XXI ENTAC – Encontro Nacional de Tecnologia do Ambiente Construído
14 a 16 de outubro de 2026 | Goiânia-Brasil
DOI: https://doi.org/10.46421/entac.v21i1.8358

Modularity in prefabrication housing A Case Study

Stifany Knop
PROGRAU | Pelotas, RS | Brasil | stifany.knop@ucpel.edu.br
Luísa Felix Dalla Vechia
PROGRAU | Pelotas, RS | Brasil | luisafelixd@gmail.com

Abstract

The Brazilian construction industry has historically exhibited low levels of productivity when compared to countries with more industrialized production chains. To obtain more competitive results, building industry must consider prefabrication as a way to high performance in productivity and quality. This paper aims to analyze one offsite prefabricated house to understand how modularity and prefabrication are used in house building in south of Brazil. The methodology is divided into four stages: the first one was a literature review, second, choose the company that could provide the elements to analyze, third, analyze the design and the last one suggestion were made to adapt the existing blocks to the modular concept. It was possible to understand that with a little adaptation, the company could optimize the off site construction and transportation. Other typologies of Housing were tested to validate the proposal modules.

Keywords: Modular construction. Offsite construction. Housing. Prefabricated house.

INTRODUCTION

The Brazilian construction industry has historically exhibited low levels of productivity when compared to countries with more industrialized production chains [1]. Among the challenges that slow the advancement of industrialization in the Brazilian construction industry are the resistance of top management within construction companies, the high tax burden, the traditional mindset of the production chain, and the shortage of skilled labor [1]. Nevertheless, there is consensus that productivity gains and waste reduction depend directly on the adoption of industrialized processes, especially those based on off-site manufacturing–style production [2].

The transition to more industrialized methods, such as off-site construction, requires profound changes in organizational culture, process management, and supply-chain integration, since the traditional sector operates with high variability and a strong dependence on on-site labor. Thus, the adoption of industrialized approaches—including prefabrication, modular volumetric systems, and factory-assembled components—proves essential to bring Brazil closer to international standards, where rationalized and repetitive practices are already well established.

Off-site and modular construction are often used interchangeably, but they represent different levels of industrialization. [3], [4]. Off-site construction encompasses any process in which components, subsystems, or complete systems are manufactured in a factory environment prior to on-site assembly. Modular construction, in turn, is a subset of this universe, characterized by the production of complete three-dimensional volumes, structurally independent, finished or semi-finished, which can

Como citar:
KNOP, S., DALLA VECHIA, L. F Modularity in prefabrication housing - A Case Study ENTAC 2026. In: ENCONTRO NACIONAL DE TECNOLOGIA DO AMBIENTE CONSTRUÍDO, 21, 2026, Goiânia. **Anais**... Goiânia: ANTAC, 2026.

be transported and connected at the final site. Each module functions as an autonomous structural unit, enabling greater speed, standardization, and precision.

In Brazil, the intensification of industrialized construction has occurred mainly since 2010, with the dissemination of dry construction systems such as drywall and steel framing [5]. This movement stimulated the emergence of companies specialized in off-site solutions, some of which have evolved toward three-dimensional modular systems aligned with the model discussed by Ferreira [6].

It is within this context of the gradual expansion of modular and off-site construction in Brazil that the present study is situated. The objective of this article is to conduct a case study of a residential building constructed off-site and transported between cities, adopting the logic of three-dimensional off-site modular construction.

METHODOLOGY

The methodology of this study is divided into four stages. The first consisted of the theoretical grounding of the concepts of modular construction, mass construction, and mass customization. The second stage involved selecting the company and, together with the architect, choosing a project that would allow for a comprehensive analysis of the construction. In the third stage, the project was analyzed to understand the modular construction concepts employed in the manufacturing of the residence. In the fourth and final stage, studies of the modules were conducted, enabling the formulation of suggestions for adapting the existing modules to the modular construction concept. This adaptation allows for greater design versatility using mass construction principles, increasing productivity and construction speed, as well as facilitating transportation with smaller modules.

THEORICAL BASIS

Modular construction

Modular construction can be understood as an industrialized approach in which three-dimensional units—complete or semi-finished—are produced in a controlled factory environment and subsequently transported and assembled at the final site. This strategy allows for greater dimensional accuracy, a significant reduction in waste, improved quality control, and shorter overall construction time, characteristics widely reported in the international literature [7]. In addition, modular construction may offer advantages in terms of building performance throughout the life cycle, including increased durability, the potential for disassembly and reuse, and a reduction in environmental impacts associated with the construction process [8] [9]. However, its adoption depends on rigorous dimensional coordination, early design decision-making, and strong integration among architecture, engineering, and manufacturing, factors that distinguish this system from traditional construction methods [10]. Although this is a common scenario in developed countries [8], in Brazil this is not an ordinary technique, and it will demand a lot of effort until the Brazilian building industry change its mindset for a more industrialized construction. [1]

Scale of modularity

Modularity can occur at different scales, ranging from simple components to complete buildings, and this gradation is fundamental for the integration of architecture, engineering, and manufacturing processes. At the basic level, elements such as boards, profiles, and component kits can be organized into two-dimensional panels; at more advanced levels, complete three-dimensional modules emerge, capable of forming entire housing units or significant parts of them [11]. The concept of modular coordination is central to this process, establishing standardized multidimensional systems that ensure compatibility among elements and reduce variability in production [12]. This coordination allows modularity to be treated as a "product architecture," in which independent subsystems are integrated through predefined interfaces [13]. In this way, the scale of modularity guides both standardization and customization, defining the limits and possibilities of spatial and functional configuration within an industrialized construction system.

