

L'architrave le plancher la plate-forme

Nouvelle histoire de la construction

sous la direction de Roberto Gargiani

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La colonne

Nouvelle histoire de la construction

Roberto Gargiani (sous la direction de)

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Jacques Lucan

Histoire de l'architecture moderne

Structure et revêtement

Giovanni Fanelli et Roberto Gargiani

Enseignement d'un temple égyptien

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Exploring modernity in the architraves and ceilings at the Mnesiklean Propylaia

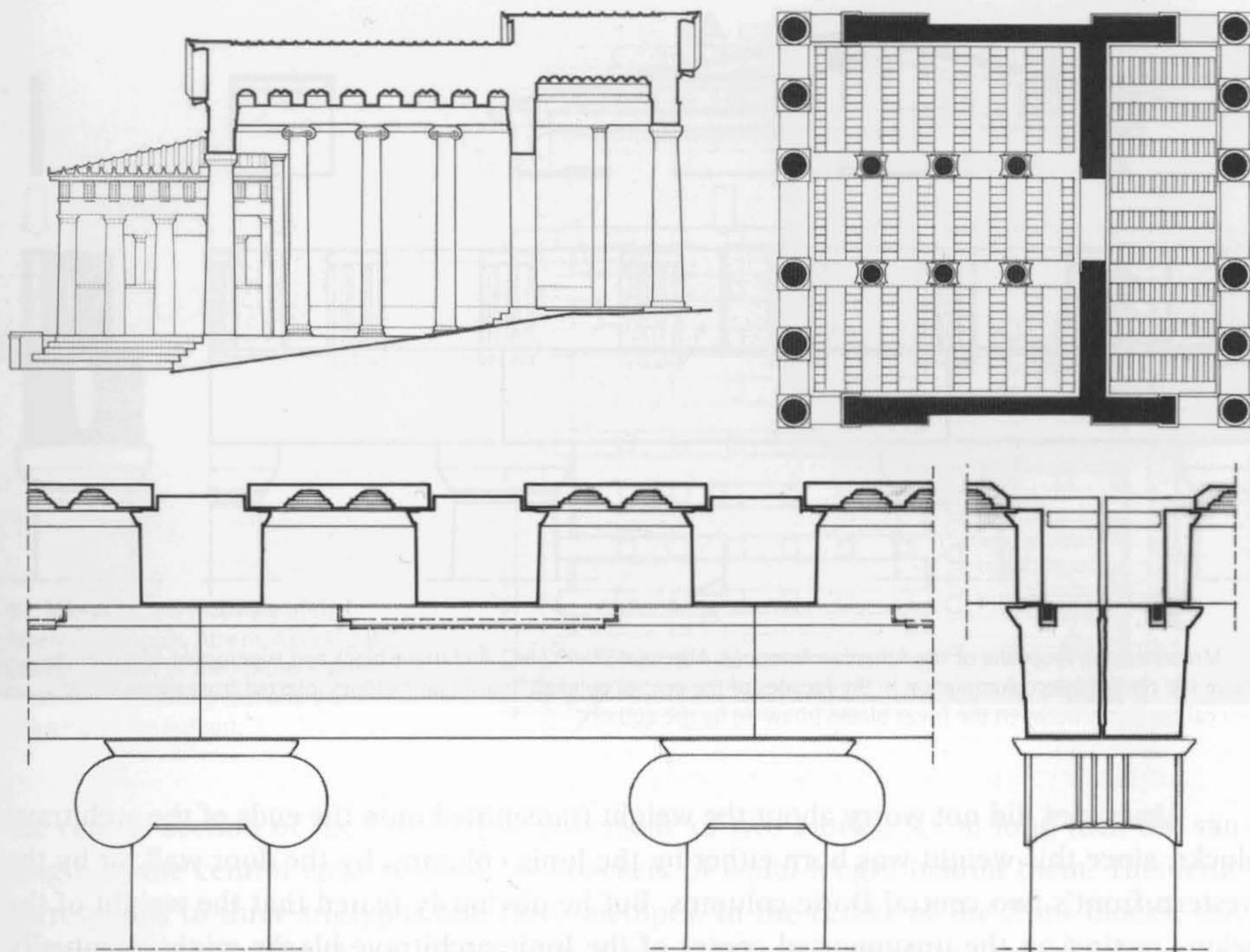
Tasos Tanoulas

The Propylaia is the monumental gate building to the Athenian Acropolis, part of the Periklean construction project that made the Acropolis the material symbol of Classical Greece. The building, as far as it was accomplished, is the result of a process that began in 437, and was halted in 432 B.C. when the war between Athens and Sparta broke out, it was finally completed after a time period of considerable but unknown length. This process consisted of successive cuts and transformations of an initial project, much more extensive than what was constructed in the end. In spite of these vicissitudes, Mnesikles, the architect of the Propylaia, created an architectural composition that had no precedent from many points of view. With the Propylaia, the concept of architecture was recast. For this reason it claimed admiration throughout antiquity, and exercised great influence on architectural schemes from the 5th century B.C. to modern times¹.

