buildings

MDPI

Article

Timber Construction Regulations in Brazil: A Perspective from Its National Industry of Timber Houses

Victor De Araujo [1,2,*], Juliano Vasconcelos [3], Elen Morales [1], Juliana Barbosa [1], Maristela Gava [1], Emerson Faustino [4], Herisson Santos [4], Felipe Arroyo [2], Sheyla Serra [2], José Paliari [2], André Christoforo [2,*], Francisco Lahr [5] and José Garcia [6]

1 Science and Engineering Institute, São Paulo State University, Itapeva 18409-010, Brazil
2 Exact Sciences and Technology Center, Federal University of São Carlos, São Carlos 13565-905, Brazil; jpaliari@ufscar.br (J.P.)
3 Faculty of Agricultural Sciences, São Paulo State University, Botucatu 18610-034, Brazil
4 Campus of Ariquemes, Federal Institute of Education, Science & Technology of Rondônia, Ariquemes 76870-000, Brazil
5 School of Engineering of São Carlos, University of São Paulo, São Carlos 13566-590, Brazil
6 Luiz de Queiroz College of Agriculture, University of São Paulo, Piracicaba 13418-900, Brazil
* Correspondence: engim.victor@yahoo.de (V.D.A.); christoforoal@yahoo.com.br (A.C.)

Abstract: Codes of practices and standards for products and activities are available regulations for global sectors, although they are dedicated to national scopes such as civil construction in Brazil. These regulations align with industry compliance as they establish mandatory or voluntary issues. Brazilian developers must properly regard construction regulations, which mostly dedicated to concrete and steel buildings but rarely to timber buildings. Through construction regulations, the production of timber buildings can become more standardized and scalable to ensure the steady quality of finished products. From this perspective, this paper evaluated Brazil's timber housing production sector's utilization and access to procedures, standards, guidelines, certifications, and seals. A standardized questionnaire was designed and refined to analyze this local perspective. Face-to-face interviews with sampled companies were conducted using a randomized sampling procedure. The margin of error was obtained using significant sampling of this sector. The findings evinced that most Brazilian developers underuse timber building regulations in their production and management practices and still need to familiarize themselves with this important subject. The codes must establish requirements for each timber construction technique to represent different technologies and also specify particularities and added performances to suit varied projects.

Keywords: codes of practice and standards; industrialized construction; timber structures; wood

Citation: De Araujo, V.; Vasconcelos, J.; Morales, E.; Barbosa, J.; Gava, M.; Faustino, E.; Santos, H.; Arroyo, F.; Serra, S.; Paliari, J.; et al. Timber Construction Regulations in Brazil: A Perspective from Its National Industry of Timber Houses. *Buildings* **2023**, *13*, 2136. https://doi.org/10.3390/buildings13092136

Academic Editors: Francisco López-Almansa and Osama Abudayyeh

Received: 27 June 2023
Revised: 9 August 2023
Accepted: 19 August 2023
Published: 23 August 2023

1. Introduction

Timber culture is being globally established and preserved through old and modern buildings [1]. Timber buildings are built from different techniques, varying from artisanal works on building sites to industrial production in plants [2]. This intense versatility is a good advantage that technologically raises timber solutions above masonry.

Timber strongly dominates light-frame construction markets in the northern nations of America and Europe [3]. The United Kingdom [4,5], Canada [6,7], and the United States [8,9] have successfully experienced the use of timber houses. Even though Brazil produces timber houses for internal and external markets, wood products can reach a prominent position in its domestic economy, especially after the definition of affirmative strategies and incentives to be established by new laws and public policies [10–13].

Brazil is a world reference in forestry production for the timber industry, boosted by its biodiversity. Tropical forests add 500 million hectares from natural areas. A survey

estimated 377,624 hectares in logging, of which 38% are not legal due to different reasons, such as inefficient monitoring, criminal networks, informality, fire, and livestock [14–17].

In turn, Brazilian plantations provide about 10 million legal hectares, comprising 75.8% eucalypt cultures, 19.4% pines, and 4.8% native and exotic woods [18]. Southeast and south states, which are more industrialized, already prioritize silvicultural activities in order to supply engineered wood product manufacture. Northern states still utilize Amazon forests to provide native woods for industry sectors from other regions—mostly located in the south and central states in Brazil—using low-yield harvesting processes that include the extraction of unknown and unsuitable species for construction [1,18–20].

Four-fifths of the timber construction production sector has consumed timber from planted forests in Brazil, although more than one-fifth of developers use native woods. About fifty wood species have been used by this sector, including five *Eucalyptus* and four *Pinus* exotic varieties and forty native species, ranging from low to high densities [19,21,22]. While exotic species are intensely produced in plantations, most native woods are harvested from natural forests, which are managed both formally and illegally [19]. These woods have been consumed by the production of dozens of techniques for timber construction, as verified by [22]. Thus, Brazil has a complex panorama when compared to more developed countries with forest areas formed by few commercial species.

In the multisided scenario experienced in Brazil, its timber construction sector still prioritizes housing solutions [10,11], although midrise buildings have recently been built in the south and southeast states [23,24], using formal approvals from public agencies based on technical certifications from testing institutes [25]; this is the reason why four-storey buildings are being built using wood-based technologies [23]. Simultaneously, taller timber buildings make up future ambitions, as upcoming plans have developed projects with ten or more storeys in the southeast–south macro region [26]. Despite this promising stage, Calil Neto et al. [24] remarked that "the current Brazilian codes and standards do not adequately address or provide engineering guidance for modern mass timber structures". As a result contrary to this perception cited, all input producers must take responsibility for the performance of their products and solutions; therefore, global codes could be utilized to meet specific conditions or gaps.

Developed countries from North America, Europe, and Oceania have performed projects on greener tall buildings to intensify the use of timber and structural products [27]. Even countries with different development levels can present representative sectors related to timber construction production, which includes Germany and Brazil [2].

Many nations still require advances in regulations and changes in people's mindsets to insert, increase, and refine the consumption of timber buildings. Developed countries (e.g., Canada, United States, New Zealand, Germany, Sweden, and France) have realized documents to explain, diffuse, and regulate timber residences and their components and parts [28]. Wood-based framed houses can meet or exceed code-established levels of wind and earthquake loads, fire safety, and sound control and adapt to different climates, ranging from hot and humid to extremely cold and dry [7]. These conditions are being established by standardized orientations, either through codes or guidelines, to design structural parts and construction details for timber-based buildings [28].

The global industry is intrinsically linked to regulations. The timber building sector has taken advantage of standard codes and building guidelines, management tools and models, and some production practices. In practice, they provide greater efficiencies.

Today, most standard codes for timber buildings and structures have addressed general approaches by timber parts, specifying minimum standards and requirements. Using two keywords, "timber" and "wood", in May 2023 through the official websites of global standardization organizations, twelve codes were identified with respect to timber construction and as being active in different regions (Table 1). This search also found ten other specific regulations on five distinct timber construction techniques (Table 2).

Table 1. Codes according to structural elements for timber structures.

Approach by Elements	Country	Standard Document	Source
Structural posts and beams	Brazil	ABNT NBR 7190	[29]
Structural posts and beams	Denmark	DS 413	[30]
Structural posts and beams	Europe	EN 1995-1-1	[31]
Structural posts and beams	World	ISO/TR 18267	[32]
Structural sawn elements	World	ISO 16598	[33]
Structural sawn elements	England	BS EN 5268-2	[34]
Posts, beams, and framing	Australia	AS 1720.1	[35]
Posts, beams, and framing	Canada	CSA O86-14	[36]
Posts, beams, and framing	Ecuador	NEC-SE-MD	[37]
Posts, beams, and framing	Ireland	IS 440:2009+A1	[38]
Posts, beams, and framing	New Zealand	NZS 3604	[39]
Posts, beams, and framing	China	GB 50005	[40]

Table 2. Codes according to timber-based construction technique.

