Traditional Construction Techniques of the Newars at the Itum Baha Monastery in Kathmandu

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This paper discusses traditional construction methods of *Newar* architecture in the Kathmandu Valley. The first part considers traditional construction and design details as well as typical structural problems associated with this kind of construction. The second part deals with construction principles and techniques as associated with the restoration of the Itum Baha monastery in Kathmandu.

NEWAR CONSTRUCTION TECHNIQUES

The traditional architecture of the Newars, the inhabitants of the Kathmandu valley, remained relatively unchanged from the 16th century until the beginning of westernization in the middle of the last century. Although this architectural style derives from Indian forms, traditional Newar architecture is highly distinctive and its origins is not fully understood.

The essence of the "Newar style" is found in the traditional farmhouse. This is a town house with two to three stories and simple floor plans. Other building types, such as houses for priests or merchants, palaces, monasteries, and shrines derive from the basic farmhouse. Although different in size and splendour, they share the same building materials and construction principles. (Slusser 1982, p.141; Hutt 1994, p. 50) The following is a brief description of the most important structural components.

Foundations and walls

Foundations of houses, small temples, and monasteries are typically shallow and often start no deeper than 100cm below grade level for a three story structure. They are sometimes slightly stepped, yet rarely measure more than 70cm in width. The base is generally formed by a few layers of large pebbles or broken stones. This is followed by the usual brickwork, which continues into the upper structure. No damp proofing was used in traditional masonry structures.

Walls usually consist of three different vertical layers of masonry, with a total width varying from 45 to 75cm. The outer face is made of a wythe of burnt brick, locally known as *ma apa*. For the main front of important buildings or temples, a special wedge-shaped brick (*daci apa*) is employed quite often to create a veneer-like façade. The taper of these bricks results in a varying thickness of the mortar joint from the front to the back. A hairline joint is created, which decreases the weathered area of the joints. These hairline joints are filled with *saldhup,* a mixture of natural black resin and mustard oil.

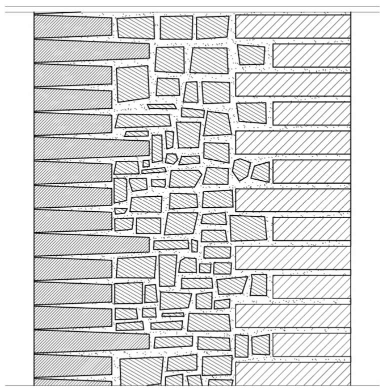

Figure 1. Typical wall cross section

The inner face of the wall is made of one wythe of burnt or even unburnt brickwork (*kaci apa*). Only rarely do those thick walls consist of continuous solid brickwork. More often they consists of a core of brick rubble infill set between an outer faces of brick **(fig.1).** The bricks are traditionally laid in mud mortar. In the 19th century lime mortar was introduced by masons from Lucknow, but only used at rare occasions until the rebuilding after the 1934 earthquake. Commonly, all bricks of the outer face are laid as runners, so that there is no or only little bonding between the different leafs. Cross walls are often simply butt jointed with no interlocking at all.

Frequently timber arcades replace a part of the masonry walls at the ground floor to provide better access to shops or storage space. Here, wooden pillars set above stone piers support a larger spandrel beam on which the upper wall portion is resting. Frames for wall openings such as doors and windows are pieced together from many wooden elements, joined with sophisticated connections. The preassembled free-standing frames are placed on the brickwork and thereafter integrated into the masonry wall.

Floor and roof systems

Floors are supported by closely spaced joists (*dhalin*) with a layer of terra cotta tiles or wooden planks. This subfloor is topped with a 10cm thick cover of fine yellow clay. The joists rest on continuous wooden wallplates that are embedded in the masonry. Wooden pegs prevent dislodgement. Floor-to-floor heights are quite low, often measuring only 2.20m.

The most prominent feature of Newar architecture are the wide projecting roofs, which typically protrude more than one meter from the façade; in the case of larger buildings and temples this can be more than 2 meters. All roofs are pitched purlin roofs, with a slope of 30 degrees. Ridge beams are typically supported by kingposts. The eave purlins are supported by often magnificently carved wooden brackets (*tunalas*). The brackets are set at an angle of approximately 45 degrees, and spaced at about 2m centers. They sit either on a brick cornice or a wooden ledge, or, less often, on a slightly projecting beam. The rafters are connected above the ridge beam with half splice joints. A layer of horizontal wooden planks or flat terra cotta tiles is placed on top of the rafters. A thick layer of mud (5 – 20cm) is put on top of this substructure, in which miniature terra cotta tiles (*djingati*) are pressed.