As built, the Propylaia comprised a central building and two lateral wings, the north of which consisted of a Doric portico and a chamber behind it, while the south wing comprised solely a portico (fig. 1). The central building was composed of two Doric hexastyle façades facing west and east. A transversal wall separated the east portico from an almost rectangular hall in a lower level to the west, covered with a vast marble ceiling supported by three pairs of Ionic columns. The two ceilings consisted of large beams measuring 6,45 m in length and weighing approximately 11 tons. These remarkable dimensions render the beams as the second largest architectural members on the Acropolis, after the lintel blocks of the Parthenon doors. The space provided between the beams was covered by coffered marble slabs which rested on the beams. The east portico had ten beams of this size. The west hall, 18,2 m wide and 13,5 m deep, required three pairs of Ionic columns to support the ceiling, which was divided into three aisles by means of two Ionic epistyles. Each of the lateral aisles had seven beams like the ones described above, spanning the gap between the lateral walls and the Ionic epistyles on top of the columns. The central aisle, which was narrower, had 7 beams measuring 5,47 m in length². The ceilings of the Propylaia, remained unparalleled with respect to size and beauty throughout antiquity³.

¹ J. Travlos, *Pictorial Dictionary of Ancient Athens*, London, Thames and Hudson, 1971, pp. 482–492, with collected previous bibliography. On the building process of the Propylaia, T. Tanoulas, «Structural Relations between the Propylaia and the N. W. Building of the Athenian Acropolis», in *Athenische Mitteilungen*, vol. CVII, 1992, pp. 199–215, pl. XLV–LVI, foldout drawings 11–12; Id., «New Information about the Ionic Stylobates and the bulding process of the Propylaia», in E.-L. Schwandner, ed., *Säule und Gebälk. Zu Struktur und Wandlungsprozeß griechisch-römischer Architektur*, conference proceedings, Berlin, 16–18 June 1994, Mainz, P. von Zabern, 1996, pp. 114–123; Id., «About Clamps and Dowels at the Central Building of the Propylaia of the Athenian Acropolis», in *2nd International Conference on Ancient Greek Technology*, conference proceedings, Athens, 17–21 Octobre 2005, Athens, Technical Chamber of Greece, 2006, pp. 448–456.

² W. B. Dinsmoor, *The Architecture of Ancient Greece*, London, Batsford, (1950), 1975, pp. 199–204, pl. XLVIII–L; T. Tanoulas, «Study for the Restoration of the Propylaia», in Id., M. Ioannidou, A. Moraitou, *Μελέτη αποκατάστασεως των Προπυλαίων. Study for the Restoration of the Propylaea*, vol. I, Athens, Ministry of Culture, Committee for the Preservation of the Acropolis Monuments, 1994, pp. 3–334 (in Greek with a summary in English, pp. 187–208); T. Tanoulas, *Τα Προπύλαια της Αθηναϊκής Ακρόπολης κατά τον Μεσαίωνα [The Propylaia of the Athenian Acropolis from 267 to 1458 A.C.]*, Athens, Library of the Archeological Society, 1997, vol. I, pp. 9–16, 30–31; *ibid.*, vol. II, drawings 1–27;



1 Mnesikles, the Propylaia of the Athenian Acropolis, Athens, 437–432 B.C. Cross-section along the central axis, looking north, and plan of the ceilings in the central building (drawing by the author).

2 Mnesikles, the Propylaia of the Athenian Acropolis, Athens, 437–432 B.C. Ionic architrave with Mnesikles' relieving iron bar. On the left, the front view of the architrave, with bar in broken lines. On the right the cross-section of the architrave, with bar in black (drawing by the author).

