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LCA ANALYSIS OF POPULAR ENVELOPE ASSEMBLIES FOR LOW-STOREY CONSTRUCTION SEGMENT

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Abstract

The life cycle assessment (LCA) analysis of the popular multilayered assemblies for the low-storey construction segment was performed. The main point of the analysis was to detect the optimal assembly type in terms of LCA parameters from those considered in the investigation. As key influence criteria were taken into consideration as follows: primary energy non-renewable - global warming potential (GWP) kg CO_2 equ./m^2, acidification potential (AP), kg SO_2 equ./m^2, the u-value of the envelope W/m^{2}K, the mass of the wall kg/m^2. There were compared five types of multilayered wall assemblies, which are quite popular in the domestic building market of Ukraine nowadays: brickwall+ insulator, aerated concrete+insulator, cavity brickwall+insulator, SIP wall, and strawbale wall in the type of infill as a variant of natural building material. The comparison of the alternatives was proceeded by the Eco2soft tool. Conducted research revealed that wall from Straw bale could be approximately defined as "optimal" and "best" ones in proposed terms of LCA analysis and Wall from SIP could be the medium one.

Keywords: LCA, thermal performance, multilayered envelopes, wall assemblies

Introduction

Global warming all over the planet which has a significant influence on our life quality enforces make a correct long-term perspective solution in terms of the "optimal choice" of multilayered assemblies of building envelopes [1] in terms of a complex integrated index (where the thermal resistance is one of the influence factors), which is significantly enlarged by Ukraine National Building Code during the last 20 years from the one hand, and to minimize the anthropogenic footprint and to recycle the material of construction in terms of its utilization with minimal costs in the end life building span from the other hand. All of those are since the building sector consumes 36% of the world's energy and produces some 40% of energy-related carbon emissions [2]. If we can consider the huge amount of energy that goes into producing building construction and materials and the emission level from buildings could be even higher [3 ,4]. Thus, the comprehensive and deep-analysis approach to the choice of any building material and construction type from this material in sense of our responsibility in face of future generations is essential [5, 6]. The appropriate comprehensive multi-criteria balanced choice of materials for the building construction plays a key or even vital role and can be expressed in various effects on energy consumption and associated harmful emissions of pollutants over the different phases of a building's life cycle [8]. The problem of choosing from plenty of energy-efficient assemblies of multilayered envelopes, in general, is still a challenge [7, 9].

Therefore, this thesis has proposed the attempt to assess several popular multilayered assemblies for the low-storey construction sector. The Eco2soft tool [10] for LCA assessment was taken into consideration as a user-friendly instrument for LCA according to the ISO 14040 [11]. There were compared such criteria as primary energy non-renewable - total (PENRT), MJ/m^2, global warming potential (GWP) kg CO_2 equ./m^2, acidification potential (AP), kg SO_2 equ./m^2, and the u-value of the envelope W/m^{2}K, the mass of the wall kg/m^2.

Results of the research

Five types of multilayered wall assemblies were considered in the investigation of LCA analysis: Wall A (brickwork+insulation), Wall B (aerated concrete+insulation), Wall C (cavity brick wall+islulation), Wall D (strawbale wall by timber frame method of construction) and Wall E (SIP with EPS insulator). The LCA analysis of multilayered envelopes was conducted by the methodology of all LCA indicators [10]. As the output results were taken into consideration such indicators as Global warming potential – GWP-total, kg CO_2 equ./m² for a time horizon of 100 years, acidification potential (AP) kg SO_2 equ./m², Eutrophication potential

(EP) kg PO_4^{3-}/m², Depletion potential of the stratospheric ozone layer (ODP) kg CFC^{-11}/m². As physic and thermo-physic parameters, the mass of 1m^2 of assembly and u-value W/m^{2}K were taken respectively. Cross-sections of considered multilayered assemblies are presented in fig.1-fig.5.

