

The Challenges for Engineers to Change the Construction Method in Brazil

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Abstract—Developing countries have some restraints towards the adoption of new technologies and construction methods. Some nations, such as Brazil, still use conventional construction methodologies, knowing its lesser cost-effectiveness. This research has been conducted to demonstrate how industrialized construction methods should be implemented in Brazil, especially in times of need. Using the common sense among different authors with different perspectives, it is clear that the second method is more suitable for construction development because of its great advantages. However, it is unlikely for this process to be adopted in the country as a result of several social-economic restraints. Nonetheless, Brazilian engineers have a major challenge ahead of them, and it will take more than creativity to solve such an issue.

Keywords—Brazilian engineers, construction methods, industrialized construction, infrastructure.

I. INTRODUCTION

THE construction industry has an important social-economic role to play in developing countries, and investments in this industry represent between 5 % to 7 % of these countries' Gross Domestic Product [6]. Unfortunately, these nations have basic problems of infrastructure, education system and government management that impacts the Construction Industry. The lack of investments in technology and innovation worsens this situation. Due to this scenario, the industrialized construction method cannot stand as a primary construction method. The logistic to transport manufactured elements from a standard facility and the need for skilled labor to construct are the basic requirements for this method to be successful. For these reasons, plus the low initial cost, conventional construction is currently more attractive to developing countries such as Brazil. The construction scenario in Brazil has characteristics like poor skilled labor, low productivity, excess of materials waste and poor project planning. The lack of technology and innovation delays Brazil's construction industry and, thus, its economy. In addition, the economic scenario worsens this problem. However, civil engineers are mainly responsible for changing this situation.

The purpose of this paper is to analyze the construction industry in Brazil, by contrasting the construction methods, focusing on the basic social-economic problems related to

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Brazil. And finally, how engineers can change the construction method in Brazil to enhance the construction industry and avoid problems related to it.

II. CONSTRUCTION SCENARIO IN BRAZIL

The construction scenario in Brazil has characteristics such as abundance of natural resources, excessive concrete operations and lack of technology. Due to these characteristics most constructions in Brazil adopt the conventional construction method. However, this method consists of problems related to poor skilled labor, poor management and poor project planning which generates materials waste, poor quality of the final product, projects delay and overbilling, especially in public constructions.

Unfortunately, engineers do not have enough power or influence to modify this scenario, due to the government's inefficiency to regulate the construction industry and normally, engineers became hostages to the corruption system ruled by powerful companies and government agencies. In addition, politics and bureaucracy hide these problems and nothing is done to change the situation.

III. CONVENTIONAL CONSTRUCTION METHODS

Conventional construction is based on labor intensive methods, in which the structural elements (such as columns, beams and slabs) are made at the construction site, normally with reinforcement concrete [2], as displayed in Fig. 1. Because this material is a hand-made component, it needs highly technical and skilled manpower to attain suitable mechanical proprieties and qualities of the concrete elements.

Other roles in the building process that require skilled labor are masonry sealing and internal jobs (like painting and ceramic tiles), as shown in Fig. 2. These roles are also made on site and can create resource waste and rework without appropriate management and quality assessment.



Fig. 1 Conventional method to mix concrete and to cast it on site



Fig. 2 Residential house made with reinforcement concrete and brick masonry

The conventional construction method has relevant characteristics, such as low productivity, low initial cost, negative environment impact and adaptability during project enforcement. A description of each is written below:

- Low productivity: Normally it takes one or two workers to conclude one activity and they are carrying out several tasks during the project reinforcement, which slows the construction speed;
- Low initial cost: The components are made on site by the companies' workers, which reduces the cost of manufacturing parts;
- Negative environmental impact: Usually, although not always, workers are educated about conserving building materials; however, sometimes they are not enough qualified for the role, which increases materials waste;
- Adaptability during project enforcement and lack of planning: as the structural elements are built on site, the owners can change the project during the construction process, if they deem it necessary. This can generate over costing, resources waste and rework, because builders do not give the appropriate relevance to the project design/planning;
- And lastly, generally there is no consideration regarding energy consumption, water re-usage, landscaping and urban planning.

The conventional construction method is considered to be an outdated method due to the long time to build and waste of materials. The industrialized construction method avoids these problems due to its manufacture process, which will be explained in depth in the next section.

IV. INDUSTRIALIZED CONSTRUCTION

The industrialized construction method assumes assembling during the building erection with structural elements, which are joined together and installed in their final position [2]. In other words, the structural elements are put together to form the building frame, and each element has a specific spot. In addition, there are no elements made on site; they are all prefabricated off-site and transported to the construction site in another phase. For this reason, construction reinforcement is faster and the project design cannot be changed.

Companies that choose the industrialized method must be aware of processes that include logistics, transportation and manufacture management. They also must be aware of appropriate site storages to accommodate the elements and the space and machines required to handle long and heavy building elements. The construction process starts at a specialized facility away from the work area until the building process is underway on site.

