The Pit Conduit Water Supply System of Kathmandu

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As ancient societies were dominated by religious faiths and ritual practices, which often recognized the ruler as descended from gods or that they exercised their power on behalf of gods, they used the best of their brains, materials and technology to eulogize and show reverence to gods, kings and emperors; in architecture, this resulted in the design, development and construction of large number of religious and royal edifices. Their continued religious and ritual importance ensured their survival and maintenance over the past ages. Buildings and structures of godly and royal importance and ruins and remains of such edifices dominate the built heritage passed on to posterity by most ancient civilizations; utilitarian structures are a general rarity amid the array of temples and tombs of the kings. Among such rarities may be listed the Great Bath of Moenjodaro, the Roman Aqua Duct and the pit water conduits of Kathmandu valley. Although consideration of some ritual need appear behind the evolution of the structure, the pit conduit, called *Hi-Ti* in local tongue, is a utilitarian structure constructed for the use of common man. Ironically, it is the commonplaceness of the Hi-Ti that often masks its very importance.

Hi-Ti: ancient and unique

Although the glitter and charm of the multiple roofed temples and palaces often draw the viewer eye skywards and the architectural marvel of the water conduit pits is, sometimes, relegated to the background, its uniqueness as an urban utility as well as its ancientness makes the Hi-Ti a heritage of Nepal as grand as the temples. With an inscribed stone that describes its construction for public use and dated to 550 AD[1], the sunken water supply pit system of Satyanarayana at Hadigaon is the oldest Hi-Ti extant in Kathmandu valley and comes from the Lichchhavi period. It is homage to the technology of the times that it continues to function to this day. It was certainly not the first of its kind to be built and Hi-Ti as a utility structure was already in use for sometime then[2]. Research in settlements sites of late Kirat occupation may well yield remains of systems much older than that of Satyanarayana.

Systems and structures of urban services, such as wastewater disposal, provide important indicator of large and dense settlements. For such reasons, the presence of terracotta Ring wells[3] is usually taken by archeologists as a physical indicator of emergence of dense settlements in Gangatic plains after the second half of the first millennium BC. This is, however, a system of wastewater disposal that would be useful in

areas with flat terrain and where absorptive soil is available. It is no surprise, therefore, that no such ring wells are evident in ancient urban centers of Kathmandu valley; the tradition of building settlement in ridges[4] must have provided a natural drainage of wastewater. Even if such a problem had been felt in some sections of the settlement, the Achaemenid knowledge of ring wells was introduced too far away to be available to the Kirat Nepal. Kathmandu's ancient urbanization appears based on a system much different from that of the Gangatic plains. It is notable that the towns belonging to the earlier Indus-Saraswoti civilization also did not use ring wells; they had developed and used a system of drains to exclude the urban wastewater.

Systems of water supply and its structures can be equally important indicator of dense settlements as every dense settlement and large population would need a good supply of water. The towns belonging to both the Indus-Saraswoti and the Gangatic urbanizations used shallow wells for the supply of water as these towns were located on river banks or close enough to give shallow well access to ground water and to recharge them. For the Kirat towns located on hilltops and ridges, even while the well was known, it was not practical enough to be a common system for supply of water. It must have been for such reasons too that even after the arrival of the Lichchhavi from the Gangatic plains in first century AD and the sitting and extension of towns onto riverbanks, the well did not become a common feature of urban centers of Kathmandu. This must also mean that an alternate water supply system was prevalent in Kirat Kathmandu; its efficiency and practicality must have made sense to the Lichchhavi too.

Analysis of Lichchhavi inscriptions makes it evident that the Kirat water supply to ridge top settlements was developed around a rain-fed reservoir pond located at the higher part of the settlement[5]. These reservoirs were also sometimes fed by canals; canals, referred to as *tilamaka* in the Lichchhavi inscriptions, were also used as much to reach water to the distribution outlets kept in sunken pits. By the Lichchhavi period, further specialization in the system appears to have taken place as the knowledge from the plains merged with that of the valley. *Tilamaka* was similar to *paniya marga* (water canal) in the Lichchhavi state language, Sanskrit; but it was also applied to the *pranali-jaladroni* system or the system of the canal and the conduit. Even as the latter phrase should have been normally used for the sunken pit system, parallel and extensive use of Kirat term, *tila*[6], in the inscriptions could suggest that the system predates the Lichchhavi arrival in the valley. Although use of reservoir ponds, whether rain-fed or canal-fed, is commonly observed in other urban societies in the region[7], the sunken water structures are rare. It should be noted that the *vavoli,* the stepped pit and well system,

seen in North India and often mistaken as of the same genus, is, in principle, much different from the Hi-Ti system of Kathmandu valley.

