

Vernacular Newar Dwelling- Its Construction Technologies and Vertical Functional Distributions

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ABSTRACT

This research examines the construction process and the techniques of vernacular residential dwellings of core area of Bhaktapur city. The physical characteristics of the buildings are rich in their heritage. The investigation mainly concentrates on assembly of building structures, scientific justification behind the technologies and the vertical functional use of the building. The paper takes an integrated view of building technologies and materials assembled by builders. This research attempts to improve the technologies applied by the builders by emphasizing the cultural context which enables us to provide an integrated explanation. The behavior of structure and material is kept as the focus of investigation. The different case study buildings are selected from upper Bhaktapur (East) to lower Bhaktapur (West) with an assumption that the knowledge may be generalized to the other buildings as well.

The main findings reveal that Newar residential dwellings are constructed of brick masonry with mud mortar and timber. The architecture of traditional dwelling is a product of different professionals. Different structure assembling techniques in different parts of the building, detail information on building materials and functional space allocation and terminologies used in building construction are described because each terminology is a meaningful invention of our past tradition on building construction technology.

Key words : *Newar residential dwelling, traditional, construction, technology, techniques, terminology*

I. INTRODUCTION

This research stems from an observation of buildings in the core areas of Bhaktapur (Figure 1) which has the stock of the traditional buildings rich in physical and cultural expression. The city is rich in heritage expressed through harmonized building materials and construction techniques. The magnificent artistry of Nepalese woodwork is renowned and is a prime essence of traditional Nepalese architecture. Historical buildings, including residences, palaces, temples and monasteries (bahals and bahils), priest house (Matha) display structural as well as decorative use of timber as evident in the skill and artistry of the medieval period.

Most of the world monuments are built in their own local technologies, using their own local materials yet these have not been well studied and well documented. Because of these reasons, it is very important to understand the use of traditional building materials and technologies and document them for future reference.

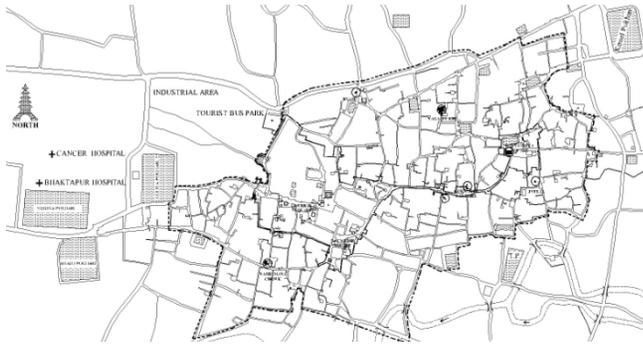


Figure 1. Map of the Bhaktapur city

From a detailed observation of the building structure and its design function, the traditional buildings like temples, mathas, satals, dyochhens, patis, palaces or the private dwellings all are of great importance to national heritage. The identity of any place or the location is reflected by its built environment, the people living there-in, their socio-cultural activities and their religions.

The system and the scientific justification behind the technologies of national heritage at present exist mainly in an oral version (BDP, 1986). This has to be documented in a written form. This paper covers only the traditional Newar residential dwelling of Bhaktapur city. Though monuments are elements open to public exhibition, the residential dwellings are less visible but no less important to the sense of harmony in all aspects of the life of the city.

The town has also suffered much from earthquakes. The worst of them occurred in 1808, 1833, 1934 and 2015. They destroyed a considerable part of its building stock, a few of which are now older than 150 years. In spite of these destructions, the external appearance of the city does not seem to have altered greatly. Temples were rebuilt in their original form, although some were changed in size and shape. The sizes of bricks, tiles, or windows have also changed. Many buildings have collapsed and have been rebuilt. All these changes have not led to a substantial change in architecture; the basic structure of the town seems intact.

Houses constructed in this century, especially those from after the great earthquake of 1934, were quite often four storeys till early 1970. Subsequently, the heights of the buildings were significantly raised, in some cases overextended from an original room height of 1.61.9 m to 2.52.9 m. From 1970 inwards new building styles crept in, mostly modern elements from western architectural styles. Such modern contemporary building styles often depart significantly from traditional building methods, especially in the number of floors, floor height, use of new materials and in the overall architectural expression.