The massive projecting roofs are a clear response to the climate conditions in the Kathmandu Valley: the wide overhangs protect the walls from the relentless monsoon rains, while the mass provided by the thick mud bed ensures reasonable cooling.

Typical damage patterns

The weakness of the brickwork laid in mud mortar, in combination with loose fitting joinery and heavy roof constructions leads to a number of structural problems. The following are the more important defects:

- Water infiltration accounts for most damage to the buildings: Rain from the heavy monsoon downpours easily finds its way past dislodged roof tiles into the mud bed, causing wet rot of the roof structure.

- Damages due to rising damp: the lack of any moisture barrier above foundation level in this very humid environment causes widespread damage at the brickwork and associated timber elements.

- Delamination of the multi-layered walls: The lack of sufficient bond between the outer shells and the rubble infill often causes degradation of the walls.

- Bulging of the veneer-like *daci apa* front face: the different amount of soft mud mortar between the *daci apa* shell and the inner shell results in different stiffness. Due to this, differential settlement is frequent under larger gravity loads, which sometimes causes the bulging or deformation of the stiffer façade shell. **(fig.2)**

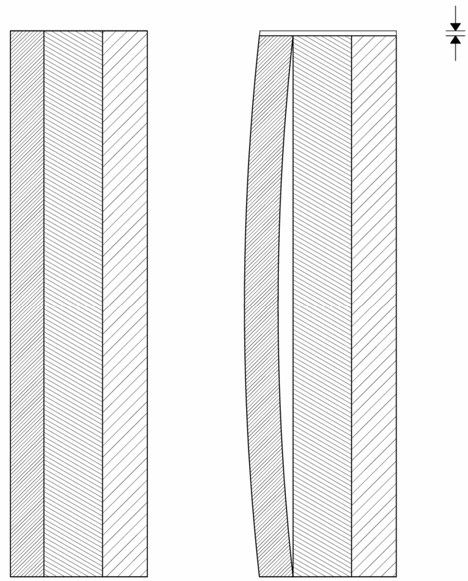

Figure 2. Bulging of the stiffer face brick shell

Historic photographs taken after the 1934 earthquake also give useful information on structural defects, which can be summarised as follows:

- Weak corners: since cross walls are often simply butt jointed with no or only little interlocking, wall separation is frequent under seismic loads.

- Failure of timber joinery: the traditional loose-fitting timber peg connections are in most conditions not able to withstand lateral movement or horizontal forces. Failure of these connections leads to progressive collapse.

- Roof collapse due to top heaviness: the thick layer of mud at the massive roofs causes a disadvantageous concentration of mass at the top of the building. This top heaviness, combined with the general looseness of the wooden peg connections, resulted frequently in the collapse of the roof structures.

- Soft story at ground floor level: Timber arcades at ground floor levels are common, to provide space for small shops or storage space, resulting in an insufficiently braced ground floor level.

ITUM BAHA MONASTERY

History

There are two different types of Newar Buddhist monasteries, the *baha* and the *bahi,* which originally owe their differentiation to respectively a non-celibate and a celibate monastic tradition. Both are free-standing two-storied quadrangles around a square courtyard. The entrance doorway is centred on the principal façade. On the opposite side, the shrine of the monastery is located, accentuated either by its elevated height or a gilded finial. Although both types are similar in their overall architectural composition, they vary in plan, allocation of space, arrangement of stairways and detailing. The baha type - deriving from the non celibate monastic tradition - is characterized by its walled courtyard front and less open layout that results in a less "ascetic" character than the airy bahi. (Slusser 1982, p. 136)

Itum Baha is one of the five principal Buddhist monasteries of Kathmandu, and, dating back to the 13th century, one of the eldest of its kind. Located about 300m north of the renowned Durbar Square, Itum Baha is situated on the eastern side of Kayagunani square. Together with the adjacent buildings, the entire grouping forms what may be Nepal´s largest monasterial complex. Throughout its eight century long history the structure was refigured several times, most notably in 1663, when it was extensively rebuilt. The catastrophic earthquake in 1934 severely damaged the structural fabric of the monastery, but many of the historic doors, windows and roof brackets survived. In the rebuilding that followed the earthquake the building was drastically altered again: the roofs were rebuilt in a simplified manner and little attention was paid to historic details. Salvaged timber of inappropriate dimensions was used often in the repair work. Inappropriate occupancy of parts of the building as a school and residential quarters led to further modifications and deterioration of the historic fabric.

