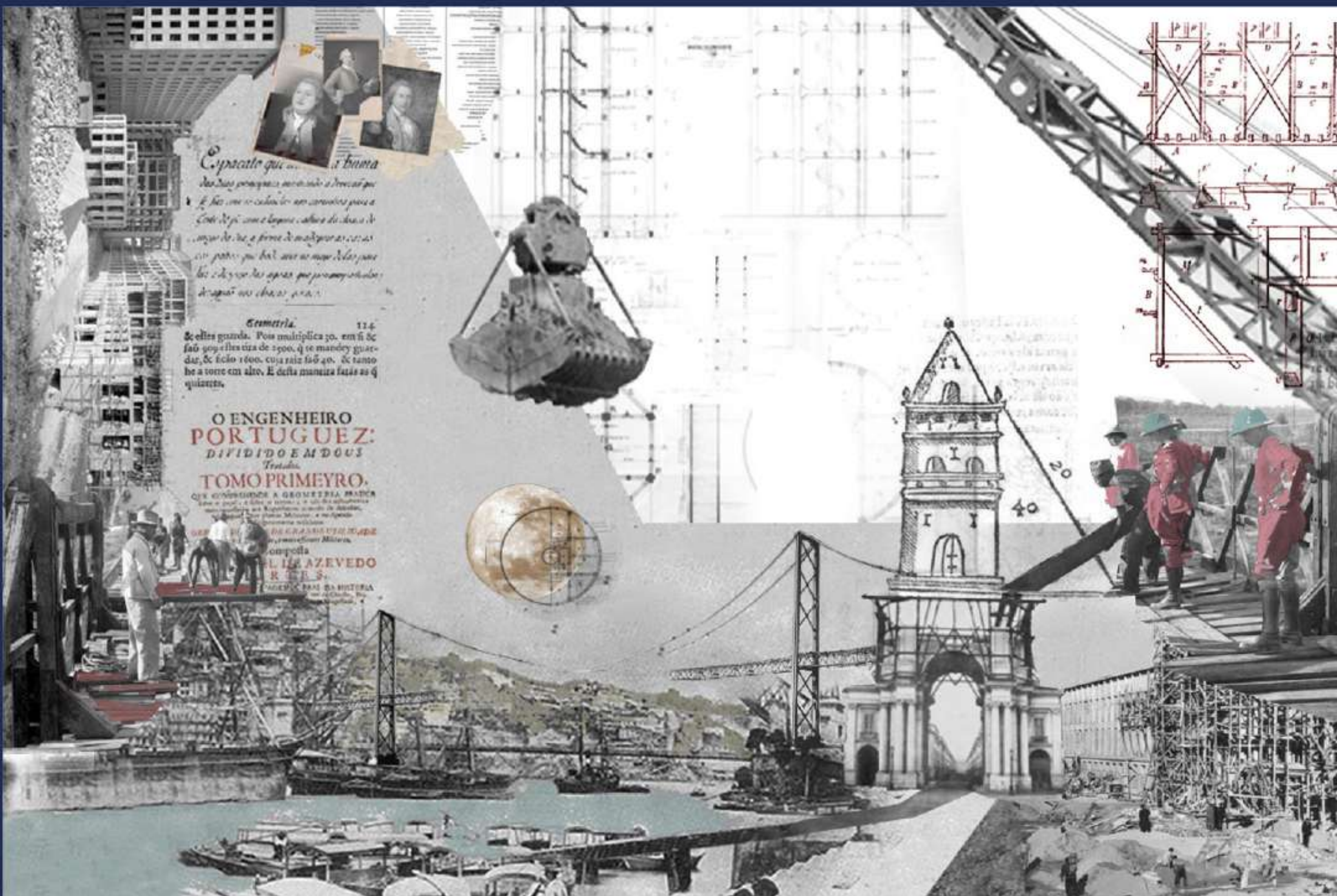
HISTORY OF CONSTRUCTION CULTURES

VOLUME 1



edited by
João Mascarenhas-Mateus
and **Ana Paula Pires**

CRC Press
Taylor & Francis Group

HISTORY OF CONSTRUCTION CULTURES

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PROCEEDINGS OF THE SEVENTH INTERNATIONAL CONGRESS ON CONSTRUCTION HISTORY (7ICCH), LISBON, PORTUGAL, 12–16 JULY 2021

History of Construction Cultures

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VOLUME 1

CRC Press
Taylor & Francis Group
Boca Raton London New York Leiden

CRC Press is an imprint of the
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Cover illustration: Julia Lyra, PTBUILDS19_20 research project, ref. PTDC/ARTDAQ/28984/2017.

