

Designing in Wood-Results of a Survey among Architects in Portugal

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Abstract—This paper presents the results of the survey carried out with architects working in Portugal, regarding wooden construction. The study was carried out between 2021 and 2022 at the Faculty of Architecture of the University of Lisbon, and corresponds to a phase of the work of the first author aiming to his PhD degree in Architecture (in the field of Construction Technologies and Management), which addresses the applicability of the CLT (Cross-laminated Timber) system to mid-rise housing construction in Portugal. The survey aims to know the openness that currently exists by architects in Portugal regarding the use of wood as a constructive option, as well as the main difficulties that the architecture sector encounters when designing in wood. The results allow to characterize the current situation of designing and building in wood in Portugal, and to identify potentialities and difficulties. The results are useful for the development of ongoing research, and, in the near future, to design strategies in order to overcome any identified constraints.

Keywords—teaching of architecture, wooden constructions, architects in Portugal

I. INTRODUCTION

According to several international reports, the construction sector is responsible for an important share of Greenhouse Gas (GHG) emissions. This sector, which encompasses the extraction and transformation of raw materials, is responsible for about 39% of global GHG emissions [1].

To combat these values, it is necessary to understand how architecture and architects can contribute, in their activity as designers and informants of how to build, by prescribing materials and processes that can begin to be used on a large scale, not only to reduce GHG emissions as well as to reduce the environmental impact that buildings currently have.

It is known that the act of building will always have an impact, however minimal, on the built place; however, today there is technology that allows the choices made by architects to better meet the Sustainable Development Goals (SDGs) and the European Green Deal (EGD). For this reason, the adoption of more environmentally

friendly construction systems and the choice of renewable materials, such as wood, is essential.

Wooden constructions emerge as an option, when trying to cross the axes of concern such as demographic growth and the need to continue to build, with the environmental concern that has increasingly become a focus of local, national and international interest, as reflected in major global climate pacts and agreements, given that “Solid wood building systems offer an exciting and innovative solution with possible long-term benefits for the construction sector, the timber industry and the fight against climate change” [2].

As it is stated by Green, “Wood is the best primary material available for building structures when considering total energy use, carbon emissions and water use” (Green, 2019), because their production and transformation for use in construction requires less energy use than “conventional” materials [3] such as steel and cement [4], appearing as a renewable alternative to reinforced concrete structures.

However, construction with wood is still a residual activity in Portugal. Despite this, there has been a greater interest in this type of construction systems, both on the part of technicians, who recognize structural, economic and ecological advantages, and on the part of customers, who are becoming more aware of the impacts of their actions on the Planet.

II. METHOD

A. Inquire Structure

The questionnaire was developed in order to ensure that the information collected meets the objectives of the study and was subject to review and testing with a small group of potential respondents. In this way, it was possible to assess interpretation difficulties that might arise and to receive suggestions and comments to improve communication with respondents in the questions asked and terms used.

The questionnaire was carried out on the Google Forms platform and designed to be completed by each of the respondents individually.

Several questions (in total of 27) were asked to respondents and a last field for comments was also

provided. However, not all the questions were applicable, depending on the answers given to previous questions.

B. Tools

The questionnaire was structured at an early stage in an Excel document and was later assembled on the Google Forms platform. In a second phase, it was sent and advertised via e-mail and through publication on the page named “*espacodearquitectura.pt*” and on the social network linkedin, and in this way each of the respondents filled out their own questionnaire answering the questions they had.

Regarding e-mail submissions, these occurred by extracting contacts from the directory of the Ordem dos Arquitectos webpage, with the filter for currently active architects. From this extraction, it was possible to collect 1357 emails. The sending was made through the institutional mail of the Universidade de Lisboa and was accompanied by a letter of introduction and explanation of the objectives of the questionnaire.

When they had contact with the Survey, respondents were able to access it through a link (either in the mail, in the letter, or in publications on the internet) that directed them to the online questionnaire. This system worked as it did not require the installation of any specific program or training on how to fill it out. In addition, once the questionnaire was submitted, the Google Forms platform automatically created a database hosted in the user's Drive, which allowed the processing of the collected data.

