

A COMPARATIVE ANALYSIS OF ARCHITECTS' VIEWS ON WOOD CONSTRUCTION

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Even though wood is locally a traditional material, it is rarely used in architecture in Bosnia and Herzegovina, which is why the constructed buildings have poor ecological properties. The main objective of the research is to determine the views of architects on sustainability principles in architecture, contemporary products and wood construction systems. An online questionnaire was used to collect responses by architects from Bosnia and Herzegovina, Serbia and Austria. The research results confirm the hypothesis that architects in Bosnia and Herzegovina, and in Serbia alike, do not have sufficient knowledge on the principles of sustainable architecture, contemporary products and wood construction systems, which is why they do not use wood in their projects. The results of a comparative analysis suggest that there is a cause-and-effect connection between the architects' views and the volume (scope) of the use of wood, and that the use of wood in constructing buildings in Austria is not only a result of better technical and technological equipment but also of the different views held by the architects. The value of the research results is that they point to the fact that by improving architects' knowledge we may improve architectural sustainability by using wood to a greater extent.

Key words: sustainable architecture, ecological properties of buildings, contemporary timber products, architects' views, advanced training.

INTRODUCTION

The term sustainable architecture derives from the term sustainable development. There is no official definition of sustainable development, and the definition given in 1987 by the World Commission on Environment and Development, the so-called Brundtland Commission, in its report titled *Our Common Future* is the one most widely used. It states that sustainable development strives to meet current needs without jeopardizing the possibility of meeting the future ones (UN, 1987). Just as there is no official definition of sustainable development so may numerous definitions be found in the literature on sustainable architecture, as well as very close terms such as sustainable, green, energy efficient, ecological, bioclimatic and so on. Knudstrup and others claim that architects rarely use the term sustainable, but they say for architecture that it is environmental, ecological, low energy, green, bioclimatic, solar and so forth, and that different terms point to different principles of this architecture (Knudstrup *et al.*, 2009). In the book *A Green Vitruvius. Principles and Practice of Sustainable Architectural Design* the authors list the terms used: environmentally friendly, environmentally conscious, energy conscious,

sustainable, green, or simply green architecture, and conclude that there is no internationally accepted definition of green architecture (Fitzgerald *et al.*, 2008). Woolley, *et al.* conclude that there are many shades of green, as many terms are used in that regard (green, sustainable, environmental, ecological), and their shades depend on the context and audience they are intended for (Woolley *et al.*, 2006). Depending on the way one looks at it and how the term sustainability in architecture is defined, certain fields get priority. For a building to be assessed as green, four groups of reference points must be observed: reduction of energy for use, reduction of external pollution and harm on the living environment, reduction of embodied energy and resource draining, and reduction of internal pollution and harm on health (*ibid.*).

With its characteristics, wood meets all the defined principles relating to sustainable architecture: use of local materials and (re)sources, use of materials from renewable sources, low energy materials and nontoxic materials (*ibid.*). Many authors stress the importance of wood as a material with minor effects on its users and the living environment, and they claim that wood is one of the best materials in nearly all situations (Bokalders and Block, 2010). Wood derives from a renewable source, i.e. forest, and after usage it may be processed into another product, or it may be used as a source of energy in the

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process of pyrolysis or ordinary combustion. As a building material, wood has a unique characteristic that is of great importance for the preservation of the living environment, namely that it reduces the amount of harmful CO₂ in the atmosphere by absorbing significant amounts of CO₂ during its growth, about 2 t CO₂ per 1 m³ of wood (Kitek Kuzman and Vratuša, 2011). Wood production and processing also requires less production of energy than any other building material. Hence, for example, aluminium requires large quantities of energy for its production, 515,700 MJ/m³, steel requires 167,648 MJ/m³, cement requires 6,378 MJ/m³, brick requires 4,956 MJ/m³, and concrete 2,551 MJ/m³ (Kirby, 2008), glass requires 151,200 MJ/m³, plastic 93,620 MJ/m³, while sawn timber only requires 165 MJ/m³, wood chipboards 4,400 MJ/m³, and laminated timber 2,530 MJ/m³ (Kitek Kuzman and Vratuša, 2011).

