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ERASMUS+ Strategic Partnerships For Higher Education

HI BI WOOD

RIGA BUILDING COLLEGE
HAMK
KLAIPĖDOS VALSTYBINĖ KOLEGIJA
Cracow University of Technology
FH CAMPUS WIEN

SUSTAINABLE, HIGH-PERFORMANCE BUILDING SOLUTIONS IN WOOD

2020-1-LV01-KA203-077513

INTERACTIONS OF DESIGN PARAMETERS

Aída Santana Sosa

14.03.2023

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CONTENT

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Interactions of design parameters

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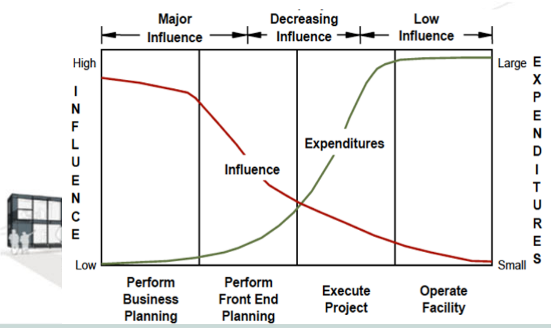
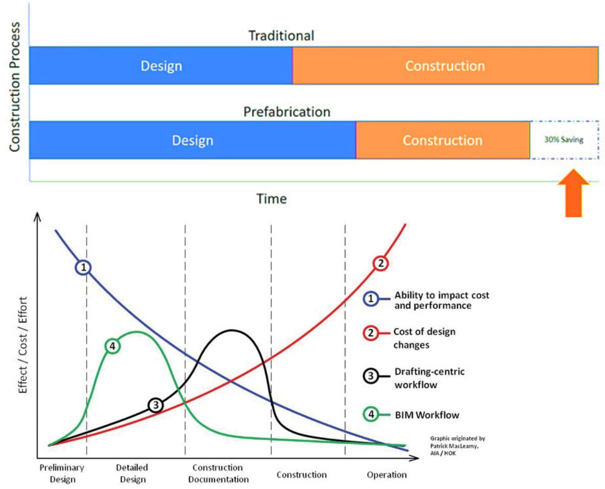
BACKGROUND

- Earlier decisions have higher influence and imply less expenditures
- Later decisions or changes have major expenditures and little influence
- **Prefabrication implies earlier decisions, higher definition and design freeze!**





Sources: Paulson (1976); MacLeamy (2004)

05.06.2023

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Interactions of design parameters

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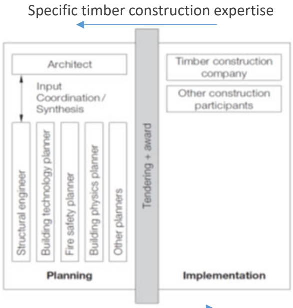
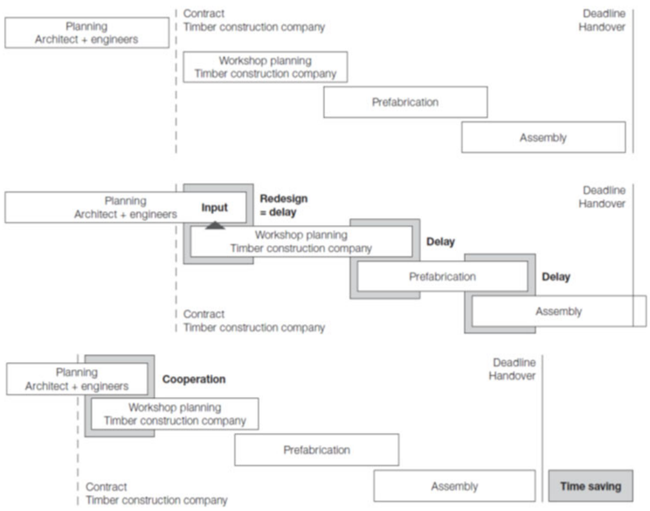
PROBLEMATIC

- Too few specialist planers
- Little competence in design team
- Late inclusion of timber competence in design
- Re-design stage





Sources: Kaufmann 2018

4

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Interactions of design parameters

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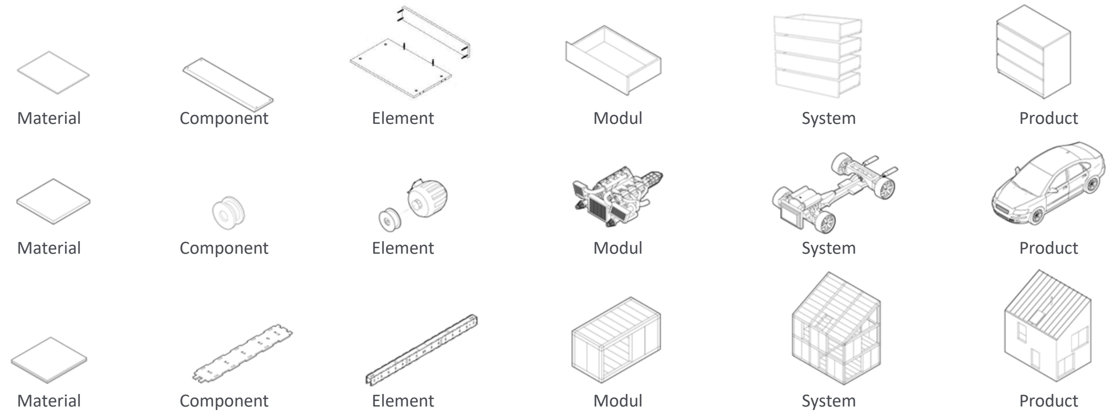
PROBLEMATIC

Timber construction industry <> Manufacturing <> Automotive industry



Sources: WiKi House

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Interactions of design parameters

