Performance-based selection of sustainable construction solutions for external walls

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why?

Decisions *photo* Mel Stoutsenberger *in* flickr

why?

ELSEVIER

Automation in Construction 8 (1999) 395–409

AUTOMATION IN CONSTRUCTION

Performance-based design

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Abstract

Even before Louis Sullivan coined the phrase 'Form Follows Function,' architectural researchers have sought, to no avail, a causal relationship between these two primary constituents of the building enterprise. This paper attempts to explain why this quest has been futile, and proposes a *performance-based* design paradigm, instead of the prevailing *process-based* paradigms. It suggests that the driving force behind any design activity is the desire to achieve a qualitative solution for a particular combination of form and function in a specific context. Furthermore, it suggests that quality can only be determined by a multi-criteria, multi-disciplinary *performance evaluation*, which comprises a weighted sum of several satisfaction/behavior functions. The paper develops a performance-based design methodology and demonstrates its application in an experimental, knowledge-based CAD system.

Keywords: Design methods; Design process; Paradigms of design; Design knowledge; Performance evaluation

1999

Performance-based Design: Current Practices and Research Issues

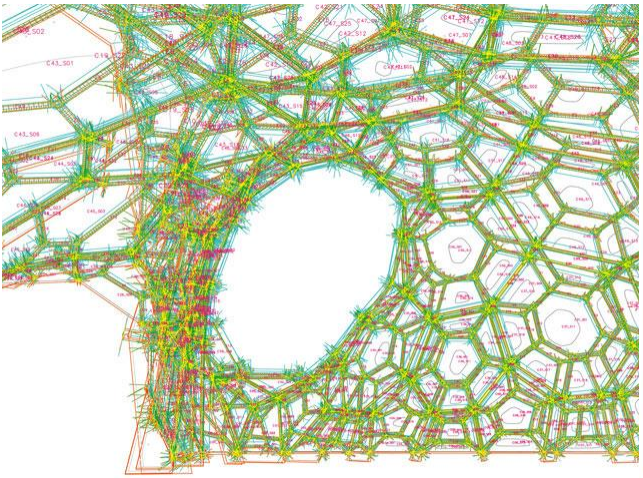
Rivka Oxman

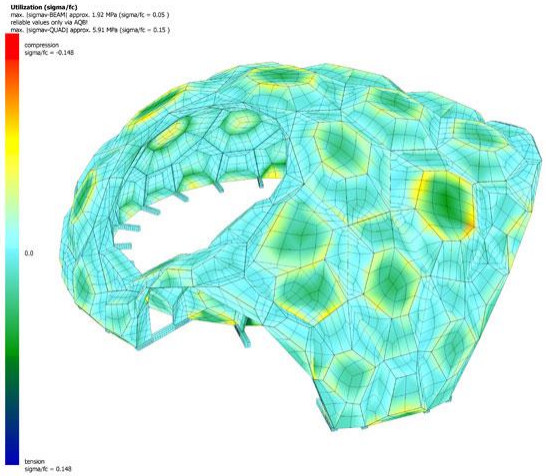
international journal of architectural computing

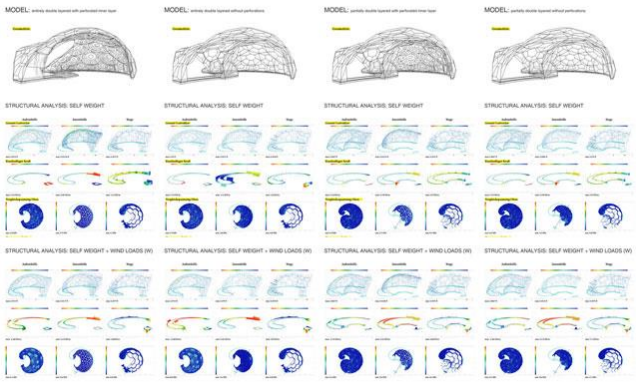
issue 01, volume 06 | 1

2008

why?

