

## Timber Structure in the Mission Churches of Chiquitos (Bolivia): Origins, Evolution and Restoration

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**Abstract** A group of churches of the 18th century in the Lowlands of Bolivia and Paraguay are characterized by a very special timber skeleton frame structure. Most of these churches belong to the famous former Jesuit missions of Guaraní, Chiquitos and Mojos, in densely wooded regions at the edge of the Spanish colonial empire. The best preserved and most important of these buildings are the six churches of Chiquitos in Eastern Bolivia, declared World Heritage sites by the UNESCO. In these villages and small towns, many traditions of colonial time have survived. The old churches are still the spiritual centers for the Chiquitanos, the Christian Native Americans of the region. The typical plan of these churches is a rectangular interior space with three naves, adobe walls, entrance hall, lateral corridors and a huge and long gable roof. The timber structures of these buildings are very simple, with free standing carved wooden columns that are anchored in the ground, using a pre-Columbian indigenous technique. It is combined with the European ways of constructing roof structures and timber joints and with baroque stylistic influences from Spain and central Europe. Since nearly 40 years, these churches have been the object of a long-lasting restoration project that saved them all, using very different restoration methods and standards.

**Keywords:** Timber skeleton structures; wide span roofing; traditional timber joint details; religious architecture of the eighteenth century in Bolivia; timber church restoration.

### Introduction

The churches of the Jesuit missions of Chiquitos, declared World Heritage Site by the UNESCO, were built at the middle of the eighteenth century in the '*reductions*' or indigenous settlements founded by Jesuit missionaries in rainforests of central South America, at today's Eastern Bolivia. The objective of the Jesuits was to Christianize natives and establish sovereignty of the Spanish Crown over the frontier area adjacent with Portuguese territory.

The first Jesuit missionary experiments similar to Chiquitos were realized in Paraguay at the early seventeenth century. With a very pragmatic strategy, the Jesuits reflected how to attract the natives to the reductions, they considered the geographical conditions of the sites designated for a new settlements, and adapted traditional techniques and materials for the construction of the church and housings. Learning from past mistakes and obstacles they developed and perfected a singular system of urban and architectural order. Every reduction was clearly divided into two parts or sectors, arranged around a large public square where the religious festivities were celebrated. The first part was the walled religious complex composed by the church, the missionary's residence, the workshops, the cemetery with the mortuary chapel and the gardens. The second part consisted of the houses of the natives, long parallel buildings separated by streets and divided into cells for each family.

Six churches of the former ten reductions of Chiquitos still survive. Five churches have a similar configuration with a rectangular interior space subdivided into three naves by two rows of carved timber columns. The roof is a long, simple gable roof with visible structure from inside the church. Two rows of timber columns are embedded in the adobe walls, and two other rows form porticos at

both sides of the church. The entrance is protected by a hall or portico that consists of an extension of the timber structure of the church (Fig. 1).



Figure 1: Church of San Javier, Chiquitos, Bolivia, in 1957 (© SJ-Bild/Plattner.)

## Origins

The building of a primitive, provisional church in a newly founded reduction followed the construction techniques of the natives, based on a framework of posts, rafters and beams as main structure, walls of bahareque (a kind of cane work covered with mud), and a roof covered with grass or palm-fronds. These techniques were used by many pre-Columbian indigenous cultures to build their large community dwellings.

Before the arrival of Jesuits in the Chiquitos region, the semi-sedentary or sedentary groups had different types of housing. In general, larger buildings were used by the chief or the community. The floor plans could be round, elliptical, oblong or rectangular, the roofs single-pitched, gabled or hipped, arched or domed. A main structure of wooden posts anchored in the ground supported the ridge and principal rafters. The roof was made of grass or palm leaves; in some cases it reached down to the ground in all directions. There was only a small entrance. The interior was an open, dark space, without separating walls, divided only by posts.

