

# Mexican conventual churches from the 16<sup>th</sup> century: some basis of design

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## Abstract

The extensive construction work performed by the Franciscans, Dominicans and Augustinians in the sixteenth century in Mexico comprises small and large masonry religious buildings of great architectural significance. This paper studies the constructive and structural characteristics of the “visiting” chapels and conventual churches. These buildings, erected by the first three mendicant orders to arrive in Mexico, are the oldest pieces of work created after the first contact between America and Europe. The main objective of this work is to identify the origin of the outline of their roofing systems, and classify and study them from the historic and structural points of view, along with their walls and buttresses. The document shows a detailed study of one building that represents each one of the types of typical roofs of the sixteenth century in Mexico, based on the review of rules of construction contained in treatises of the time, and their possible application in Mexican religious buildings. Based on this review, it was possible to see that in certain cases there is a great similarity between the geometric characteristics of their structural elements with the rules of these treatises, that might have served their builders to guarantee the stability of their buildings. Results are given for two conventual temples and one chapel, where it was possible to find this similarity and know the basics of the design of buttresses, which will be useful for future structural and constructive studies.

*Keywords: construction treatises, geometric rules of construction, Mexican religious buildings, masonry construction, Mexican viceroyalty vaults.*

## 1 Introduction

After the arrival of the Spanish in what later would be called the New Spain, the evangelization process started with the arrival of Franciscans, Dominicans and



Augustinians. These religious orders have been identified as the leaders of communities, convent builders, and educators of indigenous peoples during the sixteenth century [1]; both their schools and their missions formed the basis of neo Hispanic culture. Their first religious buildings were made of perishable materials and later masonry was the most common building material. This is how the extensive construction work carried out by the three mendicant orders during the sixteenth century started, creating hundreds of buildings that have remained to this day, whose spaces and functions explain many social phenomena, particularly those related to the evangelization of New Spain [2]. In these spaces, they created constructive shapes that were unknown in the pre-Hispanic period, such as arches and vaults. The latter are typical vaults covering the XVI century convent temples, in particular the barrel vaults [1]. Ribbed vaults were used as well, but in much smaller numbers. Sometimes the temples are totally covered with ribbed vaults, others only the presbytery or the sacristy. The main purpose of this paper is to identify the origin of the outline of the support of these masonry vaults, both in large temples and in small “visiting” chapels, to classify and study them from the structural point of view, as well as their systems of walls and buttresses.

## 2 Conventual temples and “visiting chapels”

For the expansion of the evangelizing work, the Spanish took advantage of the local government organization of the pre-Hispanic villages, with main villages and smaller ones that were subject to these [3]. When it suited the interests of the Europeans, the population of certain main indigenous villages was relocated [4], to form new villages where large monasteries were founded. The populations of many other smaller villages were also relocated, and in those a chapel with its sacristy would be built. These were called “visiting chapels”, since the friars would not live there permanently, but would come sporadically to visit the community and administer the sacraments. The religious buildings constructed in the towns of the New Spain constitute a new architecture from the miscegenation of the Spanish and Indo-American contributions, which resulted in open architecture consisting of “open chapels”, atriums and squares, which Artigas [5] identifies as “Mexico’s great contribution to the general history of architecture”. The atriums were large and contained a church and a convent; these were the only fully roofed and closed buildings. Smaller sized atriums are the “visiting chapels”, only with a sacristy to the side. The typical orientation of those chapels and temple convents is east west, with the altar towards the east.

In the hundreds of monastic buildings from that era that still remain diverse materials and shapes were used, but they have similar characteristics, especially in the central region of Mexico. In addition, many of them remain in similar conditions to the original ones [6]. This allows for them to be considered them as representative sample of the building practices of that time in that region; which can help us to know how they were originally conceived and what was the basis of the design of their structural elements in order to support the actions they endured for more than four centuries.