Approach by Technique	Country	Standard Document	Source
CLT-based modular buildings	England	BS EN 16351	[41]
CLT-based modular buildings	United States	ANSI/APA PRG 320	[42]
CLT-based modular buildings	Japan	JAS 3079	[43]
CLT-based modular buildings	South Africa	SANS 8892	[44]
Heavy timber buildings	United States	AFPA/AWC WCD5	[45]
Plank-and-beam buildings	United States	AFPA/AWC WCD4	[46]
Panelized timber frame	Denmark	DS/EN 594	[47]
Wood-frame buildings	Australia	AS 1684.1	[48]
Wood-frame buildings	Brazil	NBR 16936	[49]
Wood-frame buildings	United States	AFPA/AWC WCD1	[50]

Building guidelines are formal documents aligned to standard codes to establish better standardized practices and interpretations of construction laws to assist builders and industrialized construction manufacturers. Due to broader approaches and different expectations, many guidelines are available. Although nonstandardized procedures can be adopted, the project liability falls first on the input producers and later on the builders.

Using "timber building guidelines" and "wood building guidelines" keywords in May 2023 through the Google search engine, different guidelines for timber buildings were selected to exemplify very specific approaches and their national coverage (Table 3).

Table 3. Some examples of different guidelines for timber buildings.

Approach of Guideline	Country	Organization	Source
High performance buildings	United States	City of New York	[51]
Mass timber design	Canada	Structurlam	[52]
CLT processing and assembling	Austria	Binderholz	[53]
Timber service life design	Australia	Wood Solutions	[54]
Timber buildings	New Zealand	MBIE	[55]

Alternatively, some academic contributions have also proposed different guidelines for timber buildings in Brazil. But the direct utilization of academic guidelines without the formal support and control of any certifying body is not unanimous, especially due to the deficiency and lack of verification and confirmation of proposed steps. Consequently, unless an institution formally considers sections or fractions from an academic proposal to head or endorse new or updated regulations, these are underused.

Production practices and management models are alternatives to control, manage, standardize, and regulate the manufacture of products through different precepts of quality,

efficiency, and organization. Typically, these regulatory activities have been certified and often labeled by national associations and international institutions.

Based on technical documents, including codes (Tables 1 and 2) and guidelines (Table 3), institutes with different purposes (resource production and procurement, technique evaluation, tests of parts and components, sustainable practices, etc.) are utilized by corporations to provide well-managed processes and higher quality products. Seals and certifications are given to companies that strictly meet institutional expectations.

In Brazil, some practices and models are assigned to construction-related activities. Table 4 details those examples available in Brazil linked to timber-based construction phases from material procurement to building design and development.

Table 4. Examples of certifications from production practices and management models in Brazil.

Certification	Type	Organization	Source
Forest inventory	Evaluation	Independent professionals	[56]
Reforestation license	Licensing	National government agency	[57]
Native license	Licensing	National government agency	[57]
Technical certification	Certification	National private institutes	[58]
DATEC/SiNAT document	Evaluation	National public government	[59]
Treated timber	Seal	National private association	[60]
FSC	Seal	International private council	[61]
CERFLOR	Seal	National public government	[61]
AQUA	Seal	International private institute	[62]
LEED	Seal	International private institute	[63]

Using the keyword "construction regulation" in May 2023 through the SCOPUS database, 284 publications presented this term in their titles, abstracts, and/or keywords. From fifteen publications identified in this literature prospection on this topic, no study was dedicated to evaluate the construction regulation together with any sector of the construction industry (Table 5). However, there is no available research about building codes and regulations and their effective use from the perspective of timber construction.

Table 5. Documents about construction regulation prospected using SCOPUS database.

Goal	Sector	Citation
Economic and legal mechanisms for construction	Housing	[64]
Compliance with health and safety	Housing	[65]
Effects of noncompliance with health and safety	Construction	[66]
Encoding sets of construction regulations	Construction	[67]
Regulations in old Athens, Greece	Construction	[68]
Impact of state on construction regulations	Public schools	[69]
Hazards and measures in the subway alignment	Metro expansion	[70]
Measures from public procurement regulation	Architecture quality	[71]
Modeling through regulation constraints	Construction quality	[72]
Deep learning of constraints from regulations	Construction	[73]
Construction regulation and management formation	Engineering course	[74]
Hygienic regulation through physical factors	Construction sites	[75]
Legislative regulation and fundamentals	Construction laws	[76]
Construction regulation case	Smart urbanism	[77]
Technical–economic analysis of new regulations	Green construction	[78]

Due to the gap in construction regulation, this study evaluates the utilization and corporate access by the Brazilian developers of timber housing to procedures, seals, certifications, standards, and guidelines. Using a standardized questionnaire, face-to-face interviews were led by the research manager to analyze this sectoral perspective.

A general research issue was outlined: Have construction regulations been considered in the Brazilian timber construction production sector?

Two hypotheses were raised as follows:

H_1: *few timber developers have utilized construction regulations in Brazil*;

H_2: *standard codes are the most popular examples among all regulations*.

2. Materials and Methods

The study started with identifying Brazilian developers of timber houses, as this sector does not have any association or class entity to represent them officially. Thus, no related data are available. This problem was observed in two previous studies on the wood-based house sector. While the former publication revealed 15 companies in São Paulo state in 2001 [79], the second study confirmed a concentration of 50 companies in 2014 [80]. Different sectoral amounts forced the initial prospective step to determine a more accurate estimation of Brazilian companies driven by the production of timber houses. Only producers operating in Brazil were considered. Thus, this first step resulted in the listing of these active developers and their locations.

The prospection method was based on continuous searches using Google search engine using different terms in Portuguese—which is the national language—as follows (translated keywords): timber construction, timber house, timber housing, industry, prefabrication, prefabricated timber house, prefabricated timber building, prefabricated housing, and timber construction contractor. The companies' websites were accessed to verify the adherence of their activities to research expectations. After checking to the last page in searches with isolated and grouped keywords, the sectoral population was listed. Even so, there was the possibility of disregarding some companies, either by the industry dynamism or the existence of some companies without their own websites.

From estimated population, entrepreneurs were contacted by telephone with respect to their participations as cited by [1,10,13,19,22], and their participation was randomly linked to their motivations for participating in a personal semistructured interview.

In addition to two former studies led by [79,80], timber housing sector in Brazil has been discussed by publications with different approaches—e.g., [1,10,13,19,22]—which are directly related to the present study. This deficiency was a decisive factor in starting this analysis on the regulation topics of procedures, standards, guidelines, seals, and certifications. Thus, our research studied the access and use of regulations by timber housing developers in Brazil through a sectoral survey driven by face-to-face interviews.

The second step involved preparing a standard questionnaire for sampled companies. The first author led this phase and prepared the questionnaire to answer the research issue. This document was changed, expanded, and refined by a council formed by academics and professionals who were selected by the first and the last authors. Then, questionnaire was two-times tested to obtain validation in its third version. A small sampling of five entrepreneurs was carried out as a pretest to obtain this refined version, which was definitive (Table 6). After, the interviewer (first author) conducted this data collection from the entrepreneurs' answers, which allowed verification of the current scenario for studied topics and population.

This questionnaire considered six questions. While questions 1, 3, and 5 presented a dichotomous character (yes/no), the 3 other queries detected details exclusively about affirmative answers; specifically, queries 2 and 4 listed the possible alternatives to assist interviewees with respect to the topic, and question 6 was a free-answer quest to enable the interviewees to explain their real ambitions and motivations about the topic (Table 6).

