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Comparative budget Analysis of Residences for Population with Housing in High-Risk Area, focusing on the Conventional and Pre-Molded Construction Method in the City of Manaus-Am

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Abstract*— *This work aims to carry out a comparative analysis of conventional and precast construction systems for single-family homes for families living in high-risk areas in the city of Manaus-AM, according to the specifications and parameters of the Brazilian Association of Technical Standards – ABNT. The methodology applied was the case study, which represents a tool that serves to understand and enable the formulation of hypotheses and questioning of the work. In the analysis and discussion of the results, the differences between both construction methods were verified, through monitoring and data collection during the work and what is the best method to be used for the construction of single-family houses.

I. INTRODUCTION

In the current dynamics of civil construction, and given the numerous challenges faced, the choice of the construction system plays an essential role for the project's success, determining the best technique to be applied is a key factor for the execution of a work. In most Brazilian constructions, there is a predominance of the conventional construction method, which has been suffering detriment as it remains obsolete to other construction techniques.

However, human capacity continues to grow and evolve, creating and implementing new forms of construction technologies, and thus leaving an important legacy for future generations. Recent studies show that, in a globalized world and in face of market changes, the cost factor represents a decisive aspect for industries and civil construction is no exception.

The objective of this scientific article is to carry out a comparative analysis of the conventional and precast constructive systems of single-family homes for families living in a high-risk area in the city of Manaus-AM. For this, the research will follow the specifications and parameters of the Brazilian Association of Technical Standards - ABNT.

This research will include the following moments: at first the concepts related to construction systems will be addressed, at the second moment the execution time in the construction of the property will be measured using both methods, through the monitoring and use of the MS-Project software; present in a comparative way listing the advantages and disadvantages, in terms of quality and performance, of the constructive methods to be studied, using tools such as AutoCAD; register and identify the services, and the quantitative ones for the conventional and precast system, in the construction of single-family homes and, not least, technically and in detail, through the technical documentation, survey the execution processes inherent to each analyzed system.

Then, the analysis and discussion of the results is presented with the differences between the constructive methods, aiming to show the best method to be used for the construction of single-family houses, aiming at the fastest system, considering the cost, to remove this population living in a high-risk area in the city of Manaus-AM. It is worth noting that both study model houses will be built in Bairro Tarumã, West Zone of the municipality.

It is noteworthy that for the development of research on the topic, the option was for the case study type, where methods such as bibliographic research were used, through data collection in books, scientific articles, as well as documents and texts in a virtual environment.

II. CIVIL CONSTRUCTION AND MAN

Man, historically, has always been able to build large buildings. It continues to grow and evolve its techniques for building monumental and grandiose works, imposing and that have proven to resist time, defying gravity, to leave a rich heritage for future generations. There was, however, a "stop" on certain techniques and the use of certain materials for civil construction, mainly for homes. It is extremely urgent to review and acquire knowledge of new construction techniques toin order to modernize this sector, offer quality and facilitate the acquisition of housing in a universal way (VASQUES and PIZZO, 2014, p. 2).

In the national territory, there is a predominance of the use of the conventional system, whether construction in ceramic or concrete bricks. Despite the low productivity and, mainly, the large waste of materials and the presence of residues when this technique is used, it is noted that one of the biggest problems faced is the issue of good single-family housing at an affordable cost. The hypothesis was raised, given this situation, that little is sought or known about alternative solutions to the conventional system ((VASQUES and PIZZO, 2014, p. 2).

The lack of information and interest in alternative construction methods and techniques in relation to the conventional one ends up generating an insecurity in the choice, as it is a situation that involves high values, making it difficult for the majority of the population to acquire their own home.

2.1 SINGLE FAMILY RESIDENCE

Single Family Housing is a building designed to house only one family. Unlike an apartment building, where each apartment will house a family. Hence it is called Multifamily.

According to the Decree of Law No. 5,281 of August 23, 1985, in its art. 1st states that for the purposes of this decree, a residential unit of a single-family building is considered to be one consisting of at least 1 (one) habitable compartment, 1 (one) bathroom and 1 (one) kitchen, with the requirement of an area waived minimal useful.

Still in art. 3° establishes the following: Single-family residential buildings will have a minimum frontal distance of 3.00m (three meters) in relation to the street alignment. To better illustrate the composition of a standard single-family home, Figure 1 shows a floor plan of that home.

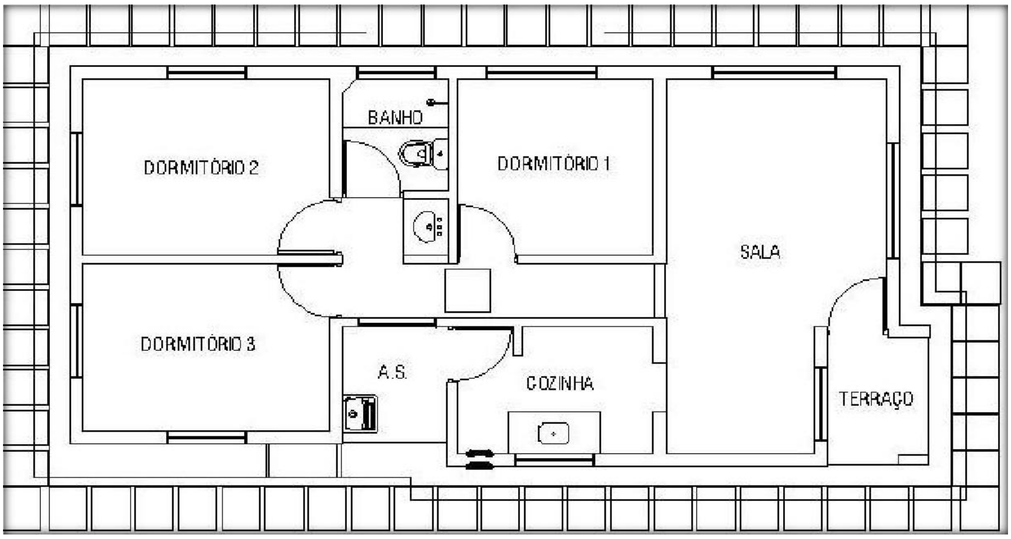


Fig.1: Planta baixa residência unifamiliar

Fonte: Campos, 2012

2.2 SOCIAL HOUSING AND REAL ESTATE FINANCING PROGRAMS IN BRAZIL

Before 1930, when the economy was based on the agrarian export sector, housing precariousness already affected the poorest population. In big cities, there were unhealthy tenements located in the central neighborhoods.