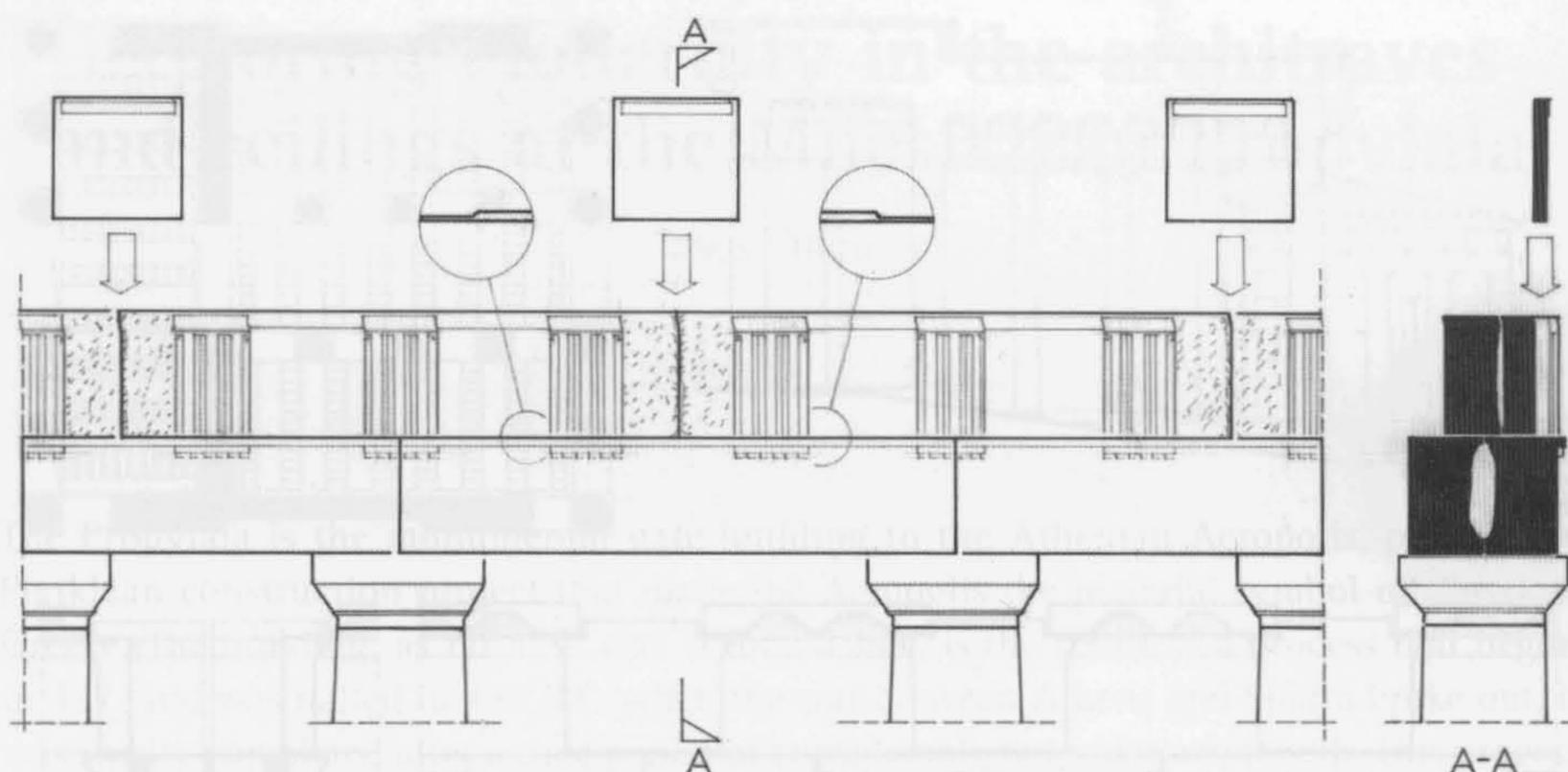
Mnesikles, due to the compositional and stylistic innovations introduced in his building, had to face some unprecedented structural issues that most likely posed several serious concern. Even if Mnesikles's precaution in most cases is rated unnecessary by modern calculations, it exhibits a very advanced understanding of engineering concepts. This is most obvious in the superstructure of the Propylaia, i.e., in the ceilings and the entablature, where some exceptionally long blocks of marble were used following the demands of plan and design.

The most well-known of Mnesicles's innovative devices is the one used in order to relieve the architrave blocks above the Ionic colonnade of the central building's west hall, from the weight of the superposed structure⁴. Upon the center of each of these architrave blocks rests a ceiling beam. If one takes into account that the ceiling beams originally bore the weight of the marble coffers, as well as the wooden parts of the roof above, including the marble tiling, one understands that each of these beams was heavily loaded, transmitting in addition its own weight to the Ionic architrave below (fig. 2).

