MULTI-CRITERIA ASSESSMENT OF ASSEMBLIES THERMAL PERFORMANCE

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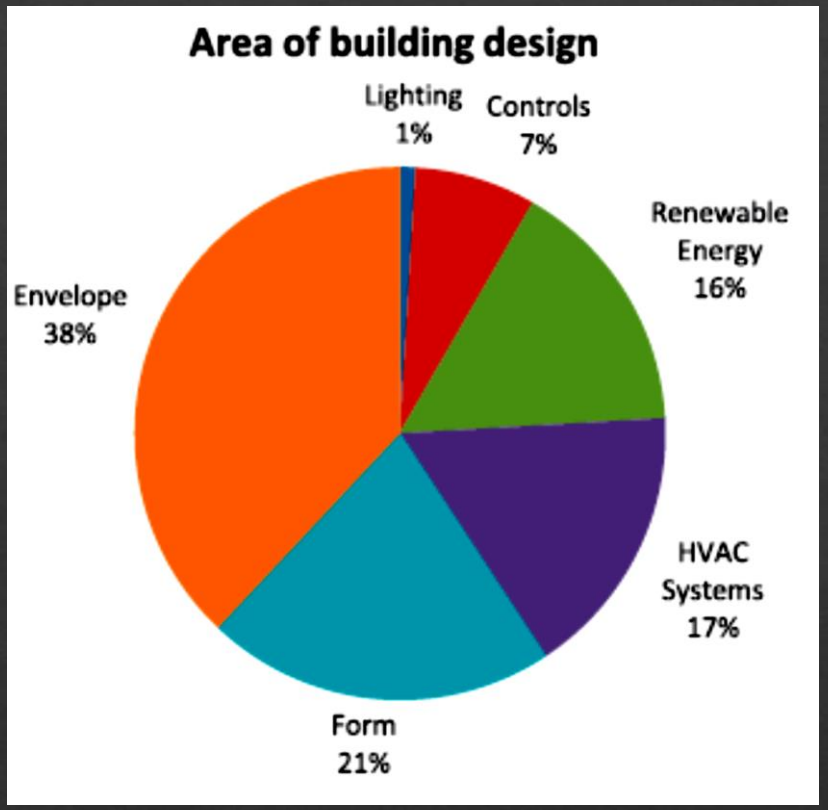
THEME ACTUALITY

Objective assessment of the thermal performance of different multilayered envelopes should conclude a comprehensive consideration of such characteristics as:

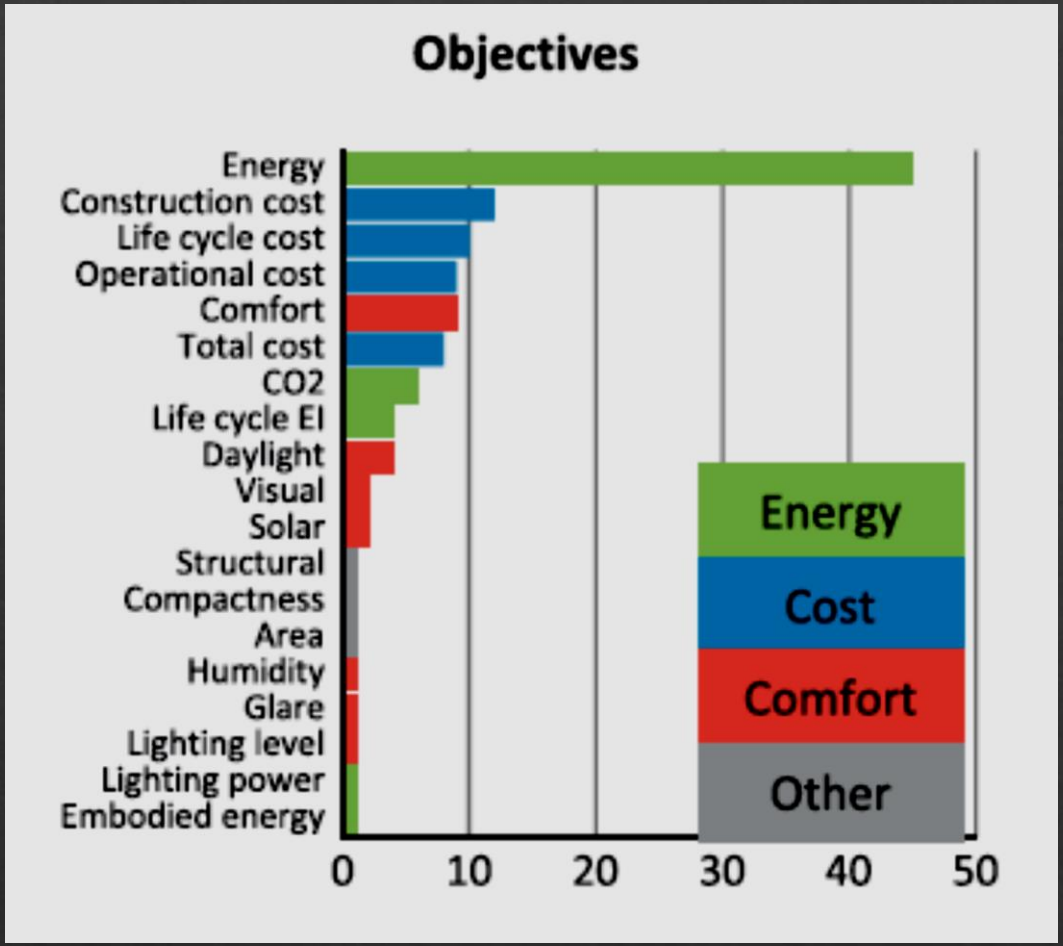
- physical-mechanical
- environmental
- economic
- other parameters of the material