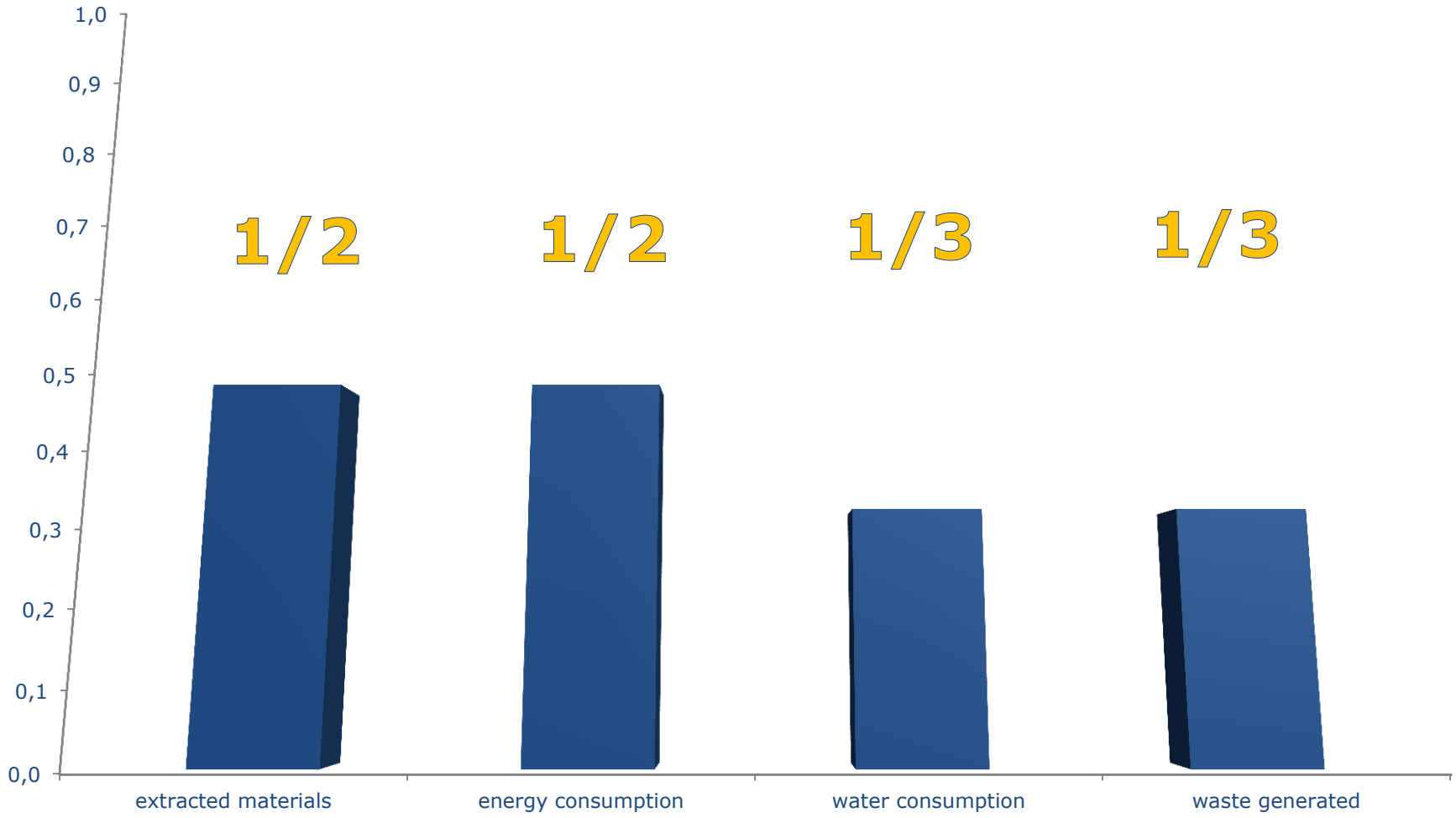






ICD (A. Menges) & ITKE (J. Knippers) Stuttgart University, ICD/ITKE Research Pavilion 2011

why?



source: European Comission (*visited 13.sep.2016*)

why?