At the end of the last century Itum Baha was disfigured and in a desperate state of repair. Encroachment by new neighbouring construction made it impossible to circumambulate the once freestanding edifice. As key part of its broader Buddhist Kathmandu campaign, the *Kathmandu Valley Preservation Trust* started an effort to safe and restore Itum Baha in 2001.

Existing Condition

The outer dimension of the square quadrangle of Itum Baha is 27.75m. The typical bay width is 3.50m and wall thickness varies between 55 and 65cm. **(fig.3)**

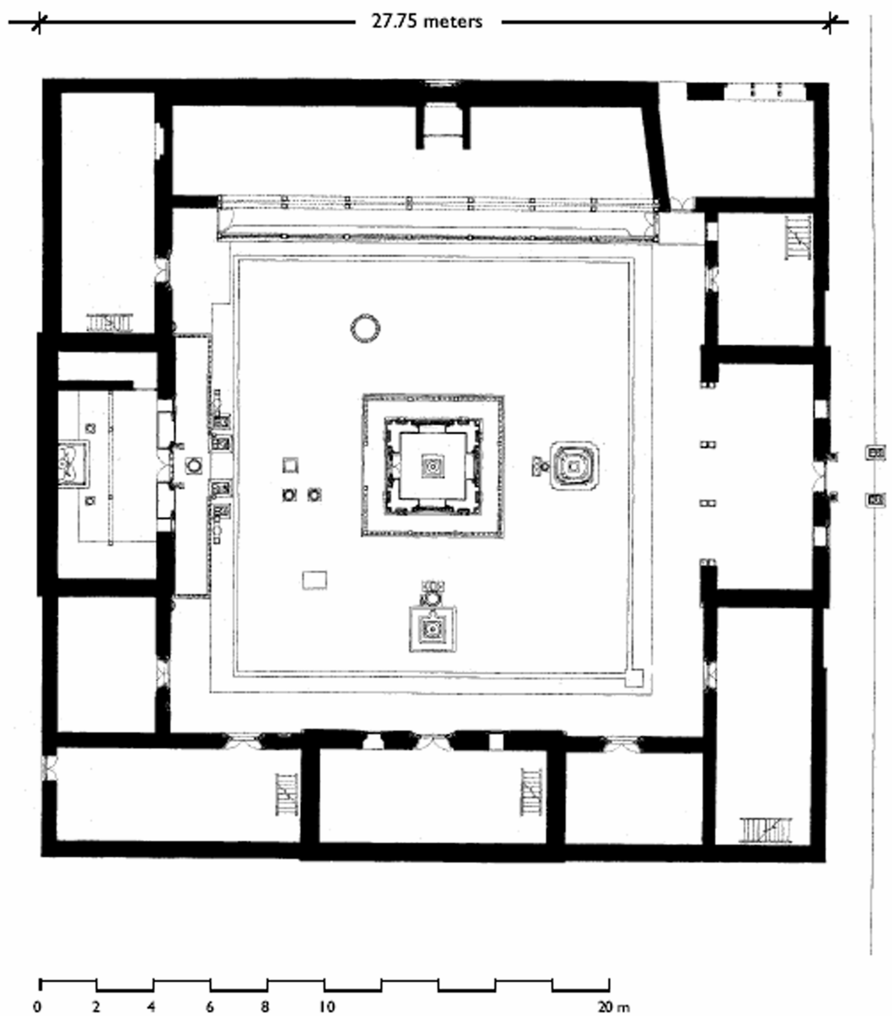

Figure 3. Floor Plan of Itum Baha

Structural investigations and excavations at the existing foundation walls were carried out in November 2002. The test pits unveiled a surprisingly high water table. Water was found only 50cm below the plinth level, making it difficult to thoroughly check the foundations. Based on observations of similar structures, it can be assumed that the brick foundation wall reaches a base of large rubble stones approximately 1m below the courtyard level. Further research brought to light that the courtyard level had actually been raised in 1924. During excavations remnants of the old courtyard were found. They proved that the paving had been raised by about 43cm. possibly to provide sufficient drainage and to avoid rising groundwater levels.