## 2.1 Construction and structural characteristics

The masonry used in these buildings is formed by a conglomerate of stones of the region and lime-sand mortars. Sandoval [7] states that these mortars could contain volcanic sand (*tezontle* stone) as well, and cactus (prickly pear) slobber, with what a quality mortar was obtained. According to Meli and Sanchez [8], in the first vaults constructed in the 16th century in the Mexican altiplano (high plains), the foundations and buttresses are built from a type of masonry that is more heterogeneous and lighter than the one that was typically used in historical buildings in other countries. According to these authors, this material has a higher tensile strength than brick masonry, mainly due to the absence of well-defined mortar joints, which are the weakest planes of the masonry. The type of stone used depended on the availability and ease of work; for example, in central Mexico the use of volcanic stones known as *chiluca*, *tezontle* and stone brace was very common [9]. *Tzales* stones in Yucatan, similar to the flagstones [10] or *muca* stone (coral) in Veracruz, obtained from nearby reefs, were used in the monastic buildings. In locations where these resources were limited, they built with the river stone or adobe that was found nearby.

Both the temples and chapels studied in this work are characterized by their simplicity and austerity; with a single nave, with the high choir to the entrance and east-west orientation, and the presbytery to the east. These buildings are constructed with masonry walls and buttresses supporting a vault that covers the entire nave. Kubler [1] mentions that the typical vault of the conventual temples of that time was that of continuous barrel vaults, of which there are still hundreds of examples. Although in much smaller numbers than the barrel vault, ribbed vaults were also used, some of which cover the entire nave of temples, and others only the presbytery or the *sotocoro* (the space directly beneath the choir loft). There are cases where these buildings originally had a wooden roof that covered them completely, which was later changed to a vault. This happened both in the great temples as in visiting chapels. When this change occurred after the sixteenth century, the vaults were replaced by vaults with lunettes, which were not as thick as barrel vaults or ribbed vaults. Such is the case of the temples of Santiago Apóstol in Ocuituco and San Juan Bautista in Tetela del Volcán, Morelos; originally, both had a wooden roof which was later changed into a lunette vault.

The elements that balance the thrust generated by the weight of vaults are longitudinal walls and buttresses. These are voluminous and have different dimensions according to the span of the vault and the period in which they were built. The determination of the geometry of these elements to support barrel vaults and rib vaults has been studied by the author of this paper [6, 11]. These studies have been based on construction treatises of the time, which are briefly discussed in the next section.

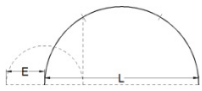


### 3 Ancient construction treatises: structural rules

Huerta [12], Sanabria *et al.* [13], Palacios [14] and Navarro [15], among others, have conducted extensive studies of the rules included in ancient architectural treatises to define the proportion, dimensions and outline of the structural elements of vaulted masonry buildings. These studies have brought us over to the methods that the builders of the first conventual Mexican temples could have applied in order to determine their dimensions and geometry. Although relevant treatises, such as Rodrigo Gil de Hontañón's, which was only known in 1868 [16], were not known in Mexico during the 16th century, their content was certainly a part of the building practices of the time in Spain. That is to say, those who built Mexican monasteries must have applied their traditional methods to build vaulted structures in the same manner as they did in their home country. They added the pre-Hispanic practices to this knowledge, whose main feature was the ability to build large masonry structures; the pre-Hispanic builders knew the use of post and lintel, and they were skilled in carving stone with no metallic tools.

Huerta [12] has tested the application of such traditional rules in order to know the depth of buttresses on European buildings, emphasizing that while it is not possible to confirm they were used in these buildings, they do show their character and time of construction. In this context, the possibility of the use of those rules in conventual Mexican temples in order to determine the dimensions of buttresses has been reviewed. This paper presents the rules that are more similar to two conventual temples and one visiting chapel, authored by writers Martínez de Aranda, Palladio and Fray Lorenzo de San Nicolás (Table 1).

Table 1: Rules for determining buttresses depth.

Rule		$E = L/3$
Author	Martínez de Aranda	Palladio and Fray Lorenzo de San Nicolás
E = Depth stone buttress, L = Span of the nave.		

### 4 Possible origin of the trace of buttresses

Based on the study of the geometry of multiple conventual temples and visiting chapels, this paper shows some buildings whose structural elements are very close to certain rules to establish the dimensions of the buttresses supporting barrel vaults and rib vaults. This document presents three of those cases; one of them is a small visiting chapel and the other two are temples located in two large convent complexes. The following briefly describes each of these buildings, as well as the data and results found.