Later, according to Sampaio and Pereira. (2003), with the appearance of epidemics and pests, the government authorities recommended the demolition of these houses and the construction of new ones, outside the urban perimeter, and, to stimulate housing production, the government offered incentives to the private sector.

Thus, the public administration not only delegated to the private sector the measures related to the occupation of urban space, but also expressed the intention to segregate the working population in areas far from the central core of the cities, which allowed real estate entrepreneurs at that time to act freely according to your interests.

The Minha Casa, Minha Vida Program (PMCMV), launched by the Federal Government and executed by Caixa Econômica Federal, is a set of measures provided for in Law 11,977 of 2009 (BRASIL, 2009) and subsequent amendments.

Law 12,424, of June 16, 2011, which amended Law 11,977/2009, defined that the purpose of the PMCMV is to create mechanisms to encourage the production and acquisition of new housing units or upgrading of urban properties and production or renovation of rural housing.

Article 82-B defines that the PMCMV aims to promote the production, acquisition, refurbishment and renovation of two million housing units, from December 1, 2010 until December 31, 2014.

2.3 HOUSING IN HIGH RISK AREA IN MANAUS-AM (CIVIL DEFENSE)

In Manaus, 28,668 housing units are located in areas considered to be vulnerable, according to the municipal Civil Defense. A survey carried out by the Geological Service of Brazil (CPRM) Mineral Resources Research Company, points out that the North and East Zones lead the number of geological risk areas in the municipality.

On December 27, 2016, the defense agency dealt with approximately 130 occurrences related to the storm that fell in the city, the majority of which were slope slides and flooding. The most serious case occurred in the Nova Vitória neighborhood, East Zone, where a mother, 42 years old, and three daughters, aged 8, 10 and 14, were buried dead.

However, even though these facts were reported by the media and with the maximum warning of the danger by the local authorities, they were not enough, as people were not aware of the danger of building houses in high-risk areas, as shown in the house in Figure 2 :

Fig.2: House located in the Japiim neighborhood in Manaus-AM

Source: G1 Amazonas, 2016

According to a survey by the Civil Defense of Manaus, which classifies the risk areas into four levels, according to the degree of insecurity of the locations, 23.37% of the buildings in the capital are located in areas considered to be of high risk (R3), with 6,732 properties. (G1 - AMAZON, 2016)

Most of the buildings - a total of 12,396, which represents 40.89% - are in medium risk areas (R2). The number of buildings at risk considered very high reaches 1,451, equivalent to 6.14%. The Civil Defense also mapped the buildings that are in flood areas, which total 21.32%, with 5,626 constructions.

The Civil Defense survey takes into account risk areas that have losses due to rain. The CPRM, in turn, has mapped the vulnerable locations taking into account the places that register damage due to the flood of rivers. Based on this, the latest survey by the Geological Survey of Brazil identified 35,620 buildings, including homes, commercial establishments, industries, public buildings and others, in risky locations.

Also the G1 – Amazonas (2016), highlights that in all, the CPRM identified 735 risk sectors in the capital. Of the buildings in locations of geological vulnerability, 8,180 units are categorized into high or very high risk areas. The study estimates that 90% of the buildings are residential and occupied, on average, by four residents, totaling more than 128.2 thousand people living in risk areas in the city. The estimate is based on a survey by the Brazilian Institute of Geography and Statistics (IBGE) carried out in 2010.

III. BUDGET IN CIVIL CONSTRUCTION

In construction companies, when intending to carry out projects, one of the aspects to be taken care of is budgets. Its main focus is the construction of homes at a lower cost, using the most suitable construction system. Be it Conventional or Precast.

Steppan (2005, p. 20) states that the civil construction sector is experiencing a moment marked by the constant search for productive efficiency, the quality of its products and quick responses to the changes that occur in this segment. The need of companies in the sector, as well as strategic realignments, caused organizational and technological changes.

There are numerous possibilities for strategies to build a project, to obtain the best efficiency in budgeting, however, it is important to use new materials and residential construction technologies at a lower cost.

The budget stands out for being a valuable tool in conducting the activities of organizations, as well as in the process of identifying coordination problems. (STEPPAN, 2006, p. 51).

No project, regardless of its size and duration, will be carried out without a prior budget structure, which allows knowing the costs of this work to be carried out. However, it is an item that needs continuous review during the construction work.

For Limmer (1997, p.86) a budget can be defined as the determination of the expenses necessary to carry out a project, according to a previously established execution plan, these expenses, translated in quantitative terms. For a project budget, the following objectives must be followed:

a) Define the execution cost for each activity and service;

b) Become a contractual document;

c) Serve as references in the analysis of the income obtained from the resources used in the execution of the project;

d) Provide, as an instrument to control project execution, information for the development of reliable technical coefficients.

Therefore, the budget is of paramount importance in preparing a project to be executed. However, one must look at these fundamental criteria in relation to the budget of any project.

IV. CONSTRUCTIVE SYSTEMS

In Brazil, most constructions are characterized, particularly, by the lack of knowledge of other construction technologies, there is a predominance of the use of the conventional system, losing market by not investing in new construction alternatives.

For a country like Brazil, where there is a high deficit rate of low-cost homes, having access to good single-family housing, at an affordable cost, is a major challenge. Therefore, the hypothesis was raised that little is sought and/or is known about alternative solutions to the conventional system (VASQUES and PIZZO, 2014, p.4)

Bortolon (2004, p. 27) states that the adequacy of a building system is directly linked to the quality of the performance of the building in which it is used, whose performance, in turn, is related to the specific conditions of the context, also specific, of the place where it is intended to be built.

As analyzed above, it is not enough just to choose a construction system, it must be adapted to the specific conditions of what is intended to be built, considering all the variables that determine the construction. In this context, we will approach two types of construction systems, precast and conventional.

