Building in the Past: A Preliminary Analysis of the Construction Materials and Methods Used in Structure A in Barangay Pinagbayanan, San Juan, Batangas

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Abstract

The Batangas Field School Program under its field director, Grace Barretto -Tesoro, has been excavating Structure A, Site I in Barangay Pinagbayanan, San Juan, Batangas for two consecutive years. In 2009, the southern portion of Structure A was investigated which resulted to the discovery of parts of an old Spanish house more commonly known as bahay na bato. This Spanish house is believed to be made up of adobe blocks and wooden sidings with capiz windows and clay roof tiles. In 2010, the focus shifted from the southern portion of Structure A to its northern portion. The results from the 2010 excavation became a vital source of additional information about the whole structure. With the whole of Structure A almost excavated, a study of the construction technology employed to create the house should be done to further understand the structure. This paper will attempt to make such study. This paper will discuss the construction materials and technology used to build Structure A and compare it with other archaeologically investigated Spanish colonial structures. An overview of the transition from nipa huts to stone houses with respect to the changes in their construction techniques will also be given. Finally, recommendations will be given with respect to conducting an archaeological research that deals with structures.

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Introduction

After the 2010 Field School Program, more evidence have been gathered to further reinforce the conclusions made about Structure A that it is in fact a *bahay na bato* structure built for a *principales* or a local elite (Barretto-Tesoro *et al*. 2009). As new evidence was uncovered, more questions were also formed about Structure A. This research is being done to answer some of the questions raised, specifically, with regards to the construction of the structure. The main objective of this research is to find out the construction technology and methods utilised to build Structure A. Through archival research and analysis of the findings from the two archaeological excavations done at Structure A, this study aims to 1) find out the specific building materials used for the architectural and structural component of the house, 2) compare the construction methods used in Structure A with other Spanish colonial structures that have been archaeologically investigated, and 3) find out the reasons behind some of the construction irregularities found in Structure A.

There have been many studies about the *bahay na bato* but mostly from the architectural and anthropological perspective. Also, most of the *bahay na bato* that have been studied were still standing or in partial ruins. This research study is rare because the *bahay na bato* to be studied is already non-existent and most of the primary data about the structure was obtained through archaeological investigation. Archaeologically, this is one of the few excavations which focus on Spanish colonial structures and the first to investigate about *bahay na bato*. Hence, this study will be coming from an archaeological perspective with the results of the archaeological investigation of Structure A used as a take-off point for this research. Its archaeological significance lies in the fact that this research will not only apply architectural principles to investigate the structure but also use archaeological principles to explain what happened to the structure.

This research will focus on the construction aspect of Structure A only. No thorough analysis of artefacts will be made due to time constraints. The researcher will instead use the initial findings of the 2010 excavation and the results and analysis from the 2009 excavation as primary source of data. Data gathered from interviews with local residents will also be used. These data will then be supported with other information gathered from archival research. The comparative analysis of archaeologically investigated Spanish colonial structures will also be limited to those recently investigated (i.e. within this decade). The comparative analysis will also focus only the construction aspect of the Spanish colonial structures.

Background Information

Since the *bahay na bato* is a Spanish adaptation of the local nipa hut or bahay kubo, it is imperative that a background information about the nipa hut should be given to have an idea of the kind of dwelling structures the Spaniards came upon when they arrived in our islands. The vernacular architecture of the Philippines before the Spanish colonial period in the 16th century was greatly influenced by its environment. Throughout the archipelago, the local nipa hut or *bahay kubo* was the predominant residential structure. The construction materials used to build the nipa huts consisted of light materials and were oftentimes indigenous to the region such as bamboo, rattan, and cogon. The form and style of the nipa hut was varied across the region as dictated by its environment. But one thing in common in all the variations of the local nipa hut was the use of the post and beam construction system. Posts and beams which were often made of bamboo or the local timber available to the region were used to support the whole house. Another similar feature noticeable in the different nipa huts found throughout the region was its elevated structure. Nipa huts were oftentimes on stilts whether on land or on water (Dacanay 1988; Hila 1992; Klassen 1986; Perez 1990).

The nipa houses were built by their owners with some help from their local community employing the *bayanihan* system. Construction methods used were simple compared to the methods used for building the *bahay na bato*. For those using local timbers as frames, mortise and tenon joints were sometimes used to join wooden members together since nails were not yet available at that time (Figure 3). One example would be

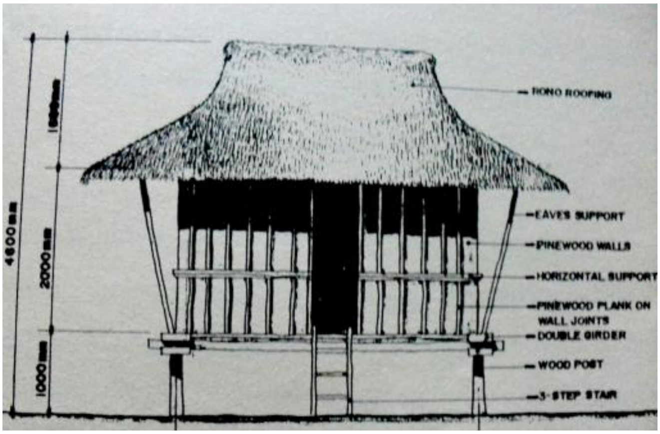

Figure 1: Example of nipa hut used in Cordillera region (Source: Balai Vernacular: Images of Filipino Private Space. Published with the permission from Cultural Center of the Philippines).

the ethnic houses found in the Cordillera region (Figure 1). More often than not, rope lashings made from rattan or *yantok* (woven split bamboo mats) were used to join the wooden frames together especially if the members were made of bamboo. This construction method is commonly seen in the lowland nipa houses were bamboo is predominantly used (Figure 2). The wooden frames consisted of posts, beams, floor joists, rafters for the roof, and horizontal and vertical studs to support the wall panels which were made from either *sawali*, bamboo, or coconut leaves (Figure 4). High-pitched roofs were often used to counter heat and rain and also allow for better air circulation inside the house (Dacanay 1992; Hila 1992; Klassen 1986).