Dry construction

Dry construction replaces wet processes with faster, cleaner techniques that are compatible with off-site logic. This type of system—comprising steel frame or wood frame structures, prefabricated panels, and three-dimensional modules—allows a high degree of precision and dimensional control, reducing rework and facilitating on-site assembly [14]. Recent studies show that such systems are highly compatible with contemporary digital tools, such as BIM and manufacturing control platforms, which enhance efficiency in production and assembly [15]. Thus, dry construction constitutes a technical foundation for the development of more complex modular and off-site solutions.

It is possible to categorize dry construction into 3 different scales:

Frame:

"Structural grid" to which panels can be attached in different configurations, allowing design freedom without compromising the precision of the construction process [16].

Panel:

Constitute an essential link between frame-based structures and three-dimensional modules. Typically based on standardized dimensions these panels enable rationalized cutting, waste reduction, and greater compatibility among building subsystems [17]

3D Module:

Three-dimensional modules represent the pinnacle of industrialization in the construction sector, as they integrate structure, enclosures, building services, and finishes into a complete prefabricated unit.

Adopting Product Modularity in House Building to Support Mass Customization

Product modularity applied to residential construction makes it possible to combine the benefits of industrial standardization with the customization options demanded by users, a core concept in mass customization strategies. The work of Rocha, Formoso, and Tzortzopoulos [13] demonstrates that organizing a building into functional and independent modules—structural, spatial, and service-related—facilitates the creation of configurable variations while reducing the complexity of the production

process. This approach transforms the building into a “product architecture,” in which standardized interfaces allow layouts to be reconfigured without compromising manufacturing efficiency. Complementary studies further indicate that modularity, when combined with digital tools such as BIM and parametric platforms, expands the ability to deliver customized variations at an industrial scale, while simultaneously reducing variability and rework [17].

SELECTION OF THE COMPANY AND PROJECT FOR ANALYSIS

The city of Pelotas has a significant number of active and formally established construction companies; however, only a few operate using dry construction systems. When considering those working specifically with off-site modular construction, only two companies can be identified as actively operating. Due to proximity and market relevance, a company was selected for this case study, and to preserve its identity, it was named after Company A.

The project used for the analysis in this study is a single-family residence composed of five modules constructed off-site. The main challenges identified in this project were the transportation of modules measuring 3,20 m × 9,60 m and the hiring of a specialized company to lift the modules from the truck to the construction site.

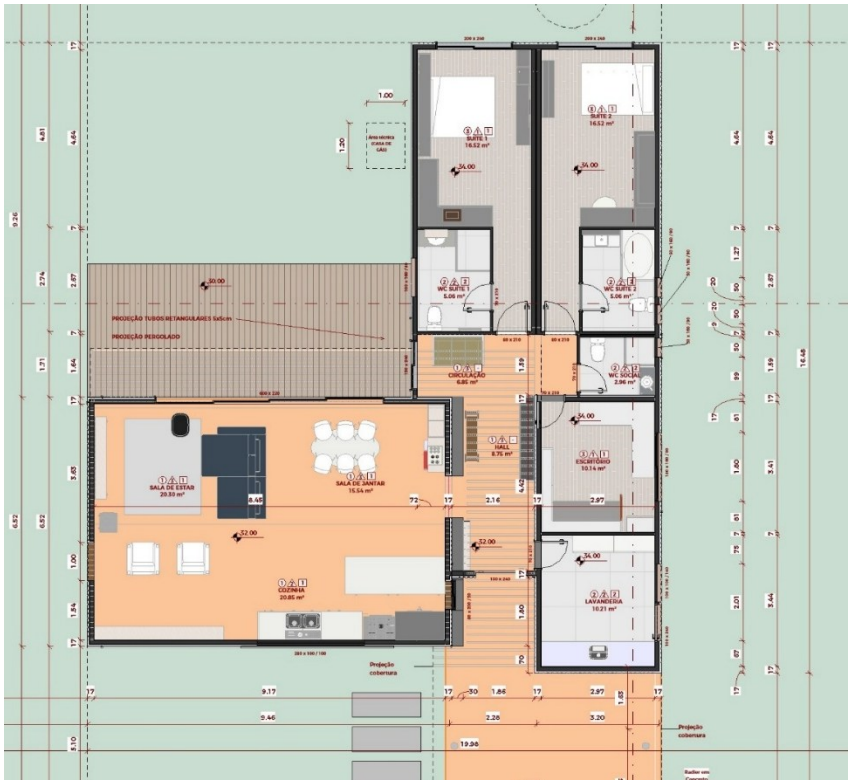
Figure 1 – Company A Design



Source: Company A.

The residence includes two en-suite bedrooms, a spacious social area comprising a living room, dining room, and gourmet kitchen, as well as a guest bathroom, a home office, and a laundry room.

Figure 2 - Blueprint – Company A

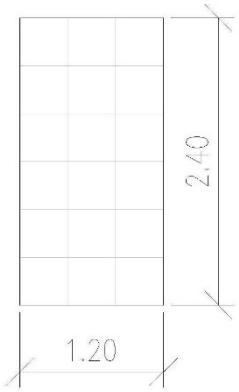


Source: Company A.