Origin: Ralph Evins "A review of computational optimisation methods applied to sustainable building design" *Renewable and Sustainable Energy Reviews 22(2013) p. 230-245.*

THEME ACTUALITY

The global energy saving trend on one hand and the sustainable development concept on the other increasingly boosted the usage of multi-criteria decision analysis methods (MCDA) in decision-making.



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As Wang et al., (2009) stated, "MCDA methods have become increasingly popular … because of the multi-dimensionality of the sustainability goal and the complexity of socio-economic and biophysical systems".

MAIN OBJECTIVE OF THE RESEARCH

To provide the comprehensive assessment of the thermal performance of multilayered wall structures by different MCDA techniques

THE BACKGROUND

The final choice of a design construction should be made after deep analysis of existing technologies and materials which suits the best in the context of:

- environmental
- economic
- physiological
- aesthetic constituents

THE BACKGROUND

The variety of multi-dimensional criteria to be compared, and what is the “correct” criterion in the decision making process is still a big issue. The optimal type of envelope’s width, type, material for modern building, which is both energy-effective, low cost and environmentally friendly, is still big challenge and unsolved problem.

CRITERIA

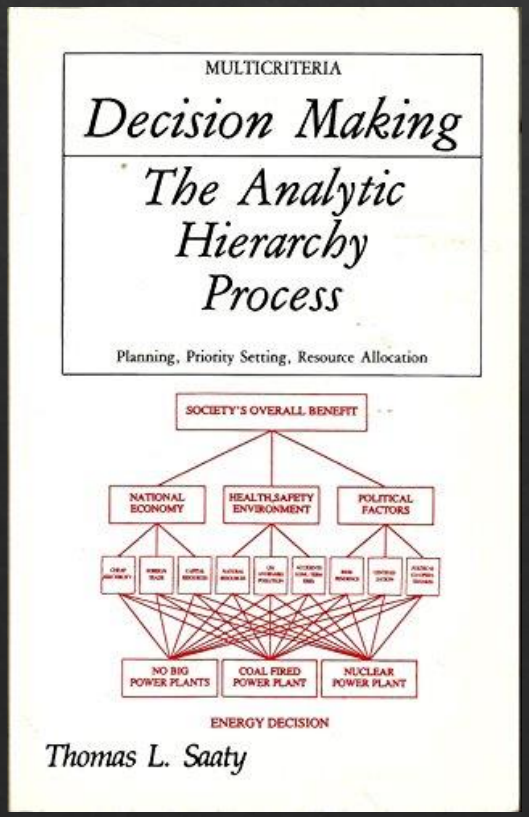
- the cost of the wall material Q, UAH/m^2
- the mass of the wall m, kg/m^2 (indirect parameter of the building fundaments cost)
- the u-value of the envelope,W/m^2K (steady-state criterion)
- the decrement factor of the envelope f (dimensionless)
- the internal areal heat capacity of the envelope k1, kJ/m^2K

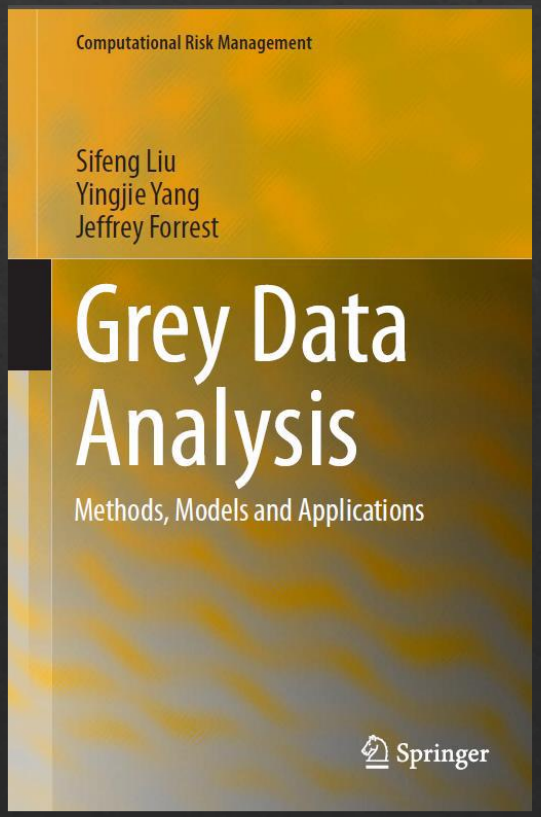
THE HEADLINE IDEA

To provide the comprehensive assessment of different parameters by applying the concept of integral index of thermal performance, which combine all of criteria