The characteristics of industrialized construction methods are a faster building process, specialized skilled labor, initial high cost and no project adaptability. An explanation of each is given below:

- Faster building process: The structural elements only need to be installed in the correct position and location, and they are ready to uphold load. Different from the elements made with conventional materials such as concrete, they do not need to wait several days until they reach the minimal resistance to uphold load;
- Specialized skilled labor: The building erection requires fewer tasks, consequently, the teams need to be specialized in doing one or two tasks, which increases productivity and reduces labor costs;
- Initial high cost: Prefabricated elements are more expensive than conventional elements, because their cost integrates labor cost at the facility, better product quality and transportation to the working area;
- No project adaptability: Due to the specific position of the elements and their predetermined shape, there is less flexibility to make modifications during building erection;
- Less environment impact: The owner's facility will not afford to lose money and resources through materials waste. In addition, this company will have a very rigid manufacture process, which reduces exaggerated materials waste and increases product quality [2].

The types of materials that are used in industrialized construction are those that must pass through a manufacture process in a standardized facility or factory. The main examples are precast concrete, steel shapes, wood frames and light steel frames. Each material has its advantages and disadvantages, and they must be used depending on their availability near the construction region/area, because the cost of transportation and handling represents an important share of the gross investment. An example of industrialized construction is shown in Fig. 3.



Fig. 3 Example of a building made with industrialized construction method in Colorado, USA

V. CONTRAST BETWEEN THE CONSTRUCTION METHODS

To better understand the contrast between the conventional construction method and the industrialized construction method, a table with broad advantages and disadvantages was developed. Table I gathers the information well accepted among the references [4], [8]-[13]. Their ideas were united in addition to the authors claim. The yellow cells highlight an advantage over one of the methods.

TABLE I
TABLE OF CONTRAST BETWEEN CONSTRUCTION METHODS

Characteristics	Conventional	Industrialized
Type of labor*	Technical skilled	Specialized skilled
Productivity	Low	High**
Construction speed	Low	High**
Initial cost	Low**	High
Environment impact	More material waste	Less materials waste**
Machines uses	Less usage**	More usage
Labor cost	High	Low**
Materials cost	Low**	High
Site cleanliness	Less clean	More clean**
Cost-benefit	Low	High**
Project planning*	Less relevant	More relevant
Project adaptability*	Can be modified	Cannot
Material logistic*	Less relevant	More relevant
Manufacture elements*	Do not use it	Use it
Site work space storage	Less relevant	More relevant

*Subjective characteristic: it can be good or not depending on the type of the engineer responsible for the construction;

**Advantage over the constructive method.

The cost-benefit is the most relevant aspect in this contrast between methods. The industrialized construction method has a higher cost-benefit than the conventional method when the entire building process is considered. Due to the faster erection from industrialized method, it takes less labor/hour to conclude the build and, thus, reduces the total cost. The labor cost represents an important share in the gross investment (in both methods), and engineers must consider it before project implementation [2].

The engineers who will develop the project design must also be aware of all the characteristics and advantages of each method. The reason for this is because there is no better method for any type of construction. This means that depending on the site constraints, such as topography, resources availability, transportation systems (infrastructure), labor availability, stiff budget, technology availability and weather conditions, one method can be suitable or not [1].

VI. WHY BRAZIL USES THE CONVENTIONAL CONSTRUCTION METHOD

The conventional construction method is widely used in Brazil in the construction industry. The reasons for this phenomenon are directly related to some characteristics and constraints, such as initial cost, unlicensed builders and lack of government regulation, and poor acceptance of new technology in the construction industry.

The initial low cost of conventional methods is an important

factor that justifies builders selecting these types of materials. According to [14], developing countries do not give relevance to construction speed due to the fact that abrupt devaluation of the domestic currency usually does not occur during the year, so materials costs are stable. In addition, low income families are motivated to choose cheaper construction materials, such as conventional materials, over the more expensive industrialized materials.

Another important factor is the poor acceptance of new types of technology by engineers and business owners. According to [5], there is a gap between the developing of new technology and the implementation of it in the construction industry. There are two reasons for this phenomenon: The first one is that as the construction industry is a very broad sector with many responsibilities, engineers are not comfortable/ secure to change the construction method because employment losses are not acceptable, and the second is, usually, new types of technology are more expensive when they are developed, so many business owners will not accept the additional costs for new and unfamiliar forms of building material. Unfortunately, informality in the construction industry has increased exponentially in the last couple of decades in Brazil, the reasons for which will be discussed. In addition, poor governmental management and a lack of professional guidance have assisted the growth of informal cities, or slums (“favelas”), next to important metropolises, such as Rio de Janeiro and São Paulo. A picture of a slum in Rio de Janeiro is shown in Fig. 4.

Social problems have devastatingly increased in Brazil due to the lack of government regulation [7], and the construction industry is negatively impacted by it.



Fig. 4 Informal city or slum (“favela”) in Rio de Janeiro, Brazil

VII. SOCIAL-ECONOMIC PROBLEMS RELATED TO BRAZIL’S CONSTRUCTION INDUSTRY

There are some social-economic issues that directly impact the construction industry such as corruption, poor education and health systems, poor infrastructure and low family income.