It is evident that the original building regulation as to height limitation served an obvious regulatory purpose. It is also manifestly cleared that this regulation is no longer observed today. It is thus possible that a modern five or six storey building is planted next to an old three storey house, towering above all the neighboring houses in an already very densely built environment, with negative effect on buildings safety as well as sunlight and ventilation is concerned.

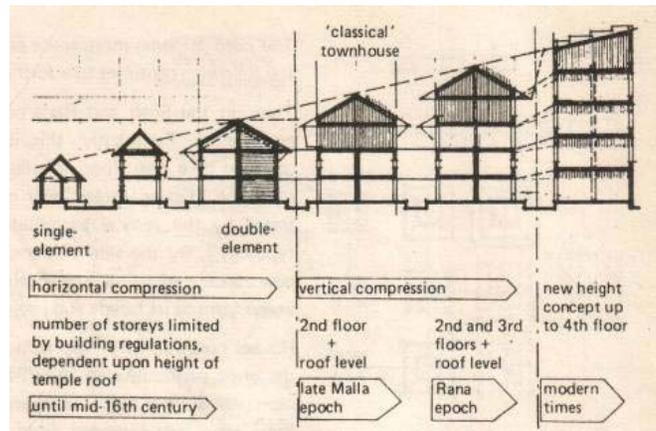


Figure 2. Development of building height (Scheibler, 1988)

Figure 2 illustrates the historical trend in the increment in the number of floors in conjunction with the simultaneous horizontal expansion from a single bay to a double bay construction. This was probably first introduced during the Rana period. Precise details as to their architectural history are lacking.

II. INTRODUCTION TO TRADITIONAL NEWAR DWELLING

In contrast to the well documented descriptions of religious buildings, the historical information concerning private dwellings is almost non-existent. A

Jesuit traveler, Father Giuseppe who visited Nepal nearly 200 years ago gives probably the earliest description of dwellings: “The houses are constructed of brick, and are three or four storeys high; their apartments are not lofty; they have doors and windows of wood, well worked and arranged with great regularity.”

The simple description of the Newar house can be stated as “small entry doors that require the visitors to bow their head when entering a Newar house, signifies a symbolic offering of respect to the place where they dwell. Newar houses were built with great care, imagination and creativity to make one feel the warmth around its coziness and richness of art. A Newar house is characterized by the use of natural materials, the intricate wood carving and brickwork, low ceilings and welcoming atmosphere”.

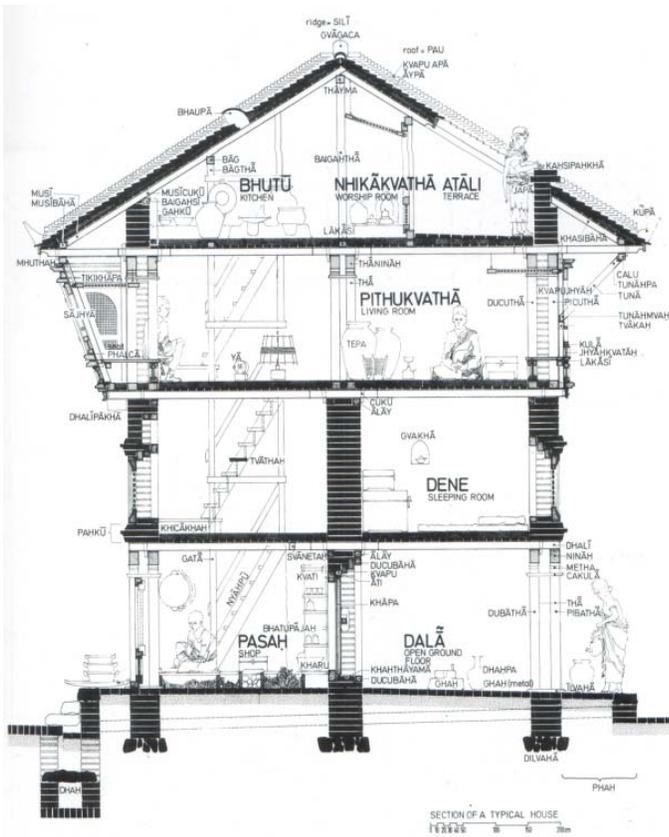


Figure 3. Section of a traditional Newari Building with space use at different levels (Gutschow, 1987)

