GEOMETRY ENLIVENED: INTERPRETING THE REFINEMENTS OF THE GREEK DORIC TEMPLE.*

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In the literature on Greek architecture, the customary practice of concentrating on the refinements of the Parthenon (fig 2) creates the impression that the Athenian temple is unique in this regard, whereas it is in fact merely the culmination of a long-established practice. The invention of refinements cannot be seen as an exclusive Attic preserve: even if they were most fully developed in that area during the fifth century, an examination of extant temples demonstrates that a number of refinements originated at an earlier date in other parts of the Greek world.

The curve in profile of the tapering column shaft, called entasis, is found in temples of the Archaic period in the western colonies only. As early as 560 BC, the first temple to Hera at Paestum (fig. 1) shows a pronounced bulge of two-and-one-eighth inches in the twenty-one foot column shafts. In mainland Greece entasis was not employed at all in early temples with heavy proportions, such as Apollo at Corinth, but was used regularly, and with extreme delicacy, in fifth-century temples. The columns of the Parthenon, for example, diverge only eleven-sixteenths of an inch in a height of over thirty-four feet: the entasis is not invisible to the eye on the alert for it, but is generally more felt than perceived.

The skill required to create this refined convex profile, a subtle transition from a slower to a more rapid taper of the column shaft, is equalled in the formation of the horizontal curves of the temple, an effect created by huge polygons, formed by the individual cutting of each block of the temple platform or stylobate and of each element of the architrave. This in turn required individual shaping of the upper surface of the capital and the top and bottom drums of the column shafts to meet the changing directions of lintels and floor. The first known example of horizontal curvature is found on the Greek Peloponnese, in the stylobate of the ruined temple of Apollo at Corinth, dated about 540 BC. Although the elaborate process of cutting the column shafts to accommodate horizontal curvature makes clear that the curves were not automatically transferred from base to superstructure, it is normally assumed that the two accompany one another, because otherwise the columns would be of varying height. Better preserved temples of the classical period, like the fifth-century temples at Segesta and Athens, have curvature in both the stylobate and the entablature. The divergence from the horizontal is extremely subtle, involving only one-and-five-eighths inches across the ends of the temple platform of over seventy-five feet at Segesta, for example.
Fig. 1. Paestum, Temple of Hera I, east façade, mid-sixth century.

Fig. 2. Athens, Parthenon, west façade, mid-fifth century.
It is interesting that the Propylaea of the Acropolis have curvature in the entablature alone, presumably because the processional ramp through the building broke the profile of the stylobate; this unusual deviation results in the columns of the peristyle being of different heights.

Yet another refinement is found in the arrangement of peristyles, which may be adjusted so that the whole range of columns tilts towards the cella. Sometimes this feature is reserved for the flanking colonnades, but if employed on both facades it required a diagonal placement of the corner column, which was usually also larger in diameter than the other columns of the peristyle. The earliest known example of this inclination and the enlarged angle column is at the temple of Aphaia, built on the island of Aegina at the close of the sixth century. At the later Hephaisteion in the Athenian agora, we find this refinement uniquely elaborated, in that not only is each colonnade inclined inwards, but in addition the columns of the end facades tilt towards a central axis, following the diagonal angle of the corner column. In classical temples the inclination of the peristyle is echoed in the outer face of the cella walls and is also continued into the entablature, with architrave and frieze leaning backward, although the cornice and decorative features of the roof line, and sometimes even the faces of the abaci, tilt forward. The vertical inclinations are thus not all in the same direction. Nor are they at the same rate of inclination: of the backward tilts at the Parthenon, for example, the faces of the steps incline 1 in 250, the columns 1 in 150 and the entablature 1 in 80. These constitute very small actual measurements: the tilt of the columns at the Parthenon is less than three inches in over thirty-four feet.

Although we must acknowledge the difficulty of generalising about the use of the refinements in temples that are rarely well preserved, there would seem to be no clear pattern in the range of application to different temples. Refinements of curvature and inclination appear individually during the archaic sixth century in different parts of the Greek world. Only by the mid-fifth century, do some temples, such as the Parthenon and Hephaisteion at Athens, consolidate a range of refinements. This has sometimes been attributed to their introduction of the full use of marble, permitting very precise workmanship, but such an explanation is clearly an oversimplification. The refinements were invented in non-marble constructions; moreover, the second temple to Hera at Paestum seems to incorporate all of them, despite being constructed of limestone. This would undoubtedly also have been the case at Segesta had the temple been completed. On the other hand, certain marble temples lack some refinements: the fifth-century temple of Poseidon at Sunion, for example, has no entasis in its slender columns, although horizontal curvature is used. The variety in the application of refinements makes clear that there was no fixed set of rules for their use, and might also sound a warning note against those theories of interpretation that would suggest a single rule motivating their existence.