Direct correlations with the questions—e.g., 1 and 2; 3 and 4; and 5 and 6 queries of Table 6—were established. Sentences 1, 3, and 5 verified the existence of observed variables, whereas questions 2, 4, and 6 were designed to define each alternative of regulation nominally. Verification and confirmation about the timber housing sector's access to regulations were possible through simple random sampling in data collection.

Table 6. Questions about regulation access and utilization by the timber housing sector in Brazil.

	Query	Alternative
(1)	Does your company follow any procedure, standard or guideline?	Yes; No
(2)	What regulation category does your company follow?	Management models; Production practices; Individual standards; Building guidelines
(3)	Does your company follow any certification, seal or standard code?	Yes; No
(4)	What regulation type does your company follow, consult or hold?	Technical certification; Technical standards; FSC seal; AQUA seal; LEED seal; CERFLOR seal
(5)	Does your company intend to get any regulation in the future?	Yes; No
(6)	What regulation does your company intend to obtain?	(free answer)

After the data collection step, these listed alternatives answered by studied samples were transformed into percentage values using Microsoft Excel, enabling measurement and comparison of responses. This stage aimed to organize responses in charts.

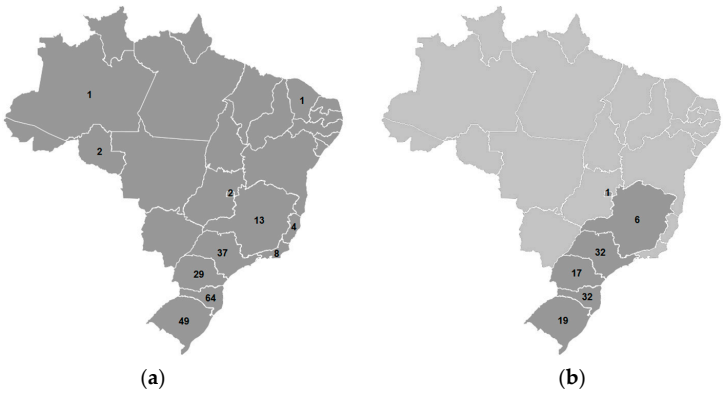
This study's margin of error was possible, which was calculated through the Raosoft Sample Size Calculator. According to Raosoft [81], the following points were prescribed: a 5% acceptable margin of error, 95% confidence level, and 50% response distribution. The margin of error was verified and compared to the literature to validate this survey.

3. Results and Discussion

3.1. Timber Construction in Brazil: Sectoral Mapping, Sampling, and Statistical Surveying

From the website searches, an estimation of about two hundred producers was verified (Figure 1a), which was significantly larger than the 50 companies cited by [80]. From the total population estimated for this sector (Figure 1a), developers from six federative states were duly interviewed in Brazil (Figure 1b). No entrepreneur from the northern region responded positively to the invitation to participate in the formal interviews. This was not a problem, as only four companies were prospected in the northern states.

The sampling results considered 50.95% of the total population (Figure 1), revealing a very low margin of error (Table 7). It was expressively below the acceptable level of 10% and very close to the ideal level of 5%, according to Pinheiro et al. [82]. Therefore, the results of sample (n) successfully validated this survey, whereas the studied variables presented a margin of error (E) of ±3.325%, i.e., 6.65%, as described in Table 7.



(**a**) (**b**)

Figure 1. Amount per state of timber housing producers in Brazil: (**a**) estimated domestic sector of 210 companies from complete population and (**b**) 107 sampled companies. Source: authors.

Table 7. Timber housing population and study's sampling.

Result	Population (Producer)	Margin of Error (%)
Overall size (estimated companies in sector)	210	–
Obtained sample size (sampled companies)	107	6.65

Shared sources from related studies [1,10,13,19,22].

3.2. First and Second Queries: Relations and Categories about Construction Regulation in Use

The follow-up and use of procedures, standards, and guidelines were observed, and about four-fifths of the sampled population declared a negative position on this topic (Figure 2). This chart revealed that the majority of this sector has produced timber houses without the proper assistance of regulations; this scenario was potentially expected, as there was a lack of literature information. The low use proves that hypothesis H_1 is true.

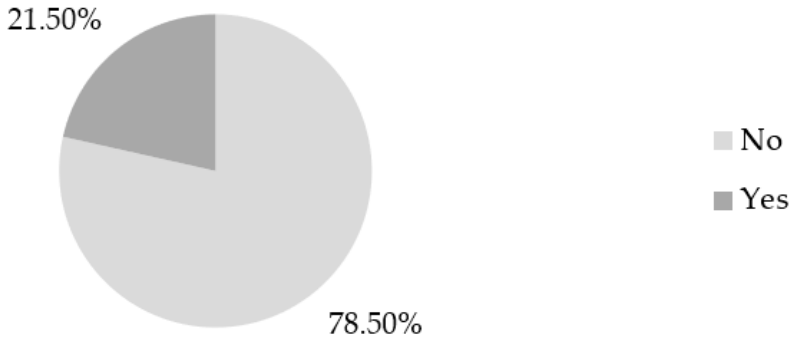


Figure 2. First query: corporate consideration and utilization of any procedure, standard, and/or guideline (n = 107; E = ±3.325%).

Particularly on the specificity of the followed procedures, standards, and guidelines, Figure 3 shows low popularities in all categories. It can be confirmed that individual standard codes were the main regulations in use by the timber construction sector. This outcome is aligned with the second hypothesis (H_2), which makes it equally valid.

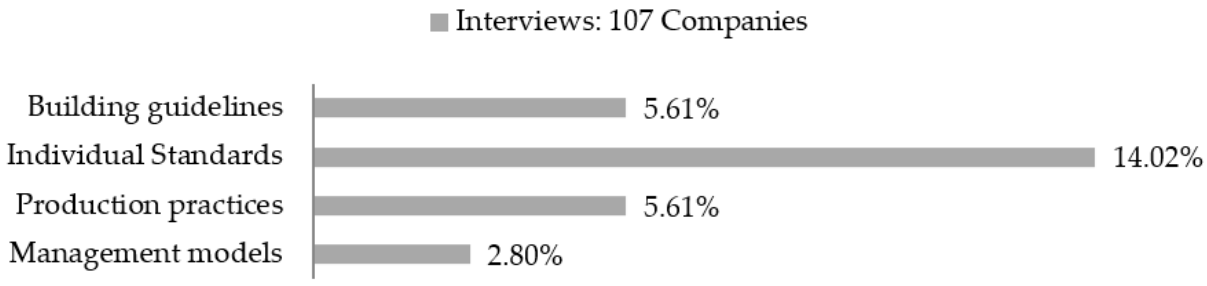


Figure 3. Second query: regulation categories followed by companies (n = 107; E = ±3.325%).

A general standard code for timber structures, named NBR 7190, is available in Brazil and is regulated by the Brazilian Association of Technical Standards, as identified by [29]. At the same time, a specific code about the wood frame is also prescribed by [49] for this lightweight construction technique by the same association.

The foreign documents cited in Tables 1 and 2 were also mentioned by a small number of developers as instruments for consultation and technical support. However, still in this second question, these samples declared that they prioritize Brazilian codes due to the specificities and approaches adapted to national conditions and, above all, the availability of such codes in Portuguese, the domestic language. Many developing nations like Brazil have national standard codes for wood-based structural elements and components. Still,

a need for more, concerning the regulations for different timber housing techniques, is present [28]. This fact is also justified by the main goals of the Brazilian code of timber structures, which prioritizes frames and roofs [83].

The world has been experiencing a proliferation of modern tall buildings driven by the positive precepts of construction efficiency, sustainability, and rationalization. This global context has motivated a timber skyscraper race, as remarked by [84]. Guidelines cited in Table 3 are being designed to satisfy high performance expectations, as these high-rise examples are being seen by [85] as the next generation of natural structures. In addition, studies are being proposed to understand applications and limitations [86–91], and books have been written to assist developers and professionals with efficient design and construction using wood products [92,93]. From the moment that Brazil needs complete engineering guidance for modern mass timber structures [24], especially for tall buildings, adequate documents are still required. Despite these demands, nations like Brazil have already made promising efforts in favor of new regulations (Tables 2 and 3).

