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ENVIRONMENTAL EVALUATION OF ALTERNATIVE WOOD-BASED EXTERNAL WALL ASSEMBLY

Jozef Mitterpach – Rastislav Igaz – Jozef Štefko

ABSTRACT

During the past decades in the construction sector, the emphasis has been laid on the development of environmentally friendly materials and structures. Therefore, the environmental impact of composite wood-based materials is crucial for sustainable construction. The aim of this paper is to present the results of research on the environmental impact assessment of the external wall assembly of wood-based structures used in wood constructions. Eight wall assemblies usable in ultra-low energy structures and nearly-zero energy buildings (passive buildings) with U-values in the range from 0.099–0.211 W/(m^2K) were included in the analysed and evaluated group. The environmental analysis Life Cycle Impact Assessment (LCIA) was performed by SimaPro software, using the IMPACT2002+ method in terms of an impact on selected components (human health, ecosystem quality, climate change, resources). An assembly based on a cross-laminated timber (CLT) panel with insulation on the blown cellulose base was evaluated as a structure with the greatest environmental impact, closely followed by the assembly based on a box beam with glass-based mineral insulation. The impact assessments of both of these assemblies were more than 16 mPt. On the other hand, structures using wood fibre, straw and especially sheep wool as insulation were assemblies with the least negative impact on the environment. Their impact assessment was from 6.6–8.2 mPt. The research results also showed that the material assembly of the external wall significantly influences the LCIA analysis result, and the choice of insulating material is the most important, as the insulation is more than 80% of the volume of the wood-based structures on average. The results of the life cycle analysis show that the selection of structural and especially insulating materials plays an important role in the case of wood constructions.

Key words: LCA, LCIA, wood construction, green building.

INTRODUCTION

At the time of the devastating environmental impact of today's civilization, the emphasis has been placed on the development of environmentally friendly materials, structures and technologies. Even in the construction sector, efforts are focused on minimizing the environmental impacts of structures, operating facilities or on producing and using the products along with the building energy efficiency trends.

Local material availability, its low cost, rapid construction, simple processing and a wide range of structural possibilities are the main benefits of wood-based structures. Significantly, a lower negative impact on the environment from the point of view of life cycle assessment is considered a significant contribution of wood in construction. Wood allows civil engineers to build light, standardized building structures with excellent thermal insulation properties (CORDUBAN *et al*. 2017). Therefore, wood constructions are popular all over the world. The progressive development in the field of timber construction results in the construction of multi-functional timber buildings accepted by a wide community of civil engineers and designers (MÜLLER *et al.* 2016).

A wide range of timber materials is used in the construction of wood-based structures. Nowadays, a number of large scale wood-based sheathing materials (fibreboards, oriented strand boards, gypsum fibreboards, cement-bonded particle boards) also a number of wood-based thermal insulation materials (wood fibre, recycled cellulose, wood crust), as well as other materials (mineral insulation, polymer foam based insulation) are used in addition to solid wood (ŠTEFKO *et al.* 2010, KRIŠŤÁK *et al.* 2019). The range of insulating materials used is growing and the research on the use of wood waste, wood bark coconut fibre or sheep wool taking into account their lesser environmental impact compared to conventional materials is also conducted (CETINER and SHEA 2018, TUDOR *et al.* 2018, PANYAKAEW and FOTIOS 2011, ZACH *et al*. 2012, IGAZ *et al.* 2017). Despite worse insulation properties of these materials, their benefit is mainly due to their low cost and lesser environmental impact. Due to the popularity of wood constructions, new materials, e.g. wood-concrete composites characterized by excellent fire resistance, good acoustic insulation properties, high heat capacity, and the possibility of prefabrication started to be used for low-energy construction (FADAI *et al.* 2016). Similar systems refer to as "hybrid building systems" (MÜLLER *et al.* 2016). Their higher negative impact in terms of the environment is the most significant disadvantage with respect to standard timber buildings. However, they provide better functional properties than wood constructions in many aspects.

Environmental impact assessment of buildings throughout their life cycle, from material manufacturing to construction disposal or another sub-period is becoming a part of a sustainable approach to the construction process in the world. Life cycle assessment methods can be applied in various scopes, partially in the case of building materials used and their production (ZABALZA *et al.* 2011, KRIŠŤÁK *et al.* 2014) or to buildings as a whole (BLENGINI, DI CARLO 2010, VILCHES *et al.* 2016). LCA analyses may include material production, their incorporation into construction, building usage, maintenance, dismantling and final waste disposal. Energy and material flows are defined in order to analyse and quantify environmental impacts in each life cycle phase. The LCA method was developed in the 1960s and now it is accepted worldwide. There is a detailed methodology, the application is internationally harmonized, standardized and used (BJORN *et al.* 2017). The requirements for the life cycle assessment (LCA) method are specified in the standards – namely EN ISO 14040:2006 and EN ISO 14044: 2006 entitled "Environmental Management. Life cycle assessment. Requirements and Guidelines."

In the life-cycle analytical methods, a number of input factors must be taken into account and their impact on various components must be assessed. The analyses show that the cumulative energy intensity of wood constructions can be up to 18% lower and the impact on climate change is up to 25% lesser in comparison to the massive constructions built by conventional construction technologies (HEEREN *et al.* 2015). The choice of materials used for construction and heating system selection is becoming increasingly important, particularly in the case of energy-efficient construction (DODOO *et al.* 2012).

In general, the LCA method is used to compare the environmental impacts of either products or services with respect to their life cycle (KOČÍ 2010 and BOGACKA *et al.* 2017). In terms of buildings, the cycle starts after the raw material are extracted, goes through the production of building materials and units, their transport to construction, installation, continues in the stage of use including maintenance and eventually to the disposal of the building after the end of its life, or recycling and energy recovery of construction waste. Effective processing of LCA studies implies access to process, material, and energy flow databases. The method is one of the most important information tools for environmentally driven product policy.

The main benefits of the life cycle assessment method are:

- Comparing the environmental impacts of products with regard to their function.
- Assessing the environmental impacts with respect to the product life cycle.
- Establishing system boundaries to clearly express the scope of the product system.
- Expressing environmental interventions not by calculating emission flows but by defined impact categories - converting weighted emission flows into specific values of impact category indicators.
- Identifying the transfer of environmental problems both in space and between different impact categories.