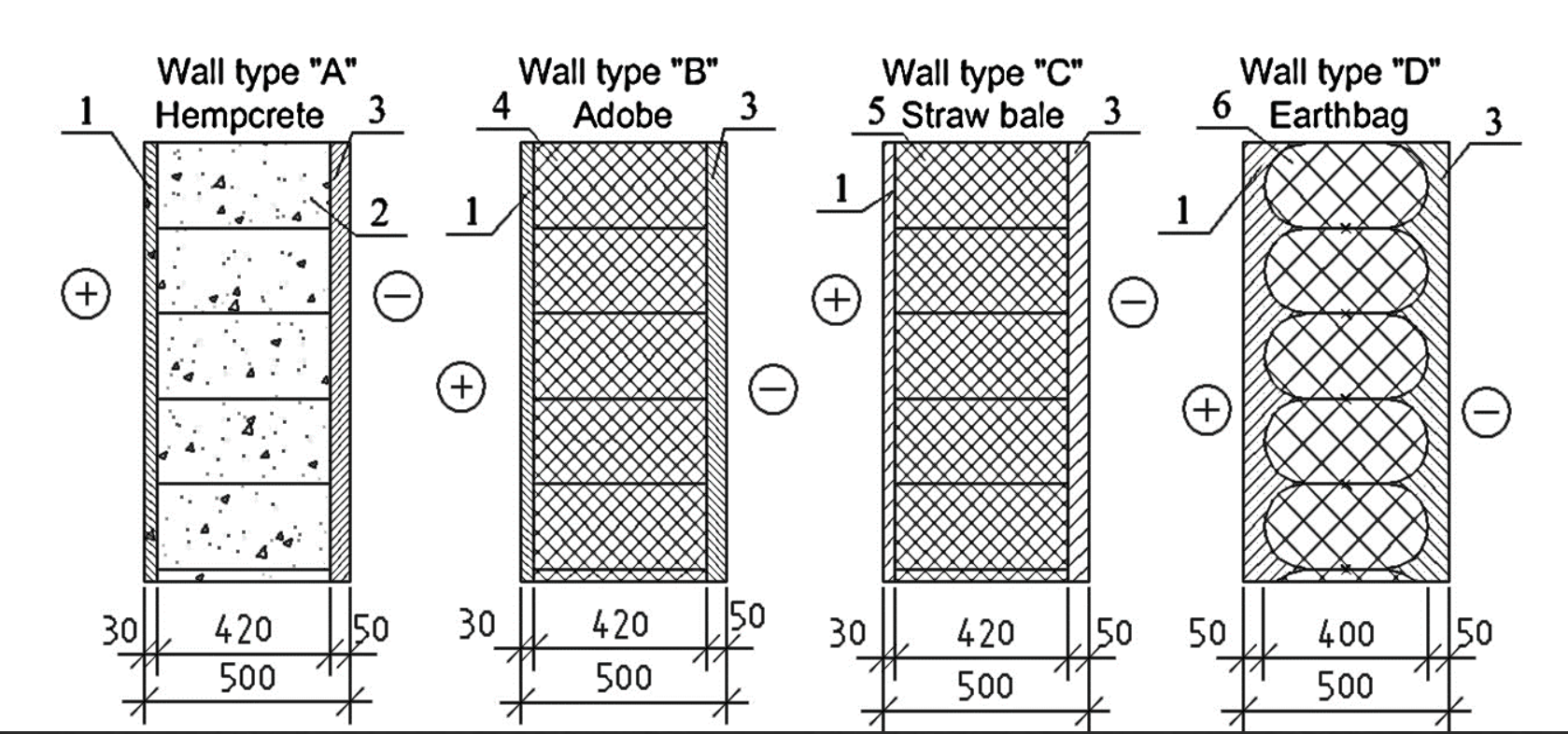
MCDA METHODS

- Analytical Hierarchy Process (AHP)
- Grey relational Analysis (GRA)
- Criteria Importance Theory (CIT)



