**Foundations of Temples of Nepal – a post-earthquake learning!**

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The built heritage of Kathmandu Valley, particularly the monuments of the seven zones listed in UNESCO's Kathmandu Valley World Heritage Site (KVWHS), suffered massively in the 2015 Gorkha Earthquake. The collapse of several multi-tiered temples with multiple plinths led some self-styled experts to speculate that these buildings were inherently unsafe, without foundations and stood on brick platforms without anchor, and had but a 'zero capacity for taking lateral loads'! Such tragic unfounded and untrue devaluation of traditional materials and technology of construction not only made our heritage buildings as dodders but also portrayed our ancestor builders as without even an iota of earthquake engineering knowledge and idea as though they lived in thick-headed oblivion of thousands of years of recurrent cycles of massive earthquakes and damages. However, serious close study of pattern of debris of many fallen temples showed as if the roofs had come falling straight down and only a few, like the upper roofs of Basantapur tower of Hanumandhoka palace, Radhakrishna temple of Swotha, Patan and Nritya Batsala temple of Bhaktapur had been thrown off plane to some distance. As critical observations and analysis over time would support later, a general understanding had formed in conservation circles that the heritage disaster was not so much a making of the earthquake as it was a consequence of material aging, a general state of a decayed buildings plagued by periods of neglect and absence of structural maintenance, and asymmetrical incompatible interventions made on to them in the name of repair, restoration and conservation. None of the damaged or collapsed structures appeared to have suffered damage or failure of foundations or due to problems associated with foundation.

UNESCO and it's World Heritage Committee (WHC), weary of our irresponsible assessments and insensitive reconstruction interventions likely to be detrimental to the outstanding values of KVWHS, took immediate note of 'ascertained and potential loss of integrity and authenticity' to deliberate whether KVWHS should not be put in the List of Heritage in Danger in June, 2015. Since then, two years have gone past and we have been so slow and demoralizingly self-deprecating in approaching their rescue and reconstruction, the monuments zones continue to rue like forlorn landscapes failing to humor the visitor to the lost civilization but not to chill the Nepali psyche day in and day out. This paper looks at the state of architecture and engineering of the foundations of the temples to critically understand and evaluate the interventions made unto them in the hope that they would not be destroyed at the hands of the callous and the uncaring.

While it was traditional in Kathmandu Valley to reconstruct temples and other heritage buildings damaged or lost to earthquake or fire disasters upwards from plinth level only and continued use of previous foundations untouched, the exploration of temple foundations had also been rarely done in recent times. The archeological excavations at Hadigaun Satyanarayan had revealed that brick strip foundations with one or two steps were already in use for *dyochem*-like rectangular religious buildings since as early as second century BC. For square temples also, similar strip foundation was in use for the

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walls forming the sanctum room. The sanctum floor space itself was provided with a *navakunda* foundation – the square plan being divided into nine small and equal sized squares using short walls crossing each other. The ceremonial offerings, such as grains, were deposited here for the *pada devata,* the spirits of the subdivided squares or to *navagraha,* nine 'planets' of Hindu/Buddhist astrological sky. They seemed to form a site of nine plots known as *pitha vastu mandala.* Similar foundation structures were also observed in another Siva *linga* sactum of Deupatan dated to late fifth century AD. This pattern of foundation appeared to have been used for *mandap* typology of temples also as corroborated by classical literature such as *Saradatilaka.* Masons experienced in temple construction also reported that such pattern of wall/pit formation under sanctum was in use until recent times in all kinds of temples. Since the divider short walls were butt-jointed with each other as well as with the main walls, they appeared to serve a ceremonial purpose rather than structural. They could however have helped strengthen the base platform of the temples if the plinth were raised or made up of a number of terraces, as became traditional from the mid-Malla period on.