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Typeset by MPS Limited, Chennai, India

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Library of Congress Cataloging-in-Publication Data

A catalog record has been requested for this book

Published by: CRC Press/Balkema
Schipholweg 107C, 2316 XC Leiden, The Netherlands
e-mail: enquiries@taylorandfrancis.com
www.routledge.com – www.taylorandfrancis.com

ISBN: 978-1-032-00199-9 (SET Hbk)
ISBN: 978-1-032-00228-6 (SET Pbk)

ISBN Volume 1: 978-1-032-00202-6 (Hbk)
ISBN Volume 1: 978-1-032-00266-8 (Pbk)
ISBN Volume 1: 978-1-003-17335-9 (eBook)
DOI: 10.1201/9781003173359

ISBN Volume 2: 978-1-032-00203-3 (Hbk)
ISBN Volume 2: 978-1-032-00269-9 (Pbk)
ISBN Volume 2: 978-1-003-17343-4 (eBook)
DOI: 10.1201/9781003173434

History of Construction Cultures – Mascarenhas-Mateus & Paula Pires (eds)
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The construction of the vaults in the cathedrals of the Viceroyalty of Peru

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ABSTRACT: In the Viceroyalty of Peru, political power was strongly linked to religion. In the first hundred years following the Spanish Conquest, the magnificent cathedrals, symbolically representing the Spanish dominion, became the reference construction model with the introduction of vaulted masonry structures. Juan Miguel de Veramendi, Francisco Becerra, Francisco Domínguez Chávez y Orellana and other architects from the Old World designed the most important colonial churches. The masons who gave life to the European forms were native, thanks to their ancestral mastery of the building material. Since these areas were frequently affected by earthquakes, many churches have been completely transformed over the years. The evolution of these structures is examined through the analysis of the remaining vaults, the evaluation of scientific literature and a thorough archival review. More specifically, the Cathedrals of Lima and Cusco explain the different experiments undertaken to make vaulted structures resistant to earthquakes.

1 INTRODUCTION

When Pizarro entered Cusco, the ancient Inca capital, in 1533, he had completed the conquest of Peru (Del Busto 1994). The following year, on 23 March, the Spaniards founded a major Spanish city in Cusco, at this time the most important colonial city in South America. Pizarro, appointed governor of the lands conquered by the Spanish Crown, founded another city on the coast of the Pacific Ocean in 1535. Lima, formerly known as *Ciudad de los Reyes*, gained prestige after being designated as the new capital of the Viceroyalty of Peru and site of a Real Audiencia (royal court) in 1543 (Hemming 1970). In Colonial Latin America, political power was strongly linked to religion, as only the need to convert natives to the Christian faith could morally justify their submission. Therefore, the construction of magnificent Christian temples with their symbolic meaning, replacing the first temporary Spanish buildings, became the opportunity for a cultural and architectural knowledge transfer from the Motherland to the New World. Between the last decades of the 16th century and the middle of the 17th century, Iberians architects were consulted or appointed to design the most important colonial churches or new cathedrals (Dorta 1960). For the purpose of this paper, a brief overview on the political context is provided only with the aim to present the findings of the research, while keeping a strictly defined perspective on the history of building technology.

2 HISTORICAL BACKGROUND

The first bishopric in the Viceroyalty of Peru, the Diocese of Cusco, was established on 5 September 1536 and stretched over a vast majority of the South American territory divided by the Archdiocese of Seville. Lima was raised into a bishopric in 1541, and subsequently decreed Metropolitan Archdiocese by Pope Paul III in 1546. In the following years, the diocesan territory of Cusco was further divided with the creation of the Bishopric of Paraguay, founded by Pope Paul III in 1547, and the Dioceses of Chuquisaca – Sucre – in Upper Peru, was founded by Pope Julius III in 1552. Shortly after the settlement of the *Conquistadores*, a small religious building was built in Cusco with adobe walls and lowly architectural features. In 1543, Jerónimo de Loayza, the first archbishop of Lima (1498–1575), signed the act of erection of the Cathedral of Lima while he was still in Madrid (Coello 2011). The possibility of being assigned the construction of remarkable churches outside of Spain quickly encouraged architects and master builders to cross the Atlantic Ocean. It is worth noting that late medieval and early modern Spanish architectural history must be considered to properly understand the sources of the early colonial architecture, as well as the local American context (Niell & Sundt 2015). Since Peru and surrounding areas were frequently affected by earthquakes, many churches have been totally transformed over time.

