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ENVIRONMENTAL AND ARCHITECTURAL ASPECTS OF WOODEN CONSTRUCTION: A COMPARATIVE ANALYSIS OF SELECTED ISSUES OF SINGLE-FAMILY HOUSING IN POLAND AND PORTUGAL

Agnieszka Starzyk[1]✉, Nuno D. Cortiços[2], Carlos C. Duarte[2], Przemysław Łacek[1]

[1] Institute of Civil Engineering, Warsaw University Life Sciences – SGGW, Warsaw, Poland
[2] CIAUD – Research Centre for Architecture, Urbanism and Design, Lisbon School of Architecture, Universidade de Lisboa, Lisboa, Portugal

ABSTRACT

In the second half of the 20th century, it seemed that wooden architecture would be replaced by other, increasingly used, technologies. Wood was primarily used in hybrid systems, rather than as the dominant construction and finishing material. However, the turn of the 20th and 21st centuries reversed this trend. There is now a growing interest in wooden structures and finishes. Wood is becoming a "fashionable" material. This shift is influenced by new technologies that provide innovative construction possibilities, as well as by new methods of protecting wood. Wood is a renewable, ecological material with a small built-in carbon footprint, making it easy to recycle and suitable for a circular economy. The aim of the study is to compare the features of wooden single-family houses in Poland and Portugal. The methods necessary for this purpose were employed: critical analysis, observation without intervention and case studies to compare contemporary architectural trends. The results of research on current trends in shaping wooden single-family architecture allowed for drawing conclusions regarding formal, functional and pro-environmental solutions.

Keywords: wooden architecture, wooden construction, single-family house, climate crisis, sustainable development, circular economy

INTRODUCTION

Wood is one of the primary building materials. It has been with us since the beginning of the period when humanity began to create shelters (Xu, 2022). Wood was a material that was easy to obtain, transport, process. Most importantly, was renewable. As technology and sources of raw materials progressed, wood fell into the background, remaining a material for the internal partitions of buildings and roof structures, and then becoming a finishing material (Youngs & Hamza, 2016). Importantly, most pitched roof structures are made of wood. In the second half of the 20th century, wooden architecture as a structure made entirely of wood was in decline. The reason for this state of affairs was low competitiveness in relation to brick technologies. It is also crucial to consider the public's perception of wooden structures as having lower durability and the necessity for ongoing maintenance and repair of components that, if not adequately protected, are susceptible to biological deterioration. However, this trend did not change on a large scale

Agnieszka Starzyk https://orcid.org/0000-0002-8704-5003; Nuno D. Cortiços https://orcid.org/0000-0002-9446-6199; Carlos C. Duarte https://orcid.org/0000-0003-1370-5379; Przemysław Łacek https://orcid.org/0000-0002-2779-8097
✉agnieszka_starzyk@sggw.edu.pl

at the turn of the 20th and 21st centuries (Viholainen et al., 2021a). We are currently observing an increased interest in wooden structures. This is primarily due to the growing ecological awareness of users and, no less importantly, also to the search for alternative technologies in relation to the traditional ones, as masonry structures are called. This search results primarily from an attempt to reduce construction costs, not only in terms of material prices, but also labour inputs and the time needed to construct the building (Branco & Alves, 2020). The trend of returning to wooden structures is noticeable (Viholainen, Kylkilahti, Autio & Toppinen, 2020), but not dominant; wood is becoming "fashionable" again, but full trust is not yet there (Lähtinen, Harju & Toppinen, 2019; Viholainen et al., 2021a). An opportunity to increase the share of wooden structures in the market is emerging through new technologies that can compete with masonry structures, providing much greater opportunities than traditional wooden construction (Alves, 2022; Dukarska & Mirski, 2023) and new methods of securing wooden structures that ensure modern utility and fire protection requirements are met. A building is classified as wooden when its supporting structure and most of its components are made of wood. We can mention here materials based on chips (laminated strand lumber – LSL and parallel strand lumber – PSL), glulam beams and columns, cross-laminated timber – CLT, mechanically joined timber – NLT and construction timber – KVH (De Araujo et al., 2016; Almeida, Barbosa & Malheiro, 2020; Lechón, La Rúa & Lechón, 2021; Tavares & Freire, 2022). What is important is its low built-in carbon footprint and the fact that it is an ecological material that can be easily recycled (Buchanan & Levine, 1999; Geng, Yang, Chen & Hong, 2017; Monteiro, Freire & Fernández, 2020; Mendonca & Vieira, 2022; Valyova, Parzhov, Hua & Koynov, 2023).