PROJECT ANALYSIS

The modular design premise highlighted during the interview with the architect and company owner is that by adopting a 0,40 × 0,40 m grid, modularity is ensured, and from this basis, design solutions become virtually unlimited. This grid is determined considering a standard drywall plate of 1,20 x 2,40 m in which a 0,40 x 0,40 m square is easily divided into 18 pieces, as shown below. This dimension is also a multiple divider for the steel frame, since it has 6,00m length. This kind of modularity helps the company to obtain a minimum waste and optimize the use of all pieces in one or other designs.

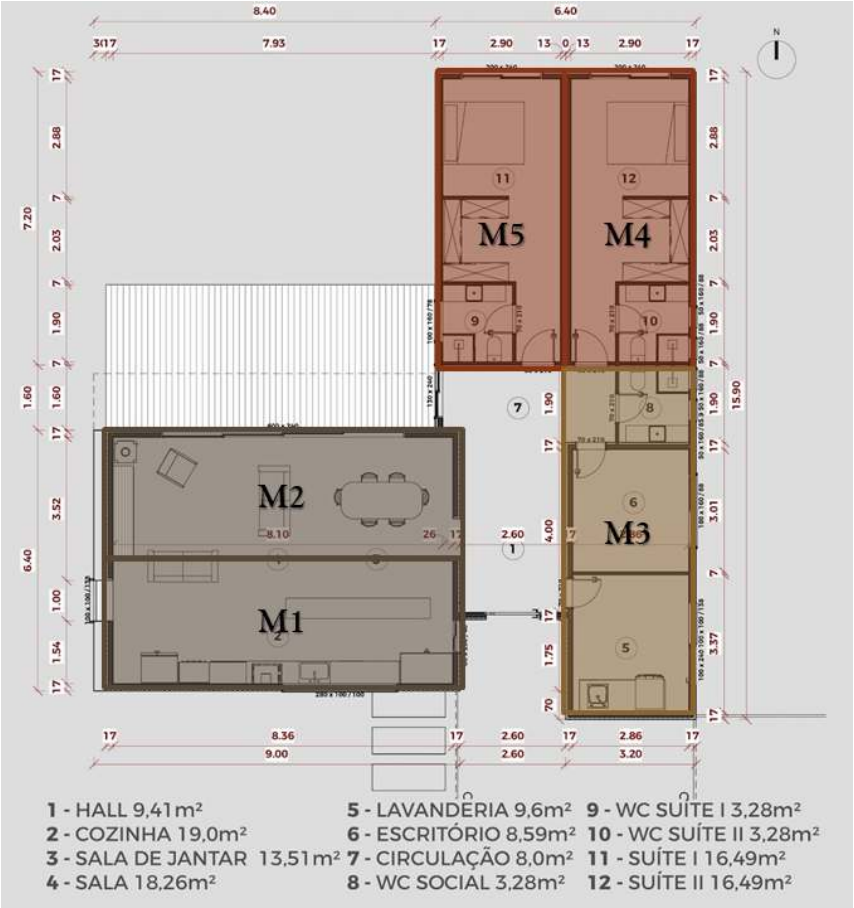
Figure 3 - drywall panel divided into 18 pieces



The project developed and delivered in the city of Viamão, RS, had module transportation as its main constraint. In this case, the maximum width of the units

could not exceed 3,20 m, which is the limit for transportation on a conventional truck without the need for escort vehicles to signal excess width, which would otherwise generate additional transportation costs. Therefore, the off-site construction of five distinct modules was defined for the project, as shown in the figure below.

Figure 4 – modules caractherization



Source: Adapted from Company A

The modules identified in the project are classified according to their assembly and numbered sequentially from 1 to 5, considering the quantity of units built offsite and transported to the construction site. However, according to the construction site plan, the modules have slight differences in dimensions, as shown in the table below.

Table 1 – Modules and measurements

Module	*Sector*	*Size (m)*
M1	Social	3,21 X 9,40
M2	Social	3,20 X 9,40
M3	Service / Private	3,20 X 8,75
M4	Private	3,21 X 7,60
M5	Private	3,20 X 7,60

Source: author.

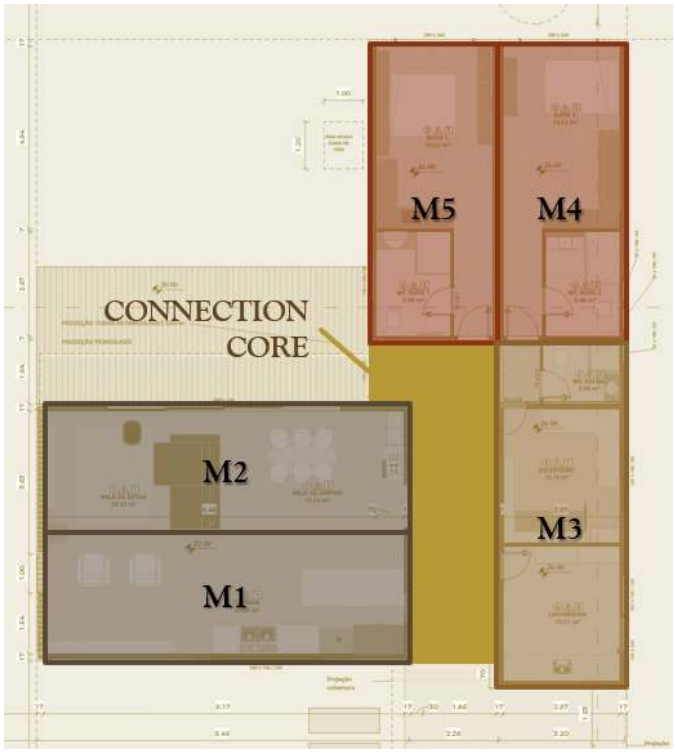
Modules 1 and 2 have very similar dimensions, however, they present very different needs. While module 1 houses the kitchen and provides for the installation of water, sewage, gas, electrical outlets, and lighting specific to its use, module 2 only requires power points and lighting. In this case, we have a clear differentiation from the concept of a module for the mass construction industry.

