateral thrust at the top of the wall, where the rafter ends push outward. As the pitch of the roof increases, so does the lateral thrust of the rafters. But if the ridge beam is supported from below by a prop, the lower ends of the rafters will be pulled inward, counteracting the outward thrust.

[7] Liebhart (1988, pp. 6–12) provides a useful summary of the formulae used to calculate the load-bearing capacity of timber and points out that a beam with twice the depth can carry four times the load of a smaller beam.




Fɪɢ. 2. Post and lintel roof design



a.

b.

FIG. 3. (a) Tie-beam truss; (b) tie-beam truss with king post

a triangular frame of beams with the ends held together in tension (Fig. 3).[8] In practical terms, this means that a horizontal tie beam spans the width of a building and is joined at each end to a sloping rafter beam. In this system the rafter beams, rather than being supported by the purlins, are part of an underlying frame that supports the primary timbers (see Fig. 10).[9] In effect, the wooden skeleton of the roof has been turned inside out. There are several practical advantages to the truss: first, wooden members need not be as large in section as their counterparts in the post and lintel system described above, since the forces are carried along beams rather than acting on them vertically; second, the truss can be used to span relatively wide areas without support from below and thus does not require interior colonnades.[10] An additional advantage to the truss, its ability to support the multiple purlins of a Gaggera roof, will be discussed below (pp. 349–351).

A truss is easily recognized when seen but more difficult to detect indirectly from architectural remains. The issue of whether or not a truss is used in a building has always been based on technical grounds and generally arises only when the width to be spanned without intermediate supports exceeds eleven meters. The largest clear span to have been roofed using the prop and lintel system is the cella of the Parthenon, which is 11.05 m wide.[11] But several Archaic buildings with apparently unsupported spans of over eleven meters are found in Sicily (Selinus E: 11.70 m; Agrigento Herakles: 11.84 m), raising the question of whether the Sicilians knew of the truss or simply had better materials. This question of "technique versus material" has formed the basis of most earlier discussions of the truss.[12] Simply stated, either the Sicilians knew how to build the truss (advantage: technique) or had access to timber supplies that were superior to those found elsewhere in the Greek world at that time (advantage: material). Hodge favored Sicilian knowledge of the truss because he believed that timber could have been transported to other parts of the

[8] Melaragno 1981, p. 84. Liebhart (1988, pp. 12–13) demonstrates how the joining of a horizontal tie beam with two sloping rafters produces tension by placing the rafters in compression and the tie beam in tension, which thus act together in a coherent system. The addition of a "king post," a vertical member between the apex of the rafters and the center of the tie beam, prevents the latter from bowing downward.

[9] Liebhart (1988, p. 13) suggests that when a truss is used the ridge beam is usually replaced by a pair of purlins at the top of the truss. Another solution would be to rabbet the rafters into the sides of the ridge beam, although the section of the ridge beam would have to be increased in proportion to the size of the notches in order to maintain its original strength.

[10] Liebhart 1988, pp. 12–13; Melaragno 1981, p. 84; Hodge 1960, pp. 40–41; Choisy 1884, p. 21.

[11] A list of buildings, along with their central span and means of support, is given in Hodge 1960, p. 39, table 1. For cella spans, see Mylonas 1953–1954; Stevens 1955, p. 251, note 10; Meiggs 1982, pp. 196–198.

[12] The primary discussions of the truss in Greek architecture are to be found in Hodge 1960, pp. 21–24, 38–44; Coulton 1977, pp. 157–158; 1980, pp. 162–165; and Meiggs 1982, p. 196.

Greek world, implying that wider spans, using better material, would have been more common than they were. He suggests that the Sicilians learned the truss form from the Carthaginians.[13] On the other hand, J. J. Coulton believes that the general superiority of West Greek roofs (revealed in their ability to span such wide distances) is due to the builders' access to the timber supplies of Mount Aetna and the Hieron mountains of northeastern Sicily and not to their knowledge of the truss.[14] As evidence in favor of this theory, he points out that the cost of transportation would have made lumber trade an improbability, although not an impossibility.[15] Russell Meiggs, in his book *Trees and Timber in the Ancient Mediterranean World,* supports this view.[16] The possibility that the truss was employed in 8th-century Phrygian buildings at Gordion, however, suggests that regions with readily available sources of high-quality timber may also have been somewhat precocious in their use of wood.[17]

While the availability of superior timber could conceivably lie behind the apparent ease with which the Sicilians roofed such wide cella spans, it does not adequately account for the apparent use of the truss in much smaller buildings. In the larger peripteral buildings such as Selinus C, D, and E, the width of the clear span is measured over the cella and could possibly be spanned with extremely large beams. Two smaller buildings for which trusses have been proposed, however, the Megaron of Demeter (II) at Gaggera and the Treasury of Gela at Olympia, have preserved rafter cuttings in the geison and entablature that do not accommodate particularly large beams. By approaching this discussion from a technical viewpoint and looking at the geison blocks of buildings from Greece and Sicily, one can trace the development of a West Greek roof, its potential role in the creation of the truss, and the way in which this design spread to the mainland in the Archaic period.

[13] Hodge 1960, p. 40.

[14] Coulton (1980, p. 164) states, "It seems reasonable, therefore, to explain the acceptance of wide spans within limited areas of the Greek world as due to the availability of better timber rather than to knowledge of the truss, for materials are more likely than skills to have a restricted range, particularly since we know there was a very high degree of intercommunication and sharing of progress among the different parts of the Greek world in other spheres of art and architecture."

[15] Coulton (1980, pp. 163–164, 295–296) notes that the Hieron and Arsinoeion at Samothrace also have extremely wide interior spans and suggests that, as in Sicily, the builders at Samothrace had access to exceptional timber resources in the forests of Thrace and Macedonia and did not know of the truss; *contra,* see *Samothrace* III, i, p. 199. The recent publication of the Arsinoeion (*Samothrace* VII, i, esp. pp. 87–88, 162–167) demonstrates that the round building, with a diameter of 15.50 m and a circumference greater than 47 m at the level of the frieze, originally had a conical roof supported by forty rafters, which were joined to a tension ring of wooden beams at the level of the frieze and held together at the top by a bronze compression ring. A secondary set of rafters to support the scale-shaped terracotta rooftiles rested on the sima at the lower end and on the primary rafters at the upper end. The purpose of the wooden tension ring was to counteract the lateral thrust of the lower ends of the primary rafters, while the ring at the top was needed to hold the beams in compression, much like the rafters in a truss. In fact, this system of using beams in compression and tension is impressive for its scale and ingenuity, far outstripping the simple form of a tie-beam truss in its use of counteractive forces. When the building was damaged by an earthquake in early Roman Imperial times the Roman architects rebuilt the roof in a far less ambitious, octagonal, form.

[16] Meiggs (1982, p. 196, note 20) states, "It is, however, much more difficult to believe that such a dramatic step forward [the truss] should have been ignored by the mainland Greeks for more than a hundred years." It may be that the truss was known but that its use entailed unacceptable changes in roof design.

[17] The abundant supplies of wood on the Anatolian plateau led to its prolific use in the Phrygian monuments at Gordion. The excavations of the University of Pennsylvania under the direction of Rodney S. Young uncovered the gabled tomb chamber constructed of wood under the Great Tumulus (*Gordion* I). The possibility that a truss was used to roof the 8th-century B.C. Megaron II (sometimes called the Mosaic Building of the West Phrygian House), with a clear span of 9.74 m, is discussed in Young 1957, esp. p. 322; 1962, esp. pp. 6–9; and Liebhart 1988, pp. 110–116. Once again, although the evidence points strongly toward the use of the truss, Liebhart expresses doubts as to whether the Phrygian builders understood its technical potential.

## MAINLAND GREEK GEISA

From the mainland of Greece about sixty Doric buildings (temples, stoas, and other types) dating from the 7th through the early 5th centuries are known to have geison and entablature blocks preserved (Table 1, pp. 342–343).[18] A detailed record of dimensions, proportions, decoration (moldings, mutules, guttae), and technical design (cuttings for rafters and ceiling beams, holes for the attachment of a terracotta/marble roofing system) permits careful analysis of the geison. Three key observations pertaining to the origin of the Doric order result from this analysis. First, the earliest monumental stone buildings established the function of the geison, but the blocks lacked a uniform system of decoration, such as moldings, mutules, and guttae. Second, the diversity of geison forms throughout the Archaic period belies theories of a linear development of the geison and suggests that early Doric architecture was characterized by experimentation. Third, most Archaic lateral geisa have no special accommodations for the woodwork of the roof. The few known exceptions are due to local traditions or owe their inspiration to influence from the West.

An examination of the "first generation" of stone geisa reveals a practical, rather than a decorative, source of inspiration for their design. Dated ca. 690–650 B.C., the earliest extant stone geisa are from Isthmia (Fig. 4),[19] and their simple form reflects the two primary functions of the geison: to support rafters and to provide an overhang to direct rainwater away from the sides of the building. A concave soffit and vertical face carried rainwater away from the walls, and some of the geisa had a shallow ledge along the back, possibly for ceiling or roofing beams. The similar design of the geison from the temple at Mycenae,[20] dated ca. 625–600 B.C., points to the effectiveness of this form as well as to communication between the two sanctuaries. The most revealing aspect of the geisa from these two sites, however, is the lack of any decoration, such as mutules and guttae, that would suggest a wooden prototype. This is an important observation to emphasize, since theories of Doric "petrification" imply that the earliest stone examples should mirror most closely their wooden forerunners. The negative evidence from these early monumental buildings therefore suggests that the stone geison was conceived primarily as a functional rather than as a decorative element and as one part of a stone building constructed using simple techniques.

By the early 6th century, buildings throughout Greece took on the more "canonical" forms of the Doric entablature. A mutular geison above the Doric triglyph-and-metope frieze is found in Athens (Akropolis, H-Architecture[21] and Building A;[22] Kerameikos, unknown building[23]), Corfu (Temple of Artemis),[24] Aigina (Aphaia Temple I),[25] Olympia (Treasury III or VII, Older Sikyonian Treasury, Unknown Building),[26] and Delphi (Old Tholos, Monopteros, Unknown Building)[27]

[18] Detailed in Klein 1991.

[19] Isthmia: The remains of the first temple were initially published by Broneer in 1971 (*Isthmia* I, pp. 36–37). Broneer postulated the reconstruction of a peripteral temple with a completely Doric entablature, many parts of which were made of wood and mud brick. His reconstruction presents a projecting stone geison (Group 10 blocks) placed above the metopes. The wooden rafters were attached between these geisa, and the ends projected beyond the face of the entablature, forming a sort of mutule above the triglyph. Note that the reconstruction by W. B. Dinsmoor Jr. (fig. 54) incorrectly shows mutules below the geison as well, contradicting Broneer's statement that the stone soffit was not sheathed with wood. The recent excavations are presented in Gebhard and Hemans 1992. They propose the reconstruction of a peripteros (7 × 18 columns) with a hipped roof at both ends. For a nonperipteral, "pre-Doric" reconstruction of the Temple of Poseidon at Isthmia, see Rhodes 1984, fig. 25.

[20] Wace 1949, pp. 84–86. Klein 1998 and forthcoming. Preliminary results were presented in a paper at the 93rd General Meeting of the Archaeological Institute of America, December 1992 (Klein 1993).

[21] H-Architecture: Wiegand 1904, pp. 1–63, 109–110; Heberdey 1919, pp. 127–142.

[22] Building A: Wiegand 1904, pp. 148–155.

[23] *Kerameikos* XII, pp. 5, 31, 47, Beil. 20, pl. 9.

[24] *Korkyra* I, p. 37, fig. 20.

[25] Schwandner 1985, pp. 42–54, figs. 26–35.

[26] Herrmann 1976, pp. 323–329, 332.

[27] Laroche and Nenna 1990.