4.1 PRECAST CONSTRUCTIVE SYSTEM

The constructive system of precast concrete houses or buildings has been seeking innovations that tend to be better modulated and more standardized than the concrete structures executed on site, so the techniques can produce more economic benefits due to production in scale.

Precast elements are an option to improve and increase rationalization in the construction process. They are associated, particularly with the speed of execution, strict quality control, modular coordination and high organizational level, typical of the construction process.

According to the Brazilian Association of Technical Standards – ABNT – NBR 9062, it defines a precast element as one that is executed outside the final place of use in the structure, with quality control specified in the aforementioned standard.

4.2 CONVENTIONAL CONSTRUCTION SYSTEM

According to Darini (2006, p. 12), open systems are still called conventional when their main elements (walls, slabs and roofs) are executed at the construction site and use of conventional construction techniques and materials, such as bricks, concrete, wood, ceramic tiles or fiber cement tiles. In this constructive system, as stated by the author, it is the basic elements that compose it and that are used in the various constructions. Being them from the walls to the slab.

Still in the context of the conventional system, Bortolon (2004, p. 29) states: In the conventional system, the forms of wood, reinforcement and concreting of the structure are performed, after this step, the masonry and installations are carried out, which can often generate waste materials . The amount of labor is also high and rework may occur in some stages, increasing the final cost of the work.

In the application of this system, one of the most representative costs refers to labor, not to mention the cost arising from the waste of materials, which, once accounted for, represents a relevant value.

According to Vasques (2014, p. 3), the conventional system is formed by reinforced concrete columns, beams and slabs, and the spans are filled with ceramic bricks for sealing. The weight of the construction, in this case, is distributed over the columns, beams, slabs and foundations and, therefore, the walls are known as non-supporting.

During construction elements such as beams and columns are used. It is important to consider that to embed the electrical and hydraulic parts, the construction of the walls must be completed. Immediately afterwards, the coating step must be started, when the so-called thick mass or roughcast is applied.

After the construction of the walls, it is necessary to tear them apart to embed the hydraulic and electrical installations. The coating step, characterized by the application of roughcast, thick mass (plaster), thin mass (plaster) and painting, must be started next (VASQUES and PIZZO, 2014, p. 3).

V. THE CONVENTIONAL STRUCTURE IN BRAZIL

In the view of Vasques and Pizzo (2014, p. 3), in Brazil, the conventional structure, due to its enormous popularity, is still the most used, hence the familiarity with which civil construction workers have with the system. .

In Brazilian civil construction, the conventional system characterized by low productivity and mainly by great waste is still predominant, but the country already shows signs of mastering the technology of industrialized works, both in the industrial and residential areas, enabling the execution of constructions quickly and quality (VASQUES and PIZZO, 2014, p. 3).

This construction system uses steel bars, such as reinforcement, which are inserted into the cast concrete "in loco", in wooden forms, enabling the construction of structures that resist any type of load (GISAH and THOMPSON, 2013).

As a main highlight, these structures are commonly used in the construction process of homes in Brazil and with a certain predominance: when the main objective is quality and speed in construction.

5.1 REINFORCED CONCRETE

Reinforced concrete is, according to Martins (2009), the constructive system of walls and walls, or similar works, executed with natural stones, bricks or blocks joined together with or without mortar connection, in horizontal rows that are repeated overlapping each other over the others, or in similar layers, forming a rigid set.

5.2 DIFFERENCE BETWEEN CONVENTIONAL SYSTEM AND PREFABRICATED SYSTEM

According to the ABCIC (Brazilian Association of Industrialized Concrete Construction) manual, each material or construction system has its own characteristics, which, to a greater or lesser extent, influence the typology, span length, building height, bracing systems , etc.

Once the work to be executed has been planned, the characteristics of each material involved must be in accordance with its specifications. Therefore, it does not negatively influence the development of the construction system.

Along the same lines, Lordsleem (2001, p.17) explains that traditional masonry (conventional system) is characterized by high waste, adoption of constructive solutions at the construction site itself (at the time the service is performed) by the mason or at the most by the master, lack of inspection of services, deficiency in standardizing the production process and lack of planning prior to execution. However Roman (2002) lists the following advantages obtained with prefabrication processes for ceramic panels:

a) Lower construction cost, both for structural panels and for fence panels;

b) Financial benefits from early construction, occupancy and sales

c) Increased quality control associated with greater construction speed and effective production of elements simultaneously;

d) Possibility of construction without climatic restrictions;

e) Cost and waste reduction due to process repeatability and transparency;

f) Greater effectiveness in monitoring the product with elimination of waste;

g) Possibility of using standardized fastening systems for masonry panels;

h) Possibility of manufacturing panels with all finishes incorporated;

i) Shorter execution time on site.

5.3 OTHER CONSTRUCTIVE SYSTEMS

Thus, we will use the parameters created by the SINAT (National Technical Assessment System) of the PBQP-H (Brazilian Habitat Quality and Productivity Program) to determine the technologies that will be analyzed.

5.3.1 Industrialized Building Systems

According to Ferreira (2014, p. 22), industrialized elements are understood as ranging from the simplest parts such as small elements of hydraulic installations to larger elements such as panels, floor slabs, etc. The qualitative derivation from the concept of element to component suggests the individualization of parts of a building into subsystems, such as roofing, fences, foundations and structures.

The constructive system is a set of essential parts in the process as a whole and that guide the most efficient method of execution. It also encompasses the systems and subsystems involved throughout construction as a whole.

In the view of Greven and Baldauf (2007), industrialized building systems have become increasingly necessary for modern civil construction, due to the need to have greater productivity within less time.

Thus, construction sites have actually been transformed into systems for assembling systems, also bringing as advantages a greater organization of the construction site and a reduction in material waste, impacting both in terms of expenses and the environment.

5.3.2 Traditional Building Systems

According to Campos and Lara (2012), these are the systems that have already been standardized by the country and have already passed the tests established in standards, having been “accredited” by the technical evaluation institutions.

5.3.3 Concrete Wall Construction System

The concrete wall construction method is a system that refers to the use of formwork that is assembled at the construction site, to then be filled with concrete, already with the

built-in hydraulic and electrical installations. The main characteristic of the system is that the fence and structure constitute a single element (MISURELLI and MASSUDA, 2009).