Module 3 presents more specific and different uses within the same module. It is housed in the same 3D block, a laundry room, bathroom, and office, with different dimensional and installation needs. The office space, due to its size and usage characteristics, could be used as a bedroom, for example, giving versatility to the use of this module.

Modules 4 and 5 are the suites and appear to be the same but mirrored. However, the customization of the modules introduced different layouts for the bathrooms.

As a construction strategy, the modules were assembled on-site using a connecting core as a strategy to unify the parts.

Figure 5 - relationship between modules and connection core.



Source: Adapted from Company A

The connection core is a non-modular component built on site. It enables the proper juxtaposition of the modules, integrating the different parts and functions of the residence in an optimized manner. In addition, the strategy of incorporating a non-modular element contributes to the customization of the building, resulting in a unique design.

After the analysis, it is possible to indicate that there is no evidence of real modularity, once Modules 1 and 2, and Modules 4 and 5, seem similar but have slightly different sizes and layouts.

For the company, modularity is seen in sizes – each module has a 0,40-width multiple, and even Modules 01 and 02 (3,21 X 9,40) do not apply to this rule and Module 03 (3,20 X 8,75) does not apply to this rule either.

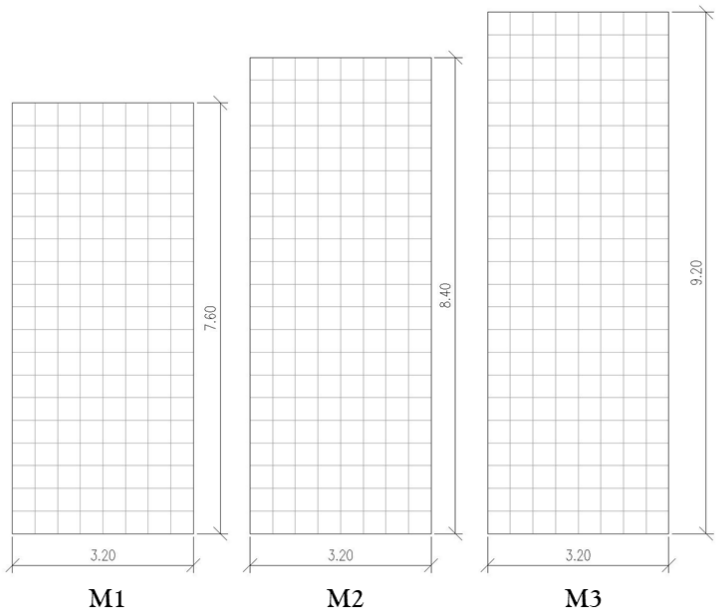
MODULES SUGGESTIONS

To adapt the modules, it is suggested we adopt measures with 0,40m multipliers. (figure 5):

- Module size 1– 3,20 x 7,60 (equal previous Modules 4 and 5)
- Module size 2 – 3,20 x 8,40 (to substitute Module 3)
- Module size 3 – 3,20 x 9,20 (to substitute Module 1 and 2)

This first idea was to only adapt with multiple of 0,40m to answer the primary modularity intend, without any other adjustment criteria.