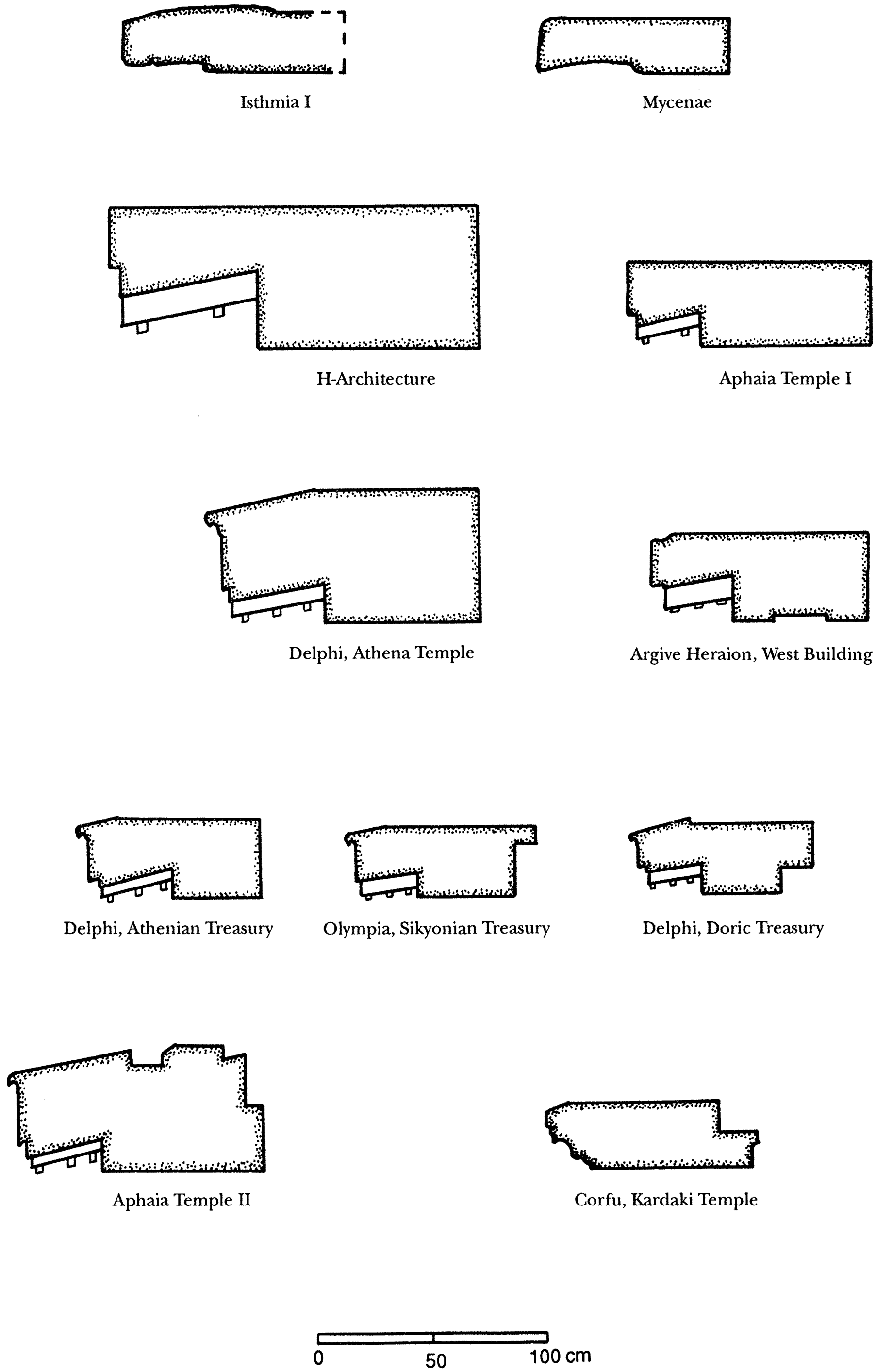



FIG. 4. Examples of lateral geisa from the Greek mainland in the Archaic period

| Site | Building | Date | Lateral Geison | Horizontal Geison | Raking Geison | Lateral Geison Design | Rafter Cuttings | Ceiling Cuttings |
|---|---|---|---|---|---|---|---|---|
| Aegina, Aphaia Sanctuary | Aphaia I | Ca. 570 B.C. | X | X | X | Mutular Geison, flat top | None | None |
| Aegina, Aphaia Sanctuary | Aphaia II | 500-490 B.C. | X | X | X | Mutular Geison, sloping top | Perhaps | Ledge |
| Aegina, Kolonna | Apollo Temple | 520-10 B.C. | X | | | Mutular Geison, sloping top | Perhaps | Ledge |
| Aegina, Kolonna | Unknown | 520 B.C. | X | | | Mutular Geison, flat top | None | None |
| Alipheira | Temple of Artemis | 500-490 B.C. | X | X | | Mutular Geison, sloping outer edge | Shallow ledge | None |
| Amyklai | Throne of Apollo | 525-500 B.C. | X | | | Non-mutular geison, flat top | None | Rectangular slots |
| Argive Heraion | West Building | 550-525 B.C. | X | | | Mutular geison, flat top | None | None |
| Argive Heraion | Unknown | Archaic ? | | X | | Non-mutular geison, sloping top | | |
| Asea | Temple of Athena Soteira and Poseidon | Ca. 525 B.C. | X | X | X | Non-mutular geison, flat top | None | None |
| Asea, environs | Unknown Temple | Early 5th century | X | | | Mutular geison, poss. flat top | None | NP |
| Athens, Agora | Former Stoa Poikile | Ca. 480 B.C. | X | | | Mutular geison, sloping top | None | NP |
| Athens, Akropolis | H-Architecture | Ca. 570 B.C. | X | X | X | Mutular geison, flat top | None | None |
| Athens, Akropolis | Building A | 560-550 B.C. | X | X | X | Mutular geison, sloping outer edge | NP | NP |
| Athens, Akropolis | Building with Painted Pediment | 550-25 B.C. | | X | | | | |
| Athens, Akropolis | Building C | 550-525 B.C. | X | | | Mutular geison, flat top | None | None |
| Athens, Akropolis | Old Athena Temple | 525-500 B.C. | X | X | X | Mutular geison, sloping outer edge | None | None |
| Athens, Akropolis | Unknown Building | 525-500 B.C. | | | X | | | |
| Athens, Akropolis | Building B | Late 6th century | X | | | Mutular geison, sloping outer edge | None | Ledge |
| Athens, Akropolis | Building E | Early 5th century | X | | | Mutular geison, sloping top | None | None |
| Athens, Akropolis | Building D | 450-425 B.C. | X | | X | Mutular geison, sloping top | None | None |
| Athens, Akropolis | Geisa with Smooth Mutules | Archaic? | X | | | Mutular geison, sloping top | None | NP |
| Athens, Kerameikos | Unknown Building | 600-550 B.C. | X | | | Mutular geison, flat top | None | None |
| Athens, Kerameikos | Round Building | 550-40 B.C. | X | | | Mutular geison, flat top | None | None |
| Corfu | Temple of Artemis | 580-570 B.C. | X | | X | Mutular geison and thrinkos | NP | NP |
| Corfu, Mon Repos | Kardaki Temple | 525-500 B.C. | X | X | X | Non-mutular geison, flat top | None | Ledge |

TABLE 1. Mainland Greek Doric Buildings and Lateral Geison Characteristics

TABLE 1, *cont'd*

| Site | Building | Date | Lateral Geison | Horizontal Geison | Raking Geison | Lateral Geison Design | Rafter Cuttings | Ceiling Cutting |
|---|---|---|---|---|---|---|---|---|
| Delphi | Monopteros | Before 548 B.C. | X | | | Mutular geison, flat top | None | Ledge |
| Delphi | Old Tholos | Before 548 B.C. | X | | | Mutular geison, flat top | None | Closed sockets |
| Delphi | Unknown (former Corinthian) | Before 548 B.C. | X | | | Flat top (soffit NP) | None | None |
| Delphi | Foundation XXIX | Before 548 B.C. | X | | | Non-mutular geison, flat top | None | None |
| Delphi | Temple of Apollo | 513-500 B.C. | X | | X | NP | NP | NP |
| Delphi | Temple of Athena | 510 B.C. | X | | | Mutular geison, sloping top | None | None |
| Delphi | Athenian Treasury | Ca. 490 B.C. | X | X | X | Mutular geison, sloping outer edge | None | Yes |
| Delphi | Doric Treasury | 470-460 B.C. | X | | | Mutular geison, sloping top | None | None |
| Delphi | 'Red Sandstone Geisa' | Fifth century | X | | | Mutular geison, sloping top | Yes | No |
| Eleusis | Telesterion | 510-500 B.C. | X | | | Mutular geison | ? | ? |
| Isthmia | Temple of Poseidon I | 690-650 B.C. | X | | | Non-mutular geison, flat top | Tapered cuttings | Ledge, cuttings |
| Isthmia | Temple of Poseidon II | 470-60 B.C. | X | | | Mutular geison, sloping outer edge | NP | NP |
| Kalydon | Temple A | 570 B.C. | X | | | Non-mutular geison, flat top | None | None |
| Kalydon | Unknown Building | 6th century | | | X | | ? | ? |
| Mavriki | Temple of Artemis Knakeatis | 550-525 B.C. | X | X | | Mutular geison, flat top | None | None |
| Mycenae | Temple | 625-600 B.C. | X | | | Non-mutular geison, flat top | None | Ledge |
| Olympia | Ts I Sikyon | Ca. 450 B.C. | X | X | X | Mutular geison, flat top | None | Yes, slot ceiling |
| Olympia | Ts II Syracuse | 500-475 B.C. | X | X | X | Mutular geison, sloping outer edge | Slanted slots | ledge |
| Olympia | Ts III/VII (Rope hole Bldg) | 600-550 B.C. | X | | | Mutular geison, sloping outer edge | None | None |
| Olympia | Ts IV (Epidamnos) | 550-525 B.C. | X | | | Mutular geison, sloping outer edge | NP | NP |
| Olympia | Ts IX (Selinus) | 550-525 B.C. | X | X | X | Mutular geison, flat top | None | None |
| Olympia | Ts XI (Megara) | 510-500 B.C. | X | X | X | Mutular geison, flat top | NP | NP |
| Olympia | Ts XII (Gela) | 540-530 B.C. | X | X | X | Non-mutular geison, sloping top | Slanted slots | Yes |
| Olympia | Older Sikyonian Ts | Early 6th century | X | | | Non-mutular geison, flat | None | None |
| Olympia | Limestone Architecture | ? | X | | | ? | ? | ? |
| Olympia | 'Geisa without Mutules' | ? | X | | | Non-mutular geison, sloping top | None | None |
| Olympia | Temple of Zeus | 470-457 B.C. | X | X | X | Tripartite | Slanted slots? | NP |
| Olympia | Bouleuterion, South | Ca. 510-500 B.C. | X | X | | Mutular geison, flat top | None | Ledge |
| Olympia | Bouleuterion, North | Ca. 500 B.C. | X | X | | Mutular geison, flat top | None | Ledge |
| Perachora | Temple of Hera Akraia III | 525 B.C. | | X | X | NP | NP | NP |

(Fig. 4). As seen in Table 1, the number and shape of guttae could vary along with the width of the corresponding mutule. In other cases, the mutules and guttae were omitted altogether. Contemporary buildings with non-mutular geisa are found at Olympia ("geisa without mutules"),[28] Delphi (Foundation XXIX),[29] and the Argive Heraion (unknown building).[30] A stone geison from Kalydon shows that the cassette geison, considered by some to be a primitive form imitating a wooden roof, is simply a decorative soffit on an otherwise simple slablike block.[31] These differences indicate a willingness to experiment with early Doric forms in the early 6th century. Each block performs the same functions, to seat the rafter(s) and create an overhang, but the treatment of the soffit is contingent upon local tastes in decoration.

These observations on early monumental architecture contrast sharply with earlier theories. In particular, the study of the origins of the architectural orders by the Roman architectural historian Vitruvius described the Doric order as based upon "carpenter's work," imitating wooden forms in stone (*De Architectura* 4.2). Vitruvian theory stresses the dependence of the Doric frieze and mutular geison on woodwork joined by nails (mutules representing the ends of rafters, with guttae depicting wooden pegs).[32] Such a design presumes regular beam placement in the hypothetical wooden forerunner and leads one to expect mutules and guttae in the earliest stone geisa. Instead, these very features appear to be decorative elements that can be adapted according to circumstance. While monumental Doric architecture consciously imitates carpentry work in stone, perhaps out of the desire to recall a more venerable form of construction, there is no evidence to suggest that such sophisticated wooden forerunners existed in reality. Instead, the mutular geison represents a second step in the decorative evolution of the Doric order that is unrelated to direct structural antecedents.

Vitruvian theory also postulates a complex system of rafter and ceiling beams for the origin of the Doric entablature, but the early Doric geisa offer only negative evidence. The raking geison blocks frequently have cuttings for the ridge beam and purlins, but the lateral geison rarely shows similar cuttings (see Table 1). This technical aspect of the geison has been largely ignored, often giving rise to false assumptions about the construction of the wooden roof frame and the roofing system above it. For example, in a recent study of the development of roof revetments Nancy Cooper discusses tile dimensions relative to rafter placement (i.e., the distance between rafters being equal to the width of a tile)[33] and infers that cuttings were made in the geison blocks before they were raised into position, and therefore that the tile dimensions were based upon an established building module, determined at the beginning of construction. While the discussion focuses on the correspondence of tile dimensions to an overall building module, the course of the argument reveals a number of underlying assumptions: first, the idea that the tiles rested directly on the rafters,[34] and second, and more relevant to the present study, the belief that cuttings were made in the lateral geison to seat the rafters. The latter assumption is contradicted by evidence that such cuttings are extremely rare on the Greek mainland in the Archaic period and, when present, do not seem to relate to the tile placement at all.[35] For

[28] Herrmann 1976, p. 330, fig. 6.

[29] *FdD* II, 1a, pp. 97–117, fig. 142.

[30] Amandry 1952, pp. 252–253, fig. 15.

[31] Dyggve 1948, pp. 20–25, 108–118, 214–219. Discussed in Klein 1991, pp. 98–104. The lateral and raking geisa of the Athena temple at Paestum have a coffered soffit; see Krauss 1959.

[32] Howe 1985, pp. 93–117; Klein 1991, pp. 163–169. A recent consideration of the influence of wooden forerunners on the Ionic order is presented in Bingöl 1990. Here there appears to be stronger evidence for the influence of wooden forms on later stone elements.

[33] Cooper 1989, p. 12.

[34] Hodge (1960, pp. 60–75) recognizes five possible arrangements: (1) tiles, clay, sheathing, battens, rafters, purlins; (2) tiles, sheathing, battens, rafters, purlins; (3) tiles, battens, rafters, purlins; (4) tiles, rafters, purlins; (5) tiles, purlins. Winter (1993, pp. 306–307) suggests that pan tiles generally rested directly on the rafters without intervening layers.

[35] Hodge 1960, pp. 60–61. The lack of correspondence between tile spacing and rafter cuttings is illustrated by the Syracusan treasury at Olympia (Mallwitz 1961), one of the few buildings on the Greek mainland to have any rafter

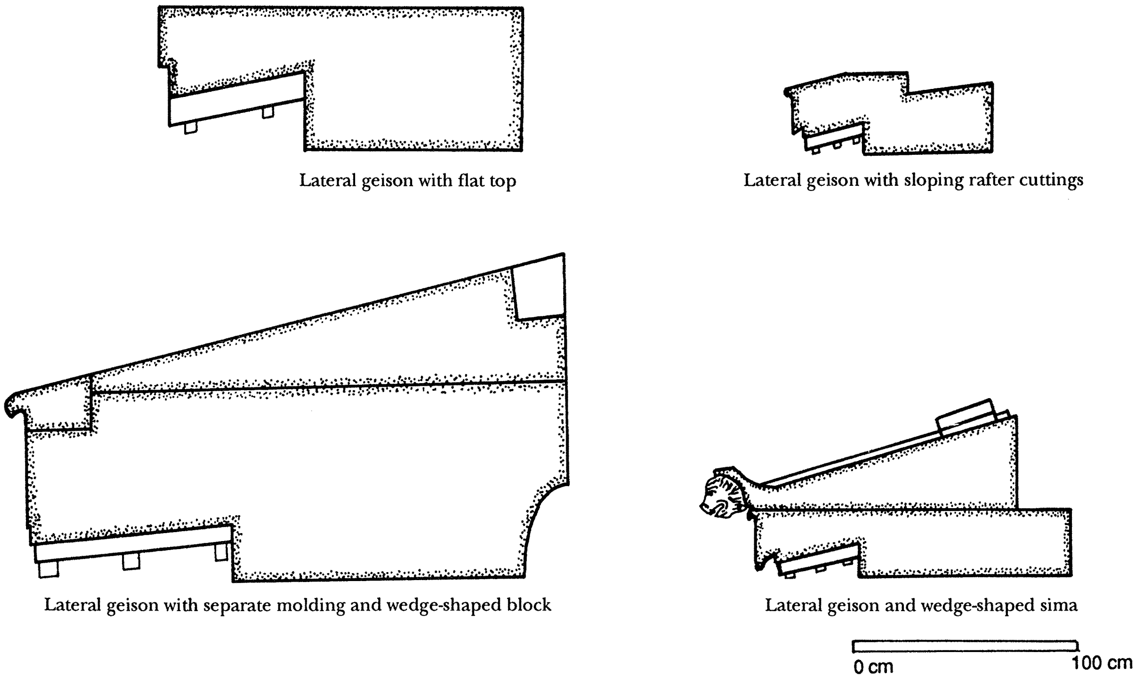



Fig. 5. Typology of the lateral geison

these reasons, this study undertakes a reappraisal of the technical role of the geison and how it relates to the woodwork and roofing system.

During the 6th and early 5th centuries mainland Greek buildings (Fig. 4) consistently employed a simple, flat-topped block. In some cases, the rough finish of the top surface and the presence of nail holes to attach architectural terracottas rule out the presence of an additional upper block. The absence of cuttings for wooden beams suggests that in most cases the wood was cut to fit the stone.[36] While the spacing of rafters may have been related to tile size or an overall building module, this cannot be determined on the basis of the extant blocks. There is no firm evidence that beams were ever placed in accordance with the mutule spacing or that they were attached by means of nails.

In addition to this common form of geison, a few mainland geisa of the Archaic period had a flat or sloping top surface with rafter cuttings or were made from multiple blocks (Fig. 5). Such exceptions are found on the island of Corfu, where the Temple of Artemis has a lateral geison made in two blocks, the uppermost of which may have had cuttings for rafter beams; at Olympia, where the treasuries of Gela and Syracuse have single-block geisa with special rafter cuttings and the Temple of Zeus has a lateral geison made in three blocks; at Delphi (red sandstone geisa); and at Aigina, where the second temple of Aphaia and the Temple of Apollo in the Kolonna sanctuary have cuttings in the lateral geison that may be a local innovation.[37] These mainland geisa blocks with cuttings are few in number and contrast sharply with the plentiful examples found in Sicily.

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cuttings at all. As discussed below, the lateral geisa from this treasury have rafter cuttings of differing widths and depths, irregularly spaced. This absence of regular rafter intervals is puzzling, but Mallwitz suggests that beam placement was determined by beam size, that is, there was a greater distance between larger beams, a lesser between smaller ones.

[36] Hodge 1960, p. 82.

[37] For the Artemis temple on Corfu, the Geloan and Syracusan treasuries, the Temple of Zeus at Olympia, and the Delphi "red sandstone geisa," see below. For Aigina, see *Alt-Ägina* I, i, p. 71, with review by William B. Dinsmoor Jr. (1977).

## SICILIAN GEISA

The earliest architecture of Sicily has yet to be fully appreciated for its potential contribution to the study of Greek architecture. Its rich diversity of forms, surpassing those of the mainland discussed above, creates an impression of dynamic experimentation in decoration and technology. The present study looks at nine buildings from Selinus (Table 2) that are the most instructive for understanding roof design in archaic Sicily.[38] Other sites may share all or some of the characteristics illustrated at Selinus, but very few temples preserve geison blocks in comparable quantity.