Swiss Re Building, London, 2004 *arch*. Foster + Partners *photo* Marc Ginesta *in* flickr

building lexicon

functional requirements

finetune

optimization of performance

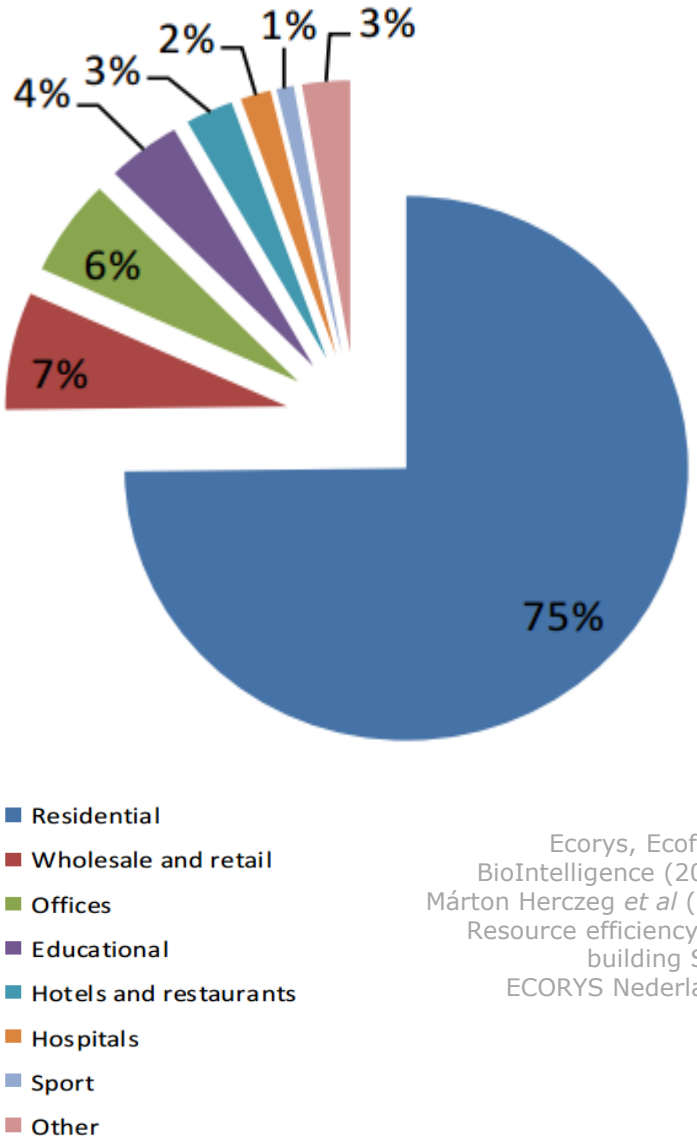
LCA

why?

drawbacks:

resources / project scale

information *vs* early stages



Ecorys, Ecofys and BioIntelligence (2010) *in* Márton Herczeg *et al* (2014). Resource efficiency in the building Sector. ECORYS Nederland BV

what?

method:

simple

expeditious

assessment:

early

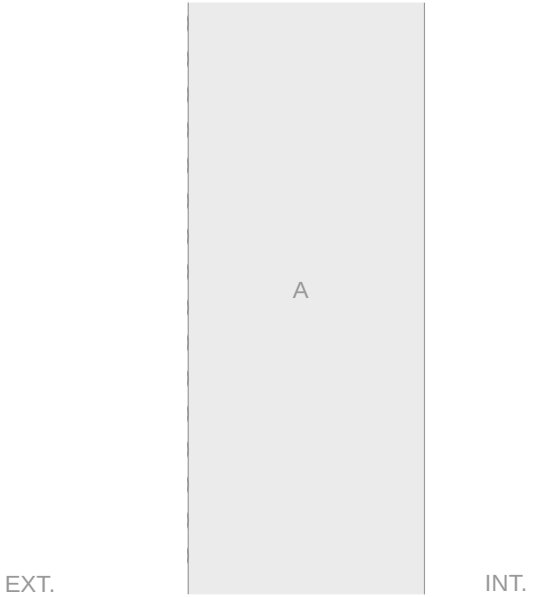
viable

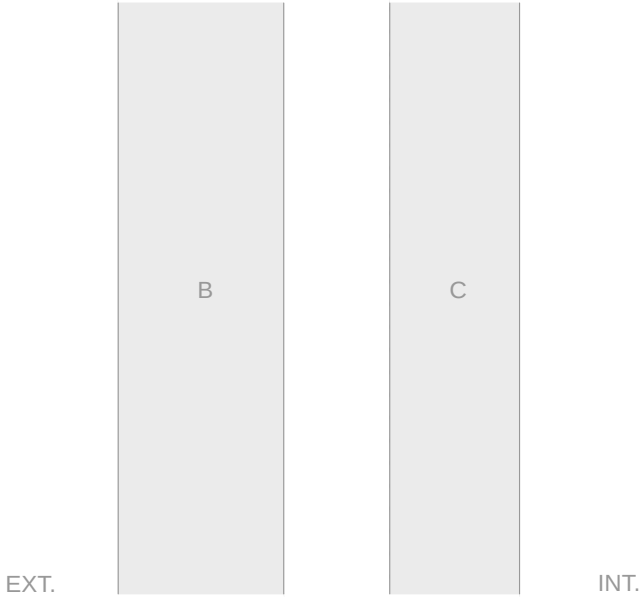
global index:

environmental impact

functional performance

what?





reinforced concrete
hollow brick
thermal brick
solid brick

what?

reinforced concrete
hollow brick
thermal brick
solid brick

cork
extruded polystyrene
rock wool

what?

reinforced concrete
hollow brick
thermal brick
solid brick

cork
extruded polystyrene
rock wool

mortar render
plasterboard

90 construction assemblies

how?

	Environment		Performance
1 global index		IS_G	
2 indicators	IS_E		IS_F
2 parameters	embodied energy per wall unit surface area EE_s [MJ/m^2]		heat transfer coefficient U [W/m^2.K]
	embodied carbon per wall unit surface area EC_s [kgCO$_2$e/m^2]		net superficial thermal mass M_{tsu} [J/m^2.K]

2 design scenarios | #1 cold climates

	Environment	Performance
1 global index	IS_G	
2 indicators	IS_E	IS_F
2 parameters	embodied energy per wall unit surface area EE_s [MJ/m²] **50%**	heat transfer coefficient U [W/m².K] **90%**
	embodied carbon per wall unit surface area EC_s [kgCO$_2$e/m²] **50%**	net superficial thermal mass M_{tsu} [J/m².K] **10%**

2 design scenarios | #2 hot climates

	Environment		Performance
1 global index		IS_G	
2 indicators	IS_E		IS_F
2 parameters	embodied energy per wall unit surface area EE_s [MJ/m²] **50%**		heat transfer coefficient U [W/m².K] **10%**
	embodied carbon per wall unit surface area EC_s [kgCO$_2$e/m²] **50%**		net superficial thermal mass M_{tsu} [J/m².K] **90%**