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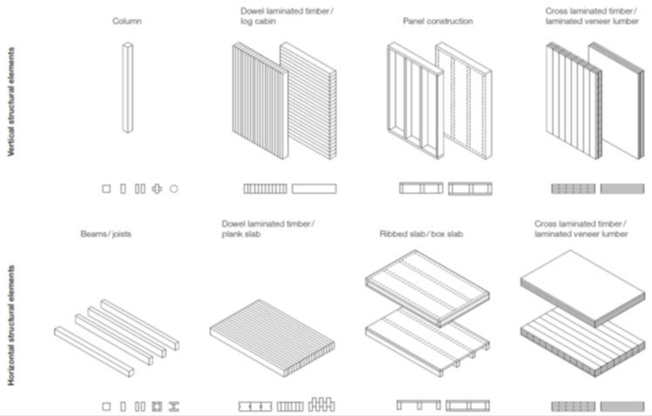
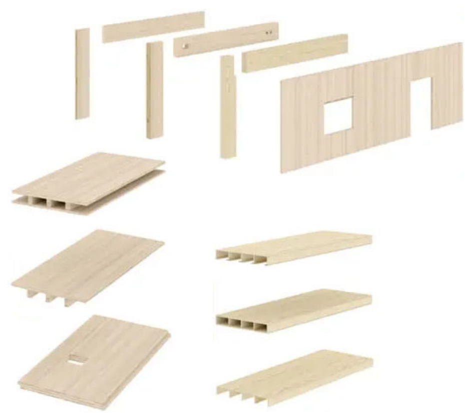
PROBLEMATIC

Structures and support Structures - From linear member to plane





Sources: Kaufmann (2018)

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Interactions of design parameters
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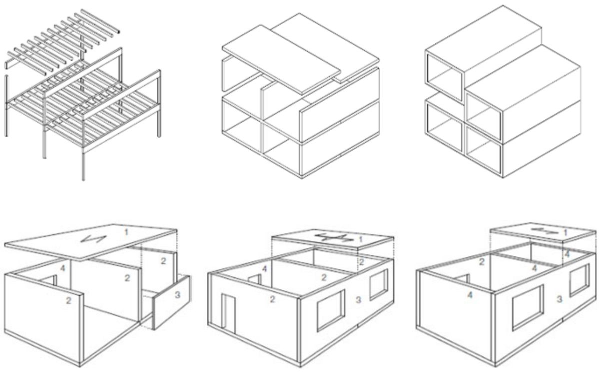
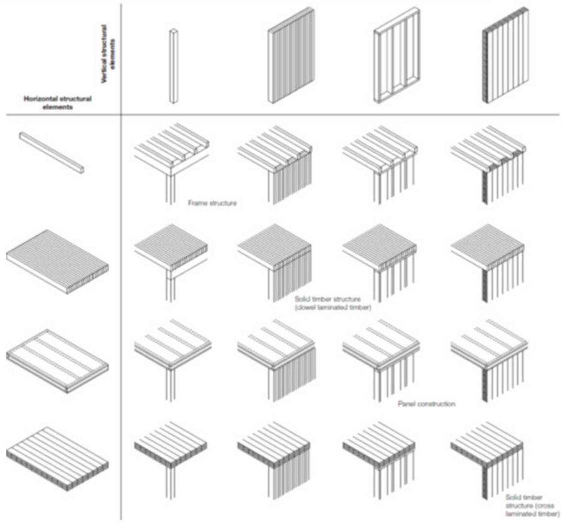
PROBLEMATIC

Combinations of various structural elements in timber construction





Sources: Kaufmann (2018)

7

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Interactions of design parameters
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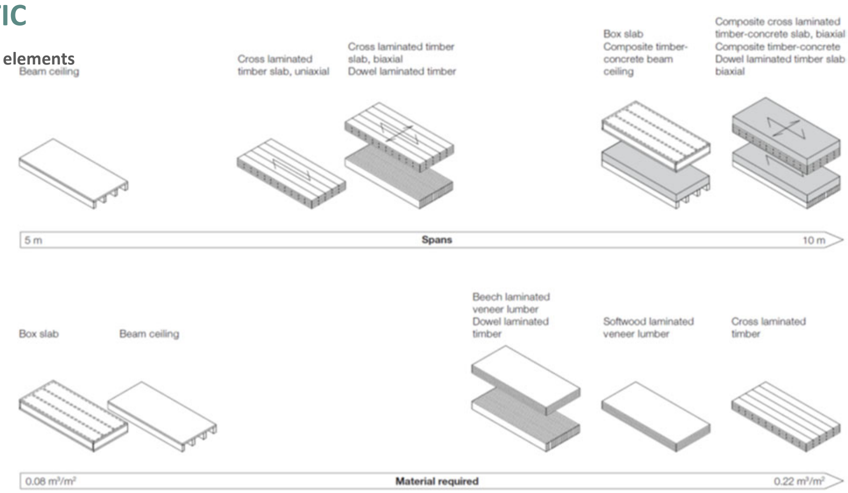
PROBLEMATIC

A comparison of slab elements



Sources: Kaufmann (2018)

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Interactions of design parameters

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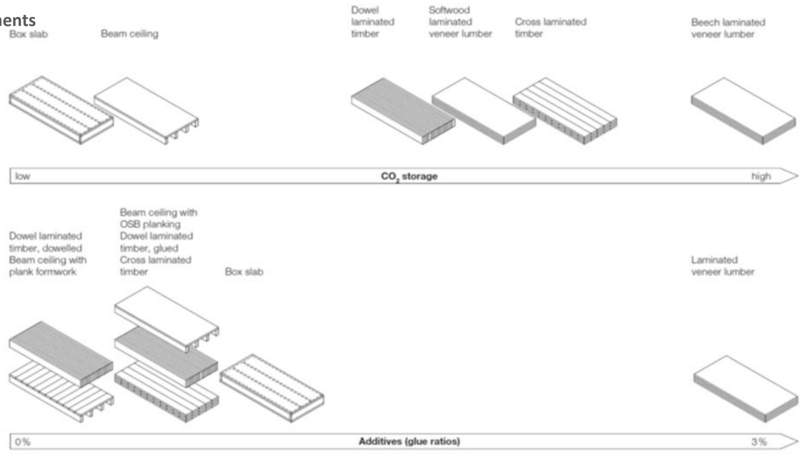
PROBLEMATIC

A comparison of slab elements



Sources: Kaufmann (2018)

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Interactions of design parameters