C. Data Collection

Despite the difficulties inherent to the methodology used, namely the expected low response rate and the difficulty in gauging the reality of the answers given, the questionnaire is considered to have obtained satisfactory results, namely:

- 18% response rate (corresponding to 243 responses);
- Balanced participation of the various levels of experience in the practice of architecture (Fig. 1);
- Large sample of educational institutions—30 faculties;
- Majority of responses by respondents trained in Portugal;
- Inexistence of invalid answers, which demonstrates the interest and care with which the participants faced the questionnaire.

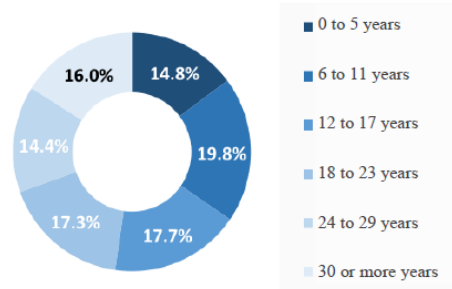


Figure 1. Distribution of respondents by years of experience.

III. RESULTS

A. Training in Wood Construction

Regarding the academic training of architects in wooden construction, the questionnaire reveals that, in general, 46% of the architects claim to have had training in different construction systems, 18% say that they had training only in wooden trusses, and 36% of the architects say that they had not any training in wooden construction during their academic courses (Fig. 2).

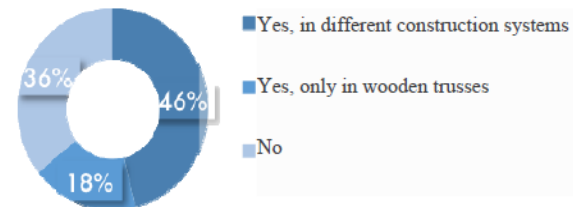


Figure 2. Distribution of training on wooden construction during the academic course.

Given the limited existence of wooden buildings in Portugal, it is not surprising that this could be due to the lack of training in architecture courses. As can be seen, an important percentage of respondents said they had no training at all, and another part only in a specific type of construction (trusses). Making the total number of respondents who have had little or no training, the result is 54%—more than half.

As for the frequency of courses on wooden construction, the architects, divided by years of experience, have different answers to the same question. It is observed that the architects with more years of experience are the ones who claim to have had more training in wood construction, close to 50% of the architects with more than 24 years of experience claim to have had disciplines on different construction systems.

In contrast, architects with less experience are those who claim to have had less training in wooden construction. In the case of architects between 0 and 5 years of experience, 42% of the respondents claim to have had no course during their academic career. It is also in this range that the smallest number of architects can be found who claim to have had training in various construction systems in wood—30%. This percentage is the lowest among all groups.

Although it is known that training on wooden construction systems is not the priority of architecture schools in Portugal, the decrease in the values on training on various wooden systems of 58% (in the group from 6 to 11 years of experience) to 30% (in the group from 0 to 5 years of experience) may indicate a lack of commitment to transmit to new generations of architects knowledge about alternative building systems, which in the future could be used as an alternative to conventional systems.

Although, in the various age groups of architects, there are some significant instances about the existence of training, the same is not reflected when questioning whether architects consider their academic training on the subject to have been sufficient. When asked about this

question, a large majority 92%, stated that they do not consider their training in wood construction systems to be sufficient (Fig. 3).

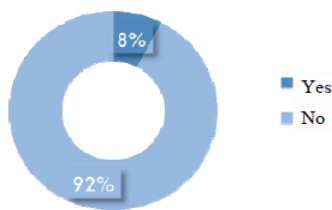


Figure 3. Distribution of answers to “Was the academic training in wood constructive systems been sufficient?”

Regarding the same question, but analyzed by groups of years of experience, it appears that there is a clear more experienced generation that considers that some of their academic training was sufficient (23%), but that in the other groups, training on the various wood construction systems was residual. It is even verified that the perception on this issue is very close to 100%.

