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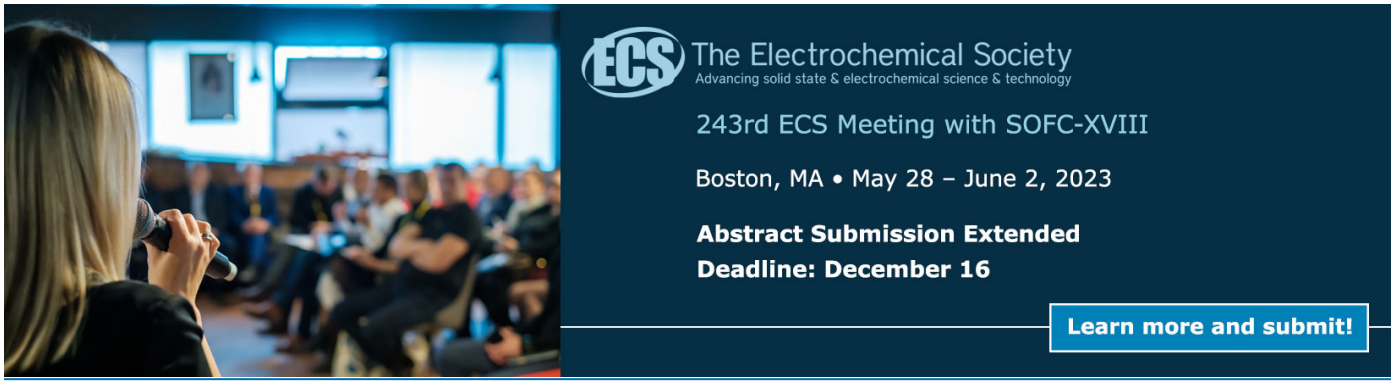
To cite this article: L R A Cardoso and G D R Freschi 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1101** 042001



Industrialization of housing construction in Brazil: current situation and trends

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Abstract. Brazilian housing needs are high. Even with important technological advancements taking place in recent decades, the degree of industrialization of housing construction remains relatively low in Brazil. The perception of the sector is that housing needs can only be equated by a significant increase in the industrialization of construction, and that the technologies available can support such increase. Currently, the existence of barriers and difficulties for industrialization are out of the production area, concentrated in the production chain, and in the macroeconomic, and political-institutional environments. The purpose of this paper is to provide an overview on the subject. For that, the following items were developed: technological base of housing construction, the main industrialization technologies available, and the barriers and difficulties to be faced in order to support the increase in industrialization. Finally, scenarios of the future trends of evolution in the sector are discussed. This research is exploratory, based on literature review, and the results may support actions in the sector aimed at overcoming the barriers and difficulties for industrialization. It may also contribute to increasing knowledge, and furthering studies on the subject.

1. Introduction

The lack of affordable housing in Brazil is a serious social problem that has lasted for decades.

Currently, this problem may be quickly translated into a housing deficit (need for new buildings) of about 6 million units (8% of all households in the country), of which more than 80% correspond to the population considered as low-income (family income lower than 3 minimum Brazilian wages, R$ 3,636.00, corresponding, in February/2022, to approximately US$ 720.00, considering an exchange rate of 0.20 US$/R$) [1]. The construction of approximately 1.5 million new homes per year with highly subsided costs, will be required within a 15-year horizon to significantly decrease the current shortage, and meet future needs [2].

The production chain of the construction sector is one of the most important industries in the country, representing about 9% of the Gross Domestic Product (GDP) [3]. It is the main creator of jobs in Brazil, employing about 10 million people [4]. The construction sector represents approximately 42% of the national production chain, followed by infrastructure, and specialized services, with 30% and 28%, respectively. In the construction sector, housing - the focus of this paper - accounts for the largest share in GDP, and job creation [3,5,6].

The construction sector is able to meet the housing needs already mentioned in this paper, also promoting the growth of economic activities, and the creation of jobs and income. But such demand can only be met by increasing the use of industrialized technologies, including high quality production, productivity, speed, and low costs [5,7,8]. However, housing construction still basically uses conventional technologies, despite the important technological evolution that the sector has gone through, especially in recent decades [9], and the high growth, between the early 2000s and 2015 [10].