The aim of the paper is to introduce the results of the research in the area of environmental impacts assessment of the material assembly and construction type of the external walls of wooden buildings (LCA analysis). To conduct the assessment, eight types of commonly used external wall assemblies were chosen considering a wide range of used materials and constructional approaches. The software package of IMPACT 2002+ was used for the LCA analysis. The assessment considered the four areas of impacts: human health, ecosystem quality, climate change and resources).

MATERIALS AND METHODS

Assembly of analysed structures

Eight types of wall assembly were created in the research and analysis of the properties of wood-based external wall structures. Various types of structural load-bearing systems were taken into account when creating the assemblies (joist column systems, I-beams, composite cross-section beams, or cross-laminated panel), various materials used as insulating materials (mineral fibre insulation, polystyrene, PU-foam, straw, sheep wool, blown cellulose), various types of internal surfaces (gypsum plasterboard, gypsum fibreboard, clay plaster), ventilated and classic facade solutions and diffuse open and closed structures. Moreover, selecting assemblies commonly used in real national conditions for wooden constructions was the most important step. The requirements of the current legislation in the field of thermal and technical requirements for wall structures were also taken into consideration. The structural and material construction of the individual S1– S8 assemblies used to determine the thermal properties and LCA analysis are shown in Figure 1 – Figure 8 (EPS - expanded polystyrene, CETRIS - cement particle board, PU – polyurethane, OSB - oriented strand board, HDF - high-density fibreboard, CLT - cross-laminated timber).

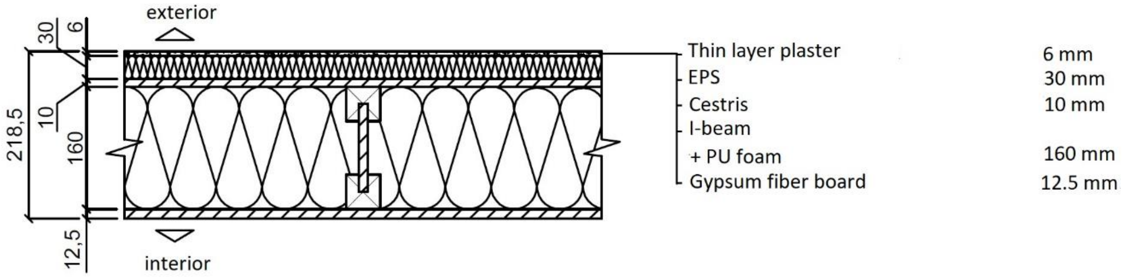

Fig 1. Cross-section and materials in the assembly of the S1 structure.

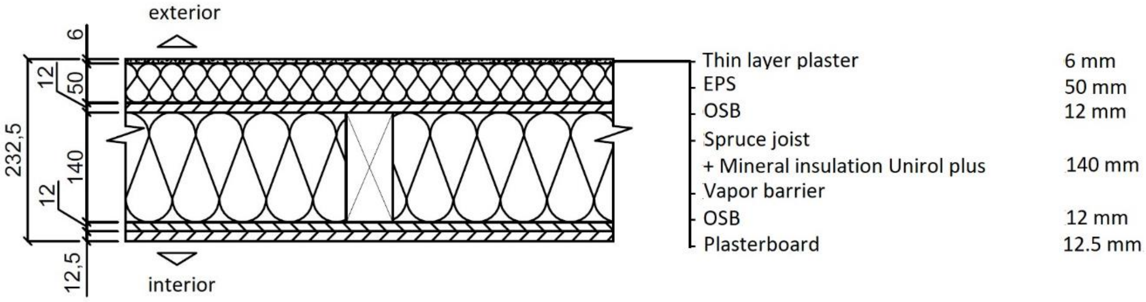

Fig 2. Cross-section and materials in the assembly of the S2 structure.

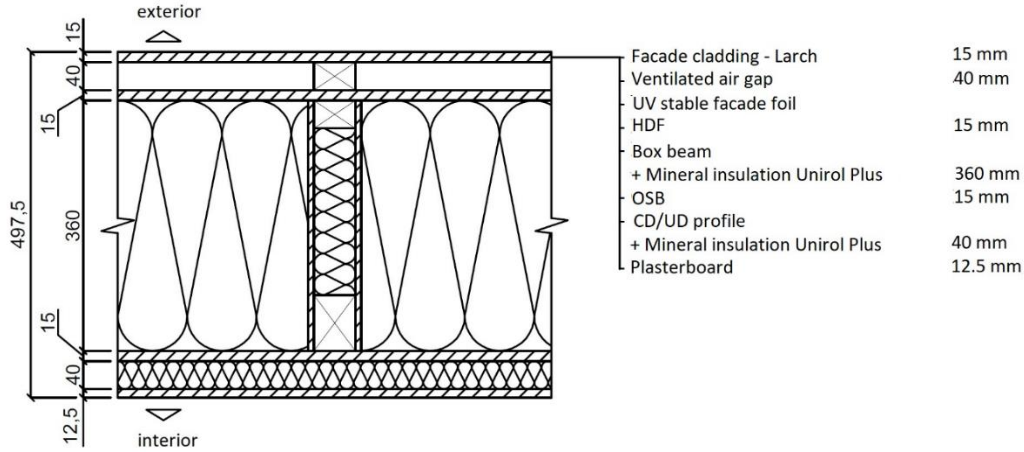

Fig 3. Cross-section and materials in the assembly of the S3 structure.

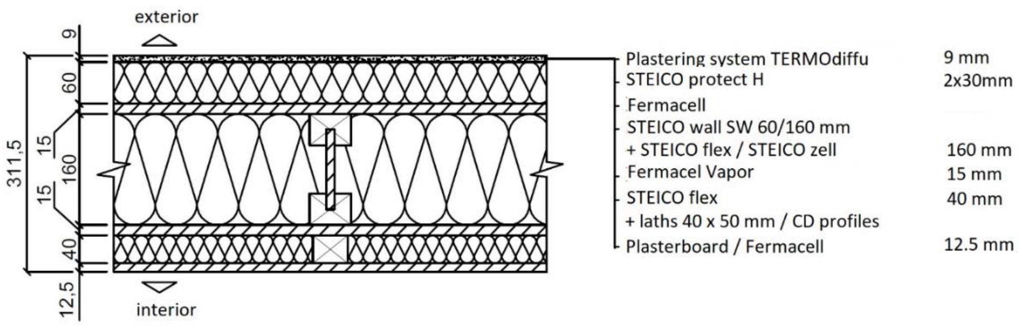

Fig 4. Cross-section and materials in the assembly of the S4 structure.