This system is recommended for projects that have high repeatability and can be used in small, medium and high standard projects, due to its great versatility. According to ABCP (2007), what defines the choice is a careful cost analysis, which takes into account all factors such as labor and construction time with their charges. They can be used in buildings of one-story houses, townhouses, buildings up to six floors, buildings up to nine floors with only compression efforts, and even having examples of use in buildings up to 30 floors.

5.3.4 Taipa or Pau a Pique

According to Campos and Lara (2012), Pau a pique, also known as hand rammed earth, rammed earth or hedge rammed earth, is an ancient construction technique that consisted of interweaving vertical woods fixed to the ground, with horizontal beams, usually bamboo tied together by vines, giving rise to a large perforated panel that, after having the openings filled with clay, was transformed into a wall.

Although it appears to be in disuse, many houses are built using this system, particularly in rural areas and further away from urban centers. In it, the living conditions do not offer any comfort, starting with the ground, which is actually made of dirt. It could receive a smooth finish or not, remaining rustic, or even receive whitewash paint. Figure 3 presents an example of this type of construction system.

Fig.3: House built with Taipa or Pau a Pique

Source: Campos, 2012

5.3.5 Wood Frame

Wooden construction has always been very present in Anglo-Saxon countries and, with the colonization of America, these people brought with them their knowledge and traditions in joinery and carpentry (CAMPOS and LARA, 2012, p 11-12).

The Wood Framing constructive system is composed of sections of wood and closing plates (OSB, cement or plasterboard) that work as bracing of the structure. As it is a relatively light building, we find the radiator and running shoes as foundations. After the structure is assembled and before the execution of the internal closures, the hydraulic and electrical installations are placed in the "shafts" of the structure.

Fig.4: Wood frame construction

Source: (Fields, 2012)

5.3.6 Steel Frame

The Steel Framing system, also known as Light Steel Framing, is an evolution of the "Wood Framing", a self-supporting constructive system used mainly in North America (Canada and the United States). Its prototype was launched at the Chicago World's Fair in 1933. Basically, the structural design is the same as the system with wood, which was replaced by steel.

"Process by which a structural steel skeleton is made up formed by several individual elements linked together, these working together to resist the loads that demand the building and giving shape to it" (FREITAS, 2006. p. 12) .

In that decade of the 1930s, particularly in New York City, many of the structures were made using this method. Even because of the durability and practicality. It has a resistance to building loads like no other material as shown in figure 5:

Fig.5: Steel Frame Construction

Source: Campos, 2012

VI. STUDY SCENARIO

At this stage, the results acquired following the study methodology are presented. Following the presentation of the results in the same way as the methodology used to analyze the information.

Comparisons between the two construction methods, both conventional and precast, the respective calculations and measurements were carried out. In addition to the budgets, which were organized in tables and charts for better understanding.

Given this assumption, the analysis and discussion of the results was based on the problem that exists for many families who are living in high-risk situations. In all, according to a survey carried out by the Civil Defense in Manaus, 28,668 housing units are located in areas considered to be vulnerable.

According to the Civil Defense of Manaus - which classifies risk areas into four levels, according to the degree of insecurity in the locations - 23.37% of the buildings in the capital are located in areas considered to be high risk (R3), with 6,732 properties (G1 - AMAZON, 2016). The data can be seen in table 1:

Table 1: Preliminary services in the Precast system

RISK AREA CLASSIFICATION	Total Buildings	Total in (%)
VERY HIGH RISK (R4)	1.451	6,14
HIGH RISK (R3)	6.732	23,37
MEDIUM RISK (R2)	12.396	40,89

LOW RISK (R1)	5.626	21,32
Others	2.486	8,28
Total	**28.688**	**100%**

Source: G1 - AMAZON, 2016

According to the previous table, a total of 12,396, which represents 40.89%, are in medium risk areas (R2). The number of buildings at risk considered very high reaches 1,451, equivalent to 6.14%. The Civil Defense also mapped the buildings that are in flood areas, which total 21.32%, with 5,626 constructions.

6.1 COMPARISON BETWEEN THE TWO METHODS

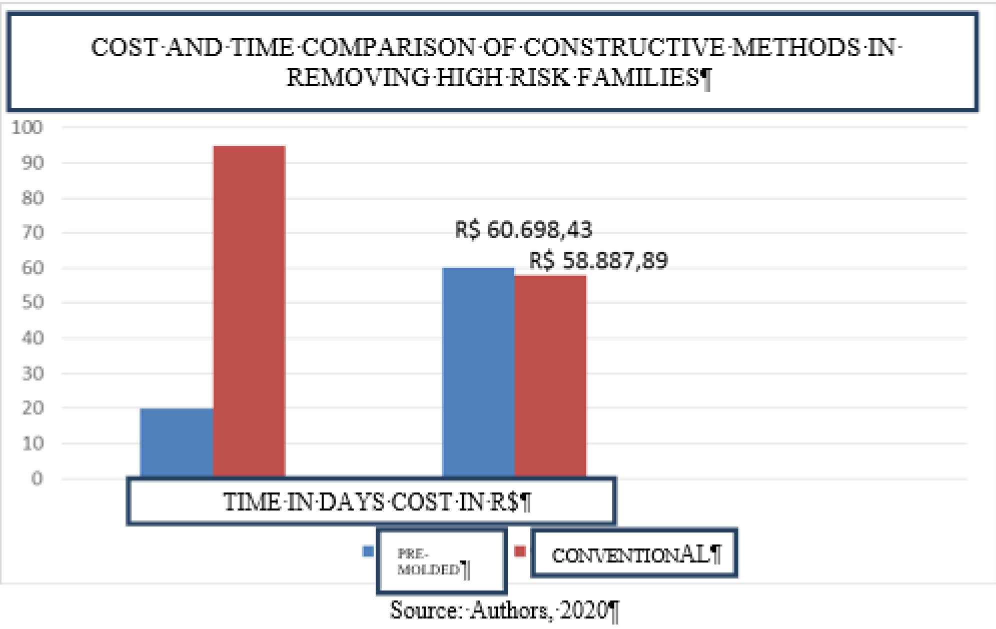
6.1.1 Comparison of the Steps Involving the Construction of Systems

This work seeks to establish the cost-benefit ratios between the construction systems discussed, that is, taking into account the aspects that involve the shortest duration and execution cost.