Nowadays, the construction sector is responsible for a significant part of the negative impact on the environment (Zabalza Bribián, Valero Capilla & Aranda Usón, 2011; Grygierek & Ferdyn-Grygierek, 2022). Its share in total emissions is 42% in the case of energy consumption, 50% in the case of greenhouse gas emissions and 22% of the total amount of waste in 2020 (Coelho & Brito, 2013; Onat & Kucukvar, 2020). In this context, the European Union establishes targets and policies to reduce the environmental impact of the construction sector (Wang, Toppinen & Juslin, 2014; Vilčeková, Čuláková, Burdová & Katunská, 2015; Morton, Pencheon & Bickler, 2019). Wood has an advantage over other building materials, mainly masonry and steel structures, due to the fact that it is a renewable material, it binds carbon dioxide during tree growth and provides more optimised and cleaner forms of construction than other technologies (Börjesson & Gustavsson, 2000; Gustavsson, Pingoud & Sathre, 2006; Høibø, Hansen & Nybakk, 2015; Heräjärvi, 2019; Amiri, Ottelin, Sorvari & Junnila, 2020; Schau, Niemelä, Niemelä, Alencar Gavric & Šušteršič, 2022).

There are regions where traditionally smaller buildings, mainly residential ones, are made of wooden structures. A significant rate of such constructions occurs in countries such as the United States of America (90–94%), Canada (76–85%), the Scandinavian countries (80–85%) and Scotland (approximately 60%). These countries have a rich tradition of this form of construction. It should be borne in mind that wooden structures must be adapted to the specificity of a given country. Important factors here include climatic conditions (dry or wet environments), the wood's greater susceptibility to biological conditions and access to good quality wood, which also ensures the renewable resources to meet the demand for the raw materials (Quintana-Gallardo, Schau, Niemelä & Burnard, 2021). In the absence of a continuing tradition of wooden structures in most countries, factors such as the lack of experience in the construction industry, a lack of developed wood processing technologies, unspecialised workers, low awareness of the design and construction sector, as well as a lack of detailed regulations and standards, will be important (Arlet, 2021; Viholainen et al., 2021b).

Wooden constructions in Portugal and Poland have a rich tradition from the 13th to the 20th century. Mixed construction solutions were most often used, because wood was rarely utilised as the only material in buildings, being most often applied as a complement to a stone masonry structure (Marcal Goncalves, Perez Cano & Rosendahl, 2019). Therefore, currently, the number of wooden buildings is relatively small

in the country. The result is that a small number of companies have specialised in wooden buildings. These are usually small construction companies specialising in this type of construction (Departamento de Edifícios Núcleo de Arquitectura e Urbanismo, 2011). This is compounded by the fact that a significant portion of wooden products in Portugal is imported as raw materials or components of ready-made solutions (Lerink et al., 2023). In Poland, unlike in Portugal, the supply of wood was abundant, which facilitated the development of wood-based structures (Terlikowski, 2022).

Table 1. Population and area

Specification	Poland	Portugal	Ratio
Area [km²]	322 575	92 152	1/3.5
Population [million residents]	37.75	10.33	1/3.6

Source: Główny Urząd Statystyczny database; Instituto Nacional de Estatistica database.

Table 2. Forests' area

Forest resources	Poland	Portugal	Ratio
Per 1 000 ha	8 331	2 199	1/3.7
Per capita	0.22	0.21	1/1

Source: Forest Europe (2020).

Table 3. Wood production

Specification	Poland	Portugal	Ratio
Roundwood [1 000 m³]	46 586	13 957	1/3.3
Sawnwood [1 000 m³]	5 190	1 140	1/4.5

Source: Food and Agriculture Organization of the United Nations (2018).

As early as the 1980s, it was discovered that architects bear greater responsibility for the state of the natural environment than other professional groups. Pro-environmental design, in addition to direct and indirect benefits for the environment, also leads to better health and well-being for users. Design decisions influence the architectural form of structures, as well as the effectiveness of implementation and operating costs (Stasiak-Betlejewska & Potkány, 2015).