Future regulations must consider all the challenges and requirements involved in high-rise buildings. The next movement should take into account different national perspectives and industrial realities in a route based on complete information, both from foreign and national publications, considering all available construction methods, guiding stakeholders to leaner and cleaner practices and generating safe and stable buildings.

Wood-based housing developers underuse managing models and production practices (Figure 3). This perspective agreed with the clues verified by [1,94] in Brazil, as production management, the layout of factories, the quality of raw materials and products, and skilled labor are still obstacles for timber housing developers, which is why the domestic timber industry is lacking industrial competitiveness. In addition, there is space to improve industrialization productivity and product quality, as confirmed by [1].

The desired masonry-to-wood exchange in construction must insert these practices and models into industry manufacturers. However, this domestic sector may not be so "prepared to assume a production increasing in future demands", as remarked by [28]. Therefore, the popularization of timber houses in Brazil may correlate with the increasing technology toward modern and efficient industrial production to mitigate the technological backwardness still present throughout the national construction sector. This transition is complex, especially due to the challenge of changing the mindset of the society in the face of the predominance of artisanal buildings built using masonry, as cited by [13].

Building guidelines are little used in Brazil (Figure 3), as they are more popular and easily accessible abroad. In Brazil, the light-wood frame is the only construction technique with a specific guideline—named SiNAT number 005—for evaluation [59], as mentioned in Table 4. The nonexistence of specific guidelines for other wood-based techniques substantially contributes to this low utilization by the sampled companies. Therefore, its presence is exclusive to these wood-frame producers (Figure 3).

3.3. Third and Fourth Queries: Specificities about Construction Regulation in Use

Timber housing producers' strong restriction on following and using certifications, seals, and technical documents (Figure 4) is also observed. No mandatory regulations act as only a prescribed direction to be followed, making them less popular with the samples.

About the perspective regarding these solutions to standardize timber buildings in Brazil, the scenario raised by Figure 4 was expected, as the certain unpopularity of this observation is similar to the general approach verified by Figure 2.

Among the seals, certifications, and technical documents used by companies (Figure 5), technical certifications from Brazilian testing institutes (Falcão Bauer, IPT, Vanzolini, Lactec, etc.) were the most popular regulations. The certifications are credentials in which quality and safety conditions are measured using distinct tests and classified through labels to establish the assurance of products. According to [95], certification influences and is influenced by a company's image, stakeholder satisfaction, and customer loyalty.

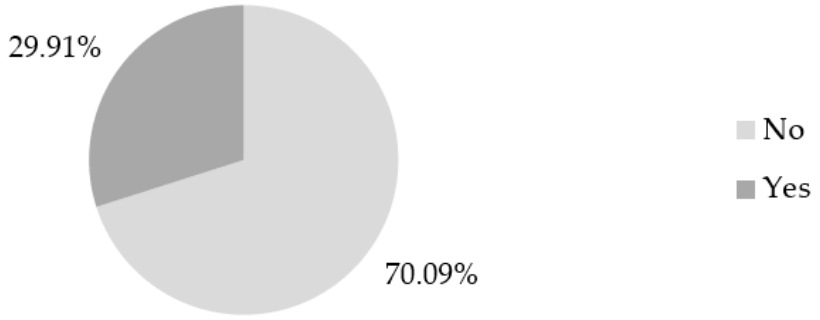


Figure 4. Third query: corporate follow-up of any certification, seal, or code (n = 107; E = ±3.325%).

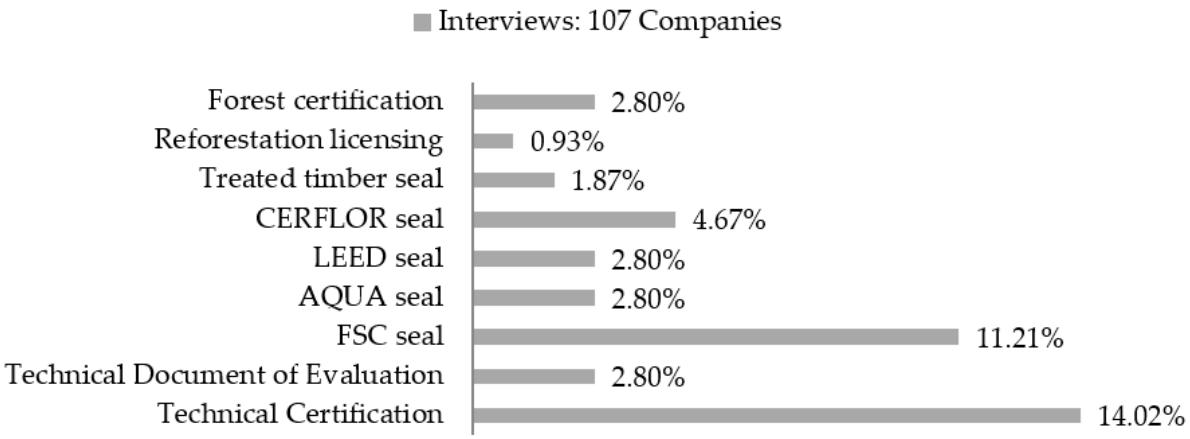


Figure 5. Fourth query: regulation types followed by companies (n = 107; E = ±3.325%).

De Araujo et al. [1] contextualized that national certification is necessary to classify and label wood products for construction. Despite this gap and underuse, seals and certifications are important ways to legitimize any construction materials or parts and buildings in front of the testing of strength, durability, decay, fire, and others.

Due to the existence of the national codes specified in Table 2 and the lack of policy cited by [13], Brazil's Government may consider timber housing in infrastructural expansions, as long as new codes can be designed for other techniques not yet covered by [29,49,59]. Anyhow, there is a low application of Brazilian technical codes for timber construction [29,49] in the production of timber houses in Brazil, as identified by [1].

This alternative could reverse the present perspective through the inclusion of other timber construction techniques. Technical documents for building evaluation—such as DATEC/SiNAT for light-wood-frame buildings (Table 4)—were declared in use by few producers (Figure 5), insofar as only the wood-frame technique has a specific code [49] and a national technical document [59], which excludes other construction techniques from this standardization process. The wide applicability of many timber construction techniques demonstrated by [2] requires specific standard codes, contrary to the scenario identified in Table 2, as these documents are essentially necessary to support building design and development with part quality and standardization. In China, a common coding system tries to address the missing information of prefabricated buildings [96].

Forest certification was another unpopular regulation, as public agencies do not require tracking control of the raw materials used in houses, i.e., wooden logs. This failure was confirmed by [1,2]. Similarly, reforestation licensing is another certification used on a minimal scale, even including the major utilization of exotic species (Figure 5).

Regarding seals (Figure 5), only the FSC seal reached visible utilization because it facilitates timber house exportation to controlled foreign markets. However, small and medium producers focused on domestic markets do not use that kind of seal due to the low appreciation of Brazilian consumers who seek cheaper houses. CERFLOR is the

Brazilian way to certify wood products, similar to the FSC seal, as mentioned by [97,98]. However, this Brazilian forestry seal still has low popularity, as the same is only available in the national context. From Figure 5, the greater popularity of the international FSC seal compared to the national CERFLOR seal was expected, as the FSC has a global awareness and, certainly, a greater acceptance in foreign markets than this Brazilian certification with goals oriented to the national perspective.