Flowing and Falling water: the objective feature

The *vavoli*[8] is also a deep pit water system. It appears to have developed during the Sultanate period in Delhi[9]. However, the idea of *vavoli* is an extension of the well system, which was known in Gangatic plains since long before the coming of the Sultans. The *vavoli* is a pond dug deep enough to be fed by sub-surface water, established first by making a well; it is not a system of water in flow. Since the water is not in flow and does not have to fall to a lower level, it is used like a pond. For the same reasons, neither there is any need to waterproof the sidewalls of the stepped access nor is the pit drained. Although excellent in artistic expression and exotic, the *vavoli* is technically simply going down to reach water at the level where it exists underground. For such reasons, it was later supplanted as a system as the use of the Persian wheel to raise well water to reservoir tanks at ground level became popular.

Photograph 1: The Three Conduit Spouts of Mani Hi-Ti, Patan

That a simple stepped well system was known to the Lichchhavis can be seen from a extant shallow stepped well at Hadigaon[10]; and an advancement in the concept seems already made through incorporation of flow too- a fact indicated by the Te Bahal inscription, which mentions *kupan-jala-dravanika*[11], literally, a water conduit fed by a well. This is obviously different from the *pranali-jala-droni*, the water supply system of the conduit fed by a canal. Thus, unlike in the *vavoli*, the improvements brought about distribution of well water through flows, a distinctive and important aspect of the Hi-Ti system that were already existing in the valley at the time of construction of Te Bahal system. Indeed, it must be the *pranali-jala-droni* system that prompted the innovation. For Kathmandu, the availability of flowing/falling water seems to have been was so important that when stagnant water sources such as wells and ponds were used, such as in the pit conduit of Bhagavati Bahal, they used machines to lift to and flow water from the conduit- a fact testified by the wordings *saliloddhara yantra* used in the Lichchhavi inscription there. We can observe that the

Hi-Ti system is, both conceptually and technologically, different from the *vavoli.* These differences, in the main, are threefold – (i) canalling of water over distances[12] to distribute and deliver at required places; (ii) delivery through conduits and provision of a small free fall for ease of use and 'ritual purity'; (iii) and provision of draining of the pit. The structure is unique to the ancient Kathmandu valley although, as will be evident from the discussions made later on this paper, a similar structure appears unearthed by archeologists at the citadel mound of Moenjodaro. Remains of a potential prototype are also discernible in an archeological structure at Tilaurakot.

It is from the term, *tilamaka,* that the medieval terminology for the sunken water structure, Hi-Ti, appears to have developed (by borrowing *Ti,* dropping *La* and adding *Hi*[13]). The fact that the inscriptions use the term *tilamaka* more frequently and along with Sanskrit phrases such as *paniya marga* (lit. water canal) would support the inference that the non-Sanskrit term *tilamaka* is Kirat for canal or a waterway (this was 'ti' or forrow) that carried water ('la' or 'lam') to the conduit pit collectively referred as 'tilam'. Such conclusion can also be drawn from the use of Sanskrit phrase, *pranali jaladroni,* which is literally exactly a conduit fed by a canal. It would appear that *ti-la* stood for 'flowing water' as different from *la-kha,* which apparently meant stagnant water as in *lakhamaka*, possibly a deep pit or well[14]. Such specialized terminologies and their use in Lichchhavi period should reinforce the conclusion that these systems of water supply were in use in Kirat period.

Today, the system of piped water supply, reservoirs, pipes and spigots may appear simple and common. However, when the Kirat came up with *tilamaka* and the Lichchhavi developed it into *pranali jaladroni*, they had only nature and natural formations, such as pond, river and waterfall to refer to. And it must be a tribute to their technological genius that the three natural elements were adapted into reservoir, canal and conduit. That such were the sources behind innovation is given away by the terminologies as well as artistic motifs seen used in the conduit pit. The Sanskrit term *Droni* means a trough or a conduit that sends down water like from a bucket and also as rain giving cloud. The imagery in the stone that supports the conduit as it comes out of the side wall is that of Bhagirath, a mythical figure who is believed to have brought the river Ganga, falling from the tresses of Siva, down to earth. Bhagirath is an obvious Saiva symbol of canalization of pure heavenly water. The *makara*, the mythical sea animal like crocodile in Saiva symbolism, invariably depicted with upturned snout to form the mouth of the conduit, provides for the fall of the holy Ganga water. Therefore, symbolically too, flow and fall requirement of water for its ritual purity is well evidenced in the conduit pit system.