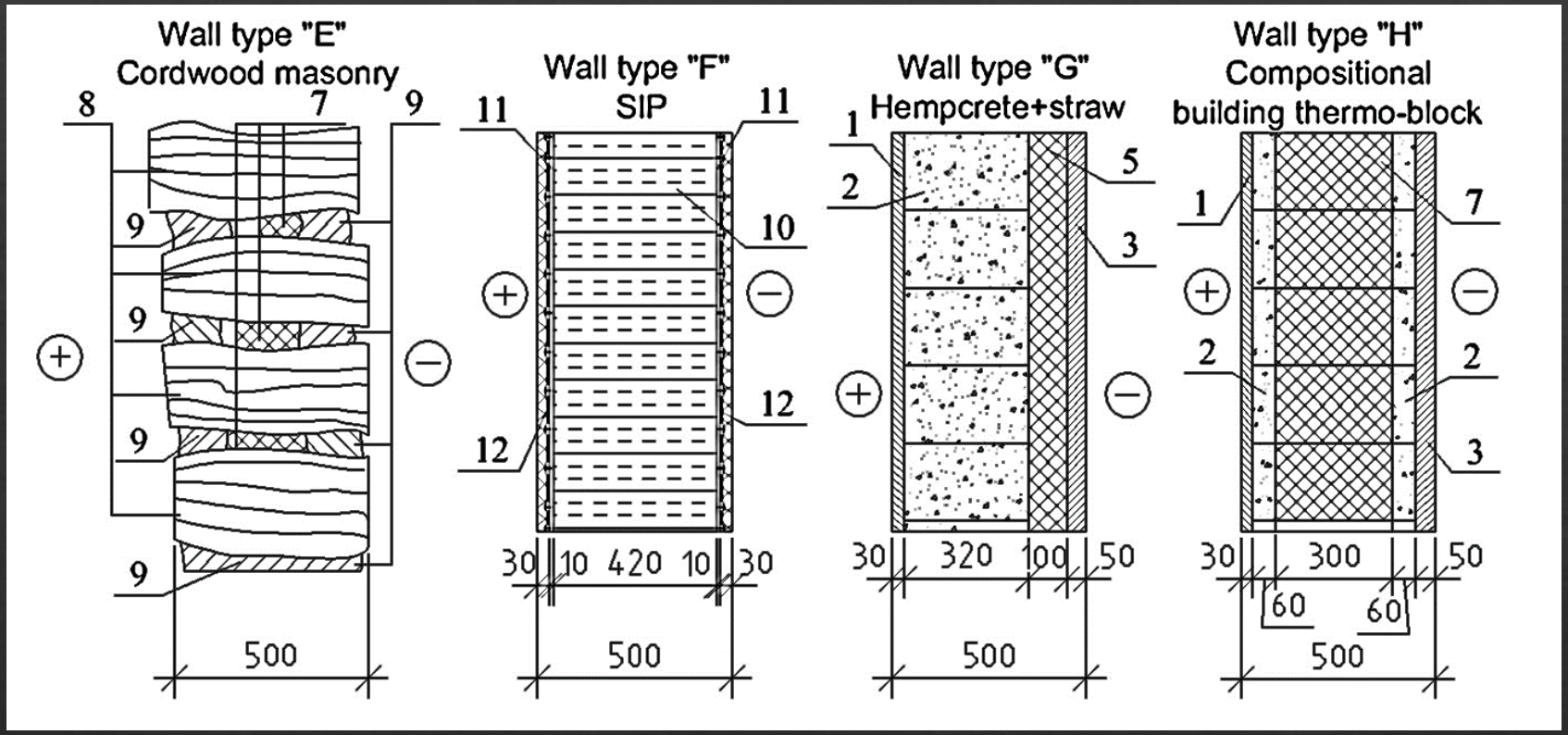


THE MULTILAYERED ASSEMBLIES



Cross sectional scheme of investigated wall assemblies:
(1 - internal lime-sand plaster, 2 - hemcrete, 3 - external lime-sand plaster, 4 - adobe, 5 - strawbale panel, 6 – earthbag)