This low percentage of architects who consider that their academic training was sufficient could be one of the reasons why wooden construction in Portugal is still residual.

Regarding the knowledge about the various construction systems, the surveyed architects commented on the main construction systems in wood. The questionnaire asked the architects about light framing system; log construction; mass timber construction systems using solid wood panels (such as CLT, DLT and NLT); and the post and beamframe system (timbered and half-timbered framing).

As for these systems, it can be seen that the system best known by the respondents is undoubtedly the post and beam system, with a positive response of 91%, followed by the light framing system with a positive response of 74%.

In the group of lesser known systems, 48% of the respondents stated that they know about systems such as CLT, DLT and NLT, and 42% gave a positive response on knowing about log construction.

B. Projects with Construction Systems in Wood

After a general perception of knowledge based on academic training, it was asked if the architects had already designed using wood as the main constructive element. Given this response, and as expected, a significant part of the architects 65% never designed using wood as the main constructive element.

Architects who answered that they had never designed in wood were asked why this never happened. The answers were mostly justified by the lack of opportunity 67%. However, the second cause mentioned is the lack of knowledge about construction systems in wood 20%, that is, one fifth of the architects assume that they did not carry out a project in wood due to lack of knowledge. The third argument is that customers do not have trust in wooden construction systems 8%. The remaining arguments referred to: (i) funding constraints, (ii) not to

be design architects, (iii) the lack of skilled labor, and (iv) other argument; this group totals 5%.

Regarding the nature of the projects carried out in wood, the responses show a wide distribution. During the questionnaire, several answer hypotheses were suggested, the only one that remained without any answer was “Health Equipment”. All other options were answered, having effectively emerged the category of “Tourism/Hotels”. In addition to this category, “Others” can also be highlighted, where the answers ranged from animal shelters, ephemeral architectures and urban furniture, among others.

Analyzing the answers given, it appears that most of the architects who designed in wood claim to have carried out “Single Family Housing projects” 39.6%; followed by the “Walkways/Viewpoints/Pergolas” projects 17.2%; “Restaurants/ Commerce and Services” 12.7%; “Sports/Cultural Equipment” 9.7%; “Schools” 6%; “Multifamily Housing” 4.5%; “Tourism/ Hotels and Industrial” 3.7%; and “Others” 3%.

With regard to the greatest difficulties encountered by architects in relation to wooden projects, the respondents revealed a set of answers that were not expected.

The greatest difficulty encountered by the architects is related to the “Structural Engineering Team” 35.2% of the responses revealed that it is at this point that the architects feel the greatest difficulties. Next, it is observed that “Suppliers” are another difficulty encountered 21.9%; “Clarification to Customers” appears only in third position, with 18%. The “City Council or Public Entities” appear with a lower response rate 11.7% of the architects assume that this was one of the difficulties; “Execution Capacity/Specialized Labor” with 5.5% of responses; and “Price and Others” with 1.6%.

It should be noted that 4.7% of respondents revealed that they did not experience difficulties when designing in wood.

When asked about the need to clarify clients during the design process, 67% of respondents answered that Yes.

Of the main problems raised by customers, concerns about the wood rotting and being subject to fungi 23.4%, and being a combustible material 23.4% stand out. Other concerns that raised the need for clarification were related to the higher cost of this material 20.4%; the wood is subject to insect and termite attacks 17.5%; the low strength of the material 11.7%; maintenance 1.5%; and finally, residual concerns arise, all of them with 0.7% representation that addressed issues of cheaper wood, acoustic issues and licensing difficulties.

C. Clarifications to Customs

After the respondents were asked about the main concerns of clients regarding wooden projects, one question was asked regarding the main arguments used to convince a client to opt for a wooden project.

