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The Construction Geometry of Early Javanese Temples

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The early development of Hindu Javanese architecture can be traced through interpretation of epigraphs, archaeological excavations, and comparison of extant temples with other traditions. However, while many scholars have speculated on connections between Javanese Hindu temples and presumed antecedents in India, these have been made on the basis of visual comparison and epigraphic interpretations. No Indian temple has been conclusively shown to be a model for the earliest Javanese temples. Archaeologist and temple historian Michael Meister has shown in his analysis of the geometric composition of early Hindu temples in South Asia how a ritual sixty-four square mandala was the geometric basis of temple construction during the formative period (fifth to eighth century) of the Indian architectural tradition. Working from an understanding of temple construction sequence as well as their ritual underpinnings, Meister found that the sixty-four square mandala's dimensions correlate closely to the constructed dimensions at the level of the vedibandha (which corresponds with the plan level of the sanctuary threshold). Furthermore, he shows how the horizontal profile of the cella depends on the number of offsets and the proportional relationships between each offset based on the subdivision of the sixty-four square grid. The authors have investigated whether a similar compositional basis can be found for the earliest Javanese temples on the Dieng Plateau in the highlands of central Java, despite differences in architectonic and symbolic expression. The analysis of relationships between ritual geometry and actual temple layouts for these buildings has the potential to furthering our understanding of the connections between Hindu temples in Java and those in India.



Origins

While the remains of temples have been found in various locations in Central and West Java, Java's oldest extant temples can be found in the centre of the island, The three major temple locations are the Dieng Plateau, the northern slopes of Mount Ungaran and the Prambanan plain, though there are many other sites that future archaeological investigations may prove to be important.¹ The earliest buildings are on the Dieng Plateau and have been dated as far back as the mid-seventh century, though there is argument among experts as to the exact dating of most early Javanese monuments. From their overall form and iconography, the early temples of Java are obviously related to the Brahmanic/Hindu tradition and to principles outlined in canonic Sanskrit texts (*shastras*).² In India, these texts provide sets of prescriptive rules that touch on all aspects of temple construction, from site selection, formal typology and location of sculptural elements, to ornamental details. The architectural elements described by such shastras are based on a number of geometric figures known as *mandalas*, and it is from these ritual and cosmic diagrams that temple plans and superstructure have been generated.³ However, while formal and iconographic resemblances have been noted between Javanese and Indian temples, this kind of geometric correlation has not yet been established, and so this is the purpose of the research behind this paper.

Embedded in the plan of most temples is a ritual grid diagram of $8 \times 8 = 64$ squares (*mandala*), prescribed for temple building in the *Brhat-samhita* and later texts.⁴ This grid is used to generate the ground plan and control measure in the configuration of stone temples. For example, Meister shows how the horizontal profile depends on the number of offsets and the proportional relationships between each offset are derived from subdivision of the sixty-four square grid.⁵ Studies of Indic temple geometry have demonstrated the correspondence of canonical descriptions of constructive geometry with the base plans of surviving monuments. However, as temples in both India and Java were built in ever-changing contexts, the actual practice of this knowledge was the subject of experimentation over several centuries within regional schools of temple building.⁶ Thus, while the *sastras* may have been prescriptive, a multitude of interpretations and variations were possible within the canonical rules. Indeed, this ambiguous relationship between strict canon and subtle experimentation presents many challenges in relating the idealised geometry to extant temples.⁷

1. Veronique Degroot, *Candi, Space and Landscape: A Study on the Distribution, Orientation and Spatial Organization of Central Javanese Temple Remains* (Leiden: Mededelingen van het Rijksmuseum voor Volkenkunde. 2009).

2. Stella Kramrisch, *The Hindu Temple* (Delhi: Motilal Banarsidass, 1976).

3. Micheal Meister, "Mandala and practice in Nagara architecture in northern India." *Journal of American Oriental Society*. 99 (1979), 204.

4. *Brhat-samhita* is the earliest surviving text, probably an astrological treatise (c. 6th century CE), containing descriptions of temple construction, attributed to Vārahmihira.