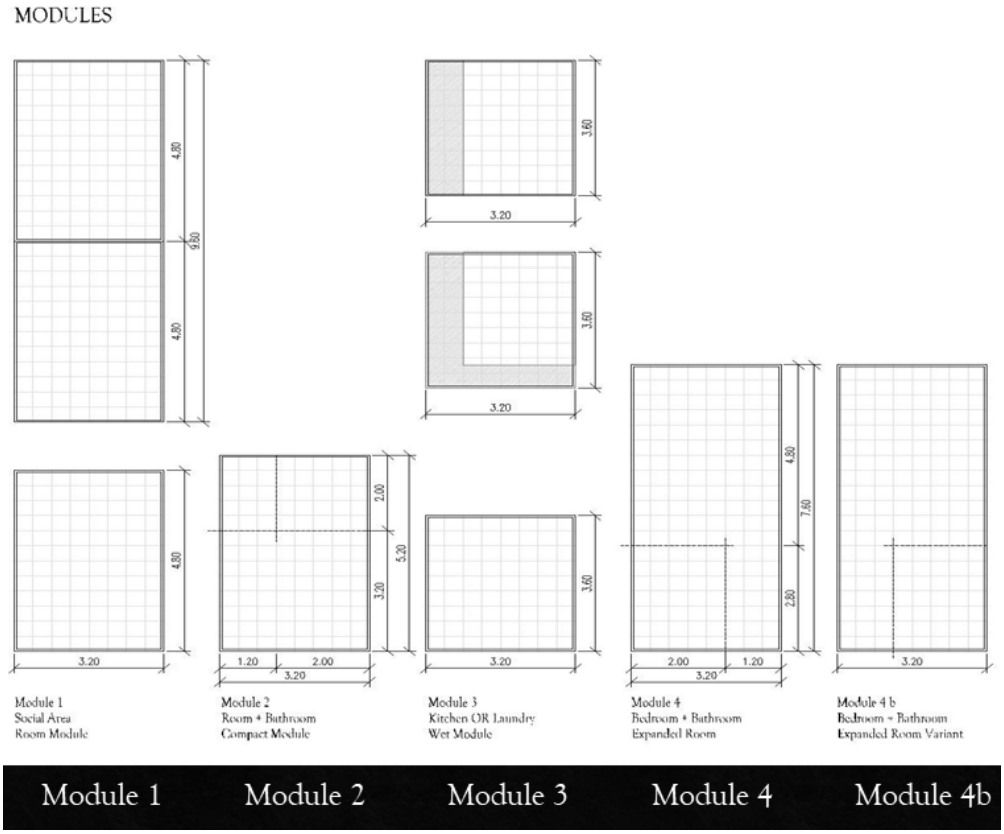
Figure 6 - First adapted modules



Therefore, second suggestions were made, since they are more versatile and could be used in different situations. They maintained the 0,40m module and approximated the measurements for the analyzed project, verifying the feasibility of the proposed ideas. For this, a maximum measurement of 7,60m was defined for the largest module.

In this scenario, 4 modules were proposed, with Module 4 potentially having a mirroring variation.

Figure 7 - Adapted Modules proposal



For Module 1, social or living use was proposed or another function that does not require special installations. It was designated as the 'Room Module' (3,20 × 4,80 m). These modules can be installed side by side, reaching the initial project dimension of 3,20 × 9,60 m.

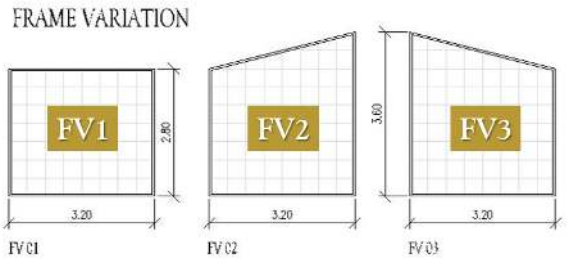
The original block that included the laundry, office, and bathroom was subdivided into two separate modules, providing greater versatility to the modular construction system. In this configuration, Module 2 encompasses the office use and a bathroom (3,20 × 5,20 m) and was designated as the 'Compact Module'. Module 3 was designated as the 'Wet Module' (3,20 × 3,60 m) and can accommodate functions such as a kitchen or laundry. In this module, a wet zone was defined to concentrate water, sewage, and gas installations. By combining Modules 2 and 3, a total dimension of 3,20 × 8,80 m can be achieved, which is close to that adopted in the original project for the described uses.

Finally, Module 4 replaces the original Modules 4 and 5 and functions as an 'Expanded Module', comprising one main space and a bathroom. The dimensions of Module 4 are (3,20 × 7,60 m), identical to the original configuration. The module variation occurs through mirroring, being designated as M4b.

It was also suggested that the elevation frame could be modular and variable. Three variations were proposed, as shown in the figure below.

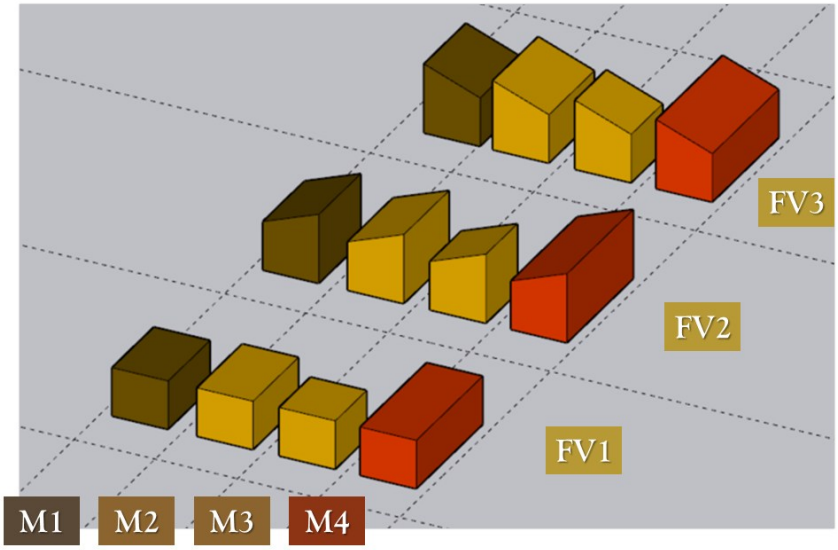
DOI: https://doi.org/10.46421/entac.v21i1.8358