The descriptions given in the previous paragraphs are the kind of dwelling structures the Spanish colonisers chanced upon when they came to our land. Instead of building their own different residential structure, the Spaniards who came to the Philippines adapted the local nipa huts and made larger versions of it. But since the nipa houses were made of light materials easily destroyed by fire and typhoon, the Spaniards eventually made use of stone to build their houses after several incidents of fire. Thus, paving the way for the early archetype of the *bahay na bato* of which was literally all made up of stone. But building with stone was a quite challenge during those times because no one among the locals was familiar with using the material. In 1581, a Jesuit priest by the name of Antonio Sedeño arrived in the Philippines after being stationed in Mexico

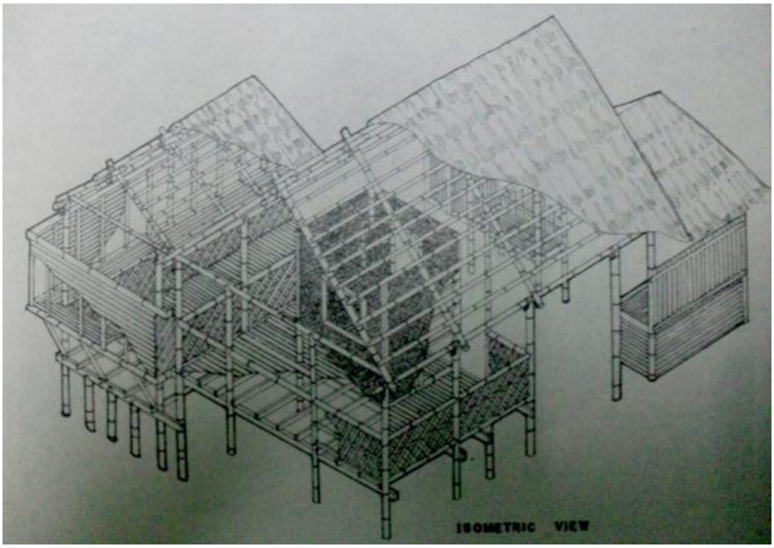

Figure 2: Lowland nipa house predominantly made of bamboo (Source: Balai Vernacular: Images of Filipino Private Space. Published with the permission from Cultural Center of the Philippines).

for nine years. His exposure to military architecture during the early years of his life and his immersion in Mexico where Spanish missions were rapidly constructed gave him enough expertise to train the locals in the art of masonry. Father Sedeño began training both Filipino and Chinese workers how to quarry, prepare, and lay stones after Governor General Santiago de Vera issued a decree in 1587 that all structures should be made of stone (Castro 2005).

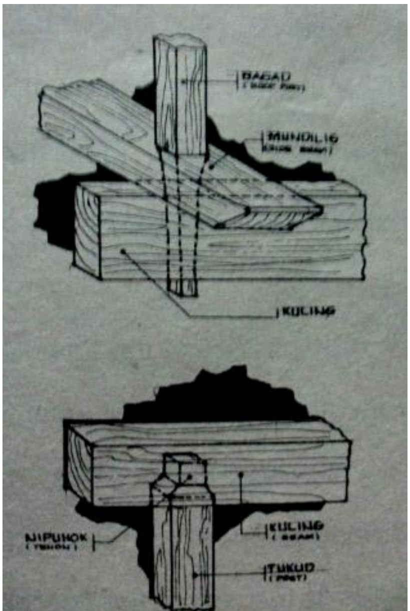

Figure 3: Mortise and tenon joint used in nipa huts in the Cordillera region (Source: Balai Vernacular: Images of Filipino Private Space. Published with the permission from Cultural Center of the Philippines).

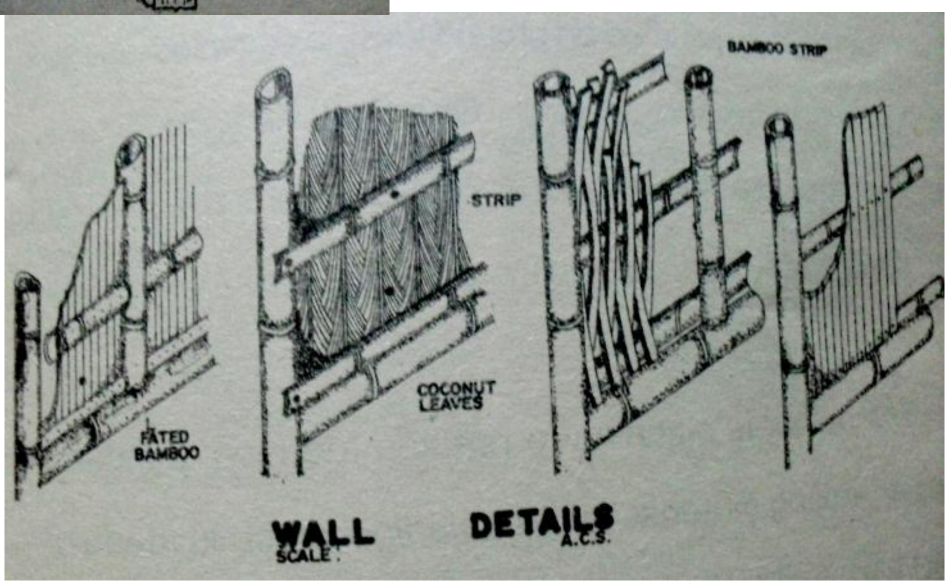

Figure 4: Examples of different types of materials used for walls in a bamboo nipa hut (Source: Balai Vernacular: Images of Filipino Private Space. Published with the permission from Cultural Center of the Philippines).

The early *bahay na bato* structures had stone walls for both its ground and second floor. Columns were also made of stone. Foundations were very deep and openings for doors and windows were only small so as not to weaken the building fabric. Timber made from Philippine hardwood was also used for beams, joists, and roof framing. Clay tiles replaced the easily flammable cogon grass for roofing. Though the construction materials used to build the *bahay na bato* were different, the layout and design of the houses were still the same as the local nipa huts, albeit in a larger scale (Zialcita and Tinio 2002).

But the great earthquakes of the 17th century destroyed these stone houses. As a result, a hybrid of the nipa hut and *bahay na bato* was made with the ground floor made up of stone and the succeeding floors made of wood (Lico 2008; Manalo 2005; Perez 1990; Villalon 2001; Zialcita and Tinio 2002). During the 19th century, the *bahay na bato* achieved the pinnacle of its form with the use of stones and bricks as mere building envelope to hide the wooden post which actually carries the weight of the whole structure. This building typology of the *bahay na bato* is what Filipinos commonly see today. The ground floor of the 19th century *bahay na bato* is made up of either stone or brick walls enclosing 8″x 8″ or 10″x 10″wooden posts.