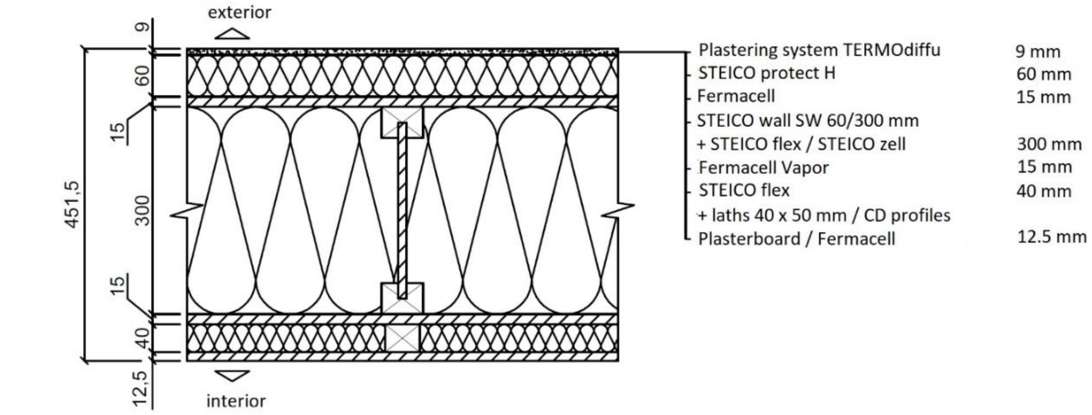

Fig 5. Cross-section and materials in the assembly of the S5 structure.

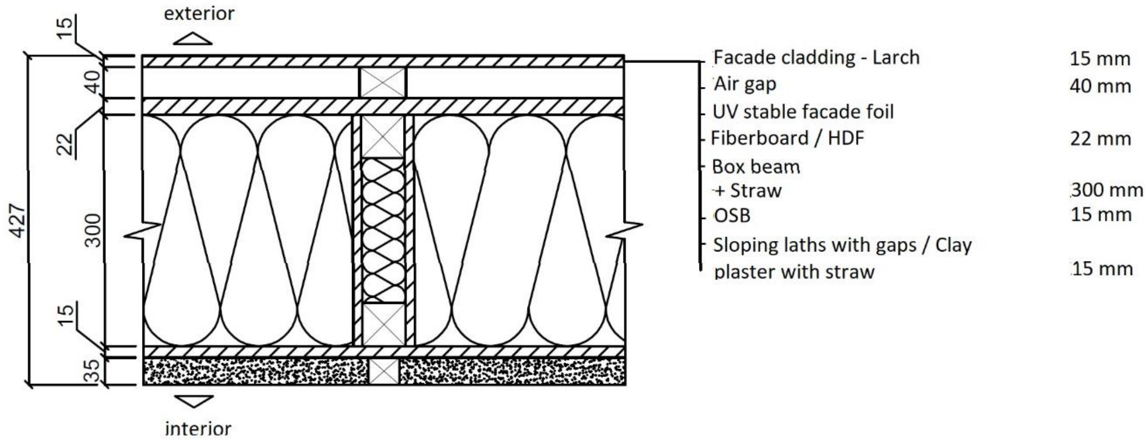

Fig 6. Cross-section and materials in the assembly of the S6 structure.

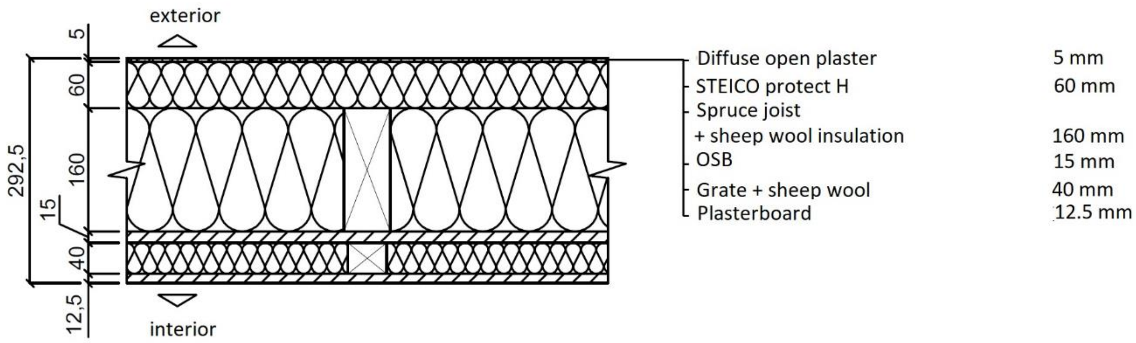

Fig 7. Cross-section and materials in the assembly of the S7 structure.

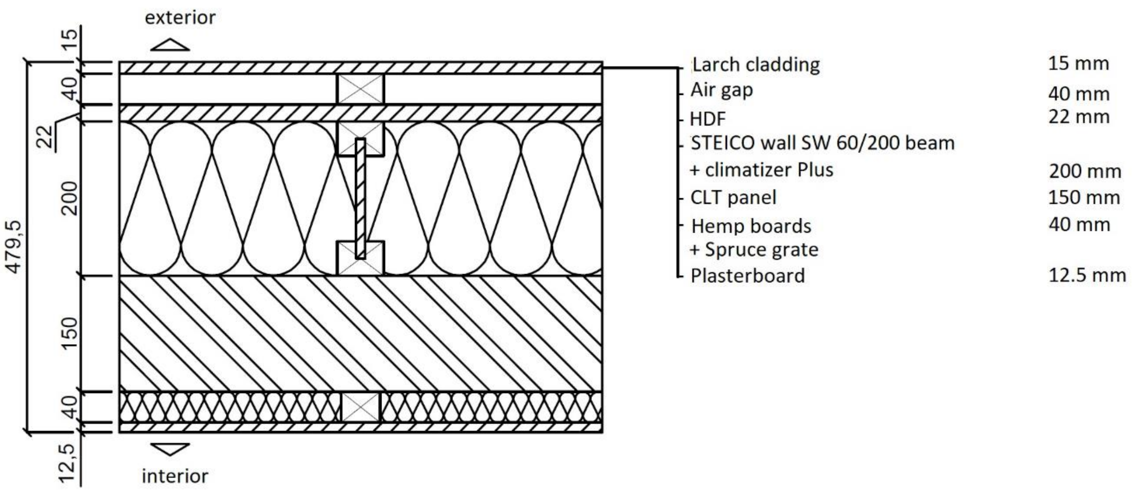

Fig 8. Cross-section and materials in the assembly of the S8 structure.