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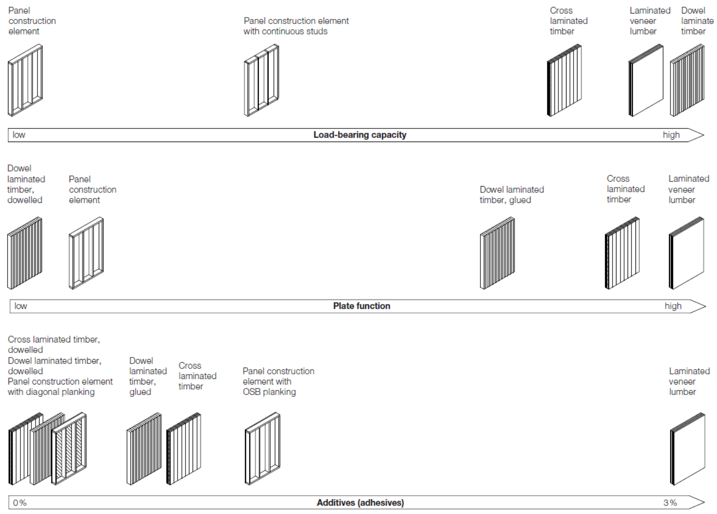
PROBLEMATIC

A comparison of wall elements



Sources: Kaufmann (2018)

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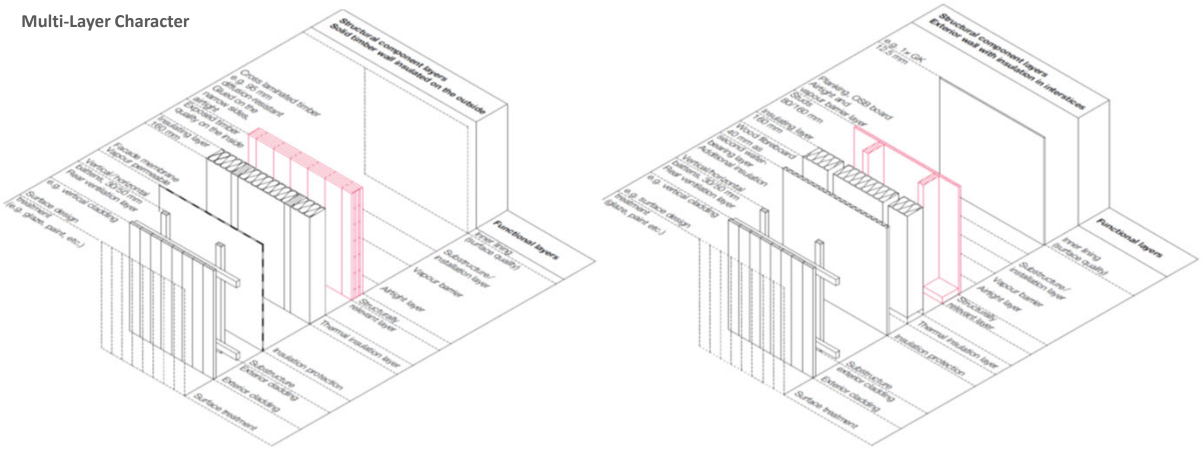
PROBLEMATIC

Multi-Layer Character



Sources: Kaufmann (2018)

11

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Interactions of design parameters
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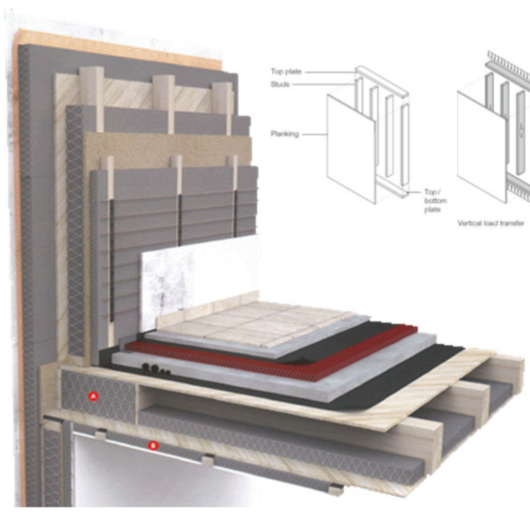
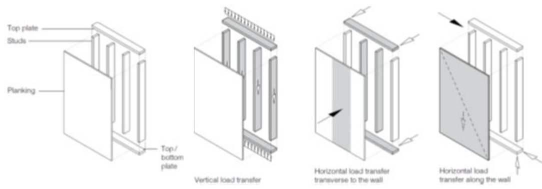
PROBLEMATIC

Timber frame construction - panel construction

- Further development of the frame construction as **a material-saving** construction
- Large complex **prefabrication level**
- Currently the **most frequently used** vertical construction element (especially for **external walls** since cost-effectively combines load-bearing functions with thermal insulation in a **single component layer**)
- Internal cladding: OSB boards (affordable and airtight + diffusion-inhibiting). For increased static requirements, three-layer boards or LVL.
- Top and bottom plates are the weak points in vertical load transfer → hardly any buildings of five storeys or more → Stronger studs or steel profiles are used for high load concentrations.





Sources: Kaufmann (2018), Benedetti (2010)

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Interactions of design parameters

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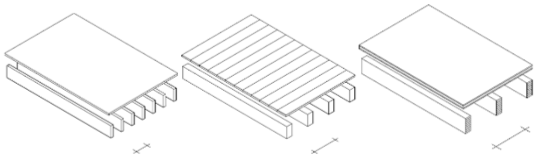
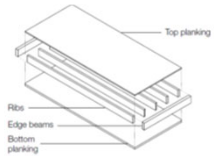
PROBLEMATIC

Timber frame construction – beam / box ceilings

- Constant construction height: **equal dimension** of all beams >> **widening** of the loaded beams >> **change of material** to a more load-bearing one.
- Either **prefabricated or assembled on site**.
- Beams/ribs cover the primary span and panels or boards from beam to beam.
- Classically has a spacing approx. **60 - 90 cm** due to adaptability, simplicity and economy.
- Economical for spans of **4 - 5 m (beam).**
- Complex production and primarily used for medium and large spans **(box).**
- Planking braces the ribs against buckling and tilting so they can be very slender. Distance of the ribs is usually small **(40 - 70 cm).**





Sources: Kaufmann (2018), Benedetti (2010)

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Interactions of design parameters

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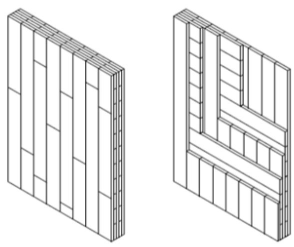
PROBLEMATIC