On the other hand, production disruptions were reported in that last period of growth, including lack of workforce, with consequent delays due to conventional technologies that use intensive labor [7,11]. In this paper, this issue is not analyzed in-depth, but a synthesis of the types of housing construction technologies for the Brazilian context is presented in Section 2. It is supposed that the depletion of conventional technologies, mainly because of the lack of workforce, has driven the sector to increase industrialization [9]. The perception is that a large repertoire of industrialized technologies is available [12,13], some of which are briefly presented in Section 3.

Given the diagnosis that conventional technologies no longer adequately meet production needs, in addition to the availability of industrialized technologies, the question is: why has not the sector become industrialized yet?

This question can be answered, in part, for historical reasons [6,14,15] that are not covered in this paper. Currently, the answer is the existence of barriers and difficulties out of the production area, concentrated in the production chain, and in the macroeconomic, and political-institutional environments [12].

The purpose of this paper is to characterize the barriers and difficulties considered as important to increase the industrialization of housing construction, as well as to discuss the alternatives proposed to overcome them, and the future trends of this evolution.

For that, syntheses of the sector's technological base, and the available technologies are respectively presented in Section 2 and Section 3. Then, the main barriers and difficulties to increase industrialization, and the actions proposed to overcome them are characterized in Section 4. The factors that influence the overcoming of the main barriers and difficulties, and trends of evolution are analyzed in two future scenarios in Section 5. Finally, the conclusions and recommendations are presented in Section 6.

2. Construction housing industry: technological base

The Brazilian technological housing construction may be classified in four types, considering the contributions of Picchi [14] and Cardoso [15], as described in this section. This characterization applies to the Brazilian context, and not necessarily for other countries.

- Traditional construction - Elements are predominantly produced on the construction site, by processing natural materials, such as sand, stone, clay, wood, etc., with intensive use of workforce. This type of construction practically no longer exists in Brazil.
- Conventional construction - Elements are produced by processing materials and components supplied by the construction materials industry. The use of workforce is still intensive, but there is already mechanization, and prefabrication, to variable degrees, but not to a great extent.
- Rationalized, or rationalized conventional construction - Elements are produced with design and procedures that provide a significant increase in productivity, and quality, compared to conventional construction, with a reduction in losses, and waste. The main examples that can be mentioned are the rationalized formworks for reinforced concrete, molded on site, designed, and used with reduced consumption of wood, and maximization of reuse. Masonry walls are also entirely designed, with definition of modulation, and specification of blocks, joints, spans, lintels, and embedding installations, eliminating the improvisation of solutions on site. Workforce is still intensive, and originated from conventional construction, but with a higher degree of qualification, and training. There is a greater use of prefabricated, and industrialized components, such as cut and bent steel, drywall, mortar for laying and coating,

as well as kits for building installations and frames. There is also increased mechanization (cranes, and pumped concrete), and the use of equipment, and tools, that increase efficiency, ergonomics, and work safety, such as scaffolding, tubes, and projectors for mortar application, among others. Structural masonry falls within this classification.

- Industrialized construction - The main elements are produced off-site, with the predominance of assembly operations. The use of workforce is significantly reduced, and the use of equipment, such as cranes, is intensive. Productivity, and execution speed are high.

Conventional and rationalized conventional housing construction technologies predominate in Brazil. The latter may be considered as predominant in large centers among leading companies in the sector [9].

3. Available technologies

The technological evolution that took place in recent decades (1990, and especially after the 2000s) has now resulted in a wide and diverse range of technologies available for materials, processes, and construction systems.

Rationalized conventional and structural masonry continue to be the technologies most used among leading companies, as mentioned. Structural masonry stands out as the main technology for social housing, and it has also expanded to the middle- and high-income groups. Besides the quantitative expansion, the mastery of technology has enabled the construction of sophisticated buildings, with high towers (15 to 20 floors), flexible layout, overhangs, balconies, garages with transition levels, and relatively slim walls [16,17]. The main highlights in technological innovation that have recently become available are described below by subsystem, with contributions of Thomas [13].