5. Meister, "Mandala and Practice in Nagara Architecture in Northern India"

6. Meister, "Mandala and Practice in Nagara Architecture in Northern India." Adam Hardy; "Sekhari Temples," *Artibus Asiae* 62, no. 1 (2002), 81-138.

7. Sonit Bafna, "On the Idea of the Mandala as a Governing Device in Indian Architectural Tradition." *Journal of the Society of Architectural Historians*. 59, no. 1 (2000), 26-49.

Computational modelling techniques provide a robust digital methodology for researching the genesis and evolution of geometry in temple architecture through the digital construction of archetypes. They establish an empirical ground to study linkages (or lack thereof) in the genesis, development of temple architecture. Using spatial information modeling, the fragmentary evidence from diverse sources can be pieced together. The extent to which the architectural typologies of the temples discussed in the paper can be related directly to any Indic canon are examined through the digital construction of these temples and their potential archetypes. To elucidate this complex material, we have deployed a comparative method on two levels. On the one hand there are ideal notions of the Hindu temple and shared cosmogony. On the other, there are individual temples as a realization of the ideal. Linkages between temples in different locations and whose appearances imply quite different influences raise questions about particular traditions, about the relation between temple and treatise, between theory and practice and between individual temples and a collective corpus. In order to permit a deeper examination of canonical connections, the authors have used methods of photogrammetric and digital modelling methods to reconstruct the architectural forms and compared them with models derived from textual canons. The purpose of digital methods is not to challenge or displace the authenticity of the physical object and traditional methods of knowledge creation. Instead, the aim is to develop unobtrusive analysis of particular sites. In this aspect, the digital approach may be compared in a propositional sense to Robin Evans' theories on geometry in architectural making.⁸ Evans uses a series of translations to track the development of architectural form through projective geometry. In his work, the building as object is cast, through a series of drawings, to the finished product, a projection informed by the subjective experience of buildings. While Evans develops a proposition about how architecture develops through the translation of drawing into building, of representation into actuality, our particular challenge is the opposite, the translation of building through the geometric and proportional clues present in its form back to its description. In this reversal, computational means such as rule-based generation, photogrammetry and parametric modelling become useful methods for projective reconstruction from multiple sources of partial evidence. The geometry that generates the temple form is projective in the sense that it projects a geometrical representation of cosmology into three dimensions, but it is not projective in the sense of an image.

8. Robin Evans, *The Projective Cast: Architecture and its Three Geometries* (Cambridge, Mass.: MIT Press, 1995).



the contemporary village of Dieng. Nearby on the southern edge of the valley is the site of Candi Gatotkaca, a single extant temple accompanied by the remains of five other temples. On the northern edge of the valley, is Candi Dvaravati, again a single temple with the remains of three other temples. Lastly, in the foothills of the southern side of the Plateau is Candi Bima, which appears to be a solitary construction. While each of the eight remaining temples at Dieng is small stone *cella* with a single interior space, they represent a variety of compositional approaches to the building type.¹² Candi Arjuna, Candi Sembadra, Candi Gatotkaca and Candi Bima will be discussed as examples of each main compositional variation.

12. The *cella* is the archetypal Brahmanic/Hindu sanctum, consisting of a single enclosed space.

Candi Arjuna

Candi Arjuna is square in plan, and consists of a cubic *cella* sitting on top of a square *pithā* and topped with a tiered pyramidal superstructure.¹³ The entire temple is constructed of grey granite blocks. The *pithā* is in two vertical parts, the lower part or being around half a metre wider than the upper and stepped in profile. The upper part of the platform is around 1.4 metres in height, and expressed as a compressed wall. Overall, the platform is about 5.7 metres square in plan, and its top forms a flat ledge evenly around the body of the *cella*. The main *cella* takes the form of a simple cubic *chaitya-grha*.¹⁴ Its *vedībandha* takes the same sequence mouldings as the platform below and above it *janṅhā* is also divided into three panels by pilasters.¹⁵ The overall exterior of the temple is about 4.2 metres square around at the main wall, and 5.0 metres at the level of the *vedībandha*. Inside is a simple cubic space with a pyramidal corbelled ceiling, dominated by a *pithika*.¹⁶ The interior space is only 2.5 metres square, and its access is from a staircase from the ground on the west side, then via a narrow antechamber. The antechamber is contained within a projecting porch, lower than the main body of the temple but with similar wall detailing, and is topped by a gabled roof. The entry threshold is framed by a *kalamakara*, a motif in which the lintel is carved into a monstrous face (*kala*), positioned as if the doorway is in its open jaw, and connected via snake-like bodies that form the door-jambs to *makara* heads flanking the threshold.