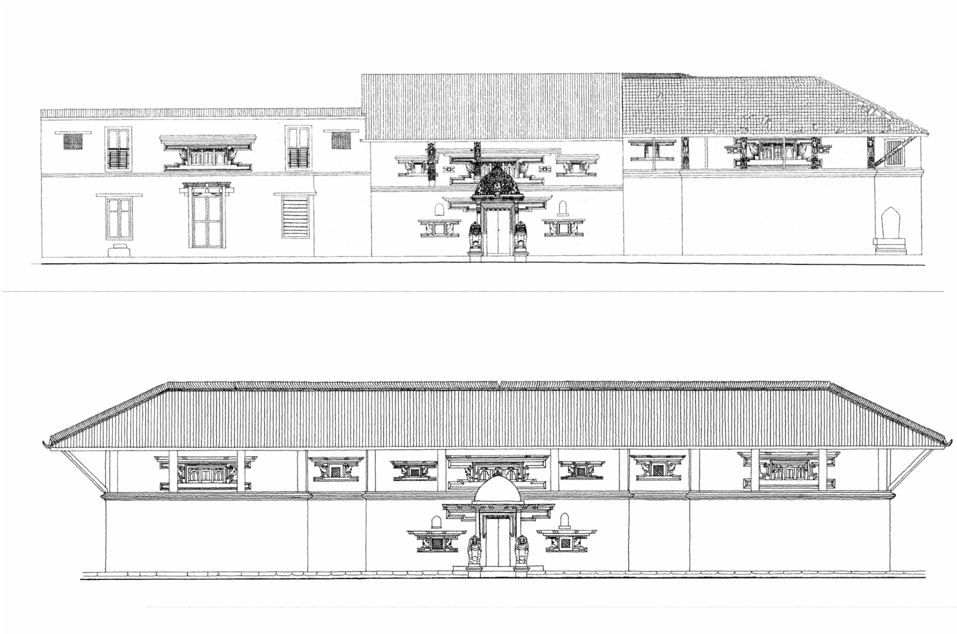

Figure 4. East Wing Façade: existing and proposed restoration. (Drawing by Bijay Basukala)

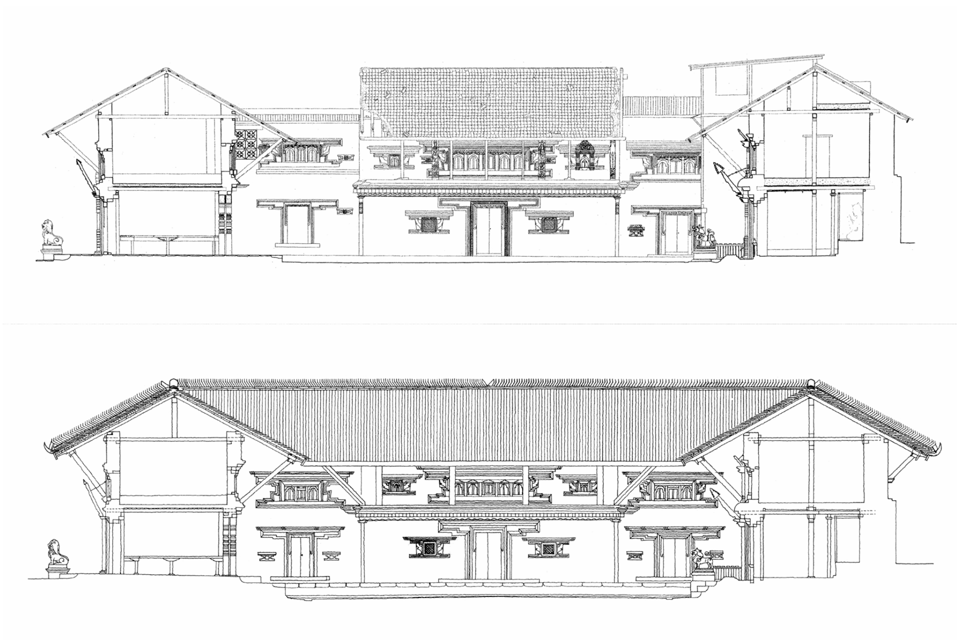

Figure 5. South Wing Façade: existing and proposed restoration (Drawing by Bijay Basukala)

The restoration started with the south wing of the building, which was in an extremely bad state of repair **(fig.5)**. A lack of maintenance had led to the partial collapse of the roof structure and the ingress of water had damaged beyond repair all the rafters and most of the joists. At the second floor level, many of the joists were rotten and severely affected by wet rot, fungus and insect infestation. Many of the timber windows on the second floor level showed boreholes caused by insects that had led to partial decomposition of the wood.