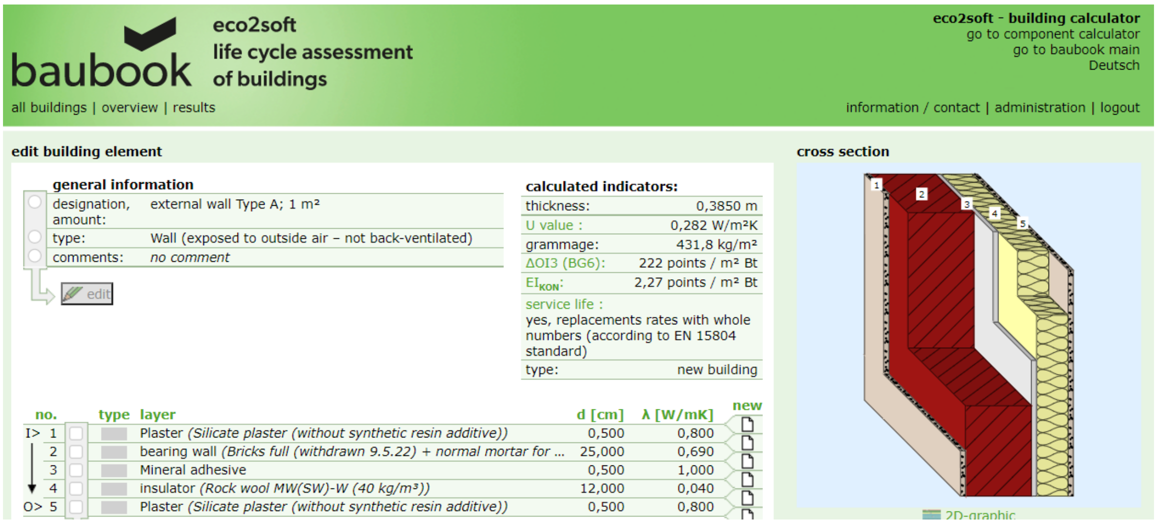

Fig.1. Characteristics of Wall A assembly

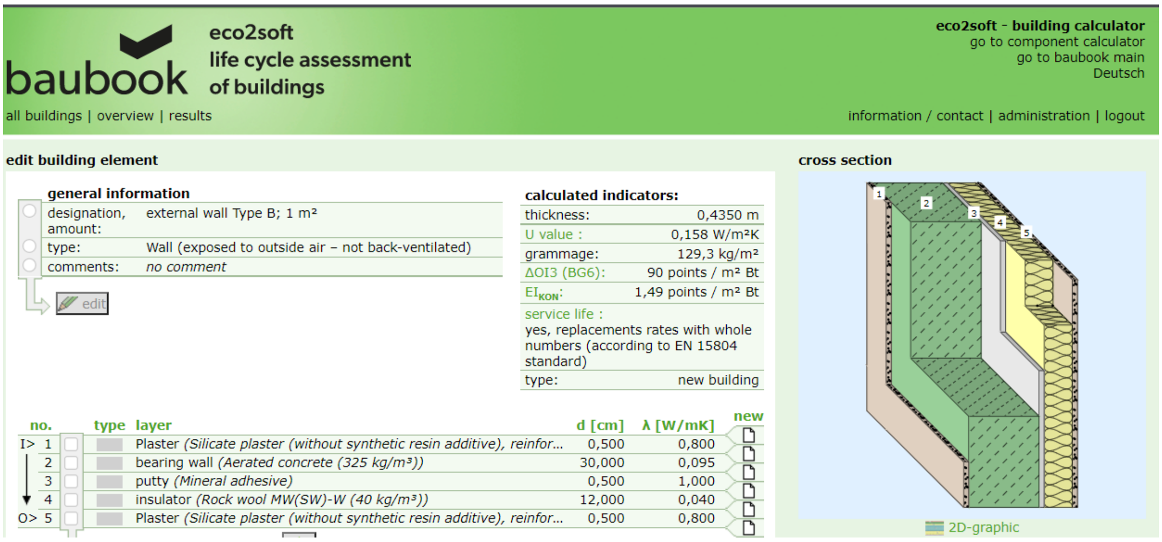

Fig.2. Characteristics of Wall B assembly

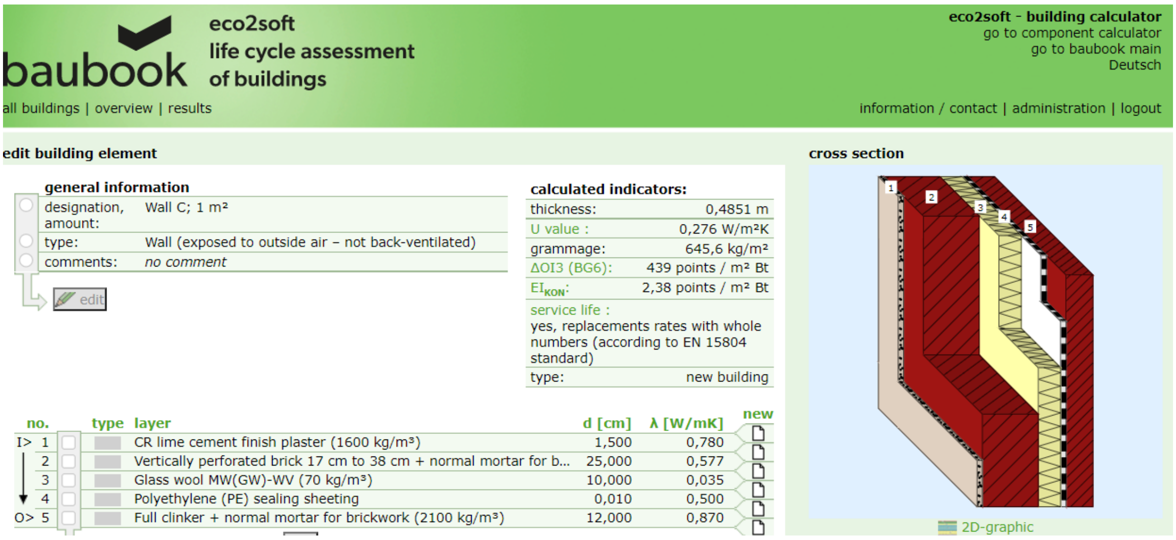

Fig.3. Characteristics of Wall C assembly

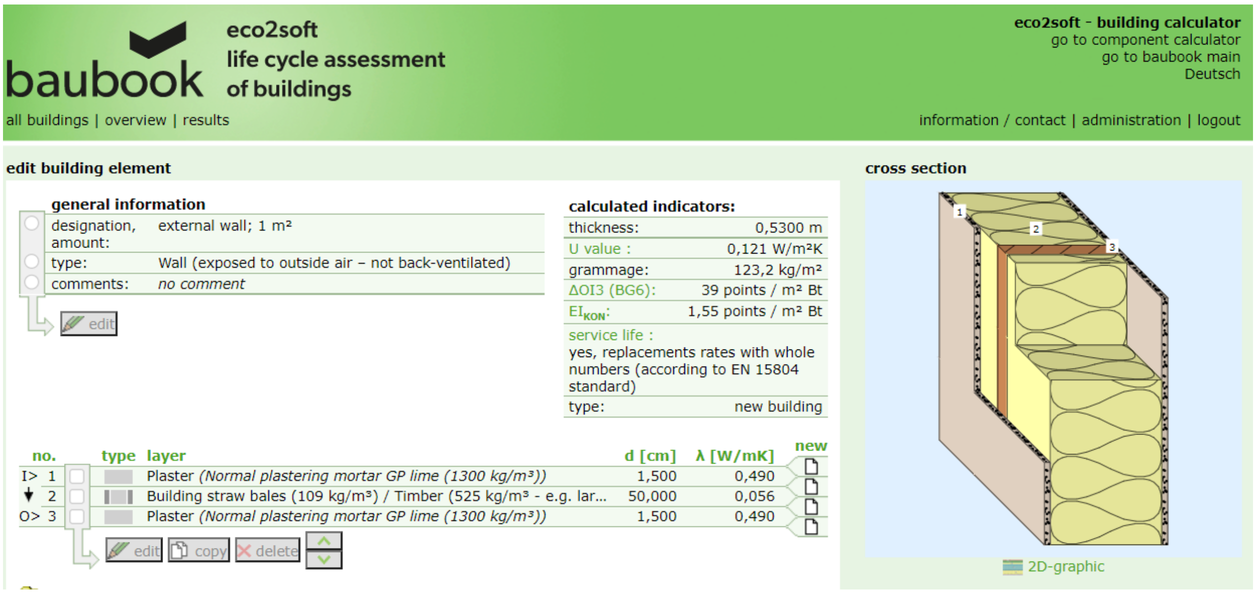

Fig.4. Characteristics of Wall D assembly

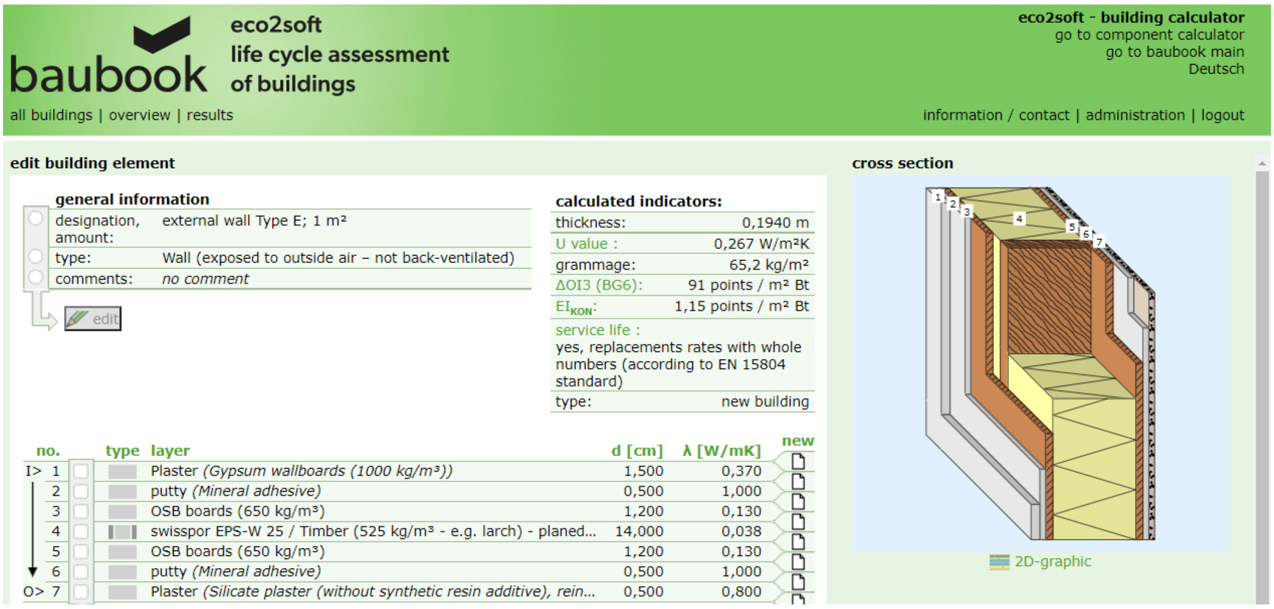

Fig.5. Characteristics of Wall E assembly

After performing all the necessary inputs to the wall assemblies A-E, the general LCA calculations have been performed according to the calculating methodology [10] and presented in Table 1.

Table 1 The thermo-physical, physical and economic characteristics of the wall assemblies

LCA parameters	GWP-total, kg $CO2$ equ./m²	AP, kg SO_2 equ./m²	EP, kg PO_{4}^{3-}/m²	ODP, kg CFC^{-11}/m²	mass, kg/m²	u-value, W/m²K
Wall A	182,00	0,85	0,27	1,390E-05	431,80	0,28
Wall B	71,50	0,35	0,12	5,020E-06	129,30	0,16
Wall C	412,00	1,14	0,47	4,530E-05	645,60	0,28
Wall D	-71,30	0,20	0,24	3,930E-06	123,2	0,12
Wall E	40,80	0,28	0,10	5,280E-06	65,20	0,27

After proceeding with the obtained data the ranking of each wall assembly from 1 to 5 (where 1 is the best alternative in terms of proposed criteria, and 5 is the worst one, respectively) was made (Table 2).