#### 4.1 San Pablo visiting chapel

San Pablo chapel is located in the historic center of the city of Cuernavaca, in the state of Morelos, Mexico. The Franciscans built it in the 16th century. Gutiérrez [16] notes that the neighborhood in which this building is located is one of the most ancient of the city, as it is known that it exists since the pre-Hispanic period in the ancient Cuauhnahuac. The chapel is built as a single nave made up of masonry walls and buttresses supported by a semicircular barrel vault. Its orientation is east west, with the presbytery to the east and the high choir at the feet of the nave, which is supported by a segmental vault. The interior of the chapel is not original; it has been altered with decorative elements that were added in later centuries. The facade shows us the simplicity of the first constructions made by the Franciscans in Mexico (figure 1), it practically has no decorations, except for the entrance door and the window of the choir; it is crowned with a small belfry over the top of the cover, which follows the geometry of the barrel vault of the nave. After comparing the geometry of the buttresses and walls of the chapel with the rules of the construction treatises of the time, it was found that the most conservative rules, such as those described by Rodrigo Gil de Hontañón, produce dimensions much larger than the actual. This does not happen with the rules in the Martínez de Aranda treatise, which Huerta [12] comments belong to the late Gothic period. Figure 1 shows the closeness of this rule with the depth of the buttress of Capilla de San Pablo, by means of a cross section of the nave.

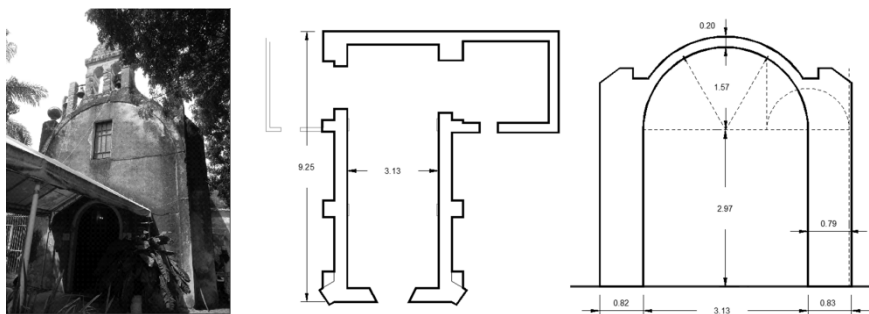


Figure 1: Capilla de San Pablo. Façade, floor plan and cross section of the nave (dimensions in meters).

#### 4.2 Templo de Santo Domingo de Guzmán in Tlaquiltenango

According to Kubler [1], the building of this convent was finished between 1540 and 1550. Initially it belonged to the Franciscan order and later it was assigned to the Dominicans, who occupied it from 1574. The Franciscans returned in 1586, but only temporarily. Figure 2 shows a diagram of the floor plan of the former convent of Santo Domingo, including the atrium. Unlike most Mexican convent facilities, the atrium is not to the front, but to a side, to the south of the temple, similar to the atrium of the former Franciscan convent in Cuernavaca, with a small courtyard to the front.

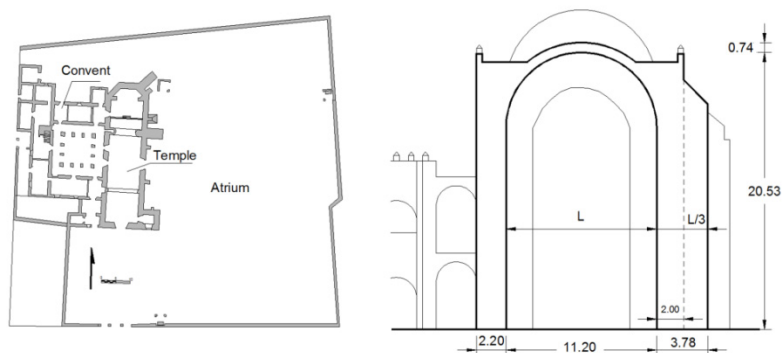


Figure 2: Ex convent of Santo Domingo in Tlaquiltenango, Morelos. Architectural floor and cross-section of the nave (dimensions in meters).