3 THE CONSTRUCTION OF THE VAULTS

3.1 *Early American religious architecture*

The evolution of building techniques in the Viceroyalty of Peru is examined through the analysis of the still existing vaults in the main churches, a scientific literature and archival review – the last of these including

DOI 10.1201/9781003173359-4

historical drawings or pictures, written documents, and photos.

Due to the long construction times, most of the early colonial churches show a range of architectural styles and building processes. As an example, the investigation on the Lima and Cusco cathedrals, as well as on some other South American architectures, shows the various processes used to make the vaulted structures resistant to earthquakes (Rodríguez-Camilloni 2006).

The early Latin American cathedrals were mainly single-nave churches with a simple wooden roof. European builders introduced solutions for the construction of masonry vaults over the monumental spaces of the news church naves and chapels. With the instruction of these architects, Gothic rib vaulting was introduced in Peru in the mid-16th century.

Stone vaults lent an air of solemnity to the sacred space while also conveying a sense of permanence to the Spanish occupation. Gothic architecture carried many ideological messages tied to the economic, politics and cultural development of ancient, medieval, and early modern Spain that helped in the colonization project. Shortly after, Renaissance and Baroque were added to the late medieval forms, such as barrel and domical vaults (Niell & Sundt 2015).

In Peru during this period, traditional and new, indigenous and imported artistic shapes engendered a visual heterogeneity (Brown 1991).

The inexperience of master builders was among the main challenges in spreading the European building technologies, alongside issues of the availability of building materials and training of a native workforce who was not familiar with European construction techniques (Niell & Sundt 2015).

Juan Miguel de Veramendi, from Biscay (early 16th century-1573) and Francisco Becerra, born in Trujillo, Extremadura (1545–1605) were among the most remarkable architects who came from Spain to the Viceroyalty of Peru in the second half of the 16th century. Their professional training, with a Gothic-Mannerist background, characterized the early colonial architecture (Dorta 1943). Both contributed to the dissemination of building techniques from their homeland to the main cities of America.

Veramendi planned the Cathedral of Sucre in 1551. In the same period, he was also commissioned the design of a new cathedral in Cusco, replacing the former adobe building. Approximately 10 years later, both the construction of Sucre and building works in the ancient capital of the Inca empire were stopped (Ugarte 1968).

3.2 *The mother churches of Cusco and Lima*

After the conquest of Cusco, the Spanish decided to take down one of the ancient temples of the Inca capital, replacing it with a Christian church in the main square of the city. Shortly after, Pizarro laid in Lima the first stone of the early church in 1535. The first cathedral in the colonial capital was also small and poor. This new temple in Lima was completed in 1538. A few years later, these first religious buildings had to be replaced with new churches that were bigger and more resistant, statelier and more representative, but still built with adobe walls and wooden roofs (Dorta 1960). In Cusco, the construction site of the new cathedral was settled in 1552. The architect Veramendi set up the foundations using large stones removed from some ancient Inca buildings, mostly from the fortress of Sacsayhuaman (Esquivel & Navia 1980). Veramendi's design is unknown, but the plan corresponded to the established foundations: a Latin cross, with various aisled naves. The roof had to be supported by 14 pillars (Flores 2013). Contemporary evidence suggests that Veramendi planned a vaulted stone ceiling for all naves, probably with more classical than Gothic features (Esquivel & Navia 1980). Back then, the indigenous people were highly skilled in building stonework, but had never erected arches and vaults. Most of the material was carried from Sacsayhuaman to the construction site of Cusco Cathedral in 1559.

The stone foundations of the church were laid in the following year (Flores 2013; Gutiérrez 2000). In 1561, the construction of the church of Sucre was interrupted due to serious technical problems. For this reason, the bishopric of Chuquisaca initiated a trial against Becerra, who could not leave the city in Upper Peru for 20 years and was unable to go to Cusco where construction had just started. In Cusco, Veramendi was replaced by Juan Correa as master builder of the cathedral from 1 September 1561 until 1564.