These wooden posts go up to the second floor and are oftentimes either embedded or anchored to lime mortar foundations on the ground floor through a strip of wood nailed to the posts. The second floor is made up of wooden planks usually made of ipil *(Eperua decandra, Bl.*), narra (*Pterocarpus santalinus*), or other Philippine hardwood. The windows are sliding and translucent brought on by panels which are made of *capiz.* The roof, on the other hand, is either made up of galvanized iron sheets or clay roof tiles (Dacanay 1988; Zialcita and Tinio 2002).

Earthquakes made a great impact in the construction method and materials employed to make these stone houses. During the 19th century, the Philippines experienced several more earthquakes that destroyed several buildings. As a result, an earthquake ordinance was passed during 1880 by the Consultative Council of Public Works. The earthquake ordinance decreed the use of thinner wooden post and light roofing materials such as galvanised iron sheets.

Foundation construction was also changed. Before, master builders thought that the sheer thickness and depth of the foundation would be enough to provide stability to a structure but the earthquake of July 1880 proved that their assumptions were incorrect. Because of this discovery, succeeding stone houses were built with shallow foundation which only ran to about a metre deep. A standard wall thickness for all structures was also ordered. The thickness of the walls made after the earthquake ordinance should be at least one-fifth of the height of the walls (Zialcita and Tinio 2002).

A different system of measurement was also used during the Spanish period. Neither the metric nor the English system was used by the Spaniards in building their structures. The Spaniards used Castilian *pie*, Castilian *vara*, and Spanish *braza* in recording their measurements. 1 Castilian *pie* is equivalent to 11 inches or 27.95 centimetres while 1 Castilian *vara* is equivalent to 3 pie or 83 centimetres and 9 decimetres. The Spanish braza, on the other hand, is equal to 2 *vara* or 1.671 metres (Zialcita and Tinio 2002). This unique system of measurement was noticed in Structure A when some parts of the structure were measured using the metric system. The recorded results yielded whole numbers with decimals.

The structure to be studied and analysed is Structure A found in Barangay Pinagbayanan, San Juan, Batangas. Based on previous and recent excavations on the structure, it is believed that Structure A is the ruins of a *bahay na bato* that was built after the town of San Juan was established in 1881 (Barretto-Tesoro *et al.* 2009). Several columns made of stone bounded by lime mortar were found during the excavations. Exterior walls made of volcanic tuff blocks locally known as adobe were also discovered. Foundations with depth reaching to more than a metre were also excavated. A total of 12 trenches were dug during the two excavations that were done on Structure A. The succeeding sections of this paper will discuss in detail the materials and construction methods used to build Structure A.

Building Materials

Column and Foundation

Based on the archaeological investigations done on Structure A, the foundations were made of lime mortar while the columns were made from rough-hewn stones that were bound together by lime cement and probably enclosed in adobe blocks. The stone columns that were still intact were measured and had varying dimensions ranging from 63 centimetres to 91 centimetres (Figure 5). The adobe blocks that might have enclosed the columns and acted as a veneer for the column were no longer present.

Based on ethnographical accounts, adobe blocks were recycled by the locals to build fish ponds during the 1950s (Figure 6) and more recently as outdoor stoves or *tungko* used for food preparation during large celebrations (Barretto-Tesoro *et al*. 2009). The voids left by the adobe blocks caused the irregularity in the size of the columns. The stone columns, based on the earthquake ordinance of 1880, may have had a height of 280 centimetres and did not continue to the second-floor. Instead, wooden posts made of Philippine hardwood such as *molave* may have been used to support the roof and walls of the second storey. The height of the ground floor columns were based on the inferred height of the ground floor walls which will be discussed in the next section.

Figure 5: Stone column of Trench 7 (Photo by Riczar Fuentes).

Figure 6: Recycled adobe blocks used in the town's fish ponds (Photo by Riczar Fuentes).

Figure 7: Northern exterior wall of Structure A viewed from the inside of the structure (Photo by Angelus Sales).

Figure 8: Decorative mouldings found in the eastern exterior wall (Photo by Marie Louise Antoinette Sioco).

Wall

The exterior walls and interior partition walls of the ground floor were made of adobe blocks (Figure 7). Blocks measured from the two previous excavations have varying dimensions. One whole block from the 2010 excavation has a length of 72 centimetres, a width of 28 centimetres, and a height of 28 centimetres while a complete block from the 2009 excavation was 76 centimetres long and 28 centimetres wide. The walls of the ground floor area of Structure A have an approximate thickness of 56 centimetres and a height of 280 centimetres. The height of the walls was estimated based on the earthquake ordinance's prescribed thickness of the walls which should be a fifth of the height of the wall. Since the thickness of the walls was known, the height was simply calculated based on the known thickness of the walls. To bind the blocks together and create the walls, lime cement was used with broken clay tiles as aggregates to form the mortar.

Decorative mouldings were also used for the exterior walls to delineate the base of the exterior walls from the ground surface (Figure 8). The mouldings have a length of approximately 75 centimetres and a height of 30 centimetres. These mouldings were made from a mixture of lime cement or what is locally known as *apog*, sand, water, and very small gravel-like stones. Pilasters were also used for the exterior columns. Pilasters are columns that are embedded in a wall and are protruding from one or both faces of the wall. In the case of Structure A, the pilasters are protruding from only one face of the wall which was the exterior side of the structure (Ching 2008).

For the upper storey of Structure A, the exterior walls and interior wall partitions may have been made from Philippine hardwood such as *molave*. The windows were made from *capiz* shells as indicated by the recovered *capiz* shells found in Trenches 6 and 9 and also from the 2009 excavation. Since the upper storey of Structure A was no longer present, these inferences were based from ethnographical accounts from the locals and from archival research of common typology of *bahay na bato* structures.