In light of this, the present article aims to compare wooden architecture, taking into account single-family houses in two countries at the opposite ends of the European Union: Poland and Portugal. Such a comparison is justified by significant differences, not only cultural and geographical ones, but also resulting climate factors such as differences in temperature, humidity, hours of sunlight and amount of rainfall. These countries also differ in terms of vegetation (i.e., raw materials, technologies, methods of design and construction, as well as the way of planning space and using buildings). The purpose of this is to compare and show differences and common points, which is intended to help in planning activities aimed at promoting and developing the wooden construction sector for both geographies.

MATERIAL AND METHODS

The following research methods were adopted: critical analysis method, observation method (without intervention), case study and comparative analysis of contemporary architectural trends. In contemporary architecture, it is difficult to talk about styles due to the fact that designers avoid clear definitions and attempts to assign them to a clearly defined style. The language of architecture is diverse, but user expectations are also aesthetically diverse. Historical periods usually had a consistent definition of beauty for a given era; today, it has many variations. Hence, the terms "trend" is used more often than "style". The work used publicly available materials regarding the examined objects, as well as the designers' own materials. Formal and substantive criteria for selecting the research sample were adopted, and comparable criteria were applied to all research subjects.

Formal criteria for selecting the research sample

Formal criteria for the subject of research were determined based on the availability of materials in the following areas: location, year of implementation, designer and graphic material. The criteria were defined in detail and the assessment of their fulfilment described (Table 4). Comparable criteria were adopted for all research subjects.

Table 4. Formal criteria for selecting the research sample

No	Criterion name	Criterion definition	Description of the criterion
1F	Location	The evaluation criteria will include: – for all research subjects – the ability to determine at least the country and city.	1. Obligatory criterion. 2. Assessment of the fulfilment of the criterion involves assigning the logical value "yes".
2F	Year of implementation	The evaluation criterion will include the possibility of determining the year of implementation.	
3F	Designer	The evaluation criterion will include the possibility of identifying at least the design studio and/or the author(s) of the project.	
4F	Graphic material	The evaluation criterion will include the possibility of obtaining the following for the research subjects: – at least one illustration of the exterior, – at least one interior illustration, – floor plans of all residential floors.	

Source: team's fieldwork.

Substantive criteria for selecting the research sample

The substantive criteria of the subject of research were divided into general (function of the building, independence of the building, year of construction of the building, structure and finishing materials) and classification (type of location, contemporary formal and aesthetic trends, contemporary functional/ /spatial trends and contemporary pro-environmental trends). The criteria were defined in detail, and the assessment of their fulfilment was described (Table 5). Comparable criteria were adopted for all research subjects.

Table 5. Formal criteria for selecting the research sample

No	Criterion name	Criterion definition	Description of the criterion
		General substantive criteria	
1M	Building function	The evaluation criteria will include: – residential function, – original residential function.	1. Obligatory criterion. 2. Assessment of the fulfilment of the criterion involves assigning the logical value "yes".
2M	Building independence	The assessment criterion will include the independence of the building for its residential function: – single-family detached building.	
3M	Year of construction of the building	The dating criteria will include: – 21st century.	
4M	Construction	The following criteria will be assessed based on the building structure: – wooden structure, – hybrid structure, dominantly wooden.	
5M	Finishing materials	The criteria for evaluation will include the building's finishing materials: – wood as the dominant material.	
		Substantive classification criteria	
1K	Location type	The evaluation criteria will include the type of location: – downtown, urban, – on the outskirts (peripheral), outside the city.	1. Obligatory criterion. 2. Assessment of the fulfilment of the criterion involves assigning the logical value "yes".
2K	Contemporary formal and aesthetic trends	As part of the classification criterion, the following will be assessed: – features of contemporary trends/currents, – features of pro-environmental architecture.	1. Optional criterion. 2. Assessment of fulfilment of the criterion consists in assigning the logical value "yes" to at least one group.
3K	Contemporary functional and spatial trends	The criterion will verify the impact of: – cultural conditions, expected standard, legislation, – location and climate conditions, – climate crisis.	
4K	Contemporary pro-environmental trends	The evaluation criteria will include: – a place in line with the principles of sustainable development, minimising the impact on the environment, – materials and/or innovative pro-environmental technologies, including: • use of materials that do not disturb the balance of environmental resources, • effective use of water resources, • efficiency of heating systems.	

Source: team's fieldwork.