13. The *pithā* is the moulded base of the temple, also referred to as *adhīsthāna*.

14. The *chaitya-grha* is the archetypal form of the *cella*, enclosing the sanctum within brick or stone walls.

15. The *janṅhā* is the upper or main section of the main wall of the temple, above the *vedībandha*.

16. *Pithika* is a square stone plinth with a dish-shaped upper surface, symbolising the *yonī* (female aspect of fertility and counterpart of Siva's *lingam*). Found inside Siva temples.

17. The prominence of the *makara* can be related to Java being an island, the ocean that surrounds it being *makaralaya* “abode of *makaras*.” Adrian Snodgrass, *The Symbolism of the Stupa* (Ithaca NY: Cornell University 1985), 294.

As a recurring feature of Javanese temples, the *kalamakara* needs a little explanation. The *makara* combines the attributes of the crocodile, the elephant and the serpent.¹⁷ The *kala*, more precisely known as the *kala-mukha* “face of time,” or *kirttimukha*



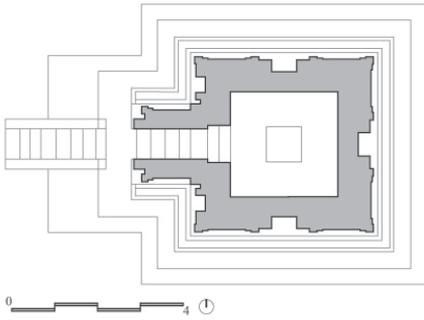


Figure 2. Candi Arjuna: (L) Plan; (R) View from the southeast.

“face of glory” is a monstrous face with staring eyes and fearsome jaws.¹⁸ The empathic presence of *kalamakaras* on Javanese temple is indicative of melding of local and Brahmanic beliefs, of indigenous spirits and Indian deities; of the adaptation of Sanskrit concepts and terminology to ancient animist conceptions within Southeast Asia. Other than the entry, the main expressive elements at well level are niches, placed in the middle of the north, east and south walls, and flanking the entry porch on the west wall.¹⁹ Tall and narrow, the niches are expressed as doorways, despite being contained by the wall surface. Each has an elaborated base, expressed as a miniature version of the main wall *vedi*, and is framed by a miniature *kalamakara* ensemble. The superstructure of the temple is pyramidal in overall form, and is composed of three tiers of evenly decreasing breadth and height, topped with a simple cylindrical finial. The main forms of these tiers are expressed as part stories, taking the same expression as the walls of the *cella* below to form a *prasada*.²⁰ Central on each face is a niche framed by a *kalamakara* surround, though unlike that of the main *cella* wall below, these are of the same proportions of the niches below (though smaller) and so project upwards into the entablatures. At the corners of each mini-platform are aedicular forms, like tiny versions of the temple with their own little bases, walls and tiered roofs. After three levels of these diminishing elements the temple is topped with a tapering finial, square in plan.

The proportional relationship between the exterior *vedibandha* and the internal walls is 2:1, or if a 64-square *mandala* grid is overlaid, 8:16. The width of the antechamber for the most part has a 1:4 relationship with the width of the interior space, though it steps outwards at the actual threshold to the interior space to be 1:3 of its width. As the superstructure diminishes, the size of each part-storey is also proportional, to maintain an overall pyramidal profile, with succeeding relationships to the main body of the *cella*

18. Snodgrass, *The Symbolism of the Stupa*, 306.

19. Each niche probably once held a statue of a deity, though all are empty.

20. A *prasada* is a literally a “multi-storey mansion” or “palace,” a superstructure composed out of successive part- or false-storeys emerging from the top of the *cella* and emulating its form and detail.

of 9:16, 8:16 and 4:16. The heights of each part-storey are similarly proportioned in relation to the height of the main *cella*, and the platform also has a similar relationship, which combined with its surface expression, means it could also be read as a part-storey.

