Modular construction to counter informal self-construction in Perú: insights from SWOT analysis and GUT matrix approach

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Abstract

This study explores the weaknesses and threats of the modular construction industry as an alternative to informal self-construction in Peru, characterized by a lack of technical design and professional supervision. Through a SWOT analysis and the application of the GUT prioritization matrix (Gravity, Urgency, and Tendency), the weaknesses and threats of the modular construction industry in the Peruvian context were evaluated, highlighting challenges related to transportation and resistance to change as the main obstacles. The research reveals that, despite these challenges, modular construction offers significant advantages in terms of quality, safety, and sustainability. It is concluded that, with appropriate strategies, modular construction could be a viable solution to reduce informality in housing construction in Peru. There is a suggested need for infrastructure and regulatory reforms, as well as the promotion of education and acceptance of this technology.

Keywords
Modular construction, informal construction, self-construction, SWOT analysis, GUT matrix.

1. Introduction

In Peru, the construction of single-family homes is largely characterized by self-construction and informality (Turner, 2018). This issue raises significant concerns for the construction and housing sectors of both central and local governments, as well as for organizations responsible for risk and disaster management. Between 2000 and 2018, out of all homes built in 43 Peruvian cities, only 7% were formal, while informal dwellings accounted for 93% (Espinoza & Ford, 2020). In Lima, the capital city, informality in construction reaches 70%, according to the Peruvian Chamber of Construction (CAPECO, 2019). In the outskirts of the capital and in cities across the interior of the country, informal homes make up 90%, as reported by the Peruvian Japanese Center for Seismic Research and Disaster Mitigation (CISMID, 2020).

This phenomenon can be explained by the widespread need among a large segment of the population for their own homes, despite low economic incomes, coupled with rapid migration flows to coastal cities between 1960 and 2000 (source citation needed). Socioeconomic classification in Peru ranges from A to E. For the poorest social sectors (C, D, E), self-construction is the only means to meet their housing needs. Conversely, higher-income sectors (A and B) opt for conventional homes that meet technical and legal requirements, as depicted in the figure (Espinoza & Fort, 2020).

Image 1. Homes produced annually by economic sectors, in Lima and the 10 main cities of Perú.

Source: Espinoza, A. & R. Fort (2020). Mapping and typology of urban expansion in Perú. Lima: GRADE; ADI.

To address this issue, the Peruvian Chamber of Construction proposes the "Building Formality" initiative, which includes a series of measures to reduce the gap between formal and informal construction in the country. However, this initiative lacks tangible proposals that would allow new construction processes to consolidate as significant players in the Peruvian construction and housing market. "Techo Propio" is another social housing program promoted by the Peruvian government aimed at assisting individuals from socio-economic levels C, D, and E in improving, building, and purchasing homes (Peruvian Association of Market Research Companies, 2018). The program involves granting bonuses and subsidies ranging from 11,845 soles to 44,804 soles, depending on the characteristics of the housing (MIVIVIENDA Fund, 2024). However, this governmental initiative to reduce housing disparities does not include explicit mechanisms for acquiring or building modular homes, nor specific subsidies to promote new construction processes. Instead, it focuses on expanding mortgage credit penetration, increasing supply to reduce land costs, and promoting rental housing (Ministry of Housing, Construction, and Sanitation, 2024).

Modular construction is a building system where two-dimensional (2D) and three-dimensional (3D) or volumetric elements (Seidu et al., 2021) are produced, optimized, and certified in a factory, renowned for its cost-effectiveness, quality, safety, and added value (Salama et al., 2018), as well as its constructive and sustainable advantages (Lawson et al., 2014). In the case of reinforced concrete modular units, are composed of reinforced concrete with steel rods, although modules of wood and metal structures also exist. The Modular Building Institute (MBI, 2024) defines a modular home as a volumetric structure consisting of reinforced concrete frames, steel frames or beams, and wooden columns, with pre-designed side walls and horizontal slabs in a factory according to technical specifications and client requirements. This research aims to analyze the attributes of the modular system that can make it a competitive option compared to self-construction, which lacks minimum technical and legal requirements and quality guarantees. Additionally, it seeks to identify and prioritize, using a matrix, the main challenges facing this industry in Peru and based on this analysis, develop solutions to replace the pillars on which informal self-construction in Peru relies.