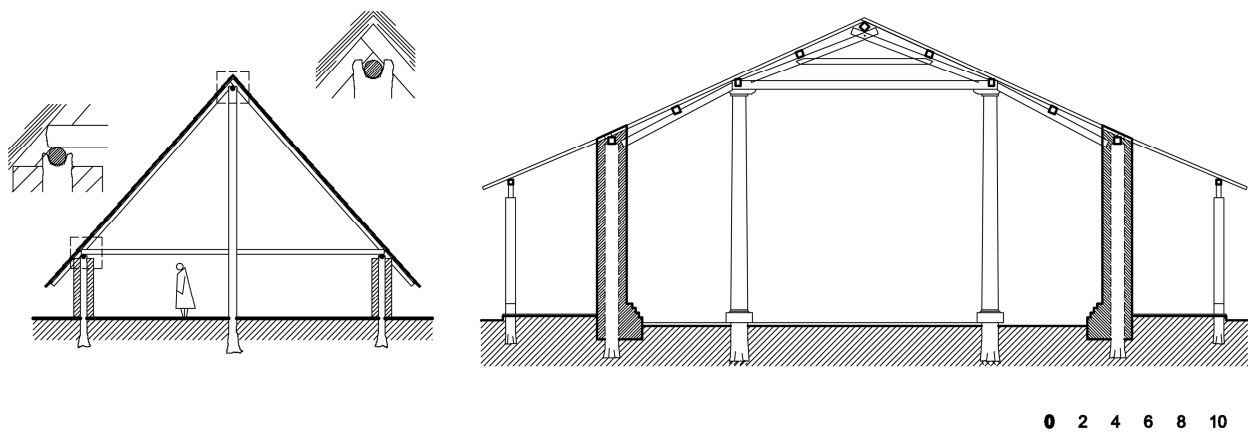
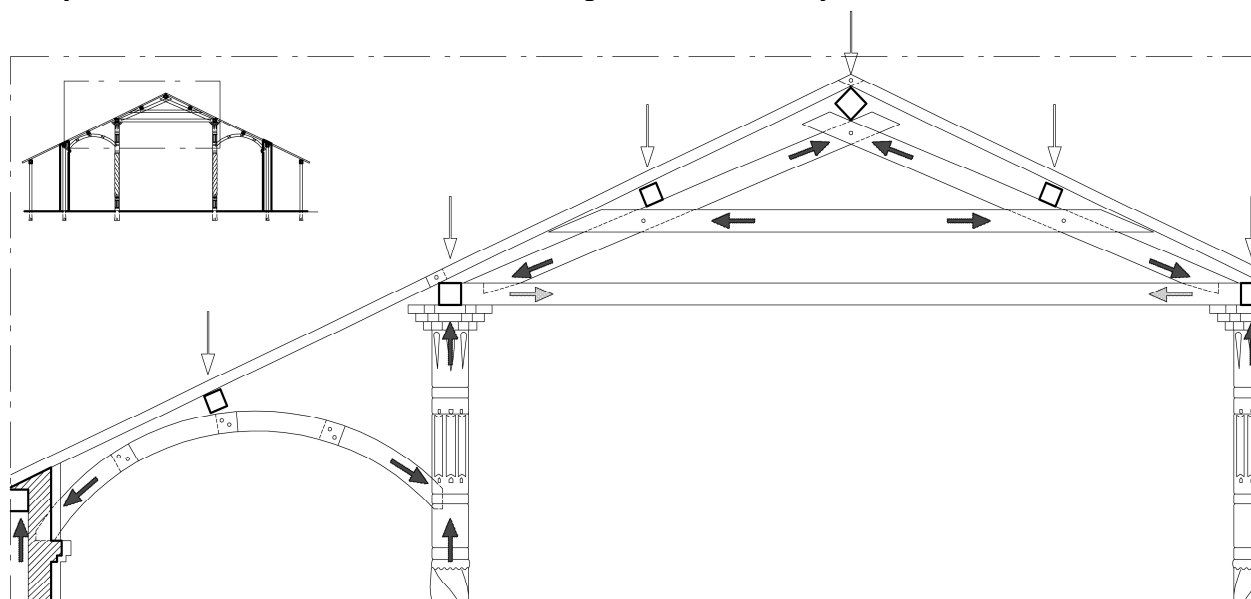