According to [6]: “The construction industry is consistently ranked as one of the most corrupt industries worldwide. The impact of corruption goes beyond bribe payments to poor-quality construction of transport infrastructure with low-economic returns alongside low funding for maintenance”. In other words, corruption is widely present in the construction industry in developing countries, such as Brazil, and its consequences directly impact related areas like infrastructure

and maintenance. In Brazil's case, it also negatively impacts the country's education and healthcare systems. Investments in these areas are often diverted by the interests of powerful corporations and government agencies. The consequences of this process are the inefficiency of government to regulate the construction industry and poorly skilled labor. As a result, there is an increase of unlicensed builders and inferior building quality, which contributes to the informality of the construction industry. The bureaucracy and the politics behind it, delays the modernization of the construction industry because new types of technologies and state-of-the-art methods cannot be established which negatively impacts Brazilian communities [6]. The corruption in this system is a result of the poor selection of representatives (populist government measures accounts for a large portion of non-informed voters), the result of a poor education system. This vicious cycle can be seen in many other developing countries such as Mexico, Colombia, Paraguay, Venezuela, Argentina, Russia, China, India and several countries in Africa.

Despite large investments being made in Brazil's construction industry, such as "Programa de Aceleração do Crescimento - PAC" (Program of Growth Acceleration) and "Minha casa, Minha vida" (My house, my life), to reduce the housing deficit in Brazil (according to the Institute of Economic Applied Research - IPEA - in Brazil, there is a 5.2 million housing deficit, [3]), are affected by these social-economic issues. In addition, the inefficient construction practices, such as poor planning design and lack of professional guidelines, facilitate corruption in the construction industry. Unfortunately, to change the socio-economic scenario in Brazil would take many generations because to do so needs political reform and an increase in the quality of the education system. However, to solve the problems related to the construction industry in Brazil, the industrialized construction method could be implemented. With more project planning and suitable management, problems like embezzlement, materials waste, non-compliance with deadlines and poor construction quality would be avoided. In this way, corrupt agencies would face difficulties in trying to take advantage of it [6].

VIII. CONCLUSION

The challenges for civil engineers go beyond the constructions constraints. Defective and inefficient systems in Brazil, such as education, transportation and healthcare, as well as ineffective administrative management of the government, delay the development of the country. The social and political scenario caused by this crisis directly influences the construction industry and factors such as lack of technology, poorly skilled labor and informal constructions are consequences of this situation, which can be reflected in conventional construction methods. This reality cannot be accepted and engineers are responsible for implementing change. They must disseminate information by networking and through education in all areas related to the construction sector, government and the education system, so that a wider decision can be taken to change the construction scenario and,

thus, to build a stronger nation.

REFERENCES

- [1] S. Azhar, M. Y. Lukkad, and I. Ahmad, "An investigation of critical factors and constraints for selecting modular construction over conventional stick-built technique" *International Journal of Construction Education and Research*, vol. 9, 2013, pp. 203-225.
- [2] M. L. De La Torre, "A review and analysis of modular construction practices" *Theses and Dissertations*, 1994. Paper 275.
- [3] L. Genasci "Infrastructure: Brazil, the world cup and Olympics" *Americas Quarterly*, 2012. Retrieved from americanasquarterly.org.
- [4] F. C. Hadipriono, and R. L. Sierakowski "Concrete construction problems in far east Asian countries". *Journal of Performance of Construction Facilities*, vol. 2, n° 3, p.22644.
- [5] Y. J. Kim "Interviewer: Yuri Bessa Cesarino". University of Colorado, Denver, 2014, US.
- [6] C. Kenny. "Transport construction, corruption and developing countries". *Transport Reviews: A Transnational Transdisciplinary Journal.*, vol. 29, 2009, p. 21-41.
- [7] M. P. Morais, B. O. Cruz, and C. W. A. Oliveira, "Residential segregation and social exclusion in Brazilian housing markets" IPEA Discussion Paper 951. Brasilia, IPEA 2003.
- [8] S. A. Mahayuddin, and W. A. Z. Zaharuddin, "Quantification of waste in conventional construction" *International Journal of Environment Science and Developing*, vol. 4, 2013, n° 3.
- [9] R. Navon, "Economics benefits of lightweight versus conventional construction methods" *Journal of Construction Engineering and Management*, vol. 121, 1995, p.27-36.
- [10] G. Ofori, "Construction in developing countries" *Construction Management and Economics*, vol. 25, 2007, p. 1-6.
- [11] V.W.Y. Tam, C.M. Tam, S.X. Zeng, C.Y. William, "Towards adoption of prefabrication in construction" *Building and Environment*, vol.42, 2007, p. 3642-3654.
- [12] H. R. Thomas, "2000 Peurifoy lecture: Construction practices in developing countries" *Journal of Construction Engineering and Management*, vol. 128, 2002, p.1-7.
- [13] H. Voordijk, "Contemporary issues in construction in developing countries" *Construction Management and Economics*, vol. 30, 2012, p. 331-333.
- [14] J. Wells, "Informality in the construction sector in developing countries" *Construction Management and Economics*, vol.25, 2007, p. 87-93.