2. Methodology

The research was conducted in three stages. The first stage involved a systematic literature review aimed at identifying the attributes of modular construction systems compared to traditional construction systems, providing an overview of the modular industry conditions in Peru. In the second stage, a SWOT analysis of this industry was conducted. The third stage consisted of applying the G.U.T. prioritization matrix (Gravity, Urgency, and Tendency) to the problems identified through the SWOT analysis.

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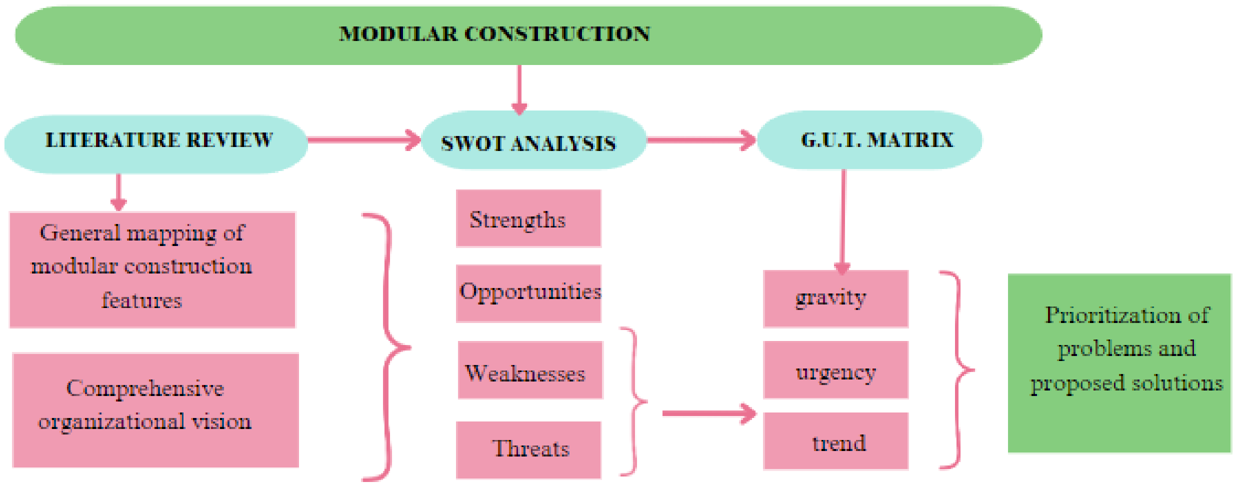
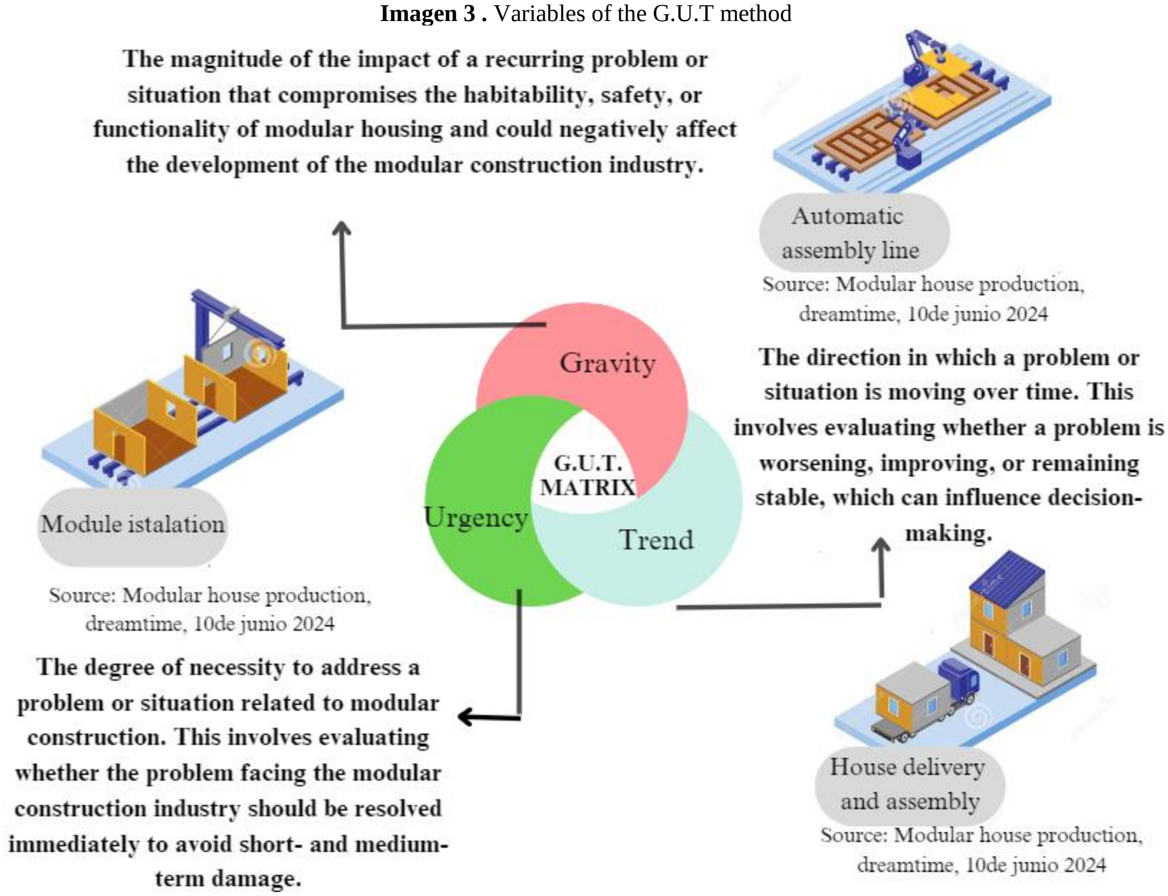
Image 2. Flowchart of the research methodology.