RESULTS

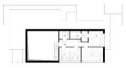
Nowadays, the profession of an architect is not limited only to design; it requires knowledge of research tools, among other things, in order to conduct interdisciplinary pre-design research before each new task. On the other hand, a new research trend in architecture is being formed – research through design. So far, the vast majority of research has been theoretical. In times of climate crisis and global social and economic problems, this approach seems to be insufficient. Practice-related research, defined as research by design, evidence-based design or action research, assumes that during design, knowledge is generated to solve a specific research problem (European Association for Architectural Education [EAAE], 2022).

Research on single-family residential houses located in Poland and Portugal

Single-family residential buildings that can obtain the status of exemplification of the thesis were selected for the study based on the established criteria. The subject of the research is a contemporary single-family residential building, constructed in a wooden or mixed structure, but with a predominant share of wood.

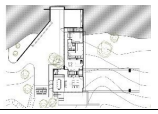
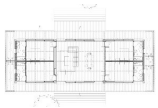
The territorial and temporal scope of the research was defined as Poland and Portugal during the 21st century. The examined facilities in both countries are listed in Tables 6 and 7.

Table 6. Surveyed single-family residential houses located in Poland

• Object number • Author's name of the building	Basic information about the object	Photography - formal and aesthetic solutions	First floor plan - functional and spatial solutions	Second floor plan - functional and spatial solutions
• 01PL • House Behind The Roof	• Location: Poland, Kraków • Year: 2018 • Area: 189 m² • Architects: Superhelix Pracownia Projektowa			
• 02PL • One Family House "Dr House"	• Location: Poland, Rosnówko • Year: 2018 • Area: 240 m² • Architects: minimalDEsign			not applicable
• 03PL • Kashubian House	• Location: Poland, Gowidlino • Year: 2016 • Area: 67 m² • Architects: Grzegorz Layer			
• 04PL • Wooden House on a Meadow	• Location: Poland, Greater Poland • Year: 2020 • Area: 150 m² • Architects: Ultra Architects			not applicable
• 05PL • House View on Brodnica Landscape Park	• Location: Poland, Pokrzydowo • Year: 2017 • Area: 160 m² • Architects: House of Architects			not applicable
• 06PL • Cedar House	• Location: Poland, Poznań • Year: 2013 • Area: 166 m² • Architects: Mariusz Wrzeszcz Office			not applicable
• 07PL • Standard House	• Location: Poland, Pszczyna • Year: 2011 • Area: 224 m² • Architects: KWK PROMES Robert Konieczny			
• 08PL • Poz 7 House	• Location: Poland, Poznań • Year: 2019 • Area: 272 m² • Architects: PL.Architekci			not applicable
• 09PL • Field House	• Location: Poland, Głogów • Year: 2016 • Area: 175 m² • Architects: Blank Architects			not applicable
• 10PL • The Farmhouse	• Location: Poland, • Year: 2021 • Area: 507 m² • Architects: BXBstudio Boguslaw Barnas			

Source: team's fieldwork.

Table 7. Surveyed single-family residential houses located in Portugal

▪ Object number ▪ Author's name of the building	Basic information about the object	Photography - formal and aesthetic solutions	First floor plan - functional and spatial solutions	Second floor plan - functional and spatial solutions
▪ **01PT** ▪ Columba Tree House	▪ Location: Portugal, Melides ▪ Year: 2022 ▪ Area: 258 ft² (23.97 m²) ▪ Architects: Madeiguincho			
▪ **02PT** ▪ Chestnut House	▪ Location: Portugal, Vale Flor ▪ Year: 2020 ▪ Area: 25 m² ▪ Architects: João Mendes Ribeiro			not applicable
▪ **03PT** ▪ Expansion of Barrocas House	▪ Location: Portugal, Estremoz ▪ Year: 2017 ▪ Area: 150 m² ▪ Architects: Carlos Castanheira			not applicable
▪ **04PT** ▪ House Quinta do Buraco III	▪ Location: Portugal, Cucujães ▪ Year: 2001 ▪ Architects: Carlos Castanheira + Clara Bastai			
▪ **05PT** ▪ Casa Costa Grande	▪ Location: Portugal, Baião ▪ Year: 2012 ▪ Architects: Carlos Castanheira			
▪ **06PT** ▪ Casa Avenal	▪ Location: Portugal, Avenal ▪ Year: 2004 ▪ Architects: Carlos Castanheira			not applicable
▪ **07PT** ▪ House in Baião	▪ Location: Portugal, Baião ▪ Year: 2021 ▪ Area: 243 m² ▪ Architects: raço Alternativo Arquitectos Associados			
▪ **08PT** ▪ Mima House	▪ Location: Portugal ▪ Year: 2021 ▪ Architects: Marta Brandão + Mário Sousa			not applicable
▪ **09PT** ▪ Eco Tróia Resort – Casa II	▪ Location: Portugal ▪ Year: 2020 ▪ Area: 300 m² ▪ Architects: GSS arquitectos			
▪ **10PT** ▪ Sister's House	▪ Location: Portugal, Penafiel ▪ Year: 2018 ▪ Area: 264 m² ▪ Architects: Balthazar Aroso Arquitectos			not applicable