Life cycle assessment

The development in building regulations and standards is headed towards near-zero energy consumption (European Council for an Energy-Efficient Economy). However, many regulations refer to zero energy consumption focused only on operating energy and ignoring the energy stored in materials.

The aim of the research was to evaluate the environmental impacts of structures of wood-based external walls used in wood constructions. The studied assemblies were created from a wide range of materials used in timber constructions with the application of various structural approaches. The LCA method (Figure 9) (ISO 14040, ISO 14044, EN 15804:2012+A1:2013) was used in environmental impact analysis while input and emission outputs throughout the production chain from exploration, extraction of raw materials to processing, transport to the final use were taking into account energy.

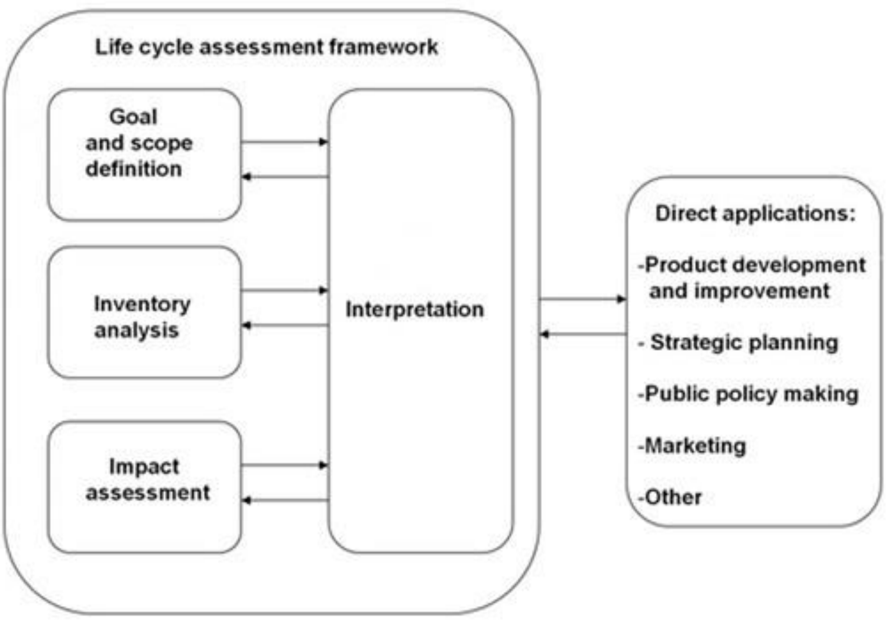

Fig. 9 LCA analysis phases and their relations.

The aim of the life cycle assessment was to identify the environmental impacts of the structures and components in the proposed S1 - S8 wall assemblies and to determine the magnitude of the negative impact of individual structures and their materials on selected components relating to the environment.

The scope of the study includes product stage (modules A1 to A3) according to ISO EN 15804. The results contain the overall environmental impact of all wall assemblies and their materials within the impact category, including the whole product stage, thus they are not subdivided into particular modules. 1m^2 of the designed structures was determined as a functional unit. Therefore, the results of this study could be compared with other wall assemblies where parameters valid for 1 m^2 are known. SimaPro 8.4 and the IMPACT 2002+ life cycle assessment method (PRÉ CONSULTANTS, 2016) were used to model and process the results of impacts of each wall assembly. Materials used in the assemblies and subsequently, in the assemblies of the external walls were analysed using the Life cycle analysis. An assessment of the impact on four components relating to the environment (human health, ecosystem quality, climate change, resources) was the result of the analysis.

IMPACT 2002+ evaluation method

IMPACT 2002+ is an abbreviation for the IMPact Assessment of Chemical Toxics. It is an impact assessment methodology originally developed by the Swiss Federal Institute of Technology - Lausanne (EPFL) with the current development carried out by the same team of experts, called Ecointesys-life cycle systems now. The current methodology offers an acceptable performance by combining midpoints and endpoints (damage) approaches, linking all types of life cycle inventory results through 14 (15) midpoints and four damage (endpoints) impact categories (Figure 10). The base unit of the overall environmental impacts in the environmental assessment is Pt or mPt (point-standard eco-indicator normalized unit) (FRISCHKNECHT *et al*. 2007 and JOLLIET *et al*. 2003).

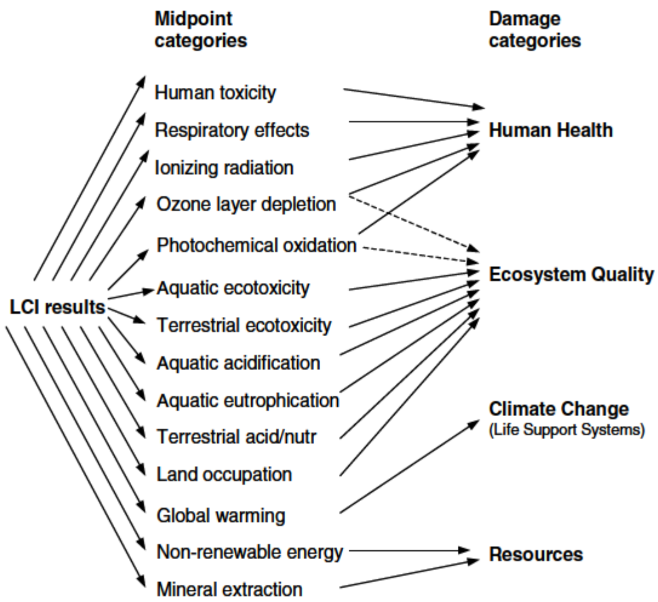

Fig. 10 Midpoints and endpoint category of impact indicators (JOLLIET *et al*. 2003).

Characterization

The factors of toxicity and Eco toxicity followed the IMPACT 2002+ methodology. Characterization factors of other categories are adapted from existing characterization methods such as Eco-indicator 99, CML 2001, IPCC and Cumulative Energy Demand. Characterization factors for nearly 1500 different LCI results were provided by the IMPACT 2002+ method (Figure 11). Environmental impacts at up to 15 midpoints (carcinogens, non-carcinogens, respiratory inorganics, ionizing radiation, ozone layer depletion, respiratory organics, aquatic Eco toxicity, terrestrial Eco toxicity, terrestrial acidification and nutrification, land occupation, aquatic acidification, aquatic eutrophication, global warming, non-renewable energy, and mineral extraction) that transforms into 4 endpoints: human health, ecosystem quality, climate change and resource consumption can be evaluated with the latest version of the IMPACT2002+ life cycle impact assessment (www.presustainability.com).