The load bearing walls consist of locally produced fired brick – *ma apa* - laid in mud mortar, with the typical three-layered cross section. Most parts of the brickwork were in poor condition. The rear wall brickwork had suffered severely from water ingress through the leaking roof and had been repaired repeatedly with modern bricks and cement in the last decades. Heavily decayed brickwork could be seen along the entire front and rear walls of the south wing. Rising damp had caused spalling of bricks and washed out the mud mortar in the evaporation zone of the wall, between 50 - 180cm above ground level. Below this zone, heavy efflorescence and moss could be witnessed along the walls. The rising water, exacerbated by an unusually high water table, had led to a substantial weakening and decomposition of the structure **(fig.7)**.

Figure 6. South wing before restoration

The damages at the west wing were minor in comparison to the south wing. At the courtyard façade some parts of the face bricks next to the shrine had been coated with cement plaster. At the rear of the west wing a parallel running wall had been added to stabilize the slanting bearing wall in the 1970s.

Restoration

The aim of the restoration was to preserve as much of the historic fabric as possible, and – in cases where conservation wasn't achievable – to adopt historic construction techniques for reconstruction. Remembering the 1934 earthquake it was deemed necessary to subtly reinforce some of the structurally weaker parts of the building in an unobtrusive manner. This seemed to be of particular importance in the case of Itum Baha since unique religious artefacts are stored in its premises.

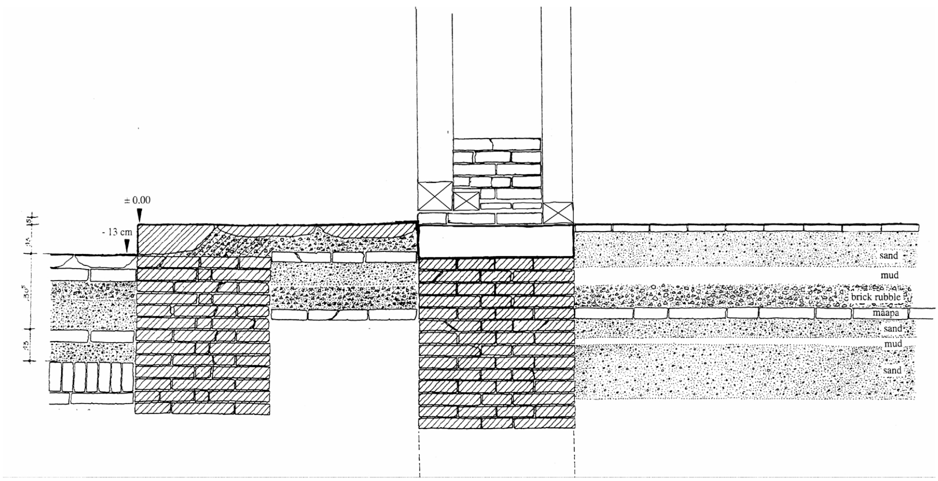

Figure 7. North-south section through the central door of the south wing showing the inserted ring beam (22x65cm)

The lack of authentic brickwork as well as the extremely poor condition of the structural fabric led the design team to the decision to dismantle some parts of the South wing and reconstruct them. To protect the masonry walls from rising water, and to increase the seismic shear resistance of the foundations, it was decided to incorporate a reinforced concrete ring beam just below grade level on top of the existing foundation walls **(fig.7)**. The walls were rebuilt on top of the new ring beam in the traditional fashion with mud mortar, using both new and historic bricks. Instead of the typical three-layered wall construction with the rubble infill, a two layered cross section was used, with proper bonding between the face brick and the *ma apa* bricks behind. The new *ma apa* bricks were specially ordered to match the historic dimensions of 4 x 13.5 x 20cm. To this day bricks are still hand made using traditional wooden moulds and wood-fired kilns **(fig.8)**.