The GUT method was developed in 1980 by Kepner Tregoe as a management tool for decision-making and prioritization of problems, based on three variables: gravity, urgency, and trend. In the construction industry, this tool can help managers identify, prioritize, and rank situations that need to be addressed first (De Fávieri & Da Silva, 2016). For example, if certain types of structural problems in the assembly of modular components are frequently observed in a series of modular homes, this could indicate a manufacturing or quality control failure that requires preventive action. In addition, Feldmann, Birkel, and Hartman (2022) mention that modular construction faces interconnected barriers such as supply and demand. In the Peruvian context, demand for traditional construction prevails over other innovative systems.

Imagen 3 . Variables of the G.U.T method



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This research develops a G.U.T. matrix focused exclusively on the weaknesses and threats identified in the SWOT analysis, as these factors encompass the key issues to be addressed to achieve a truly competitive modular construction industry. The procedure involves assigning values on a scale from 1 to 5 to each identified problem based on its characteristics, drawing on information from other research, reports, or metrics from governmental organizations. In this scale, a value of 5 corresponds to the highest complexity of the problem, while a value of 1 indicates the least complex issues (Braga et al., 2019), applying this methodology specifically to the modular construction industry within the context of Peru.

Table 1 . Scoring criteria

Values	Gravity (G)	Urgency (U)	Tendency (T)
5	Extremely severe	Extremely urgent	It will be uncontrollable
4	Very severe	Urgent	It will be difficult to solve
3	Severe	As soon as possible	Gets complicated
2	Slight severity	Not urgent	It could become complicated
1	No severity	Can wait	It will not change or could improve

The prioritization of identified problems is obtained by multiplying the values of the three variables, that is, (G x U x T) (Braga et al., 2019). Problems that obtain higher values should be addressed with greater priority by decision-makers to ensure the sustainability and competitiveness of the modular construction industry.

3. 1 SWOT Analysis

The acronym "SWOT" comes from the words Strengths, Opportunities, Weaknesses, and Threats, and generally, it is a strategic tool used to evaluate these four characteristics in an organization, project, or real-life situation. In the case of modular construction, a SWOT analysis allows dissemination of the main characteristics of the industry and directs government policies to strengthen this sector.

3.1.1 Strengths

We define strengths as the positive internal aspects of modular construction, such as solid resources, competitive advantages, and production speed. The main strengths of modular construction in Peru include better quality control of construction materials; being carried out within a facility allows for better quality control of prefabricated modules, reducing the risk factors for implementation and assembly failures (Hamza Pervez et al., 2022). Additionally, sustainable features such as reducing construction waste and the ability to incorporate clean energy systems add to its strengths, enabling the development of more environmentally friendly homes. Another strength of modular construction is its profitability, directly linked to reduced construction time and return on invested capital (Lusby-Taylor et al., 2004). This time reduction can reach up to 50% compared to traditional construction methods in countries where these industries are more established (Seidu et al., 2021), while Alderton (2023) places it between 30% and 50%. This is crucial given Peru's history of stalled projects or delayed schedules due to external factors affecting conventional construction. Lastly, modular construction is flexible, easily adapting to confined spaces, unlike traditional construction which requires more space for mixing, material placement, machinery, etc.