Cross Laminated Timber - CLT

- Introduction in 1998 in AT. **Turning point** im modern timber construction.
- Made of **glued crosswise** arranged layers (3-11 layers, 60-400 mm) of boards → reduces **swelling and shrinking**.
- Minimizes the timber's inherent **anisotropic** properties.
- Air- and smoke-**tight** elements → Higher **fire resistance**.
- Spruce, pine or fir wood. Oak or birch for harder or decorative top layers.
- Stiffness, surface quality and good workability



Sources: Kaufmann (2018), Benedetti (2010)

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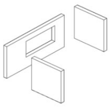
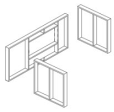
PROBLEMATIC

Requirements	Cross Laminated Timber	Timber Frame Construction

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Interactions of design parameters

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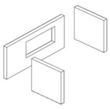
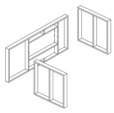
PROBLEMATIC

Requirements	Cross Laminated Timber	Timber Frame Construction
Moisture protection	• Through a wind- and airtight completion. CLT can fulfil airtightness requirements. • Higher risk of moisture penetration on site.	• Via a wind- and airtight completion. Planking for airtightness necessary. • Reduced risk of moisture penetration on site, due to high degree of prefabrication.

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Interactions of design parameters

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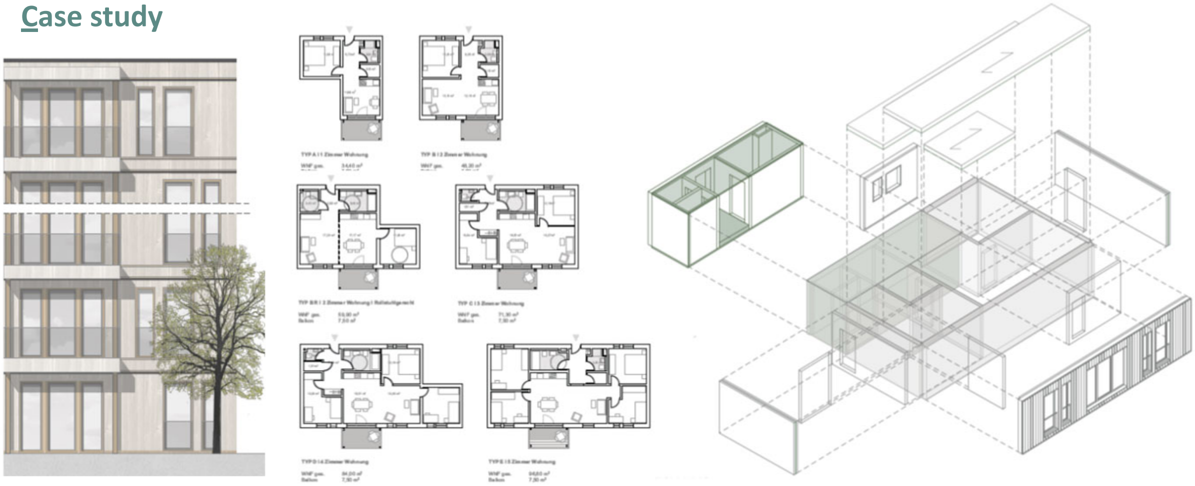
HiBi WOOD

Case study



Sources: TU Wien (2020)

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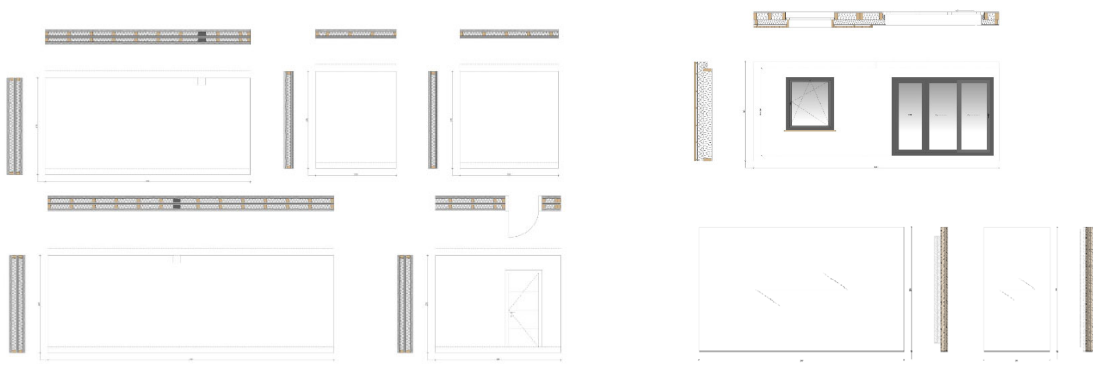
HiBi WOOD

Case study

Catalogue of building elements



Sources: TU Wien (2020)

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Interactions of design parameters

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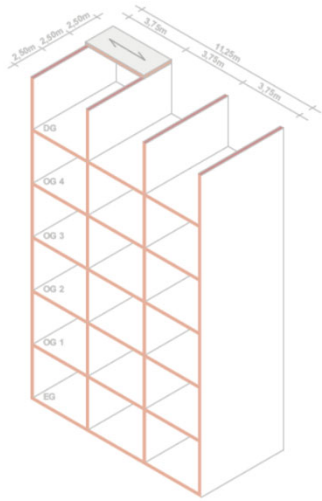
Case study

Selection of building elements



Sources: TU Wien (2020)

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Interactions of design parameters

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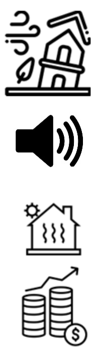
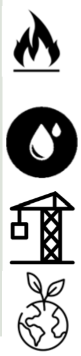
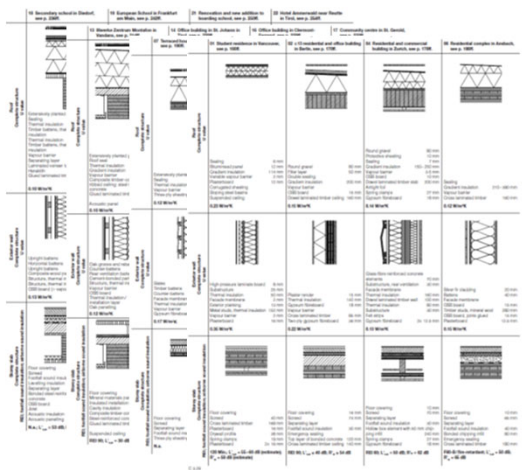
Case study