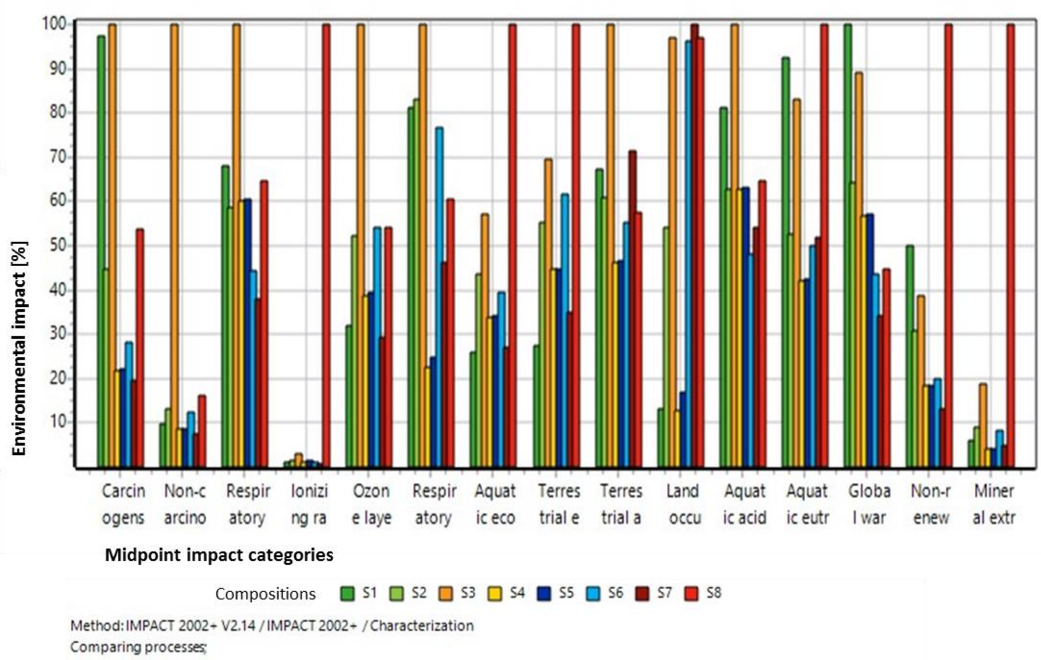

Fig. 11 Characterization of S1- S8 structure assemblies, SimaPro, IMPACT2002+.

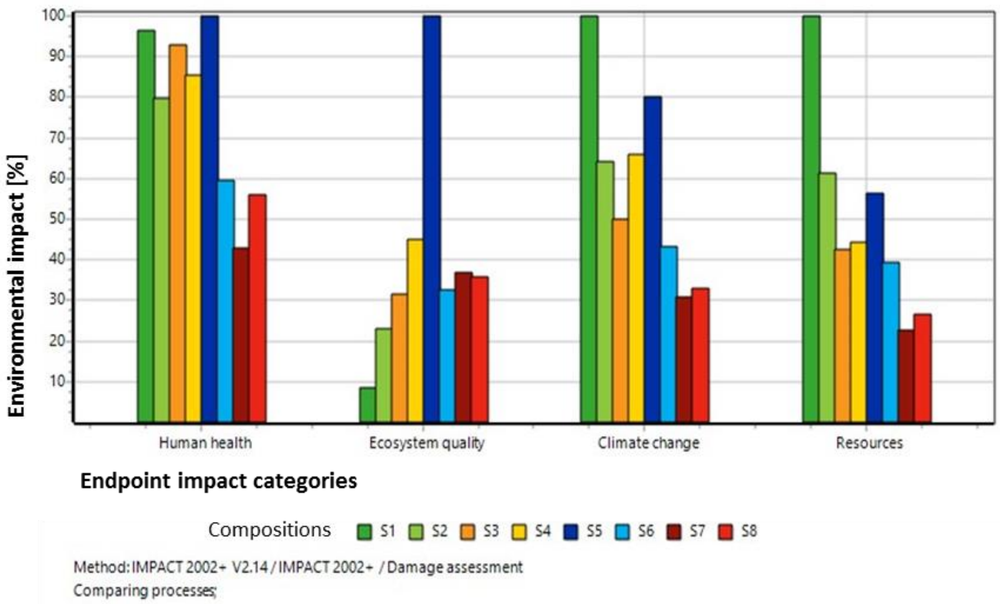

Fig. 12 Damage assessment of S1- S8 structures assemblies, SimaPro, IMPACT2002+.

Damage assessment
Damage assessment is identical to the environmental profile (Figure 12). It refers to impact categories, where damage corresponding to the selected impact categories is measured. It is expressed as a percentage of the impact of individual materials in the S1 - S8 structures on the environment at each endpoint (presustainability.com).

Normalization
Damage factors are standardized (Figure 13) by dividing the impact into the emission unit by the overall effect of all substances of the different impact categories for which the characterization factors exist, e.g. per person per year. The unit of all standardized midpoints and endpoints is then (number of persons x year) / emission unit, thus the number of equivalent persons concerned in one year per emission unit (presustainability.com).

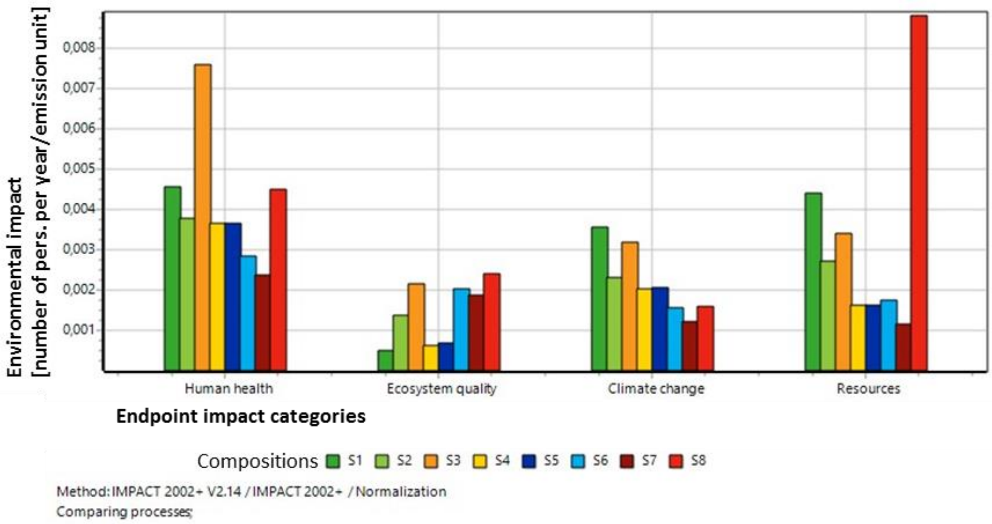

Fig. 13 Normalization of S1- S8 structure assemblies, SimaPro, IMPACT2002+.