Two types of lateral geison may be distinguished among the earliest examples of lateral geison blocks found in the sanctuaries at Selinus.[39] The first has cuttings with slanted bottoms to hold individual rafters, and the second has square or rectangular cuttings with flat bottoms that pass through the entire height of the geison. The first style is illustrated by the geison from a building on the acropolis of Selinus, known as the Building with Mutuleless Geisa (Fig. 6).[40] The lateral geison is simply designed, with a flat, smooth soffit and a straight, unarticulated profile. The top surface has an outer sloping edge with iron nails for attaching architectural terracottas still preserved along the front edge, but in back the surface is flat, with angled cuttings to seat the rafters. The width of individual cuttings varies widely (35 cm, 41 cm, 43 cm), and they are 5–9 cm at their deepest end.[41] The horizontal geison has a flat top, a simple vertical face, and a plain soffit. An example of the second style of geison comes from the Malophoros sanctuary to the west of the acropolis (Contrada Gaggera) and belongs to the building identified as the Naiskos of Demeter (I), built in the early 6th century and replaced a few decades later. Its slablike blocks (Fig. 7) have a simple profile without moldings, mutules, or guttae, and the geison is comparable to the horizontal geison from the Building with Mutuleless Geisa.[42] Rectangular cuttings in the backs of the blocks reveal the important technical function of these geisa as opposed to their minimal decorative role. The cuttings (ca. 31 cm deep and 20 cm wide) pass through the blocks (18 cm high), and while some are placed in the center of a single block, others are divided between two adjoining blocks. Each one held the end of a rafter in a fixed position, to avoid any movement forward or to the sides. As shown in Gabrici's reconstruction (here redrawn as Fig. 8), the purlins were seated in closed sockets (cut in the lower edge of the raking geison) and, in the case of the lowest purlin, in a shallow ledge along the back of the lateral geison. The placement of this ledge *above* the cuttings for the rafters demonstrates that the purlins rested on top of the rafters, rather than vice versa. There is nothing to suggest that there were also horizontal beams held in the lateral geison cuttings, and so the ceiling must have been placed at a lower level or omitted altogether. A date in the first quarter of the 6th century has been suggested for both buildings. Because the Building with Mutuleless Geisa and the Naiskos of Demeter (I) are among the earliest monumental buildings at Selinus, the presence of two different solutions for securing rafter beams indicates a time of experimentation and innovation in stone architecture.

[38] On the prominence of Selinus and its sanctuaries, see Jameson et al. 1993.

[39] Gabrici 1935, cols. 137–262; 1956, cols. 238–243.

[40] Gabrici 1935, cols. 218–219, figs. 63, 64. Blocks of the lateral geison and horizontal geison, all without mutules, were found in the fortification of the acropolis in the same area as the blocks of Temple Y (Temple of the Small Metopes).

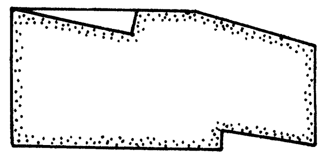
[41] Gabrici (1935, cols. 218–219) described them as being 18–20 cm apart, but it is unclear whether he measures from the center or from the sides of each. He does note that the geisa also have fragments of iron nails in the top surface, spaced 18–21 cm apart. Since the nails probably held cover tiles in place, their placement would correspond to the presence of a rafter beam, and suggests that the rafter cuttings were spaced 18–20 cm apart.

[42] Gabrici 1927–1928; 1935, cols. 141–146; 1956, cols. 238–245. The recent discovery of another precinct to the south of the Demeter complex has revealed another early temple (600–575 B.C.), probably dedicated to Hera, with a simple geison with slanting underside: Parisi Presicce 1986; Tusa et al. 1986, p. 40.

| Site | Building | Date | Lateral Geison | Horizontal Geison | Raking Geison | Lateral Geison Design | Rafter Cuttings | Ceiling Cuttings |
|---|---|---|---|---|---|---|---|---|
| Selinus | Building with mutuleless geisa | 600-575 B.C. | X | X | | Non-mutular geison | Slanted slots | None |
| Selinus | Naiskos of Demeter (I) | 600-575 B.C. | X | X | X | Non-mutular geison | Flat slots | Same as rafter? |
| Selinus | Megaron of Demeter (II) | Ca. 550 B.C. | X | X | X | Non-mutular geison | Flat slots | Flat slots |
| Selinus | Temple of the Spiral Acroteria | Ca. 550 B.C. | X | X | X | Non-mutular geison | Flat and slanted slots | Flat (with rafter?) |
| Agrigento | Archaic sacellum | 560-550 B.C. | X | | | Mutular geison | Slanted slots | None |
| Selinus | Temple Y | 580-560 B.C. | X | X | | Mutular geison and sloping thrinkos | NP | NP |
| Selinus | Temple C | Ca. 550 B.C. | X | X | X | Mutular geison and flat thrinkos | Slanted slots | None |
| Selinus | Temple D | Ca. 540 B.C. | X | | X | Mutular geison and separate moulding | NP | NP |
| Selinus | Temple F | Ca. 530 B.C. | X | X | X | Tripartite geison | NP | NP |
| Paestum | Temple of Hera I/Basilica | 550-520 B.C. | X | X | | Thrinkos only, no mutular geison | None | None |
| Paestum | Temple of Poseidon/Hera II | 480-470 B.C. | X | X | X | Tripartite geison | Slanted slots | None |
| Selinus | Temple E | 480-470 B.C. | X | X | X | Tripartite geison | Slanted slots | None |
| Himera | Temple of Victory | 480-460 B.C. | X | X | | Flat with wedge-shaped sima | None | None |

TABLE 2. Lateral Geison Characteristics of West Greek Doric Buildings

a.



b.

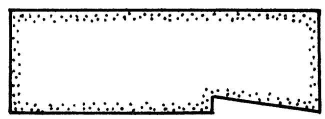


Fig. 6. Selinus, Building with Mutuleless Geisa: lateral (a) and horizontal (b) geison blocks (after Gabrici 1956, fig. 64)

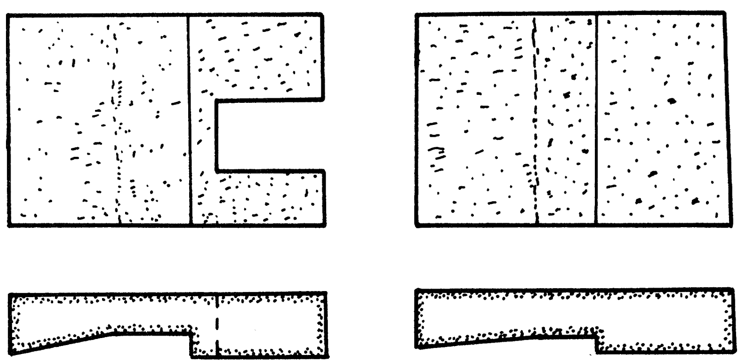


Fig. 7. Selinus, Sanctuary of Demeter Malophoros, Naiskos of Demeter (I): lateral geisa (after Gabrici 1935, figs. 5, 7)

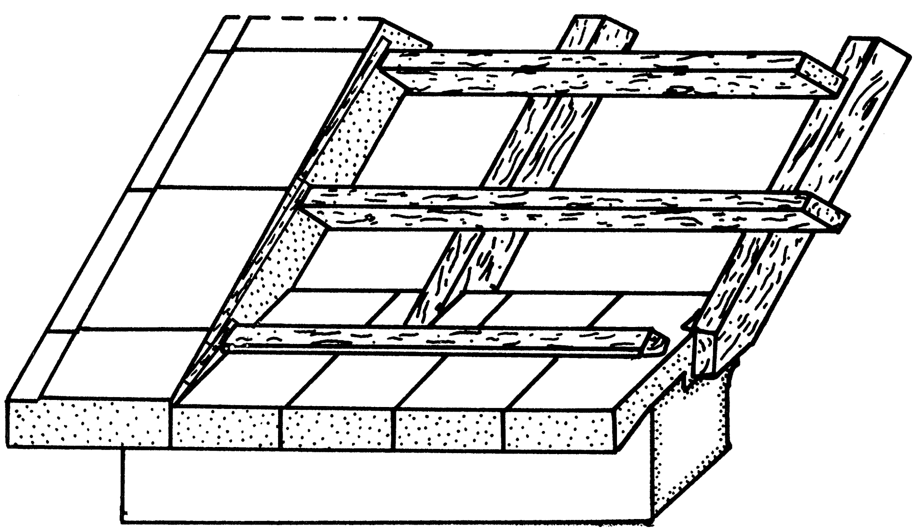


Fig. 8. Selinus, Sanctuary of Demeter Malophoros, Naiskos of Demeter (I): reconstruction of woodwork (after Gabrici 1956, fig. 10)

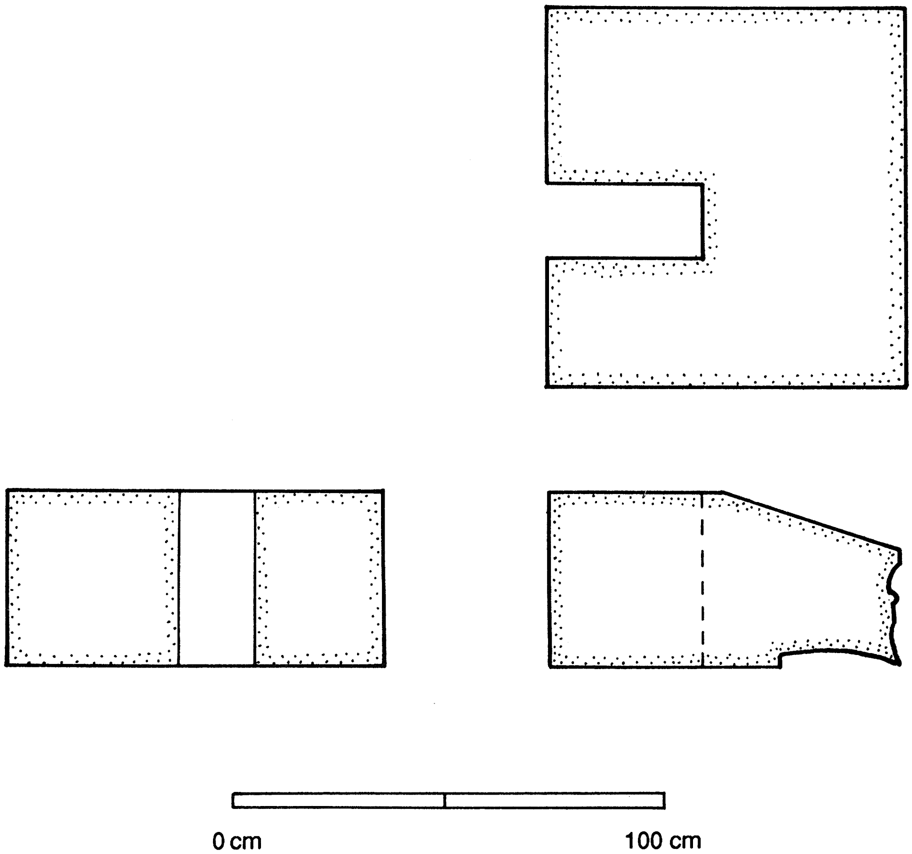



FIG. 9. Selinus, Sanctuary of Demeter Malophoros, Megaron of Demeter (II): lateral geison and reconstruction of corner (after Koldewey and Puchstein 1899, pl. 11)

An important advance in lateral geison design is seen in the Megaron of Demeter (II), built ca. 550 B.C. (Figs. 9, 10:a). Much better preserved than its predecessor, Megaron (II) was a closed building with a tripartite plan: pronaos, naos, and adyton.[43] The walls were of ashlar masonry crowned by a geison with a smooth soffit and an elaborately profiled face and with cuttings to receive wooden beams. A reconstruction of the roof was attempted by Hodge, who notes that, unlike in other buildings, the cuttings for the primary beams (ridge beam and purlins) are found in the tympanum as opposed to the raking geison, since here the raking geison sits above the beams.[44] There are cuttings in the tympanum blocks for the ridge beam and ten small purlins (five on each side of the ridge beam) that ran the length of the building. Above the pronaos, the purlins were small beams in square sockets, while above the cella and adyton the beams were larger (20 cm square) and were secured in tapering sockets (Fig. 10). The lowest purlin rested on top of the lateral geison, in a design first seen in the Naiskos of Demeter (I). Hodge rightly points out that above the cella the cuttings in the tympanum blocks (of the pronaos wall) allow for a rafter to be placed on top of the purlins but that it would have been extremely thin (ca. 4 cm) and would have had "little structural significance" (1960, p. 20). While eleven separate props could

[43] Koldewey and Puchstein 1899, pp. 85–90; Gabrici 1927–1928, cols. 21–52, 150; 1935, cols. 155–156, 250; Gruben 1986, p. 276. For the later history of the sanctuary, see White 1967.

[44] Hodge 1960, pp. 17–24, fig. 7:a, b; Gruben 1986, p. 276.

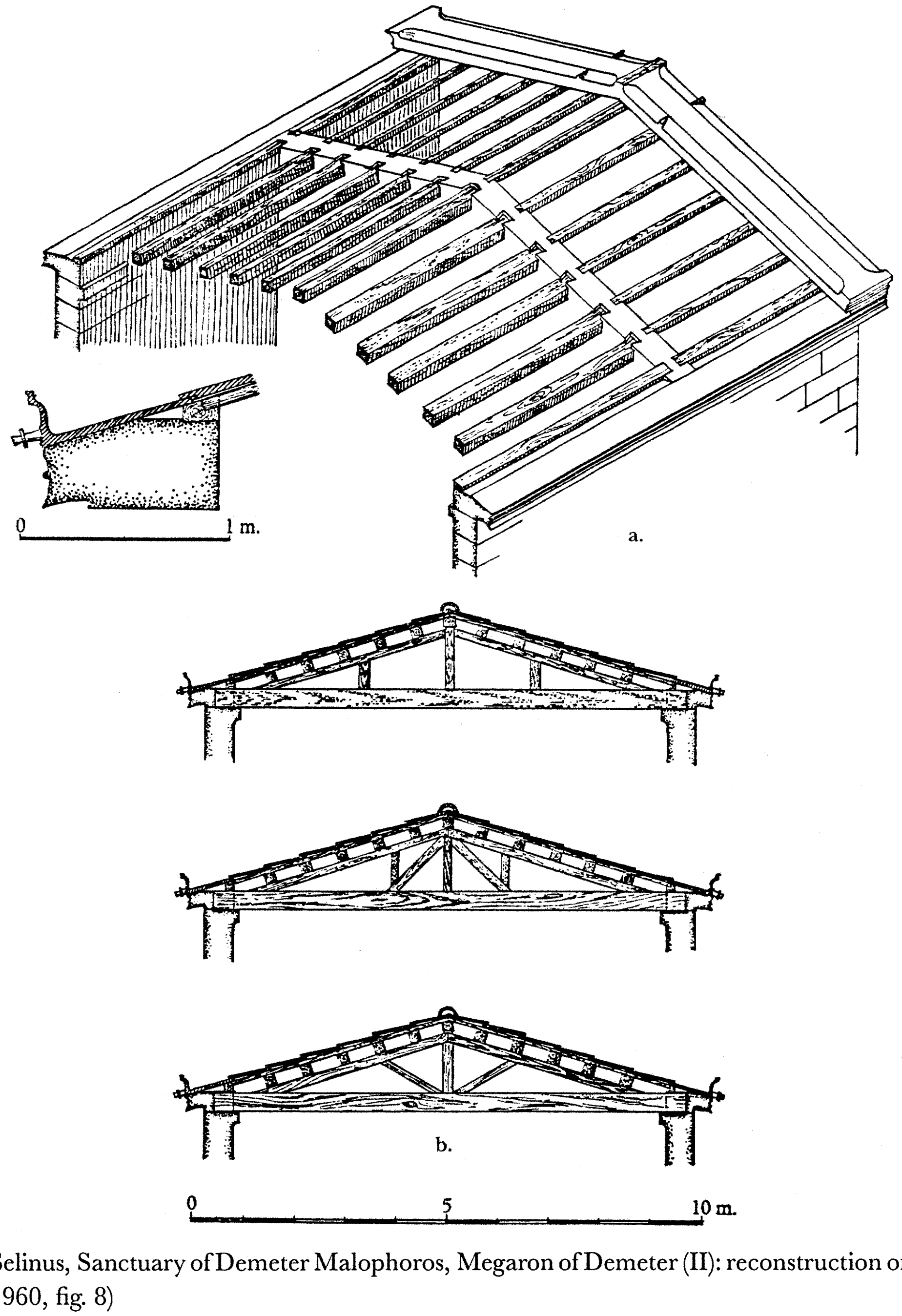



FIG. 10. Selinus, Sanctuary of Demeter Malophoros, Megaron of Demeter (II): reconstruction of roof (Hodge 1960, fig. 8)

have supported the individual beams, Hodge proposed another arrangement. As in the Naiskos of Demeter, rectangular cuttings in the back of the lateral geison have rectangular sections with flat bottoms, 40.5 cm high and ranging from 17.0 cm to 27.5 cm in width. These variations in width led Hodge to suggest that the smaller cuttings held only a ceiling beam, while the larger cuttings held a rafter together with a horizontal beam. While it is necessary to point out that rafters of different sizes could also be accommodated in this position, the smaller beams would serve as relatively small rafters for a building of this size. By contrast, Hodge's reconstruction is attractive because the combination of two rafters with a horizontal beam forms a triangular frame that could have supported the purlins and ridge beam. This solution to the problem of supporting multiple, tilted purlins may represent the creation of the truss, an innovative technique of placing the ends of the rafters in tension with a horizontal beam.[45]