While the niches in the main body of the temple are contained entirely within its wall surfaces, those of the upper part-storeys maintain their proportions by interrupting both base and entablature of their respective levels and reinforce the centrality of the square form of the temple.

Candi Arjuna is paired with Candi Semar immediately to its west. This is a small rectangular building directly facing Candi Arjuna, and so orientated towards the east. Its close proximity (the two buildings' bases are set apart by less than two metres) and the diminutive size of Candi Semar indicate that it was a subsidiary shrine to Candi Arjuna. Possibly Candi Semar once contained an image of Nandi, the vehicle of Siva, though currently the building is empty inside. Candi Semar's doorway is also adorned with a *kalamakara*, but otherwise the walls of the temple are plain, with only small, corbelled window openings. The temple has *limasan* stone roof.²¹

21. A *limasan* roof is a rectangular hipped roof, emulating timber/tile/thatch techniques in stone, found on Javanese shrines.

Candi Sembadra

Apart from Candi Semar, this is the smallest of the Arjuna Group, but it has the most elaborate exterior plan form, and so represents the most distinct variation in composition. While the interior of the *cella* is square (and only 1.6 metres square), the exterior form of the temple is elaborated from this by exaggerated *bhadra* projections of both platform and body. The *pithā* is lower than that of Candi Arjuna and simpler in expression. The *bhadra* projections of both *pithā* and body are emphasised to the point that the essentially square plan of the temple is obscured and the building appears cruciform. The entrance to the west is narrow and further exaggerated to distinguish it from the north, south and east *bhadra* projections.²² *Bhadra* may also project from the false stories of a superstructure. Similar to Candi Arjuna, the centre of each face has tall niche/false doorway, and each has the remains of a *kalamakara* surround.

22. *Bhadra* are formal projections of the central portion of walls (corresponding to the cardinal axes).

Above this, there is one part-storey remaining of the superstructure, though unlike that of Candi Arjuna, this is not horizontally compressed but equally reduced in both width and height. This



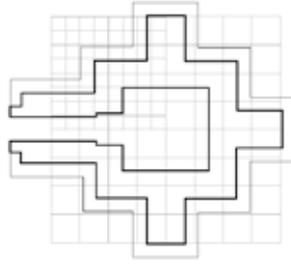


Figure 3. Candi Sembadra: (L) view from northwest. (R) Plan showing 64 square mandala grid and offsets

part-storey has slightly projecting *bhadra* sections at the centre of all faces, but much less exaggerated than that of the *cella* below, so it appears square as a complete (though inaccessible) second storey. Above this level there may have been another diminishing part-storey or two, or a stone capping, but this can only be speculated. Looking more closely at the constructive geometry of Candi Sembadra, there are clear proportional relationships between its constituent parts, but this is more complex than at Candi Arjuna. Here the superimposition of the cruciform plan over the square plan is done in such a manner as to depart from the clear inside/*vedibandha* proportional relationship. If a sixty-four square *mandala* is overlaid on the plan, a straightforward correspondence can be seen between the proportions of the internal walls and that of the projecting *vedibandha* (which here relates directly to the width of the base platform). While further division or expansion of this grid does not relate clearly to the projecting faces of the cruciform exterior, a grid of different size, overlaid to fit around the projecting *jūṅghā* walls of the north, south and east faces, corresponds with the *vedi* proportions of the main body of the square temple. A relationship of 3:2:3 can be seen; from the centre of the interior space to interior wall; then through the thickness of the wall; then to the *bhadra* projection either to the north, south or east. These relationships suggest increasing sophistication and imaginative use of proportions than at Candi Arjuna, as the superimposition of different outlines simultaneously contain differently-based geometries.