Table 2 The comparison of wall assemblies ranking by different MCDA techniques

Assembly type	Rank of alternative					
	GWP-total, kg CO_2 equ./m²	AP, kg SO_2 equ./m²	EP, kg PO_{43}-/m²	ODP, kg CFC-11/m²²	mass, kg/m²	u-value, W/m²K
Wall "A"	4	4	4	4	4	5
Wall "B"	3	3	2	2	3	2
Wall "C"	5	5	5	5	5	4
Wall "D"	1	1	3	1	2	1
Wall "E"	2	2	1	3	1	3

The conducted research has shown, that the true answer to the question "What is the best/worst assembly?" is still a challenge in terms of the proposed criteria of LCA analysis. The wall D assembly can be the optimal one considered in the investigation. Wall E can be the moderate alternative. The traditional brickwork+insulation Wall A and Wall C have the last acceptable results. The current thesis is only part of the general investigation process, which is aimed at the optimal wall assembly definition in terms of the LCA analysis. Further analysis should be conducted to reveal the key role of specific LCA criteria in the best wall alternative. In Fig.6 the results of the LCA analysis of wall assemblies are given.

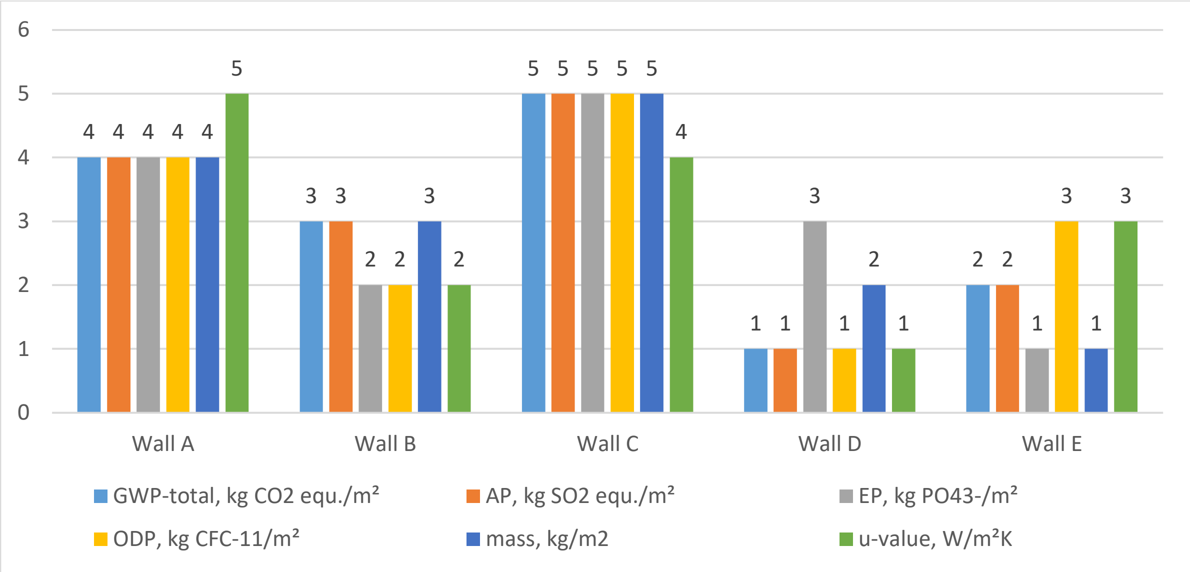

Fig. 6. Final results of different MCDA techniques assessment of the thermal performance for envelopes

Conclusions

Each method of assessment of multilayered assemblies can lead to the incorrect interpretation of results in the terms of thermal performance, reliability, carbon footprint etc. The best alternative for wall assembly should be chosen by a comprehensive analysis of different criteria evaluations. In the presented research the best wall assembly is the strawbale one (Wall A). The rest of the alternatives have disputable and ambiguous ranks according to the proposed LCA criteria, thus additional research should be done for verifying the obtained results.

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