The design and construction of sustainable architecture using wood is the practice of many countries, a practice based on its traditional use, but also upon applying the modern technologies of wood and timber processing and the production of new elements and products. Hence, cross-laminated timbers (CLT panels) can be used to build not only interfloor constructions (mezzanine lofts) and walls, but also whole premises. New systems enable greater freedom in design, and also in constructing several-storey buildings. Owing to the properties of CLT panels, an eight-storey building was constructed in London (Kujundžić, 2014).

The idea of sustainable architecture is not recognized enough in Bosnia and Herzegovina, so the same is not systemically used in the process of designing and constructing buildings. As for the materialization of houses, the several-century long traditional and local materials (in Bosnia and Herzegovina a local material is wood) are not sufficiently used (Truhelka, 1901; Redžić, 1974; Findrik, 1994; Arnautović-Aksić, 2009; etc.). In 2010 only 13,479 m² of prefabricated houses were built in Bosnia and Herzegovina, which is not even 1% of the total number of family houses (BHAS, 2011). In Austria the percentage of family houses constructed of wood is high, with a total of 35.7% (Kitek Kuzman, 2010). Prior to the war that broke out in 1991 in Bosnia and Herzegovina, 250,000 m² of prefabricated houses were manufactured (Iličić, 2011).

Architects in Bosnia and Herzegovina are not sufficiently aware of the significance of the use of wood for the ecological propriety of architecture, or for the overall sustainable development of Bosnia and Herzegovina. While the significance of the use of wood is increasing worldwide, in Bosnia and Herzegovina buildings are constructed in the same way as twenty years ago, and with each day the number of buildings with poor ecological performances is growing.

REVIEW OF PREVIOUS RESEARCH

The ecological performance of residential buildings in terms of the materials used was subject to the research of the author for the needs of the ongoing doctoral dissertation *The Application of wood in the residential architecture of Bosnia and Herzegovina from the viewpoint of the environmental safety of buildings*. One result of the research points to the scientific finding that family houses built of easy panel

elements or by the mass use of CLT panels have far better ecological properties compared to the buildings that are currently being mass-constructed in Bosnia and Herzegovina with reinforced concrete and bricks. The research results prove that only the use of wood as the underlying material for construction may significantly improve the ecological properties of a building.

During the research, after exploring the characteristics of existing family houses, the author evaluated selected houses. The reference house (T) constitutes a typical family house in Bosnia and Herzegovina constructed between 1991 and 2014. Two of its variants were also evaluated – one built using easy wooden prefabricated panels (Tp), and the other using CLT panels (Tc). The evaluation was carried out using the *eco2soft* software from the Austrian Institute for Building Biology and Ecology (IBO, 2011). The evaluation results are given in Table 1 and Figures 1 and 2. The total ecological assessment of houses was illustrated by the ecological indicator OI3: Data on the consumption of energy from renewable sources (PENTR), as well as ecological indicator values – global warming potential (GWP) and acidification potential (AP) – give additional information on the ecological performance of houses.

Table 1. Results of the ecological evaluation of houses T, Tp and Tc

House	Assessment	PENTR	GWP	AP
		MJ	kgCO ₂ eq.	kgSO ₂ eq.
	BG3	per m ² of reference surface (OI3)		
T	270	3.426,00	234,57	0,874
TP	189	2.806,00	-23,88	0,745
TC	186	824,20	-118,40	0,804

The research results suggest that houses in which wood was used as the underlying material for structural elements, marked as Tp and Tc, have far better ecological characteristics than houses built in classical mass (Figures 1, 2).