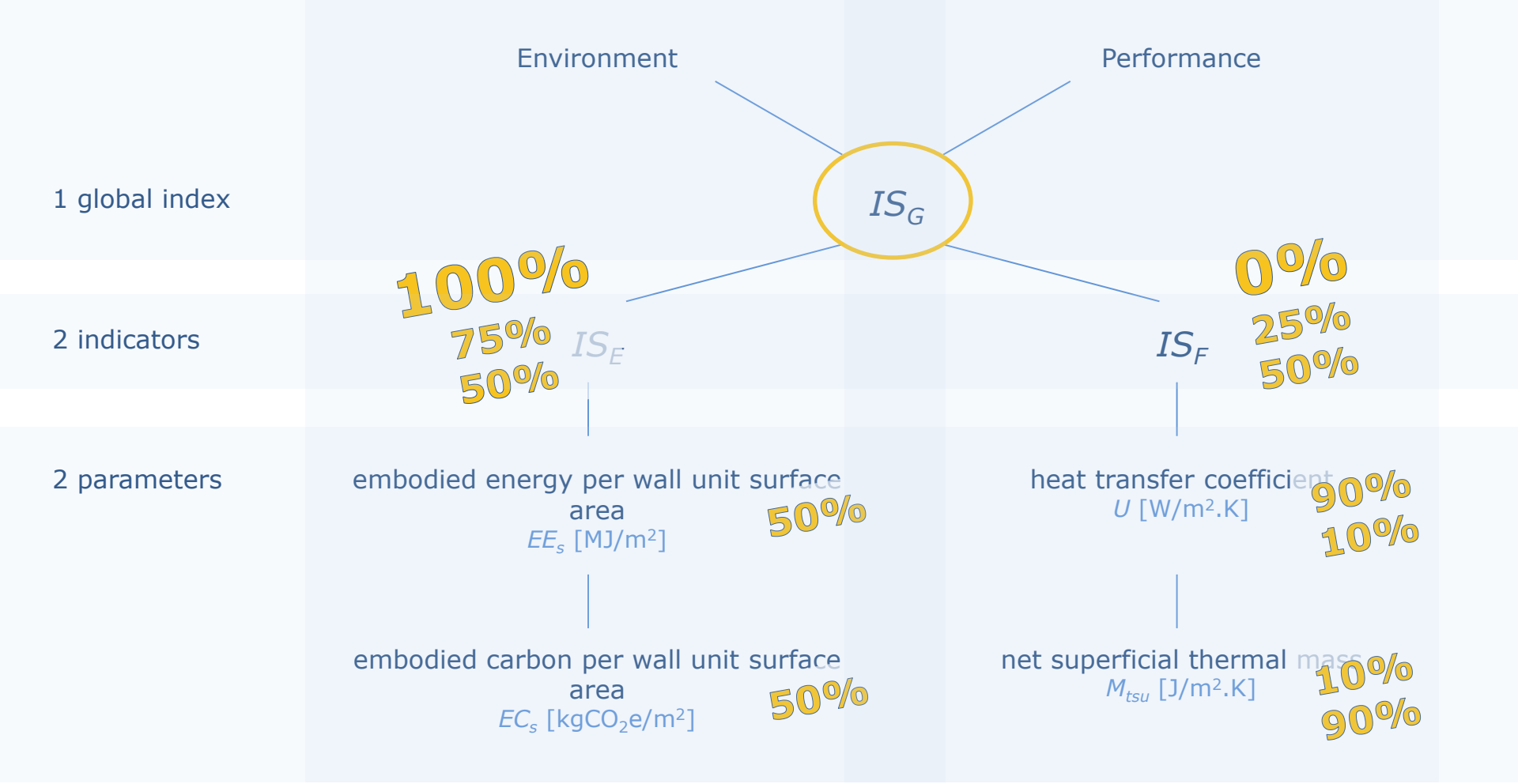
2 design scenarios | #1 cold climates #2 hot climates

	Environment	Performance
1 global index	IS_G	
2 indicators	50% IS_E	IS_F 50%
2 parameters	embodied energy per wall unit surface area EE_s [MJ/m²] 50%	heat transfer coefficient U [W/m².K] 90%
	embodied carbon per wall unit surface area EC_s [kgCO$_2$e/m²] 50%	net superficial thermal mass M_{tsu} [J/m².K] 10%
		10%
		90%

