

THE EVOLUTION OF THE DESIGN AND CONSTRUCTION OF MASONRY BUILDINGS IN BRAZIL

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Abstract

This paper presents an overview of the use of masonry in Brazil. Some historical remarks are presented showing how masonry was introduced and has been developed in the country. A brief on the Brazilian Universities is also reviewed, showing the extensive efforts made to improve the educational system and to insert Brazil into the international masonry research environment. Current materials are shown, focusing on the use of structural and non-structural masonry. The paper points out the development of Codes, considering the most important regulated characteristics of masonry in order to be used in Brazilian constructions. The building situation is addressed, stressing the large housing demands and how the masonry industry can help to partly solve the problem. Finally, present and future challenges are discussed, showing Brazil's constructions needs, as an emerging country.

Keywords: *masonry, Brazil, past, current, future*

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1. INTRODUCTION

Masonry is a building system that is largely used in Brazil, competing with other ones such as reinforced and prestressed concrete, concrete walls, steel and timber frames, etc. The use of masonry is spread all over the country, displayed by the assorted types, shapes, materials, etc. Masonry is used to build houses, hospitals, schools, shopping centres, low and high-rise residential and commercial buildings. The units are typically clay bricks or blocks made

of fired clay, concrete, calcium silicate, etc. Both reinforced and unreinforced masonry are used in buildings, in which the walls are usually single wythed and 140 mm thick. Masonry is also used for non-loadbearing walls, predominantly made of fired clay and concrete blocks, competing with dry-walls as a partition device, however with better sound and heat insulation properties.

2. HISTORICAL REMARKS

Masonry was introduced in Brazil by the European settlers. Brazil was a colony of Portugal from the 16th to the 19th centuries. In 1808, The Portuguese court, fleeing from Napoleon's invasion of Portugal in a large fleet escorted by British warships, arrived in Brazil and enhanced the development of its tropical colony. Many buildings were erected to serve as houses, palaces, government offices, theatres, churches, etc, following the European tradition that was maintained in Brazil even after its independence in 1822, using mainly clay fired bricks, see Figure 1.



Figure 1. Belem's neoclassic theatre – 1874 (WIKIPEDIA, 2011).

Shortly after masonry changed from art to science in the middle of the 20th century, the first concrete block industry was introduced in Brazil by the Camargo Corrêa group in the 1960s, which imported a Besser machine from the USA and used the byproducts (fine gravel and stone powder) of a quarry in Guarulhos, SP, to produce the blocks, Tauil (2008). In the 1970s this building system was first used in São Paulo city, constructing a set of 4 and 16-floor residential buildings. At the same time the first Brazilian Codes appeared, strongly inspired by the ACI documents. These initial Codes dealt with the specification of materials and the compressive tests of blocks and prisms.

In the 1980s the masonry system spread across the country, largely used to build low-cost housings, with financial support from BNH (Housing National Bank).

Meanwhile two new Brazilian Codes were launched to regulate the design and execution of concrete block masonry, NBR 10837-1989 (BRAZILIAN..., 1989) and NBR 8798-1985 (BRAZILIAN..., 1985), respectively. These Codes were also used by the designers and builders to develop clay block and brick constructions, after being properly adapted.

The 1990s saw considerable development in the use of masonry in Brazil, with improvements fomented by two large associations: ABCP (Brazilian Association of Portland Cement) and ANICER (National Association of Ceramic Industry). The first Brazilian machines to manufacture concrete blocks also appeared in this decade. High rise reinforced masonry buildings, with close to 20 floors, began emerging in the larger cities, see Figure 2.



Figure 2. 19-storey high building in Londrina, PR, Grauna Construções Civas Ltda (2012).