However, a lack of economic resources stopped the works. Although Francisco Toledo, shortly after becoming Viceroy of Peru, financed the construction of Cusco, the erection of the Cathedral proceeded very slowly above the foundations level (Dorta 1943; Flores 2013). In 1564 Jerónimo de Loayza, the Archbishop of Lima, commissioned the reconstruction of the Cathedral to Alonso Beltrán, with instructions to set up his design with five naves, just like the Cathedral of Seville, in Spain.

The building of Seville was the main church of the Archdiocese on which the New World initially depended. In Lima, the reconstruction of the Cathedral began in 1572 with the demolition of the existing adobe walls. In the capital of the Viceroyalty of Peru, the construction of the new main church was quickly interrupted because of the high cost (Mazzanti 2020). When Viceroy Toledo's government came to an end in 1581, he was succeeded by the 6th Viceroy of Peru, Martín Enríquez de Almansa, a new promoter of the cathedral works in Lima and Cusco (Figure 1). Martín met Francisco Becerra in Mexico and requested his presence also in South America (Harth-Terré 1945).

3.3 *Becerra's designs for Cusco and Lima*

Becerra's presence at the construction site of the Cathedral of Cusco is still under investigation; he almost surely made some changes to the original plan in 1581 (Flores 2013). Three years later, the architect revised the design again: in this new phase the church was planned with five naves, similarly to the mother church of Seville (Covarrubias Pozo 1958).

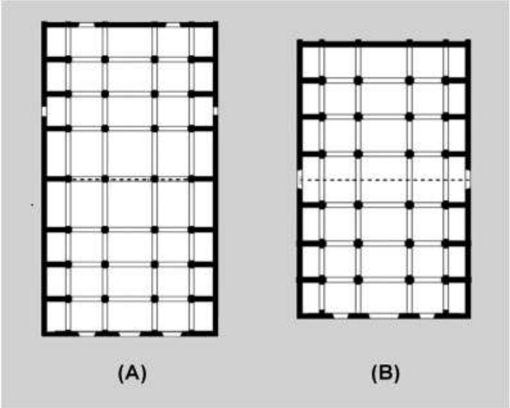

Figure 1. Schemes of the plans of the cathedrals with three naves and lateral chapels, designed by Francisco Becerra in the Viceroyalty of Peru: A) Lima; B) Cusco.

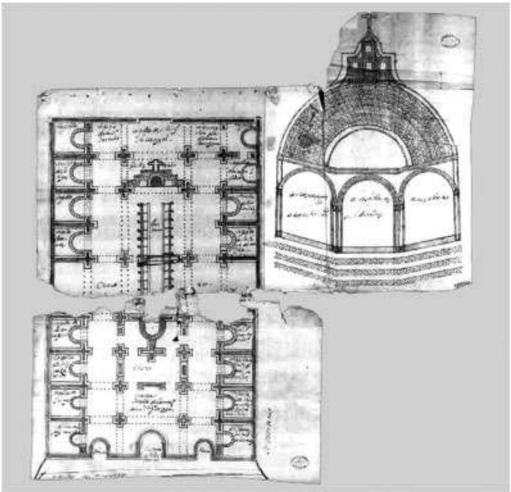

Figure 2. Cathedral of Cusco. Plan after Becerra's death, early 17th century (Flores 2013).

Becerra's buildings were similar to some Spanish churches, especially in Andalusia and Castile, as well as comparable to the models presented by the Spanish architectural treatises of the time. Luis de Velasco, Marquis of Salinas and 9th Viceroy of Peru as of 1596, also had to deal with the construction problem of Cusco Cathedral in 1598 (Flores 2013).

During those years, Andrés de Espinosa, the master builder – *alarife* – at the Cathedral of Lima was already preparing the centerings to build the ribbed vaults. However, he was replaced by the architect Becerra (Figure 2).