The value of the truss lies not in its ability to span an extraordinarily wide building without interior supports, but rather in its acting as a means of support for the tilted purlins. The sizes of the rafters and horizontal beams, with a width of no more than 27.5 cm, as attested by the preserved cuttings in the lateral geison, are not exceptional. The relatively small size of this cross section is revealed by the measurements of primary timbers given by Hodge.[46] Thus the crossbeams represent timbers of a commonly available size, frequently employed both in Sicily and on the Greek mainland and certainly not requiring a special timber source. This triangular frame cannot be replaced by larger, stronger beams, and the design cannot be attributed to better building materials. Instead, it seems likely that the Selinuntine architect may have attempted this innovative solution in the face of the particular demands of roofing Megaron (II). This building required a frame to support eleven individual purlins along the length of the cella, which was not unusually wide (width 8.47 m). If Hodge's reconstruction is accepted, the Megaron of Demeter (II), dated ca. 550 B.C., would represent one of the earliest known uses of the truss in Greek architecture.[47]

The so-called Temple with Spiral Acroteria on the nearby acropolis at Selinus demonstrates a similar preference for a roof with tilted purlins (Fig. 11:d).[48] Its foundations reveal a pronaos and naos of almost equal size, with the building as a whole measuring 15.94 × 5.64 m. Barbara Barletta has noted that the lateral geisa have a long, shallow ledge to hold the lowest row of purlins, as well as vertical slots (30 cm wide) for horizontal beams. As in the Megaron of Demeter (II), these slots pass through the entire height of the block and may, as Barletta suggested, have held a rafter and a horizontal beam in the form of a triangular frame, or tie-beam truss.[49] The presence of these two buildings at Selinus may indicate a local preference for roofs with

[45] It should be noted that in this roof design the span of the cella was not so large as to demand a truss in place of a prop and lintel support, but the technique of using multiple tilted purlins in association with the ridge beam to support the roof (identified as a Gaggera roof), when placed above a cella, requires a triangular frame to support the roof. Hodge (1960, p. 22) argues that the awkward use of a Gaggera roof over the cella was undertaken only because the triangular frames (or trusses) were going to be used in the first place. It may be that the opposite is true: the presence of *tilted* purlins, as opposed to beams placed parallel to the ground, is an innovation in itself. The member providing support for the purlins would ideally have a surface at the same angle, that is, at a slant. While it is conceivable that eleven individual props supported by a wide horizontal crossbeam, each with its top surface cut at an angle to seat a purlin, could have supported the Gaggera roof over the cella of this building, this arrangement seems far less stable than would an underlying support, whether a triangular frame or rafters.

[46] Hodge 1960, p. 46, table 2.

[47] Gruben (1986, p. 276) noted the developed ashlar construction and argued for a date around 550 B.C. See also Barletta 1983, p. 182.

[48] Gabrici 1935, cols. 150–155, 249, pls. II–V; 1956, cols. 245–249; Barletta 1983, pp. 182–183. This temple has been attributed to the foundations previously associated with Temple Y (Temple of the Little Metopes). For a discussion of the foundations, see Gabrici 1929, cols. 80–81; 1956, cols. 245–248.

[49] Barletta 1983, p. 182; Gabrici 1935, col. 154, pl. IV:2, 3.

multiple tilted purlins placed on top of either rafters or a triangular truss. Barletta suggests a date for the Temple of the Spiral Acroteria contemporary with that of the Megaron of Demeter (II), thus around 550 B.C.

At Agrigento a small building known as the Archaic sacellum has foundations preserved within those of the Temple of Vulcan and is restored with a distyle-in-antis facade with pronaos and cella.[50] Two geison blocks and many fragments of architectural terracottas are assigned to this building, including a lateral sima with trumpet waterspouts above a geison revetment. The lateral geison (Fig. 12) has a flat top surface, with holes along the sloping front edge, where the roofing system was attached. At the back are slightly slanted slots (34.6 cm wide; 6–7 cm deep) for individual rafters. This treatment of the top surface is similar to that of the geison on the Building with Mutuleless Geisa at Selinus (albeit somewhat contracted) and indicates that knowledge of this construction technique existed elsewhere in Sicily.[51] A date for the Archaic sacellum of ca. 560–550 B.C. is based on the decoration of the architectural terracottas.

Other buildings illustrate a similar concern with securing rafters. At Selinus, in other temples, the builders continued to secure rafters by means of slanted cuttings in the lateral geison, including that of Temple C, dated ca. 550 B.C. (Figs. 11:e, 13).[52] Here the lateral geison is distinguished not only by its slanted cuttings for securing the rafter ends but also by its construction in two separate blocks: a lower mutular element and a flat-topped upper block with rafter cuttings. The so-called thrinkos, or "Terrakottenträger," is a simple block with a flat or sloping top surface placed above the mutular geison. The use of a two-block geison is not related to the size of the building, since Temple Y, a structure slightly less than half as big as Temple C, shares the same two-part geison design (Fig. 11:f).[53] Fragmentary remains from Temple Y, best known for its sculptured metopes, were reused in the fortifications of the acropolis.[54] As described in Gabrici's publication, these blocks include several lateral geisa with a completely smooth, flat top surface, indicating that a second stone element was placed on top of the lower, mutular element.[55] The building is dated ca. 580–550 B.C. and thus provides one of the earliest examples of a two-block geison. Unfortunately, no blocks from this upper element have been identified.

[50] De Miro 1965.

[51] De Miro suggested that the building could have been roofed only with a truss, but he did not fully develop his argument.

[52] Koldewey and Puchstein 1899, pp. 95–105; Gabrici 1935, cols. 167–198; 1956, cols. 257–272. The date of Temple C has been much discussed. The following possibilities have been suggested: *ca. 590:* Holloway 1991, pp. 70–71; *ca. 570–560:* Di Vita 1967, p. 45; 1983; *after 550:* de la Genière 1975; de la Genière and Martin 1976; de la Genière and Theodorescu 1980–1981, p. 978; *late 6th century:* Andrén 1940, pp. C–CII, CXIII–CXV. A summary can be found in Barletta 1983, p. 202. For the sculpture, see Ridgway 1993, p. 193, note 9. Goldberg (1983, p. 308) suggests an early construction with a Chinese roof, which was later supplanted by one with a normal, unbroken slope. Her argument that an antefix from Olympia can be attributed to a Sicilian treasury and that it represents the presence of a Chinese roof in Selinus, possibly on Temple C itself, has been refuted by recent studies. Heiden (1990, p. 43, pl. 3:c) confirms the attribution of the antefix to the Bouleuterion and notes that it belongs to a Lakonian-style roofing system.

[53] Gabrici 1935, cols. 206–217; 1956, cols. 238–244, 249–256.

[54] Tusa 1983, pp. 109–114, 183–184.

[55] This is confirmed by the architectural terracottas belonging to Temple Y, the geison revetment from the flanks having an obtuse angle between the plaque by which it was attached to the top of the thrinkos and the vertical fascia. Since the angle is obtuse, the revetment must have been attached to a sloping surface, not a flat one. This surface may also have had sockets for rafter cuttings, as in Temple C.

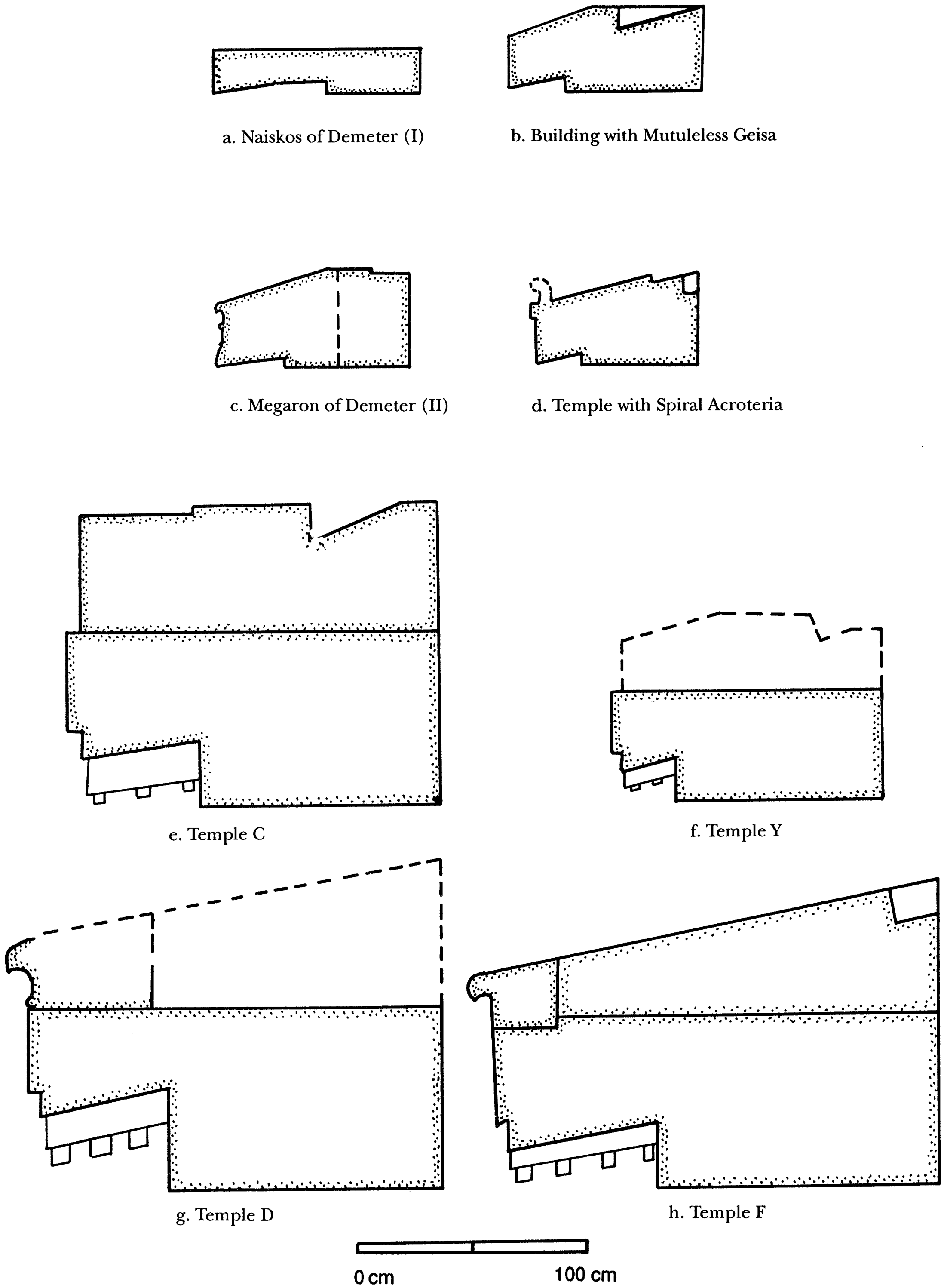



FIG. 11. Lateral geisa from Selinus (adapted from Hodge 1960, fig. 19)

## WEST GREEK ARCHITECTURAL TERRACOTTAS

While the cuttings in the lateral geison offered a structural advantage by securing rafters from shifting laterally or pushing outward, the motivation behind the two-part geison comes from the use of the Sicilian roofing system with the terracotta sima and geison revetment.[56] Architectural terracotta production in Sicily has been the subject of numerous studies.[57] In the most recent work by Charlotte Wikander, three phases of development are distinguished. The first is represented by a short period in the late 7th or early 6th century B.C., when Sicilian forms were apparently dependent on mainland Greece for inspiration. The second phase is marked by the development of the cavetto sima and geison revetment (known as the Geloan sima), which dominated the first half of the 6th century. Finally, the third phase sees the introduction in the second quarter of the 6th century of the openwork anthemion sima with lotus-and-palmette decoration. The present study is concerned with only the last two phases, which represent distinctly Sicilian roofing styles.

The Geloan sima, one of the first uniquely Sicilian roofing systems, is distinguished by a sima and geison revetment placed along the flanks, the rakes, and the bottom of the pediment. Each piece is made separately, but the profile and decoration of the sima and geison revetment are coordinated in a strictly established sequence. The typical geison revetment has an upper horizontal plaque, by which it is attached to the top surface of the thrinkos, while the profile of the revetment is marked by a single or double roll, a vertical face, a single or double roll at the base, and, in some cases, a lower return. The painted decoration of the face is always a single or double guilloche.[58] Although Wikander says the geison revetment is not found on the Greek mainland except at Kalydon and Thermon, and on Corfu, the Kalydon and Thermon examples should not be considered geison revetments but rather geison tiles, a feature of certain regional roofing systems.[59] This leaves only the geison revetment from Corfu, which is discussed below (pp. 359–361).

Although its name is suggestive of its function, the geison revetment does not cover the geison but in fact decorates the thrinkos, leaving visible the face of the geison proper below. The profile of the thrinkos is reflected in the angle between the vertical face of the terracotta geison revetment and the plaque that attaches it to the block. A survey of the catalogue of Sicilian terracottas compiled by Wikander suggests that the sloping-topped thrinkos existed alongside the flat-topped examples throughout the first three quarters of the 6th century B.C.[60]

The Archaic sacellum at Agrigento presents another solution, in which the geison revetment is fitted around the upper corona of the geison itself (Fig. 12). This is similar to the system used

[56] In recent years much effort has been devoted to the identification of regional roofing systems as evidenced by architectural terracottas. In particular, the congresses held at the American School of Classical Studies at Athens and elsewhere have served to reveal the important contribution of architectural terracottas to our understanding of the development of regional styles and their dissemination throughout the ancient world. See Winter 1990a, 1990b, and 1994.

[57] In general, see Darsow 1938; Süsserott 1944a; Bernabò Brea 1949–1951; Scichilone 1961–1962; Wikander 1986; Winter 1993, pp. 273–281.

[58] Wikander (1986, pp. 26–27) notes that the earliest geison revetments are found at Selinus in association with a typical Sicilian sima. See also Süsserott 1944b.