Nowadays masonry is well consolidated in Brazil, fulfilling an important part of the construction market, currently used to build houses, low and high buildings. Block and brick manufacturers have improved the quality of their products and are present in most of the Brazilian States, providing concrete, clay, AAC, and calcium silicate units. The execution and control of calcium silicate masonry is

governed by NBR 14974-2 (BRAZILIAN..., 2003b). Recently, the most important Codes were revised/ developed, particularly the launching of NBR 15961 (BRAZILIAN..., 2011c, d) and NBR 15812 (BRAZILIAN..., 2011a, b), which regulates design, execution and control of concrete and clay masonry, respectively. These Codes are based on the Limit States as the design philosophy.

3. THE BRAZILIAN UNIVERSITIES

In the last three decades, the Brazilian Universities have come closer to the building market and have initiated research studies on the subject, resulting in a relevant contribution to the Brazilian development of the masonry building system. The Universities also participate by providing graduate and undergraduate courses on masonry, taking part in the development and improvement of the Masonry Codes, publishing books and other documents and helping manufacturers to improve their products.

Many Brazilian researchers have gone to foreign Universities for their Phd programs or sabbatical leaves, aiming to acquire knowledge on masonry. The growing attendance to international conferences has also provided much experience to the Brazilian researchers, which have resulted in collaboration works with many strong groups all over the world. Besides private universities, Brazil has nearly 100 Federal and State Universities. Many of them provide graduate courses. Nowadays Brazil produces approximately 10,000 Phds per year, being that



Figure 3. Some masonry research groups in Brazil.

Table 1. Concrete blocks basic requirements.

Class	Characteristic compressive strength (MPa)	Average absorption (%)		Shrinking (%)
		Usual gravel	Fine gravel	
A	≥6.0		≤13% (average)	
B	≥4.0			
C	≥3.0	≤ 10%	≤16%	≤ 0.065%
D	≥2.0 (*)		(individual)	

(*) For non-loadbearing walls.

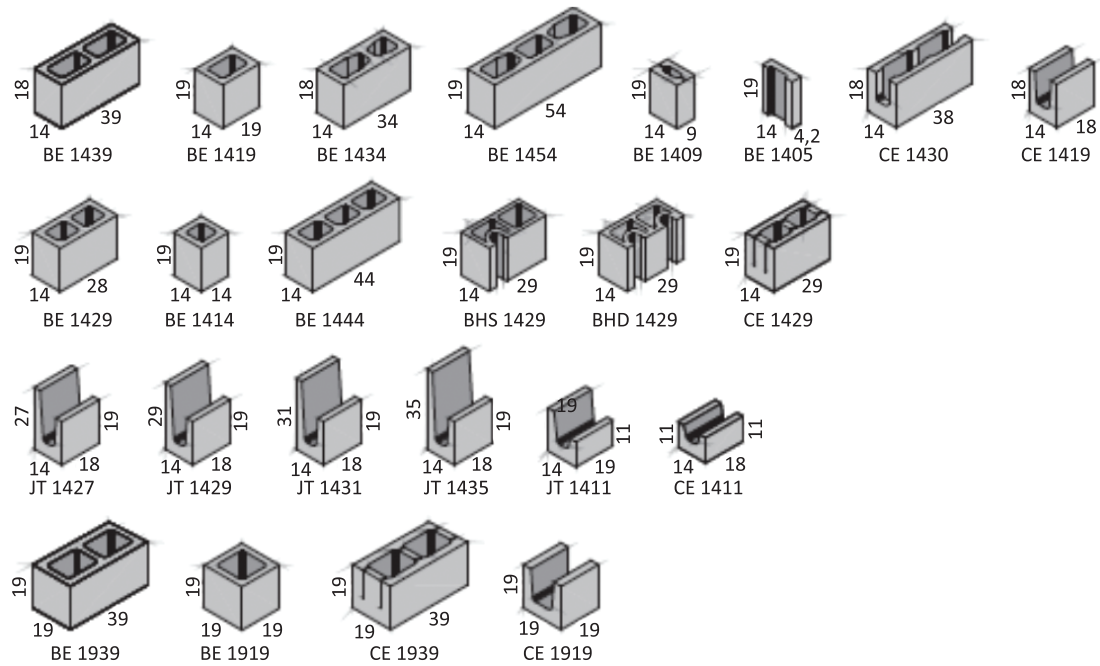


Figure 4. Typical shapes of concrete blocks, Tatu Concrete Blocks (2012).