T. Tanoulas, M. Ioannidou, *Μελέτη αποκατάστασης των Προπυλαίων τ. 2. Μελέτη αποκατάστασης της ανωδομής του κεντρικού κτιρίου. Study for the Restoration of the Propylaea, Restoration of the Superstructure of the Central Building*, vol. II, Athens, Ministry of Culture, Committee for the Preservation of the Acropolis Monuments, 2002 (in Greek with a summary in English, pp. 141–149).

³ Pausanias I, 22, 4.

⁴ Dinsmoor, *op. cit.*, p. 203; A. Orlandos, *Τα υλικά δομής των αρχαίων Ελλήνων και οι τρόποι εφαρμογής αυτών [The Building Materials of the Ancient Greeks and the Ways of Using them]*, Athens, Η εν Αθήναις Αρχαιολογική Εταιρεία, 1958, vol. II, p. 21, fig. 9.



3 Mnesikles, the Propylaea of the Athenian Acropolis, Athens, 437–432 B.C. Architrave block and superposed frieze blocks above the central intercolumniation in the façades of the central building. Individual metopes inserted from above are to conceal the joints between the frieze blocks (drawing by the author).

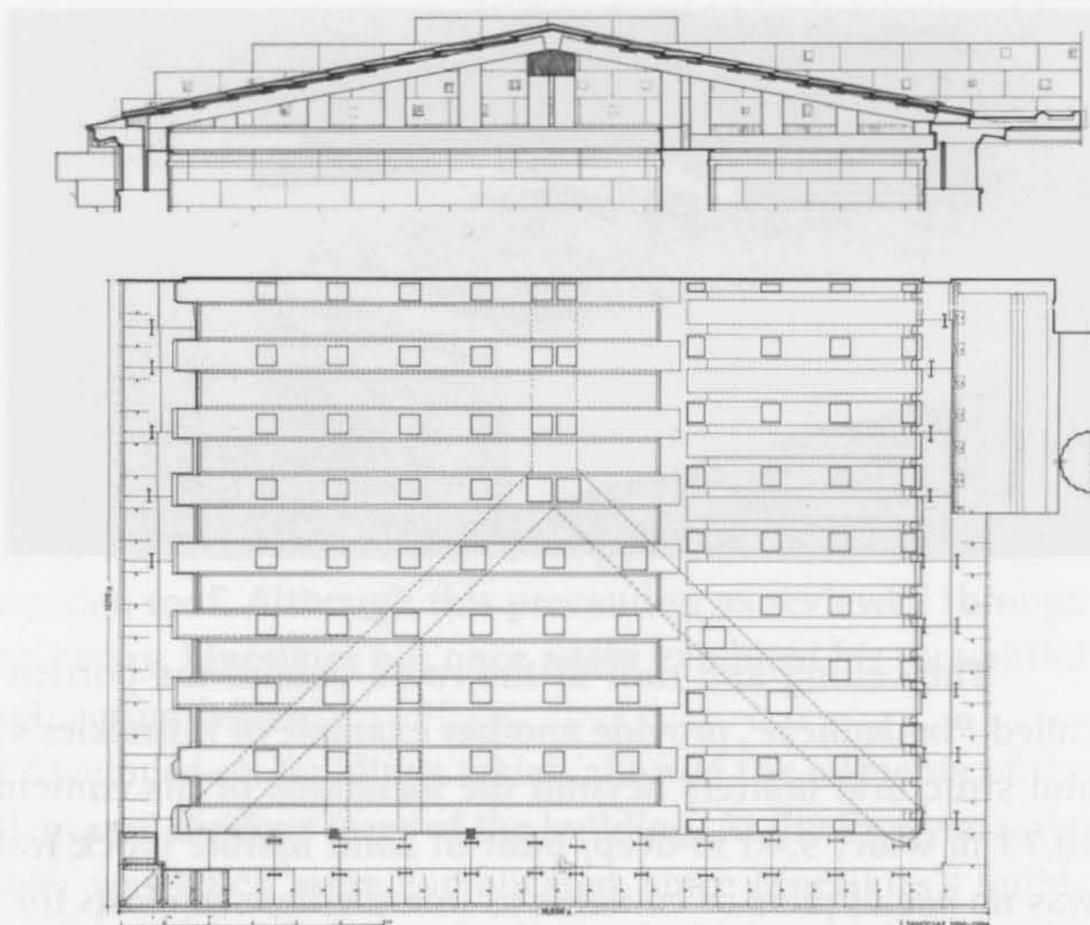
Mnesikles did not worry about the weight transmitted onto the ends of the architrave blocks, since this weight was born either by the Ionic columns, by the door wall, or by the western front's two central Doric columns. But he obviously feared that the weight of the beams resting on the unsupported center of the Ionic architrave blocks might eventually make them sink and break. His concern is proved by the fact that he very ingeniously managed to relieve the center of the Ionic architraves. To obtain this result, he used an iron bar accommodated in a channel cut along the upper surface of each architrave block. The iron bar rested on the raised ends of the bottom of the channel, while the top of the bar was elevated above the top of the architrave. This way, the marble beam rested not on the marble block, but on the middle of the iron bar. Thus, the weight of the beam was transmitted to the lateral ends of the bar and, subsequently, to the lateral ends of each architrave, which in turn rested on supports underneath. If the iron bar arched in the middle under the weight of the superposed beam, the space beneath the bar and the bottom of the channel, allowed for sagging.