Floor

The flooring material for the ground floor area of Structure A was quite varied. In the northern portion of Structure A, clay tiles or *baldosa* was used to finish the floor surface of the area occupied by Trench 5 and 7. This was based from the *baldosa* found in-situ in Trenches 5 (Figure 9) and from the *baldosa* impressions found on the mortar floor of Trench 7. The *baldosa* that was found in-situ measured 28 centimetres long and 28 centimetres wide. Adobe blocks were also found in-situ in Trench 4 (Figure 10) at the southern portion of Structure A. The adobe blocks served as pavers for what was believed to be a storage area for rice grains (Barretto-Tesoro *et al.* 2009). Compacted dirt floor was also used in some areas of the ground floor as indicated by the very compact dark reddish brown layer encountered during the excavations. Different flooring materials were used in the ground floor of Structure A to signify change in the function of the space and also to denote hierarchy of space.

Since the upper storey of a *bahay na bato* was mostly made up of wood based on the archival research, the flooring was no different. Wooden planks used as floorboards may have been used for the second storey of Structure A. The floorboards may be an inch thick based on the recovered square nails used to fasten the floorboards.

Figure 9: Baldosa found in-situ in Trench 5 (Photo by Noel Amano and Kate Lim).

Figure 10: Flooring made of adobe blocks found in Trench 4 (Photo by Archie Tesoro).

Roof

The roof of Structure A was made up of Spanish clay roof tiles. This is indicated by the broken fragments of clay roof tiles recovered from the site. During the 2009 excavation, a V-shaped clay roof tile was recovered almost intact. This artefact is a ridge cap which further supported the possibility of Structure A using Spanish clay tiles for its roofing material since ridge caps are used only when roof tiles are used as roofing materials.

Construction Methods and Systems

Foundation

At the time Structure A was constructed, the use of metal reinforcements was not yet widely practiced. As such, a foundation greatly depended on its sheer massiveness and depth for stability and strength (Figure 12). The thickness of the foundation of Structure A was varied. Column foundations were thicker and therefore, much deeper than wall foundations. The column foundations were more than a meter thick such as those in Trench 6 (100cm) and Trench 10 (180cm). The base of the column which was connected to the foundation was more than a metre wide.

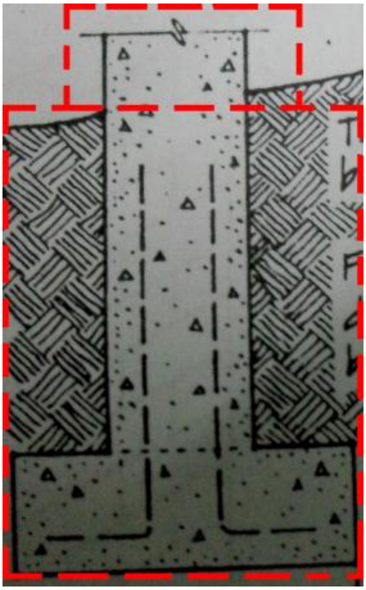

Figure 11: An illustration of a modern spread footing foundation. (Source: Building Construction Illustrated, 2nd edition. This material is reproduced with permission of John Wiley and Sons, Inc.). The red dash lines are outline of the spread footing used for Structure A.

Figure 12: Actual photo of a foundation located in Trench 8 (Photo by Marie Louise Antoinette Sioco).

The type of foundation used was a spread footing foundation (Figure 11). A spread footing foundation is a kind of foundation that uses a "pad" to spread the weight of the building over a sufficiently large soil area (Fajardo 2001). Two different types of spread footing foundation were used in Structure A. The wall foundation was constructed using a strip footing while the column foundation made use of isolated footing. A strip footing is a continuous spread footing used mainly for wall foundations while isolated footing is a single spread footing that supports a column (Ching 1995).

To be able to build the foundation, formworks were needed to mould the foundation. Formworks used for Structure A were wooden planks that were joined together. Once joined together, the mixture of lime, sand, and water were poured unto the formworks to create the foundation (Figure 13). The use of wooden planks as formworks were indicated by the plank impressions found on the excavated foundations (Figure 14).

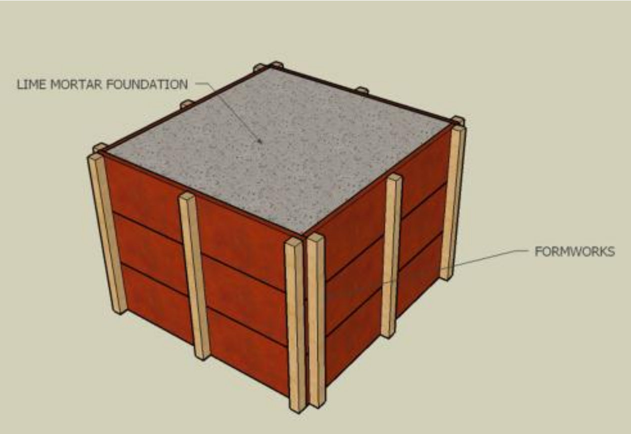

Figure 13: 3d rendition of how a column foundation is created (Illustration by Angelus Sales).

Figure 14: Actual photo of an excavated foundation in Trench 6. Red circles show the plank impressions found on the foundation (Photo by Angelus Sales).

Structural System

Since the *bahay na bato* is an adaptation of the local *bahay kubo*, the structural system used for both type of dwelling structure was the same. A linear structural system was used in building Structure A. In a linear structural system the weight of the building is uniformly carried out to linear structural elements such as columns and beams. Columns and walls are the vertical elements in a linear structural system while beams and floors are the horizontal elements. This kind of structural system also makes use of a grid system (Figure 15). The point of intersection of the grid lines is where the columns are located (Ching 1991). The grid pattern of the linear structural system was very useful in inferring the location of the other columns which were already destroyed. All in all, Structure A had 27 columns and out of those 27 columns, 15 were found during the excavation (Figure 16).