It is a single nave church, covered by a barrel vault; the presbytery (rectory) has a hemispheric cap, as a dome with no drum, higher than the roofing of the nave. These two spaces are separated by a large hollow toral arch. The longitudinal walls are about two meters thick, and reinforced by buttresses. In the latter several construction stages can be noticed; original buttresses are placed at regular intervals and are smaller than the ones that were added later, which are extremely voluminous; one of them is a flying buttress and it was placed to reinforce the presbytery. Kubler [1] comments that the period in which this campaign of structural consolidation took place is not known. What we can conclude is that the presence of these shows the serious problems of stability that the temple had at a certain point in its history. It is known that in the first decades of the 19th century the nave was cracking along its length, and the problem became worse later with the telluric movements happened in the 20<sup>th</sup> century. Several decades ago, high-impact interventions were made in the building, using corrugated steel and concrete reinforcing.

In attempting to apply the geometric rules of ancient treatises of construction in the temple of Santo Domingo, the same results were obtained as for most of the temples with similar characteristics located in the State of Morelos; that is to say, monastic churches with barrel vaults without transversal arches and the height-opening ratio of the nave higher than 1.5. The most approximate rule is the one contained in the treatises of Palladio and Fray Lorenzo de San Nicolás, which consists of assigning one-third of the width of the nave to the buttress (figure 2).

The convent has a small two level cloister. It is located to the north of the temple, a rare feature in these complexes. Since this happens in certain convents in hot areas of the country, some authors have supposed that climate is an important factor that influenced the change of the typical orientation of the convent to the south of the temple, in order to avoid direct sunlight.

### 4.3 Temple of the ex-convent of Santo Domingo in Oaxtepec

The first Dominican settlement in the State of Morelos was established in Oaxtepec in 1528. The construction of the convent complex occurred throughout the 1530s on a platform that is more than three meters higher than the level of the street at the front ; the back and the sides are level with the street because the topography rises there. The convent is located to the south of the temple and has a cloister of two levels with buttresses, whose arcades are covered with carved stone. The floor plan of the temple has the shape of a Latin cross, but Artigas [5] refers that it is a church with a single nave and small choirs to the sides. Its orientation is east west, with the presbytery to the east and a high choir at the entrance of the nave, which is entirely covered with ribbed vaults. According to Kubler [1], its roof was built after 1561. It is supported by masonry walls and buttresses around its perimeter. In the interior of the church there are small depth arcades in the lateral walls. The facade has buttresses at the ends, inclined with respect to its plane and topped by bell towers; the simplicity and austerity of the front suggest the possibility that it was never concluded. The interior of the presbytery has a trapezoidal shape and the outer shape is rectangular. Its walls have no windows; these are only found in the longitudinal walls, located above the impost. The windows on the south wall overlooking the convent are walled; this indicates that at least the second level of the convent was constructed after the temple.

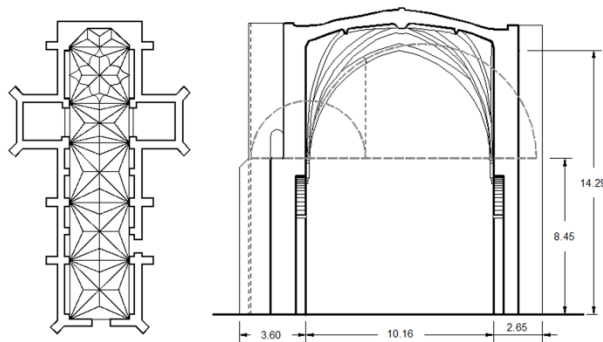


Figure 3: Architectural plant and cross-section of the Santo Domingo nave in Oaxtepec, Morelos.

In Mexico a few more than ten buildings are totally covered with ribbed vaults like the ones of the church in Oaxtepec. After studying four of these buildings, it was found that only the buttresses of the Oaxtepec temple are very close to the rules of Martínez de Aranda and Hernán Ruiz, although with some modifications; according to Huerta [12], these rules belong to the late Gothic period. Figure 3 shows the outline and application in the conventual temple of Santo Domingo. It is worth mentioning that the other three temples with ribbed vaults studied have buttresses with more conservative dimensions and are close to the results of the rules developed by Rodrigo Gil de Hontañón.