Sustainable seals, such as LEED and AQUA (Table 4), are still underused (Figure 5), as Brazil does not present any public policy to stimulate the application of environmentally friendly houses, as well as timber-based architecture solutions, as confirmed by [13], which suggests a real domestic demand. An assertive strategy to consider different perspectives is required to motivate the timber construction industry to consider and appreciate seals. For example, the development of certification systems based on domestic contexts and new trends—such as construction technologies and prefabrication manufactures—is proposed by [99] as a key role in establishing more sustainable practices. The practical evaluation of all the environmental impacts of any construction lifecycle is still a complex, time-consuming, and high-cost process [100].

Yet, the treated timber seal focused on certifying the resistance of lignocellulosic raw materials against decay has low popularity (Figure 5) despite the need for wood preservation in Brazil due to its climate and the presence of attack by fungi and termites.

3.4. Fifth and Sixth Queries: Prospects for Future Uses of Construction Regulations

The low explanation and elucidation of the importance of construction regulations for Brazilian people, mainly for timber professionals and entrepreneurs, contributes to the minimum popularity of these solutions (Figure 6). Most sampled timber house producers have no intention to consult and follow any construction regulation.

Despite the benefits of certification, this process is costly for small and medium businesses, as these compact stakeholders need to make investments continuously [101]. For example, a scenario of basic costs can require the initial investment of USD 16,000 for preparation and auditing, as well as annual sums of USD 10,000 for monitoring auditing and increments from the certification requirements. In contrast, a full perspective for larger developers can easily reach adequacy costs of USD 20,000 and yearly expenses above USD 70,000 for requirements, auditing, marketing, and operationalization [102].

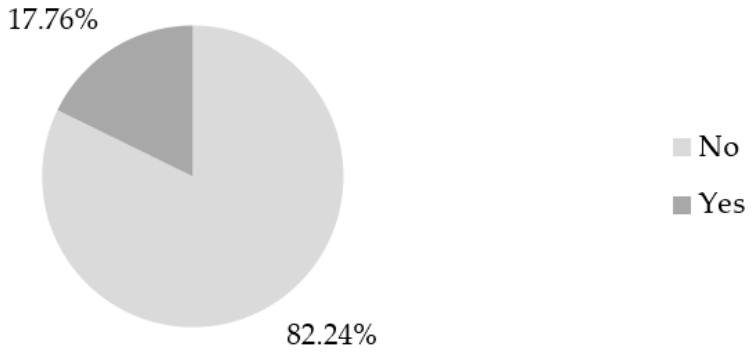


Figure 6. Fifth query: future corporate intentions about regulations (n = 107; E = ±3.325%).

The highest cost does not represent the certification process itself or its maintenance through payments or annual fees but refers to the adjustment of manufacturing processes to meet the required criteria [101]. Therefore, certifications and seals become a hard path for Brazilian timber house developers, as most individuals are micro or small stakeholders, which require efficient public support to be better developed [13].

Despite the low popularity of regulation access and utilization by this studied sector (Figure 6), the management model certification (ISO 9000, ISO 14000, etc.) and technical document of evaluation (DATEC/SiNAT for wood-frame houses) specified in Table 4 were

the main desired regulations to be followed and used by this sampled production sector, as reported in Figure 7.

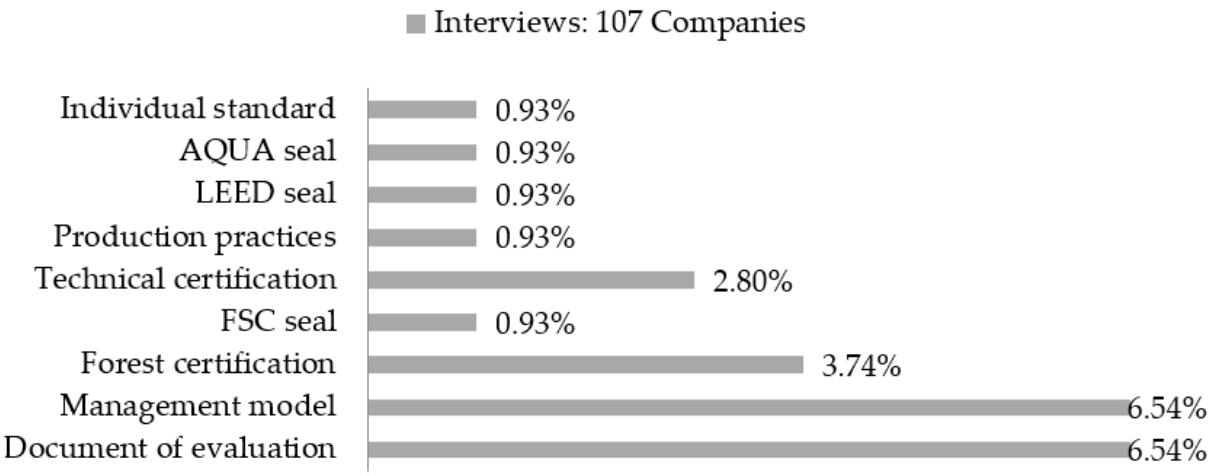


Figure 7. Sixth query: possible regulation types desired by companies (n = 107; E = ±3.325%).

Forest certifications and technical certifications by specific institutes were intended by these companies (Figure 7). The sustainable seals for building (LEED and AQUA) and for wood tracking (FSC) were little ambitioned, as these regulations increase house costs due to their cost operations and licensing, bureaucracy, and limitations.

According to the sampled producers (Figure 7), the Brazilian market does not value and covet sustainable seals because the local population must prepare to invest more in sustainable-sealed, added-value wood-based houses. Before the insertion of these more expensive solutions, Brazil still needs to reduce its housing deficit through smarter and cheaper examples, as cited by [1,10].

3.5. Final Considerations

Although there is a reasonable number of institutes specifically dedicated to the use of wood, whether those with a more academic focus (e.g., the Brazilian Institute of Wood and Timber Structures—"IBRAMEM", the Wood Technology Reference Center—"Núcleo da Madeira", etc.) or those focused on practical issues (e.g., the Brazilian Tree Industry —"IBÁ", the Brazilian Mechanically Processed Wood Industry Association—"ABIMCI", the Brazilian Association of Wood Preservers—"ABPM", etc.), they play relevant roles in wood dissemination in Brazil, which may even be more intense due to the growing interest in wood solutions. However, the timber construction production sector still requires a specific entity to officially represent all Brazilian developers, as emphasized by [1,10,13,22]. Public policies need to stimulate the proliferated utilization of this renewable, sustainable, and natural raw material in housing construction aligned with industrialized standardization. Furthermore, industrialized timber presents many advantages against steel, cement, and others. Such questions must be observed in creating and developing stimuli for wood-based house production, as suggested by [13], allowing a product with positive features. The stimuli need to use the available codes (Tables 1 and 2) and construction regulations (Figures 3, 5, and 7) to standardize the manufacturing processes, improve product quality, and promote timber housing in Brazil.

4. Conclusions

From a very significant sampling, this study confirmed that construction regulations are available in Brazil, although they need greater popularization in timber buildings.

The visible utilization of green seals and certifications is related to those developers focused on international markets, which demand specific and rigid requirements. The national market still depends on future incentives to establish certified housing. Future

access to building regulations still needs to be conscious, as national construction still has a visible housing deficit. Brazilians need to prepare to assimilate and consume more expensive certified housing products.

The major popularity of individual standards and technical certifications are related to construction standardization, ensuring conditions for the durability, stability, safety, and structural resistance of wood-based houses. Unfortunately, there are no specific technical documents for each timber housing construction technique in Brazil and is only limited to the lightweight-wood frame. Developing specific standard codes for each timber construction technique is essential. They will become readable coding to establish recommendations and considerations to support the design and manufacture of different types of timber-based construction. Creating new specific codes will contribute to the efficient manufacture and standardization of houses according to additional requirements, raw materials, and other specificities intrinsic to each available technique. In practice, these construction particularities can be taken into account to meet different levels of project requirements, over-performance demand, and customer expectation.