- Foundations – The most important technological innovation was the introduction of augercast pile, which has become one of most important alternatives for deep foundations in São Paulo, and in other centers [9].
- Containment – Diaphragm walls, traditionally used in infrastructure works (subways), along with anchors, have become a widely used solution for buildings. Reinforced earth walls, and soil nailing also stand out as solutions for containment.
- Structural materials – The development of the high performance concrete technology stands out in the construction of a pioneering milestone in São Paulo, in 2005, using 125MPa concrete: the 160m-height E-tower building [18]. Several other types of concrete have also been developed, such as fiber-reinforced concrete, in addition to next-generation additives.
- Slabs – Steel deck, bubble deck, ribbed slabs, pre-slabs, waffle slabs, plain slabs, prestressed slabs, and not-prestressed slabs (in the case of prestressing using unbonded tendons) stand out.
- Structure-sealing systems – Concrete walls molded on site using various types of highly reusable formworks, prefabricated walls, steel and wood frame systems, engineered wood, and drywall are some examples.
- Facades – Prefabricated concrete panels, lightweight panels (cement slabs, and Glassfiber Reinforced Cement (GRC) slabs), steel and aluminum composite (ACM) panels, glass façades (glazing and unitized, with thermo-absorbent, and thermo-reflective glass), and engineering plastics (carbon fiber, polycarbonate, and stone façades) stand out as other examples.
- Coatings and paintings – High performance ceramic coatings, decorative mortars, textures, thermo-acoustic coatings, plastics, vinyl, rubber, natural and industrialized woods, and waterproofing systems stand out.
- Building systems – Ready bathroom, Chlorinated Polyvinyl Chloride (CPVC) pipes, thermo-cast pipes, PEX (cross-linked) systems, automated systems, water and energy saving devices and appliances, HVAC (Heating, Ventilation and Air Conditioning) systems, solar heating, and photovoltaic systems are also some of the innovation technologie.

4. Barriers and difficulties for industrialization

4.1. Costs and accessibility to industrialized technologies

Industrialized technologies generally have higher costs than conventional ones. One of the causes is the tax system, which penalizes industrialized construction, making it more advantageous to produce elements on site than to purchase them on the market [11,19]. This is the case, for example, with steel or precast concrete structures, which have significantly higher costs than those made of reinforced concrete molded on site. Industrialized structural systems are only feasible for industrial or commercial projects, in which the speed of construction provides a faster return on investment. This is not the case for long-cycle residential developments, as shown below. The Brazilian tax system also causes structural distortions that make it excessively burdensome, and unfair, to most taxpayers, especially those consumers of basic needs products, including housing. Currently, there are legislative bills in progress in the Brazilian National Congress aimed at improving this system, with no expectation of rapid approval, and no assurance that they will adequately resolve these issues [20].

Another factor related to this matter is production scale. Industrialized technologies require capital investments, and need large and continuous production scales, as well as the continuity of housing policies [6,19]. This does not always occur. In the 1970s, industrialized technologies were introduced for the first time in Brazil for the construction of large complexes aimed at reducing the housing deficit. These technologies were brought especially from Europe, and focused on structure-sealing subsystems: concrete walls and slabs molded with metallic forms (tunnel systems), and prefabricated concrete panels and slabs. Structural masonry was also used. Except for the use of structural masonry, which remained and expanded, the other subsystems were abandoned after the 1980s due to performance problems and the subsequent economic crisis in the country which resulted in the interruption of government housing programs [9].

The fact that industrialized technologies are available does not mean they are accessible to most companies and consumers, especially those outside large cities. In addition to the cost, there is a lack of available designers, specialized companies, supplies, and technical assistance for executing, operating, and maintaining industrialized systems [11]. This also relates to the need for increasing, and expanding the supply market, which depends on housing policies that encourage financing and production, especially for low-income groups.

Currently, the real estate market is relatively heated, mainly due to the more intense resumption of activities after the most difficult period of the Coronavirus pandemic. But, from a more general point of view, the situation is stagnated, or showing a slow economic recovery, and inflation is high. This scenario results in a loss of purchasing power in the consumer market, especially for low-income groups, which are the main potential housing consumers [21].

4.2. Lack of standardization, and performance issues

Brazilian standardization is still generally restricted to conventional technologies, which represents a barrier to the use of industrialized technologies [11]. In 2007, the National Technical Assessment System (SiNAT) was created, aiming to evaluate and certify non-standardized systems. In 2013, the Performance Standard [22] came into force, establishing minimum performance requirements, which must be complied with by law, regardless of the technology used. These actions represented an important advance for the use of industrialized innovations and systems, and also to curb the use of technologies not yet properly tested and evaluated, with the risk of compromising performance, as occurred in the 1970s, and 1980s. Many of the industrialized technologies currently used, such as concrete, and precast walls, also present performance problems, and require development, and adaptation to use [9]. However, SiNAT certification requires that companies using the technologies demonstrate compliance with performance standards. This results in high costs and deadlines, making large-scale certification unfeasible in practice [11]. Overcoming these challenges involves expanding the standardization of the industrialized components supplied by the materials and components industry. This industry is interested in expanding the market, and can afford certification costs. This

expansion requires actions from the production chain itself, involving certifying entities, and partnerships between companies, research centers, and universities, aiming at increasing standardization, and also technologically developing industrialized systems [5,8,23].