Both the west and the east front of the Propylaea are Doric, each carrying six columns. For the accommodation of a stepped ramp that divided the floors and steps in the central building into two halves, the central intercolumniation was wider than the rest by a triglyph and metope pace. Due to the unusual size of the central Doric architrave (5,5 m), Mnesikles took special measures to strengthen it and relieve it from its own weight as well as from that of the superposed structure⁵ (fig. 3).

First, the architrave consisted of two blocks, i.e., a front block and a backer, instead of a front block and two backers, which was the usual practice with architrave blocks of normal length. Thus, the central architrave blocks were thicker and stronger. In addition, they were both hollowed along the rear vertical surfaces of mutual contact, so that their own weight was eliminated.

Second, the blocks of the superposed structure were arranged in a manner preventing the weight from being transmitted to the central architrave blocks. For this purpose

⁵ W. B. Dinsmoor, «The Gables of the Propylaea at Athens», in *American Journal of Archaeology*, vol. XIV, 1910, n° 2, pp. 143–184, pl. IV–V, especially pp. 145–147.



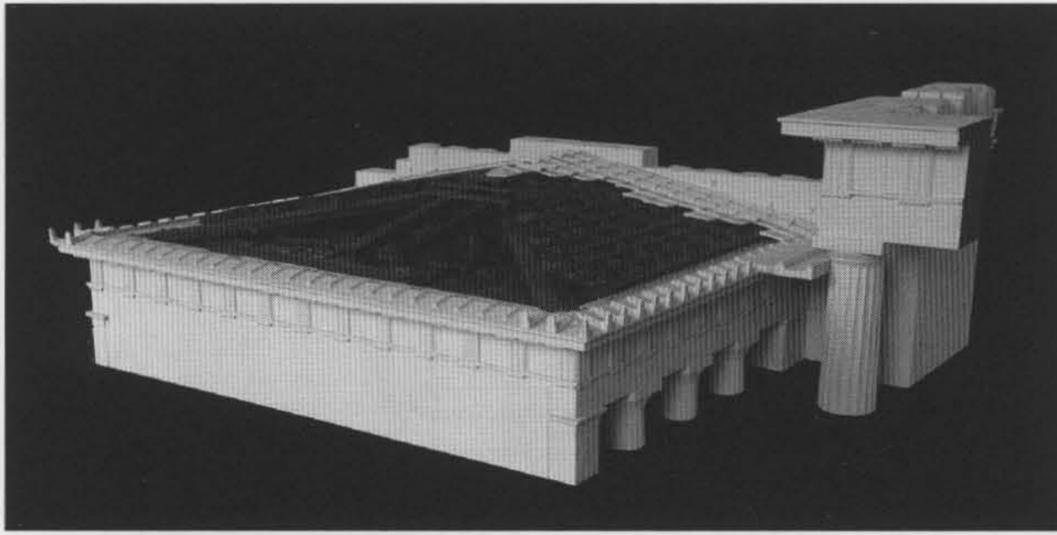
4 Mnesikles, the Propylaia of the Athenian Acropolis, Athens, 437–432 B.C. Ceiling and roof of the northern wing. Cross-section looking east and plan (drawing by the author).

the central section of the Doric frieze was made of two blocks, 5,5 m long (i.e., the same length as the central epistyles) and two backers of equal length behind them. This length corresponds to three triglyphs and three metopes. In the center of the front blocks, three triglyphs were carved, divided by two metopes, while the remaining length of a metope was divided equally at the two ends, each of which was cut in the form of a slot for the accommodation of half a metope slab. Each of these blocks equilibrated above the axis of each of the columns framing the central passageway.