When we begin to examine the literature on Greek architecture for such theories, it seems remarkable to us today, equipped with the hindsight of
research, that the earliest investigators of the Doric temple failed to observe its refinements. Yet the concept could not have been unfamiliar to architectural scholars, as many refinements are discussed in well-known theoretical works, notably the Ten Books of Architecture by Vitruvius, a Roman architect of the first century BC. However, it was assumed that such elements as entasis did not form a part of ancient Greek practice. In his 1812 translation of Vitruvius, the English architect, William Wilkins, specifically comments on the Roman writer’s reference to entasis, saying, “This great refinement . . . does not appear to have entered into the execution of the works of the ancients.” His statement seems all the more extraordinary when we recall that Wilkins had earlier visited the temples of Paestum where entasis is very pronounced. A perusal of his Antiquities of Magna Graecia, published in 1807, reveals that he had observed curvature but was not prepared to credit his empirical observation to Greek practice. The old temple of Hera was nicknamed the Basilica, because it was thought not to be Greek at all, and Wilkins thus attributed its inescapable entasis to the ‘vitiated taste’ of a much later period. The entasis of the columns of the fifth-century temple to Hera he explained away with the comment that, ‘The deception is caused by the decay of the stone in the lower part of the shafts, which there has taken place in a greater degree than elsewhere.’ This example of special pleading is matched by the Frenchman, Delagardette, who also observed entasis at Paestum, as early as 1793, but attributed it to Roman recutting.

Before we ridicule such explanations, however, it is relevant to note that many previous visitors to the site apparently did not observe the entasis at all. The vague reference to entasis in Winckelmann’s Anmerkungen üuber die Baukunst der Alten seems to have a literary basis and is certainly not applied to specific examples. In early publications on Paestum, such as those by Berkenhout in 1767, Major in 1768 and Dumont in 1769, the engravings of the columns do not show any deviation from a straight line in the general views, or even in Thomas Major’s detailed drawings of the orders. The only exceptions I have been able to identify in eighteenth-century publications are the engravings of Paestum by Piranesi, published in 1778, the year of his death; here entasis is depicted, although of course in a picturesque rather than an objective context. In an interesting article on ‘The Early Publications of the Temples at Paestum’, Lang may give us the reason for the continued lack of observation of entasis amongst architectural scholars, by demonstrating that their publications were highly dependent on each other during this period, so that it seems likely that many who published on Paestum had never visited and certainly never drawn or measured the site. But the lack of observation of curvature is equally true of those who recorded and measured with scholarly care. James Stuart and Nicholas Revett, authors of the eighteenth-century Antiquities of Athens and acknowledged as the most accurate of the early investigators of Greek architecture, reconstructed all the monuments of Athens with straight lines. They did notice some irregularities of measurement, such as the enlargement of the columns at the angles of the Parthenon peristyle; but they observed no other refinements, neither inclination
nor curvature.

This was in part the result of expectation: they came prepared to find proportional regularity and geometric precision and therefore presumed that one measurement could be re-used in every equivalent case. But in all fairness we should remember the difficult conditions under which they worked, particularly the chaotic state of the Greek sites. Thus it was not until the second decade of the nineteenth century that entasis in Greek temples was acknowledged and measured, curiously enough at the Parthenon where it is relatively understated. The architect, Charles Robert Cockerell, is usually credited with the first measurement of entasis in about 1814, and thereafter further deviations from geometric regularity were discovered. In the 1820s another English architect, Thomas Donaldson, noted the use of the inclination of vertical elements in the Parthenon peristyle. Horizontal curvature was discovered at the time of the clearing of the Parthenon platform in 1836, possibly first by the German architect in charge of the reconstruction, Joseph Hoffer. Initially scholars were sceptical of the existence of these refinements and a lively debate on their validity ensued. They gained fairly widespread respectability, however, when they were verified and carefully measured by Francis Penrose during research in Athens in the 1840s. He published his findings in the Principles of Athenian Architecture in 1851, sponsored by the same Society of Dilettanti that had encouraged the first investigations of Stuart and Revett for the Antiquities of Athens a century before.