[59] Wikander 1986, p. 26. The geison tile is defined as "an eaves tile with a curved soffit forming a drip" in the glossary of the proceedings of the First International Conference on Architectural Terracottas (Winter 1990a). On their use in northwestern Greece, see Winter 1990b. Other roofing systems using a geison tile are found in the Argolid; cf. Cooper 1989.

[60] Wikander 1986. Examples of roofs with a sloping-topped thrinkos include the Apollo temple in Syracuse, Wikander no. 66; no. 55 Syracuse, "Secondo nucleo, Tipo 1," ca. 580 B.C.; no. 63 Syracuse, "Tipo 3"; no. 64 Syracuse, "Tipo 4"; no. 46 Selinus, "Temple of the Small Metopes," Temple Y, 580–550 B.C.; no. 48 Selinus, "Rivestimento A"; no. 7 Gela Frieze B, perhaps post 550 B.C.; no. 9 Gela Frieze D, 550 B.C. or later; no. 14 Molino di Pietro (no date given). Flat-topped examples known are Wikander no. 1 Agrigento (slightly obtuse angle); no. 6 Gela; no. 20 Himera Temple B; no. 35 Monte San Mauro; and no. 47 Selinus Temple C. Note that the flat-topped examples are specifically listed as belonging to lateral geisa, not horizontal geisa, where a flat-topped thrinkos would be expected.

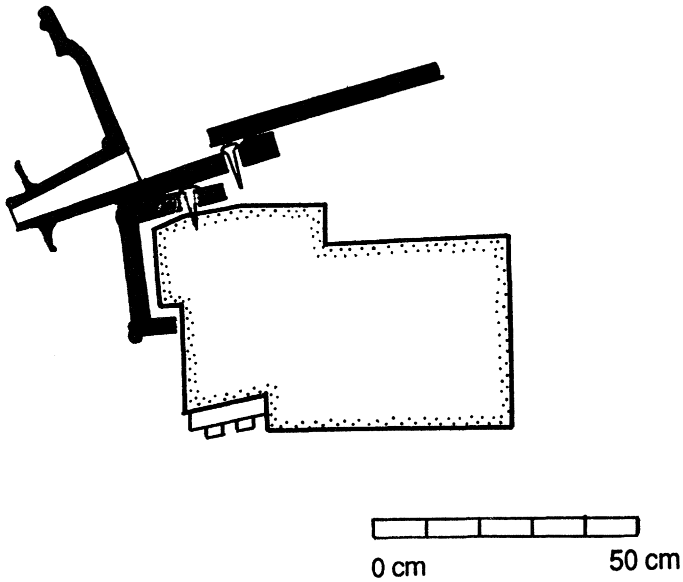



FIG. 12. Agrigento, Archaic sacellum: lateral geison with architectural terracottas (after De Miro 1965, fig. 1)

in the Geloan treasury at Olympia. Given the small scale of the Agrigentine building relative to either Selinus Temple C or Temple Y, it may be that the scale of the building determined the type of "Terrakottenträger" to be used, whether a simple ledge or a separate block altogether. The lateral geisa from both the Archaic sacellum at Agrigento and the Geloan treasury at Olympia have a proportionally taller fascia below the edge of the geison revetment. This suggests that in cases where the geison and thrinkos were combined, the height of the geison was increased to compensate for its dual role, whereas for the larger buildings it became necessary to subdivide the geison into two courses: a geison proper surmounted by a thrinkos.

The connection between geison revetment and thrinkos, to the exclusion of the mutular geison, is illustrated by several buildings in South Italy.[61] In the so-called Basilica, or first temple of Hera, at Paestum (ca. 550/40–520/10 B.C.), the elaborate architectural terracottas are attached to a thrinkos, but there is no mutular geison below. In contrast to the mutular geison, whose decoration corresponds to the horizontal rhythm of the triglyph-metope frieze below, the design of the thrinkos is dependent upon the terracotta geison revetment and thus associated with the roof. The functional role of the thrinkos block is further attested by cuttings in the block for rafters.

In the third developmental phase of the Sicilian roof, an openwork anthemion sima replaces the earlier cavetto sima, and the form of the geison revetment is consequently altered.[62] The

[61] Mertens 1976, pp. 169–170; see esp. fig. 10, where it is illustrated that the thrinkos and architectural terracottas with geison revetment are found together at Metaponto (Temple of Apollo, Temple of Hera [B], Tavole Palatine) and on the Basilica at Paestum, but when the geison revetment is not used, the thrinkos disappears as well, as on the Athena temple at Paestum and the Temple of Hera at Foce del Sele. Mertens (1993, p. 90) suggests that construction on the first temple of Hera at Paestum was begun ca. 550–540 B.C. and completed 520–510 B.C. See also Mertens 1984, pp. 141–142; Wikander 1986, pp. 26–29. A related phenomenon is the emphasis on horizontal decoration found in the architecture of Magna Graecia: Barletta 1990, pp. 62–69. In particular, moldings can be used to create a horizontal decoration in place of the vertical accents of a mutular geison.

[62] Wikander 1986, p. 9.

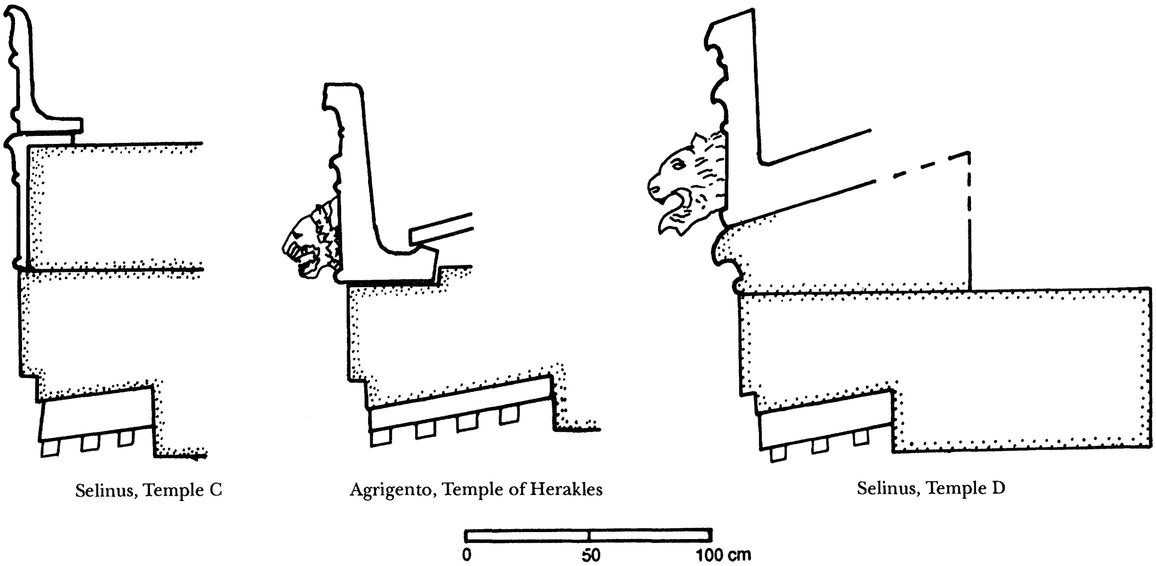



FIG. 13. Profile of geison and architectural terracottas: Selinus, Temple C; Agrigento, Temple of Herakles; and Selinus, Temple D (adapted from Mertens 1984, Beil. 3, and Gabrici 1956, fig. 21)

subsequent development of architectural terracottas in the 6th century saw the introduction of lateral simas without an accompanying geison revetment below. This simple omission indicates a fundamental change in geison design within the strictures of a decorative and structural system defined by earlier buildings. Architectural terracottas were made according to established guidelines for profile and painted decoration—an architectural syntax and grammar rendered in three dimensions. When the terracotta geison revetment was discontinued altogether, its structural and decorative aspects were accordingly rendered in a new manner. The best example of this development is seen when the stone sima from the Temple of Herakles at Agrigento is compared to the terracotta sima and geison revetment from Selinus Temple C (Fig. 13). The profile of the Herakles temple sima (dated to the early 5th century B.C.) is virtually identical to that of the terracotta revetment and sima from Selinus Temple C, with the omission of the lower ovolo from the base of the Temple C sima.[63]

### Tripartite Lateral Geisa

The disappearance of the geison revetment corresponds with the transformation of the thrinkos. Previously seen to accommodate the geison revetment and provide support for the rafters, the thrinkos block per se disappears completely from buildings that omit the geison revetment. While this should not be surprising, given the inseparable nature of the two elements, the metamorphosis of the block into two new, separate elements is intriguing. The decorative syntax between sima and roof edge, the latter marked by a hawksbeak molding in the anthemion roof at Selinus (and others at Himera and Agrigento), was maintained in the new roofing system by replacing the molding of the terracotta geison revetment with an inserted stone hawksbeak crowning molding below the lateral sima. As seen in Selinus Temple D, built ca. 540 B.C.,[64] a stone hawksbeak molding is placed atop the geison, in much the same way that the earlier terracotta

[63] Mertens 1984, p. 142, Beil. 33a, no. 3 (Selinus, Temple C) and no. 4 (Agrigento, Temple of Herakles).
[64] Gruben 1986, p. 279.

geison revetment carried a hawksbeak molding below the sima (Fig. 13).[65] The overall design is transformed by the introduction of a third element, a wedge-shaped block behind the crowning molding and atop the mutular geison. While this block may have been used in Temple D, the earliest preserved example is from Temple F, dating to ca. 530 B.C. (Fig. 11:h),[66] and it continued in use in Selinus Temple E (ca. 480–470 B.C.[67]) and at Paestum in the Temple of Poseidon (Hera II) (ca. 480/470 B.C.) during the 5th century (Fig. 14).[68] This third block assumes the structural role of the thrinkos and is usually provided with sloping cuttings to secure the ends of rafters. The motivation for the shift from a two-block (geison and thrinkos) to a three-block design must have been the change in the terracotta roofing system, from the use of a sima and revetment to a sima alone. As a result, the architect chose to recreate the thrinkos in two separate elements, dividing its structural (seating the rafters) and decorative (carrying the painted and profiled geison revetment) roles between them. In this manner the exterior appearance of the entablature maintained a traditional profile, but the underlying structural design of the geison was pushed in a new direction.

The development of Sicilian geison design through the 6th century can be summarized as follows (Fig. 11; Table 2). The earliest monumental stone buildings at Selinus show that two early geison forms existed side by side. The Building with Mutuleless Geisa on the acropolis had a lateral geison with a sloping surface and angled cuttings for individual rafter beams, while a lateral geison with cuttings for rafter ends was used for the Naiskos of Demeter (I). The advantage of individual sockets was their ability to prevent rafters from slipping sideways or forward. This innovation, in conjunction with the multiple purlins of a Gaggera roof, may be related to the introduction of the tie-beam truss, as proposed for the Megaron of Demeter (II). In the second quarter of the 6th century, a uniquely Sicilian roofing system emerges, with the sima and geison revetment carried around all four sides of a temple, including the rakes and across the bottom of the pediment. The lower member demanded a correspondingly taller geison to accommodate its overhang and still preserve the usual geison profile, and so the new roofing system was accompanied by the invention of new geison forms. As seen in Selinus Temple C, and probably already in Temple Y, the geison has a lower mutular block and a thrinkos with a flat or sloping top and cuttings to seat rafters. A related development, the single block with a front ledge to hold the geison revetment, is found in smaller buildings (Agrigento, Archaic sacellum, Olympia, Geloan treasury). As the design of architectural terracottas developed over time, the profile and decoration of the simas and revetments changed in concert with one another but always within an established vocabulary of moldings and painted decoration. This conservatism is reflected in the transition from the Sicilian roof (Geloan sima) to a roofing system of lateral simas without geison revetment. When the geison revetment ceased to be used, the simple thrinkos disappeared and a multipart geison with an inserted crowning molding and wedge block with cuttings for rafters took its place (Selinus Temples D, F, and E; Paestum, Temple of Hera II [Poseidon]) (Figs. 11, 14).

[65] Its presence may be attributed to a conservative decorative repertory attempting to accommodate changing styles of construction. See Koldewey and Puchstein 1899, p. 109; Gabrici 1956, cols. 273–275; Shoe 1952, pp. 13, 177, 179, pl. 31:7; Barletta 1983, pp. 207–208.

[66] Gruben 1986, pp. 284–287; Koldewey and Puchstein 1899, pp. 117–121.

[67] Gullini (1977, p. 37) states that the stratigraphic evidence indicates a date of completion around 475–470 B.C., with the construction of the stereobate and crepidoma around 500–475 B.C. The traditional date of Selinus E is somewhat later, ca. 465–450 B.C.; cf. Barletta 1983, pp. 210–212; Gruben 1986, pp. 292–296; Koldewey and Puchstein 1899, pp. 127–131.

[68] On the date of the Temple of Poseidon (Hera II) at Paestum, see Mertens 1990, esp. p. 83. Mertens draws a comparison between the temple at Paestum and earlier Sicilian temples such as the Temple of Athena at Syracuse. The similarities suggest that construction was begun at Paestum ca. 480–470 B.C. Mertens' date for the Paestum temple, like that of Gullini (1977) for Temple E at Selinus, places doubt on their traditional dependence on the Temple of Zeus at Olympia, begun ca. 470 B.C.

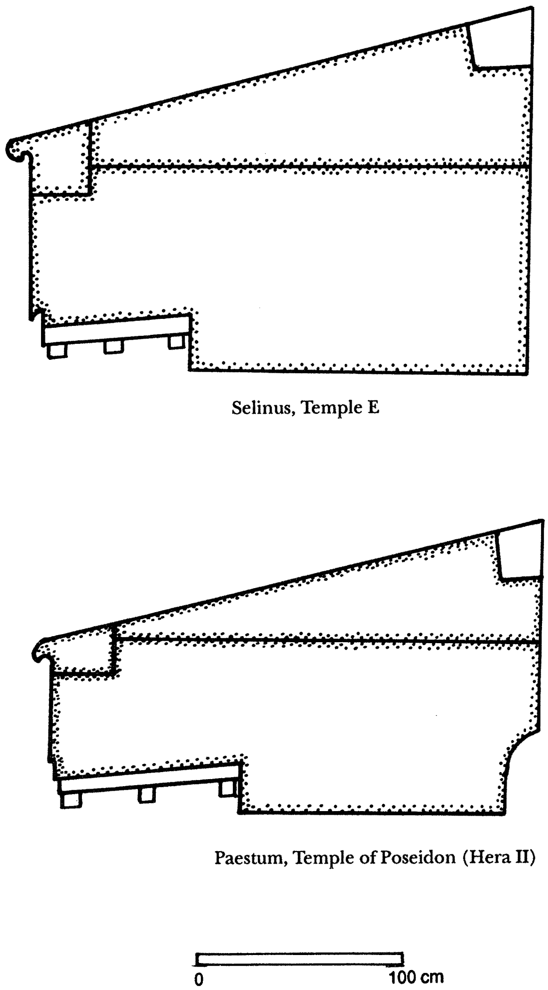



FIG. 14. Selinus, Temple E, and Paestum, Temple of Hera II (Poseidon): lateral geisa (adapted from Hodge 1960, fig. 19)

Although the architectural examples discussed so far have been largely limited to Selinus, the indirect evidence provided by the architectural terracottas suggests that these developments were known elsewhere in Sicily and in South Italy. By contrast, contemporary architectural practices on the mainland of Greece have been seen to have developed along different lines altogether. Only sites such as Corfu, with acknowledged ties to the West, show any knowledge of Sicilian practices at this early stage. Equally revealing is the sporadic appearance of West Greek terracotta roofing systems and geison forms in the Panhellenic sanctuaries of Delphi and Olympia.[69]

[69] For West Greek roofs in the Panhellenic sanctuaries of Delphi and Olympia, see Süsserott 1944a; Mertens-Horn and Viola 1990; Heiden 1990; *FdD* II, pp. 65–87, 101, 119–120, pls. 21–23; Le Roy 1990; Wikander 1986, no. 87 Delphi; p. 50, fig. 13, no. 88 Olympia; and Winter 1993, pp. 288–291. For the Geloan treasury, see below.