Figure 5. Typical concrete products, Tatu Concrete Blocks (2012).

2% are in Civil Engineering. This figure is 10 times higher than it was a decade ago. Many research groups in Brazilian Universities are dedicated to the study of masonry. Some of them started the

first investigations in the 1980s, as for instance, POLI-USP and UFSM. Figure 3 shows the distribution of some of those groups in the country.

4. TYPICAL BRAZILIAN MATERIALS

ABNT (Brazilian Standards Association) is a private association founded in 1940 and responsible for all technical Codes in Brazil. A large number of them deal

with masonry. Concrete blocks are regulated by NBR 6136:2007 (BRAZILIAN..., 2007), which establishes all their requirements. Table 1 shows some of

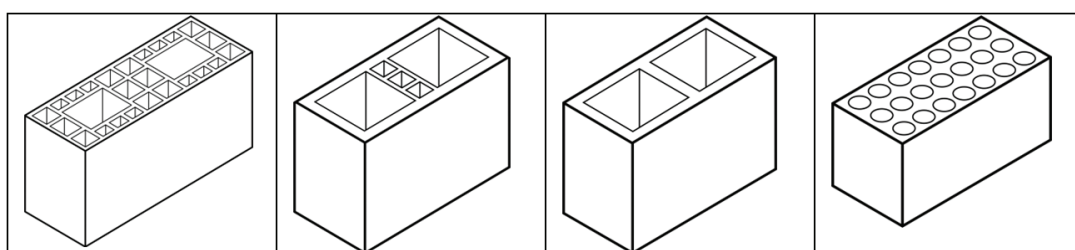


Figure 6. Typical shapes of clay blocks.

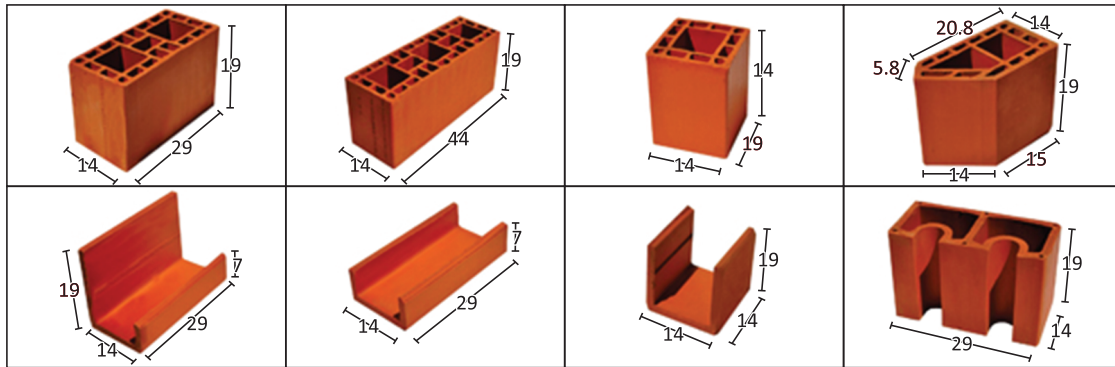


Figure 7. Typical family of clay units.

Table 2. Ceramic blocks basic requirements (*).

Characteristic compressive strength (MPa)	Thickness (mm)	Average absorption AA (%)
≥3.0	115	8% ≤ AA ≤ 22%

(*) for loadbearing masonry.



Figure 8. Typical shapes of calcium silicate bricks and blocks (ASSENARTS, 2012).

Table 3. Calcium silicate bricks and blocks basic requirements (*).

Characteristic compressive strength (MPa)	Thickness (mm)	Average absorption AA (%)
≥4.5	115	10% ≤ AA ≤ 18%

(*) for loadbearing masonry.

the requirements for characteristic compressive strength, absorption and shrinking. The concrete blocks are typically manufactured with different modular dimensions and shapes, see Figures 4 and 5. Considering class A concrete blocks, the highest characteristic compressive strengths, related to the gross area, is close to 20MPa. Using 140 mm thick walls, the commonly accepted limit to the number of floors of a high-rise building is twenty, taking into account the rule of thumb: 1 MPa per floor.