Penrose favoured theories of optical correction in his important publication, as did many nineteenth-century scholars, and this interpretation of Greek architectural refinements has pervaded the literature of the twentieth century, despite the attempts of William Goodyear to refute it conclusively in 1912. Repetition has reinforced the concept of optical correction from a probability into a firm conviction. Such explanations became more and more extensive and elaborate as the theory passed from hand to hand, until there is hardly an element of the Doric order that has not been accounted for in this way somewhere in the literature. So well established is the notion of optical correction that, although it is regularly challenged, it does not seem to have been unseated. This may be because other explanations for the refinements are offered, not as alternatives, but as secondary to the pervasive theory. No one entirely dismisses optical correction as the primary motivation for the refinements.

This is certainly the case with the entasis of the column shaft. William Taylor, for example, writes that, 'The entasis counteracted the hollow appearance which is seen in straight-sided columns. It was a device for correcting optical illusion as well as imparting a line of strength'. William Dinsmoor, too, accepts the basic premise, while adding secondary explanations:

The entasis had 'the purpose of correcting a disagreeable optical illusion, which is found to give an attenuated appearance to columns formed with straight sides, and to cause their outlines to seem concave instead of straight'. But it also gave to the column an appearance of elastic strength and vitality...
The secondary explanation does not challenge the basic notion of optical correction, and it is one that is difficult to refute empirically. Rudolf Arnheim comments, 'If there is any reliable evidence for these psychological effects, I have not come across it', but adds, '... which does not mean that the explanation is wrong'. We may point out that the columns of the temple of Apollo at Corinth, where no entasis has been measured, do not appear concave in silhouette. But if we are to believe that convex cutting will make a column appear straight-sided, then we can never be sure visually that a column which seems perfectly straight has in fact been corrected by an invisible curve. The converse argument may be advanced with more certainty, however: that is, if a column clearly has a convex silhouette, then it is hardly logical to propose the theory that the curve was intended to create an appearance of straight-sidedness. The pronounced bulge of the earliest example of columns with entasis at Hera I, Paestum, would therefore seem to refute conclusively that Greek architects used it for optical correction. Even if we were prepared to allow the somewhat far-fetched argument that correction was over-enthusiastically applied at the first temple at Paestum, this would not account for the continued obtrusiveness of entasis at the later temples there. Moreover, entasis can be perceived by the trained eye even in subtle mid-fifth-century examples in Athens, so it seems improbable that the Greeks, whose understanding of Doric architecture was certainly better developed than ours, would have failed to notice it, and suppose that the columns were really straight-sided.

It is interesting to note that the documentary source for the theory that entasis compensated for an optical effect of concavity is not found in ancient architectural writing, but in the works of Heron of Alexandria, who wrote on mechanics and applied mathematics, during the second half of the first century AD, and of Damianos/Hermodoros, who wrote on optics as late as the third or fourth century. We may wonder whether such very late explanations were not attempts to rationalise a practice for which the original purpose had long been forgotten. It is noteworthy that Vitruvius, who elsewhere demonstrates his proclivity for optical theories, gives no explanation for entasis; indeed he does little more than mention its 'graceful and appropriate manner', and refers his readers further to a diagram which regrettably no longer survives. It is not anywhere suggested in his writings that there is an effect of concavity in straight-sided columns. Vitruvius does recommend the Greek practice that the corner columns of the peristyle should be enlarged, to compensate for being 'cut into by the air', stating, 'what the eye cheats us of, must be made up by calculation'. He also recommends that columns should be proportionately thicker as they are more widely spaced, to avoid their appearing 'thin and scanty', but this is directly contrary to Greek practice. In the Doric order, columns of heavier proportions are invariably associated with relatively narrow intercolumniations, and vice versa; so Vitruvius' theories of optical correction in this context cannot be applied.