3.1.2 Opportunities

The opportunities for modular construction in Peru encompass all favorable external circumstances that this industry can leverage for its benefit, such as market changes, innovations, emerging trends, and technological integration. In the Peruvian context, modular construction allows for cost reduction due to automation, decreased labor requirements, and bulk purchases of raw materials, characteristic of economies of scale (Endzelis & Daukšys, 2018). Furthermore, this industry is efficient, as modules are manufactured in controlled environments, providing an opportunity to enhance the construction process and reduce timelines.

3.1.3 Weaknesses

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The main weaknesses faced by modular construction in Peru are related to design standardization, which allows for cost reduction and mass production but limits customized architectural design, making it less appealing to clients. The second weakness is related to structural aspects. When assembled, it is challenging to prevent cold joints and insufficient rigidity against horizontal forces, in addition to problems with joint resolution—a vulnerability of these structures (Yee et al., 2021). Given that Peru is located in a high seismicity zone, these weaknesses pose a significant challenge to the widespread adoption of modular construction. Furthermore, modular construction requires skilled personnel to build, transport, and assemble modules from factories to construction sites. This presents a challenge for a country like Peru, which lacks qualified labor and experience in executing modular projects. Additionally, transportation and logistics pose challenges, as intraurban streets in Peru do not have the necessary dimensions to transport medium or large modular units. This logistical constraint is further complicated by traffic regulations and permits for prefabricated module delivery. Prefabricated elements can experience transient load states during transportation and placement, potentially affecting the structural integrity of the piece. Moreover, mishandling during storage, manipulation, and transportation can lead to fractures if not performed by trained personnel. Other weaknesses stem from internal factors typical of an emerging industry, including resource scarcity, inefficient processes, and lack of experience.

3.1.4 Threats

All external factors that can pose a risk to the emerging modular construction industry, such as in the case of Peru, where industry fragility, lack of regulatory standards for modular construction projects, and economic fluctuations can limit or delay its development (Akinradewo et al., 2021). On the other hand, the need for an efficient and competitive supply chain is crucial for the system's profitability, and any delays, quality issues, or lack of information can impact it (Jin et al., 2022). Finally, López and Froese (2016) consider the resistance to change imposed by a strongly entrenched traditional construction system in the Peruvian market as a threat. Migrating to modular solutions represents a challenge in terms of trust, durability, and quality

3.2 G.U.T. Matrix

Table 2 . G.U.T Matrix for Weaknesses

Problem	Gravity	Urgency	Tendency	GxUxT	Priority
The need for skilled labor	4	3	2	24	3
Structural aspects	5	3	3	45	1
Transportation challenges	4	4	3	32	2
Standardized and parametric designs	2	2	2	8	4

In Table 3, it is highlighted that the highest priority for addressing weaknesses lies in tackling 'transportation challenges.' This aspect requires a significant change in Lima's road infrastructure, as it is currently ill-suited for module transportation. Narrow areas, obstacles such as low-voltage electrical wiring, and improper use of sidewalks in various parts of the city contribute to this issue. Secondly, there is a need for a 'skilled workforce,' a crucial aspect that could be addressed through the establishment of workshops or other initiatives funded by municipal authorities. Finally, 'standardized designs' are mentioned, which are limited by module transportation difficulties. However, architectural options exist for customizing each unit through furniture arrangement or space distribution.

Tabla 3 . G.U.T Matrix for Threats

Problem	Gravity	Urgency	Tendency	GxUxT	Priority
Resistance to change	3	2	2	12	3
Lack of regulatory standards	3	4	4	48	1
Lack of information and experience	4	2	1	8	4
Fragmentation of the supply chain	3	4	2	24	2