The traditional building from Malla period differs from the building of Shah and Rana period. The major differences, which can be observed visually, are floor height, window style, ornamentation, and carving on

the wooden members. However, in general, traditional buildings are considered to be three to four storeys high with floor height between 1.60m to 2.40m connected by a narrow (approx. around 0.45m - 0.60m) and steep (at least 60 degree) wooden staircase (Figure 3). The plan is usually of a simple rectangular shape with a depth of about 6m and length varying from 3m to 10m. The buildings are constructed in brick masonry structure and the materials for the superstructure is locally available sun-dried or burnt bricks with mud-mortar as the binding material while the material for the foundation is stones or brick. Timber is used for window/ doorframe and carved elements, staircase, beam, strut, purlin. The roof is a special architectural feature of the whole building, which is usually in slope with pola aapa (tile roofing), locally called ‘Jhingati’. It is constructed with wooden beam over which wooden boards are placed and then a thick layer of mud topping is applied as the base for Jhingati (Figure 4).

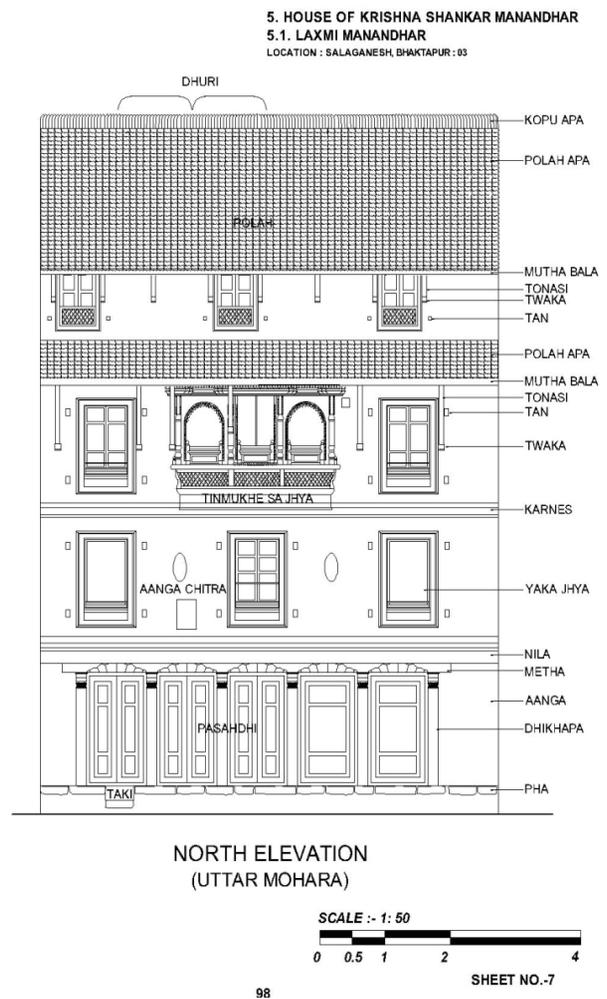


Figure 4. Elevation of a traditional Newari Building with terminologies of the elements at different levels (Author, 2012)

Wolfgang Korn (1976) also elaborated that a characteristic and universal feature of this design is the vertical room arrangement, which is not dependent on the size of the house. Security considerations, and the need to use as little irrigable land for building purposes, caused the Newar house to be vertically orientated. Generally it is threestoreyed, but twostoreyed houses occur among the poorer inhabitants on the town's fringes, and four storeys in the centre of town. The uniform depth facilitates the building of additional floors on to existing ones, to form blocks of houses. The extensions were of equal height, the depth being determined by that of the main house, and either the full depth of 6 meters or only half that depth was used.

Common lifestyles within each habitation, together with similar building methods, led to uniformity in architectural style, with only superficial variations.

III. PHYSICAL STRUCTURE

The development of urban settlements and the street patterns within these settlements usually meant that domestic dwellings are either groups of interlocking courtyards in the more dense developments, or linear contiguous buildings facing the street or access road. In the latter case a less controlled form of courtyard development may grow up of inferior structures interlocked by a series of enclosed passages running at ground level beneath the dwellings, which link the various courtyards.

The buildings that overlook the main access roads and those that occupy key positions in large enclosed spaces are usually of architectural importance. Their facades are generally symmetrical and contain finely detailed and carved windows and doors. Symmetry is achieved on a central axis on each succeeding floor, with the central window of each floor emphasized by both its size and quality of detail. The houses are usually of two to three storeys set above a ground floor (Figure 4).