Analysis of building elements



- Structural performance
- Fire protection
- Noise insulation and acoustics
- Moisture protection
- Thermal performance
- Prefabrication und Assembly
- Costs
- Environmental impact





Sources: TU Wien (2020)

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Interactions of design parameters
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Case study

Approved building products

- Structure:
  - Timber frame → Egger / ELK
  - CLT → KLH / Binderholz / Stora Enso / Diemme / Hasslacher / Mayr-Melnhof
- Timber
  - KVH → Hasslacher / Reisecker / Stora Enso / Weinberger
  - GLT → Binderholz / Franz Kirnbauer / Hasslacher / Mayr-Melnhof / Mosser / Weinberger / Wiehag
  - I-Beams → Suiss Krono
- Insulation
  - Wood-fibre insulation board → Steico / Sto
  - Mineral wool → Isover
  - Cellulose insulation → Isocell
- Particle composites
  - Particle board / Oriented Strand Board (OSB) → Pfleiderer / FunderMax / Fritz Egger / Kronospan / Swiss Krono
- Lining materials
  - Gypsum fibre board / Gypsum plasterboards → Rigips / Fermacell
- …

Sources: TU Wien (2020)

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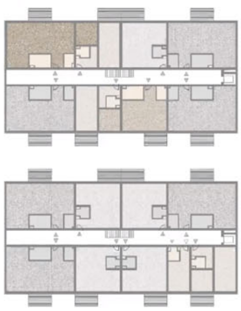
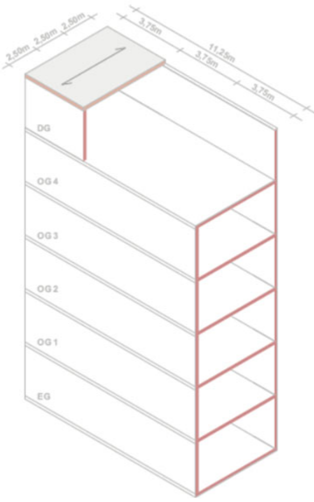
Case study

Possible situations





Sources: TU Wien (2020)

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Interactions of design parameters
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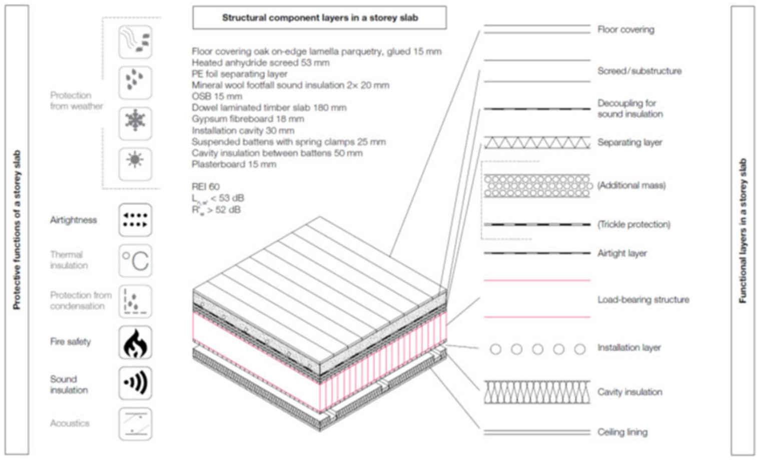
Case study

Structural analysis: Slabs

- **Roof:** REI60
  - Spanwith (m) >> Ld1= 3,75
    >> Ld2 = 5,00
    >> Ld3 = 7,50
  - Live load: non walkeable roof (kN/m2)
  - Snow load (kN/m2)
  - Dead load (kN/m2)
- **Storeys:** REI90
  - Spanwith (m) >> Ld1= 3,75
    >> Ld2 = 5,00
    >> Ld3 = 7,50
  - Live load: residential floors (kN/m2)
  - Dead load (kN/m2)



Sources: TU Wien (2020)

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Interactions of design parameters
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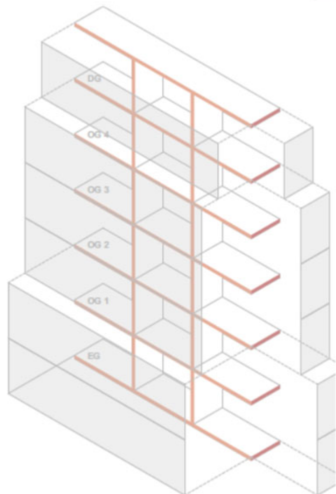
Case study

Structural analysis: Walls

- **Lw0: Non-load bearing suspended external walls**
  - Lw0.1: Roof floor REI60
  - Lw0.2: Intermediate floors REI90
- **Lw1: Non-load bearing continuous external wall**
  - Lw1.1: Roof floor REI60 = Lw0.1
  - Lw1.2: Intermediate floors REI90
  - Lw1.3: Ground floor + first floor REI90
- **Lw2: Load bearing external and separation walls**
  - Lw2.1: Roof floor REI60
  - Lw2.2: Intermediate floors REI90 (2-4 floor)
  - Lw2.3: Ground floor + 1 floor REI90



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Interactions of design parameters
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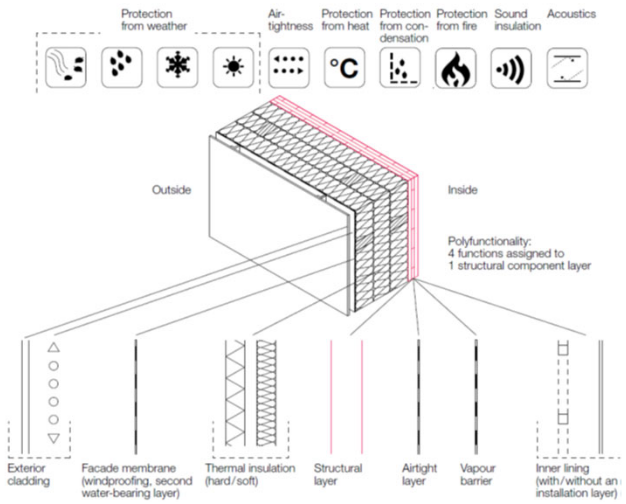
Case study

Analysis of functional layers: slabs and walls

- **Insulation**
  - Mineral wool, glass wool, wood fibre insulation board, cellulose fibre, sheep's wool...
- **Interior cladding** (vs.installation layer or suspended ceiling)
  - Visible, gypsum fibre board, gypsum board....
- **Substructure**
  - Spruce cross lathing, suspension...