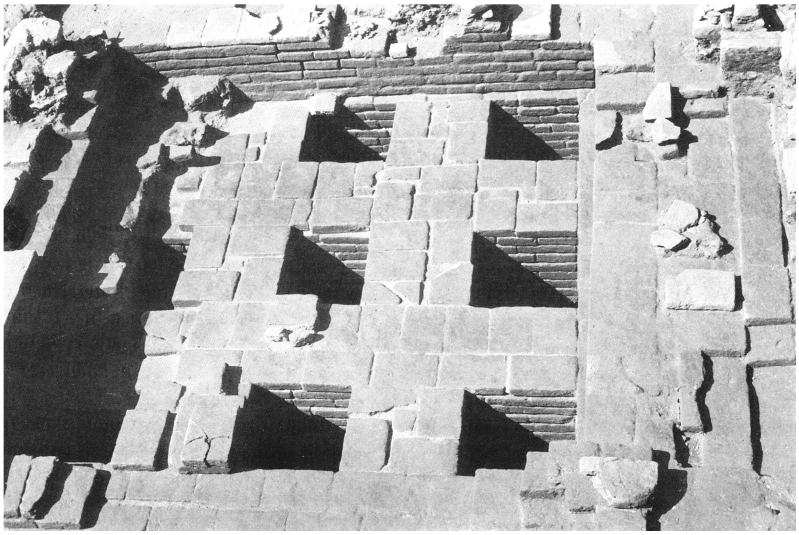

**Fig.1: The *navakunda pitha* mandala of a temple sanctum, Hadigaun Satyanarayan (sixth century CE)**

UNESCO funded a team from Durham University (DU), the University Stirling (US) and DOA (shortened hereafter as DUSA) to undertake post-disaster archeological assessments and evaluations of sites and monuments within KVWHS in October-November 2015. The major focus of DUSA investigation was in the 'ruins making where the Kashthamandap had stood. It revealed that its 'brick foundation walls reached depths of two meters and had been set within mud mortar, on a surface prepared prior to construction and with an organized sediment fill material, which we suggested gave the foundations of the monument resilience and flexibility during seismic shock'. The uniformity and designed nature of mix of clay, silt and sand in the filled material suggest a very careful and studied construction practice for such an early building. This construction of foundations, dated to seventh century CE, had not been damaged by this or prior seismic activity. The investigation also found a formation of one-brick-thick cross-walls patterned akin to the *navakunda pitha* mandala discussed above and seen in earlier smaller temples. Interestingly, the depth of foundation in all cases has been reported as two meters. This is equal to 36 courses of brickwork or one *byoma* of ancient measure. While widths of cross-walls vary from one brick to one and a half brick breadths, the thickness of main wall appears related to the size of the temple and ranged from one and a half brick breadths to half a *byoma* (I meter) in the case of Kashthamandap.

Therefore, it is difficult to agree with DUSA inference that foundation design 'included cross-walls for stability, bracing the massive one meter thick and two meter deep outer walls against a central free-standing pier'. As a matter of fact, such thin and tall divider wall would itself have problems of its own stability during construction, while freestanding and also while back filling it. It is also obvious that larger the temple, the pits would be proportionally larger and free standing wall segment also longer compounding self-stability problem.

The nine pit formation has a ceremonial and ritual role and its structural action purely incidental and minor. The finding of another nine-pit formation with cross-walls of eight courses depth within the central pit of the outer nine-pit mandala during the 2016 season of archeological works also substantiates the form's ritual nature (See Fig. 3). It is likely that the inner *pitha* mandala (8 courses in height) is dated to first consecration (7th century CE) and the outer *pitha* mandala (36 courses in total) belongs to its re-consecration dated to 9th century CE. It should be understood that for positioning the four piers, the outer mandala should be geometrically known and so the foundation of the outer wall (24 courses with step of 8 courses each) must have been constructed at the very beginning. Because of the cuts made in second phase re-consecration, all the eight outer pits of the outer mandala have lost their geometric purity.

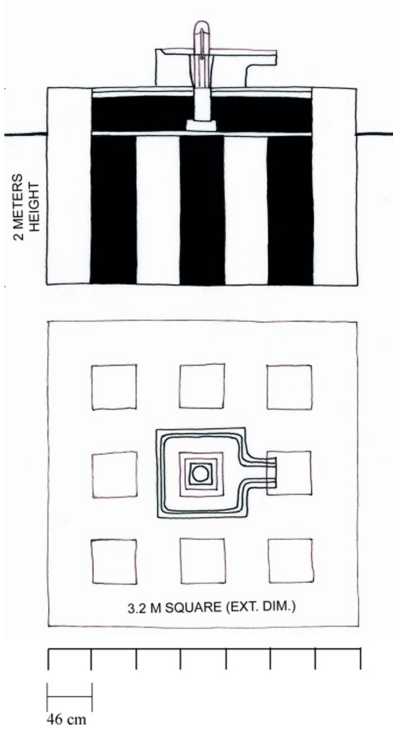


**Fig.2: The *pitha* mandala of Bimalasangha Siva *linga*, Deupatan (484 CE)**

However, the structural intent is clear in the choice of width and depth of strip foundations for main walls, both inner and outer one, and the designed infill could also add to the structural performance of foundations though mat action (?). The use of 36-brick course standard foundation depth through centuries long periods does tell of a serious and stringently practiced building culture of ancient Nepal. Similarly the standard for outermost wall appears set at 24 courses. DUSA team also believed "that the use of brick in mud mortar enhances the piers' resilience to seismic shock".