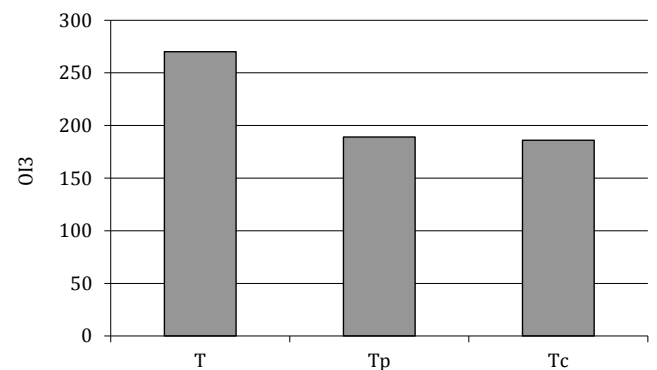


Figure 1. Results of the ecological evaluation of houses T, TP and TC (Source: author)

Wood, the impact of which on the ecological propriety of houses in Bosnia and Herzegovina has been proved in previous research, is not sufficiently used to have a greater impact, even though all the necessary prerequisites are there – raw materials (forest), a tradition of wood construction, and wood processing capacities. Due to the fact that there are good conditions for using wood, the question now

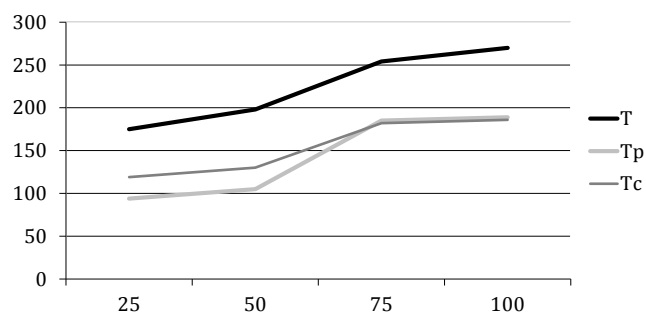


Figure 2. Results of the ecological evaluation of houses after 25, 50, 75 and 100 years (Source: author)

relates to the role of architects and their responsibility for the situation we have today. Architects and planners have an important role in achieving sustainable architecture, and they must, according to Bokalders and Block (2010), think holistically and have good basis in all aspects of sustainability, a wide and integrated approach, and a good understanding of different parts relevant for the sustainability of the whole building.

The attitude of architects on the use of wood in architecture has not been subject to more comprehensive research. Sanela Klarić conducted research related to the topic when she carried out a survey on employees in urbanism departments in certain municipalities of Bosnia and Herzegovina with respect to their knowledge of the principles, laws, regulations and standards of clean technologies and green construction, and the levels of requirements for building sustainable buildings, as well as the need for informal education in the institutions of Bosnia and Herzegovina. The survey results suggest that the level of knowledge on the subject matter is low and that the knowledge is only theoretical. The results also show that they did not have any investors with requirements for building low energy or passive buildings. Accordingly, she concluded that it is necessary to organize education on the application of clean technologies in construction that would be intended for civil servants, but also other participants in the construction process – investors, construction companies, etc. (Klarić, 2015).

A study on the use of wood as the material for building family houses in Slovenia was conducted in 2006 by Manja Kitek Kuzman and Jasna Hrovatin (2007). Through a survey intended for potential investors they asked for their views on the use of wood as a building material. The survey results showed that 60% of investors prefer classical construction, while only 34% respondents prefer wooden fabricated construction. In their view, the main reasons for this are tradition and their unfamiliarity with wood construction (in regard to its duration, stableness, confidence, safety and quality), and only 45% stated that they know what the advantages of wood construction are, such as ecological building, energy safety, fast building and resistance to the effects of earthquakes.

The author conducted the research in order to determine what views architects take on sustainable architecture, their education system, the use of wood in construction and to find out their attitude on wood as a building material, as

well as how well they know the wood products market in three different countries: Bosnia and Herzegovina, Serbia and Austria. Two countries of similar social-economic circumstances and scope of the use of wood were selected (Bosnia and Herzegovina and Serbia), in addition to one with significantly greater use of wood in architecture (Austria). The research results point to potential measures, the implementation of which should result in the greater use of wood in architecture, and consequently in the improvement of the ecological performance of houses in Bosnia and Herzegovina.

The main hypothesis is that architects in Bosnia and Herzegovina, as well as in Serbia, have insufficient knowledge on the principles of sustainable architecture, contemporary products and wood construction systems, which is why they rarely use wood in their projects. The difference between the volume of wood used in construction in Bosnia and Herzegovina and Serbia, on the one hand, and in Austria, on the other hand, is not only the result of different technical and technological equipment, but also of the different views of architects.