Weighting
Analysing the normalized results of four endpoint (damage) impact categories or fourteen midpoint indicators separately for the interpretation of the individual phases of the LCA is recommended by the authors of the IMPACT 2002+ method (Figure 14). Another step of weighting the data is added by PRé Consultant96s. For each damage category, a weighting factor of 1 is determined (JOLLIET *et al*. 2003).

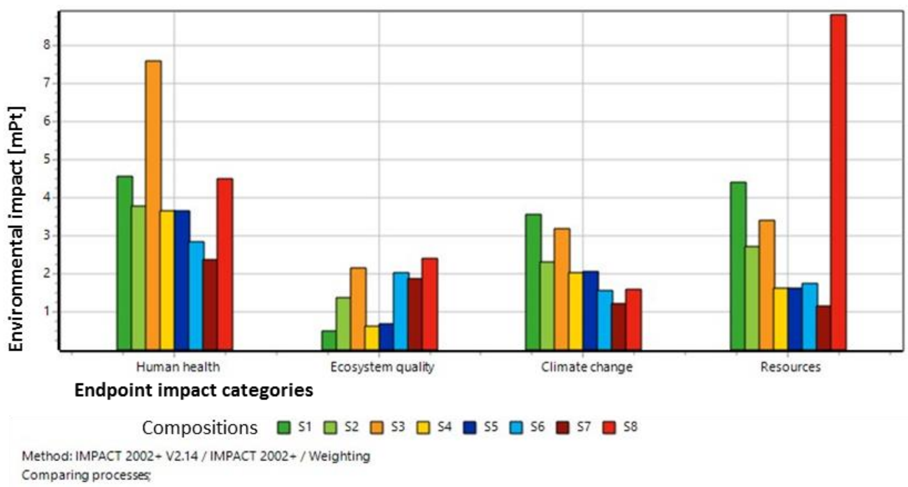

Fig. 14 Weighting S1- S8 structure assemblies, SimaPro, IMPACT2002+.

RESULTS AND DISCUSSION

Analysis of thermal and technical properties of wall assemblies

Selected external wall structures were assessed in terms of the required values of heat transfer coefficient U (U-value), thermal resistance R, minimum internal surface temperature θ_{si} and the temperature factor f_{Rsi} with respect to the requirements of valid legislation – standards for thermal protection design STN 730540 as a national application document in the Slovak Republic. Following the values of the heat transfer coefficients U^{2D} (Table 1) determined using the 2D models taking into account the two-dimensional heat conduction in volume of the constructions, the fact that all of the considered wall assemblies meet the required value [U = 0.22 W/(m^{2}K)] according to STN 730540 can be stated. The maximum value of the heat transfer coefficient [U = 0.15 W/(m^{2}K)] meets three of the considered assemblies (S3, S5 and S8). It is considered a reference value and according to the standard STN 730540 it is a normalized value from 1st January 2021 and a reference value for passive houses in some regions. Thus, all of these three assemblies can be used to design almost zero (passive) structures. A detailed analysis of the thermo-technical properties of these assemblies taking into account other parameters are mentioned in the work (MITTERPACH *et al*. 2018).

However, only the energy consumption during the operating stage of the life cycle is affected by the thermal protection quality of the sheathing fragment defined by the heat transfer coefficient U. U-value is a key variable in the calculation of specific heat loss, demonstrating the required specific heat and energy needs for heating or building classification in energy certification. However, in the current compulsory energy certification the overall energy consumption during the whole life cycle of the building, as well as the incorporated materials is not taken into account. Though, initiatives taking into account LCA analysis in the process of building certification in the world have already existed (ZABALZA BRIBIÁN *et al.* 2009).

Based on the above-mentioned evaluation of thermo-technical properties, it can be stated that the S4 assembly (I-beam with wood fibre) is the most effective in the structures complying with the normalized values [U ≤ 0.22 W/(m^{2}K)]. In the group meeting target standard values [U ≤ 0.15 W/(m^{2}K)] the S5 assembly is the most effective (I-beam with wood fibre). However, it is necessary to consider the fact that the insulation thickness used plays an important role, by which the monitored parameters can be changed in a relatively wide interval. In addition, an increase in the thickness of the insulation results in an increase in its volume in the assembly, and thus, the life cycle impact assessment results are affected significantly. A further important area, particularly for the investor is the financial intensity of the individual structures (e.g. price per 1 m^2). This area was not a subject of the research, so it is not evaluated.

Tab. 1 Thermal transmittances L^{2D}, heat transfer coefficients U^{2D}, minimum internal surface temperature $\theta_{si,\,min}$ and temperature factors f_{Rsi} for individual assemblies based on 2D models.

label	*d* (m)	L^{2D} ($W·m^{-1}·K^{-1}$)	U^{2D} ($W·m^{-2}·K^{-1}$)	R^{2D} ($m^2·K·W^{-1}$)	$\theta_{si,min}$ (°C)	f_{Rsi} (-)
S1	0.2185	0.11487	0.1838	5.271	18.47	0.956
S2	0.2325	0.13154	0.2105	4.581	18.18	0.948
S3	0.4975	0.06170	0.0987	9.922	18.90	0.969
S4	0.3115	0.10092	0.1615	6.022	18.56	0.959
S5	0.4515	0.06446	0.1031	9.529	19.10	0.974
S6	0.4270	0.11472	0.1978	4.846	18.97	0.971
S7	0.2925	0.10611	0.1698	5.719	18.37	0.953
S8	0.4795	0.09297	0.1488	6.510	18.81	0.966

Note: The thermal resistance value R2D was determined on the basis of U2D taking into account the heat transfer resistance values Rsi = 0.13 m2K/W and Rse = 0.04 m2K/W or Rse = 0.08 m2K/W for exterior side ventilated air gap assemblies

Environmental impact assessment

Numerous building LCA studies from various international stakeholders are published which compare conventional buildings and timber buildings to ascertain specific advantages and specificities of the latter. Moreover, most of them take into account only GHG emissions. These studies all differ in approach, system boundaries, database and scope, and therefore cannot be compared. However, they demonstrate that wood-based materials have advantages in terms of carbon storage capacity, therefore resulting in lower GHG emissions in the product stage. (HAFNER and SCHÄFER 2017).