IV. THE INNER STRUCTURAL FORM OF THE NEWAR BUILDING

Because of the limitation in the spans of the timber beams, a central support of either a Dhathu Anga (central wall) or a row of supporting Tha (timber post) is placed systematically through the building.

The roof and floor structures of residential buildings are well integrated with the wall structure. The floor Dhalins (joists) rest on Nuss (wall plate) and are held in position by si chuku (wooden peg) through holes on either side of the plate. The Dhalins (joist) are supported on the Dhathu Anga (central wall) which reduces the overall span of the timbers and over this central support, the Dhalin are set side by side and span alternately to the front and back walls; the spacing between the Dhalin is equal to the breadth of a Dhalin. The Dhalin are laid flat with the depth being less than the width; occasionally the Dhalin sections are of square shape.

Sipu (Boarding) is normally laid over and runs transverse to the Dhalin. Occasionally these boards are substituted with a purpose made brick or tile which is laid between the Dhalin. The Ba: (floor finish) is laid over thick bedding consisting of either brick and clay or clay alone. If the floor is part of an external terrace then a greater thickness of special Kasi Pachha will be selected and laid by flimgimng from above with force. Over the clay bed, Chhikan Apa is laid which are glazed but they are not burned as bricks. In some interiors the tiling is replaced by a firm beaten clay base that is sealed over with clay slurry (Figure 5).

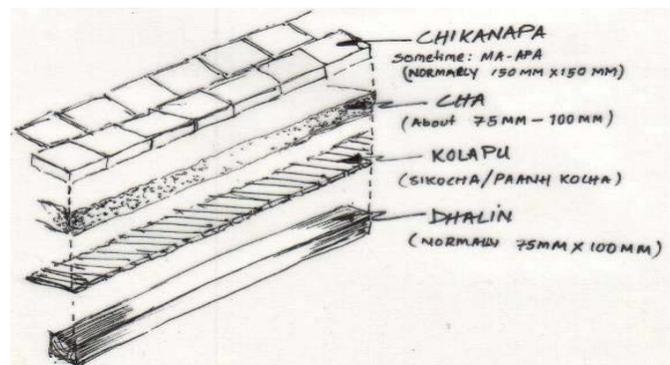


Figure 5. Ba: (Floor) Construction details and design (Author, 2012)