CORFU

The island of Corfu is recognized as the site of a confluence of artistic trends from the Greek mainland and the West, and the architectural evidence suggests that Corfiot geison design and roofing systems are closely related to those of contemporary Sicilian architecture. The Temple of Artemis is one of the earliest Doric peripteral buildings, and excavation allowed the recovery of its plan: pseudo-dipteral (8 × 17 columns), with tripartite interior (pronaos, cella, and opisthodomos or adyton).[70] Elements of the superstructure are frustratingly scarce but provide tantalizing information about early Doric architecture.[71] The extant raking geisa were found in front of the west facade of the temple.[72] They are flat, slablike blocks distinguished by a small half-round crowning molding and a series of nail holes on the top surface for the attachment of the roofing system. At the lower back edge of three blocks are rectangular cuttings, each of which serves as the upper half of a closed socket to receive purlin beams, the lower half of which was carved into the tympanum block below.[73] The tilted purlins indicate the use of a Gaggera roof above the pronaos. Only fragments of the lateral geison blocks were known at the time of the original publication: part of the small half-round crowning molding and a bit of a mutule.[74] The molding sits at the edge of a fragment with a sloping top surface and thus cannot be assigned to the raking geison. In Rodenwaldt's reconstruction (redrawn in Fig. 15:a) the lateral geison has two courses: an upper thrinkos with sloping front edge to seat the rafter beams, and a lower mutular block, similar to that postulated for the Apollo temple at Syracuse.[75] Recently, however, a piece of geison was found in a late wall in the Artemis sanctuary that may belong to this temple.[76] Ernst-Ludwig Schwandner has suggested that the geison fragment and crowning molding be combined, producing the following design: a thrinkos with sloping front edge and half-round crowning molding above a mutular geison with cavetto molding in place of a drip (Fig. 15:b).[77] The association of these fragments is attractive but not conclusive.

In its earliest years the Temple of Artemis was decorated along the flanks with a combination sima and geison revetment, which was attached to the sloping top of the thrinkos by means of a plaque and which overhung its face as well as the upper edge of the mutular geison below.[78] The placement of the sima and geison revetment is confirmed by the trumpet waterspouts,

[70] For a suggested reconstruction with adyton rather than opisthodomos, see Matz 1950, p. 368, fig. 19. Such a reconstruction would provide further evidence for shared traditions between Sicily and Corfu.

[71] *Korkyra* I; *Korkyra* II. Fragments of the superstructure are limited to a column drum, a single capital, a fragment of the architrave, seven triglyphs and two metopes, the pedimental sculpture, some fragments of the lateral geison, four raking geison blocks, and elements of two roofing systems (an earlier roof with terracotta sima and geison revetment in one piece and a later roof with marble sima).

[72] *Korkyra* I, fig. 19. I was unable to find these blocks during a recent visit to Corfu. My description is based on Rodenwaldt's publication.

[73] *Korkyra* I, pl. 25. Hodge (1960, p. 54) points out that this is one of the few known examples of the use of closed sockets for purlins, along with the Naiskos and Megaron of Demeter at Selinus and the Kardaki temple in the Mon Repos sanctuary on Corfu.

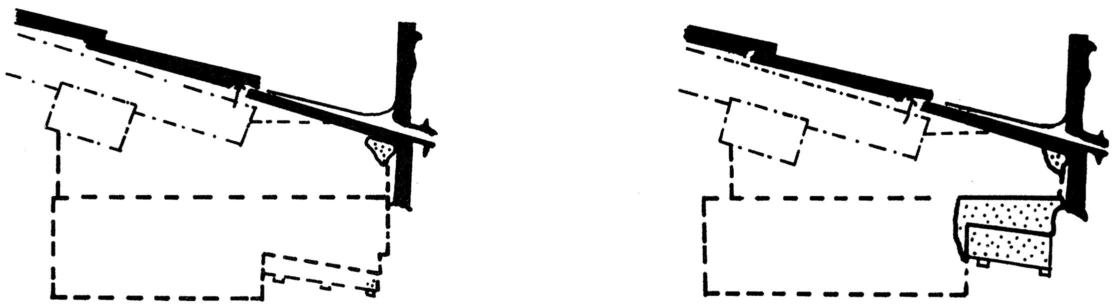
[74] *Korkyra* I, p. 37, fig. 20. Lucy Shoe (1936, pl. L:18) also published a very elaborate hawksbeak/cyma recta molding as the geison crown from the Artemis temple, but the profile she illustrates as plate L:18 does not correspond to the marble sima published by Rodenwaldt, so that its relevance to the Artemis temple is unclear. For the Apollo temple at Syracuse, see Cultrera 1951.

[75] *Korkyra* I, p. 25. The resulting geison has a half-round crowning molding at the top of both the upper and lower blocks: the profile beginning with a half-round above a fascia on the upper block and a second half-round and second fascia on the second element above a mutular soffit.

[76] Schwandner 1985, pp. 124–126, fig. 76. The mutule is restored with two rows of six guttae to a width of 62.1 cm, only 0.3 cm greater than the preserved triglyph width of 61.8 cm.

[77] Schwandner 1985, p. 125, fig. 77.

[78] *Korkyra* I, pp. 100–124, figs. 73–87, 91, 93. On the relation of the Corfu terracottas to Sicily, see Wikander 1990. While admitting the originality of the Corfu sima and the existence of a two-way exchange, Wikander argues for Sicilian influence on Corfu, based on an earlier example of a lateral sima with overhanging geison revetment from



a. b.

FIG. 15. Corfu, Temple of Artemis, section through flank entablature: (a) Rodenwaldt (after *Korkyra* I, pl. 25) and (b) Schwandner (after Schwandner 1985, fig. 77)

which must belong on the flanks, and by the angle of the attachment plaque, which sat atop a sloping surface. What makes this roof unique, however, is the absence of a horizontal sima. Here the terracotta revetment is used only along the flanks of the building and continuing up the rakes, but not along the bottom of the pediment, as we would expect in a traditional Sicilian roof. While the design of this revetment is clearly related to Sicilian practices, there is no conclusive proof of its origins at the present time. Similar terracotta revetments have been found at Himera and at Delphi; at the latter site it has been attributed to a Corfiot treasury.[79]

A problem remains, however, in the relationship of the architectural terracottas to the geison fragments. In particular, the presence of a half-round crowning molding on the thrinkos poses some unique questions. Such a molding is unusual; although the half-round is an Ionic profile, the small size and minimal projection of the Corfu molding are far removed from the enormous scale of early Ionic moldings. A greater problem is posed by its position on the thrinkos. While all the Sicilian examples of the sloping-top thrinkos were clearly intended to carry a geison revetment, the crowning molding at Corfu would have been covered by the overhanging revetment. While it is tempting to dissociate the thrinkos fragment from the temple on these grounds, other facts suggest it was part of a uniquely Corfiot design. The raking geisa share the same half-round crowning molding. In addition, the profile along the eaves of the temple (the crowning molding of the thrinkos; the lower corona of the geison, with cavetto molding and the mutular soffit below) is very close to the that of a geison at Olympia assigned to the Treasury of Epidamnos, a colony of Corfu (Fig. 16). The similarity of these two buildings indicates that the sloping thrinkos with half-round crowning molding was an intentional design. The relationship between this geison and the combination sima and geison revetment remains problematic. We know that the original roof of the Temple of Artemis was replaced by one with a marble sima around 530 B.C.[80] While the association of the marble sima and geison is likely, the latter would have been unsuitable for use with the combination sima and geison revetment. Rather than suggesting that the molding was hidden or the design misunderstood, it seems possible that the geison had two phases, as did the roof itself: a first phase that featured a simple sloping thrinkos (not preserved) for the combination sima and

Himera, Temple A. For the Himera sima, see Wikander 1986, pp. 36–37, no. 19, fig. 7; Bonacasa et al. 1970, pp. 84–87, pl. XIII:1–3; the sima is dated to 635–625 B.C.

[79] *FdD* II, 65–70, Roof 27.

[80] *Korkyra* I, fig. 42. As shown in Rodenwaldt's illustrations, the raking geison has setting lines for the sima, and there is a correspondence between the dowel holes in the geison and in the marble sima, which demonstrates that they were used together.

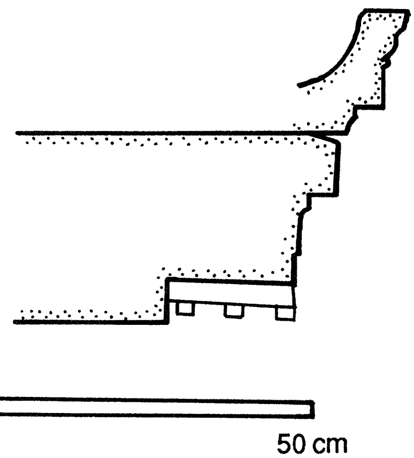



FIG. 16. Olympia, geison and sima from Epidamnian treasury (after Hermann 1976, fig. 10)

geison revetment, and a second phase, in which the thrinkos with half-round crowning molding was created to support the marble sima. The Artemis temple, dated by the style of its pedimental sculpture to ca. 580–570 B.C., is roughly contemporary with the first examples of mutular geisa with sloping-topped thrinkos from Sicily (Syracuse, Apollo Temple).[81] While this may suggest a Corfiot origin for the two-block geison, further development of the design took place in Sicily. The lack of evidence to support the primacy of either place simply reinforces the theory that there was a long-standing exchange of ideas between Corfu and the West.

## SICILIAN-STYLE GEISA ON THE MAINLAND OF GREECE

### OLYMPIA: TREASURY OF EPIDAMNOS (FOUNDATION IV)

The remains of the Treasury of Epidamnos, Foundation IV on the treasury terrace at Olympia,[82] include fragments of the lateral geison, pieces of a capital, an architrave, and a terracotta sima.[83] The profile of the geison is unusual: a short fascia projects slightly above a cavetto molding, the latter in the position usually taken by an upper taenia and drip (Fig. 16).[84] Although lacking the half-round crowning molding of the Corfu thrinkos and raking geison, the

[81] *Korkyra* I (590–580 B.C.); Ridgway 1993, p. 193 (ca. 570 B.C.). Holloway (1973, pp. 60–61) suggests that Temple C is in fact contemporary with the temple on Corfu, placing them both ca. 590–580 B.C. Wikander lists several roofs with geison revetments that must be attached to a sloping-topped thrinkos. See the discussion above, note 60.

[82] Pausanias 6.19.8; *Olympia* II, p. 46, pl. XXXIV (identified as the Treasury of Syracuse); Herrmann (1976, pp. 332–333, figs. 9, 10) notes that most of the fragments discussed here were found within the area and in the cella of Foundation IV (Treasury of Epidamnos).

[83] Mallwitz (1972, pp. 169–170, fig. 130) suggests a date ca. 525 B.C.; Heiden 1990, p. 45. The attribution of the sima to the Epidamnian treasury is assured by the correspondence between the holes in the sima and those in the geison. The capital (Herrmann 1976, fig. 8; *Olympia* II, pl. XXXIV:7) has a row of sculptured leaves below the echinus, probably four per flute, with twenty flutes per column. A discussion of the leaf necking is found in Barletta 1990, pp. 45–52. The architrave (*Olympia* II, pl. XXXIV:5) has a half-round in the middle of the taenia, also seen in the Temple of Artemis on Corfu, Selinus Temple C, and on architectural fragments recovered from the Palaiopolis Church in Corfu. For the latter, see Kallipolitis 1959, p. 117, fig. 2.

[84] Schwandner (1985, p. 125, note 219) attributes the geison at Olympia to the Syracusan treasury. He suggests that its upper edge must have been covered by a geison revetment and that the form was best understood as a "Terrakottenträger."

terracotta revetment and geison from the Epidamnian treasury have virtually the same profile as the marble replacement sima found at Corfu.[85] A date for the treasury in the late third or early fourth quarter of the 6th century would accommodate both the *terminus post quem* given by the Corfu marble sima and other architectural evidence.

While paying attention to such minute details as the sima and geison profile may seem to be an obscure pursuit in the quest for regional building styles, the importance of decorative syntax in architectural terracottas has been clearly demonstrated for the Sicilian workshops. Moreover, we have seen that the combination sima and geison revetment of the Artemis temple on Corfu was probably copied for a Corfiot treasury at Delphi, and the archaeological evidence also supports a Corfiot origin for the cavetto molding used on the geison fascia. The straight, shallow cavetto molding used in place of the upper taenia and drip was first seen on the Temple of Artemis and later here on the Epidamnian treasury.[86] Other molding fragments with the same cavetto profile were found in the Artemis sanctuary on Corfu and were assigned by Rodenwaldt to an interior architrave, but Schwandner suggests they may be from the top edge of other, smaller, geison blocks.[87] If this were the case, it would be possible to add the geison with cavetto drip to the list of characteristics that define Corfiot architecture in the 6th century. The importance of specific moldings and profiles to architects can be recognized in their repeated use and, more important, in their appearance in the decoration of treasuries erected in the Panhellenic sanctuaries at Delphi and Olympia.

The construction of a treasury using building techniques and decorative styles from the donor's city or region is likely to be the mechanism by which Sicilian roofing practices were introduced to the mainland, via the Panhellenic sanctuary at Olympia. In light of our observations concerning the distribution of Sicilian architectural terracottas and geison design, it should not be surprising to note that the only examples of lateral geisa with sloping tops and rafter cuttings from the Greek mainland in the Archaic period are found at Olympia, in the treasuries of Syracuse and Gela.

### Olympia: Treasury of Gela (Foundation XII)

Mentioned by Pausanias as the treasury nearest the stadium, the Treasury of Gela was originally a simple, closed building with the entrance in the middle of the south side and gables at the east and west.[88] In the late 6th or early 5th century a Doric porch was added to the south facade.[89]

The most distinctive elements of this treasury include the geison and its terracotta revetments. The lateral geison blocks are massive, with a sloping top surface terminating in a horizontal ledge above a short fascia and a broad, flat drip (Fig. 17). The soffit is smooth, without mutules, set at an acute angle to the face, and without any lower taenia. In the top and back surfaces are at least two series of cuttings. The horizontal geison has a similar profile but with a flat top and dowel

[85] Mertens-Horn and Viola (1990, pp. 239–240) note that the lower fascia of the Epidamnian sima is painted with a continuous spiral with intermediate palmettes much like the decoration incised on the terracotta sima from Corfu. For this reason they accept a date for the treasury sima in the third quarter of the 6th century, before the terracotta sima was replaced by one in marble.

[86] Klein 1991, p. 99.

[87] *Korkyra* I, fig. 36:f; Schwandner 1985, p. 125, note 219. For a triglyph altar from the sanctuary of Artemis crowned by a short fascia above a hawksbeak molding, see *Korkyra* I, figs. 51–53. Other triglyph altars with a hawksbeak or cavetto below a fascia are known from Aigina, Corinth, and the Temple of Artemis Knakeatis near Tegea: *Korkyra* I, pp. 66–68, fig. 67. For the site near Tegea, cf. Klein 1991, pp. 105–110.

[88] Pausanias 6.19.15; *Olympia* II, pp. 53–55, 215–217, pls. 39–41; Schleif and Süsserott 1944; Hodge 1960, p. 35, note 2, pp. 41, 60–61, 68, 87, 140; Herrmann 1976, pp. 343–348; Mallwitz 1972, p. 176.

[89] Herrmann 1976, pp. 343–348; Mallwitz 1972, p. 176, fig. 126 (model reconstruction). The entablature proportions are earlier than those of the Megarian, Syracusan, or Sikyonian treasuries and thus probably date to ca. 500 B.C.