This question had several possible answers, and respondents were able to select more than one. Thus, it can be seen (Fig. 4) that the main arguments used by architects are that wood is a resistant material 41.1% (A), provides good hygrothermal comfort 39.3% (B), and is

related to prefabrication processes and dry construction 39.3% (C). This is followed by the fact that wood is a renewable material, retains CO₂ and contributes to the increase of sustainable forests 33.9% (D) that there is reduced waste at work 32.1% (E); and that wood construction is fire safe with the same percent of 32.1% (F). The following arguments were: the best integration in the landscapes 30.4% (G); wooden buildings have good seismic behavior 25% (H); wooden buildings have lower operating costs than current construction 19.6% (I); and wooden buildings are fashionable and eco-friendly. With 1.8% of answers (L, M, N and O) were the Finally, the answers about good sound insulation, quick construction, aesthetic benefits and customer choice correspond to 1,8% of the answers.

It should be noted that the cost argument obtained 19.6% of the answers from the architects, who during the clarification process had to argue about the issue.

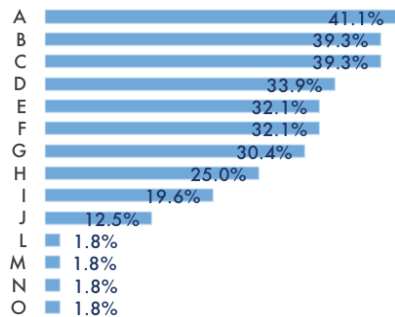


Figure 4. Distribution of the main arguments used by architects to convince a client to opt for a wooden project.

D. Mass Timber

In the final phase of the questionnaire, architects were asked directly about solid wood panel systems such as CLT, NLT or DLT. These questions came last since the first set of questions was about the various construction systems (in general) and how in professional practice architects deal with the various systems.

However, as this questionnaire was prepared in the context of a doctoral research focused on the application of the CLT system in Portugal, it was imperative to introduce specific questions about these particular systems.

At this stage, the question posed was: “Given what you know, in which situations would you choose to use solid wood panel systems (CLT, DLT, or NLT)?”. The answers to this question could be multiple, but they were not without surprise. If, on the one hand, 48% of respondents claim to know this type of systems (see 2.1), on the other hand, the answers given to this question leave some doubt as to the level of knowledge.

For example, “Single-family housing up to 3 floors” received 58.7% of responses; “Walkways/Viewpoints and Pergolas” received 36.2% of responses, and 27.7% were in the “I don’t know” category.

If it is true that single-family housing can be built in CLT, it is also true that it is a type of construction whose means may not justify the ends, given the characteristics of the material. The construction of houses (up to 3 floors)

in wood can be achieved through light framing and other timber frame systems, saving a substantial amount of material.

The answer about the construction of walkways, pergolas and viewpoints in CLT indicates some lack of knowledge about this constructive system, since it enables to build architectural objects with a more permanent character, which contain interior space and with the possibility of growing in height.

An alternative answer that was the main target of the question was the “Multifamily Housing with more than 3 floors.” This option only raised 14.1% of the answers, which indicates a lack of knowledge about the capabilities of this system.

Taking into account the answers given to the previous questions, and anticipating that a residential building with more than 3 floors would not be one of the most answered possibilities, a final question was asked to the architects.

“Which construction system would you consider best for a housing project with more than 4 floors?” The following results were obtained: “Mixed Systems” (wood and other materials) – 48.8%; “timber Frame” 38.5%; “I don’t know” 17.8%; “Light framing system” 10.3%; “Solid Panels” 8.0%; and “Concrete and Masonry” 6.1% (Fig. 5).

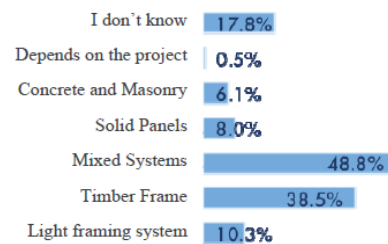


Figure 5. Distribution of answers about the best system for residential buildings over 4 floors.