2 design scenarios | #1 cold climates #2 hot climates

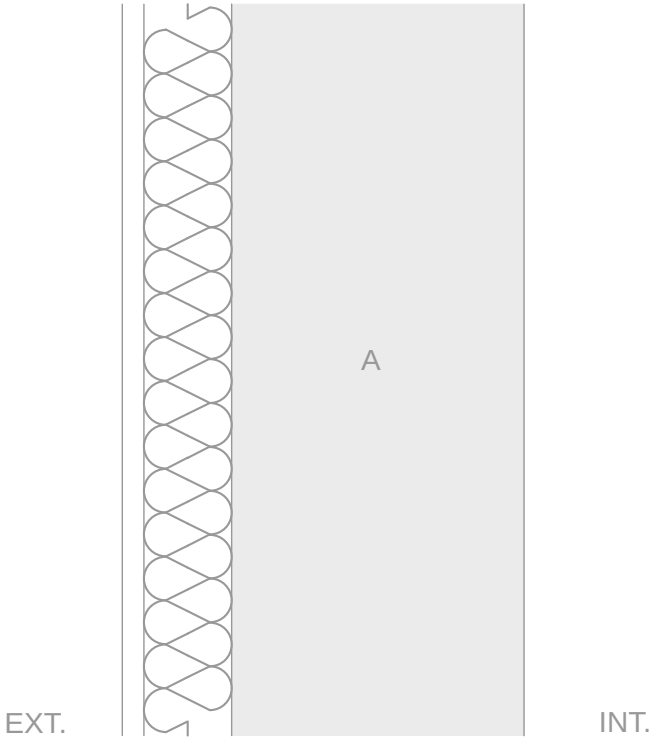
	Environment	Performance
1 global index	IS_G	
2 indicators	75% IS_E 50%	IS_F 25% 50%
2 parameters	embodied energy per wall unit surface area EE_s [MJ/m²] 50%	heat transfer coefficient U [W/m².K] 90% 10%
	embodied carbon per wall unit surface area EC_s [kgCO$_2$e/m²] 50%	net superficial thermal mass M_{tsu} [J/m².K] 10% 90%