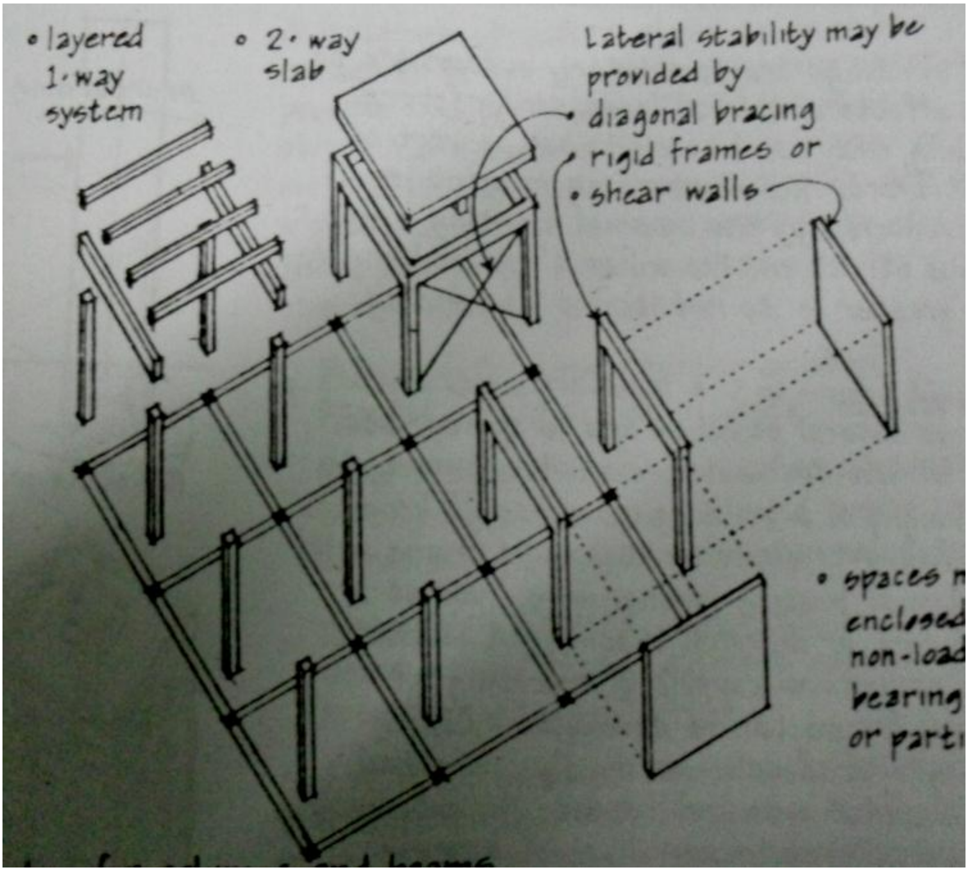

Figure 15: An illustration of a linear structural system (Source: Building Construction Illustrated, 2nd edition. This material is reproduced with permission of John Wiley & Sons, Inc.).

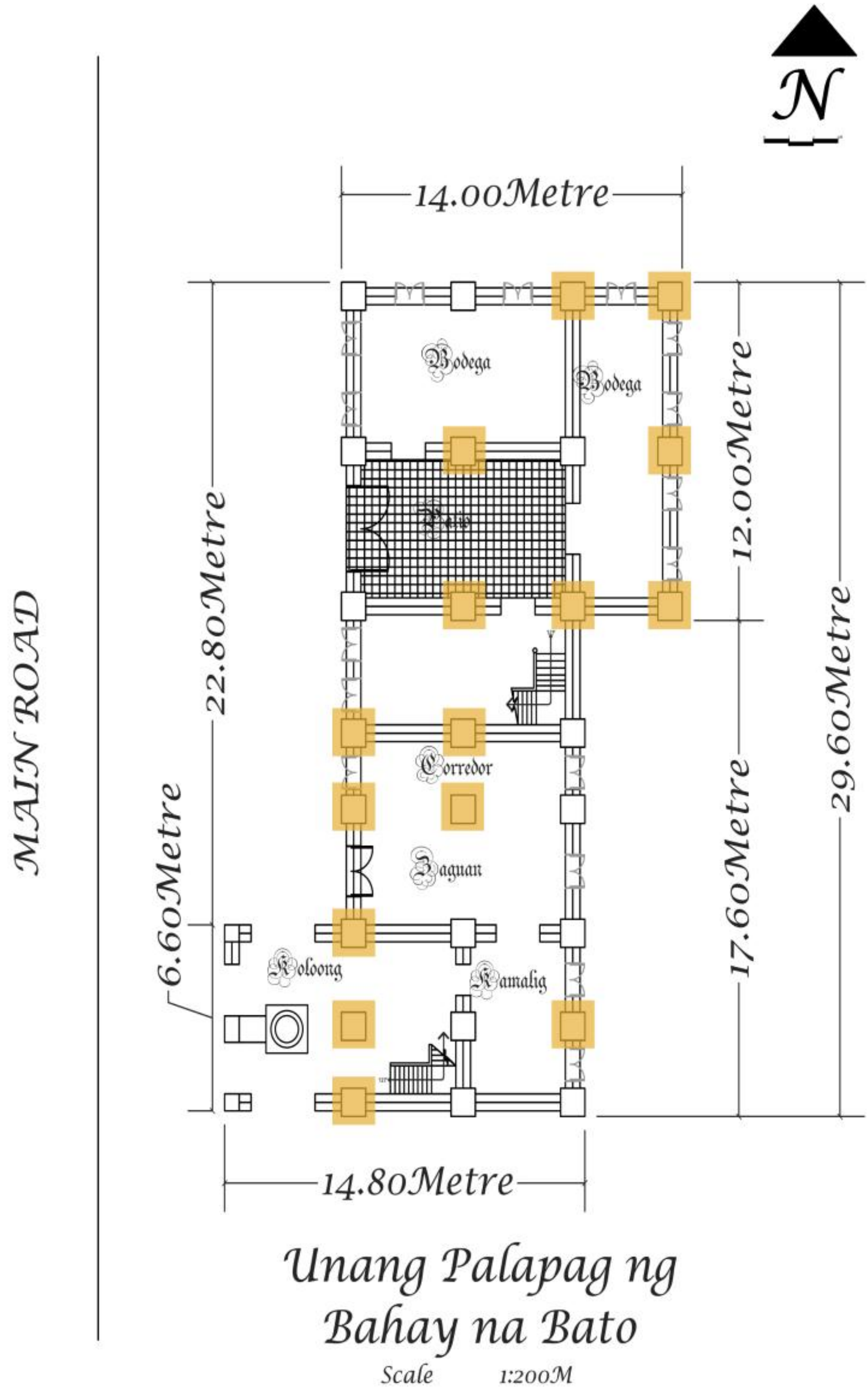

Figure 16: Possible ground floor plan of Structure A. Coloured columns are the columns found still standing in the site (Illustration by Angelus Sales).

As previously mentioned, the columns were made of rough-hewn stones that were bound by lime mortar and enclosed by adobe blocks (Figure 17). The stones were probably enclosed by adobe blocks on all its four sides (Figure 18). The adobe blocks were laid out first acting like the formworks for the stone columns. Once the adobe blocks have been laid, the lime mortar mixture together with the rough-hewn stones can be poured into the enclosure.