Figure 2(a): Cross section of primitive church (b): Typical Chiquitos missionary church (Rodríguez, 2009)

The Jesuits used similar constructions to build the first churches (Fig. 2a). Thus, the natives, who knew well to work with wood, were responsible to erect these primitive churches, a situation that

helped to the Jesuits to introduce a deep cultural change. Adapting elements of the traditional culture was a way of persuasion the native, so that they remained in the reductions and did not return to the forest. The temporary huts were modified progressively according to the human and technical skill available in the consolidating village. The new church was larger than the first one and had a skeleton timber structure with trusses and wood joints according to European models; the construction was improved with the introduction of burned tiles and non-supporting adobe walls that were erected after the roof (Fig. 2b). The rich decoration was in baroque style.

But still, all wooden columns or embedded posts were anchored to the ground, according to the indigenous legacy. A similar mixed technology with anchored timber frames and non-supporting adobe walls was used since the 17th century in the churches of the Paraguay missions and since early 18th century in Mojos (Northern Bolivian Lowlands). In whole Europe, this technique had been rejected in all timber buildings since the 11<sup>th</sup> century, due to the danger that the wooden columns putrefy at floor level, so that the whole building loses its stability.



*Figure 3: Detail of roof truss with member stress. Compressive stress (dark arrow); bending stress (light arrow) (Rodríguez, 2009)*

The central truss has two rafters that form together with a collar beam and a tie beam a triangulated, not deformable structure. This kind of truss stands in a Roman tradition, is common in little medieval churches in Spain and was also used the missions of Paraguay. The upper part of the column is connected by a wooden pin with the capital, the lengthwise beam and the truss. There are pegged mortises and tenon joints. The roof structure has lengthwise beams above the columns and a ridge beam above the central trusses. In the lateral aisle, arched braces or rafters support additional lengthwise beams. The roof structure is completed by inclined purlins placed without joints above the lengthwise beams (Fig. 3).

The carpentry structure follows clear rules of proportions that use geometry guides based on anthropomorphic measures to define in a bay system the wide and height of the structure.

### **Architectural Details and Their Evolution**

All Chiquitos churches have a similar architectural plan with a rectangular interior space subdivided by rows of timber columns in a central nave and two aisles (Fig. 4). Two external rows of columns form lateral corridors. The entrance hall portico is protected by a roof that is an extension of the interior timber structure. These porticoes help to protect the walls from water in raining season. The adobe walls had no structural function and embedded two rows of columns of the timber skeleton structure.

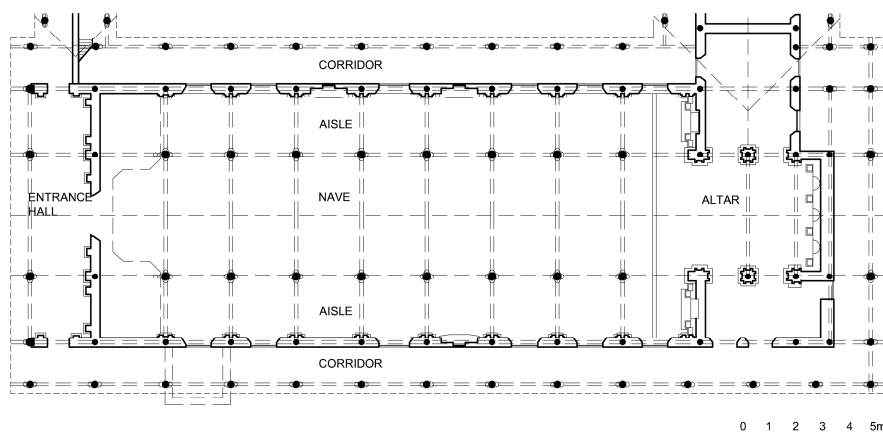


Figure 4: Typical plan of Chiquitos Church (Rodríguez, 2009)