Few ambitions in the greater utilization of management models, standard codes, and technical documents are visible arguments to reinforce the demand for new scientific studies to mitigate the scenario identified and establish strategic housing policies for product standardization by the national industry. In addition, there is space to design sectoral surveys dedicated to developing and proposing affirmative policies concerning standardized solutions for social housing, insofar as their application could consider and intensify construction regulations in the domestic scenario.

Author Contributions: Conceptualization, V.D.A.; methodology and investigation, V.D.A., J.V., E.M., J.B., M.G., F.A., S.S. and J.P.; validation, all authors; formal analysis, V.D.A., J.V. and A.C.; resources, E.F. and H.S.; data curation, V.D.A. and J.G.; writing—original draft preparation, V.D.A., J.P., M.G., F.L. and A.C.; writing—review and editing, all authors; supervision, J.G., A.C. and F.L. All authors have read and agreed to the published version of the manuscript.

Funding: No external funding was used in the research development. The publication costs were funded by the Dean of Research, Innovation and Graduate Studies of the Federal Institute of Education, Science and Technology of Rondônia (PROPESP/IFRO), funding number 04/2023/REIT.

Data Availability Statement: Data will be available on formal request from the main author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. De Araujo, V.A.; Vasconcelos, J.S.; Morales, E.A.M.; Savi, A.F.; Hindman, D.P.; O'Brien, M.J.; Negrão, J.H.J.O.; Christoforo, A.L.; Lahr, F.A.R.; Cortez-Barbosa, J.; et al. Difficulties of wooden housing production sector in Brazil. *Wood Mater. Sci. Eng.* **2020**, *15*, 87–96. [CrossRef]
2. De Araujo, V. Timber construction as a multiple valuable sustainable alternative: Main characteristics, challenge remarks and affirmative actions. *Int. J. Constr. Manag.* **2023**, *23*, 1334–1343. [CrossRef]
3. Perstorper, M.; Pellicane, P.J.; Kliger, I.R.; Johansson, G. Quality of timber products from Norway spruce—Part 1. Optimization, key variables and experimental study. *Wood Sci. Technol.* **1995**, *29*, 157–170. [CrossRef]
4. Hamilton-MacLaren, F.; Loveday, D.L.; Mourshed, M. Public opinions on alternative lower carbon wall construction techniques for UK housing. *Habitat Int.* **2013**, *37*, 163–169. [CrossRef]
5. Moore, N. *Timber Utilisation Statistics 2015*; Timbertrends: Alicante, Spain, 2015; pp. 1–40.
6. Canada Mortgage and Housing Corporation—CMHC. *Wood Frame Envelopes*; CMHC: Ottawa, ON, Canada, 1999; pp. 1–151.
7. Burrow, J. (Ed.) *Canadian Wood-Frame House Construction*, 3rd ed.; CMHC: Ottawa, ON, Canada, 2014; pp. 1–378.
8. Wherry, G.; Buehlmann, U. Product life cycle of the manufactured home industry. *BioResources* **2014**, *9*, 6652–6668. [CrossRef]
9. Ahmed, S.; Arocho, I. Feasibility assessment of mass timber as a mainstream building material in the US construction industry: Level of involvement, existing challenges, and recommendations. *Pract. Period. Struct. Des. Constr.* **2022**, *26*, 04021008. [CrossRef]
10. De Araujo, V.; Vasconcelos, J.; Biazzon, J.; Morales, E.; Cortez, J.; Gava, M.; Garcia, J. Production and market of timber housing in Brazil. *Pro Ligno* **2020**, *16*, 17–27.

11. De Araujo, V.; Švajlenka, J.; Vasconcelos, J.; Santos, H.; Serra, S.; Almeida Filho, F.; Paliari, J.; Lahr, F.R.; Christoforo, A. Is the timber construction sector prepared for e-commerce via Instagram®? A perspective from Brazil. *Sustainability* **2022**, *14*, 8683. [CrossRef]
12. Shigue, E.K. Panorama Sobre o Uso da Madeira na Construção Civil no Brasil. Ph.D. Thesis, University of São Paulo, São Carlos, Brazil, 2018.
13. De Araujo, V.; Morales, E.; Cortez-Barbosa, J.; Gava, M.; Garcia, J. Public support for timber housing production in Brazil. *Cerne* **2019**, *25*, 365–374. [CrossRef]
14. ter Steege, H.; Pitman, N.C.A.; Sabatier, D.; Baraloto, C.; Salomão, R.P.; Guevara, J.E.; Phillips, O.L.; Castilho, C.V.; Magnusson, W.E.; Molino, J.F.; et al. Hyperdominance in the Amazonian tree flora. *Science* **2013**, *342*, 326–334. [CrossRef]
15. SFB. *Mapa das florestas do Brasil*; SFB/SNIF: Brasília, Brazil, 2019.
16. Rede Simex. *Sistema de Monitoramento da Exploração Madeireira (Simex): Mapeamento da Exploração Madeireira na Amazonia-Agosto 2020 a Julho 2021*; Imazon/Idesam/Imaflora/ICV: Belém, Brazil, 2021; p. 1.
17. Kleinschmit, D.; Ziegert, R.F.; Walther, L. Framing illegal logging and its governance responses in Brazil—A structured review of diagnosis and prognosis. *Front. For. Glob. Chang.* **2021**, *4*, 624072. [CrossRef]
18. IBÁ. *Relatório Anual 2022*; IBÁ: São Paulo, Brazil, 2022; pp. 1–87.
19. De Araujo, V.; Vasconcelos, J.; Gava, M.; Christoforo, A.; Lahr, F.; Garcia, J. What does Brazil know about the origin and uses of tree species employed in the housing sector? Perspectives on available species, origin and current challenges. *Int. For. Rev.* **2021**, *23*, 392–404. [CrossRef]
20. Nahuz, A.R. (Ed.) *Catálogo de Madeiras Brasileiras para a Construção Civil*; IPT: São Paulo, Brazil, 2013; pp. 1–103.
21. Braga, E.; Sarrouf, L. (Eds.) *Aquisição Responsável de Madeira na Construção Civil: Guia Prático para as Construtoras*; Sinduscom-SP/WWF-Brasil: São Paulo, Brazil, 2011.
22. De Araujo, V.; Vasconcelos, J.; Cortez-Barbosa, J.; Morales, E.; Christoforo, A.; Gava, M.; Lahr, F.; Garcia, J. Wood consumption and fixations of carbon dioxide and carbon from timber housing techniques: A Brazilian panorama. *Energy Build.* **2020**, *216*, 109960. [CrossRef]
23. Santos, M.M. *Sistema Construtivo Wood Framing*; CTE: São Paulo, Brazil, 2019; pp. 1–30.
24. Calil Neto, C.; Takata, A.; Silva, V.A.N. The first mass timber building in Brazil. In *WCTE 2023—World Conference on Timber Engineering*; WCTE: Oslo, Norway, 2023; pp. 1–7. [CrossRef]
25. ABDI. *Manual da Construção Industrializada*; ABDI: Brasília, Brazil, 2015.
26. Tieghi, A.L. São Paulo terá prédio feito de madeira. In *Valor Econômico*; Globo: São Paulo, Brazil, 2022. Available online: https://valor.globo.com/empresas/noticia/2022/10/07/sao-paulo-tera-predio-feito-de-madeira.ghtml (accessed on 18 August 2023).
27. Gosselin, A.; Blanchet, P.; Lehoux, N.; Cimon, Y. Main motivations and barriers for using wood in multi-story and non-residential construction projects. *BioResources* **2017**, *12*, 546–570. [CrossRef]
28. De Araujo, V.A.; Vasconcelos, J.S.; Cortez-Barbosa, J.; Morales, E.A.M.; Gava, M.; Savi, A.F.; Garcia, J.N. Wooden residential buildings—A sustainable approach. *Bull. Transilv. Univ. Bras. Ser. II For Wood Ind. Agric. Food Eng.* **2016**, *9*, 53–62.
29. *ABNT NBR 7190-2022*; Projeto de Estruturas de Madeira. ABNT: Rio de Janeiro, Brazil, 2022.
30. *DS 413*; Code of Practice for the Structural Use of Timber. DS: Copenhagen, Denmark, 2003.
31. *EN 1995-1-1*; Eurocode 5: Design of Timber Structures—Part 1-1. EN: Brussels, Belgium, 2004.
32. *ISO/TR 18267*; Timber Structures—Review of Design Standards. ISO: Geneve, Switzerland, 2013.
33. *ISO 16598*; Timber Structures—Structural Classification for Sawn Timber. ISO: Geneve, Switzerland, 2015.
34. *BS EN 5268-2*; Structural Use of Timber—Code of Practice for Permissible Stress Design, Materials and Workmanship. BSI: London, UK, 2002.
35. *AS 1720.1*; Timber Structures, Part 1: Design Methods. AS: Sydney, Australia, 2010.
36. *CSA O86:19*; Engineering Design in Wood. CSA: Toronto, ON, Canada, 2019.
37. *NEC-SE-MD*; Estructuras de Madera. NEC: Quito, Ecuador, 2015.
38. *I.S. 440:2009+A1*; Timber Frame Construction, Dwellings and Other Buildings (Including Amendment 1, Consolidated). NSAI: Dublin, Ireland, 2014.
39. *NZS 3604*; Timber-Framed Buildings. NZS: Wellington, New Zealand, 2011.
40. *GB 50005*; Standard for Design of Timber Structures. GB: Shenzhen, China, 2017.
41. *BS EN 16351*; Timber Structures. Cross Laminated Timber. Requirements. BSI: London, UK, 2021.
42. *ANSI/APA PRG 320-2019*; Standard for Performance-Rated Cross-Laminated Timber. ANSI/APA: New York, NY, USA, 2019.
43. *JAS 3079*; Cross Laminated Timber. JAS: Tokyo, Japan, 2019.
44. *SANS 8892:2020*; Standard for Performance-Rated Cross-Laminated Timber. SANS: Pretoria, South Africa, 2020.
45. *AFPA/AWC WCD5*; Plank-and-Beam Framing for Residential Buildings. AFPA/AWC: Washington, DC, USA, 2003.
46. *AFPA/AWC WCD4*; Heavy Timber Construction. AFPA/AWC: Washington, DC, USA, 2003.
47. *DS/EN 594*; Timber Structures—Test Methods—Racking Strength and Stiffness of Timber Frame Wall Panels. DS: Copenhagen, Denmark, 2011.
48. *AS 1684.1*; Residential Timber-Framed Construction, Part 1: Design Criteria. AS: Sydney, Australia, 1999.
49. *ABNT NBR 16936-2022*; Edificações em Light Wood Frame. ABNT: Rio de Janeiro, Brazil, 2022.
50. *AFPA/AWC WCD1*; Details for Conventional Wood Frame Construction. AFPA/AWC: Washington, DC, USA, 2001.