Figure 17: An isometric view of how the columns were possibly constructed (Illustration by Angelus Sales).

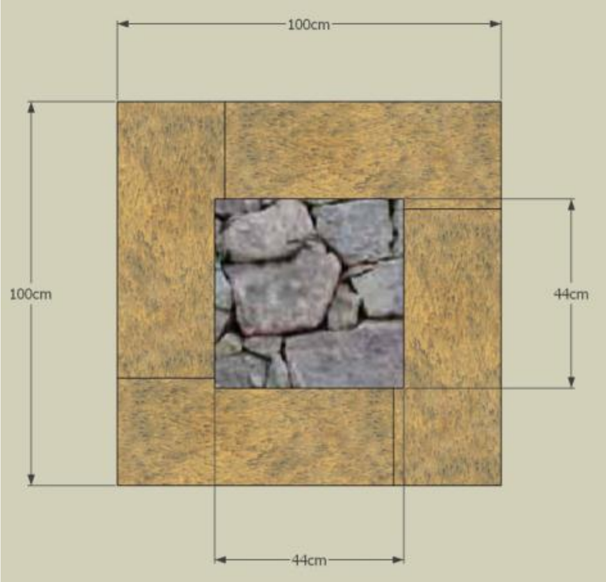

Figure 18: Plan view of the stone columns enclosed by adobe blocks (Illustration by Angelus Sales).

Wall System

The exterior and interior partition walls were constructed using adobe blocks that were laid out in a side by side fashion forming a double wall which makes the walls very thick (Figures 19 and 20). In between the adobe blocks were the lime mortar binding the blocks together. No metal reinforcements were used since the practice of putting reinforcements in walls was not yet known to every master builder. Common bond was used as a method for laying the adobe blocks. Common bond or also known as stretcher bond is the typical method of brick laying. With this method, the blocks are laid on its bed showing the stretcher face or sides of the block. Bed is the term used to refer to the top and bottom surfaces of a brick or block (Fleming 2005). The mouldings that were used for decorative purposes were made with the use of formworks from which the lime mortar mixture was poured unto.

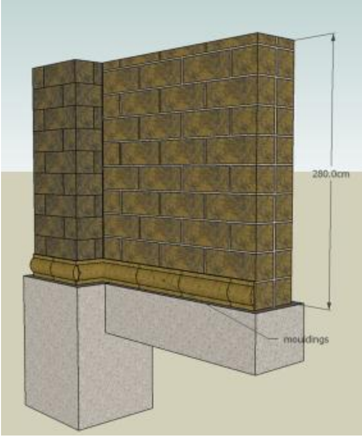

Figure 19: A 3d modelling of how the exterior wall may have been constructed (Illustration by Angelus Sales).

The mouldings must have been built on the construction site itself. The double wall system is the preferred construction method of the Consultative Council of Public Works which issued the Earthquake Ordinance of 1880 (Zialcita and Tinio 2002) Arches were also used for the doorways of the ground floor area. Arches are curved structures used primarily for wall openings. The use of arches in Structure A is indicated by the excavated debris of fallen arches. Voussoirs were found in Trenches 3 and 5 (Figures 21 and 22) while a keystone was found in the trench extension of Trench 7. Voussoirs are the wedge-shaped portion that comprises an arch while a keystone is a type of voussoirs that is found in the middle of the arch. Adobe blocks were worked by stone masons to form pieces of the arches.

Figure 20: Actual photo of the northern exterior wall found in Trench 10 (Photo by Angelus Sales).

Figure 21: Arch debris found in Trench 5 excavated during the 2010 excavation (Photo by Noel Amano and Kate Lim).

Figure 22: Arch debris found in Trench 3 excavated during the 2009 excavation (Photo by Archie Tesoro).

For the second floor of Structure A, the exterior and interior wall partitions made use of a stud wall for its construction (Figure 23). A stud wall is a wall or partition framed using a series of slender, vertical members usually made of wood or steel and faced with sidings, wallboards, or plasterwork. The slender vertical members are called studs (Ching 1995). For Structure A, wooden studs were used and wooden planks became sidings for the wall surface. This inference is based on archival research of different typology of *bahay na bato* structures during the 19th century since no archaeological evidence were recovered from the site.

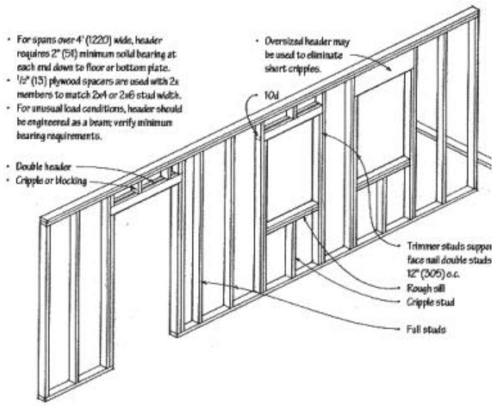

Figure 23: An illustration of what a stud wall looks like (Source: Building Construction Illustrated, 4th edition. This material is reproduced with permission of John Wiley and Sons, Inc.).

Floor and Roof Framing System

As mentioned before, the second of floor of the *bahay na bato* is no longer existing hence, all the given data are based on ethnographical accounts from the locals and from archival research. The floor framing system used for Structure A was composed of wooden floor joists and beams (Figures 24 and 25). Wooden planks were also used as floor boards which may have been an inch thick while the timber used as floor joists may have been two to three inches thick. These measurements are derived from the recovered square nails that were used to fasten the floor boards and floor joists together. Floor joists are the horizontal members on which the flooring material is fastened unto. They carry the dead weight of the floor as well as the weight of the occupants and distribute it to the beams. The beams in turn distribute the load to the columns and the columns to the foundations. In fastening the wooden members, square nails and bolts were used together with different wooden joinery , methods such mortise and tenon joints and lap joints.

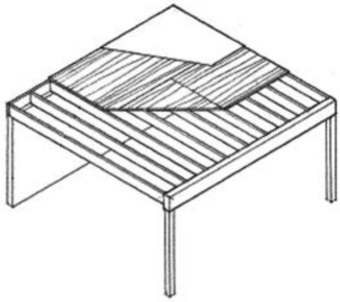

Figure 24: An illustration of a floor framing system consisting of floor joists and floor boards (Source: Building Construction Illustrated, 4th edition. This material is reproduced with permission of John Wiley and Sons, Inc.).