Why is Hi-Ti a technological marvel?

Although the application of the principle of gravity flow to transport water from the reservoir to the pit may not be taken as an earthshaking technology, successfully using the same principle for draining out the deep pit and development of a design and construction technology that would work for more than a thousand year is marvelous. Brick arched drainage channels constructed at such depths and in built up contexts demand deep trenching and/or tunneling techniques. Construction of a chain of conduit pits with each following conduit at a level lower than the previous and using the drained off water from the higher as supply to the lower demands use of filters in between to assure the purity of water all along the chain. Indeed a complex maze of brick lined, tile covered circulating contraption with sand bed in sections, is constructed immediately behind the conduits; this system is capable of settling silt, filtering and, even more amazingly, controlling and regulating the flow of water as it comes out of the spout. What looks like an architectural feature of progressively reducing terraces leading down to the pit actually covers under it the filtration and regulating structure of the conduit system. Similar marvel may be seen in the waterproofing technology applied to the sides and bottom of the conduit pit so that sub-surface water did not ooze out to turn it into a well or pool. Not only the conduit pits but also the sides and bottom of the reservoir ponds were made waterproof by application of almost a foot thick layer of a particular type of lake silt deposit of gray/black soil.

The small section of the drain off channel and its use as supply channel to lower conduits in later development defy even a guess as to how these were maintained or kept running and operational for long. Whereas indigenous cultural practice linked to maintenance of supply canal and well system is very distinct and articulated in the *sithi* festival, no such practices are known about the Hi-Ti drainage and filter bed maintenance. Local people relate an unbelievable means in that the drains are unclogged and cleared annually by the snakes as they go into the system in pursuit of their prey, the toads! Could it a case of a self-maintaining aqua-technology assisted by animals such as fish, toads and even snakes!

Further questions on uniqueness: possible precedents?

Two structures, the famed Great Bath from Moenjodaro and another from Tilaurakot, also labeled as Bath by archeologists, appear as possible precedents of the Hi-Ti system. Although the long physical distance and separation in time frame might, at first glance, may inhibit one from seeing these structures as precedents, the cultural linkage between the Saka of Indus, the Sakya of Kapilvastu[15] and the Kirat of

Kathmandu valley is traceable[16] and possibility of such a path of influence and development is quite plausible.

The famed Great Bath of Moenjodaro[17], possibly dating from 1500-2000 BC ca., is a finely built brick structure 39 feet long, 23 feet broad and 8 feet deep (See Fig. 1). The bath is placed in a paved courtyard with a colonnaded covered passage all round. The court appears to have been defined by ceremonial rooms to the north, entrance wing to the south and service rooms to the east. The floor of the bath is approached from the north and the south by flights of brick steps. The floor have bricks on edge set in gypsum mortar and the side walls are also made water proof through the use of similar mortar as well as mud packing. A floor outlet provided at the southwest corner of the pit leads wastewater to corbel-arched brick drain. From a well located in one of the service rooms in the northeast, water was fed to the pit by way of floor channels.

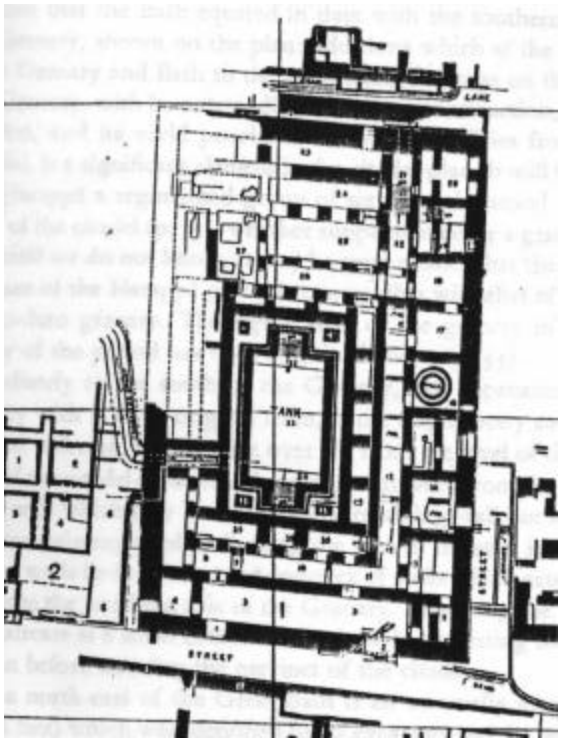


Fig. 1: The Great Bath of Moenjodaro

The provision of the flight of steps on two sides and also the drainage outlet clearly show that the pit was not meant to function as a shallow pond. The elaborate arrangement of feeding well water to the system should also tell us that the ritual use of water in Moenjodaro also needed it 'flow and fall' like in the Hi-Ti of Kathmandu. As a matter of fact, the archaeological remains of the Great Bath compare exactingly with the form and technology of construction of the Hi-Ti of Kathmandu- it can be conjecturally reconstructed into a conduit pit system with three channel spouts to the east and possibly also with another three on the west (Figure 2).