This change led to abandoning that already antiquated type of vaults, specific to the medieval period, and the subsequent adoption of groin vaults according to the Renaissance shape (San Cristóbal 1996). Nevertheless, Becerra did not direct the works of the Cathedral of Cusco and his presence in the city was

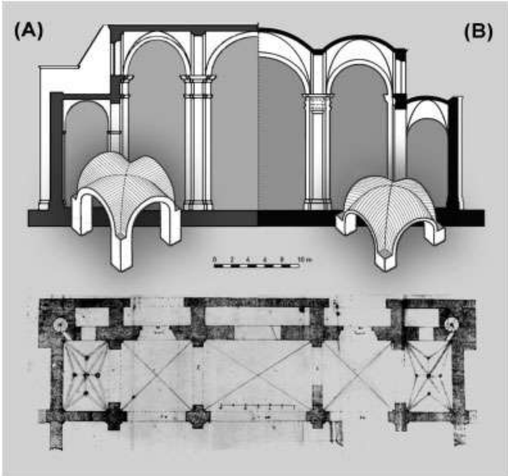

Figure 3. Cathedral of Lima. In the upper part: A) Becerra's design, the hypothetical section according to Rodríguez-Camilloni (2006); B) The building after Becerra's death, according to Flores (2013). Below: floor plan, Corral's proposal of 1609 (Archive of the Ecclesiastical Chapter, Lima).

only reported as a visitor. Indeed, his name did not appear in the registers of the time. But the design of the Cathedral of Lima is surely attributable to Becerra (Figure 3), being similar to the final configuration of the main church of Cusco.

Construction of the Cathedral in Lima continued following Becerra's plans, and on 2 February 1604, when the eastern end of the new church was consecrated, the first two bays of the central nave with the aisles and lateral chapels had been completed and the web or stone shell of the vault was laid on them (Montesinos 1906). The Lima earthquake of 1606 seriously damaged Becerra's Renaissance vaults. In the following three years, the works continued westward at a slow pace due to financial difficulties as well as Becerra's death. At least two additional bays, including the lateral chapels, were standing when the strongest earthquake of 1609 struck the city (Dorta 1960).

3.4 *The construction after Becerra in Lima*

After the earthquake, structural damage to the vaults was assessed by Luis de Palomares Vega, superintendent of the construction site Cathedral – the *obrero mayor*. Additionally, before the Real Audiencia he requested the calling of a council of experienced architects to define the most suitable repairs (Rodríguez-Camilloni 2006). The master builder Alonso de Morales was the first to give an opinion on the repairs. In his report, he stated that the collapsed vaults were located towards the eastern end. In addition, the larger chapels – or rather, the transept of the Cathedral according to the Becerra design – suffered considerable damage in the piers and arches (Rodríguez-Camilloni 2006). In the apse, Alonso de

Morales decided against the use of exterior buttresses to avoid making unsightly the space of the nearby cemetery, but also increasing the lack of longitudinal stiffness. Instead, he proposed a reduction in the height of the naves and the construction of chapels similar to the lateral ones so that they would work as strong buttresses, increasing the solidity of the whole structure. Also on the council of architects was the architect Juan del Corral, born in Burgos, Spain, in 1571. Corral was active in Quito as of 1601, where he had earned the prestigious title of *Maestro mayor de reales fábricas* (Harth-Terre 1945; Webster 2012). In the year before the 1609 earthquake, he moved from the north of the Viceroyalty of Peru to Lima, to build the city's Old Stone Bridge. Corral recognized the need for buttressing the apse of the church and submitted his report on 27 October 1609 (Dorta 1960; Harth-Terre 1945). His floor plan for the eastern end, an important historical testimony (Figure 3), is currently preserved in Lima, in the Archive of the Ecclesiastical Chapter (*Cabildo*) (Ballesteros 1972). Corral's proposal contained some advice, also included in the aforementioned plan, such as the use of Gothic rib vaults over the lateral chapels following the medieval tradition that was part of his training (Vargas 1972; Ugarte 1968).

For the nave and the aisles, Corral decided to keep the shape of the groin vaults without changing the Becerra setting, but he planned to use wood instead of brick. Even though his suggestion was rejected at the time, Corral predicted the definitive structural solution that was adopted more than a century later, after the great earthquake of 1746 (San Cristóbal 2011). The Jesuit Martín de Aizpitarte was another architect who endorsed the idea of using wood to cover the naves of the Cathedral (Ugarte 1968). As for the construction materials, he indicated that the poor quality of the mortar could be blamed in part for the structural failure of the piers and vaults (Rossi et al. 2019). At last, in 1614, the master builder Juan Martínez de Arrona presented a plan with a comprehensive solution for rebuilding the Cathedral. The new design was approved in February of the following year. The construction works culminated with the completion of the western half of the church in 1622 and its consecration in 1625 (Harth-Terre 1961). The main transformation of the Cathedral, compared to the Becerra's design, concerned the replacement of the groin vaults for Gothic rib vaults (Wethey 1949). Arrona's own preference would have been to rebuild the Renaissance vaults, *a la romana*, like his predecessor Becerra. However, as he conceded, experience showed that rib vaults were the most effective in the event of an earthquake (Figure 4). The thrust of the Gothic cross vault built by Becerra is less than half the thrust of a Renaissance barrel vault designed by Corral. Some structures with rib vaults had survived the violent shaking following the Lima earthquakes of 1609.