The results of the LCIA analysis of the S1 - S8 structure assemblies are graphically shown in Figures 15 and 16. An exact quantitative assessment of the impacts of individual assemblies on selected environmental compartments is summarized in Table 2.

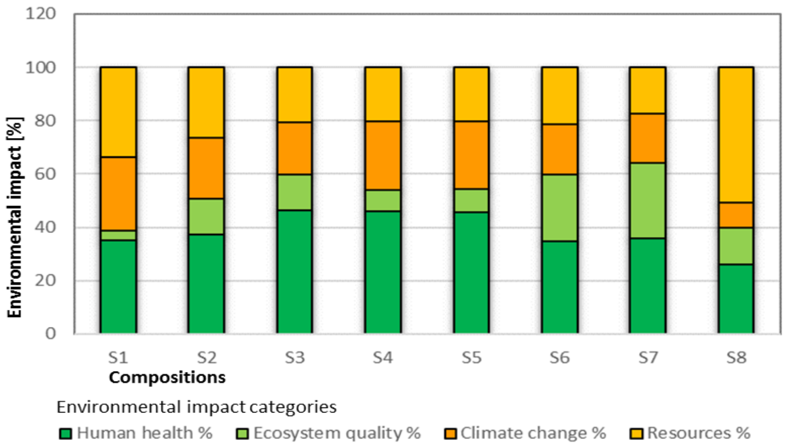

Fig. 15 LCIA of the S1- S8 structure assemblies, endpoints (%), SimaPro, IMPACT2002+.

The diagram in Figure 15 shows the comparison of the individual wall assemblies. The relative (percentage) impacts of the four categories of the assessed negative impacts of the individual structures within the life cycle can be seen there.

Summarized comparison of all considered assemblies is given in Fig. 16. Moreover, the relative effect ratio of individual assemblies in terms of impacts within the life cycle assessment was determined.

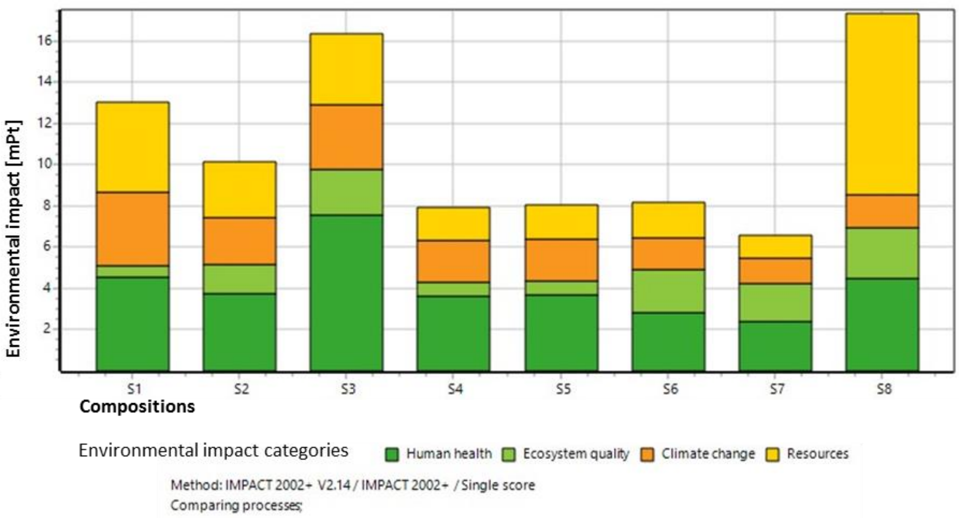

Fig. 16 LCIA of S1- S8 structure assemblies, endpoints (mPt), SimaPro, IMPACT2002+.

The assessment of the materials used for the creation of $1m^2$ of a given wall assembly and its environmental impacts at endpoints is provided by the values calculated in Table 2 and Figure 16.

Tab. 2 Endpoint life cycle assessment for S1-S8 structures' assemblies, IMPACT2002 +, mPt.

Label	**Human health** (mPt)	**Ecosystem quality** (mPt)	**Climate change** (mPt)	**Resources** (mPt)	**Total** (mPt)
S1	4.569	0.501	3.576	4.393	13.039
S2	3.776	1.364	2.296	2.702	10.138
S3	7.585	2.161	3.182	3.400	16.328
S4	3.642	0.638	2.036	1.615	7.931
S5	3.664	0.698	2.049	1.628	8.038
S6	2.844	2.043	1.561	1.744	8.191
S7	2.366	1.867	1.220	1.143	6.596
S8	4.508	2.419	1.596	8.807	17.330
Total (mPt)	32.954	11.691	17.516	25.432	87.593
Total (%)	37.6	13.4	20.0	29.0	100.0

The "human health" category was the most affected category in assessing the environmental impact of wood-based building structures with conventional insulation materials. In this impact category, the effect of the S3 assembly at 7.59 mPt seemed to be the most negative due to the large volume of used glass fibre insulation ($220·10^{-3}$ m^3/m^2). In addition, the use of plasterboard construction profiles, gypsum plasterboards ($7.8·10^{-3}$ m^3/m^2) and OSB boards ($15.1·10^{-3}$ m^3/m^2) made a significant contribution. The effect of remaining structures, S1 and S8 assembly, was the greatest one. The S7 assembly comprising sheep wool had the lowest impact on the environment (2.37 mPt).

The "ecosystem quality" impact category was generally assessed as the category with the least relative negative impact in terms of the selected wood-based building structures. Following the more detailed analysis, the impact of the S8 assembly consisting of the CLT panels was the highest in this category ($93.8·10^{-3}$ m^3/m^2). This negative feature was caused by the use of a large volume of solid glued timber. The S1 assembly containing PU foam (0.50 mPt) was the best-rated structure in this category.

In terms of the impacts on the "climate change" category, the S1 structure with PU insulation was evaluated the worst one (3.59 mPt) due to the negative impact of the large volume of the polyurethane foam insulation used ($92.8·10^{-3}$ m^3/m^2). The S7 structure using sheep wool as an insulation system (1.22 mPt) seemed to be the best option in this category.

The worst-ranked structure, in the "resource" impact category, was the S8 assembly (8.807 mPt). Due to the large volume of cellulose insulation used ($118.4·10^{-3}$ m^3/m^2), it reached the negative primacy. The S1 and S3 structures also showed relatively high negative ratings in this category. In the case of the S1 assembly, it was because of PU foam and gypsum fibre boards. For the S3 assembly, the negative assessment is primarily due to mineral insulation, however, the impact of the use of OSB boards and gypsum plasterboards was also significant. The S7 sheep wool structure (1.143 mPt) achieved the best rating.