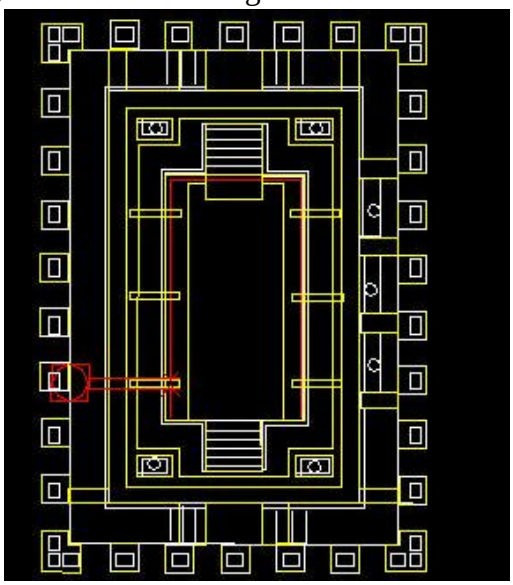
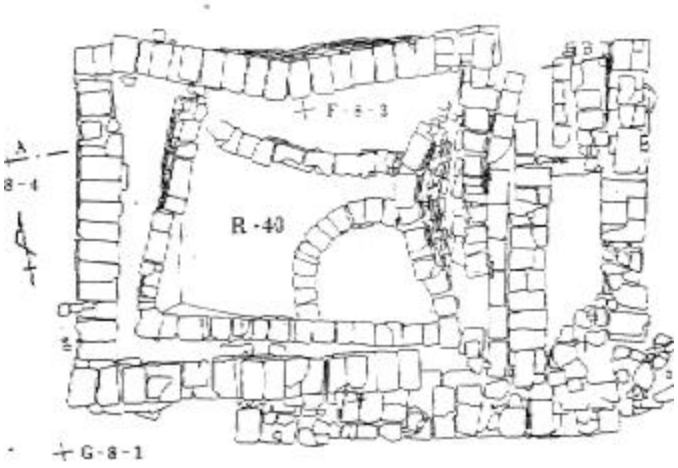


Fig. 2: A Conjectural Plan of the Bath

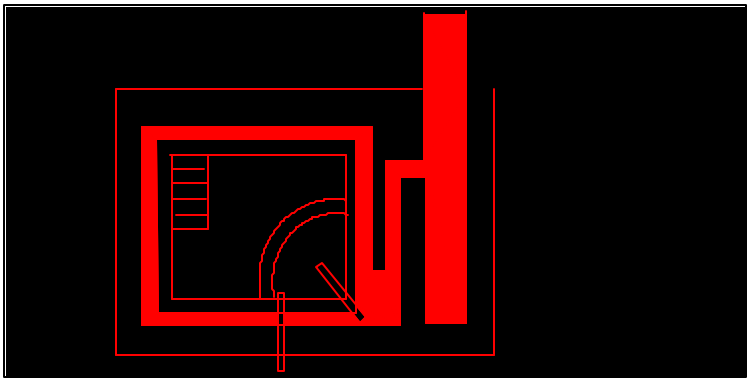
It is notable here that the ruins of the Great Bath of Moenjodaro are related to Nepalese Hi-Ti not only by way of the architectural form of the pit but also in terms of application of technique of water proofing; filtration and settling of water through circulation in a maze of channels and ritual use of water. Unlike in Kathmandu where the Hi-Ti has developed into a common utility structure and its ritual aspects became peripheral, the Great Bath of Moenjodaro with its associated building around the court and its prime location seems to indicate its dominant role in water rituals central to the then society.

Fig. 3: Archaeological Ruins R-40 in Mound VII of Tilaurakot



A less exotic but nevertheless interesting ruin of a structure (See Fig. 3) reported from Tilaurakot[18] also seems to be a miniature pit bath[19]. Tilaurakot-Kapilavastu in ancient times - was the capital of the ancient Sakya kingdom, which gave birth to Lord Buddha. Its habitation has been established to have extended from 8th century BC to 2nd century AD. Like Moenjodaro, the Sakya city of Kapilavastu is also planned on a grid iron street pattern with buildings based on courtyard system. It's architecture is also fully based on backed brick construction. It is in this context that the miniature bath structure of Mound VII assumes significance in that it appears as an intermediate state of a central civic-religious structure, such as the Moenjodaro Bath, turning into utilitarian ones like those in Kathmandu.