Source: team's fieldwork.

Recapitulation of research results

The adopted substantive classification criteria were used to draw up detailed conclusions for further research (comparison of Table 5):

- 1K – Each location is different and requires a separate, in-depth analysis and decisions regarding formal and functional solutions in connection with pro-environmental solutions. The analysed facilities are located on the outskirts of the city or outside the city. This is the preferred type of location for wooden single-family houses; globally, new wooden buildings located in city centres are rare.
- 2K – The design solutions are similar and are based on a frame structure (Almeida De Araujo et al., 2016; Monteiro, Freire & Fernández, 2020). There were no significant implementations in other wood-based technologies such as CLT or log structures. Of course, such implementations exist, but they are not dominant. Visible differences in the construction of building partitions result from local conditions and the method of thermal insulation protection of buildings (Sousa, Bragança, Almeida & Silva, 2013; Brandão De Vasconcelos, Pinheiro, Manso & Cabaço, 2015). Due to climatic reasons, buildings in Poland are better protected against weather conditions in winter, which translates into a thicker number of layers within the building envelope or building enclosure. This is reflected in the form of the building. Projects in Portugal are characterised by lightness and greater freedom in creating space. The architectural form of buildings in Poland and Portugal differs, especially with regard to the roofs of the buildings. Projects in Portugal are characterised by flat or shed roofs with one slope. In Poland, they most often have a gable form, which can be related to the climate and current snowfall in winter, but also to historical conditions. Buildings in Poland often refer in their form to traditional agricultural buildings, often barns with a simple rectangular form covered with a gable roof. In the case of Portugal, the lack of timber references and the absence of 100% timber traditional buildings resulted in architectural freedom to explore and design other forms. All examined objects in Poland and Portugal are characterised by a strong architectural expression emphasising wood as the main building material. This is not obvious considering the possibility of using cheaper façade cladding. The use and emphasis of wood on the façades of the examined buildings results, among other things, from the desire to emphasise the natural character of the building. This is a manifestation, apart from aesthetic factors, of pro-ecological solutions resulting from the building's construction. This creates a trend to notice this type of investment, creating popularity and fashion for ecological construction among given communities (Stepien et al., 2022; Sano, Saito & Boontharm, 2023).
- 3K – The trends in shaping wooden buildings in Poland and Portugal in terms of functional solutions are similar. The functional division of living space and zoning into general/daytime and private/nighttime areas result from contemporary design trends and is universal for continental Europe. The functional layout dominates, with three bedrooms in the private/night zone. In the case of Portugal, more often than in Poland, one can observe a more extensive external part of the area functionally connected to the interior of the house. This is due to the climate and the longer period of time that allows for staying outdoors. Houses in Portugal are generally characterised by greater openness to the surroundings, most often through the use of large glazing in the living areas. In the case of Polish houses, the dominant feature is to allocate space for a garage for cars, which is also determined by the climate and winter protection (Morgado, Correia Guedes, Gomes Ferreira & Cruz, 2020).
- 4K – Contemporary wooden single-family buildings are designed and implemented with awareness of environmental problems. The location is not accidental; various ecological aspects are analysed in order to minimise the impact of the investment on the environment. Wood is an ecological, renewable material, which means it does not disturb the balance of environmental resources. Moreover, the case studies are characterised by efficient use of water resources through the harvesting and use of rainwater and, to a lesser extent, grey water. The examined facilities have various heating systems; most of them are energy-saving or passive. Most of them use renewable energy sources (RES) systems, mainly photovoltaic panels. Due to diverse location conditions, regional environmental priorities were taken into account in the design and implementation process.