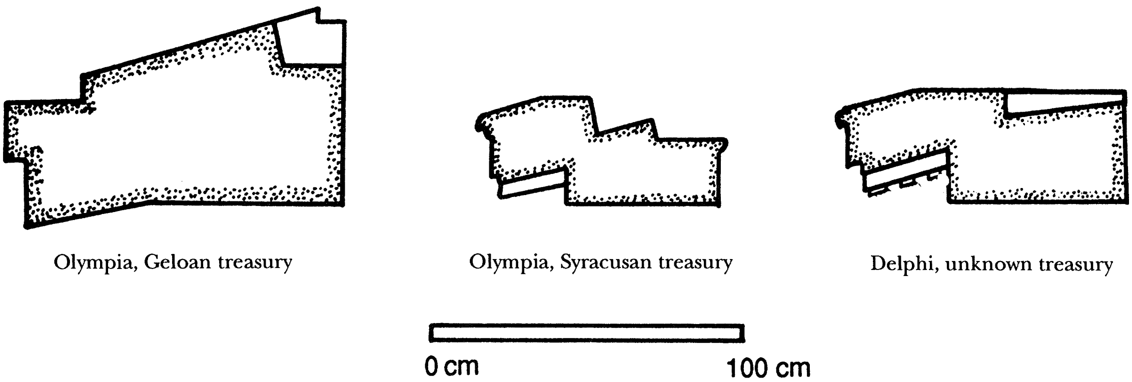



FIG. 17. Sicilian geisa from Olympia and Delphi

holes to secure the tympanum blocks.[90] By contrast, the raking geison is thinner and slablike. Preserved holes in the top and face of all the geison blocks indicate where the sima and geison revetments were attached with iron nails.

The deceptively small overall dimensions of the building disguise the fact that in the Archaic period it had the widest unsupported interior span of any building on the mainland of Greece. Indeed, until the construction of the Parthenon, no interior span was wider. The complexity of the remains of the treasury roof is complicated by the fact that the roof was rebuilt one or more times, each reroofing evidently requiring new or additional cuttings. Hodge describes "upwards of 30 cuttings in the lateral geison" but notes also that some of them had level bottoms while others sloped.[91] The sloping cuttings can only have held individual rafters, while the level bottoms may have been for single crossbeams or for a tie beam and rafter together. All the cuttings are for beams no more than 28 cm wide, and the ridge beam has a very small section, 37 × 37 cm. Given the modest dimensions of the beams for a building 9.68 m wide, Hodge suggests that several triangular tie-beam trusses were placed across the cella at regular intervals to provide support for the ridge beam. This reconstruction is attractive for several reasons: first, a truss could support the ridge beam and remove the need for interior supports; second, the design of a truss would explain the use of smaller timbers for rafters.[92] On the other hand, the quantity of cuttings in the lateral geison suggests that different designs where used when the building was reroofed. Whatever technique was used originally, it required improvement.

The terracotta roofing system used on the Geloan treasury is typical of Sicily and Magna Graecia,[93] having a cavetto sima and geison revetment along the flanks, the rakes, and the

[90] Cuttings at the back of the horizontal geison are 32 cm deep, leaving a small (6 cm) ledge at the bottom. If the beams placed here were any taller than 27 cm, they would interfere with the beams placed in the lateral geison. The original publication by Dörpfeld (*Olympia* II, pp. 53–55) suggested that ceiling beams be placed in these cuttings, but Schleif and Süsserott (1944, pp. 83–110) correctly noted that such beams would run the length of the cella without obvious means of support. Their suggestion that the cuttings were intended for "Wandbinderstiele," which with additional members supported the ridge beam and two lateral purlins, is not entirely satisfactory.

[91] Hodge 1960, pp. 39–41; Schleif and Süsserott 1944, p. 88.

[92] If the roof of the Geloan treasury had simply relied on larger, heavier beams, it would be difficult to explain how the timbers were available for this but for no other building within the sanctuary. I owe this observation to Brunilde Ridgway.

[93] The primary publication of the architectural terracottas is Schleif and Süsserott 1944, figs. 22–24, 28–34, pls. 39–42, 47–53. Schleif and Süsserott dated the treasury and its terracottas to ca. 560 B.C. See *OlForsch* XXIV, pp. 96–102, where Heiden suggests a date around the middle of the 6th century.

bottom of the pediment. Early scholarship suggested that the revetments were made in Gela and transported to Olympia, but more recent studies of the painted decoration have noted a closer similarity to terracottas manufactured in South Italy.[94] Both hypotheses suggest that the roof was made in a West Greek workshop and shipped to Olympia. Dates ranging from the early though the late 6th century have been suggested for the Geloan treasury, based on the decoration of the architectural terracottas. The most recent study by Heiden places the construction of the treasury around the middle of the 6th century.

Here we should note that the two most important features of the Geloan treasury, the architectural terracottas and the roof construction, are both reflected in the form of the geison and have been shown to derive from Sicilian building practices. Since the terracottas were made in the West and shipped to Olympia, a probable corollary is the employment of Sicilian architects to design and execute the building itself. First, it is hard to imagine how people unfamiliar with such practices could have built the treasury without extensive instruction in the attachment of the terracottas. Men who were familiar with the revetments and the underlying construction of the roof frame and entablature would have had the expertise to assemble a building having this roof. Second, the geison design has the same style of rafter cuttings and profile as does the Archaic sacellum at Agrigento. Since these features have a well-documented precedent at Selinus, their appearance at Olympia is also likely to be due to Sicilian craftsmen.[95]

### Olympia: The Treasury of Syracuse (Foundation II)[96]

The Syracusan treasury is dated to the first quarter of the 5th century, and its features exhibit the ongoing assimilation of West Greek architectural practices into the traditions of the Greek mainland, while retaining its trademark technical design.[97] The external appearance of the treasury conforms to the standard distyle-in-antis plan with Doric columns and entablature found at Olympia, but a closer look at the details reveals its originality. The extant corner geison blocks have guttae on the first lateral mutule, giving the false impression that the lateral geison also had guttae. In fact, guttae were limited to the south facade and omitted on the flanks and rear facade, where they would not have been easily visible in any case. A single separately worked horizontal geison block has been found with the front top surface sloping gently outward.[98] The lateral geison

[94] Mertens-Horn and Viola 1990, pp. 238–240. Mertens-Horn suggests that the Olympia terracottas are the product of a South Italian workshop dating to the third quarter of the 6th century B.C.

[95] The possibility of the presence of itinerant craftsmen working at Olympia is discussed by Heiden (*OlForsch* XXIV, p. 87) in the context of a West Greek roof there (Roof 37, which he assigns to a treasury of Syracuse that he would place on Foundation III) made of local clay. By contrast, another roof (Roof 42, Treasury of Selinus) may have been made by Elian craftsmen in imitation of the Treasury of Gela (*OlForsch* XXIV, p. 162). Miles (1998, pp. 54–55) discusses the activities of West Greek cities in the Panhellenic sanctuaries as acting as a medium for the exchange of architectural design.

[96] Pausanias 6.19.7; Dörpfeld (*Olympia* II, p. 50, pl. 33) identified the superstructure as the Treasury of Selinus but assigned it to Foundation III; Mallwitz 1961 (Treasury of Syracuse). Most recently Joachim Heiden (pp. 86–87) has proposed placing a treasury of Syracuse on Foundation III, to which he would assign a West Greek roof (Roof 37) dated ca. 580 B.C.

[97] The Syracusan treasury is dated, on the basis of its hawksbeak crowning molding, earlier than either the Sikyonian Treasury (ca. 450 B.C.) or the Temple of Zeus (470–457 B.C.); it may date as early as the first quarter of the century. Although Pausanias (6.19.7) notes that Gelon dedicated three linen cuirasses in the treasury following the Battle of Himera (480 B.C.), he does not say that Gelon built the treasury. The passage has been cited as evidence for a construction date of 480.

[98] Mallwitz (1961, p. 42, note 17, pls. 7, 8) observed that the same form has been suggested for the Temple of Artemis on Corfu. This type of horizontal geison, with the top of the block sloping away from the tympanum, is also found on the Athenian Akropolis (Building A, Unknown Building with Painted Pediments), at Delphi (Athenian treasury), and at Olympia (Foundation III/VII, "Seilöhr Bau"). The presence of pedimental sculpture or decoration on some of the buildings with a sloping horizontal geison top (Unknown Building with Painted Pediments [Akropolis], Athenian treasury [Delphi], probably Akropolis Building A) suggests a possible connection between the sloping horizontal geison and pedimental decoration, perhaps as an early refinement to improve visibility.

has a sloping top with nail holes for rooftiles along the front, 8–10 cm from the edge and 57.5 cm apart, which equals the width of a single tile.[99] The geison carries a hawksbeak crowning molding above a fascia with slanting drip, a soffit with mutules of equal length, no guttae, and a simple lower taenia (Fig. 17).[100] Such a profile is extremely common on the Greek mainland in the 5th century, and there is nothing to distinguish it as being representative of the West.

What is West Greek, however, is the technique used in installing the roof. On the back of many lateral geison blocks are rafter cuttings with sloping bottoms to receive single rafters. They are irregularly cut in regard to both size (width and depth) and distance from one another; if contemporaneous, they would indicate that rafters of differing sizes were used and that the spacing may have been greater between larger beams. As one of the few examples of lateral geisa with rafter cuttings from the early-5th-century Greek mainland, it is also important to note the lack of correspondence between rafter placement and tile size.

The importance of the Sicilian comparanda is highlighted by the lack of earlier or contemporary examples on the Greek mainland outside the Panhellenic sanctuaries. But while geison blocks with sloping tops and similar rafter cuttings are found in 6th-century buildings at Selinus and at Agrigento, there are no exact parallels for the Syracusan treasury. One reason may be that the single-block geison of the Syracusan treasury is an adaptation of Sicilian techniques in response to mainland influence. Thus, while lateral geisa from the Syracusan treasury exhibit the decorative appearance of 5th-century Doric architecture, their technical design sets them apart from contemporary buildings on the mainland.

The fact that the two treasuries with exceptional lateral geison blocks were dedicated by Sicilian cities cannot be mere coincidence. Since all other buildings with such exceptional geisa are found in Sicily, it appears that the practice of seating rafters in sloping-topped lateral geisa with special cuttings for the wooden roofing beams was introduced to the Greek mainland from Sicily through the example of these two Sicilian treasuries in Olympia.[101]

### Delphi: Unknown Treasury

Corroboration for the diffusion of West Greek building techniques via the Panhellenic sanctuaries may also be found at Delphi. Architectural terracottas have been excavated there that are attributed to Sicily and Magna Graecia.[102] In addition to the combination sima and geison revetment of Corfiot origin discussed above, a sima and geison revetment comparable to examples from Syracuse and Gela has also been found and is attributed to an unknown Sicilian treasury.[103] A series of red sandstone geison blocks may also indicate a Sicilian treasury at Delphi. As described by Hodge, the geison is designed along the same lines as that of the Syracusan treasury at Olympia, with outer sloping edge, hawksbeak crowning molding, and mutular soffit (Fig. 17). At Delphi, however, the lateral geison has slanted cuttings for individual rafters set in a continuous row.[104] As in the treasury at Olympia, the cuttings are not uniform, suggesting that the rafters were not cut down to size but rather used "as is." There are no other blocks, architectural terracottas, or foundations associated with this geison. A date in the 5th century seems likely on the basis of the hawksbeak crowning molding and the similarity of design to the Syracusan treasury at Olympia.

[99] Heiden (1990, p. 45) suggests that one of two West Greek roof types must belong to this treasury, but since both date to the first half of the 6th century, while the building is much later, such an attribution is unlikely. The presence of a hawksbeak crowning molding excludes a roof with a geison revetment, and Mertens-Horn and Viola (1990, p. 240) suggest that the treasury may have had a stone/marble roof, as was common in important 5th-century Sicilian buildings.

[100] Shoe 1936, pl. LIII:1, 2, "Treasury of Selinus," 550–500 B.C.; Mallwitz 1961, p. 36.

[101] Unfortunately, the scanty remains of the Treasury of Selinus (Foundation IX) offer no further information to support this theory. Herrmann (1976) has recently assigned several geison blocks to this treasury but does not mention any cuttings for rafters.

[102] *FdD* II, pp. 65–87.

[103] *FdD* II, pp. 70–75, Roof 28.

[104] Hodge 1960, pp. 61, 77, note 2, fig. 18 (top right), pl. IX:b.

## FIFTH-CENTURY DEVELOPMENTS ON THE GREEK MAINLAND

### Olympia: Temple of Zeus

A surprising example of West Greek influence is to be found in the Temple of Zeus at Olympia, where the tripartite lateral geison makes its first appearance on the mainland of Greece (Fig. 18).[105] In the case of the raking and horizontal geisa, the complete blocks allow for the reconstruction of the gables surrounding the magnificent sculptural compositions. The raking geison, with a hawksbeak used for the crowning and soffit moldings, sheltered the sculpture from above, while the horizontal geison, with its flat top and mutular soffit, formed their base below. A corner block of the raking geison demonstrates how the pronaos was roofed with tilted purlins.[106]

The lateral geison has a more complex design. The earliest excavations uncovered a mutular geison with a flat top surface and a second block with rafter cuttings, which sat atop the first block (geison). Only later did the discovery of a third block, wedge-shaped and with hawksbeak molding, permit a full reconstruction. The complete lateral geison has a lower mutular element with a flat top (abutting a backer/epikranitis block) and an upper wedge element in two parts: a crowning molding at the front and a second block with rafter cuttings at the back (Fig. 18).

This tripartite design, with separately worked crowning molding and a block with rafter cuttings atop a mutular geison, has no parallels in mainland Greece, but earlier (Selinus F) and contemporary parallels (Paestum, Temple of Poseidon [Hera II], Selinus E) can be found in Western Greece (Fig. 14).[107] Furthermore, the Zeus temple had a lateral sima with lionhead waterspouts, the first of its kind on the mainland, but the type is also known in the West and in the Cyclades.[108] It is therefore necessary to wonder if Libon of Elis, a virtually unknown architect who built one of the largest temples on the mainland of Greece, could have learned this technique from West Greek architects who brought their expertise and traditions to the Panhellenic sanctuaries at Delphi and Olympia.[109]

Concurrent with these developments, a new geison design made its appearance: a flat-topped lateral geison surmounted by a wedge-shaped upper member whose top surface has been shaped like an eaves tile or sima. The first example is found in Sicily in the Temple of Victory at Himera (Fig. 19). This combination of mutular geison and wedge-shaped sima is closely comparable to the two- and three-block geisa developed in Sicily during the second half of the 6th century, with the simple attachment of the sima to the sloping upper member(s). Although Hodge notes an early-5th-century date for the Himera temple, he does not make a connection between this Sicilian geison and a similar design found in later-5th-century Athens (Fig. 20). There, a wedge block with its upper surface carved like an eaves tile is employed in the Parthenon, the Propylaia, the Nike Temple, and the Erechtheion. While the presence of the tripartite geison in the

[105] Dörpfeld's study of the architecture (*Olympia* II, pp. 4–22, esp. pls. XIII, XIV) provided the initial data, while subsequent studies have focused on the refinements and details.

[106] Hodge 1960, pp. 53–54, fig. 12:d.

[107] A multiple-block geison has been suggested for two Arkadian temples, the Temple of Artemis Knakeatis near Tegea and the Temple of Athena Soteira and Poseidon near Asea, but without strong evidence; cf. Rhomaios 1952; 1957. On the Athenian Akropolis, it appears that the architect of the so-called H-Architecture attempted to reduce the size of certain geison blocks by making them in separate pieces, but this practice was applied to other building elements as well and is not in evidence in the Sicilian geisa. More important, these examples from the mainland are not related to the concept of a *tripartite design,* which was used on the Zeus temple.

[108] Mertens-Horn (1988, pp. 61–67) compares the lionhead waterspouts of the Zeus temple to a sima in Paros and suggests that a Cycladic workshop was responsible for the Olympia sima. See also Ridgway 1993, p. 248, note 6.8.