The entire weight of these frieze blocks, including the weight of the superposed blocks carried by them, was transmitted to the columns below. This was achieved by securing tight contact between the frieze blocks and the parts of the architraves above the abacus of the Doric capitals below and by undercutting the lower surfaces of each of the frieze blocks by 1,40 m on both sides of their mutual joint in the axis of the central intercolumniation. The central joint was concealed by an individual metope slab which was lowered into the socket formed by the abutting ends of the frieze blocks. The joints between the other ends of these frieze blocks and those abutting them were concealed by two additional individual metope slabs which were lowered in the same manner in similar sockets cut into the frieze blocks.

In the east portico, the backers of the epistyles of the colonnaded front were reflected in the epistyles sitting on the transversal wall, above the epikranitis. This application follows precisely the design principles of ancient Greek architecture. Furthermore, it permitted the lintel of the exceptionally wide central doorway below to be relieved from the weight of the superstructure. This became possible since the length of the epistyle (5,50 m) allowed both of its ends to rest on the area above the doorjambes framing the central door (the width of the opening at the top is 4,65 m). It is more than probable that this epistyle block was undercut, in order to ensure that the central part of the lintel below was not burdened by the epistyle. Further up, above the thranos (or inner cornice) course, there was another opening in the central part of the transversal wall superstructure aiming at the same result: relieving the lintel of the central doorway⁶.

⁶ *Ibid.*, pp. 155–173, especially pp. 169–173, pl. V.



5 Mnesikles, the Propylaea of the Athenian Acropolis, Athens, 437–432 B.C. Ceiling and roof of the northern wing. View from the west (model made by G. Kanellos after drawings by the author, photo by M. Toufeklis).

The ceiling and roof of the room behind the portico of the northern wing, the so-called *Pinakothekē*⁷, provide another example of Mnesikles's ingenuity in conceiving design and structural matters beyond the standards of his contemporaries⁸ (fig. 4–5). The room is 10,73 m wide, 9,40 m deep, built of solid marble block walls. Despite its large size, there was no use of piers or columns as intermediate supports for the structure of the ceiling and roof above, which was notably heavy. The study of the cuttings in the surviving marble parts of the monument, for the accommodation of structural elements, provides all the data required for the restoration of the ceiling and superposed roof.

The ceiling of the *Pinakothekē* consisted of nine wooden beams running north-south; they were 9,7 m long⁹, 0,44 m high, and 0,70 m, except for the two beams abutting the east and west walls, which were 0,42 m and 0,54 wide¹⁰. The space between the beams was 0,70 m wide, except for the westernmost gap which was narrower (0,54 m). The proportions of height and width of the wooden beams, in relation to the width of the spaces between them, were similar to the proportions of the equivalent dimensions in the marble ceilings of the central building of the Propylaea. This leads to the conclusion that the ceiling of the *Pinakothekē* was intentionally designed to resemble those of the central building. Consequently, it was almost certain that there would be wooden inter-beam slabs, between the wooden beams while wooden coffers would cover the spaces between the beams.

In the portico of the *Pinakothekē*, there were 18 wooden beams running north-south. These beams measured 4,45 m in length¹¹, 0,27 m in height and 0,465 m width, except for the two beams abutting the east and west walls, which were 0,25 m and 0,29 m. The spaces between the beams were 0,17 m wide and must have been covered with wooden planks. Vertical wooden planks would almost certainly seal the spaces between the ends of the beams' sides above the *epikranitis*¹².

The timber structure of the roof consisted of 25 raking rafters, two raking and one horizontal ridge beams, planks and marble tiles. The weight was transmitted to the horizontal ceiling beams by means of vertical wooden posts. The wooden elements in this structure stood so close together, in spite of the immense weight and the great span of the

⁷ *Pinakothekē* means picture gallery; in modern literature, the room of the northern wing of the Propylaea is commonly known with this name, due to Pausanias' reference to it as «a building bearing paintings» (Pausanias, I, 22, 6).

⁸ Tanoulas, «Study for...» cit., pp. 97–125 (English summary, pp. 200–202), drawings 45–82, photographs 33–53, three foldout drawings; Id., «New discoveries at the Propylaea», in R. Economakis, ed., *Acropolis Restoration, The CCAM interventions*, London, Academy Editions, 1994, pp. 180–183.

⁹ The length of the beams visible from below was 8,85 m.

¹⁰ Since one side of the east and west beams was accommodated in sockets along the top of the respective walls just above the *epikranitis*, the visible width of the beams seen from below was 0,36 m for the east beam and 0,45 m for the west one.

¹¹ The length of the beams visible from below was 3,55 m.

¹² Horizontal molding that crowns a wall.