METHODS

The countries in which the study was conducted are on different levels regarding their economic development, with Austria having the highest GDP and population size (World Bank, 2010). The GDP per capita in Austria is more than ten times higher than that of Bosnia and Herzegovina, and eight times higher than Serbia. Austria differs significantly from the other two countries not only in regard to its economy, but also in regard to its manufacturing and consumption, i.e. its use of wood in construction (UNECE, 2010). An overview of the data relevant for the research is given in Table 2.

It should be pointed out that some sources give only data on woodlands (wooded lands), while others give data on wooded land and forest vegetation in wider terms. Therefore, there are a lot of different data on percentages of woodlands. Austria has the highest percentage of woodlands, at nearly 47%, whereas in Serbia that percentage is the lowest at 31%. There are significant differences among the countries with respect to tree species, so evergreen tree species dominate in Austria, whereas in Serbia, and Bosnia and Herzegovina, deciduous trees are dominant. Forests in Austria are primarily privately owned, while in Serbia, and Bosnia and Herzegovina the forests are mainly publicly (state-) owned.

Data on architects' views across the three countries were collected using an online survey, which took place from June to July 2015. The author of this paper independently (on her own accord) prepared the questions in the survey questionnaire. In Austria ProHolz Styria carried out the same survey, and submitted its results to the author of the paper. The author personally sent the online survey to the members of the Chamber of Engineers (Architects) in Serbia, as well as to a number of architects in Bosnia and Herzegovina. The survey covered a larger number of architects, and 290 responses were collected, 105 in Serbia, 123 in Bosnia and Herzegovina, and 62 in Austria. The survey results were first analyzed separately (individually) per state, and then a comparative analysis was made.

Table 2. Research relevant data: number of citizens, GDP, surface of the country and data relating to forests and wood products

Indicator	B&H	Serbia	Austria
Population*	3.835.258	7.291.436	8.363.404
GDP (US billion \$)*	16,85	39,46	389.679
GDP/ per capita \$*	4.780,0	6.423,3	51.131,0
Surface (km ²)	51,197	88,361	83,855
Forest area (% of land area)	42,7	31	46,8
Forest area (km ²)	21,85	27,13	38,87
Growing stock (million m ³)	209,78	271,41	1075,27
Growing stock (m ³ /ha)	167,56	176,93	321,64
Publicly owned (%)	81	53	19,46
Private and other (%)	19	47	80,54
Production (million m ³ rwe)	3,09	2,40	41,84
Consumption (milion m ³ rwe)	1,96	3,6	22,11

(Source: World Bank, 2010a; 2010b; 2010c; UNECE, 2010)

The structure of the architects questioned differs significantly. Male respondents prevail in all three countries, and they are clearly dominant in Austria. Austrian architects have the longest years of service, and those in Bosnia and Herzegovina have the least, mostly below 10 years. Experts working in the field of architecture are most common in Austria and make nearly 81% of the Austrian respondents, in Bosnia and Herzegovina they account for only 41.5%.

RESULTS AND DISCUSSION

On the basis of the online survey questionnaire and answers collected in the respective countries, the answers were systematized per state, and then together for all the countries. The results, together with the discussion, were presented textually for groups of questions, and in figures for the most important issues.

Groups of questions referring to the educational system and advanced training

Most of the architects believe that the knowledge on wood construction gained during their higher/university education is not enough. Differences recorded among the countries were only those presented in the form of the percentage of architects giving the aforesaid opinion, thus in Bosnia and Herzegovina it is 81%, in Serbia 73.3% whereas in Austria the percentage is somewhat lower, at 60%.

For further research it would be interesting to compare the curriculums of the higher education institutions in all three countries. Based on the results of that research, steps could be taken to innovate within the curriculums of the higher education institutions. The results with answers are given in Figure 3.

After graduating from school, a lot of architects undergo advanced training, but there is a noteworthy difference between the respondents from EU countries and those that are not from EU countries. In Austria 60% of the architects questioned attended advanced training, whereas 43% of architects in Bosnia and Herzegovina confirmed that they had taken advanced training, and 48% in Serbia. Possible reasons are that in some countries legislation obligates the architects to lifelong education, while this is not the case in other countries.