Figure 8 - Frame variation



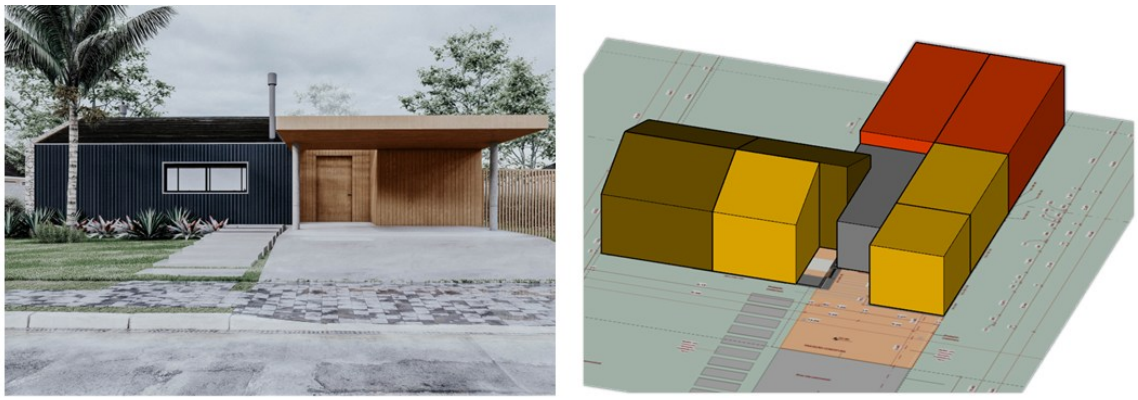
All these variations of modules and frames resulted in 12 modules that can be used according to specific needs (Figure 9).

Figure 9 - Modules and frames



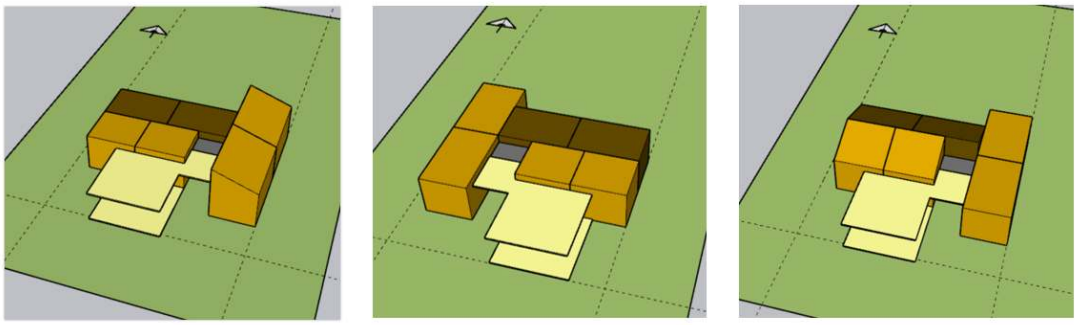
These suggestions for dimensional modifications of the modules were adapted to the dimensions of the residential project under analysis and enabled volumetric simulation, which yielded an acceptable result.

Figure 10 - Volumetric simulation



To test the proposed modules, an exercise was carried out in which the same site and program of the original project were used, proposing new architectural solutions.

Figure 11 - new layouts - same site and program

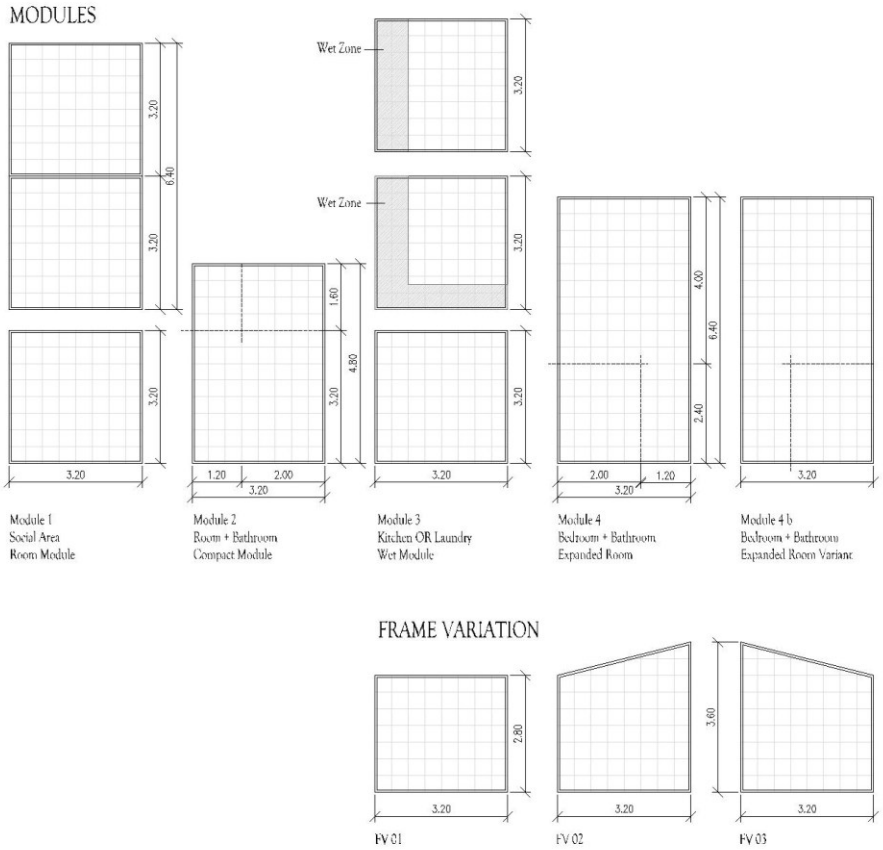


A key point highlighted by the studies is the lack of dimensional relationship between Module M1 (Room Module) and Module M3 (Wet Module), as they do not share proportional alignment in their longer dimension, resulting in connection cores with arbitrary dimensions.