51. City of New York Department of Design and Construction. *High Performance Building Guidelines*; NY-DDC: New York, NY, USA, 1999; pp. 1–144.
52. Structurlam. *Mass Timber Design Guide*; Structurlam: Penticton, BC, Canada, 2019; pp. 1–64.
53. Binderholz. *Processing Guideline Binderholz CLT BBS*; Binderholz: Hallein, Austria, 2016; pp. 1–78.
54. Wood Solutions. *Timber Service Life Design*; FWPA: Melbourne, Australia, 2020; pp. 1–103.
55. Ministry of Business, Innovation and Employment—MBIE. *Part C: Timber Buildings—C9*; MBIE: Wellington, New Zealand, 2017; pp. 1–16.
56. Vibrans, A.C.; Gasper, A.L.; Müller, J.J.V. Para que inventariar florestas? reflexões sobre a finalidade do inventário florístico florestal de Santa Catarina. *Rev. Est. Amb.* **2012**, *14*, 6–13.
57. Bergmann, N.T.; Cardoso, J.H.; Velasques, N.C.; Grinberg, P.S. Licenciamento de espécies florestais nativas em sistemas agroflorestais no contexto da agricultura familiar. In *III SIEPE—3rd International Seminar of Education and Research in Ecology*; SIEPE: Pelotas, Brazil, 2012; pp. 1–5.
58. Gomes, N.S. Investigação da Viabilidade de Implementação de Programa de Rotulagem Ambiental de Produtos em uma Universidade Federal: Estudo de caso da UTFPR. Ph.D. Thesis, Federal University of Technology—Paraná, Curitiba, Brazil, 2016.
59. *PBQP-H SiNAT n.005*; Revisão 02. SNH/PBQP-H: Brasilia, Brazil, 2017; pp. 1–72.
60. ABPM. *Regulamento Técnico Programa de Certificação Qualitrat*; Instituto Totum: São Paulo, Brazil, 2020; pp. 1–15.
61. Spathelf, P.; Mattos, P.P.; Botosso, P.C. Certificação florestal no Brasil—Uma ferramenta eficaz para a conservação das florestas naturais? *Floresta* **2004**, *34*, 373–379. [CrossRef]
62. Herzer, L.A.; Ferreira, R.L. Construções sustentáveis no Brasil: Um panorama referente às certificações ambientais para edificações LEED E AQUA-HQE. *Cad. Meio Ambiente Sustentabilidade* **2016**, *8*, 34–55.
63. Piccoli, R.; Kern, A.P.; González, M.A.; Hirota, E.H. A certificação de desempenho ambiental de prédios: Exigências usuais e novas atividades na gestão da construção. *Ambient. Constr.* **2010**, *10*, 69–79. [CrossRef]
64. Sidorenko, E.L.; Batyukova, V.E.; Malakhova, V.Y.; Batashev, R.V.; Smirnova, E.A.; Kozhukhova, N.N. Economic and legal mechanisms for housing construction regulation: International experience and prospects. *Int. J. Civ. Eng. Technol.* **2018**, *9*, 86–921.
65. Firl, C. OSHA residential construction regulations compliance: Your go-to overview. *Occup. Health Saf.* **2012**, *81*, 51–52. [PubMed]
66. Othman, A.A.E. A study of the causes and effects of contractors' non-compliance with the health and safety regulations in the South African construction industry. *Archit. Eng. Des. Manag.* **2012**, *8*, 180–191. [CrossRef]
67. Beach, T.H.; Rezgui, Y. Semantic encoding of construction regulations. In *LDAC 2018—6th Linked Data in Architecture and Construction Workshop*; CEUR Workshop Proceedings: London, UK, 2018; pp. 52–61.
68. Monioudi-Gavala, D. Construction regulations in Athens, 1833–1864: Creating a metropolis. In *Building Regulations and Urban Forms, 1200–1900*; Slater, T.R., Pinto, S.M.G., Eds.; Routledge: Abingdon, UK, 2017; pp. 271–288.
69. Vincent, J.M.; Monkkonen, P. The impact of state regulations on the costs of public school construction. *J. Educ. Financ.* **2010**, *35*, 313–331. [CrossRef]
70. Ghiasi, V.; Omar, H.; Rostami, J.; Huat, B.K. Construction regulations along metro alignment. *Aust. J. Basic Appl. Sci.* **2010**, *4*, 5972–6009.
71. Baksiene, D.; Matvejenkaite, K. Measures guaranteeing architecture quality in public procurement regulation. *J. Archit. Urban.* **2013**, *37*, 122–132. [CrossRef]
72. Hu, Y.Z.; Zhong, B.; Luo, H.; Hu, H.M. The regulation constraint modeling and semantic inferring in construction quality checking. *Struct. Surv.* **2013**, *31*, 387–400. [CrossRef]
73. Zhong, B.; Xing, X.; Luo, H.; Zhou, Q.; Li, H.; Rose, T.; Fang, W. Deep learning-based extraction of construction procedural constraints from construction regulations. *Adv. Eng. Inform.* **2020**, *43*, 101003. [CrossRef]
74. Ataei, H.; Salem, O. Construction regulations and organizational management—A case study of a new course introduction to the civil engineering curriculum. In Proceedings of the 123rd ASEE Annual Conference and Exposition, Conference Proceedings, ASEE, New Orleans, LA, USA, 26 June–28 August 2016; p. 123120.
75. Kuznetsova, E.B.; Bulavina, I.D. The substantiation of the volume of investigations of physical factors at the construction site in terms of hygienic regulation. *Gig. Sanit.* **2017**, *96*, 651–656. [CrossRef]
76. Zolotareva, M.V.; Ponomarev, A.V. Legislative regulation and fundamentals of architecture and construction in the first half of the nineteenth century (Russian experience). *Lect. Notes Civ. Eng.* **2022**, *227*, 131–147. [CrossRef]
77. Ortegón, L.G.; Zapater, J.; Garciá, F.; Garciá, O.; Herrera-Quintero, L.F. Smart urbanism: A use case using construction regulation in Colombia. *ACM Int. Conf. Proc. Ser.* **2020**, *2020*, 16737. [CrossRef]
78. Majid, M.I.; Khan, M.I. Techno-economic analysis of green construction regulations plus survey for prototype implementation in Karachi. *Pak. J. Sci. Ind. Res. A Phys. Sci.* **2021**, *64*, 161–172. [CrossRef]
79. Sobral, L.; Veríssimo, A.; Lima, E.; Azevedo, T.; Smeraldi, R. *Acertando o alvo 2: Consumo de madeira amazônica e certificação florestal do Estado de São Paulo*; Imazon: Belém, Brazil, 2002; pp. 1–72.
80. Punhagui, K.R.G. Potencial de Reducción de las Emisiones de CO_2 y de la Energía Incorporada en la Construcción de Viviendas en Brasil Mediante el Incremento del uso de la Madera. Ph.D. Thesis, Universitat Politecnica de Catalunya, Barcelona, Spain, 2014.
81. Raosoft. *Raosoft Sample Size Calculator*; Raosoft: Seattle, WA, USA, 2004. Available online: http://www.raosoft.com/samplesize.html (accessed on 18 August 2023).