Vitruvius supplies direct documentary evidence of a theory of optical correction for only one refinement of curvature used by the Greeks. He explains the need
for the curvature of the stylobate of the temple platform, by saying, ‘... if it is set out to a level it will seem to the eye to be hollowed’. He later adds the need to adjust the levels of the capitals and entablature to correspond with the stylobate, but gives no further explanation for this adjustment. It is sometimes suggested in the literature that the shaping of the stylobate may have served to shed rainwater from the open peristyle, but this could equally well have been met simply by tilting the surface, as is the case in the Croesus temple at Ephesus. Such a function did not require the subtleties of curvature, nor did it require that the curves be repeated in the entablature: thus the shedding of rainwater would appear to be a secondary benefit, not a primary cause. But this need not lead us to conclude with Vincent Bruno and many other scholars that there therefore ‘... seems little reason to doubt Vitruvius when he tells us that horizontal curvature served an optical, not a functional, purpose.’ For many Greek temples, especially in the early period, do not have such curvature, and yet do not noticeably seem to sag. Penrose had suggested, perhaps realising the visual dubiousness of the Vitruvian explanation, that the curvature was developed as an optical correction of the effect of the gable ends of the temple, where the sloping lines of the pediment created a visual effect of depression in the horizontal cornice. He supports his theory with the example of the Propylaea, where only the entablature of the portico is curved. However, as has already been pointed out, the break in the platform provided a perfectly logical reason for the omission of stylobate curvature in this case. Further, Penrose’s explanation does not account for the customary curvature of the stylobate elsewhere, or on the flanks of temples where no gables exist. In the case of the temple of Concord at Akragas, it is not found on the temple front at all, but only on the flanks. Altogether it is difficult to credit Penrose’s theory.

William Goodyear is at pains to point out the limitations of all theories of optical correction for horizontal curvature. He argues that horizontal lines above eye level are seen as bowing, or curving downwards towards their extremities, rather than the other way around. As a great majority of Greek temples are seen above eye level, because of the favouring of elevated positions, this effect would apply as much to the lines of the stylobate as to those of the entablature. He postulates that the bowing of the platform and entablature tended to follow rather than counteract an optical illusion. By exaggerating the effects of curvature perceived at the extremities of a long line, this refinement might have served to increase the apparent length of the horizontal lines of the temple, rather than to make them more regular in appearance.

Such an interpretation is not inconsistent with other Greek architectural practices. The most obvious of these is the tapering of the column shaft from base to capital, increased in effect by entasis; this can be understood as a device to increase the apparent height of the column by exaggerating the normal diminishing effects of perspective. Vitruvius discusses column taper and also recommends its inter-relationship with the inward tilt of the peristyle, though without explaining the use of either. The refinement of inclination could be read
in a similar way, as exaggerating perspectival effects for the temple as a whole. Many writers also point out that the 'pyramidal' effect of the inclination would enhance the appearance of stability in the temple. The continuation of this inclination into the entablature serves to heighten these impressions. Such effects can reasonably be called optical, but they are optical exaggerations rather than optical corrections.

Those scholars who wish to be consistent in their theoretical explanations of Greek refinements tell us that the inward tilting of the peristyle '... is an optical refinement calculated to correct the tendency of the human eye to perceive a long row of columns as moving outward', as Richard Brilliant expresses it. It is difficult to find empirical evidence for this very uncomfortable postulation, except in so far as the tapering of the columns, which results in wider gaps at the top of the colonnade than at the bottom, might be seen to create a lateral fanning effect. But this would surely best have been met by inclining the columns towards the central axis of the colonnade, that is laterally, not inwards as was the invariable practice. (A single exception is found in the Hephaisteion portico.) Only the diagonally tilted angle columns could have served this purpose. Moreover, if the inward tilting of the colonnade was intended to correct an optical illusion of falling outwards, the outward tipping of the face of the abactus, the cornice and the decorations of the roof line must be read as contradictory to this purpose.

It is interesting to note that Vitruvius introduces a further contradictory note with regard to this issue, for he recommends that the elements of the entablature...

This statement is problematic in two ways — first of all, it recommends a practice which is the opposite of that found in Greek temples; secondly, the optical effect which it endeavours to correct is the opposite of the one claimed by those who explain the inward tipping of the Greek peristyle and entablature as a correction of the effect of leaning outwards. At this stage we must undoubtedly question again the validity of the concept of optical correction when such contradictory interpretations can be offered, but we should also be asking just how reliable a guide to Greek practice Vitruvius really is.