For this purpose, budget spreadsheets and construction statements are being presented, as can be seen in Appendix B, with a particular focus on the cost and execution time variable of each of the construction methods under study.

Graphs 2 and 3 show the emphasis of each stage of the construction methods, thus showing the duration of each construction system through the Gantt chart, being able to visually demonstrate the most efficient system that presents a shorter execution time.

Graph 1 shows the comparison of cost and time it would take to use each building system to remove families from high-risk housing.



Graph 1: Comparison of costs and time between the two construction systems

Source: Authors, 2020

According to Graph 1, it can be seen that, despite the precast system becoming more costly, in terms of time it is more advantageous for the removal of families who are living in high-risk situations.

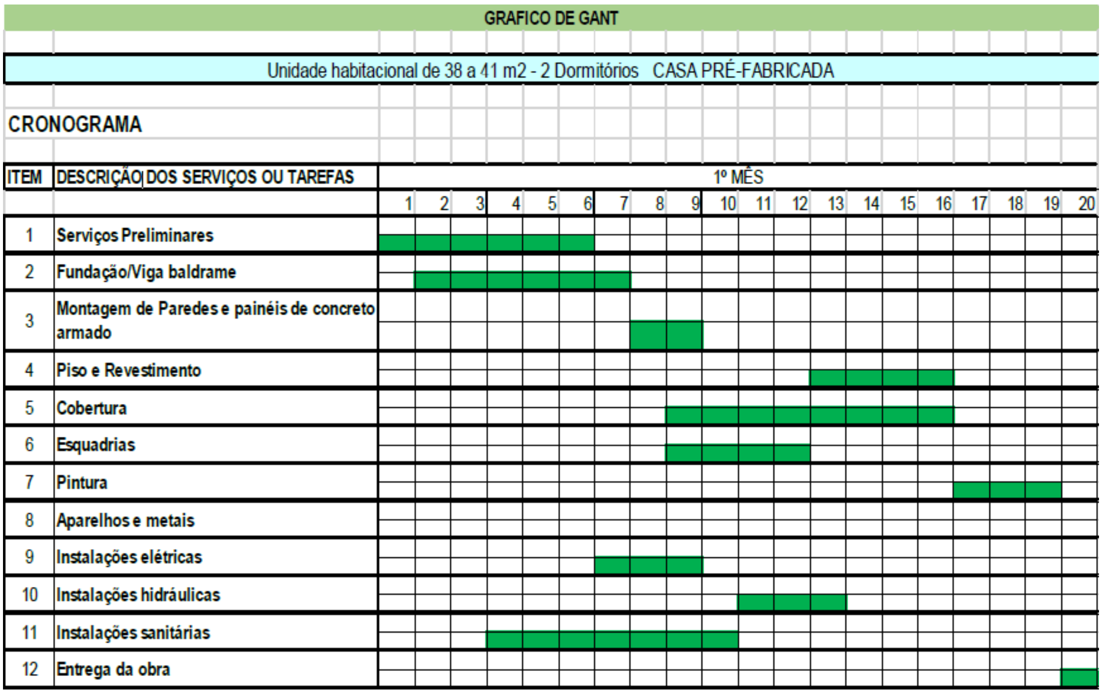
6.2 PREFABRICATED SYSTEM - WORK EXECUTION TIME

In order to carry out the schedule, the MS Project 2013 software was used, in it, the services and their respective dependencies were launched, that is, which service needs the other to finish to start being carried out.

For this purpose, it was defined (based on the data obtained in the dimensioning of teams) how many days each service would take, thus obtaining the schedule of the works.

According to the schedule for the execution of a work corresponding to a housing unit, consisting of 2 bedrooms and a corresponding area of 38 to 41 m². Throughout this work, it was found that the precast construction system was able to complete the delivery of the work within 20 days.

Graph 2: Construction Execution Schedule for a Prefabricated Housing Unit



Source: Authors, 2020

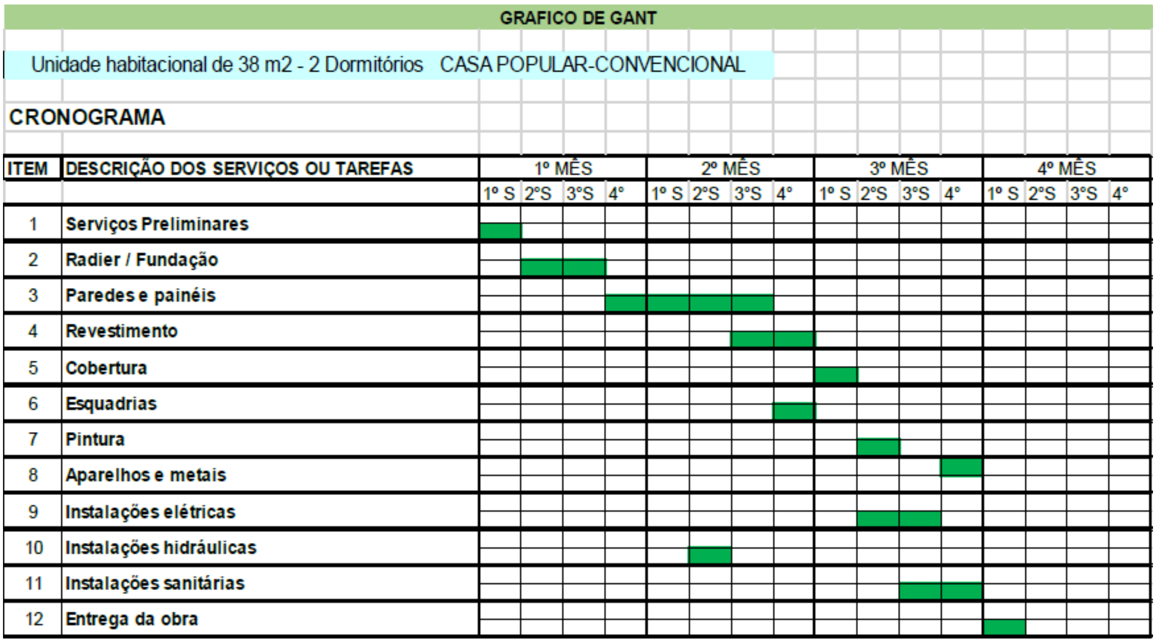
As illustrated in Graph 2, the precast system presented a reduction in the time of execution of the work, it was carried out in a period of 20 (twenty) days.