3.5 *The Cusco Cathedral after Becerra*

In the early 17th century, various events happened in Cusco – including Becerra's death, after which several architects modified the design of the Cathedral. Then, between 1615 and 1616, serious disagreements occurred between the construction workers in the city which halted the building process for nine years (Figure 5).

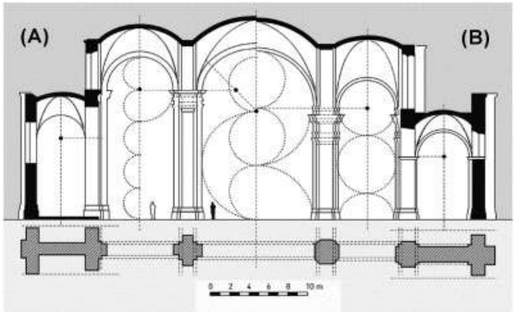

Figure 4. Sections of the cathedrals of Lima (A) and Cusco (B) at the beginning of the 17th century (in Flores 2013).

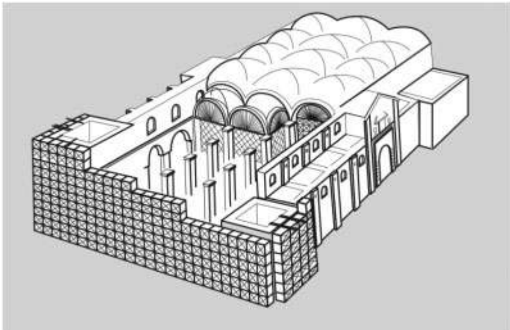

Figure 5. Cathedral of Cusco. Work in progress, at the time of the 1650 earthquake. The complete vaults in the area towards the altar (in Flores 2013).

The completed structure reached the level of the cornice at the top of pillars and walls. The layout was later modified by the master builder Gutiérrez Sencio in 1625 (Tesoros: 64). Nearly 20 years later, in 1643, the Spanish architect Francisco Domínguez Chávez y Orellana arrived in Cusco.

At the same time, Juan Alonso Ocón became Bishop of the city. Both the architect and the bishop made a vast contribution to the conclusion of the main church of Cusco. Meanwhile, Gutiérrez Sencio continued to direct the building site at the cathedral until his death in 1649.

The progress of the cathedral works had been accurately noted until then by the friars Juan Alonso Ocón and Juan de Córdoba. The latter, who was also Rector of the Society of Jesus in Cusco, wrote a report on the Cathedral in 1645. In this report, he gives us significant information about the walls, pillars, façade, and part of the towers. Above all, the most important testimony concerns the structure of the vaults (Flores 2013).

Figure 6. Cathedral of Cusco. The structure of a vault without the plaster, during the restoration works in 1997 (in Flores 2013).

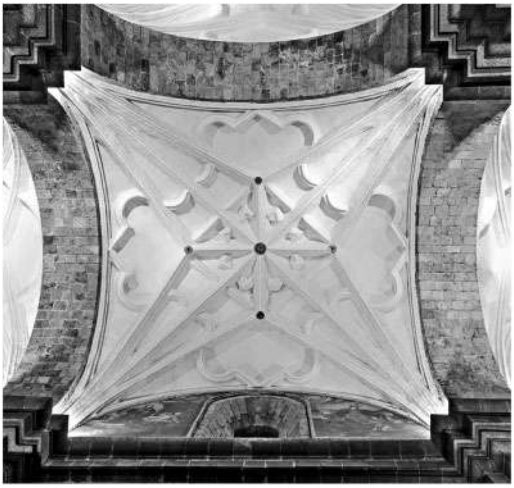

Figure 7. Cathedral of Cusco. A cross vault in the aisle, bottom view, current state after restoration (in Flores 2013).

In the same period, the early Santo Francisco church of Cusco was demolished in order to modernize its structures (Angles Vargas 1983). The aforementioned architect Chávez y Orellana was involved in 1648 in the construction of the cross vaults in the aisles, transept and presbytery (Flores 2013).