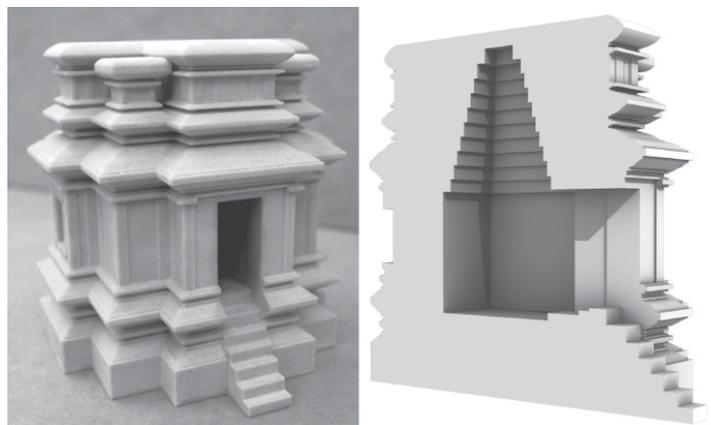
Candi Gatotkaca

Candi Gatotkaca represents a third distinct form found at Dieng, or perhaps an amalgam of the square form of Candi Arjuna and the cruciform shape of Candi Sembadra. At first glance Candi

Gatokaca seems far more massive and muscular than any of the Arjuna Group, though this may be due to its incomplete superstructure. Its base *pithā* is in two distinct parts, and is barely wider than the body of the *cella* above. The lower part of the *cella* platform is plain and vertical. The upper part is far more expressive, with a cyma recta, single stepped fillet and reversed cyma recta profile. Above this, the *vedibandha* begins smoothly at the capping of the platform, and the same sequence of mouldings graduates to the *janghā*. For both platform and body, there are central *bhadra* projections from an essentially square plan form, but unlike those of Candi Sembadra, these are proportionally broader, so the overall effect is of an offset-square rather than cruciform plan. The interior, like those of the other Dieng temples, is around 2.2 metres square. Inside is an intact *pithika*, and there is a step-corbelled ceiling. The entrance to the west is via a step-threshold and there does not seem to involve any obvious projection of the temple via a porch in this direction.

Like the other Dieng temples, each of the cardinal faces other than the west-facing entry have niches/false doorways, each of which has a *kalamakara* surround. However, on Candi Gatokaca there are no niches flanking the west-facing entrance, perhaps because the treatment of the real doorway projection is more similar to that of the other faces than is the case in Candi Arjuna or Candi Sembadra. Apart from this, the walls have simple expression of corner pilasters but are otherwise plain. The superstructure is also different to any of those in the Arjuna Group. While only a single part-storey/tier is extant, this is quite compressed in height but almost as wide in cross-section as the main body of the building, giving the overall superstructure a particularly heavy aspect. From a distance this part-storey seems

Figure 4. Candi Gatokaca: (L) Physical 3D print of digital model. (R) Sectional view of digital.



to follow the outline of the main body of the *cella*, but actually it is more markedly cruciform, and above the corners of the square body below are free-standing aedicular structures. In this, elements found at Candi Arjuna (the corner aediculae) and at Candi Srikandi (the staggered square/cruciform plan form) are combined.

Candi Gatotkaca contains a different proportional relationship between interior and exterior than either Candi Arjuna or Candi Sembadra. Here the *vedi* of the exterior square of the *cella* has a 4:1 proportion with the interior, with the 4:2 relationship being with the interior and the *vedi* of the projecting *bhadra* faces. This suggests that instead of an additive relationship (*bhadra* projecting from the square) perhaps the plan was conceived as subtractive (corner offsets withdrawing from the centres of each face).

Candi Bima

The remaining temple at Dieng is Candi Bima and this building stands alone, both in its siting and its formal composition. The largest of the Dieng temples, Candi Bima faces east, and the main body of the temple is rectangular, rather than square in plan.²³ Also, it incorporates a *mandap*, rather than a simple porch.²⁴ Candi Bima's *pithā* is made up of simple courses of vertical stonework, and is around 1.3 metres in height. From the outside, it seems that this is the lower half of a base. However this modulated part is actually the *vedībādhā* of the *cella*. The overall effect, in the absence of other buildings for scaling reference, is to make Candi Bima seem larger than it actually is. The platform/wall mouldings continue around the *mandap* at the same level, so the doorway slices through them. There is a *kala* head carved into the lintel above the entry, and also remnants of *makarās* on the jambs. The main body of the temple has projecting *bhadra* faces to its north, west and south and at the centres of these there are niches/false doorways similar to those of the other Dieng temples. Apart from these elements, the upper parts of the *cella* walls expressed as panels framed by pilasters, with the addition of garland motifs expressed on the underside of their entablatures. The upper walls of the *mandap* are similarly expressed, but lower in height.