Pinakothek ceiling beams, that sagging would not be more than 0,013 m, according to modern calculations. In conformity with modern engineering, the wooden structure on top of the northern wing would function as a horizontal bonding diaphragm holding the walls and colonnade together by means of its inflexibility and weight, allowing the omission of supports for the ceiling. This was a pioneering structural solution for the 5th century B.C.

On the upper surface of the Doric frieze backers of the west marble wall have survived two cuttings for iron dowels which would bond the top of this wall with the west end of the wooden superstructure, i.e., with the wooden beam of the ceiling set along the backers of the Doric frieze on the west wall. This proves beyond any doubt that Mnesikles had conceived that, possibly, the top of the west wall risked to be pushed westwards because of horizontal thrusts from the wooden roof. Although this precaution as reviewed through modern calculations proves unnecessary, Mnesikles has once again exhibited his thoughtful calculating spirit in tackling engineering issues.

The Doric order had been developed on buildings which allowed the elements of the order to spread uninterrupted all around the four faces of the building. At the Propylaia, the accommodation of the Doric order was much more complicated, since Mnesikles's building was planned as a combination of five buildings, only three of which were built in the end. Among these three buildings, only the central one presented four faces. The other two – the lateral wings – presented only three faces, since to the east they abutted the taller walls belonging to the parts of the architectural complex which were never built. One of the resulting implications was the following.

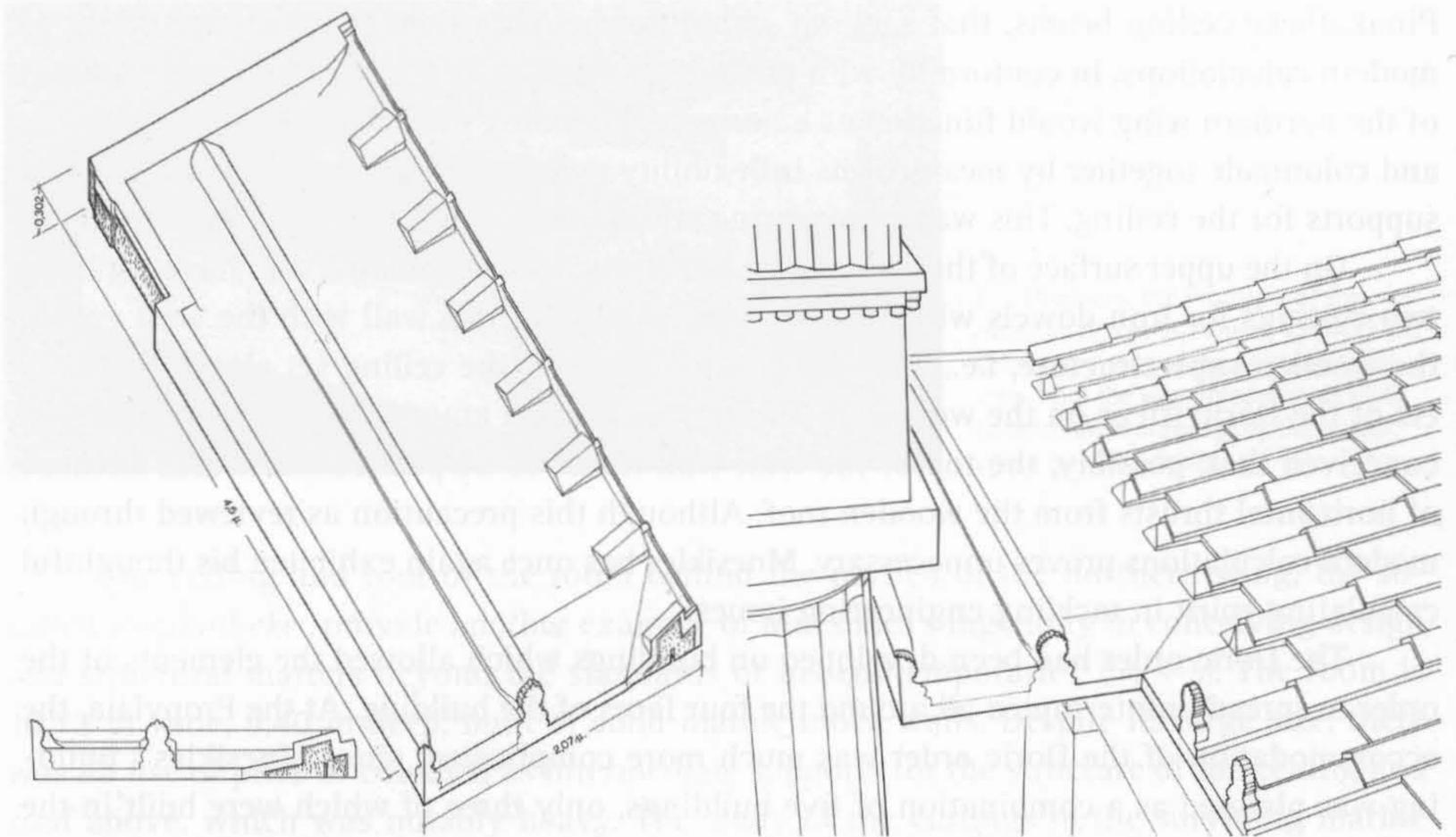
The strictness of the Doric order did not allow the architecture of the lateral wings to integrate normally with the architecture of the central building. The result provided the creation of two loosely integrated areas found between the west end of the central building and the east end of each of the colonnades of the wings. These spaces are usually named the north and the south *niche* of the Propylaia, and are essentially hypaethral (roofless) areas in which the rainwater from the roofs of the central building and the neighboring wing could flow freely. However, Mnesikles must have thought that the *niches*, as parts of the building, should be protected against rainwater by means of a roof.