Figure 8. Rebuilding a part of the South wing rear wall

Wooden doors and window elements were preassembled by wood carvers and carpenters. Where it was absolutely necessary, damaged parts were carefully replaced by new wooden components. (The master carvers still use the same tools and techniques as their fathers and forefathers to work with the wood.) Lost parts were skilfully reconstructed with the help of historic documentation and meticulously integrated into the historic parts. After having finished the assembly of the door or window frames, the complete frames were set on the brickwork with the masonry later wrapping around them. **(figs. 9, 10)**

Figure 9. Detail of restored doorframe at south wing (Photograph Niels Gutschow)

Figure 10. Restored historic roof strut. Missing parts were carefully replaced (head).

To connect the floor systems more tightly to the walls and to achieve better bracing, the floor construction was slightly altered: The joists were extended to the wooden cornice on the outer side of the wall using a dovetail connection.

At the roof level, 2cm thick marine-grade plywood panels, staggered in plan, were mounted on top of the rafters above the building. The panels form a stiff diaphragm and increase the cohesiveness of the roof system. The overhanging part of the roof, which is visible from below, was covered with traditional terra cotta tiles. To protect the roof from infiltrating water, a waterproof membrane was inserted. Sloped battens were installed to prevent the mud layer from sliding. Finally, the traditional, palm-sized roof shingles were pressed into the mud bed. **(fig 11-13)**

Figure 11. Rebuilding of the roof structure

Figure 12. Rebuilding of the roof structure and stiffening of the roof with staggered plywood panels

Figure 13. Installation of the mud bed and the roof tiles

CONCLUSION

Newar society has changed drastically since 1950 when Nepal opened her borders to foreigners, and the country became increasingly westernized in the following decades. However, unlike many parts of the Western world, century-old cultural traditions are still intact in pockets of society. Some of the historic buildings, and particularly the temples, have not yet lost their original function and are still used in the same way.

The traditional building trades, although in rapid decline, are still active. Techniques of masons, carpenters, and carvers are still passed on from father to son. Because of this buildings can be restored using traditional techniques.

The construction techniques and building methods of traditional Newar architecture appear to derive more from climatic considerations than concern about structural efficacy and/or durability. In some restoration projects the structural defects outlined previously require additional strengthening and replacement to resist earthquake loads. In the case of Itum Baha, some concealed low-tech measures were incorporated to upgrade the structural fabric at a few locations. They were deemed to be a compromise between the authentic spirit of the building and its traditional construction methods on the one hand, and the need for structural stability.

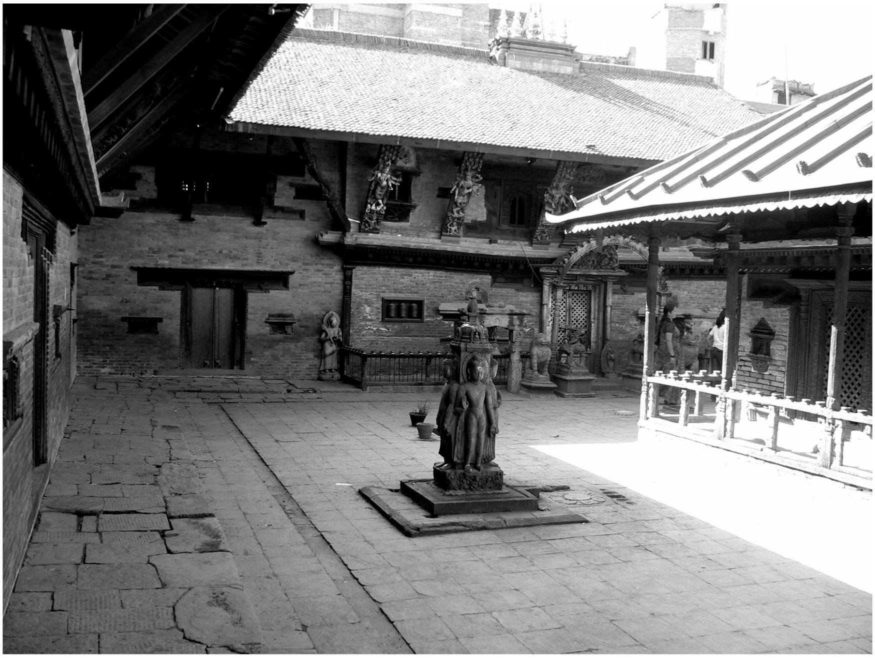

Figure 14. Restored west wing

Figure 15. Restored south wing

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