The longitudinal axis connects the main entrance to the altar. The internal length of the six Chiquitos churches is between 50 m. and 62 m., with a transverse distance between the central posts of 7,70 m. to 10,30 m. The aisles are 4,00 m. to 5,15 m. wide from the post center to the inside of the exterior wall, giving a total internal width between 15,70 m. to 20,60 m.

*Martin Schmid*, the most outstanding missionary, musician and architect of Chiquitos, projected and built the three excellent churches of *San Rafael* from 1745 to 1749, *San Javier* from 1749 to 1752 and *Concepción* from 1752 to 1755. He obtained singular details with the described construction technology. Slender twisted columns, painting murals on the main facade as well as in the interior walls, flower-like rose windows over the main doorway, wood baroque altarpieces and a great precision of proportions, proved in the measurements previous to restorations works.

The church of *San Miguel*, built around 1749 to 1756 and the church of *San José*, build by stages from 1725 on, were projected by unknown architects. The San José church is slightly different, has a stone and brick front as well as a brick arcade on the courtyard side. The last one, *Santa Ana* church, was built after 1772; it is smaller and has a balcony in the entrance hall.

## The Restorations

The first serious restoration project for the mission churches of Chiquitos was presented in 1971 by the German architects Georg and Ingrid Küttinger of the Munich University, on the initiative of Felix Plattner, Swiss Jesuit and biographer of Martin Schmid. In the following year, Plattner sent the Swiss architect *Hans Roth* (1934-1999) for half a year to Bolivia, to save the San Rafael church, following Küttingers proposal. But the planned short intervention resulted to be more complicated and took much longer. Finally, Roth stayed for over 27 years in Bolivia, restoring all six mission churches of Chiquitos and the only preserved one in Moxos (San Ignacio), beside the construction of a big number of new buildings, such as churches, chapels, convents, schools, hospitals and low cost housing, most of them with timber structures related to the local missionary building tradition.

In the *San Rafael* church, the whole wooden structure was dismantled and reconstructed in 1972-1979, exchanging many columns and wooden beams. Following Küttingers proposal, the bases of the huge wooden columns were cut off and replaced by a reinforced concrete foundation, connected to the columns by visible, screwed flat steel bars, restoring by this means the lost rigid restraint of the columns (Fig. 5). Additionally, parts of the roof construction were locked with nails or stud-bolts, changing in this way the basic structural system of the building. The restoration was realized in a totally underdeveloped village, with very modest resources and extremely low technical equipment, by a young and enthusiastic architect without knowledge of modern restoration standards, and without any assistance or control by cultural assets institutions. These may be the reasons for some unsatisfying results, like the total repainting of the murals and a certain lack of authenticity of the restored building.