[109] Mertens 1996, p. 333; *OlForsch* XXIV, pp. 104, 162. The evidence from the architectural terracottas suggests that local workmen may have imitated West Greek styles in local clay. Given the number of large temples constructed in Sicily and South Italy in the early 5th century, it is also possible that Libon may have "apprenticed" in the West. I owe this observation to Kevin Glowacki.

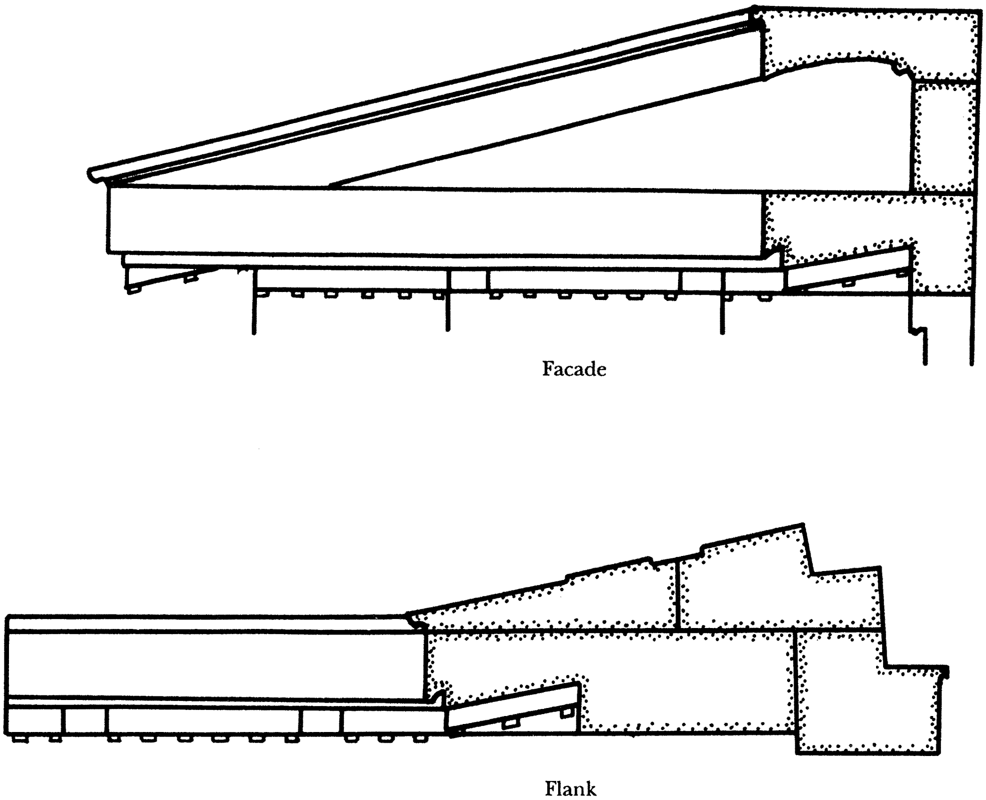



FIG. 18. Olympia, Temple of Zeus: facade and flank entablature (after *Olympia* II, pl. XIII)

Temple of Zeus at Olympia demonstrates mainland Greek knowledge of this design, it is tempting to attribute its appearance in Athens to direct contact between West Greek architects and their Athenian counterparts.

Further evidence for the influence and transmission of elements of West Greek architecture in the 5th century comes from the Cyclades, from the "Great Temple," or Temple of Apollo, on Delos. In the original publication of the temple, Fernand Courby suggested that this building was designed to be Doric from the beginning, with the superstructure dating to the 5th century, but that the building was completed in the Early Hellenistic period.[110] Dinsmoor questioned this interpretation, contending that the absence of angle contraction precluded a 5th-century date and that a major Doric building in the Cyclades would be unparalleled.[111] Evidence supporting Courby's original interpretation has been discussed by Coulton in his study of "The Parthenon and Periklean Doric."[112] Coulton's research into column, capital, and entablature proportions

[110] *Délos* XII, pp. 1–106.

[111] Dinsmoor (1950, p. 184, note 5, p. 221) suggested that the building had been planned as an Ionic temple, that this plan was abandoned before completion, and that the temple was subsequently completed in the late 4th or early 3rd century B.C. For a discussion of Doric architecture in the Cyclades, see Schuller 1985, esp. p. 352, note 84, pointing out that many features of the Apollo temple that are difficult to reconcile with mainland Doric architecture (slender column proportions, gradual widening of intercolumniations) have a clear tradition in the Cyclades and owe much to Ionic techniques.

[112] Coulton 1984, note 38. Further evidence to support this theory has been presented in Miles 1991.

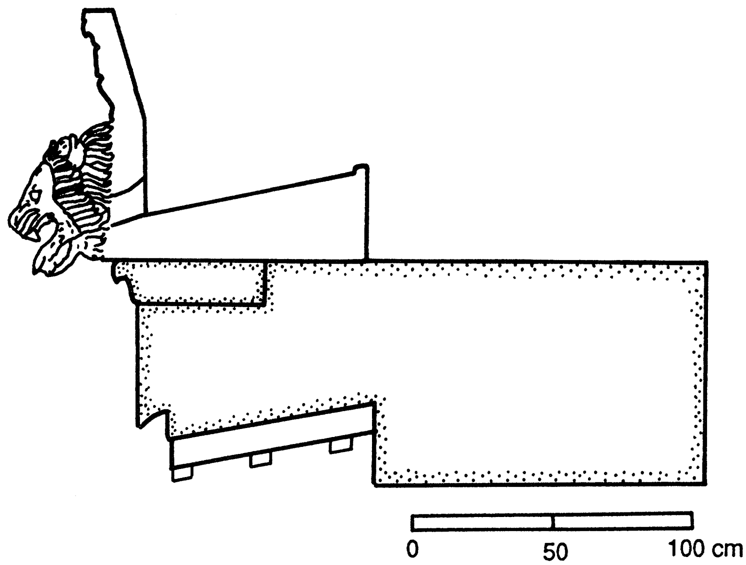



FIG. 19. Himera, Temple of Victory (adapted from Bonacasa and Adriani 1970, fig. 42)

reveals that those of the Apollo temple are more appropriate for the 5th century than for the Hellenistic period.[113] Moreover, the temple shares certain column proportions, molding profiles, and elements of ceiling design with West Greek temples, and Coulton suggests that "the Western Greek features of the 'Great Temple' at Delos could be due to an architect who had emigrated to the West, but returned in the safer times of the second quarter of the century."[114] Although the building seems to have been finished only up to the level of the entablature during the 5th century, the geison, as attested by the one surviving block, was designed with the upper block cut as a sima, similar to the geisa in the temple at Himera and in the Periklean buildings on the Akropolis (Figs. 19, 20). The design suggests that some of the geisa were in fact executed during the 5th century B.C. and copied during the Hellenistic completion of the temple.

While the study of the ongoing developments of 5th-century architecture in the Cyclades and the Greek mainland goes beyond the limits of the present analysis, it is interesting to note that Attic temples subsequent to the Parthenon also have lateral geisa with additional wedge-shaped blocks on top to secure the rafters. It seems that the structural advantages of this element were widely recognized in 5th-century Attica. These observations, taken together, indicate the influence of the West on the 5th-century architecture of the mainland itself.

## SICILIAN ROOFING TECHNIQUES AND THE CREATION OF THE TRUSS

On the basis of arguments presented above, Sicilian architecture is seen to have contributed both decorative and technical innovations to the nascent Doric order throughout the Greek world. The tradition of innovative roof design is well documented in the Archaic buildings at Selinus by the obvious technical advance of using special cuttings to secure beams in the lateral geison,

[113] Coulton 1984, p. 44; Miles 1991.

[114] Coulton (1984, p. 44) goes on to suggest that we owe the presence of West Greek features in the Parthenon to a Cycladic intermediary. While this is possible, it is equally possible that the roof design in all the Akropolis buildings can be attributed to direct contact between Athens and the West.

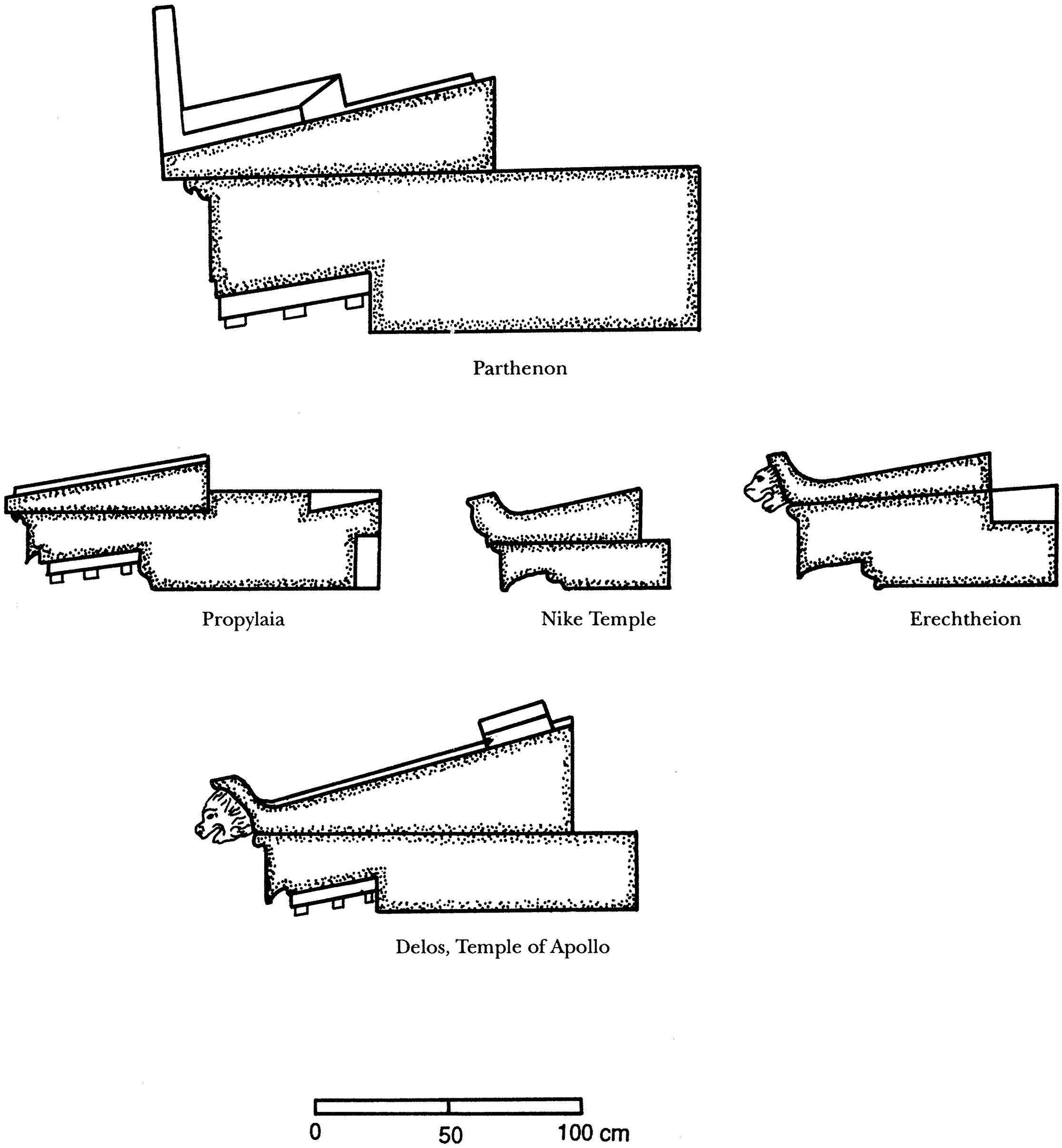



FIG. 20. 5th-century geisa with upper block cut as sima (adapted from Hodge 1960, fig. 18)

or entablature.[115] The importance of individual cuttings is their ability to hold wooden beams in a fixed position and keep them from moving either from side to side or outward. The advantage seems obvious, regardless of the means of supporting the ridge beam, but the fact is that in the Archaic period few if any buildings on the mainland of Greece (besides the exceptions mentioned above) had lateral geisa with beam cuttings of any kind (Table 1). The frequency with which such cuttings are found at Selinus indicates an understanding of their advantages and suggests a

[115] The use of sockets for wooden beams is widespread at Selinus, contrasting with the lack of clamp cuttings and carved moldings.

relationship between the cuttings and the use of a truss (Table 2). As described above, the tie-beam truss is a triangular set of beams held together in tension. The connection and compression of the beams at the corners of the triangle are crucial to the stability of the truss.[116] Cuttings in the lateral geison would not only assure that the end of the rafter be held close to that of the tie beam but also that, by limiting lateral movement, they would keep the rafters and tie beam in the same vertical plane, thus satisfying two primary requirements for truss stability.

The arguments in favor of the use of a truss in the Megaron of Demeter (II) at Selinus are presented above, but the question of whether a truss was used to span the cellas of the large buildings at Selinus remains unanswered. The matter cannot be settled on the basis of the preserved architecture, since there are no preserved blocks from the top of the cella walls (blocks whose function would correspond to that of the lateral geison in a nonperipteral building). We are left with the inference that the large interior spans of these buildings were either roofed with extraordinarily large beams or that the truss was used. Modern architectural historians have argued that, although the Sicilians may have "inadvertently" created the truss or learned of it from others, they did not recognize its structural capacity. Two facts may be elicited from the present study, however, in support of a more thorough understanding of the truss's capabilities and applications: (1) the use of sockets to secure beams reflects an understanding of the need to stabilize the roof frame; (2) the cross section of the beams used in the proposed trusses for both the Megaron of Demeter (II) and the Geloan treasury was average or below average for the span and load carried. This would indicate that the architect understood that smaller beams, when used in a truss, had better weight-bearing ability than when used alone. If these observations are accepted, there is substantial evidence in favor of the Sicilians' deliberate use of the truss for its particular advantages by the middle of the 6th century B.C.[117]

Although the evidence presented here supports the hypothesis that the invention of the tie-beam truss took place at Selinus, it is puzzling to see that it did not find widespread acceptance at other sites. While there is substantial evidence to demonstrate that geison design on the mainland of Greece was influenced by Sicilian developments via the Panhellenic sanctuaries and the adoption of rafter cuttings and the multiblock lateral geison in 5th-century mainland architecture, there is no hint of a truss. Its absence is particularly striking in the Temple of Zeus at Olympia and in the Parthenon, where the interior span, even with the presence of a double colonnade, is considerable. Three points may be cited by way of explanation: (1) The traditional technique of prop and lintel roof design may have been preferred by mainland architects, since a double colonnade can be used to define and focus the interior space of the naos. (2) The use of a truss requires the placement of rafters below the purlins and ridge beam, with additional changes made in the use of battens, sheathing, and clay. Since this effectively turned the woodwork inside out, the design changes may have been enough of a disadvantage to outweigh the advantage of the truss. (3) The tie-beam truss may have been used in those few cases where its triangular form was needed to meet other, preexisting conditions in the building. For the Megaron of Demeter (II) at Selinus it was the use of a Gaggera roof over the cella, while the Geloan treasury at Olympia is, indisputably, one of the widest spans in early Greek architecture. This last example may also offer an additional reason why the truss did not gain wide acceptance. The roof of the Geloan treasury was rebuilt several times in its history, for whatever reason, but it may be that the structural aspects of the roof were not fully understood or well executed.

[116] Melaragno 1981, p. 355.

[117] From the time of Vitruvius onward we have buildings and written documentation that demonstrate a knowledge of the technical ability of the truss to span large distances unsupported. The unsupported spans of the Bouleuterion at Priene (14.50 m) and the Bouleuterion at Miletos (15.00 m) have led to the suggestion that they were roofed with trusses. For Priene, see Wiegand and Schrader 1904, pp. 219–231. For Miletos, see *Milet* I, ii. Dinsmoor (1950, pp. 295–296) believed that the bouleuterion at Priene had a simple truss. See also Melaragno 1981, pp. 6–8.

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