The importance of Vitruvius for our understanding of ancient architecture is of course hard to over-estimate, in that his is the only architectural text that has come down to us from antiquity. However, it may be that his accuracy with regard to Greek practice has been over-estimated because of this unique survival. Coulton, for example, is somewhat sanguine when he says of Vitruvius,
... although he was writing some four centuries after the heyday of refinements, he formed part of a continuous literary tradition which included the work of Iktinos on the Parthenon. The fact that refinements had been used rarely and elaborated not at all in the intervening period makes it all the more likely that the explanations he gives are derived directly or indirectly from the architects of the fifth century, for whom refinements were important.\textsuperscript{34}

Although we know that Vitruvius had access to Greek texts, this is not in itself evidence that he had read, understood or agreed with their content, if indeed they dealt with refinements in the first place. The many aspects of Vitruvius’ text which contradict Greek practice, that have already been mentioned, do not support the idea of an unbroken tradition from Classical times, but rather remind us of the intervention of the Hellenistic period, when the Doric order fell from favour. This is further corroborated by a certain lack of sympathy in his treatment of the frieze of the Doric order. The Doric frieze was characterised by the rhythmic alternation of vertically grooved triglyphs with blank or figurated metopes: the triglyphs were arranged across the frieze to fall regularly above and between column axes, and were understood as the positive element appropriate to end the sequence on each face. As the corner of the entablature usually fell beyond the axis of the corner column, it was necessary to modify either the metope intervals or the spacing of the colonnade to make up the difference. Vitruvius points out the possibilities for adjusting the triglyph frieze by widening the metopes or narrowing the intercolumniations (although he prefers the uncanonical use of a half-metope), but states that either solution is inadequate. ‘Hence the ancients, as it seems, avoided the Doric order in temples,’ Vitruvius writes.\textsuperscript{35} This is, of course, manifestly untrue: the only ancient Greeks who in fact avoided the Doric and its problems were Hellenistic architects, like Hermogenes of the late third century BC.

An examination of the solutions applied to the tricky problem of the Doric frieze gives us some insight into the thinking patterns of the Greek architects, which seem far removed from the Vitruvian ideal of precisely defined rules by which architectural perfection could be achieved. It might rather be construed that the earlier Greek architects had found the problem ‘a pleasantly teasing exercise’.\textsuperscript{36} Because it was accepted that the triglyph must fall on the corner, various modifications in frieze and column spacing were freely tolerated. To avoid excessive irregularity in the units of the frieze, a narrowing of the column spacing at the corners, referred to as angle contraction, was freely tolerated. However, although it would have been simple enough to work to a formula so that the angle contraction exactly met the discrepancy in the frieze, it is often found in combination with slight modifications in the metopes, as at Apollo at Corinth and Hera II at Paestum. The latter temple also employs a more subtle gradation of column spacing across two intercolumniations on the peristyle flanks. This concept of double contraction is applied to all facades of some later colonial temples, such as that of Concord at Akragas and the one at Segesta. Thus a wide
and varying range of adjustments may be observed, which suggest ad hoc solutions rather than fixed rules.

We may also surmise that the visual effect of the adjustments was felt to be pleasing in its own right, in that a contraction of the angle intercolumniation, in combination with the enlarged angle column, strengthened the appearance of the corner of the temple where the load of the entablatures of both front and flank converged. This is surely the explanation of the radical increase of the angle contraction at the Parthenon: a diminution of some eleven inches was required, but it was increased to over two feet, thus consolidating an impression of strength. It also necessitated an unexpected narrowing of the metopes towards the corners, reversing the usual practice, which has led some scholars to postulate that the narrowing of the intervals of the columns and the triglyphs was intended to produce an exaggerated perspectival effect, increasing the apparent length of the temple colonnades. This theory cannot be sustained when one considers that any such effect would have become incoherent from a viewing position other than one central to each colonnade, and that it was contradicted in effect by the increased size of the angle columns. We must conclude rather that the unusual adjustments in the spacing of the elements at the Parthenon had their origin in the problem of the arrangement of the triglyph frieze, but were developed further to achieve an effect that was pleasing to the Greek eye.

And in such a simple statement I think we may find the only general explanation for the refinements of Doric architecture. I have attempted to show that the widely-accepted theory that they were evolved for the purpose of the correction of optical illusions does not seem to be supported by empirical observation. Dinsmoor tells us that this is irrelevant, saying,

We are justified in regarding these as optical refinements; for, in spite of certain modern experiments made with the purpose of demonstrating that the optical illusions, which these refinements were supposed to correct, might not actually have occurred, we have nevertheless definite evidence that the ancient Greeks believed that such illusions required correctives and, in consequence, must admit that such was the primary purpose of their employment.