THE MULTILAYERED ASSEMBLIES

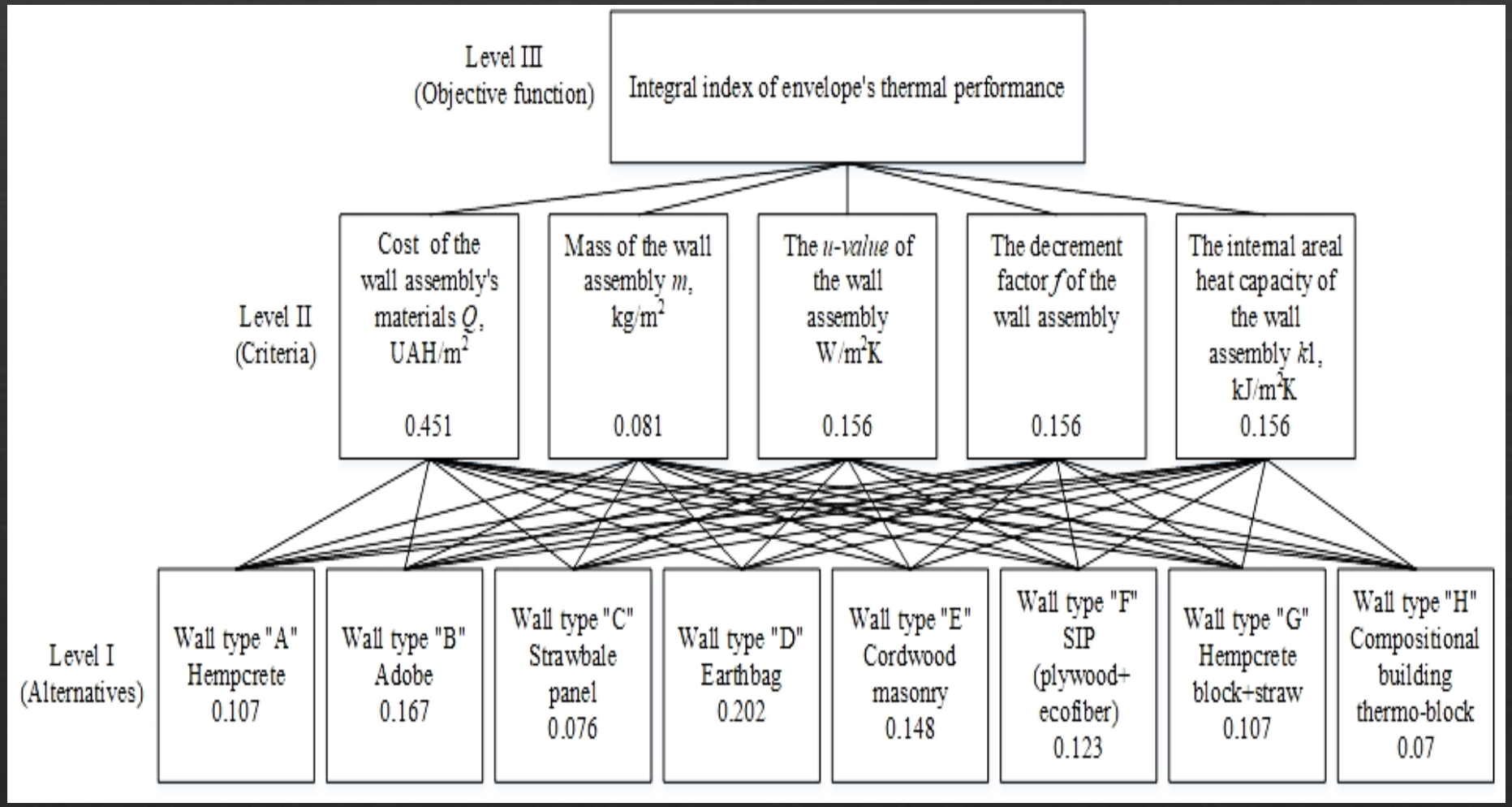


Cross sectional scheme of investigated wall assemblies:
(1 - internal lime-sand plaster, 2 - hemcrete, 3 - external lime-sand plaster, 4 - adobe, 5 - strawbale panel, 6 - earthbag, 7 - chopped straw as insulator, 8 - cordwood, 9 - lime-sand plaster, 10 - ecofiber, 11 - lime-sand plaster, 12 - plywood)