Sources: TU Wien (2020), Kaufmann (2018)

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Interactions of design parameters
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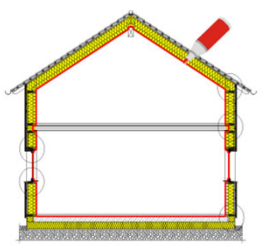
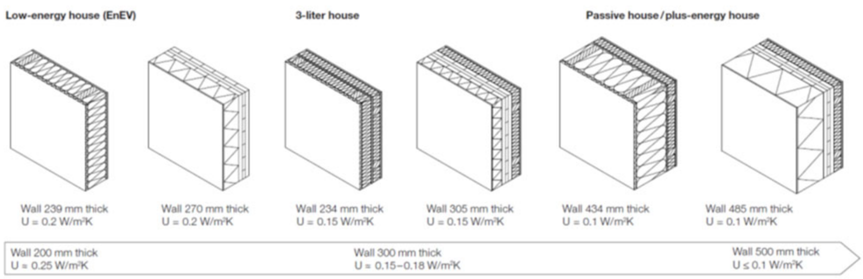
Case study

Building physics: slabs and walls

U-value: External walls and roof [W/m2K]

- **Q1:** Komfort → Uv < 0,15
- **Q2:** Basic+ → 0,16 < Uv < 0,20
- **Q3:** Basic → 0,21< Uv





Sources: TU Wien (2020), Kaufmann (2018)

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Interactions of design parameters

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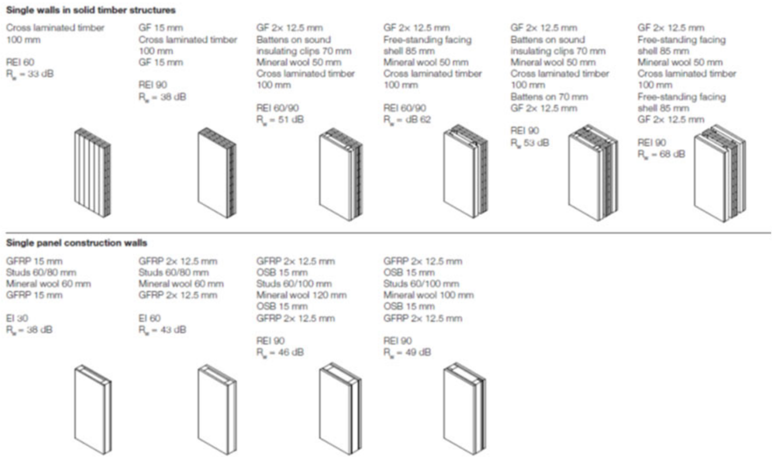
Case study

Building physics: slabs and walls

Airborne sound insulation: All elements Rw [dB]

- **Q1:** Komfort → 58 < Rw
- **Q2:** Basis+ → 48 < Rw < 57
- **Q3:** Basis → 43 < Rw < 47



Sources: TU Wien (2020), Kaufmann (2018)

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Interactions of design parameters

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Case study

Building physics: slabs and walls

Airborne sound insulation: All elements Rw [dB]

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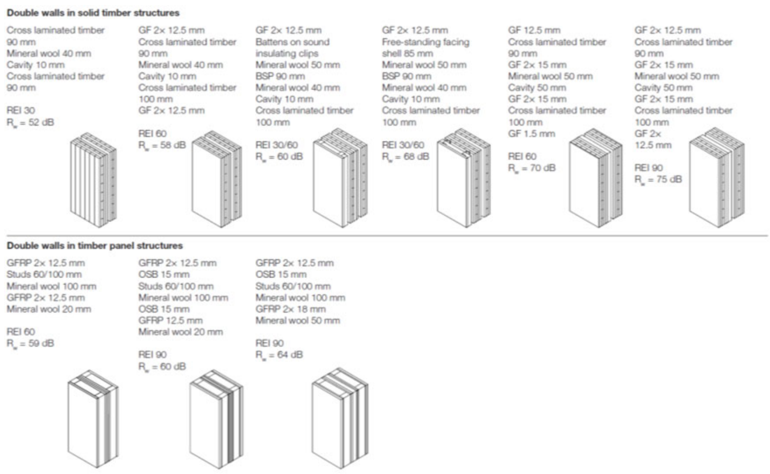

Sources: TU Wien (2020), Kaufmann (2018)

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Interactions of design parameters
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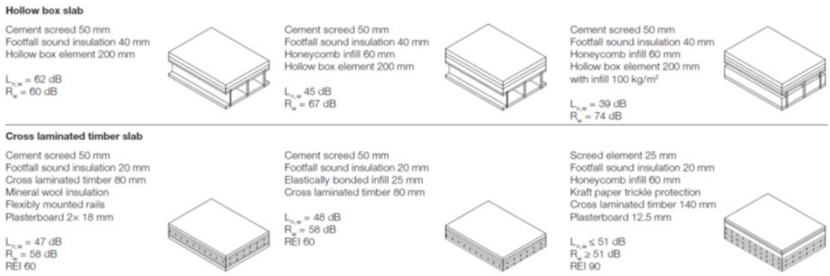
Case study

Building physics: slabs and walls

Impact s. insulation: Intermediate floors and separation walls Ln [dB]

- **Q1:** Komfort → 48 < Ln
- **Q2:** Basis+ → 49 < Ln < 50
- **Q3:** Basis → 50 < Ln < 53



Sources: TU Wien (2020), Kaufmann (2018)

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Interactions of design parameters
Aída Santana Sosa