As highlighted by Melo (2004, p. 11), prefabricated materials have facilitated the construction process, minimizing concerns about the execution time and focusing more on the aesthetics of the work.

6.3 WORK PERFORMANCE TIME - CONVENTIONAL SYSTEM

Regarding the execution schedule for the conventional construction system, the delivery time for the work was much longer than that presented in the prefabricated construction system. The present work found that, in the conventional constructive system, the time for the execution and delivery of the work, constituted of 2 bedrooms and a corresponding area between 38 to 41 m². The same, extended for a period of 95 days approximately - 3 months and 1 week.

As expressed by Lordsleem (2001, p.17), mentions that traditional masonry (conventional system) is characterized by longer time in the execution of the work, due to the factors presented. See Graph 3 below, which highlights the duration schedule for the execution of the construction work in a housing unit using the conventional method.



Construction Execution Schedule of a Housing Unit Using the Conventional Method

Source: Authors, 2020

6.4 PRELIMINARY SERVICES

For the survey of the Preliminary Services variables, they were carried out through information collected during the empirical research at the construction site and through the budget spreadsheets for the comparison between the constructive methods under study – conventional and precast method. See Table 2 and Table 3 respectively.

Table 2: Preliminary services in the Precast system

	Quantity	**tems.**	**Unit Cost MDO.**	**Unit Cost MATERIAL**	
Preliminary Services					**R$ 1.756,60**
Construction shed, provisional installations	0,00	m²	R$ 286,00	R$ 398,00	R$ 0,00
Land clearing, construction site	100,00	m²	R$ 3,66	R$ 0,00	R$ 366,00
Location of work, land demarcation	70,00	m²	R$ 12,88	R$ 6,70	R$ 1.370,60
work plate	0,05	m²	R$ 0,00	R$ 400,00	R$ 20,00

Source: Authors, 2020

Preliminary services, in the Precast system, and foundations indicate 15% of the total cost

Table 3: Preliminary Services in the Conventional System

	quantity	**Items.**	**Unit Cost MDO.**	**Unit Cost MATERIAL**	
Preliminary Services					**R$ 7.912,00**
Construction shed, provisional installations	9,00	m²	R$ 286,00	R$ 398,00	R$ 6.156,00

Land clearing, construction site	100,00	m²	R$ 3,66	R$ 0,00	R$ 366,00
Location of work, land demarcation	70,00	m²	R$ 12,88	R$ 6,70	R$ 1.370,60
work plate	0,05	m²	R$ 0,00	R$ 400,00	R$ 20,00

Source: Authors, 2020

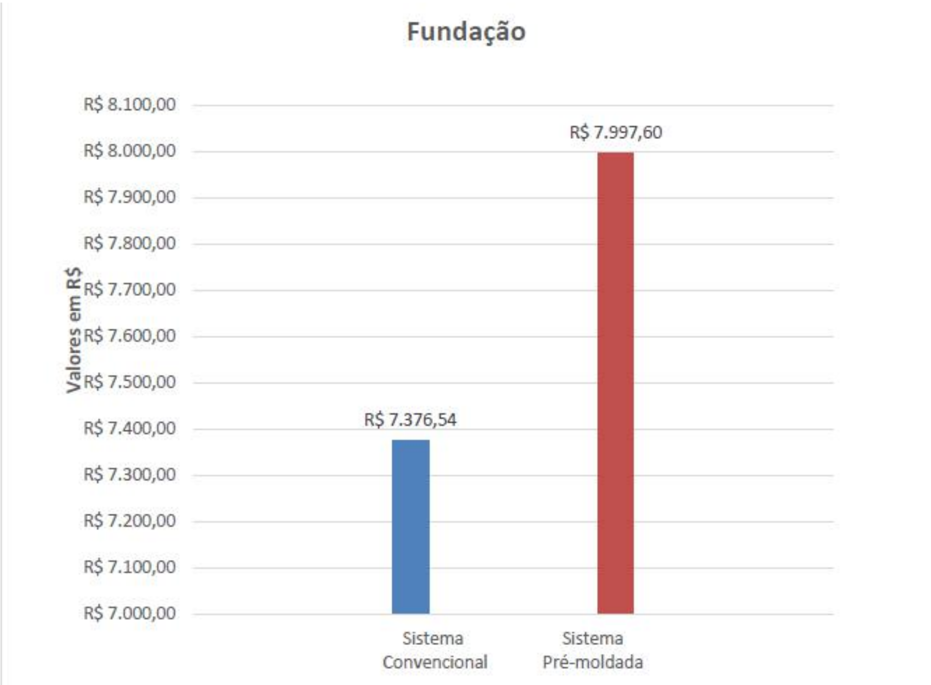
This emphasis on budget costs or to assess the best construction system is in line with what is intended to be achieved. The cost and time category is the most representative when choosing a construction method.

According to Steppan (2005, p. 20), the civil construction sector is going through a moment marked by the constant search for productive efficiency, the quality of its products and quick responses to the changes that occur in this segment.

6.5 DIRECT COST ANALYSIS

From the surveys, it is possible to compare the total prices of each service. The foundation service also has a difference in values between the three systems, shown in Graph 4.

Graph 4: Comparison of Foundations Costs



Source: Authors, 2020

In the previous graph, taking into account the foundation in prefabricated baldrame beams - reinforced concrete (worked) fck = 25 MPa, since the procedure has a certain similarity between both construction systems.

Thus, there is a difference of R$ 621.06 between the baldrame beams of precast masonry and the conventional system, being the most expensive first option. Therefore, one aspect that differs significantly for the mentioned price difference is the way in which they are not performed for the beams in the conventional system.

As shown in Graph 5, it shows the prices between the sealing structures of the two systems of studies, they are composed of the structure's services – masonry and panels in homes.