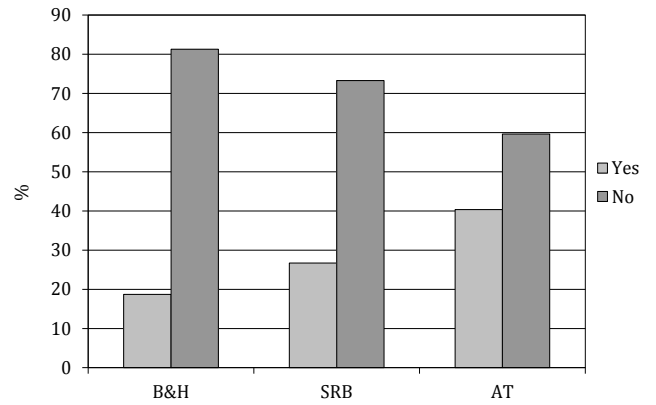


Figure 3. Answers to question no. 1 (Source: author)

Advanced training for architects is an important element in keeping up with modern technology and materials as well as the innovative use of classical materials. The architects took different forms of advanced training such as attending seminars and conferences, reading technical literature and so forth. A high percentage of respondents took advanced individual training in the form of reading technical literature. There is a significantly lower number that attend seminars and conferences.

Group of questions referring to the architects' views

The architects' attitude towards the use of wood can best be illustrated by their answers to the question "would you build your own house with a wood construction?" Most of the architects answered affirmatively, and the only difference recorded was in the percentages of affirmative answers. The highest percentage was in Austria, with 93% of the architects, and the lowest in Bosnia and Herzegovina, accounting for less than 60% of the architects there. The answers indicate that personally they value wood as a building material, and the results with the answers are given in Figure 4.

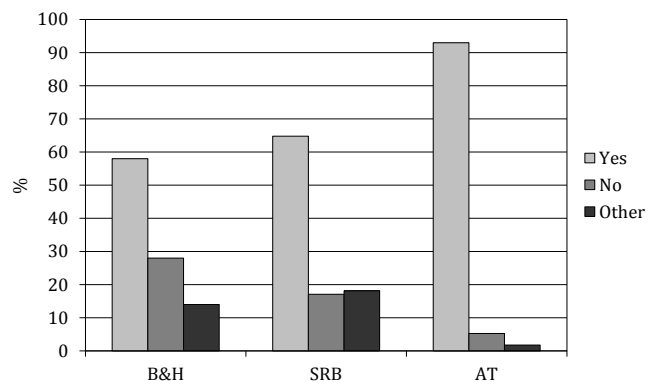


Figure 4. Answers to question no. 8 (Source: author)

In their work with the investor, most of the architects suggest using wood as the building material, the difference being in their percentage of the total number. Nearly 97% of Austrian architects suggest wood to be used as the building material, compared to 57% in Bosnia and Herzegovina. Their work with the investor may affect the use of wood in construction building, so the architects' views and their

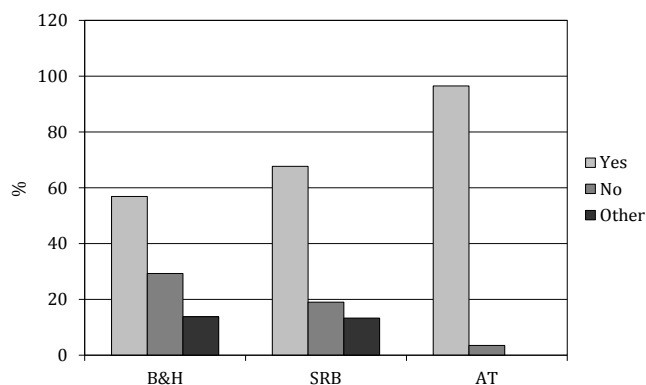


Figure 5. Answers to question no. 4
(Source: author)

efforts in presenting the advantages of wood construction to the investor are of great importance. Unfortunately, the architects' positive views are not always supported by the supply of wood and timber products in the country or by good contractors. The results with the answers are given in Figure 5.