Case study

Life cycle Analysis

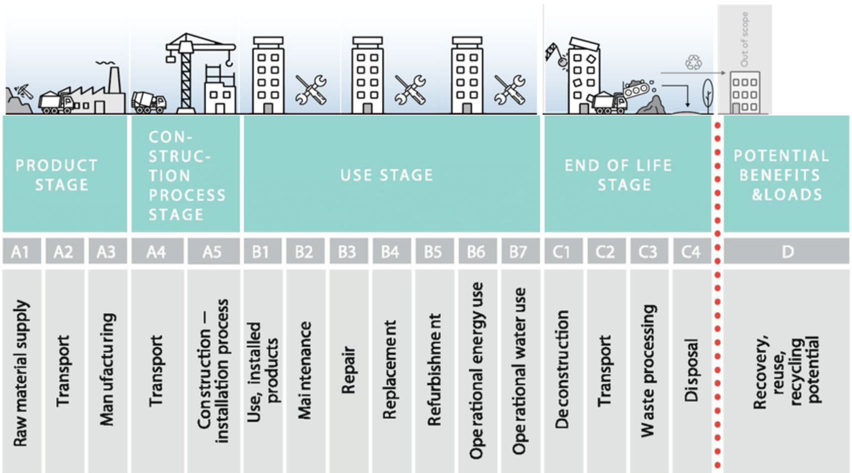
PENRT: Primary Energy Non-Renewable, Total [MJ]

PERT: Primary Energy Renewable, Total [MJ]

GWP: Global Warming Potential [kg CO_2-Äq.]

AP: Acidification potential of the component layer [kg SO_2 äqui./m²]

…



Sources: TU Wien (2020)

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Interactions of design parameters
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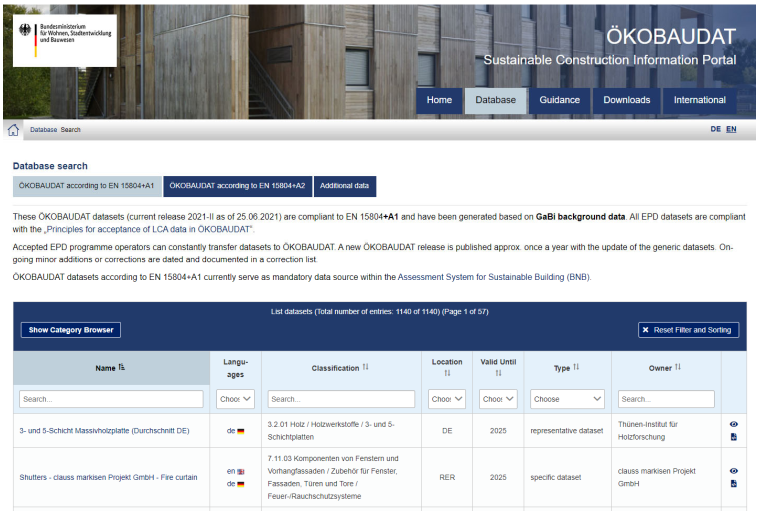
Case study

Life cycle Analysis



Sources: https://www.oekobaudat.de/

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Interactions of design parameters
Aída Santana Sosa

Case study

Costs Analysis

- **Material costs**
  - [€/m3] → KVH, GLT, Insulation…
  - [€/m2] → CLT, Separating fleece, bitumen membrane, vapour barrier, floor covering, GRP planking…
  - [€/to] → Gravel…
  - [€/kg] → Screed…
- **Labour time**
  - [h/Stk] → Wooden beams / CLT…
  - [h/m2] → Vapour barrier / GKF... Lay parquet flooring / separating foil / thermal, impact sound insulation platics / trickle protection…
  - [h/m3] → Screed / Gravel fill…
- **Labour costs** [€/h]
- **Machine labour use** [€/h]
- **Unit price** [€]
- **Total price** [€]
- …

Sources: TU Wien (2020)

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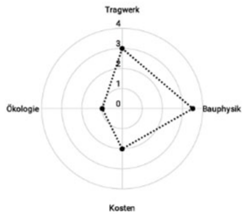
Interactions of design parameters

Aída Santana Sosa

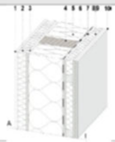
Case study

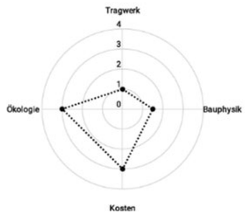
Results

AUSSENWAND	Var.bez. auf Kombination Achsabstände Steher	
AW nicht tragend Fassade B Rahmenbau Mineralwolle		Lw2.3
Skizze	Schichten (von aussen nach innen)	[mm]
	Putzsystem	7
	Holzfaserdämmplatte	60
	Gipsfaserplatte	15
	KVH	160
	Dämmung (Steinwolle oder Zellulosefaser)	160
	Dampfbremse	0,2
	Gipsfaserplatte	15
	Holzlattung (Querlattung)	40
	Dämmung (Steinwolle oder Zellulosefaser)	40
	GFP (1x/2x)	15



AUSSENWAND	Var.bez. auf Kombination Achsabstände Steher	
AW nicht tragend Fassade B Rahmenbau Zellulose		Lw2.3
Skizze	Schichten (von aussen nach innen)	[mm]
	Putzsystem	7
	Holzfaserdämmplatte	60
	Gipsfaserplatte	15
	KVH	160
	Dämmung (Steinwolle oder Zellulosefaser)	160
	Dampfbremse	0,2
	Gipsfaserplatte	15
	Holzlattung (Querlattung)	40
	Dämmung (Steinwolle oder Zellulosefaser)	40
	GFP (1x/2x)	15





Sources: TU Wien (2020)

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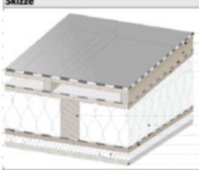
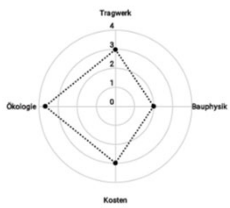
Interactions of design parameters
Aída Santana Sosa

Case study

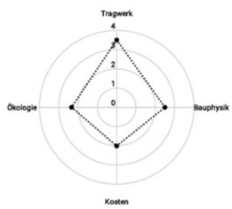
Results

DACH	Rahmenbau	Trägerabstand
V1.He1b.Zellulose	He1b	0,625
Skizze	Schichten (von oben nach unten)	[mm]
	Dachabdichtung EPDM	3
1	OSB	22
2	Konterlattung = Hinterlüftungsebene	60
3	Unterdeckbahn diffusionsoffen	1
4	OSB	15
5	KVH / Keilpfosten	220
	Dämmung (Zellulose oder Steinwolle)	220
	Dampfbremse	0,2
6	OSB	15
7	Dämmung (Steinwolle oder Zellulose) + Metall-UK entkoppelt	50
8	GKF (x2)	25
9		
10		
11		