## 5 Conclusions

The study presented in this document shows three conventual vaulted buildings constructed in the 16th century in Mexico, which come closer to the measuring rules contained in ancient treatises of construction. Two large monastic temples and a small visiting chapel are the examples presented here, among other cases that share this feature. Although the studied treatises did not arrive to the New Spain until the end of the century, it is possible to draw the preliminary conclusion that their content was a part of the construction practices in Spain, which were also used in the early constructions of the New Spain in the Americas.

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## References

- [1] Kubler, G., *Arquitectura mexicana del siglo XVI*, Fondo de Cultura Económica: México, D. F., 2012.
- [2] Chanfón, O. C., *Arquitectura monástica del siglo XVI: temas escogidos*, UNAM: México, D. F., 1988.
- [3] García, Z. A., El repoblamiento de indios en América colonial: sometimiento, contemporización y metamorfosis. *Historia general de América Latina*, **3(2)** pp. 459-496, 1999.
- [4] Rubí, A. R., Comunidades indígenas del siglo XVI y XVII del centro y la montaña de Guerrero. *Estudios de Cultura Náhuatl, Instituto de Investigaciones Históricas*, 23, pp. 297-341, 1993. [www.historicas.unam.mx/publicaciones/revistas/nahuatl/pdf/ecn23/418.pdf](http://www.historicas.unam.mx/publicaciones/revistas/nahuatl/pdf/ecn23/418.pdf)
- [5] Artigas, J. B., *México: Arquitectura del siglo XVI*, Taurus: México, D. F., 2011.
- [6] García, G. N and Meli, P. R., On structural bases for building the Mexican convent churches from the sixteenth century. *International Journal of Architectural Heritage*, **3(1)**, pp. 24-51, 2009.
- [7] Sandoval, Z. B., *Manual de conservación preventiva del exconvento de Tepoztlán*, INAH: México, D. F., 2010.
- [8] Meli, P. R. and Sánchez, R. R., Criteria and experiences on structural rehabilitation of stone masonry buildings in Mexico city. *International Journal of Architectural Heritage*, **1(1)**, pp. 3-28, 2007.
- [9] Chávez, C. M., *Estudio experimental de las propiedades mecánicas de mamposterías de piedra natural*. Tesis de Maestría. UNAM: México, D. F., 2005.
- [10] Román, K. M. A., La arquitectura religiosa del Yucatán virreinal. *Boletín de Monumentos Históricos, Tercera Época*, **1(8)**, pp. 2-21, 2006.



- [11] García, G. N., Trazo de las bóvedas de nervaduras mexicanas del siglo XVI. *Revista de Arquitectura*, **1(14)**, pp. 106-115, 2012.
- [12] Huerta, F. S., *Arcos, bóvedas y cúpulas. Geometría y equilibrio en el cálculo tradicional de estructuras de fábrica*, Instituto Juan de Herrera: Madrid, 2004.
- [13] Sanabria, S. L., Rodrigo Gil de Hontañón's new arithmetical structural rules at the parish church in Villamor de los Escuderos. *Proc. of the 1<sup>st</sup> Int. Congress on Construction History*, ed. S. F. Huerta, J. de Herrera, SEdH, ETSAM, A. E. Benvenuto, COAM & F. Dragados: Madrid, pp. 1795-1800, 2003.
- [14] Palacios, J. C., Spanish ribbed vaults in the 15th and 16th centuries. *Proc. of the 1<sup>st</sup> Int. Congress on Construction History*, ed. S. F. Huerta, J. de Herrera, SEdH, ETSAM, A. E. Benvenuto, COAM & F. Dragados: Madrid, pp. 1547-1558, 2003.
- [15] Navarro, J. C., *Bóvedas de la arquitectura gótica valenciana*, Valencia: Universidad Politécnica de Valencia, 2006.
- [16] Gutiérrez, Y. H., Personal file, October 2011, Instituto Nacional de Antropología e Historia, Morelos.