Regarding the clay blocks, NBR 15270:2005 (BRAZILIAN..., 2005a-c) regulates all the requirements for hollow blocks for non-loadbearing (Part 1) and for loadbearing masonry (Part 2), while Part 3 describes all the testing methods to be used.

Figures 6 and 7 show the shapes of typical Brazilian clay blocks that are manufactured in many different modular dimensions. Regarding the blocks to be used in load-bearing masonry the aforementioned Code prescribes minimum values shown in Table 2. Calcium silicate blocks are regulated by NBR 14974-1:2003 (BRAZILIAN..., 2003a), which establishes the minimum requirements and testing methods for non-loadbearing and loadbearing masonry. Figure 8 shows typical shapes of these blocks. With a characteristic compressive strength ranging from 4.5 MPa to 35.0 MPa, calcium silicate blocks have to fulfil minimum requirements to be used in loadbearing walls, see Table 3.

The evolution of the design and construction of masonry buildings in Brazil

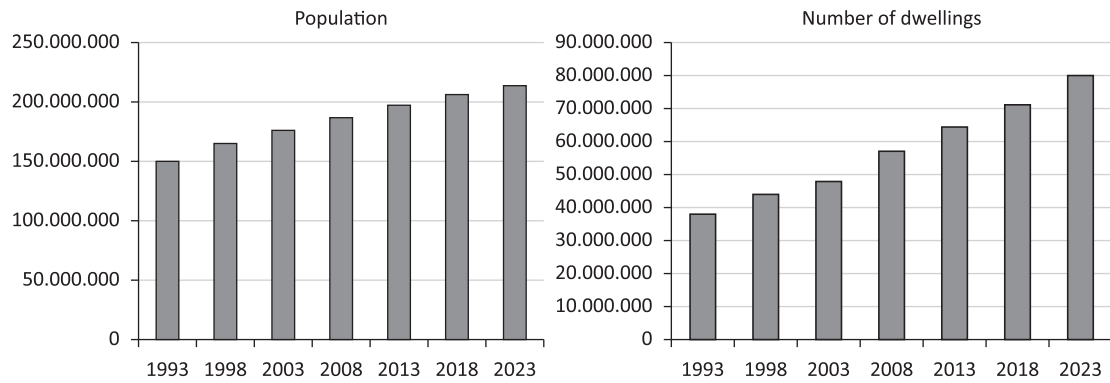


Figure 9. Population growth and housing demand in Brazil.

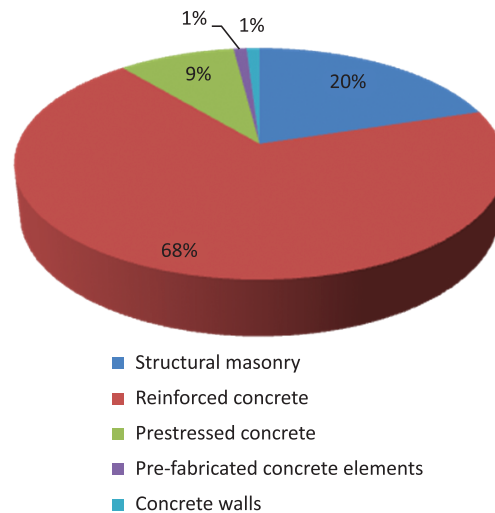


Figure 10. Different structural systems used in Brazil.

5. BUILDING SCENARIO IN BRAZIL

Brazil is an emerging country with wide-ranging challenges to deal with. One of them is the high housing demand. Presently the Brazilian population is of around 195 million inhabitants, with a housing deficit of 5.5 million. According to a recent demographic study conducted by IBGE (Brazilian Institute for Geography and Statistics) (OLIVEIRA; GIVISIEZ; RIOS-NETO, 2009) the population growth shows that the aforementioned demand is increasing, see Figure 9.