MODULES OPTIMIZATION

After the initial analysis, it was possible to observe that merely adapting the dimensions to the 0,40 × 0,40 m grid did not allow for optimal interchangeability among the modules in relation to the overall block dimensions. In this sense, a new adjustment was carried out, this time considering the possibility of more modular connections between the units. The adjustment considered a true proportional relationship among Modules 1, 2, and 3, resulting in the following solution.

Figure 12 - Modules and frame optimization - Study 2



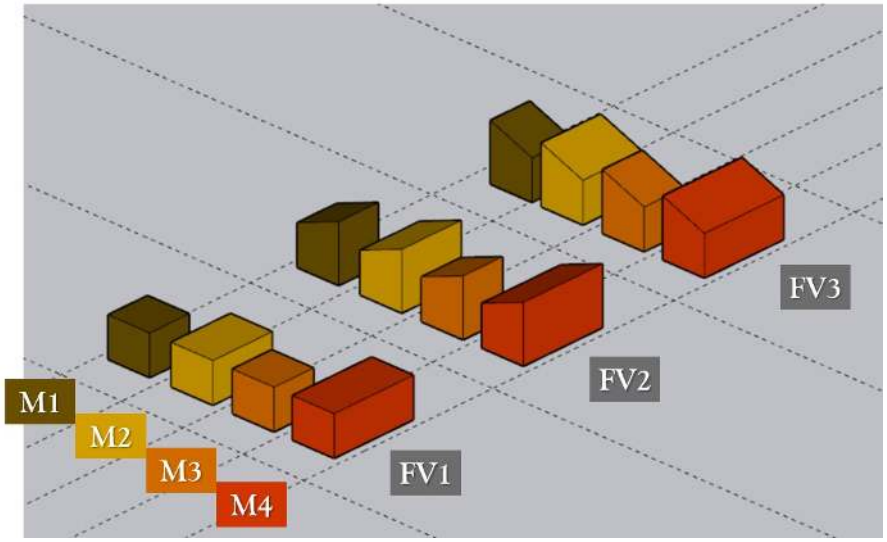
In this configuration, the modules are defined as follows: a full module (3,20 × 3,20 m – Modules 1 and 3), a one-and-a-half module (3,20 × 4,80 m – Module 2), and a double module (3,20 × 6,40 m – Module 4). With this modification, the volumetric studies were redone, resulting in a more consistent and optimized modular system.

Table 2 – Modules, designation and measurements

Module	*Designation*	*Size (m)*
M1	Room Module	3.20 X 3.20
M2	Compact Module	3.20 X 4.80
M3	Wet Module	3.20 X 3.20
M4	Expanded Room Module	3.20 X 6.40
M4b	Expanded Module Room Module Variation	3.20 X 6.40

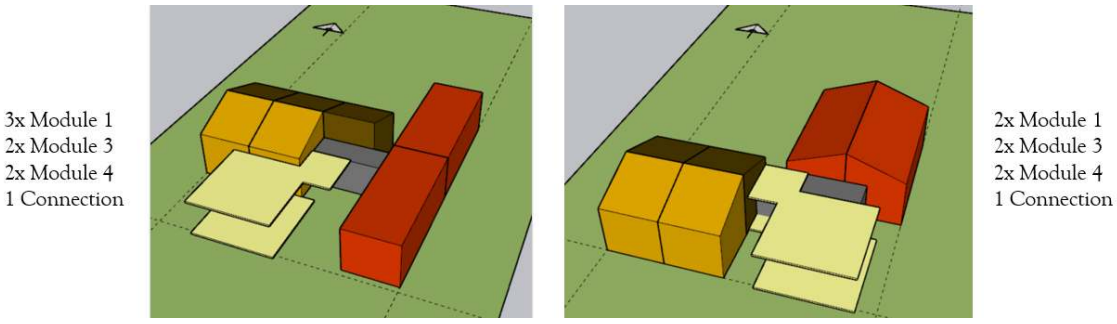
Source: author.

Figure 13 - New modules and frames



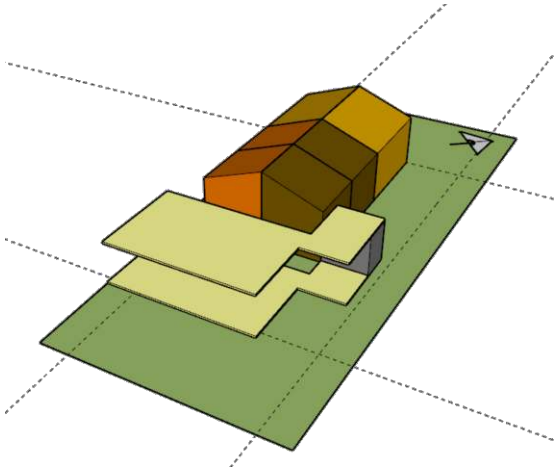
As a first study, the site and program of the original project were maintained, and new studies were carried out.