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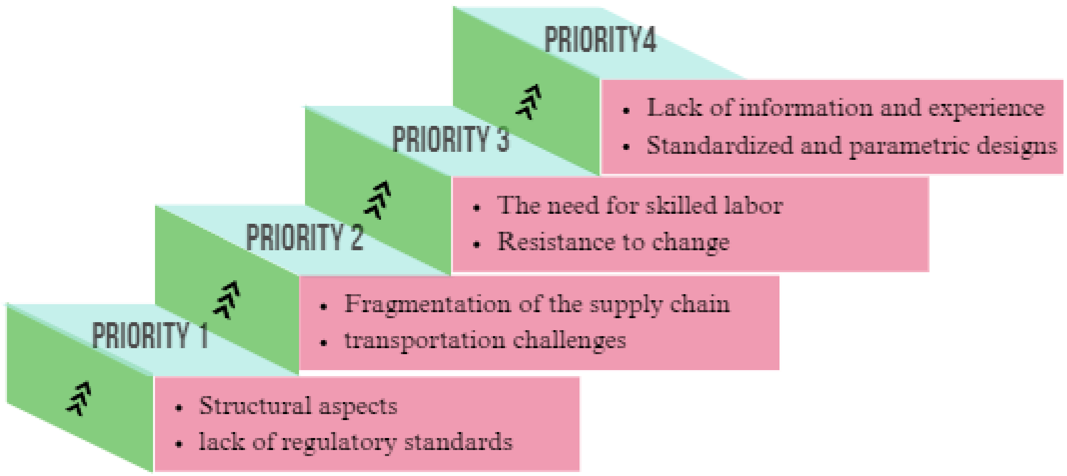
In Table 2, the primary threat identified is “resistance to change.” The entrenched tradition in conventional construction hinders the adoption of modular methods in Peru, primarily due to limited awareness of this approach among the population and skepticism regarding its safety and benefits. Additionally, it faces the challenge of a “lack of regulatory standards,” whose implementation is crucial for ensuring proper control of modular constructions. In this regard, the absence of a robust regulatory framework poses a hurdle to development and acceptance in the Peruvian context. Another significant concern is the “fragility of the supply chain.” Given the novelty and limited presence of modular construction in the country, there is no robust supply chain to guarantee effective operation and adequate provisioning in Lima and its surroundings. Finally, “lack of information” stands out because the limited number of projects undertaken in Peru thus far does not provide sufficient data to confidently evaluate the success of this construction approach.

Imagen 3 . Priority order of identified issues.



4. Conclusions

Based on the results of the SWOT analysis and its subsequent prioritization using the G.U.T. matrix, it can be concluded that the implementation of modular construction could be a viable solution to address informality in Peru. This conclusion is supported by numerous strengths and opportunities within the industry. However, when considering the identified weaknesses and threats, also assessed through the G.U.T. matrix, transportation emerges as the primary challenge to overcome for creating a competitive modular construction industry. Leveraging new urban developments could be a way for this industry to showcase its advantages in major cities across the country and enhance its competitiveness compared to the traditional model of housing construction. Finally, the resistance to changing the construction model represents the most significant challenge among the analyzed threats. This resistance persists in many areas of the capital where construction costs are similar to informal methods. It’s important to note that this study has limitations. While the methodology used can analyze the issue based on bibliographic sources, empirical validation of findings is lacking. Addressing this limitation through case studies could provide further insights. Additionally, the study’s regional focus is limited to the Peruvian construction market, so results may vary in other countries.

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References

Akinradewo, O., Aigbavboa, C., Aghimien, D., Oke, A., & Ogunbayo, B. (2021). Modular method of construction in developing countries: the underlying challenges. International Journal Of Construction Management, The International Journal Of Construction Management, 23(8), 1344-1354. https://doi.org/10.1080/15623599.2021.1970300

Alderton, M. (2023). Construcción modular como solución a la crisis de vivienda asequible. ArchDaily Perú.

Aigbavboa, C., Aghimien, D., Oke, A., & Ogunbayo, B. (2021). Modular method of construction in developing countries: the underlying challenges. International Journal Of Construction Management, The International Journal Of Construction Management, 23(8), 1344-1354. https://doi.org/10.1080/15623599.2021.1970300

Asociación peruana de empresas de investigación de mercado (2018). Niveles socioeconómicos 2018. Lima: APEIM

Braga, I. C., Brandão F. da S., Ribeiro, F. R. C., & Diógenes A. G. (2019). Application of GUT Matrix in the assessment of pathological manifestations in heritage constructions. Revista ALCONPAT, 9(3), 320 - 335. https://doi.org/10.21041/ra.v9i3.400

Camara peruana de la contrución. (2019). 24º Estudio de mercado de edificaciones urbanas en Lima Metropolitana. Lima: CAPECO.

De Fáveri, R., & da Silva, A. (2016). Método GUT aplicado à gestão de risco de desastres: uma ferramenta de auxílio para hierarquização de riscos. *Revista Ordem Pública*, *9*(1), 93-107.