2 design scenarios | #1 cold climates #2 hot climates



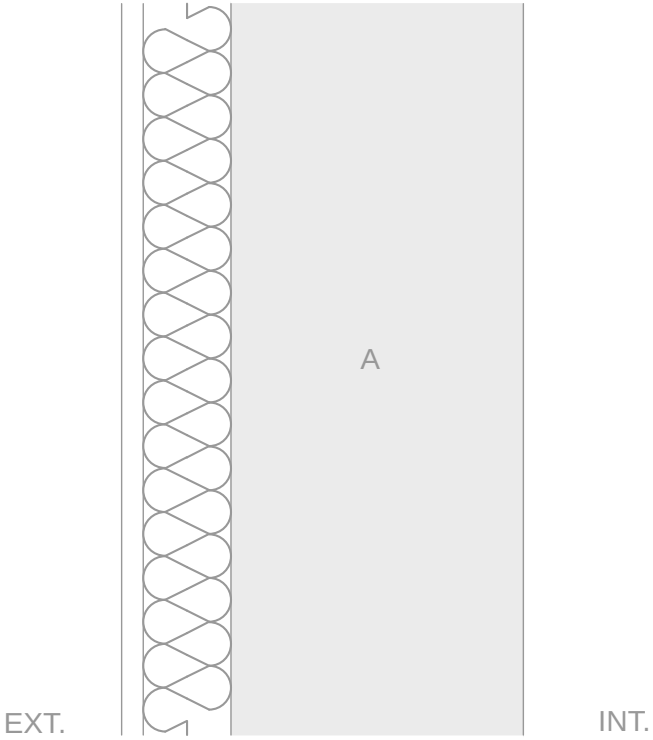
#1 cold climates

Environment 50%
Performance 50%



6cm thermal brick 19&24cm

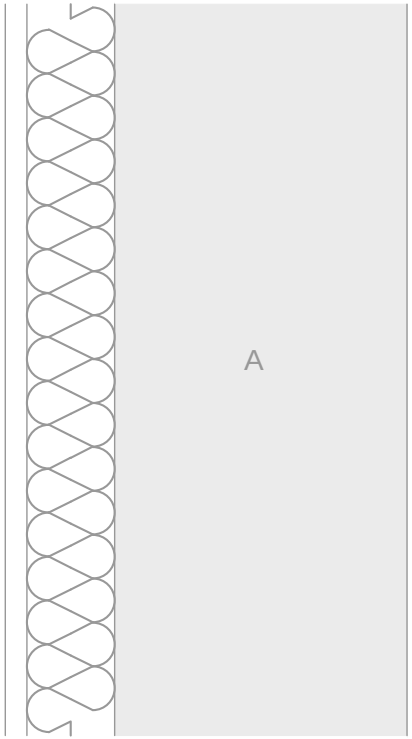
Environment 75%
Performance 25%



4cm hollow brick 20cm
6cm thermal brick 19

#2 hot climates

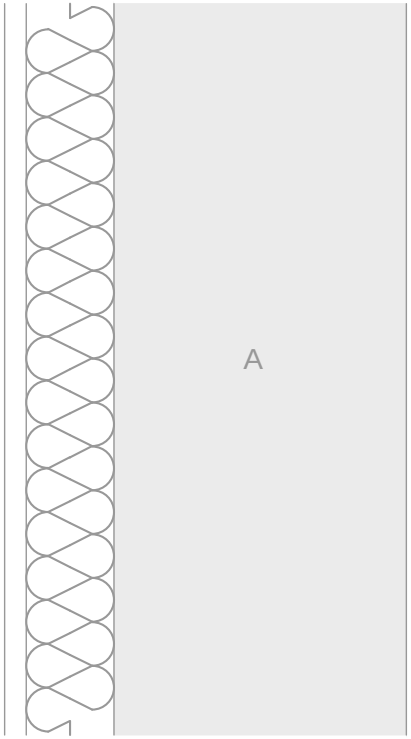
Environment 50%
Performance 50%



EXT. INT.

6cm concrete 20cm
4cm

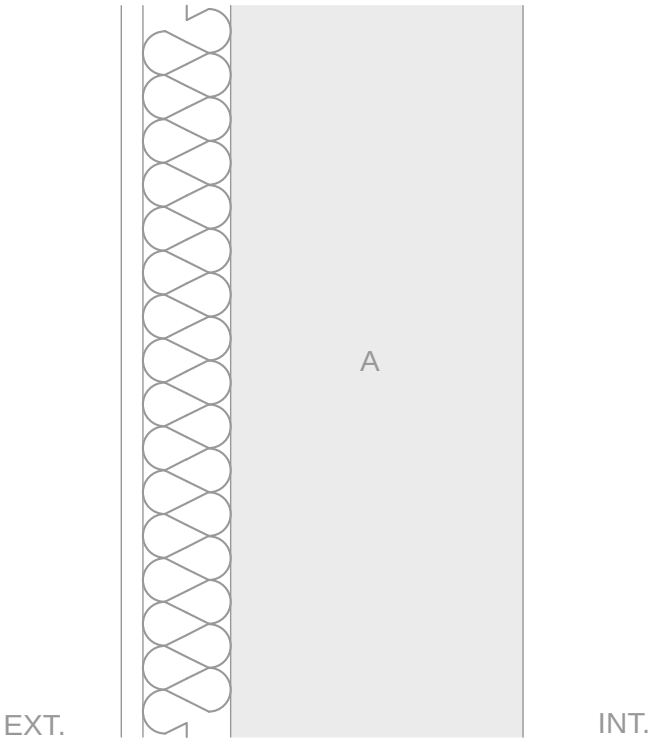
Environment 75%
Performance 25%



EXT. INT.

4cm hollow brick 20cm
6cm thermal brick 19

Environment 100%



4cm hollow brick 20cm
6cm thermal brick 19

discussion… / conclusions…

cold climates

single brick masonries

type of brick depends on environmental relevance

hot climates

concrete OR single brick masonries

(depends on environmental relevance)

cavity walls are not among top ranked

thermal inertia *vs.* environmental impact

simple method + effective data = informed selection

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thank you!...

$$EE_s = \sum_i \left(M_{si} \cdot EE_i \right)$$

$$EC_s = \sum_i \left(M_{si} \cdot EC_i \right)$$

$$U = \frac{1}{R_{si} + \sum_i \frac{e_i}{\lambda_i} + R_{se}}$$

$$M_{tsu} = \frac{\left(R_{se} + \frac{R_1}{2}\right) \cdot M_{ts_1} + \sum_{i=2}^{n} \left[\left(R_{se} + \sum_{j=1}^{j=i-1} R_j + \frac{R_i}{2} \right) \cdot M_{ts_i} \right]}{R_T}$$

$$\overline{P_i} = \frac{P_i - P_{*i}}{P_i^* - P_{*i}} \forall_i$$

$$IS_j = \sum_{i=1}^{n} \left(\overline{P_i} \cdot w_i \right)$$

$$IS_G = IS_E \cdot w_E + IS_F \cdot w_F$$