DUSA investigation (2015) at other Durbar Squares also exposed the outline of foundation of the outer walls of Charnarayan in Patan and Nritya Batsala in Bhaktapur, both belonging to the late Malla period. While the depth of foundation in both cases was made up of thirty six courses of brick laid in mud mortar, the standard brick foundation was found built over a pad made of river rounded stone boulders. This appears as a major technological development in the design and construction of foundations in the Malla period over Lichchhavi standard practice of laying brick straight on excavated earth surface. It may also be noted here that the original foundation of Chysilin Mandap of Bhaktapur Durbar Square, destroyed and replaced by a RCC mat by German 'restorers' in 1978, was a mat pack of similar river rounded stone boulders of medium grade. It is speculated that such boulder packs acted as 'earthquake shock absorber of some kind' and empirical micro-tremor studies aimed at understanding the behavior of such boulder packs encased in earth have been initiated at NAST.

More foundations have since been opened and sadly, also continue to be wantonly destroyed in the name of reconstruction. DOA opened the plinth and foundations of main and perimeter walls of Rato-Matsyendranath (Karunamaya) temple, Bungamati. In this *granthakuta* temple too, we find the foundation of the sanctum core wall built with the standard thirty six courses of fine glazed-on-the-outside bricks laid on clay mortar. This platform like foundation laid straight on excavated earth surface and without the river rounded stone boulder pad, portends to be of Lichchhavi period origin, possibly sixth century CE as the associated popular legend is dated. The core sanctum platform was surrounded by a two bricks wide strip foundation constructed of fine glazed-on-the-outside bricks aligned under the colonnade tie band – the space between the square solid platform and the sides of perimeter foundation was filled solid with coursed bricks laid on sandy dry clay mortar. A further perimeter wall foundation built to form the last of the three plinth steps was built with fair quality bricks of smaller size and the space between the inner and outer foundation walls was packed solid with coursed brickwork on loose sandy clay mortar. In the name of engineered earthquake resistant construction, all of this elaborate foundation except the core platform was cut to below ground level and thrown away undocumented. The historicity, knowledge and earthquake resilience of the ancient foundation system of buttressing a solid brick sanctum platform by a number of tubular brick squares separated by dry laid solid brick infill has been lost at the hands of a callous, uncaring and sacrilegious mindset!