After his death, Gutiérrez Sencio was replaced by Chávez y Orellana, chosen only for his previous experience in the construction of San Francisco. On 16 August 1649 he signed a contract to build 17 brick rib vaults in the three naves of the Cusco Cathedral, from the facade to the choir, following a new design. Four experienced Spanish bricklayers worked under the architect's supervision. Their work would be completed in 40 months: each vault needed approximately a month and a half to be built, plus a whole year to carry out the finishes (Figures 6, 7 and 8).

Religious people and the population of the city supplied the construction with the economic resources

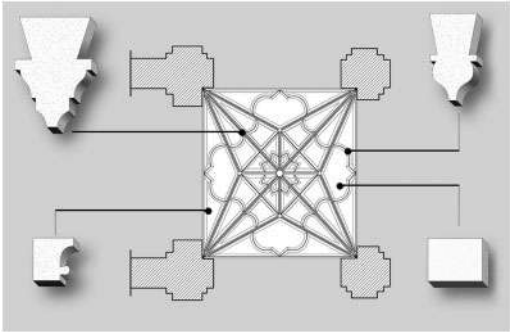

Figure 8. Cathedral of Cusco. Technical detail of a rib vault in the aisle: identification of the specially shaped bricks of the vault brick web.

Figure 9. Cathedral of Cusco. The "flat roof" and the extrados of the vaults (the slope of the surface in evidence).

needed and the available materials, typical of the Andean areas (Proaño et al. 2004), such as brick, lime, and roof trusses.

The extrados of the vaults was not covered by a wooden roof but by very thin, light bricks commonly called *ladrillo pastelero*, forming the slope of the surface (Figure 9). Waterproofing the flat roof was crucial, especially during the heavy rains typical of Cusco.

A similar example is the cathedral of Málaga in Andalusia, a region with very little atmospheric precipitation during the year, unlike Cusco. The 1650 earthquake destroyed the ancient Inca capital, but the unfinished roof structures of the Cathedral (Figure 5) were only slightly damaged, so the Spanish architect was able to complete the building in the following four years. The work was completed in 1654. On 21 May 1950, a new, violent earthquake struck Cusco, damaging a lot of buildings – especially the colonial churches, which were 250 to 350 years old, and the adobe constructions. But the Cathedral structure suffered only light damage, and only the façade and the two towers were affected. More specifically, some crenellations and the upper finials on the façade toppled over.

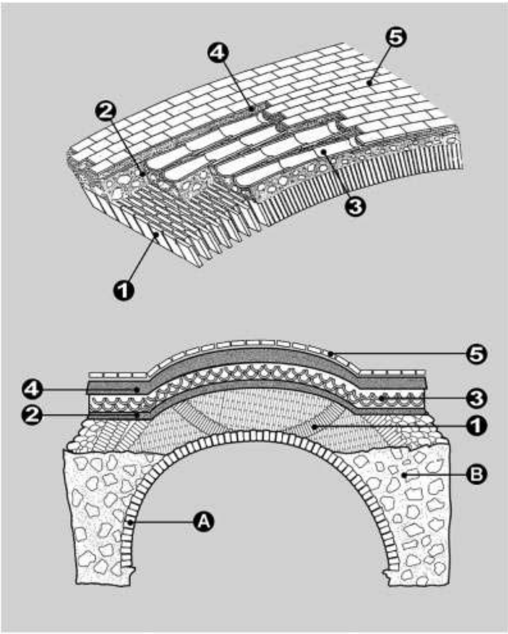

Figure 10. Cathedral of Cusco. Structure of the vaults: A) main arches; B) spandrel, conglomerate of stones and mortar; 1) web vault and ribs; 2) mortar conglomerate; 3) tiles; 4); mortar conglomerate; 5) bricks, *ladrillo pastelero*.