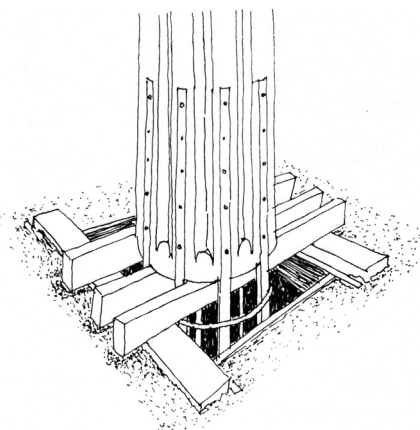


Figure 5: *San Rafael, new anchoring of wooden column. (Roth, 1995)*

The same proceeding was used in the two following restorations in *Concepción* (1975-1982) and *San Miguel* (1979-1983). The positive experience of the strong social impact of the first restoration led to pioneer projects focused on the apprenticeship of qualified local craftsmen by the means of the restoration of historic buildings. But the higher resources and better equipments were disastrous for the cultural value of the monuments, especially in *Concepción*, where the German bishop wished to flaunt with a magnificent, totally renewed cathedral. All wooden columns were replaced by approximate copies, and the whole timber structure was changed. To stabilize the roof, its sheathing of cane was replaced by wooden boards, covered by lime mortar instead of mud to place the roofing tiles. This change had fatal results: after 30 years, most of the cedar boards are rotten due to condensation and the lack of ventilation, whereas the cane sheathing had lasted for more than a century.

These splendid renovations were praised by many people, especially by the local churchgoers, but they also evoked heavy critics from professional architects and art historians. Hans Roth reacted to these critics with the restoration of Martin Schmid's church of *San Javier* (1987-1993). For first time, it was based on a detailed survey, extensive measurements, archeological and historic investigations. The Swiss Jesuit carpenter Joseph Herzog invented a better adapted construction procedure with a respectful treatment of the original building fabric. There was no total dismantling like in the previous sites, but the columns were replaced or adapted under the roof maintained in place. Many old columns and beams were kept in situ, and if necessary adapted to the renewed construction. Instead of the visible flat steel bars, the anchoring of the columns in the reinforced concrete foundations was now made with four to six corrugated 3/4 inch armoring irons, two meters long, of which 80 cm were lubricated and driven into tight pre-drilled holes (Fig. 6). Afterwards, the column with the irons was placed and fixed in final position over the foundation pit, and the concrete was filled in.



Figure 6: *Santa Ana, new anchoring of wooden column. (Photo Hans Roth)*

Similar rehabilitation systems were used in tree later restorations that were initiated by Hans Roth, but lasted until after his death. The work in *San José de Chiquitos* started in 1988, was interrupted several times for political reasons and couldn't be finished until 2010. *San Ignacio de Moxos* was a big but very simple building in poor condition that required to be partly reconstructed in 1995-2003. Finally, the small and charming church of *Santa Ana* that was built after the Jesuits had left the country in 1767 was restored in 1997-2001. Here, the lone warrior Hans Roth had to adapt himself to a whole crew of professionals that introduced new methods and standards.

The restoration of the missionary churches of Chiquitos is a success story. It began as a project implanted from Europe, with rough and since long obsolete restoration methods, without any collaboration from Bolivian professionals or institutions - they didn't even notice what was going on. At this time and in this place it was probably the only possible way to save these extraordinary buildings from imminent destruction. In 1990, the Chiquitos churches began to receive broader attention, as they were included in the UNESCO List of the Cultural Heritage of the World. Nearly forty years after the beginning of the story, the restorations are still going on. Now they are integrated with the local development plans and formation programs, they have all-Bolivian staff and direction, and they are using standards and methods that bear any comparison with modern restoration works in other parts of the world.

## References

- [1] Kühne, E (2008). "*Die Missionskirchen von Chiquitos im Tiefland von Bolivien: Bau und Restaurierung der Kirchen von Martin Schmid (1694-1772)*." Doctoral thesis, ETH Zürich.
- [2] Querejazu, P Ed. (1995). "*Las Misiones Jesuíticas de Chiquitos*." La Paz, Bolivia: Fundación BHN.
- [3] Rodríguez, V (2010). "*Arquitectura de madera en las Misiones Jesuíticas de Chiquitos (Bolivia) del siglo XVIII y sus orígenes prehispánicos y europeos*." Doctoral thesis, UPC Barcelona.
- [4] Roth, H (1995). "Urbanismo y arquitectura en Chiquitos desde los testimonios materiales," in Querejazu, P Ed., "*Las Misiones Jesuíticas de Chiquitos*," La Paz, Bolivia: Fundación BHN, 462-526.