Fig. 4: Conjectural Plan of Conduit Pit and Water Channel



It can be observed that water to the bath pit system was fed by a channel starting from a well located further to the north and that the channel circulated water around the pit. This appears very much like the filtration and

settling system and apparently clean water collected on the southeast corner before being fed into the pit by way of a conduit. The proportioning of the pit is clearly based on a square and the drainage pit was a quarter circle. The system was possibly approached by a timber ladder placed north-south along the west wall. The remains clearly carry positive means of supporting the conjecture that it is a pit conduit of a small size, possibly meant as a private bath. This is shown in Figure 4 above.

It may therefore be concluded that the Hi-Ti of Kathmandu are unique only in so far as they are public urban service structures and their antecedents as civic ritual structure or as private baths come from sources that precede the Aryan developments.

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[1] Constructed by Bharabi, the grandson of Manadeva.

[2] An inscription issued by King Manadeva, whose rule started ca. 464 AD, documents construction of a similar structure. Local folklore, an indigenous information source, indicate that Hi-Ti were already in use by early 5th century AD (ref. Folklore associated with Bajrayogini of Sankhu).

[3] Called *varchakupa* in early Buddhist literature. The idea of such wastewater disposal wells is believed to have arrived to the Indus area with the expansion of the Achaemenid Empire, although its presence in such contemporary towns as Mahanagar as far away as Bangladesh may be telling other stories. The ring wells had been known to Mesopotamia as early as the 4th millennium BC.

[4] The Kirata settlements were always located on ridges and were called *Pringga.* With the coming of the Lichchhavi, settlements such as *Devagarta Grama* (current Deupatan) and *Daxinakoli Grama* (currently part of Kathmandu to west of Indrachowk) were build on river banks.

[5] SR Tiwari, 2001: The Ancient Settlements of the Kathmandu Valley, CNAS, Kathmandu.

[6] As Kirata noun words were usually ended with short '-m', '-ng', etc., the root term for *tilam-aka* should be *tila.* Likewise *di* for *dim-aka* and *lakha* for *lakham-aka* may be inferred.

[7] The Sakya capital city of Kapilavastu (Tilaurakot) shows the use of large reservoir pond that was fed by water diverted from Banaganga River.

[8] Series of steps are built leading down to a sunken pit fed by a well on its side. These go down depths of 20 to 50 feet below ground level. See ROA Becker-Ritterspach, Water Conduits in the Kathmandu Valley, Munshiram Manoharlal, New Delhi, 1995. (pp. 4: sketch of a *vavoli* from Vardhawan dated to 1294 AD).

[9] WH Saddiqi, 'Water Supply System of Fatehpur Sikri', a paper presented at Third South Asian Archeological Congress, Islamabad.

[10] Located in a private compound west of Bhimnani, Kwotal Tole, Hadigaon.

[11] *Dravanika* is a small *droni* - the former word being a diminutive of the latter in Sanskrit.

[12] So far only a few water conduits, such as those about Kumveswor in Patan, are known to have been based on local aquifer. These belong to mid Malla period.

[13] Hi-Ti is written as Yi-Ti in Gopala Raja Vamsavali, a fifteenth century document.

[14] Kirata term for water was apparently *la* and *vala*.(cf. *la* and *vaa* of Newari). Likewise, *ti* meant conduit, *kha* a pit or well and *khu* a river.

[15] The Sakya were called Saka(na) in Ashokan period. This is evidenced by the inscription 'Sa-ka-na-sya' seen in a token datable to 2nd century BC, found from Tilaurakot (BK Rijal: Archaeological Remains of Kapilavastu Lumbini Devadaha, Edn. Enterprize Kathmandu, 1979, pp. 36).

[16] SR Tiwari: The Brick and the Bull, Himal Association, Lalitpur, 2002.

[17] Sir Mortimer Wheeler: The Indus Civilization, Cambridge Univ. Press (3rd Ed.), pp. 40-43 for general description and interpretation.

[18] Z Nakamura & Others Eds.: Tilaurakot, Vol. 1, Rissho Univ., Japan, 2000, pp. 135, 276 (R-40, Mound VII).

[19] BK Rijal: 1979, pp. 35.