It is however the superstructure of Candi Bima that is most unusual. Compositionally, the superstructure consists of six visible

23. It is usually referred to as a square *cella*, but the authors measured the interior as 2.82 metres east-west by 3.15 metres north-south, enough of a difference for this to be deliberate.

24. A *mandap* is a vestibule or porch, where this is articulated as a separate antechamber or pavilion to the main *cella*.

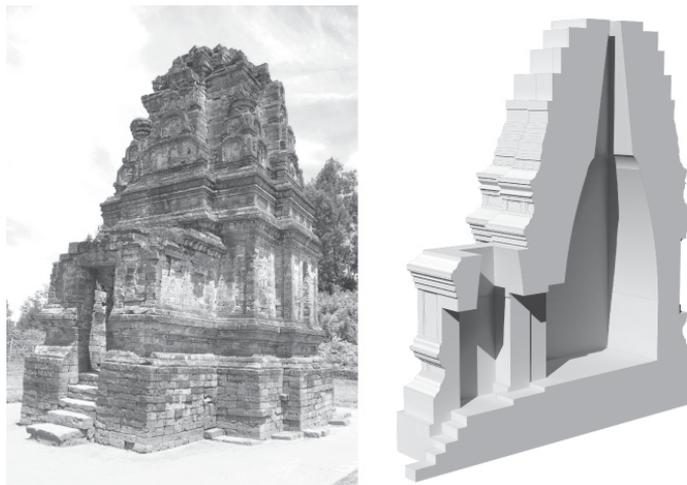


Figure 5. Candi Bima. (L) View from northeast. (R) Section of digital model.

25. A *candrasala* is an ogee or horseshoe-shaped arch. It may also be called a *gavaksha* or *kudu*.

tiers. The first is a simple part-storey following the faceted form of the body of the temple in diminishing proportion. However the next tier, while also proportionally reduced, is elaborated by *candrasala* niches.²⁵ In each of these is the image of a deity figure, where they have not been removed or destroyed. As these tiers rise and recede from the staggered plan below, those aligned with the *bhadra* projections are wider and their vaulted niches more dominant. The overall effect is of a cluster of towers that have merged into each other, with the cardinal ones dominant. These are aligned with the *bhadras* below. Additionally, all these “towers” merge into a central square tower that rises vertically from the centre of the temple. In terms of proportions, Candi Bima is quite different to the other Dieng temples. With Candi Bima the relationship between the north-south (longer) and east-west (shorter) plan proportions is 8:9. If the 64 square grid is overlaid, a grid shift of half a square of brings alignment between interior and exterior walls at the *vedibandha* level. However, the rationale for this grid-shift remains a matter for speculation.

The Development of Javanese Temples

Not far from the Dieng Plateau in Central Java is a scattered group of temples on the south side of Mt Ungaran. This site is known as Gedong Songo and here are generally considered to be the second oldest extant Javanese temples, though a lack of local stone inscriptions or written records mean that, as with Dieng, dating is a more matter of stylistic interpretation than reference to any historical records. Dumarçay has suggested that Gedong



Songo is where the prevalent model of Javanese temple architecture became established after the more experimental compositions of Dieng.²⁶ At Dieng, the variations of the Arjuna Group and Candi Gatotkaca and Candi Bima, parallel the experimentation found at Pattadakal and Aihole in India, locations where a variety of temple forms and styles; notably the northern Latina and the southern Drāviḍa can be seen in close proximity. At Gedong Songo, however, the temples all resemble Candi Arjuna and a consistent compositional method has been applied. This compositional method can be seen in other early temples found scattered around Central Java. Candi Gebang on the outskirts of Yogyakarta, Candi Mendut and Candi Pawon near Borobodur and Candi Pringapus near Temanggung all date from the early to mid ninth century and all share, though with different decorative expressions, the same basic composition of broad *pithā*, cubic (sometimes with *bhadra* offsets) cella and *prasada* multi-storeyed superstructure, as the Gedong Songo temples.