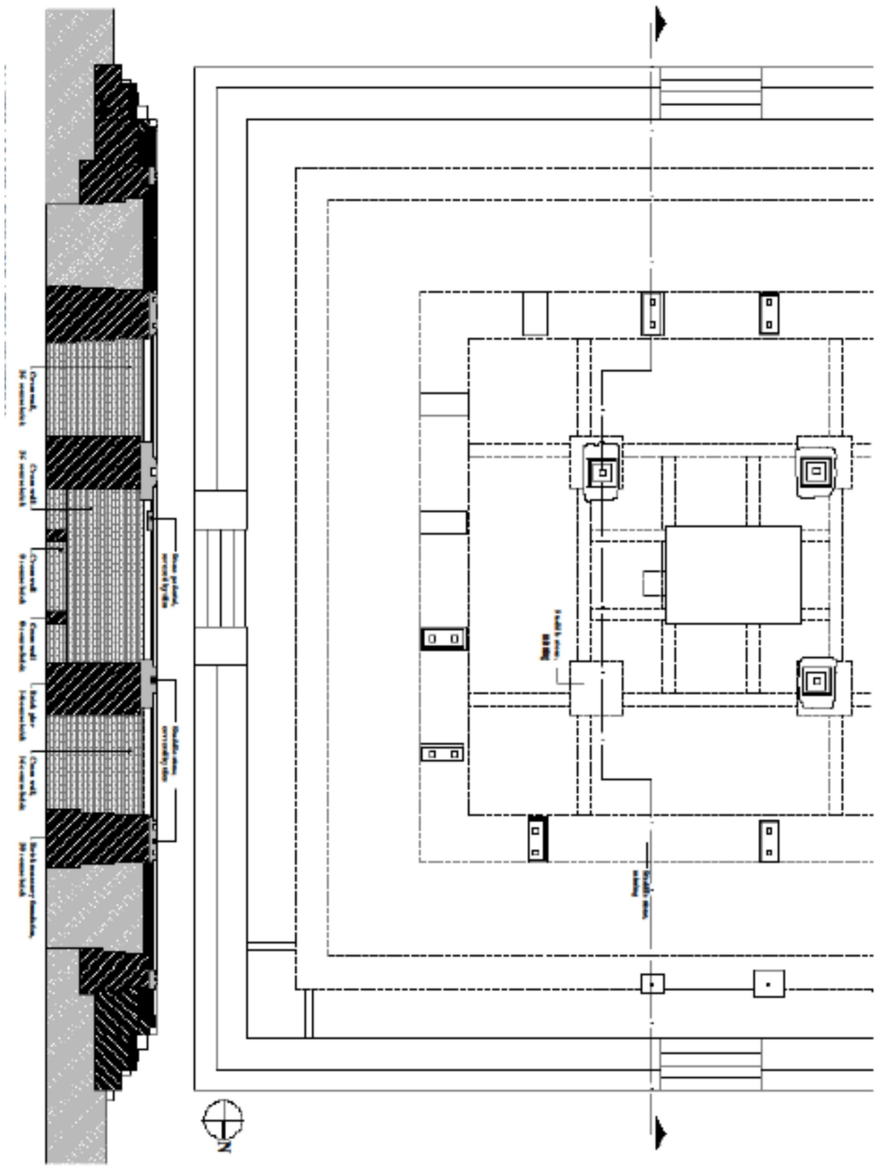

**Fig.3: The double nine-pit *pitha* mandala of Kashthamandap (DUSA report, 2016)**

A disgraceful mass foundation of brick on lime mortar has been built all around the core on a broken stone boulder pad.

**Fig. 4: Destroyed Lichchhavi foundations (left and center) and the disgraceful replacement (right)**

In January 2016, Kathmandu Valley Preservation Trust (KVPT) opened up the plinth and foundations of Bhaidega temple in Patan monuments zone also to discover the use of core platform foundation retained by a tubular brick square perimeter foundation with the in-between space filled with dry laid solid brick infill. The use of river rounded stone boulders to form the lower sections of the perimeter wall was also observed in southern side of the temple plinth. Realizing its technical worth and heritage value, KVPT is planning to 'retain this foundation morphology to the extent possible'. But even here, the resilient dry laying of coursed brick infill is being replaced by semi-monolith forming lime mortar jointed brickwork!

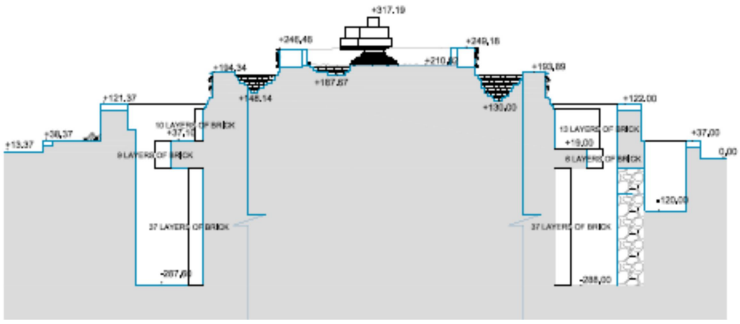

**Fig 5: Foundations of Bhaidegah temple at Patan Durbar Square (KVPT drawing)**

Archaeological exploration of foundations and plinths of a number of temples in Kathmandu city core such as Jaisidewal, Majudegah, Trilokya Mohan Narayan, Jagannath and Gopinath, was also made in November-December, 2016 by a team of archeologists and students from Durham University, University of Stirling, University of Sydney and Lumbini Buddhist University led by Robin Coningham (DUSSL). Although the report of this study have not been made available as yet, from observation of the excavation works and discussion with team members working on the sites, this author can infer that all the temples explored used the foundation morphology of core sanctum platform ringed by perimeter wall square with the in-between space packed with dry laid brickwork or soil infill for resilience. While

using this type of foundation in multiple plinth temples with significantly raised sanctum, such as Jaisidewal, the core platform appears to have been constructed first to its required height as a freestanding brick tower to support the ritual consecration with mandala of the nine-pit configuration (or a symbolic stone tablet as seen at Bungamati). This was retained by construction of a perimeter wall square of commensurate height separated by a gap of space from the core later filled to gain resilience. The construction of the stepped plinth was done later using short wall perimeter foundations to support a number of such plinths at a time and was not intended to act as a structural buttress.