4.3. Long financing cycle

The construction business cycle is long-lasting. According to Leomil [24], the usual period between making the land available and handing over the keys is about 50 months. Within this cycle, the launching and construction stage lasts about 30 months, during which the purchasers of units pay 20% to 30% of the construction cost. The remainder is financed by banks and, upon the handing over of the keys, the financed amount is transferred to purchasers, to be paid off in up to 30 years.

This cycle requires a construction period long enough to enable purchasers to pay the financing installments. That is why conventional technologies are used [19]. In an industrialized process, the construction stage could be halved to just 10 to 18 months, and the development stage to 20 to 36 months. This would give the purchasers the advantage of significantly reducing delivery time. However, it would be more difficult for the same purchasers to pay 20% to 30% of the cost in such a short period. A proposal advocated by the construction sector is to discuss with the banks, especially the private ones, the use of another type of credit, called associative credit (already used by public banks for low-income groups). Within this modality, some adjustments would also be necessary to increase the guarantee of the banks, and increase the construction financing to up to 100%. The proposal also considers that the installments to be paid by purchasers during the construction stage are restricted to interest, which would substantially reduce their amount [24].

The adoption of these measures depends on negotiations between the sector, and the banks responsible for real estate credit.

5. Future scenarios and trends

As seen, of the 3 points mentioned in the section above, the one related to costs (Section 4.1) depends heavily on measures to be implemented by the legislature. The costs also depend on market growth, housing policies, and how the economy is conducted. All these factors are in the macroeconomic, and political-institutional environments. The standardization, and in part, the financing of the construction stage (Sections 4.2 and 4.3) depend more on actions by the sector itself.

As overcoming these barriers and difficulties will depend to a large extent on how the macroeconomic, and political-institutional environments will evolve in the coming years, two scenarios can be expected.

One scenario is the total or partial maintenance of the current situation, with a more conservative, and more liberal general orientation of the economy, with slow economic recovery, and low social spending. In this scenario, the real estate market should grow less, especially the segment targeting low-income groups, hindering industrialization. Meanwhile, the parliament tends to follow government guidelines, as has been the case in recent periods, with a greater possibility of approving the reforms that favor industrialization mentioned in the previous item.

Another possible scenario is the change in the current situation, in which a more progressive, and developmental government orientation would prevail, prioritizing social spending. In this scenario, the real estate market tends to grow and, unlike what took place in the last period of growth until 2015, this time with more intensive use of industrialized technologies. This scenario would favor the intensification of industrialization, and reforms that favor industrialization, and depend on the parliament, could be more hindered.

In either of the two scenarios, actions that depend on the sector should continue, and may favor industrialization.

6. Conclusions and recommendations

Brazilian housing needs have lasted for decades, and to face this situation, it is necessary to intensify industrialization.

The country counts on a technological base capable of sustaining the growth of industrialization, translated into an expressive range of technologies available and in use in the sector. However, further technological development is necessary to solve performance problems and adjust industrialized technologies to be applied in the country.

The barriers and difficulties for the industrialization of construction related to costs, standardization, and financing need to be overcome. This will depend to a large extent on how the future scenarios of the macroeconomic, and political-institutional environments will evolve, in addition to the actions of the sector itself.

It is concluded that, in the two possible future scenarios, industrialization is expected to grow, which may be more or less intensified depending on each context.

It is recommended that the diagnoses, and analyses presented in this paper are the object of further in-depth and follow-up studies, and that the actions of the sector itself are pursued with a view to increasing industrialization. It is also proposed that efforts are made by the sector to intensify engagement in the monitoring, and participation of institutional actions that favor industrialization in the macroeconomic, and political-institutional environments.