On the basis of the analysed single-family buildings with wooden structures constructed in the 21st century and located in Poland and Portugal, an attempt was made to identify contemporary trends in shaping wooden residential architecture. The context of the place – urban, historical or natural – differs in each case. The single-family houses presented are mainly located mainly on the outskirts of cities or outside urban areas. They reference to local history or present universal aesthetic solutions. The natural context is crucial. It was necessary to ascertain whether, in connection with the above, it was possible to identify clear directions for shaping the architecture of wooden single-family houses and, if so, whether the conclusions could be described as general or specific. The authors aimed to indicate general directions based on their own observations and features important for designers highlighted in the authors' descriptions, divided into two problem areas that often co-occur.

1. Formal-aesthetic and functional-spatial trends – combinations of various types of shapes, more or less ordered, repeatable or single, related to greenery and terrain. Often shaped according to the principles of addition or subtraction, mainly of cubic elements, but also of rotational forms or displacements of solids relative to each other. Moreover, the examined objects can be classified according to their essential and common features: contextual and acontextual/universal, compact and fragmented, atrial and opening to the surroundings, single-storey and two- or more-storeys, modular and non-modular/single-storey.
2. Pro-environmental trends – all facilities examined were designed with ecological sensitivity in the context of the climate crisis, but the assumptions translate into implementation solutions to varying degrees. The importance of such solutions also varies, but the direction of ecological/sustainable architecture and the related bioclimatic architecture is clearly evident. The principle is the design of single-family residential buildings in functional harmony with the surrounding natural environment, making maximum use of its natural conditions without negative intervention and ensuring full comfort for all users in a friendly space.

DISCUSSION

Wooden house constructions in Poland and Portugal have a rich tradition. Based on the study's findings, it was found that in Portugal, the entire structure was less often made of wood and more often used wood as a cladding material, which was mainly due to the availability and ease of obtaining raw materials. This influenced the construction methods and the character of the architecture compared to Poland, where wood was a widely material (Silva, Mendonça & Branco, 2012).

Nowadays, the great importance of wooden structures in the context of climate change (Sulaiman, Abdul-Rahim & Ofozor, 2020; Rybak-Niedziółka et al., 2023), circular economy solutions (Kaziolas, Zygomalas, Stavroulakis & Baniotopoulos, 2013; Łacek & Starzyk, 2023), especially in relation to the Green Deal arrangements for the European Union area (Sikkema, Styles, Jonsson, Tobin & Byrne, 2023), is indicated. Prefabricated solutions in particular should be pointed out here, which may make such solutions more widespread due to their lower price and speed of installation (Araujo et al., 2022; Tenório, Branco & Silva, 2023; Švajlenka & Kozlovská, 2023). The main future solution is a system based on CLT (Balasbaneh & Sher, 2021; Krzosek & Kłosińska, 2021; Leszczyszyn et al., 2022). Both in Poland and Portugal, there is a market and realisations of such solutions (Oliveira, Couto, Mendonça, Silva & Reis, 2013; Radziszewska-Zielina & Gleń, 2014). These markets differ in housing issues, but common features can be found in terms of housing space requirements (Rącka & Khalil Ur Rehman, 2018; Instituto Nacional de Estatística, 2022; Starzyk et al., 2023).

The main differences that can be demonstrated are due to solutions resulting from climatic conditions. In the case of Poland, it is necessary to use more resistant buildings to the effects of mainly low temperatures, which is not left without an impact on the external form (Grygierek et al., 2020).

CONCLUSIONS

The authors conducted architectural research on single-family buildings with wooden structures in Poland and Portugal. The projects examined were created in the 21st century. Poland and Portugal differ in their geographical location, climate, land area and population. These factors influence the development of buildings and the adopted technological solutions adopted. However, some commonalities can be identified. One should begin by comparing conditions based on area, population and estimated forest production for construction purposes. Considering the proportion of differences in these indicators, it can be noted that Poland and Portugal are similar in terms of population density and the area of wood resources per inhabitant. A similar proportion was obtained when comparing the domestic production of wooden assortments and sawmill wood (Forest Europe, 2020). This allows us to conclude that, despite geographical, economic and social differences, Poland and Portugal have similar conditions for the development of the construction sector based on wooden structures (Nunes, Meireles, Pinto Gomes & De Almeida Ribeiro, 2019).