82. Pinheiro, R.; Castro, G.; Silva, H.; Nunes, J. *Pesquisa de Mercado*; Editora FGV: Rio de Janeiro, Brazil, 2011.
83. Pinheiro, R.V.; Molina, J.C.; Lahr, F.A.R. Estrutura treinada de madeira tipo "howe" para cobertura—Exemplo de cálculo. In *Coberturas em Estruturas de Madeira: Exemplos de Cálculo*; Calil Junior, C., Molina, J.C., Eds.; Pini: São Paulo, Brazil, 2010; pp. 37–100.
84. Cornwall, W. Tall timber. *Science* **2016**, *353*, 1354–1356. [CrossRef] [PubMed]
85. Ramage, M.; Foster, R.; Smith, S.; Flanagan, K.; Bakker, R. Super tall timber: Design research for the next generation of natural structure. *J. Archit.* **2017**, *22*, 104–122. [CrossRef]
86. Wells, M. Tall timber buildings: Applications of solid timber construction in multistory buildings. *CTBUH J.* **2011**, *1*, 24–27.
87. Wiegand, E.; Ramage, M. The impact of policy instruments on the first generation of tall wood buildings. *Build. Res. Inf.* **2021**, *50*, 255–275. [CrossRef]
88. Krtschil, A.; Orozco, L.; Bechert, S.; Wagner, H.J.; Amtsberg, F.; Chen, T.Y.; Shah, A.; Menges, A.; Knippers, J. Structural development of a novel punctually supported timber building system for multi-storey construction. *J. Build. Eng.* **2022**, *58*, 104972. [CrossRef]
89. Ilgin, H.E. A study on space efficiency in contemporary supertall mixed-use buildings. *J. Build. Eng.* **2023**, *69*, 106223. [CrossRef]
90. González-Retamal, M.; Forcael, E.; Saelzer-Fuica, G.; Vargas-Mosqueda, M. From trees to skyscrapers: Holistic review of the advances and limitations of multi-storey timber buildings. *Buildings* **2022**, *12*, 1263. [CrossRef]
91. Orta, B.; Martinez-Gayá, J.E.; Cervera, J.; Aira, J.R. Timber high rise, state of the art. *Inf. Construcción* **2020**, *72*, e346. [CrossRef]
92. Green, M.; Taggart, J. *Tall Wood Buildings Design, Construction and Performance*; Birkhäuser Verlag: Basel, Switzerland, 2017; pp. 1–176.
93. Kaufmann, H.; Krötsch, S.; Winter, S. *Manual of Multi-Storey Timber Construction*; Detail: Munich, Germany, 2018; pp. 1–271.
94. Shimbo, I.; Ino, A. A madeira de reflorestamento como alternativa sustentável para produção de habitação social. In *1st ENTAC—Encontro Nacional Sobre Edificações e Comunidades Sustentáveis*; ANTAC: Canela, Brazil, 1997; pp. 157–162.
95. Pandanwangi, K.; Putra, A.R.S.; Haryadi, F.T.; Astuti, A.; Syahlani, S.P. Does product certification matter? A review of mechanism to influence customer loyalty in the poultry feed industry. *Open Agric.* **2023**, *8*, 20220160. [CrossRef]
96. Shan, Z.; Fu, D.; Qiu, L.; Liang, Y.; Huang, C. A semi-explicit practical coding method for prefabricated building component parts in China. *Buildings* **2023**, *13*, 1236. [CrossRef]
97. Imaflora. *Resumo Público FSC e CERFLOR—Auditoria de Monitoramento 2019: CMPC—Celulose Rio Grandense LTDA*; Imaflora: Piracicaba, Brazil, 2019. Available online: www.imaflora.org/public/media/biblioteca/cmpc_fsc_cerflor_coc_audit_19_por_public.pdf (accessed on 18 August 2023).
98. Pinto, S.H.B.; Granja, C.P. Análise crítica da certificação florestal brasileira—CERFLOR e Forest Stewardship Council—FSC: Um estudo de múltiplos casos. In *33rd National Conference of Production Engineering Proceedings*; ENEGEP: Salvador, Brazil, 2013; pp. 1–13.
99. Jamoussi, B.; Abu-Rizaiza, A.; AL-Haij, A. Sustainable building standards, codes and certification systems: The status quo and future directions in Saudi Arabia. *Sustainability* **2022**, *14*, 10314. [CrossRef]
100. Di Santo, N.; Guante Henriquez, L.; Dotelli, G.; Imperadori, M. Holistic approach for assessing buildings' environmental impact and user comfort from early design: A method combining life cycle assessment, BIM, and active house protocol. *Buildings* **2023**, *13*, 1315. [CrossRef]
101. Moura, A.M.M. Contribuição da certificação de florestas para o cumprimento da legislação florestal no Brasil. In *Mudanças no Código Florestal Brasileiro: Desafios para a Implementação da nova Lei*; Silva, A.P.M., Marques, H.R., Sambuichi, R.H.R., Eds.; IPEA: Rio de Janeiro, Brazil, 2016; pp. 327–345.
102. Alves, R.R.; Jacovine, L.A.G. *Certificação Florestal na Indústria: Aplicação Prática da Certificação na Cadeia de Custódia*; Manole: São Paulo, Brazil, 2015; pp. 1–130.