References

[1] Fundação João Pinheiro (FJP) 2021 *Déficit habitacional no Brasil*. Seminário Internacional/Pesquisa Déficit Habitacional e Inadequação de Moradias no Brasil. (Webinar), 04/03/2021
[2] ECCONIT/ABRAINC-Associação Brasileira de Incorporadoras Imobiliárias 2020 *Estudo técnico dedicado à atualização das necessidades habitacionais 2004-2030*. ABRAINC, nov/2020
[3] Castelo A M 2020 *Economia da Construção*. Apresentação. São Paulo, FGV
[4] FIESP/Departamento da Indústria da Construção 2021 *Indicadores econômicos da cadeia produtiva da construção*. São Paulo, FIESP
[5] Abiko A K, Cardoso L R A and Gonçalves O M 2005 O futuro da indústria da construção civil habitacional. *Ministério do Desenvolvimento, Indústria e comércio Exterior (MDIC)*. Brasília, Instituto Euvaldo Lodi, MDIC/STI
[6] Instituto McKinsey 1999 *Produtividade no Brasil: a chave do desenvolvimento acelerado*. Rio de Janeiro, Campus, 1999
[7] Souza R 2012 *Diálogos com a construção*. São Paulo, O Nome da Rosa
[8] Ceotto L H 2021 *Brasil Viável: Construção industrializada*. Webinar. São Paulo, CTE/Enredes/C3, 24/06/2021
[9] Barros M M S B 2013 *Tecnologias construtivas para produção de edifícios no Brasil: perspectivas e desafios*. Texto preparatório. São Paulo, EPUSP/PCC
[10] Maricato E 2011 *O impasse da política urbana no Brasil*. Petrópolis, RJ, Vozes
[11] Castro M L and Kruger P G 2013 Unidades de seleção tecnológica e inovação na construção habitacional no Brasil. *Ambiente Construído.* Porto Alegre, **v 13**, n 3, jul/set 2013
[12] Souza R 2021 *Brasil Viável: Construção industrializada*. Webinar. São Paulo, CTE/Enredes/C3, 24/06/2021
[13] Thomas E 2012 *Tendências de materiais, tecnologias e processos de construção de edifícios*. Seminário Gerenciamento de Obras, Tecnologia, Planejamento e Coordenação de Projetos. Manaus, 2012
[14] Picchi F A 1993 *Sistemas da qualidade: uso em empresas de construção de edifícios*. Tese (Doutorado). São Paulo, Escola Politécnica, Universidade de São Paulo
[15] Cardoso L R A 1999 *Metodologia de avaliação de custos de inovações tecnológicas na produção de habitações de interesse social*. Tese (Doutorado). São Paulo, Escola

Politécnica, Universidade de São Paulo
[16] Franco L S 2009 in Antunes B Alvenaria estrutural. *Construção Mercado*. Edição 41, jan/2009
[17] Nakamura J 2003 A redescoberta da alvenaria estrutural. *Techne*, Edição 75, jun/2003
[18] Thomas E 2016 O que caracteriza o concreto de alto desempenho, qual é sua aplicação e como o mercado tem usado essa alternativa? *Techne*, Edição 232, jul/2016
[19] Fundação Getúlio Vargas (FGV)/Câmara Brasileira da Indústria da Construção (CBIC) 2013 *Tributação, Industrialização e Inovação Tecnológica na Construção Civil*. CBIC, 2013
[20] Gonçalves R 2021 *Brasil Viável: Construção industrializada*. Webinar. São Paulo, CTE/Enredes/C3, 24/06/2021
[21] Câmara Brasileira da Indústria da Construção (CBIC) 2021 *Aumento persistente no custo da construção é principal marca de 2021*. https://cbic.org.br/, 16/12/2021
[22] Associação brasileira de normas técnicas (ABNT) 2013 NBR 15.575 Edificações habitacionais – Desempenho. Rio de Janeiro, ABNT
[23] Instituto de Pesquisas Tecnológicas do Estado de São Paulo (IPT)/Escola Politécnica da Universidade de São Paulo (EPUSP)/Faculdade de Arquitetura e Urbanismo da universidade de São Paulo (FAUUSP) 2006 *Projeto Brasil sem Chamas*. Grupo de Trabalho 01 – Diagnóstico e Prospecção. Brasília, Ministério da Ciência e Tecnologia/FINEP
[24] Leomil T 2021 *Brasil Viável: Construção industrializada*. Webinar. São Paulo, CTE/Enredes/C3, 24/06/2021