Since the *niches* were restricted between two very clearly defined architectural entities – the central building and the wings – Mnesikles could not provide them with a roof supported by an additional architectural order. Thus, he had to revert to the only part of Greek architecture that was beyond architecture: roof tiles. Indeed, roof tiles were allowed to change their regular shapes in order to protect the building from rainwater.

In this case Mnesikles extended the roof tiling of each wing above the relevant *niche* by installing a huge marble slab 2,07 m wide, 4,50 m long and 0,302 m high (fig. 6-7)¹³. This slab rested on the *geison* (cornice) of the colonnade of the wing which was extended on the east wall, providing an L-shaped surface for the slab to lay on along its two sides. Mnesikles took care to create an additional support for the only free corner of the slab by providing an iron dowel fixed in the neighboring column of the central building; this dowel projected from the column and supported the slab from below.

The bottom of the slab was flat, but the upper surface was carved in a way that allowed it to receive the rainwater of the wing's roof on one side and, on the other side, was provided with a raised rim to prevent water from flowing into the central building. The rest

¹³ See n. 8; see also, Tanoulas, «Πρόσφατες ταυτίσεις αρχιτεκτονικών μελών των Προπυλαίων» [Recent Identifications of Architectural Members of the Propylaia], in *5th International Meeting for the Restoration of the Acropolis Monuments*, Conference Proceedings, Athens, 4-6 October 2002, pp. 281-283, fig. 1-4.



6 Mnesikles, the Propylaia of the Athenian Acropolis, Athens, 437–432 B.C. Marble cover of the southern *niche*. Axonometric view and west front (drawing by the author).

7 Mnesikles, the Propylaia of the Athenian Acropolis, Athens, 437–432 B.C. Marble cover of the southern *niche*. Perspective view from the north west (drawing by the author).

of the upper surface was carved to look like two very long pan-tiles divided by an equally long cover-tile running east-west. The «pan-tile» along the ridge of the wing's roof was horizontal for most of its length in order to remain at the same level with the horizontal lower end of the east part of the wing's roof. The west end on the other hand took a slope in order to conform with the ridge tiles (*hegemones*) above the entablature of the wing colonnade. The other «pan-tile» had a delicate slope westwards in order to let the rainwater to flow freely out of the west end and was bordered by a raised rim towards the central building. The free corner next to the column of the central building had a corner antefix, while the west end of the central «cover-tile» had the form of a regular antefix; both antefixes had their lower parts sculpted in the vertical face of the rim¹⁴, while the outline of the top was free. Due to the presence of the antefixes and the drop of the lower surface that was needed in order to prevent rainwater from leaking, the western end of each marble cover of the *niches* has a total height measuring 0,383 m.

This hybrid element functioned at the same time as the roof and ceiling, and is reminiscent of an entablature. It remained unique in its boldly unconventional character. Its closest example is the slabs covering the porch of the Caryatids in the Erechtheion, with the function of a coffered ceiling underneath and of roof tiles on top, although the upper surface is not carved to look like tiles. However, this device was rather conventionally integrated into the idiosyncratic architecture of the Caryatid porch.

For this presentation, I tried to confine myself to the most striking structural innovations in the Propylaia, related to the central topic of the volume in hand which concerns horizontal structural elements, especially architraves and ceilings. But one would need many more pages to describe every detail from the parts of the Propylaia that were built, in which Mnesikles' innovative genius is manifested.

¹⁴ The vertical face of the rim had the full height of the slab, 0,302 m.