The results of research on contemporary trends in shaping wooden single-family architecture allowed for drawing general conclusions regarding formal solutions. The dominant forms are based on a combination of various shapes, repeatable or single, more or less ordered, often shaped on the basis of addition or subtraction. Houses take into account the context of the place; relatively few can be classified as acontextual. Mostly, they are related to the topography and greenery, taking into account the pro-environmental factor. The above important and common formal features served as the basis for the author's classification of contemporary wooden single-family houses into two main trends – neo-vernacular and neo-modernist. There are objects created with reference to the features of other trends, but these are rare cases. Both main trends can and most often coexist with the ecological trend.

Polish and Portuguese people are aware of climate change and the need to reduce the environmental burden of the construction sector (Correia Guedes, Pinheiro & Manuel Alves, 2009; Lee, Markowitz, Howe, Ko & Leiserowitz, 2015). Hence, there are more and more ecological solutions with wooden structures in these areas. This is not a dominant trend; traditional construction methods are still the most popular. This is still due to the lack of trust in wooden structures, the lack of specialised companies and the low price competitiveness of building a wooden house compared to traditional solutions (Viholainen et al., 2020; Palma, Gouveia & Barbosa, 2022). This applies equally to Poland and Portugal, despite the relatively good and comparable conditions of both countries for the development of the wooden building construction sector.

While Polish and Portuguese people are aware of climate change and the need to reduce the construction sector's environmental footprint, increasing the share of wood presents a potentially viable solution. Although there are challenges – such as timber construction not a being a dominant trend and trust in its structural integrity not yet being fully established – a long-term perspective reveals significant environmental benefits without compromising the buildings architectural and construction quality of buildings. Consequently, discussions on incentives for wood construction incentives through government policies or awareness sensibilisation campaigns should be pursued with the aim of broader implementation.

Authors' contributions

Conceptualisation: A.S., N.D.C. and C.C.D.; methodology: A.S.; formal analysis: A.S., N.D.C. and C.C.D.; investigation: A.S.; writing – original draft preparation: A.S., N.D.C., C.C.D. and P.Ł.; writing – review and editing: A.S., N.D.C., C.C.D. and P.Ł.; visualisation: A.S., N.D.C., C.C.D. and P.Ł.; supervision: A.S. and N.D.C.; funding acquisition and project administration: A.S.

All authors have read and agreed to the published version of the manuscript.

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ŚRODOWISKOWE I ARCHITEKTONICZNE ASPEKTY BUDOWNICTWA DREWNIANEGO: ANALIZA PORÓWNAWCZA WYBRANYCH ZAGADNIEŃ BUDOWNICTWA JEDNORODZINNEGO W POLSCE I PORTUGALII

STRESZCZENIE

W drugiej połowie XX wieku wydawało się, że budownictwo drewniane zostanie wyparte przez inne, coraz częściej stosowane technologie. Drewno było głównie stosowane w układach hybrydowych, nie jako dominujący materiał konstrukcyjny i wykończeniowy. Przełom XX i XXI wieku odwrócił tę tendencję. Obecnie obserwuje się zwiększone zainteresowanie konstrukcjami drewnianymi oraz wykończeniowymi drewnianymi. Drewno staje się materiałem „modnym". Mają na to wpływ nowe technologie dające nowe możliwości konstrukcyjne, a także nowe metody zabezpieczania drewna. Drewno jest odnawialnym surowcem o małym wbudowanym śladzie węglowym, materiałem łatwym do recyklingu i do stosowania w gospodarce

o obiegu zamkniętym. Celem badania jest porównanie cech drewnianych domów jednorodzinnych w Polsce i Portugalii. Zastosowano metody niezbędne do założonego celu: analizy krytycznej, obserwacji bez interwencji, studium przypadku w celu porównania współczesnych trendów architektonicznych. Wyniki badań współczesnych trendów w kształtowaniu drewnianej architektury jednorodzinnej pozwoliły na wyciągnięcie wniosków dotyczących rozwiązań formalnych, funkcjonalnych i prośrodowiskowych.

Słowa kluczowe: architektura drewniana, budownictwo drewniane, dom jednorodzinny, kryzys klimatyczny, rozwój zrównoważony, gospodarka o obiegu zamkniętym