It should be noted that when asked about the use of CLT, 14.1% replied that they would make housing buildings over 3 floors; on the other hand, when asked what system they would use to build housing buildings over 4 floors, only 8% answered CLT. The option for light framing system also appears with relevance in the responses, which also indicates some lack of knowledge.

Despite the points already mentioned, there is a significant response in the item “Mixed Systems” (i.e., systems involving wood and other materials). When thinking about a residential building with 8 or 9 floors, the integration of steel and concrete may make perfect sense at the same time as the CLT. But, not knowing which systems would be behind this answer, it is assumed that there could have been some way to scrutinize this hypothesis, creating more chances of answer.

IV. CONCLUSIONS AND DISCUSSION OF RESULTS

A. Training in Wood Construction

From the responses to the questionnaire, it is clear that architects in Portugal have some training in the field of wooden constructions. However, regarding the academic

training, there is a discrepancy when architects are divided by age groups of professional experience, as the younger generation of architects is the one that admits to having less training in wooden constructions. However, this generation is the one with greater awareness of the necessary transformations to be carried out in order to enable the transition to a more sustainable world. In this group, only 30% of the respondents admit that had some training in the various construction systems.

An important situation to point out is the feeling of ease when designing in wood. When asked whether their training in this field was sufficient, all groups responded negatively (Fig. 3). This data may indicate the need to invest in academic and post-academic training in this type of subject. Another aspect that corroborates this situation is given by the comments left by some of the respondents, highlighting the interest in the existence of training on the subject.

B. Projects in Wood

With the answers given by the respondents, it can be seen that most architects have never carried out a project in wood. This fact may be due to the issues of knowledge about the various systems, addressed in the previous point, and also to the existence of difficulties in the act of designing.

Regarding the difficulties presented, most respondents say that their main difficulty is related to the structural engineering team, thus indicating that the training in this type of construction by civil engineers is also deficient.

As for the architects who have never designed in wood, there is a large share that justifies it because they never had the opportunity, which may be due to the fact that most architects are self-employed, and thus have little autonomy in the decision. Still on this issue, the 20% of respondents who assume that they have not designed in wood due to lack of knowledge should not escape attention (III-B). As before, this factor can be mitigated with the increase of training.

C. Clarifications

The biggest doubts raised by customers, when faced with a wooden project, are related to the fears that the wood is prone to rotting and being a victim of fungal attacks, as well as being a combustible material (and, therefore, not fire resistant). The issues of price, physical resistance and maintenance were also mentioned in the responses (III-C).

As for the necessary clarifications to be given to clients, the architects admit that these are related to the need to explain that the material (wood) is resistant enough, it presents a good thermal and humidity performance, it is fire safe and has good seismic resistance (Fig. 4). These points directly address some of the doubts raised, but the architects also clarify the fact that wooden constructions are dry constructions and made up using prefabricated elements, that they constitute a type of construction with little construction waste, and that the use of wood from renewable sources not only stores CO₂, but also contributes to the development of sustainable forests.

It can be seen from the clarifications given that architects are awake and up to date on some of the advantages of wooden construction, despite the little application of it.

D. Mass Timber

The mass timber system is among the least known construction systems by the respondents, and among those for which it is more difficult to find information about. It is known that it is not a conventional system in Portugal, which may explain these results, moreover, when asked directly about whether they knew the system, there were affirmative answers. In the end, when asked where they would use the system, many answers went to the pergolas, walkways and viewpoints. Furthermore, with a majority of responses pointing to the construction of housing with up to 3 floors, it should be noted that, despite claiming to know the system, the uses and application of the same lacks better clarification.

It is interesting to note that a system that allows the construction of multi-storey buildings had a low response rate for this option 14.1% (see IV-D). Therefore, it can be concluded that there may still exist a lack of confidence in the system, revealing that there is still a long way to go to make CLT and Mass Timber systems viable options in Portugal.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

J. G. developed the study, sent the inquiries and analyzed the data; P. A. and P.M. reviewed and tested the inquiries and reviewed the data analysis and the paper. All authors had approved the final version.

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