Daman, A. B. A. (2012). Research report submitted to the Faculty of Engineering and the Built Environment, University of Witwatersrand, Johannesburg, South Africa.

Eng, TK y Zainal, R. (2021). El estudio de la aplicación del sistema de construcción modular (MCS) para viviendas asequibles en Malasia. Investigación en Gestión de Tecnología y Negocios, 2 (1), 794-811. https://penerbit.uthm.edu.my/periodicals/index.php/rmtb/article/view/1918

Endzelis, J. y Daukšys, M. (2018). Comparación entre la tecnología de construcción modular y la construcción tradicional. Revista de Arquitectura Sostenible e Ingeniería Civil DOI: http://dx.doi.org/10.5755/j01.sace.23.2.21579

Fort, R., & Espinoza, A. (2020). Mapeo y tipología de la expansión urbana en el Perú. https://hdl.handle.net/20.500.12820/632

Feldmann, F. G., Birkel, H., & Hartmann, E. (2022). Exploring barriers towards modular construction–A developer perspective using fuzzy DEMATEL. Journal of Cleaner Production, 367, 133023. https://doi.org/10.1016/j.jclepro.2022.133023

Fondo Mi Vivienda (2020). Información del mercado inmobiliario y estadísticas. En: https://www.mivivienda.com.pe/PORTALWEB/promotoresconstructores/pagina.aspx?idpage=120

Khan, A., Yu, R., Liu, T., Guan, H., & Oh, E. (2022). Drivers towards adopting modular integrated construction for affordable sustainable housing: A total interpretive structural modelling (TISM) method. Buildings, 12(5), 637. https://doi.org/10.3390/buildings12050637

Lacey, A. W., Chen, W., Hao, H., & Bi, K. (2018). Structural response of modular buildings an overview. Journal of building engineering, 16, 45-56. https://doi.org/10.1016/j.jobe.2017.12.008

Lawson, M., Ogden, R., & Goodier, C. (2014). Design in Modular Construction (1st ed.). CRC Press. https://doi.org/10.1201/b16607

López, D. y Froese, T. (2016). Análisis de Costos y Beneficios de Viviendas Prefabricadas Panelizadas y Modulares. Ingeniería Procedia, 145, 1291-1297. DOI: 10.1016/J.PROENG.2016.04.166O.

Aigbavboa, C., Aghimien, D., Oke, A., & Ogunbayo, B. (2021). Modular method of construction in developing countries: the underlying challenges. International Journal Of Construction Management, The International Journal Of Construction Management, 23(8), 1344-1354. https://doi.org/10.1080/15623599.2021.1970300

Lusby-Taylor, P., Morrison, S., Ainger, C. y Ogden, R., Diseño y métodos modernos de construcción. *La Comisión para la Arquitectura y el Entorno Construido (CABE), Londres*, 2004.

Pervez, H., Ali, Y., Pamucar, D., Garai-Fodor, M., & Csiszárik-Kocsir, Á. (2022). Evaluation of critical risk factors in the implementation of modular construction. Plos one, 17(8), e0272448. https://doi.org/10.1371/journal.pone.0272448

Turner, J. F. (2018). Autoconstrucción: Por una autonomía del habitar. Musica, 400, 4.

Salama, T., Moselhi, O., & Al-Hussein, M. (2018). Modular industry characteristics and barriers to its increased market share. Modular and Offsite Construction (MOC) Summit Proceedings. https://doi.org/10.29173/mocs34

2.

Seidu, R. D., Young, B., Thayaparan, M., & Appiah-Kubi, J. (2021). Modular Construction Innovation in the UK: The Case of Residential Buildings. ResearchGate. https://www.researchgate.net/publication/348658485_Modular_Construction_Innovation_in_the_UK_The_Case_of_Residential_Buildings

Xhexhi, K., & Shtepani, E. (2023). NUEVOS HORIZONTES Y OPORTUNIDADES DE LAS CONSTRUCCIONES MODULARES Y SU TECNOLOGÍA.

Yee, S., Kong, KH, Liew, J. y Dai, Z. (2021). Comportamiento de respuesta de edificios modulares de gran altura bajo cargas sísmicas y de viento. ce/papeles, 4.

Jin, H., Qu, X., Liu, B. y Liu, C. (2022). Examinar los factores de éxito y las barreras de los proyectos de construcción modular mediante un análisis comparativo cualitativo. Revista Internacional de Gestión de la Construcción, 24 , 601 - 609. DOI: 10.1080/15623599.2022.2135937