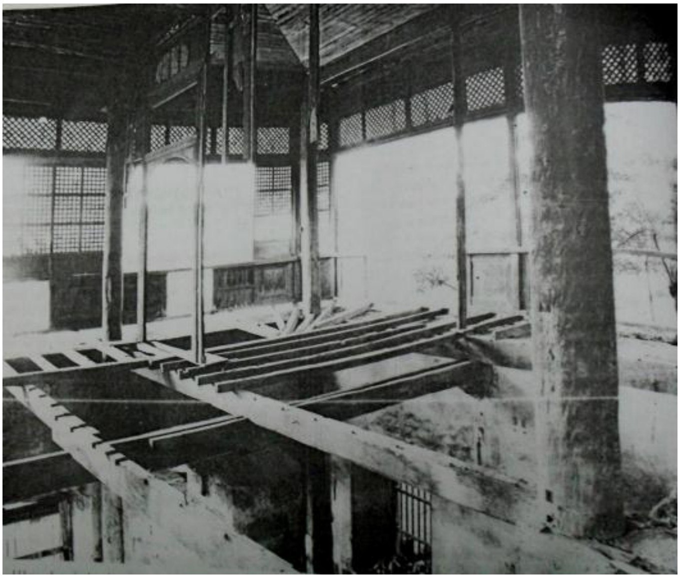

Figure 25: Photo of a framing structure of a bahay na bato in Taal, Batangas. Similar framing system may have been used in Structure A (Source: Philippine Ancestral Houses. Published with permission from Professor Fernando Zialcita).

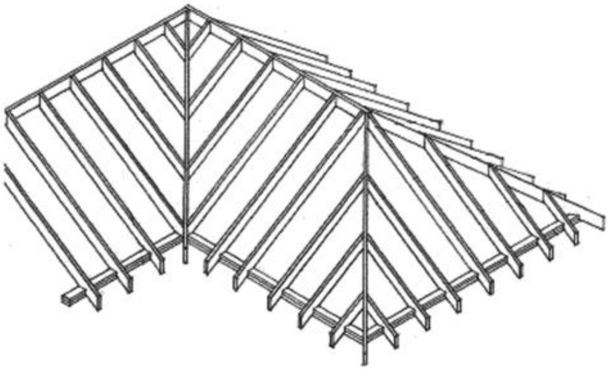

Figure 26: An illustration of a floor framing system consisting of floor joists and floor boards (Source: Building Construction Illustrated, 4th edition. This material is reproduced with permission of John Wiley and Sons, Inc.).

Figure 27: A 3d modelling of Structure A showing the hipped roof (Illustration by Mary Nolyn Ventura).

For the roof of Structure A, a hipped roof construction may have been used as this was the typical roof typology at that time (Figure 26). A hipped roof is a type of roof construction where all its four sides are sloping (Figure 27). It is also known as *quarto aguas* in the local language. This type of roof construction is quite common even today because it is considered as the most stable of roof types and cannot easily be uplifted by strong winds especially if constructed properly. The roofing members must be made of thick lumber to adequately support the heavy clay roof tiles and usually joined together by bolts. Wooden posts connected to the stone columns were used for the upper floor to support the weight of the entire roof structure.

Discussion

Inconsistencies Found in Structure A

During the course of the excavation and the research for this study, there were several inconsistencies that were discovered. One obvious inconsistency is the use of stone columns as the main structural support of the house. If the house was built after the Earthquake Ordinance of 1880, why did it not conform to the protocol of using wooden posts for columns? There were no evidences of postholes large enough to suggest the use of wooden post as the main structural support for the ground floor. The use of stone columns as the main structural support of the house can be attributed to fact that stone after being quarried and worked can instantly be used for building as compared to timber. According to Zialcita and Tinio (2002), timber takes three years to dry after it has been harvested before it could be used by the owner for house building. With the columns numbering to a total of 27, the master builders involved must have seen the economical value of using stones instead of timber. The logistics involved in erecting 27 pieces of good quality lumber which may have been at least 5 metres in length and 10 inches thick is quite troublesome during those times. Also sourcing timber with a length long enough for a two-storey house will also take some time since fully mature trees are needed for this kind of lumber.

Figure 28: Encircled portion in the photo is the crumbling lime mortar foundation (Photo by Angelus Sales).

Another inconsistency in the structure is that some of the foundations were poorly constructed and the materials used were not consistent such as the case of the lime mortar foundation found in Trench 6 (Figure 28) which was crumbly and the use of adobe block in the foundation of Trench 8 (Figure 29). These inconsistencies may be brought about by poor craftsmanship in some of the workers. It is also possible that the workers may have skimped on the lime and added more water than usual which resulted to a brittle lime mortar foundation. The consequence of lessening the lime in a lime mortar mixture is that it lessens the compressive strength of the lime making it susceptible to brittleness and crumbling. The materials may have also run out while construction was on-going resulting to substitution of other materials. Master builders at that time do not have knowledge of standard cost estimating procedures that architects and engineers of today have. They rely on previous experiences to calculate how many materials were needed (Zialcita and Tinio 2002).

Figure 29: Encircled part is the adobe block used for the lime mortar foundation (Photo by Marie Louise Antoinette Sioco)

One more noticeable anomaly in Structure A is the mouldings found in Trench 8. The mouldings in Trench 8 do not look the same. The mouldings that looked different from the rest of the mouldings found in Structure A seemed to have been chipped off (Figure 30) but this hypothesis is still being debated. The people who worked on Trench 8 argued that it may not have been a moulding at all because of the unusual angle of the supposed chipped moulding. But based on ethnographical accounts, there are clear evidences that the mouldings may have just really been chipped off to be used as building blocks for making other structures in town. A case in point is the storage area used for rice milling machines (Figures 31 and 32).

Figure 30: Chipped-off moulding found in Trench 8 (Photo by Marie Louise Antoinette Sioco).

Figure 31: Storage structure for rice milling machine that made use of a moulding (Photo by Angelus Sales).

Figure 32: Close up photo of the chipped moulding used as part of the wall of the storage structure (Photo by Angelus Sales).