Considering the data in Figure 9, it is easy to conclude that in the next decade Brazil has to build nearly 15 million dwellings. The masonry sector is well prepared to play a role in this process.

A recent study developed by the Construction Community (BRAZILIAN..., 2008), a well organized group supported by ABCP, monitored 200 building companies throughout the country for the duration of three years, to assess the present situation. That study showed that the building sector¹ uses mostly

reinforced concrete structures (68%), while 20% represents the participation of structural masonry, see Figure 10.

Another interesting finding of the study is that 63% of the monitored companies were undertaking some innovative methods. And of these, 51% were innovating with the use of structural masonry, see Figure 11. This is largely due to the lower cost of masonry constructions in comparison to other competing systems. Studies conducted by specialized engineers that work in the construction segment show that the use of the masonry system can reduce the costs up to 30% for 4-floor buildings and 15% for 20-floor buildings, in comparison to the traditional reinforced concrete beam/column system, IBDA (BRAZILIAN..., 2011e). This is related primarily to reducing waste as well as the use of timber in the construction site.

A large part of Brazil's construction needs can be fulfilled by masonry. As stated by Tauil (2011), consultant architect of Blocobrasil (Brazilian Association of Concrete Block Producers), the concrete block manufacturers are prepared to

¹ Civil construction represents 16% of the Gross Internal Product.

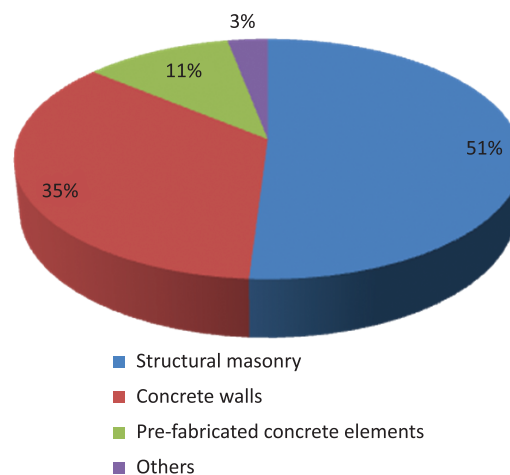


Figure 11. Innovations in the structural systems in Brazil.

provide more than 56 million blocks per month, enough to build 56,000 50 m² dwellings (www.blocobrasil.com.br).

6. PRESENT AND FUTURE CHALLENGES

Besides the vast housing need, Brazil faces numerous challenges in order to guarantee a sustainable economic growth. To some extent, many aspects have to be faced, which are related to the masonry segment:

- The reduction of social differences;
 - The respect to natural resources;
 - The modernization of the industrial park;
 - The development of technology;
 - The improvement of the educational system;
 - The efficient streamlining of workmanship.
- Considering specifically the masonry sector, many subjects have to be dealt with:
- Strengthening the international links to consolidate Brazil's insertion in the global scenario;
 - Improve the standardization of Brazilian masonry products;
 - Modernize certain outdated masonry codes;

- Disseminate masonry courses in more Engineering Schools;
- Develop a broad coordinated research program to characterize the Brazilian masonry products, considering a set of uniform experimental procedures;
- Incorporate local natural materials, such as vegetal fibres, to improve masonry properties;
- Investigate themes directly related to high-rise buildings, mainly the efficiency of grouted blocks in compression and reinforced/grouted clay blocks under tensile stress;
- Training construction technicians.

7. SUMMARY AND CONCLUSIONS

Brazil is a young country with a number of needs. In the past few years the economic stability has provided the means for important developments. One of the country's largest demands is an improved housing system, in which the masonry sector has an important role to play. Industry and academia have their responsibilities in the process that can be largely improved by means of close cooperation. Brazil's insertion in the international research environment is mandatory to establish strong links, to benefit Brazil's improvement in technology and to provide room for international involvement in the whole process of masonry development.

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