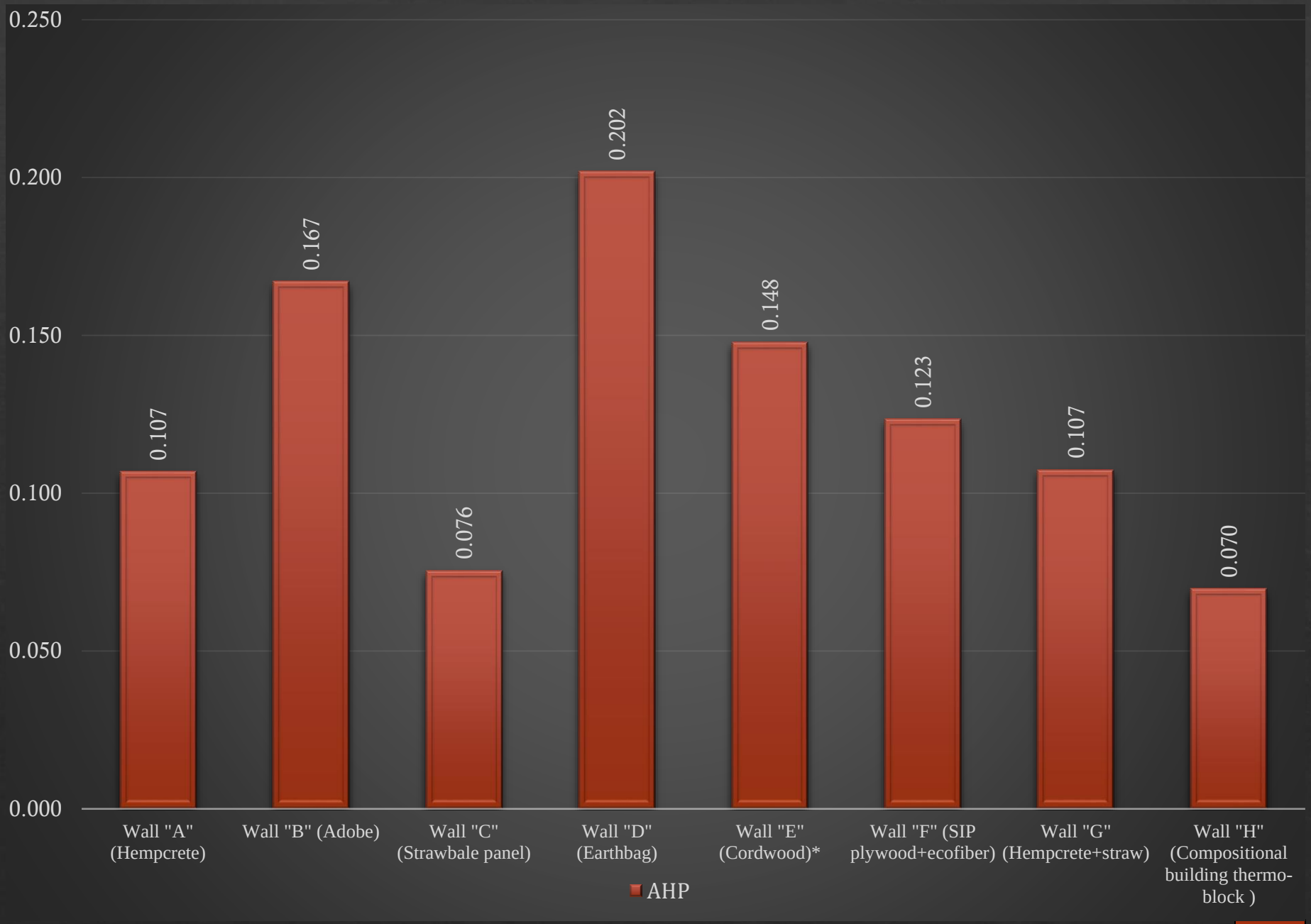
WALL'S CHARACTERISTICS

Assembly type	Q	m	u-value	f	k1
Wall "A"	1146.00	275.00	0.15	0.0067	45.61
Wall "B"	358.50	716.00	0.77	0.0586	59.46
Wall "C"	1154.40	161.60	0.16	0.2336	41.77
Wall "D"	360.00	880.00	1.51	0.1219	68.53
Wall "E"*	810.00	272.00	0.24	0.0506	64.20
Wall "F"	918.00	131.10	0.14	0.2225	57.00
Wall "G"	1148.00	248.00	0.15	0.0119	45.59
Wall "H"	1152.00	194.00	0.16	0.1394	46.77