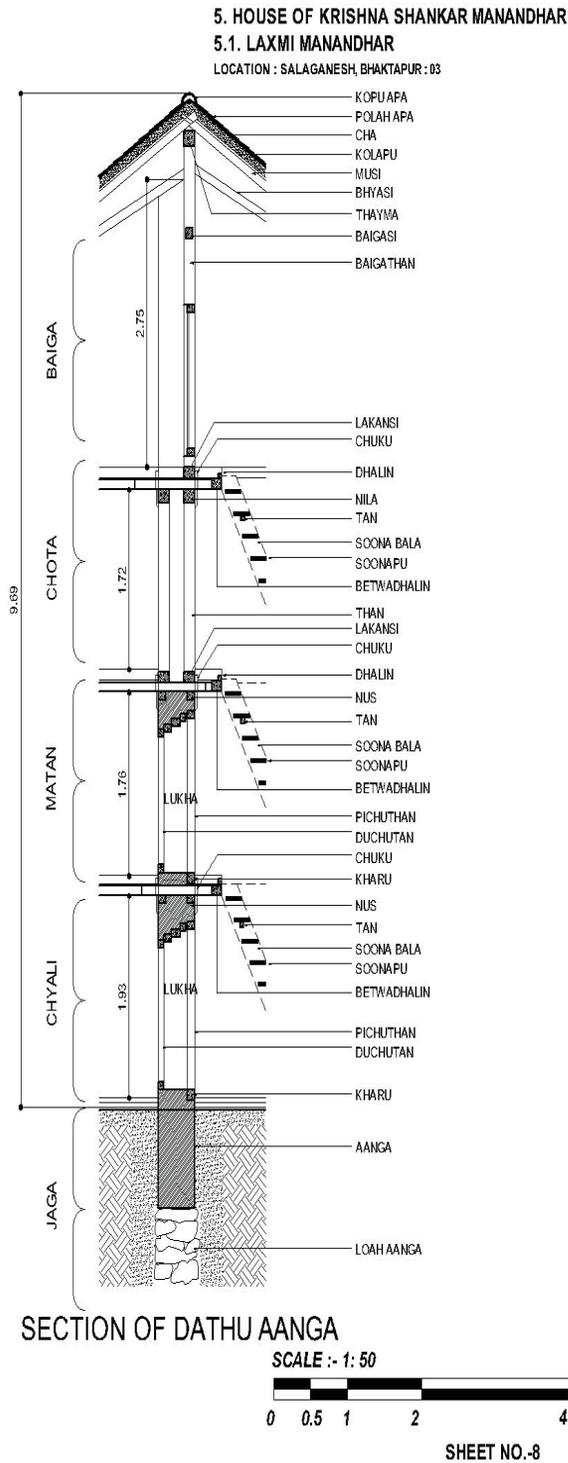


Figure 6. Section of Dathu Aanga of a traditional Newari Building with terminologies of the elements at different levels (Author, 2012)

When a large area for gatherings is required in these dwellings, the upper floor is opened from front to back and Dathu Aanga (the central spine structural wall)

is replaced with than (timber posts) and nila (beam) construction. The posts are stub tenoned into a floor plate and a long tenon passes through the supporting brackets into the beam above. The beams are usually two timbers of sizeable sections set side by side and the Dhalin are again Si chuku pegged on both sides of the beam. (Sandy, 1978)

A. Jaga (The Foundation)

The Jaga (foundation) is an underground structure which is strong enough to transfer load of superstructure to the ground. It is a longitudinal structure made of masonry stone blocks in trenches 0.60 m wide and 1 m deep in average. It is usually extended above the ground level by about 0.45 m in order to preserve and protect the base of the brick walls from rain water. There are also cases where these are stopped below the level of the ground (Figure 6).

B. Chyali (The Ground Floor)

Normally the Chyali (ground floor) is raised onto a platform of approximately 0.6m to 1m above the main street level outside (Figure 3). The practical reason for this is an attempt to protect the lower walls and floor against rising damp. As a result of the lack of proper DPC, the buildings are very vulnerable to dampness both from direct penetration through the wall and by capillary action up through the foundations. Even though the floor level is raised, there is still considerable dampness and these areas are mostly used for storage or as work-shops. The floors are generally solid and either finished with a clay tile, or when they are used as a workshop, a boarded floor is laid.

Where the ground floor is not used as shop or a workshop, it is used as store room or stable. The elevation remains simple and unadorned with a low door flanked by two small windows to admit light (Korn, 2007). Irregularities that may occur in this storey are never repeated in the more formal layout of the upper storeys. The entrance door is closed by two heavy wooden planks that slide under wooden hasps (Bagah) at the back of the door leaves (Figure 7) (Sandy, 1978).

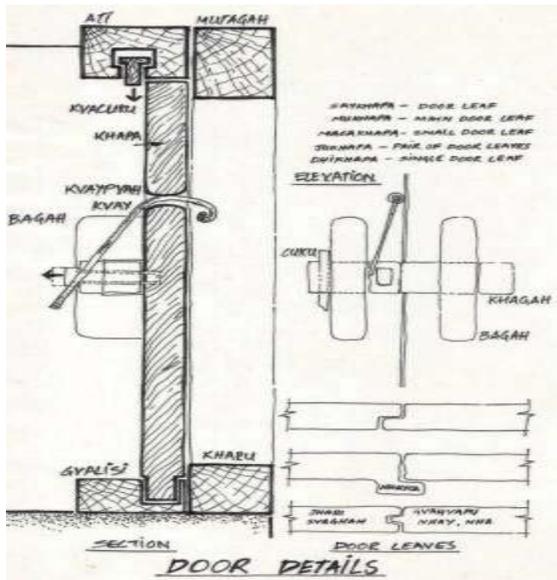


Figure 7. Wooden door detail (Author, 2012)

C. Matan (The First Floor)

The Matan (first floor) level is used both for sleeping accommodation and, at the same time, security. Depending on the size of the house, the two rooms created by the Dathu Aanga (central wall) are further divided by either solid masonry brick or light timber/bamboo partitions to form sleeping quarters (Figure 8) for family members, or for married sons, who remain in the parental home with their own family (Korn, 2007). Safety is reflected in the massive wall construction, in the Tikki jhyas (tiny windows) enclosed with latticework and the dhalinkhapa or kochukhapa (horizontal trapdoor) placed above the stairs. Subdivision into many small chambers provides private and individual rooms. Jewelry, valuables and clothes are stored here in wooden trunks and tin chests (Scheibler, 1982).