In a complex view of the proposed assemblies and their life cycle impact assessment, it is clear that the S8 assembly based on CLT panel and cellulose insulation had the highest negative impact with a total score of 17.33 mPt followed by the S3 structure (box beam with mineral insulation) with a total impact of 16.33 mPt and the S1 structure (I-beam with PU foam), with a total impact of 13.04 mPt. On the other hand, the S7 sheep wool structure (6.60

mPt), followed by the S4 and the S5 structure (both on the I-beam basis and wood fibre insulation) and the S6 structure (box beam with straw) was the best rated.

Based on the evaluation and analysis of the results it can be concluded that wall assemblies made using a large volume of foamed plastic materials such as PU foam, glass fibre and surprisingly CLT or cellulose-based insulation had the greatest negative impact.

For example, a study by DODOO *et al*. (2014) compared timber buildings using different construction methods (CLT panel, beam-and-column, and modular structures). Hereby structure made of CLT panel offers lowest life cycle GHG emissions on contrary to the beam-and-column assembly as the worst wood-based structure in terms of produced GHG emissions.

However, the technology was not precisely specified in the available databases. The calculation can be significantly affected by the different representation of chemicals and raw materials (e.g. recyclate ratio), especially the cellulose-based insulation system evaluated in this study. In terms of large-scale materials, the greatest negative impact was performed by OSB and gypsum-based boards. Though, their volume representation in the assemblies was relatively small and so the negative impact was reflected particularly in the assemblies where insulation with good environmental assessment was used. On the other hand, the use of wood fibre materials (HDF board, wood fibre board, wood fibre insulation), straw and especially sheep wool appeared to be convenient. Therefore, taking into account environmental impacts, the use of different types of materials in the structure of wood-based assemblies must be discussed. A detailed analysis of the environmental impacts of the assemblies and used materials is mentioned in the work (MITTERPACH *et al*. 2018).

The research showed significant differences in the assessment of the environmental impacts of wood-based external wall assemblies. Insulation materials were identified as the most important materials for overall environmental assessment. Their significance relates to their proportional representation in the wood-based building structure where they account for more than 80% of the volume. Nevertheless, a case study done by PETROVIC *et al*. (2019) proved that cellulose-based insulation had dramatically low CO_2e emissions in comparison with other materials mainly used in the building industry, such as glass wool and stone wool.

Looking at the current segment of the wood construction market, it is worth noting that the materials evaluated as relatively unsuitable from the environmental impact point of view are currently used most, especially because of their affordability and low price. Hence, it is rational that builders and investors prioritize such materials. Moreover, when there is a demand, manufacturers can make even more profit when producing these materials on a large scale. On the contrary, materials rated positively (with a low negative impact) have not been significantly applied to the market yet and their production is therefore burdened by relatively high fixed costs. However, they offer a number of advantageous properties (greater bulk density and heat capacity with a positive effect on thermal stability, good diffusion properties, ability to actively regulate and stabilize indoor humidity) not only in terms of environmental impacts. A major disadvantage and limiting criterion is their low availability (the investor generally has to search for a supplier) and a higher price.

Wood-based materials are currently employed for their significant structural, thermal, acoustical and environmental properties and, last but not least, for their aesthetic and formal features (ASDRUBALI *et al*. 2017).

Among the various environmental properties of wooden materials, embodied energy is one of the most important (ESTOKOVA *et al*. 2017, SHIRAZI and ASHURI 2018). Regulations on energy use and emissions of buildings have been mostly about operational energy, often overlooking other life cycle components such as embodied energy which can account for a significant portion of life cycle emissions. For example, the study by SHIRAZI and ASHURI (2018) showed that older buildings can have lower embodied environmental impact per square meter and lower embodied energy than younger residential buildings, not considering a major renovation or retrofit over the entire life span.

The exact environmental impact of a new structure of wood construction materials is always linked to the specific material used. Some other environmental impact assessments (ONDOVA and ESTOKOVA 2016) have shown that the selection of materials for the construction of buildings throughout the life cycle is an important tool for sustainability when building a life cycle model for civil engineering.

CONCLUSIONS

Eight types of wall assemblies representing a wide range of materials used and design approaches were created for the assessment of the environmental impacts of wood-based structures. From the thermo-technical characteristics point of view, 2D models of temperature fields of the considered assemblies were created. Subsequently, the thermal resistance and the heat transfer coefficient (U-value) were determined. In the evaluated group, there were five assemblies usable for low energy construction [$U \leq 0.22$ W/(m^{2}K)] and three assemblies for ultra-low energy (passive) construction [$U \leq 0.15$ W/(m^{2}K)].

The LCA analysis made it possible to identify the environmental impacts of the individual assemblies on the four environmental components and consequently the cumulative impact. A assembly based on a CLT panel with blown cellulose-based insulation was evaluated as a structure with the greatest environmental impact, closely followed by a assembly based on a box beam with glass-based mineral insulation. The impact assessments of both of these assemblies were more than 16 mPt. On the other hand, assemblies with the least negative impact on the environment were structures using wood fibre, straw and especially sheep wool as insulation. Their impact assessment was at 6.6–8.2 mPt.

The analysis showed that the material assembly significantly influences the LCA analysis result and so the environmental assessment should be taken into account in the case of wood construction. The use of natural materials without high demands on energy-intensive processing was proven to be advantageous. The choice of insulating material is the most important as the insulation is more than 80% of the volume of the wood-based structures on average.

Following the research results, the fact that there is the need to specify and complete the environmental assessment database data with respect to production technology or recycling used can be stated.

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AUTHORS'ADDRESS

Ing. Jozef Mitterpach, PhD.
Technical University in Zvolen
Faculty of Wood Science and Technology
T .G. Masaryka 24
960 01 Zvolen
Slovakia
jozef.mitterpach@gmail.com

Ing. Rastislav Igaz, PhD.
Technical University in Zvolen
Faculty of Wood Science and Technology
T .G. Masaryka 24
960 01 Zvolen
Slovakia
igaz@tuzvo.sk

prof. Ing. Jozef Štefko, PhD.
Technical University in Zvolen
Faculty of Wood Science and Technology
T .G. Masaryka 24
960 01 Zvolen
Slovakia
stefko@tuzvo.sk