THE HIERARCHICAL MODEL BY AHP



Three-level hierarchical model of the integral index of envelopes' thermal performance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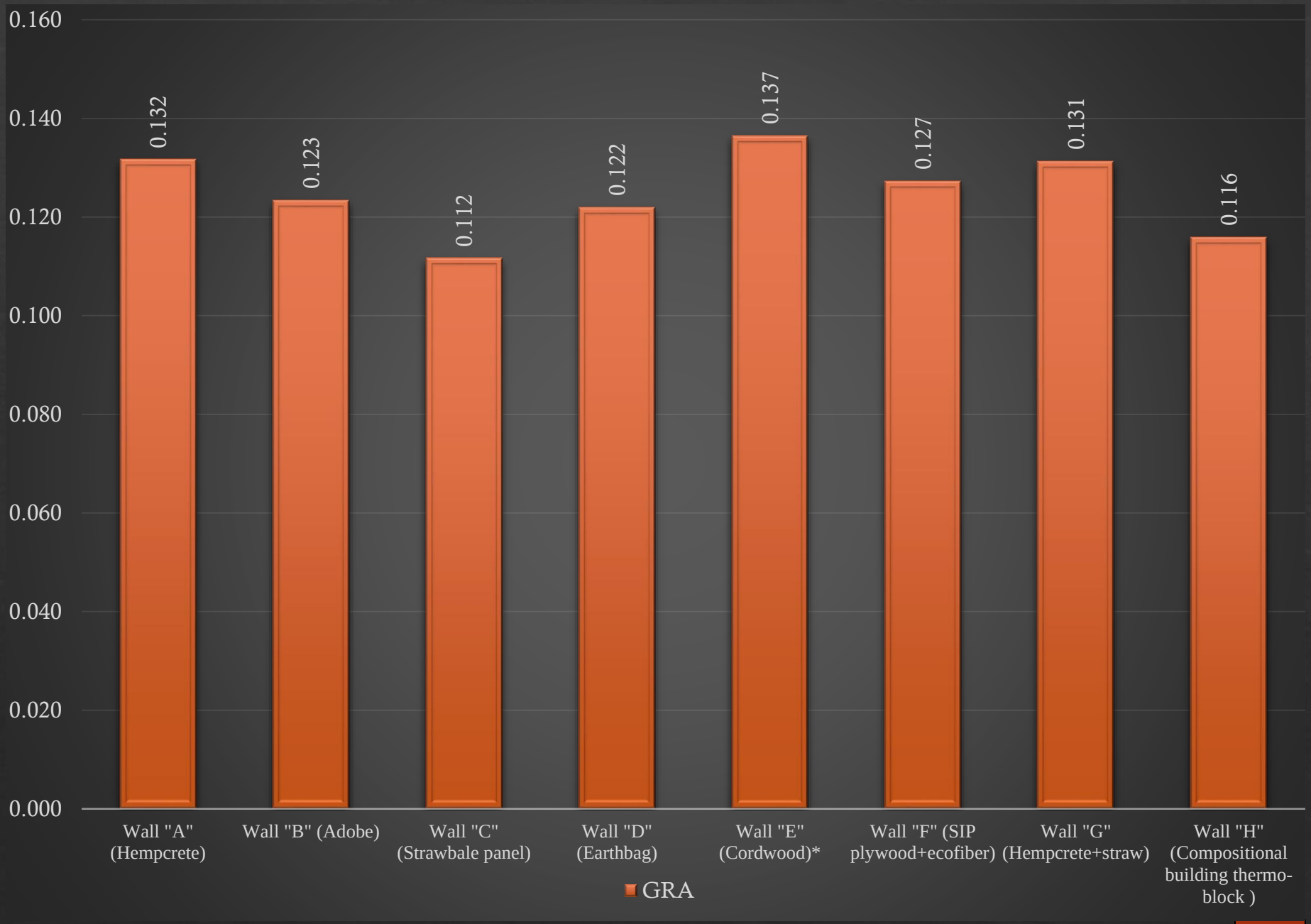
Wall "A" (Hempcrete)
Wall "B" (Adobe)
Wall "C" (Strawbale panel)
Wall "D" (Earthbag)
Wall "E" (Cordwood)*
Wall "F" (SIP plywood+ecofiber)
Wall "G" (Hempcrete+straw)
Wall "H" (Compositional building thermo-block)
AHP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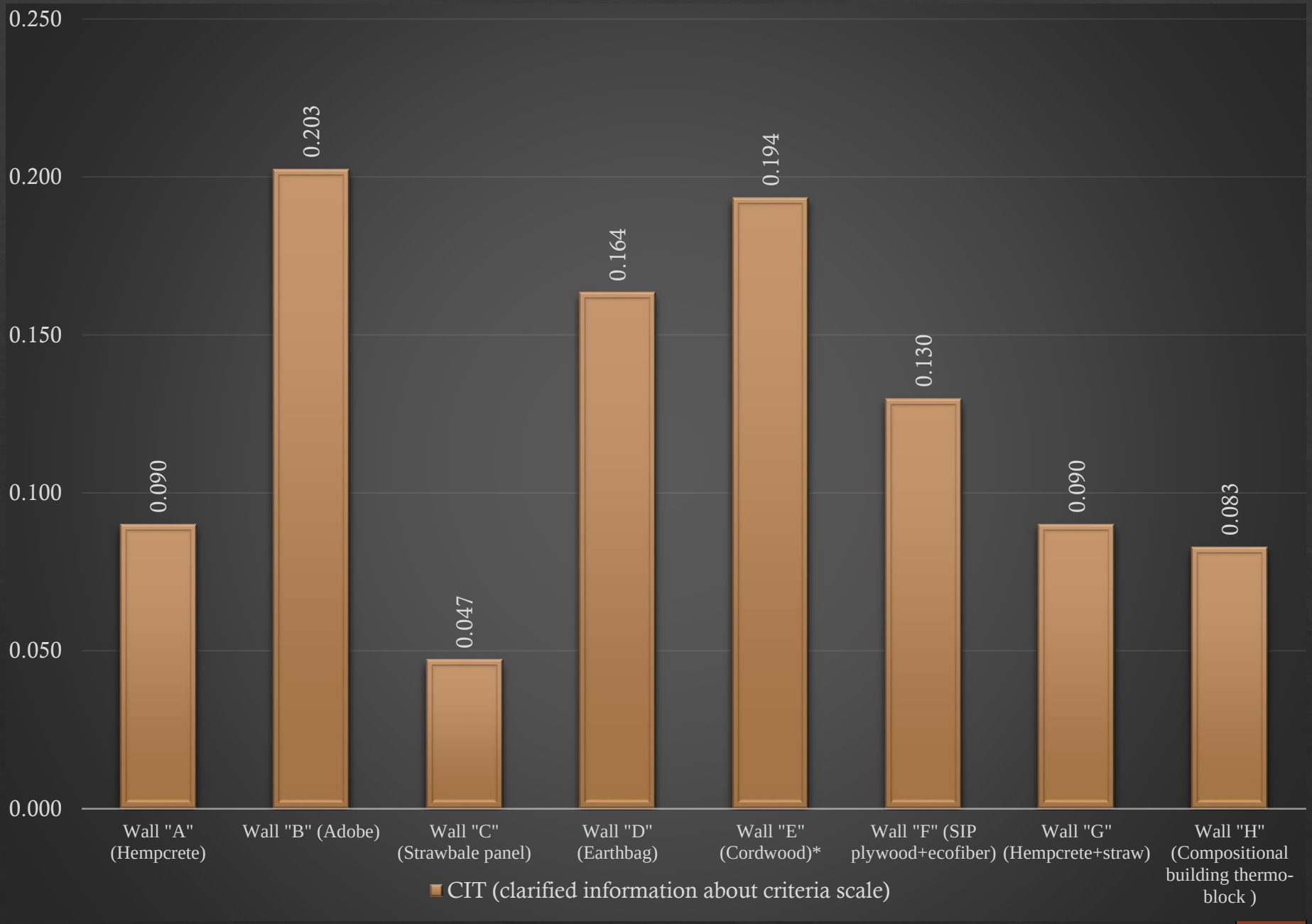
GRA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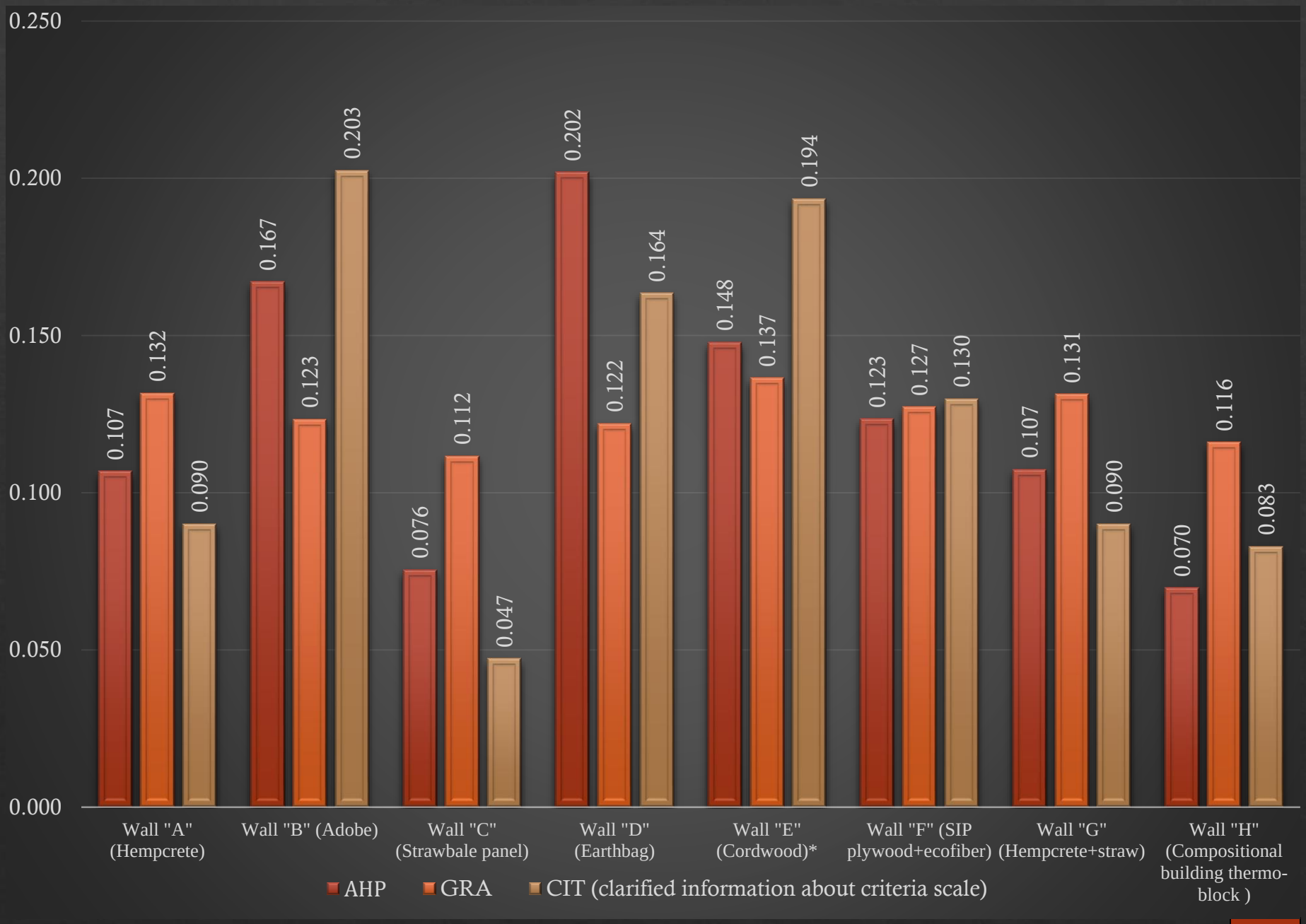
CIT (clarified information about criteria scale)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AHP
GRA
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THE RANK OF ALTERNATIVES

Assembly	MCDA technique		
	AHP	GRA	CIT
Wall "A"	6	2	5
Wall "B"	2	5	1
Wall "C"	7	8	8
Wall "D"	1	6	3
Wall "E"	3	1	2
Wall "F"	4	4	4
Wall "G"	5	3	5
Wall "H"	8	7	7

CONCLUSIONS

The analysis of the conducted research has shown that:

- there is no absolute “leader” in the ranking of the wall assemblies according to the proposed criteria and MCDA technique;
- there is no universal “right” method or technique for MCDA assessment;
- with the high level of probability, it could be noted that the best wall assembly according to the proposed criteria of integral index’ criterion according to AHP, GRA and CIT MCDA technique would be Wall “E” (Cordwood) with different ranking order, meanwhile the worst types are “C” (straw bale) and “H” (Compositional building Thermo-block).
- As a further step of the investigations, authors see in supplementing of the results by Building Energy Modelling (BEM) of the case study house. Also, at the next step, the optimization model for the best wall assembly could be designed, which should meet the requirement of minimum value of the decrement factor *f, u-value* of the wall, mass *m* and cost *Q* and maximum of the internal areal heat capacity *k*1.

THANK YOU

FOR YOUR ATTENTION!