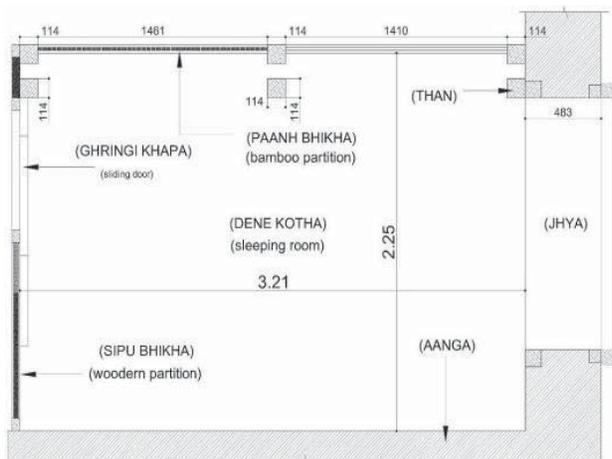


Figure 8. Plan showing different bhikha (Partition wall) (Author, 2012)

D. Chota (The Second Floor)

The Chota (second floor) is one large undivided room where the whole family gathers and visitors are received in accordance with one's class, and where there is ample room for the frequent large banquets to be carried out and enough space for the voluminous domestic chores to be done while from the benches on the balcony one can follow the events taking place below on the street (Scheibler, 1982). In this floor, Than (a row of twin columns) replaces the Dathu Aanga (central wall), so that the room becomes a hall. The large windows (sajhya) which lie opposite each other in both outer walls facilitate through ventilation and allow sufficient light into the room. By these means, a pleasant internal atmosphere is established, purely by natural means (Korn, 2007).

E. Baiga (The Third Floor)

The Baiga (attic storey) comprises the kitchen, the dining area for the family's daily meals and the Puja kotha (place of worship) with its house altar. In most cases there is also a Kausi (flat roof terrace) directly adjoining the kitchen and the dining area (Figure 3). There many social activities take place in the sunshine; many household chores are performed such as the washing and drying of fruits and vegetables. Old people, convalescents and newly delivered mothers can enjoy sunbathing undisturbed in peace and quiet (Scheibler, 1982). Because of their religious significance, strangers and members of lower castes should never enter the kitchens or the precincts of a higher caste shrine. Room divisions seldom occur except for an elementary separation of the shrine (Korn, 2007). The Kausi is specially constructed to prevent water seepage during rainy season.

F. Polan (The Roof)

The Polan (traditional roof) structure is a simple pitched timber roof. The most striking architectural feature in the traditional Newar buildings is the huge projecting roofs which, in the religious buildings, are stacked one above the other with, in a few cases, up to five diminishing tiers. The projections are large in order to protect the walls of brick and mud mortar from the driving rains and strong sunlight (Sanday, 1978).

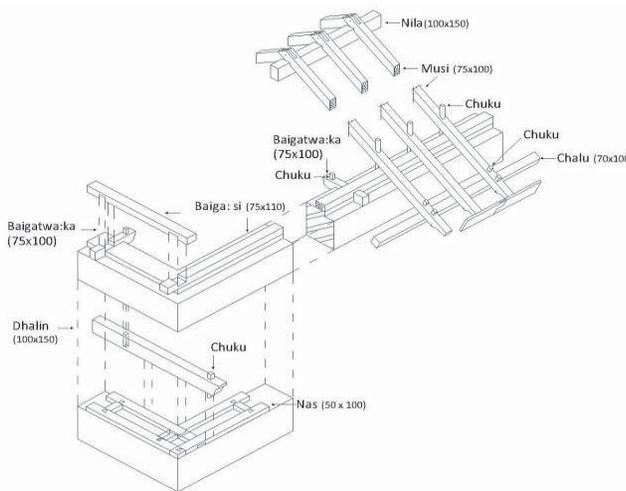


Figure 9. Assembly of structural members. (Author, 2012)