Graph 5: Comparison of Masonry Costs

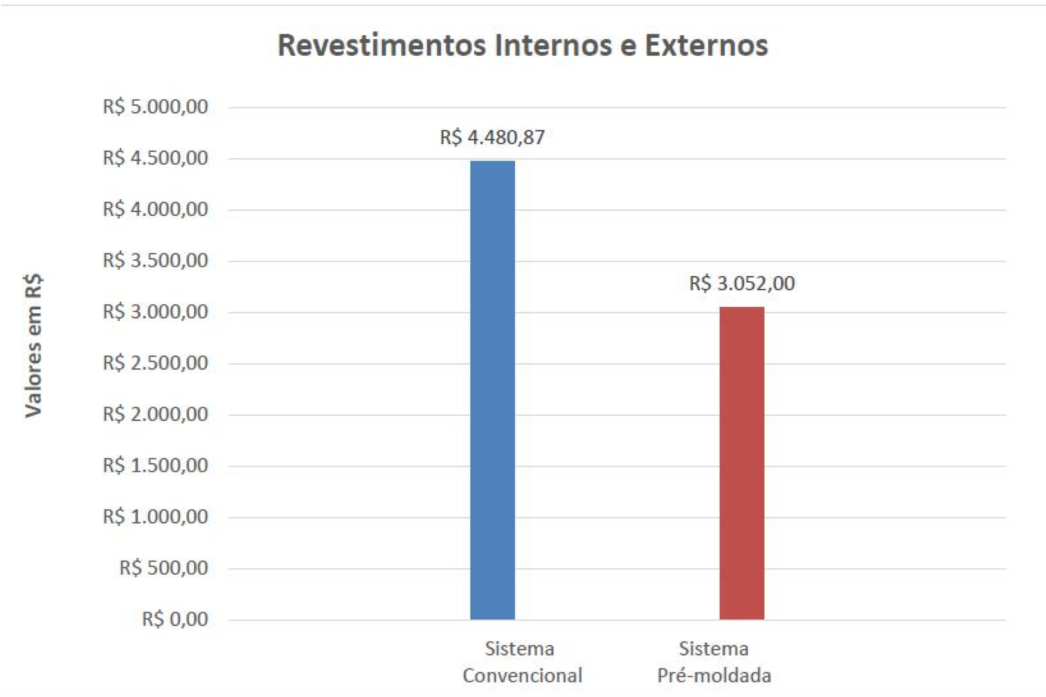
Source: Authors, 2020

Analyzing Graph 5, we can see the difference of R$ 8,432.35 between Conventional Sealing and Precast Sealing, the latter being more costly than the conventional method, when it comes to masonry structure.

This higher value is due to the high price of precast bases, joining this value with precast forms, cement slabs and plasterboard, which is also a higher price, thus having a more structure. costly than the traditional ones made of bricks and plaster.

It was found that when dealing with superstructure, the most affordable system, when analyzing only its direct costs, is that of conventional masonry. Next, in Graph 6, we can compare prices for internal coating, external coating and painting services.

Graph 6: Comparison of Internal and External Coating



Source: Authors, 2020

It is noticed that, in the comparison of the internal and external coating, a legitimate price advantage in the two construction methods, for the precast, it was R$ 1,428.87 cheaper than the conventional one.

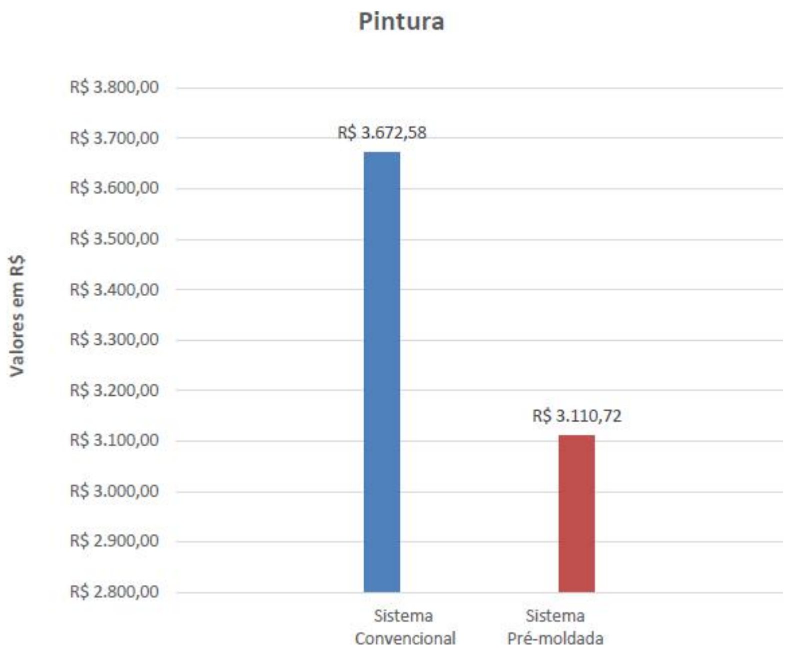
The total for the external and internal coating for the conventional system is R$ 4,480.87, resulting in more costly than the precast system, which totaled R$ 3,052.00.

This large price difference in coatings can be explained by the fact that roughcast, plastering and plastering services in the Conventional System are not performed.

The advantage of the Precast over the Conventional system was evident when it came to coverings, the reason is simple, the roughcast service is not performed on precast masonry. Therefore, in the external and internal coating, the precast system represented the best cost ratio, being less expensive than the conventional system.

Graph 7 is presented below with comparisons of costs in relation to painting in the two methods under study.