Comparison to Other Archaeologically Investigated Spanish Colonial Structures

As mentioned before, Structure A is the first archaeologically investigated bahay na bato structure in the Philippines but there have been other Spanish colonial structures that were archaeologically excavated during the last decade. Churches and fort-like structures have been investigated by other archaeologists from the UP Archaeological Studies Program. These investigations have yielded significant finds that is essential to better understanding the construction methods used in creating these Spanish colonial structures. Based on reports from these archaeological excavations, one of the common denominators is the use of stone as the main construction material. Different stones were used in building churches and other Spanish colonial structures such as the cobble stones in the San Raymundo de Peñaforte Church Complex (Bautista 2005) and the coralline stones that were found during the Bulalacao and Bancuro excavations in Oriental Mindoro (Paz 2004 and 2006). Adobe blocks were also commonly used in church structures such as the ruins of the Old Taal Church (Dizon 2005) and the Second Monastery of San Agustin Church (Archaeological, Cultural, and Environmental Consultancy, Inc. 2005). The use of lime cement as binding agent or mortar for the stones was also another common practice in building construction during Spanish colonial period. The difference between Structure A and the above mentioned Spanish colonial structures may lie in the building construction methods that were used. This may be brought about by the fact that the above given examples were constructed at a much earlier time period than Structure A. The differences in building construction methods used can also be attributed to the master builders who were in-charge of the construction and their skill level and knowledge in stone masonry construction.

One obvious difference is the use of stones piled on top of each other and binded by lime mortar as method used for building the foundation of the above mentioned structures. Formworks were not used not in creating this kind of foundation unlike in Structure A. Another difference in construction method is the use of deeper foundation. A case in point is the excavation of the Second Monastery of San Agustin Church. One of the foundation wall that was excavated may have reached a depth of four metres (Archaeological, Cultural, and Environmental Consultancy, Inc. 2005). In comparison to the earlier Spanish colonial structures, the foundation of Structure A was relatively shallower but still quite deep if compared to modern simple foundations.

Buttresses were also used for the walls of the churches just like in San Agustin Church (Archaeological, Cultural, and Environmental Consultancy, Inc. 2005) and the Simbahang Bato of Bancuro (Paz 2004). Buttresses were often used as support mechanism for structures with massive and heavy walls. Structure A did not use any buttressing technique since the structure is only small compared to the big Spanish colonial churches. One similar building construction method is the use of the post and lintel construction system. The post and lintel construction system is the most basic and simple construction system. It does not require complex technology and highly skilled builders in doing it making it suitable for regions that do not possess the latest technology in building construction just like the Philippines during the Spanish colonial period.

Summary

The choice of construction materials to be used in Spanish colonial structures is highly influenced by the environment on which the structures will be built. The availability of the raw materials to be used for construction is also a crucial factor that determines the kind of construction materials to be used. This was manifested in Structure A when rough-hewn stones and adobe blocks became the preferred construction materials despite the 1880 Earthquake Ordinance that called for the use of lighter materials. Also, according to ethnographical and historical accounts Barangay Pinagbayanan experienced flooding episodes especially since it is situated near a river (Barretto-Tesoro *et al.* 2009). The recurrence of flood could have also influenced the master builders in preferring stone over wooden construction materials in the ground floor area since wood rots easily when constantly exposed to moisture.

The construction method used in building Spanish colonial structures is dependent on the knowledge and skill level and expertise of the master builders and their labourers. The change from wooden construction to stone masonry is a good example. Before Spanish colonisation, wooden construction and its system of construction was the prevalent construction method used in creating structures in the Philippines. When the Spaniards came, they brought with them the knowledge of stone masonry construction and the use of dressed stones and lime cement for mortar (Castro 2005). This is not to say that stones were not used by pre-Spanish Philippine society. Evidences from the Bulalacao excavation have shown that stones were also used for wall construction even before the arrival of Spanish missionaries in the area but without the use of lime mortar as binding agent (Paz 2006). The stones were piled on top of each other without using any mortar to bind the stones together relying solely on gravity and the massiveness of the stones.

In Structure A, it was evident, based on the archaeological evidences, that skilled masons were used in building the structure though the possibility of also having labourers with poor craftsmanship should not be discounted also. The presence of tool marks in some of the adobe blocks and the creation of the decorative mouldings suggest that the stone masons employed had adequate knowledge of stone masonry construction.

Recommendations

With the construction materials and methods used in Structure A initially analysed, the next step should be how the structure changed over time after the occupants moved out of the house and the influence of the change in the original function and occupants of the house had on structure. Were there renovations done to the house when it was turned into a school during the early part of the 20th century? If yes, did the builders made use of the same materials? A look into the changes done to the structure would provide great insights on the transitions of the construction materials and methods used during the Spanish period to American period and eventually to modern times and the factors that come into play to influence such change.

This initial study could also be a stepping stone to a broader investigation of other surrounding structures in the area. With the presence of other stone ruins in the area such as the supposed Lumang Simbahan (Old Church) and Structure B, a general pattern of the building construction technology present in the area during the Spanish period could be made if the same type of study will be done to the rest of the structure. It is therefore essential that future researchers should have basic knowledge of building construction to correctly interpret any discoveries that will be made.

Finally, this researcher realised the need for archaeology to have basic knowledge of the terms used in architecture and building construction if the archaeological site to be investigated is a built environment. This will facilitate uniformity in the site reports and also avoid ambiguous descriptive terms that may lead to confusion if those reading have a background in architecture. The same goes for making illustrations. Archaeology can also borrow drawing conventions from architecture and engineering to illustrate structures. Also, it is also important that actual measurements be taken and not just relative measurements when taking elevation or depth measurements. Readers who do not have a background in archaeology might not understand what datum points are and may mistake the elevation figures as actual height measurements. If possible a floor plan or site plan of the area being investigated should be made before excavation ends as well as elevation and section drawings to better visualise the structure being investigated.

The researcher fully understand the reasons behind such inadequacies but an understanding of architectural and engineering principles or even just its history is essential to archaeology if the built environment will be the focus of the study. It is just similar to having knowledge of biology and botany for zooarchaeology or archaeobotany. Having said that, archaeology also plays an important role in helping to uncover the architectural past of our country. They provide the initial step to recovering architectural gems and treasures that may otherwise be forever lost in time since most practicing architects do not focus much on architectural history. The investigation of Structure A and other Spanish colonial structures is a great venue for the synthesis of archaeology and architecture that hopefully will be a trend in archaeology.

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