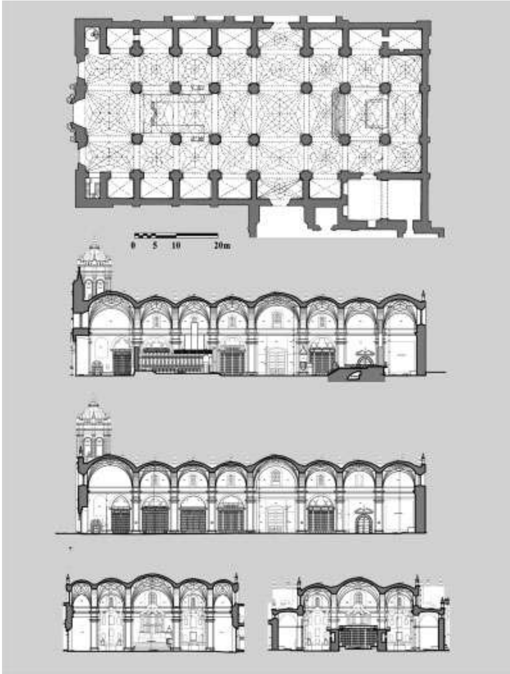

Figure 11. Cathedral of Cusco. Architectural survey: floor plan, longitudinal and transverse sections.

In the corner supports, the grinding action of the rubble fill within the rusticated facings was clearly evident. In contrast, in all the vaults of the naves, damage was negligible (Kubler 1953). In 1986, another, less devastating earthquake caused minor but significant damage in Cusco. Once again, the Cathedral vaults withstood the event. The vaults were repaired during the restoration of the building in 1997 (De La Serna & Carrillo 1996).

4 CONCLUSIONS

Following the destructive Lima earthquake in 1746, the brick rib vaults of the Cathedral were rebuilt in wood by the Scottish architect Alejandro Campobello between 1751 and 1758 (Harth-Terre 1951). Therefore, the most effective protective solution in the most important church of Lima was found in *quincha* construction (Rodriguez-Camilloni 2003). In the whole Viceroyalty of Peru, only the Cusco cathedral preserved the vaults built at the beginning of the 17th century. The analysis of the Gothic vaults (Figure 10) showed the technical features which made the entire structure resistant to earthquakes, as demonstrated by its response following the destructive event of 1950 (Brando et al. 2019). The presence of transverse ribs, liernes and tiercerons, with straight and curvilinear shapes, split the web of the vault into independent wall elements. Brick vaults were arranged in rowlock courses, following concentric rings, to build vaults with a minimum of temporary wooden centering.

The complex roof shape, with a very light double curvature masonry structure, increases the stability of the vaults. Beyond any stylistic consideration, rib vaulting was very popular among colonial architects because they believed that Gothic construction would show greater resistance to earthquakes.

Even for architects who had been trained in the classical tradition of the Renaissance, the adoption of rib vaults became a matter of structural expediency rather than a stylistic preference (Figures 11 and 12).

A broader knowledge of the construction history in the Viceroyalty of Peru allows us to understand the process with which the Viceregal builders of origin and training built an autonomous and specific architecture from the mid-17th century. A distinctive relationship with the materials characterizes the Andean, and particularly the Inca, approach to the built environment. The native bricklayers were deeply engaged with materials and with the processes that transformed those materials into structures (Webster 2011). Their active cooperation in the construction of the vaults in the main churches of ancient Peru allowed them to quickly learn this construction technique.

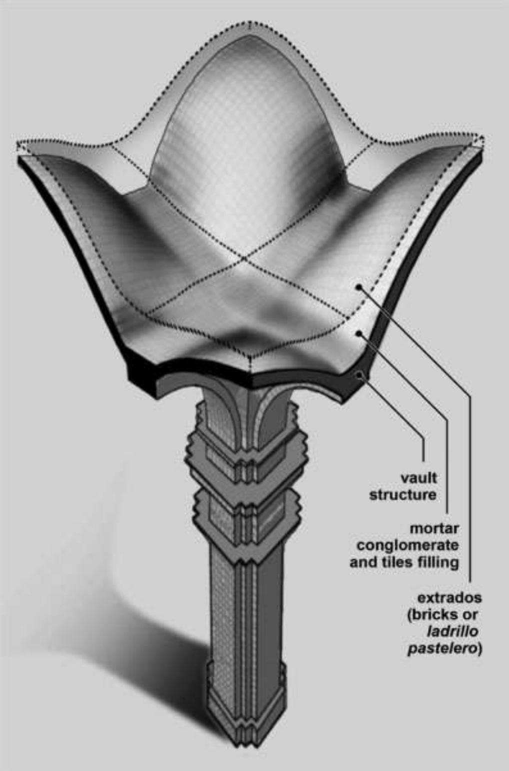

Figure 12. Cathedral of Cusco. Pillar and section of the vaults.

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