As part of its restoration campaign, KVPT also opened up the foundations of Charnarayan temple, which is also patterned after the core platform ringed by square of perimeter wall with the in-between space packed with soil infill. Some sections of the platform appear deformed with slight bulges. The infill soil has been removed and packed with brick laid in mud mortar, which gives a better resilience than a lime mortar jointed brick infill. However, the same agency has opened up and virtually obliterated the original foundation forms of Manimandap as it cleared 'the trash under its suspended floor structure. The proposed 'reconstruction' of this pavilion with new designed steel foundations sadly promises to be as destructive as or worse than the Chyasilin Mandap construction of 1988 both from the perspective of ethnic heritage value and longer term salvage and restoration.

It can therefore be concluded that the post-earthquake archeological and reconstruction excavations have revealed use of two distinct types of foundations constructed of brick in mud mortar, both developing significant resilience against earthquake while transferring the load of temples to ground. They have confirmed that the *mandap*-type temple structures used brick strip foundations for the main walls of the sanctum room while the sanctum floor was 'supported' by a set of intersecting cross-walls, two in each direction, forming a nine-pit ceremonial *mandala*. In larger structures like Kashthamandap, the four pillars defining the central square of the *mandala* were each provided with pier foundations as deep and wide as the foundations for the main wall. While the brick cross-walls were built thin, the width of foundation of main walls were made thick, half as much as it was deep. The depth of foundations was standardized at thirty-six courses of standard bricks laid regularly in well prepared mud mortar. The mud mortar mix design is very close to present day recommendation of clay 18-22%, silt 40-45%, and sand 30-40%. The foundations for all other tiered temples or *granthakuta* temples (i.e. popularly but wrongly called Shikhara), whether with single or multiple stepped plinth or whether with sanctum at low or raised level, was formed of a central solid cuboid brick core build up to the required sanctum level ringed by fairly thick perimeter foundation wall square with the in between space packed with dry laid bricks or soil infill. For temples with very high sanctums and multiple plinths, a further set of perimeter wall and tubular infill space is added. The square top of the cuboid core is sized to support the sanctum and it's circumambulatory. Both the core and perimeter wall are built by laying regular bricks in mud mortar. A nine-pit mandala made of cross walls on top section of the core platform provided 'ceremonial ground' for consecration rituals. Because of such requirements, it is believed that the cuboid core platform is constructed first and rest of the temple construction including the stepped plinth is then sequenced. This design and method of constructing foundation as number of square tubular brick walls and in-fill sheaths supporting the core cuboid brick platform appear aimed at

developing resilience against earthquakes. In Malla period, these cores and walls were raised on a base mat or pad of river rounded stone boulders for similar structural behavior.

The above appraisal of reconstruction works also shows that these methods and forms of traditional foundation of heritage structure are being destroyed recklessly and replaced by new incompatible and less effective interventions in the name of building earthquake resistance. At Tunaldevi, which has images and stones dated to fifth century CE and whose intangible festive practices go even further back in history, DOA has shamelessly put in a RCC paving destroying the ancient archeological layers without even recording such. This and the destructive rebuilding of Rato-Matsyendranath temple foundations put to shame even those others we have built back in somewhat acceptable ways. Indeed, we have taken out and destroyed so many of the fine traditional foundations and replaced with unimaginative and punitively engineered primitive constructions executed in irreversible technologies and materials foreign to them, against all norms and much to the chagrin of UNESCO and others who see heritage value in authentic foundations in local materials and methods, we have put our civilized past and our ancestors to great ignominy. Such actions continue to threaten to obliterate the values of KVWHS altogether and forever after.

The so-called reconstruction engineers and architects should inform themselves with available assessment reports or do serious analysis of their own and work towards saving the heritage value of the materials, methods and morphologies of the traditional foundations. Destruction of such foundation structures is destruction of heritage and will eventually destroy our identity. The self-inflicted destruction of heritage must stop. It has to be the responsibility of the government to dismantle the wrongs and restore the traditional.