Connections between these temples and early Javanese polities are also the subject of ongoing speculation, and there is a paucity of evidence to explicitly connect any Central Javanese temple sites to any particular dynasty or ruler. At Prambanan itself, there were also temples being constructed by the mid 7th century. Candi Kalasan is described in the Kalasan inscription of 778 CE, though this description refers to an earlier version of the monument that stands today. Given their mountain settings, these groups of temples seem to have been places of pilgrimage rather than centres of political power. In the absence of a clear historical record, the architectural evidence has been the basis for much supposition. Bosch, for instance, hypothesized that if there were Hindu migrants to Java, they would have created monuments

26. Dumarçay, *The Temples of Java*, 1986, p.16.

27. F.D.K. Bosch, "Les rapports entre l'Indochine et l'Indonésie," *Comptes-rendus des séances de l'Académie des Inscriptions et Belles-Lettres* 96, no. 1 (1952), 25.

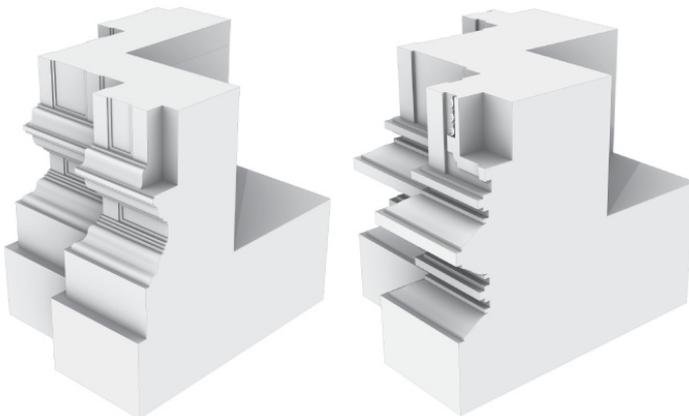


Figure 6. Comparison between base mouldings: (L) Candi Gatotkachi, (R) Candi Bima.

that carried on the building traditions of their homeland.²⁷ However Bosch observed that the oldest Javanese monuments only related to contemporary Indian monuments in isolated instances and suggested that there was no evidence that they had been constructed by Indian artisans. However, in the absence of Indian prototypes, Bosch suggested that *s āstras* would have been the basis for Hindu-Javanese architecture. Bosch's view is that this might have been via Javanese pilgrims rather than Indian architects or missionaries, suggesting that early Javanese architecture was a synthesis of the different traditions they encountered in India. Soekmono supported Bosch's hypothesis, also positing a direct connection between builders of *candi* and present Indonesians, though this is perhaps more tenuous.²⁸ Conversely, Jordaan has more recently questioned the possible influence of Indonesian pilgrims, surmising in the absence of conclusive data that pilgrims would not have felt free to interpret a tradition to which they had recently been converted.²⁹ The exact nature of Central Javanese temple construction remains contested.

As can be seen in their adherence to the ritual 8 x 8 grid diagram (apart from Candi Bima), the temples of Dieng are evidently Hindu, and thus by some means related to broader Indian traditions. The exact nature of this adherence varies from temple to temple, and as might be gleaned from the descriptions in this paper, the extant monuments are too idiosyncratic to be connected to a single Indian school, so what is known of their historical and cultural background suggests a mixture of creators and influences. Since there is also considerable variation in temple form and construction technique in India itself, it should not be so surprising to see temples in Java with typological similarities, but otherwise unique characteristics. As there is also some unity evident in the different examples of Javanese architecture, it can be suggested that they form a coherent and largely independent body of work, into which Indic details and elements were incorporated, but as component parts, not the whole.

* All photographs, models and diagrams by authors.

28. R. Soekmono, *The Javanese Candi: Function and Meaning*, (Leiden: E.J. Brill, 1995).

29. R.E. Jordaan, "The Śailendras, the Status of the Kṣatriya Theory, and the Development of Hindu-Javanese Temple Architecture," *Bijdragen tot de Taal-, Land- en Volkenkunde* 155, no. 2 (1999), 216.