Graph 7: Comparison of Painting Costs



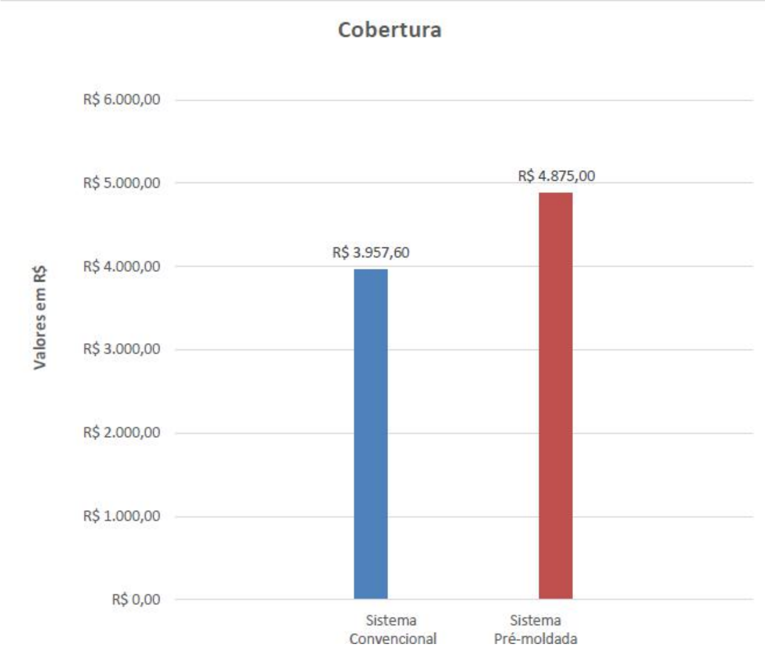
Source: Authors, 2020

In painting, we have an advantage of the Precast System compared to the Conventional System with similar values, the fact is due to the fact that it is not necessary to use mortar on cement slabs and plasterboard to apply the paint.

Therefore, painting in the Precast System was less costly, with a difference of R$ 561.86 in relation to the Conventional System.

Next, we present the coverage assembly, which is another system that has price disparity when this comparison of so-called direct costs occurs. Below is graph 8 referring to this analysis.

Graph 8: Coverage cost comparison



Source: Authors, 2020

When analyzing the data, it was observed that the coverage in the precast system was more expensive than the conventional one. That is, with a total of R$ 4,875, and in the conventional it was R4 3,957.60, with a difference of R$ 917.40 between both systems.

Note, then, that the precast system is R$ 917.40 more expensive than the conventional system. This difference is due to the cost of the transverse metallic structure on the roof, with roofing in trapezoidal galvanized tile.

6.6 COSTS PER SQUARE METER BETWEEN THE CONVENTIONAL SYSTEM AND THE PRECAST SYSTEM (R$/M²)

The budget was prepared based on the SINAPI Table (National Cost and Index Research System) and with TCPO cost composition budget spreadsheets (Price Composition Table).

Analyzing the results obtained by the work carried out and the field research, it was observed that for the Conventional Construction System, the total cost per m² without BDI (Indirect Benefits and Expenses), for the execution of a work on a 2-bedroom housing unit and an area between 38 and 41 m² was R$1,152.72, whereas with BDI it was R$1,436.29.

In the Precast Construction System, the total cost per m², without BDI, for the execution of the aforementioned 2-bedroom housing unit, and an area between 38 and 41 m² was R$ 1,188, 17 and with BDI it was R$ 1,480, 45. These values are well detailed in table 4.

Table 4: Budget of total costs per square meter, for both construction systems

CONVENTIONAL SYSTEM	**Total (R$)**	**R$/M²**
TOTAL WITHOUT BDI (BRL)	47.261,55	1.152,72
TOTAL WITH BDI 24.6% (BRL)	58.887,89	1.436,29
PRE-MOLDED SYSTEM	**Total (R$)**	**R$/M²**
TOTAL WITHOUT BDI (BRL)	48.714,63	1.188,17
TOTAL WITH BDI 24.6% (BRL)	60.698,43	1.480,45

Source: Authors, 2020

It is noticed that there is a difference between the conventional system and the precast system of R$ 35.45. Making the latter less expensive per square meter (m²), without the BDI. In this case, with the BDI included 24.6 % Indices given by the press, the difference between both systems was R$ 44.16. Representing a relatively low margin in quantitative aspects.

In this aspect, reinforces Limmer (1997, p.86), a budget can be defined as the determination of the expenses necessary to carry out a project, according to a previously established execution plan, these expenses, translated in quantitative terms.

VII. CONCLUSION

Given the facts presented, constructive systems have numerous advantages and disadvantages when compared to each other. Both in terms of costs and time of execution of a given work. Just like with regard to productivity.

Although, even with the numerous advantages presented over industrialized construction systems, the conventional construction system is still used on a larger scale in Brazil.

In the comparison presented in the work, it was noticed that one of the aspects that deserve to be highlighted was the time factor, as one of the work priorities, the displacement of the population living in high-risk areas. Based on MS-Project software, the Gantt chart was created, which shows the execution time of each system, visually explaining the execution time for each stage of the work, in this way the work pointed out the best constructive system to be used for the execution of these single-family houses, in relation to the time factor.

As in any constructive system, both the techniques and the materials have advantages and disadvantages, not only with regard to cost, but also related to the availability of materials, workability and execution, the performance of the workforce. All these factors influenced the choice of a constructive method.

The two construction systems were evaluated from a standard project with equal symmetry, it is noteworthy that the above-mentioned graph had an essential basis for the delineation of this work, it dealt with the physical and financial physical schedule, in addition to the difference between two methods. became spare in relation to the runtime.

As more "ad eternum" constructions are no longer admitted, with exorbitant prices, the precast system proved to be efficient with the results obtained, in the following parameters: shorter execution time, reducing the cost of project implementation due to the number of units to be built; increased quality control associated with greater construction speed and effective production of elements simultaneously; greater effectiveness in product monitoring, reducing waste; repeatability and transparency of the process; financial benefits from the speed of construction, and without climatic restrictions, having standardized fastening systems for the fence panels; in addition to the manufacture of panels with the finishes all incorporated.

Therefore, with this work it was determined that the best option when building a housing unit; with the best performance and the most cost-effectiveness in economic terms, it is undoubtedly the precast method. Due to the numerous advantages presented during this work.

Thus, as the term of execution of the work, as this work has shown to be carried out in 20 days, it definitely becomes the most effective system to be able to remove people who are in a high-risk area as soon as possible, also protecting the life of this population.

On the contrary, in the conventional construction system, this time would take an average of three months and a week, which would make it impossible to evacuate people, who are at high risk of housing in the city of Manaus. For future work, research in the areas of budget planning is suggested, which would add extensive technical knowledge in terms of projecting and building a work in Civil Construction.

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APPENDIX A *- Popular House Project - Floor Plan*