The architects point to the ecological properties of wood as the main reason for suggesting wood as a building material (77-93%), while only in Austria is faster construction almost equally important. The lower price of wood as a building material is of greater importance than fast construction in Bosnia and Herzegovina and Serbia. The significance of the ecological properties of wood construction points to the fact that architects know the building materials and their impact on the environment quite well.

The greatest number of architects who suggest the use of wood for construction are Austrian, more than 85% of them. In Serbia and Bosnia and Herzegovina 74-80% of architects suggest using wood for floors. Suggestions to use wood for front finishing carpentry were ranked second by their importance in Bosnia and Herzegovina, and in Serbia facade coverings were ranked second by their importance. The answers given are the result of the high level of development of the wood processing sector in Austria, which for years now has been supporting and promoting wood construction.

Architects who do not suggest the use of wood as a building material say that the main reason for that is, first and foremost, the prejudice that investors have towards wood construction (Bosnia and Herzegovina, and Austria), and then the problem of finding good contractors in Serbia. In Austria, and Bosnia and Herzegovina higher prices of wood products do not affect the architects' views on recommending wood construction to the investors they work for.

Group of questions referring to the knowledge of wood product markets

Most of the architects are not that familiar with the situation on the market regarding wood products, which certainly results in the fact that wood products are not used enough in their projects. The market for wood products in the country is something only the architects in Austria know well, more than 75% of them. The results with answers are given in Figure 6.

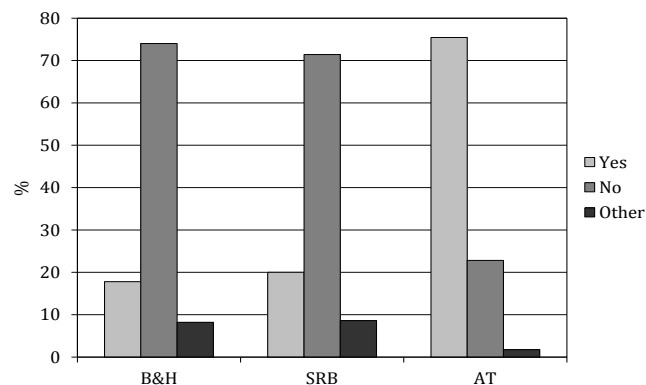


Figure 6. Answers to question no. 9
(Source: author)

Although over 84% of the architects in Austria know the wood products market quite well, they have problems in finding good contractors.

The architects had the opportunity to contact and cooperate with different companies in their countries, but also abroad. However, having in mind their views that they do not know the market well, it is obvious that those contacts were not sufficient and that there is scope for the promotional activities of wood product manufacturers.

CONCLUSION

The survey results confirmed the hypothesis that architects in Bosnia and Herzegovina, and in Serbia alike, do not have sufficient knowledge on the principles of sustainable architecture, contemporary products and wood construction systems, which is why they rarely use wood in their projects. The difference between the volume of wood used in construction in Bosnia and Herzegovina and Serbia, on the one hand, and in Austria, on the other hand, is not only the result of different technical and technological equipment, but also the fact that there is a cause-and-effect connection between knowledge of contemporary wood construction and use of wood in construction.

Based on the findings that during their education architects do not gain enough knowledge on sustainable architecture and the use of contemporary products and wood construction system, measures could be taken in order to organize additional education for them. An example of a country that offers excellently organized professional training is Austria, in which the State finances seminars and conferences. The research recorded a higher level of knowledge and different attitude towards wood and the application of the principles of sustainable architecture in designing buildings and houses for Austria.

To improve the architects' knowledge of sustainable architecture, products and wood construction systems in Bosnia and Herzegovina, and in Serbia alike, the following should be continuously worked on:

1. improvement of the education system, especially higher education, in the field of architecture and civil engineering, with special reference to the modernization of curriculums in the field of sustainable architecture, modern products and wood construction systems;

2. education on the principles of designing ecological architecture, where special attention should be paid to the materials used: use of local materials traditionally used, use of materials from renewable sources, replacement of high-emission materials with low-emission ones, such as wood and wood products, use of innovative constructions for improving the energy performances of existing buildings and so on;
3. establishment of a more intensive international cooperation and exchange/share of technologies, on all levels – chambers of engineers, professional associations, institutions of higher education and individuals.

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