The evidence on which the purported Greek belief is based, however, is by no means as definite as Dinsmoor would have us believe. Theories of optical correction have come down to us from much later times, notably in the writings of Vitruvius. There are so many statements in Vitruvius that contradict Greek practice of which we are certain, that it seems a questionable method to use his work to verify practices of which we are not certain. Moreover, it should be remembered that he offers explanations of only two refinements used by the Greeks — the horizontal curvature of the stylobate and the thickening of the angle column of the peristyle. The latter example is possibly the only case of optical correction that is really convincing, for it is visually verifiable that a column seen against the bright Greek sky would seem thinner than its fellows in front of cella walls of the same tonality.
But to concede that one of the refinements may have been intended to correct an optical illusion is not to accept that all had the same purpose. It seems absurd to postulate the concept of an elaborate system devised to promote an appearance of mathematical regularity, when one considers the numerous irregularities which were tolerated in Greek architectural design, of which only the varied solutions to the spacing of the triglyph frieze have been discussed here. As Goodyear points out, only those who entertain the prejudice that architectural lines ought to be straight could believe that 'geometrical effect is . . . sought by departure from geometrical fact'. It is also worth remembering that perspectival effects prevent us from ever seeing strict geometrical regularity anyway. More plausible than the concept of a devious plan of invisible modifications creating apparent architectural regularity, is the idea that Greek designers were fully aware of irregularities and curvatures and promoted their enlivening effect. As Coulton expresses it, they ' . . . were intended to save a temple from a mechanical, lifeless appearance, and to create a slight and desirable tension between what the eye saw and what the mind recognised as the underlying form'. While agreeing with this concept, I wish to take a little further the idea that the refinements had something positive to express.

Although they evolved independently, I would like to suggest that the various refinements were different solutions to the same problem. I have accepted that the thickening of the angle column served a purpose of optical correction, but the desire to counteract the thinning effect on the angle column may have met a more pressing need than mere regularisation: it must have seemed particularly important that the corner support of the temple, where the loads of the entablatures converged, should look convincingly sturdy. It is interesting that this refinement is first found together with the inclination of the peristyle, which also seems calculated to enhance the effect of stability in the temple. The use of these modifications, together with an enlarged angle contraction at the Parthenon, that has already been discussed, would seem to give credence to the interpretation that these refinements were intended to express the structural effectiveness of the temple. It seems possible that in the colonies of Magna Graecia a similarly felt need was met by a different solution. The pronounced curve forming the entasis of the column shaft gives visible expression to the concept of support, and the compressed curve of the echinus in the capital above continues the metaphor of loadbearing. In more refined versions of entasis, the interaction between load and support is not as dramatically expressed, but is still implicit in the tension expressed by the taut curve of the contours of shaft and capital. And the curvature of the horizontals of the temple fulfils a similar purpose. As Mavrikios points out, the downward curve of the stylobate towards the corners of the temple platform gives a strong sense of emplacement, tying the temple to the earth beneath. But equally, the upward curve suggests a counteraction of the weight of the architecture, a sense of convincing load-bearing. Each one of the refinements thus gives expression to a need felt by an empathetic response to the structural function of the elements of the Doric order. In addition, it has been
demonstrated that these refinements may also be read as increasing the apparent scale of the temple, further enhancing the monumentality of its architectural form.

It is thus postulated that the refinements are not merely devices for enlivening architectural language, but that they are a fundamental expression of the creative intention of Greek architecture, giving its structural meaning metaphorical form. Singly, the refinements act as visual reinforcement of the temple's stability, its load-bearing and its scale. In combination, they create a complex language of visual metaphors, demonstrating the meaning and monumentality of Doric construction. Through this metaphorical language, the Doric temple evolves from the clarity of fine structural prose to the evocative subtlety of architectural poetry.

NOTES

* This article is a slightly condensed version of a paper read at the first conference of the South African Association of Art Historians, held at the University of Natal, Pietermaritzburg, in July 1985.

1. J. Coulton, *Greek Architects at Work*, London 1977, 111. Not all scholars agree that both refinements are present.
10. G. Piranesi, *Différentes vues de quelques restes de trois grands édifices... de Pesto*, Rome 1778.
21. Vitr. 3.3.11 (v.1, 179).
22. Vitr. 3.3.11 (v.1, 177).
23. Vitr. 3.4.5 (v.1, 185).
24. Vitr. 3.5.8 (v.1, 191).
25. Dinsmoor, *op. cit.*, 166 n.2.
27. Penrose, *op. cit.*, 78.
30. Vitr. 3.3.12 (v.1, 179).
31. Vitr. 3.5.4 (v.1, 187).
33. Vitruvius 3.5.13 (v.1, 195–7)
35. Vitruvius 4.3.2 (v.1, 221).
38. Dinsmoor, *op. cit.*, 165.
42. In Bruno, *op. cit.*, 224.
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