Figure 14 - new volumetric studies



To verify and validate the new modular proposal, a study was carried out for a smaller building, comprising two en-suite bedrooms, a kitchen, a laundry room, and an integrated living and dining area. A smaller plot was adopted, resulting in a reduced overall building size.

Figure 15 - Study 2 - volumetric



The solutions regarding formal composition and dimensions were deemed satisfactory.

CONSIDERATIONS AND CONTRIBUTIONS

The study carried out was conducted based on the bibliography used for the course Mass Customization in Architecture and Design and on the analysis of the modularity concept adopted by a company in a single project. It is noteworthy that the concept of modular construction, in the context of the analyzed project, consists of a three-dimensional block (floor, walls, and roof) built off-site and designed to be transported to the construction site. In contrast, the concept of modular construction at an industrial scale, or within mass construction, establishes that modules should be conceived as elements to be produced even before a client requests a project, thereby optimizing the construction process. In this sense, mass customization can be achieved at the level of finishes, block arrangement, and the size and positioning of openings, for example, unlike the analyzed project, which is specifically developed and customized for a particular client.

Perhaps the central issue of this study lies in the suggestion of a middle ground between these two approaches—the prefabrication of fixed modules that can be connected and combined according to client needs, allowing greater flexibility at the personalization stage. In this regard, the steel frame structure could be produced according to modular dimensions and maintained as a certain level of inventory, to be subsequently used and customized according to the specific project.

DECLARATION

During the preparation to this paper, first author used Gemini and ChatGPT to improve parts of the translation to English. All text was reviewed and edited by the author whose assumes total responsibility for the paper content.

REFERENCES

[1] ENREDES; CTE**. Industrialização e construção off-site.** Vol. 2. 2025. Disponível em: https://enredes.com.br/2025/04/06/industrializacao-e-construcao-off-site-vol-2/. Acesso em: 09 dez. 2025

[2] BERTRAM, Nick; FUCHS, Steffen; MISCHKE, Jan; PALTER, Robert; STRUBE, Gernot; WOETZEL, Jonathan. **Modular construction: from projects to products**. McKinsey & Company, June 2019.

[3] SMITH, Ryan E. **Mass prefabrication: investigating the relationship between prefabrication and mass customization in architecture.** In: KOLAREVIC, B.; DUARTE, J. P. (org). *Mass Customization and Design Democratization*. Routledge. (Eds.). (2019) p.. 175-184

[4] OLIVEIRA, Paulo Sérgio Ferreira de. **Construção modular: startup apresenta sistema construtivo inovador e jornada do cliente disruptiva para o mercado imobiliário.** Brazilian Journal of Development. 2022. DOI: 10.34117/bjdv8n1-558.

[5] TECVERDE**. Histórico da implantação da fábrica e do sistema wood frame no Brasil**. 2010. Disponível em: https://tecverde.com.br/. Acesso em: 09 dez. 2025.

[6] FERREIRA, T. C. **Produção e customização na construção volumétrica offsite: estudos de caso no Reino Unido.** 2024. Tese (Doutorado em Arquitetura e Urbanismo) – Universidade Federal de São Carlos, São Carlos, 2024.

[7] ALAZZAZ, A.; WHYTE, **A. Labor productivity in off-site construction: A literature review**. 2008. International Structural Engineering and Construction Society (ISEC). Disponível em: https://www.isec-society.org/. Acesso em: 09 dez. 2025.

[8] LAWSON, R. M.; OGDEN, R.; GOODIER, C. **Design in Modular Construction**. Boca Raton: CRC Press, 2014.

[9] KAMALI, M.; HEWAGE, K. **Life cycle performance of modular buildings: A critical review**. Renewable and Sustainable Energy Reviews, v. 62, p. 1171–1183, 2016. DOI: 10.1016/j.rser.2016.05.031.

[10] GIBB, A.; ISACK, F. **Re-engineering through pre-assembly: client expectations and drivers**. Building Research & Information, v. 31, n. 2, p. 146–160, 2003.

[11] GORGLOEWSKI, M.; SMITH, R.; POTTINGER, G. **Modular and Offsite Construction in Sustainable Development.** Kingston: Sustainable Building Canada, 2011

[12] SZALAPAJ, P. **Modular Coordination and Industrialized Building Systems: A Review of the State of the Art**. Journal of Architectural Technology, v. 5, n. 3, p. 101–122, 2017

[13] Rocha, C., Formoso, C., & Tzortzopoulos, P. (2015). **Adopting Product Modularity in House Building to Support Mass Customisation**. Sustainability, 2015. https://doi.org/10.3390/su7054919

[14] SILVA, R.; MELO, F.; FERREIRA, P. **Construção a seco e a evolução dos sistemas industrializados no Brasil**. Revista Engenharia e Construção, v. 12, n. 2, p. 55–70, 2020.

[15] CHENG, J. C. P. et al. **Digital Technologies in Offsite and Prefabricated Construction: Theories and Applications**. Buildings, v. 13, n. 1, p. 163, 2023. DOI: 10.3390/buildings13010163.

[16] GORGLOEWSKI, M.; SMITH, R.; POTTINGER, G. **Modular and Offsite Construction in Sustainable Development**. Kingston: Sustainable Building Canada, 2011.

[17] LI, Z.; JU, S.; KIM, H. **Building Information Modelling and Mass Customization in Modular Construction**. Automation in Construction, v. 130, 2021. DOI: 10.1016/j.autcon.2021.103832.