The design and details of the Polan (roof) construction as well as the traditional roof covering are basically the same in all buildings. The pitched roofs of large spans are of Musi (a rafter) construction, either set off a supported Thayma (ridge beam) piece in the case of Newar buildings, or off a Nus (wall plate) in the case of the lower tiers of the temples. The Newar building roofs are supported off a central ridge piece which is carried by a row of simple Baigathas (vertical posts) that follow the line of the structural spine wall below. Over the external walls or supports on a row of pillars, as extensions of lower walls, there is an intermediate support for the Musis (rafters). The outer support is usually from a further Garbha Nus (wall plate) that is supported on Tona si (inclined wooden struts) which, in the more prestigious buildings and in nearly all religious buildings, is carved with representations of various divinities. The Musis (rafters) and Thayma (ceilings beams) are set very close together, the distance apart often equaling the width of the timbers. Over the central wall or over the ridge piece they are set tightly together and run alternately to the front and rear walls. All the joints employed are complex interlocking scarf joints and the components making up the roof structure are kept in place with Chukus (wooden pegs). Dhalins and Musis (rafters) are always laid flat over the supports, contradicting the principle that the strength of the timber section lies in its depth rather than its width (Figure 9).

However, the safety factor in all these traditional timber structures is in excess of that which is necessary. In these traditional structures, it is not normal to find even the crudest form of truss and only in the larger

and probably later buildings is any further intermediary supports to be found. Over the main structure is laid either Sipu (boarding) or a Kolapu (tight mesh) of split battens with a rough upper surface to act as a key to the mud bed for the tiling. The mud or clay should be free of any vegetative growth and it should traditionally be dug from below a depth of 1.5m (5 feet), i.e. well below the topsoil. Tradition also dictated that the roof needed to ensure that there was no growth on it. The Polan Apa is then bedded onto the clay bed while it is moist. These tiles vary in size between 20cm and 25cm in length and of an average 10cm width. These tiles are loosely bedded on a clay base that is laid directly over the boarding of the roof. The eaves and hips are covered with Kopu Polan Aapa (vertically stacked tiles) that stay in position due to friction. The corner tiles are usually Gongga (decorative tiles), diamond shaped and measuring as much as 60cm in length. These tiles are nailed into the Musi (hip rafter) and often act as the “Book-end” to the vertically stacked tiles.

V. CONCLUSION

This research work was carried out to find out the construction technologies of the traditional Newar residential dwellings constructed of brick masonry with mud mortar and timber elements located in the historical city of Bhaktapur. This research made case studies of the dwellings constructed between the periods from 17th century to 20th century and analyzed them in a time sequence. The research found out the various technical details and techniques of the traditional buildings and the changes that occurred over time.

The Newar dwellings are easy to construct, as all the construction materials like aata (brick), aapa (brick), cha (mud), si (timber) or the product of cha (mud) are easily available within the surrounding areas. These materials have emotional attachment and provide comfort.

The technology innovations developed by the Newars are scientific and logical. The building technologies are not rigid in structure, i.e. the building construction elements like dhalin (joist), nila beam), than (post), musu (rafter), kolapu (wooden pieces), aanga (wall), thayma (ridge beam) and other can be replaced if damaged or decayed. The structural elements can be replaced without much difficulty.

The traditional buildings are well assembled and show harmonized combination of the materials. The structures in the building are well fixed by means of chukus (pegs) and sa: (joints), and the means of tightening materials like tei kachi (rope of bamboo), or pu. Ata or apa (brick) used on the buildings are also flexible in nature. The single piece can be removed or replaced whenever materials are damaged or decayed. The method of dhalin phyakyagu is another technology which holds the whole weight of upper part of building. Gwaneh, an inclined timber post is provided to support the building from collapse when bulging. This gwaneh rests on ki, a long chuku which is bigger than the normal chuku used on the buildings. The upper peg is called bilay which transfers the load of the bulging part of the wall. This is only possible in the wall structures of traditional buildings.

However, the Dhalins (timber joints) used in the buildings are found to be similar though the time period of construction is different. The different types of Dhalins (timber joints) are used for different parts of the building for the specific location and particular members. Also the brick layout joint, though it is a composite massive structure, is well compiled and well bonded with mud mortar.

This research, in addition, has brought forth a considerable extent of terminologies used in the building construction, which are not found in the existing literature. This is important because each terminology is a meaningful invention of our past tradition on building construction technology.

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