DACH	Rahmenbau	Trägerabstand
V1.He1b.Steinwolle	He1b	0,625
Skizze	Schichten (von oben nach unten)	[mm]
	Dachabdichtung EPDM	3
1	OSB	22
2	Konterlattung = Hinterlüftungsebene	60
3	Unterdeckbahn diffusionsoffen	1
4	OSB	15
5	KVH / Keilpfosten	220
	Dämmung (Zellulose oder Steinwolle)	220
	Dampfbremse	0,2
6	OSB	15
7	Dämmung (Steinwolle oder Zellulose) + Metall-UK entkoppelt	50
8	GKF (x2)	25
9		
10		
11		



Sources: TU Wien (2020)

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Interactions of design parameters

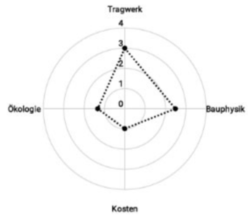
Aída Santana Sosa

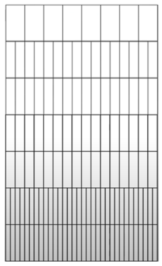
Cracow University of Technology · FH Campus Wien · Riga Building College · HAMK · Klaipėdos Valstybinė Kolegija · HiBi WOOD

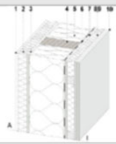
Case study

Results

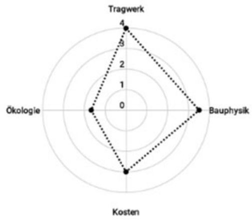
AUSSENWAND	Var.bez. auf Kombination Achsabstände Steher	
AW tragend Fassade A Rahmenbau Variante 1 Mineralwolle		Lw2.3
Skizze	Schichten (von aussen nach innen)	[mm]
	Putzsystem	7
	Holzfaserdämmplatte	60
	Gipsfaserplatte	15
	KVH	160
	Dämmung (Steinwolle oder Zellulosefaser)	160
	Dampfbremse	0,2
	Gipsfaserplatte	15
	Holzlattung (Querlattung)	40
	Dämmung (Steinwolle oder Zellulosefaser)	40
	GFP (1x/2x)	15







AUSSENWAND	Var.bez. auf Kombination Achsabstände Steher	
AW tragend Fassade A Rahmenbau Variante 2 Mineralwolle		Lw2.3
Skizze	Schichten (von aussen nach innen)	[mm]
	Putzsystem	7
	Holzfaserdämmplatte	60
	Gipsfaserplatte	15
	KVH	160
	Dämmung (Steinwolle oder Zellulosefaser)	160
	Dampfbremse	0,2
	Gipsfaserplatte	15
	Holzlattung (Querlattung)	40
	Dämmung (Steinwolle oder Zellulosefaser)	40
	GFP (1x/2x)	15



Sources: TU Wien (2020)

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Interactions of design parameters

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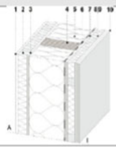
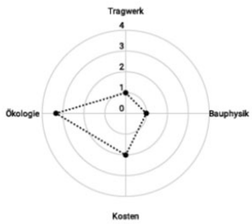
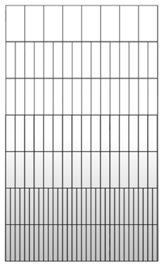
Case study

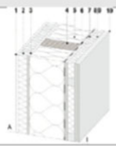
Results



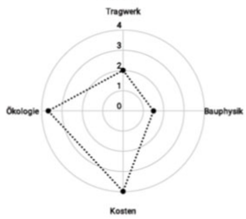
AUSSENWAND	Var.bez. auf Kombination Achsabstände Steher	
AW tragend Fassade A Rahmenbau Variante 1 Zellulose		Lw2.3
Skizze	Schichten (von aussen nach innen)	[mm]
	Putzsystem	7
	Holzfaserdämmplatte	60
	Gipsfaserplatte	15
	KVH	160
	Dämmung (Steinwolle oder Zellulosefaser)	160
	Dampfbremse	0,2
	Gipsfaserplatte	15
	Holzlattung (Querlattung)	40
	Dämmung (Steinwolle oder Zellulosefaser)	40
	GFP (1x/2x)	15







AUSSENWAND	Var.bez. auf Kombination Achsabstände Steher	
AW tragend Fassade A Rahmenbau Variante 2 Zellulose		Lw2.3
Skizze	Schichten (von aussen nach innen)	[mm]
	Putzsystem	7
	Holzfaserdämmplatte	60
	Gipsfaserplatte	15
	KVH	160
	Dämmung (Steinwolle oder Zellulosefaser)	160
	Dampfbremse	0,2
	Gipsfaserplatte	15
	Holzlattung (Querlattung)	40
	Dämmung (Steinwolle oder Zellulosefaser)	40
	GFP (1x/2x)	15



Sources: TU Wien (2020)

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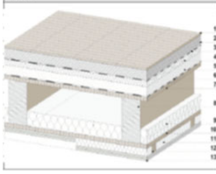
Interactions of design parameters
Aída Santana Sosa

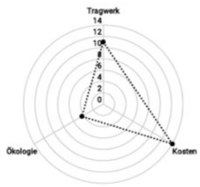
Case study

Results

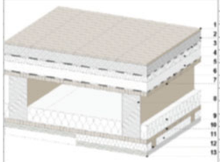
He1 = 62,5 cm
He2 = 125 cm

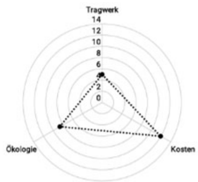
DECKE	Rahmenbau	Trägerabstan
He1.Mineralwolle	He1	0,625
Skizze	Schichten (von oben nach unten)	[mm]
	Massivparkett	10
	Zementestrich	50
1	PE-Folie	0,2
2	TSDP Mineralwolle	30
3	Splittschüttung (ev. massereduziert)	50
4	PE-Folie	0,2
5	OSB-Platte	18
6	Holzträger	240
7	Dämmung (Glaswolle oder Schafwolle)	80
8	OSB-Platte	18
9	Holzlattung (verringert. Achsabst.max 40cm)	40
10, 11, 12	Dämmung (Glaswolle oder Schafwolle)	40
13	GKF (x2) / GKF (x3)	30





DECKE	Rahmenbau	Trägerabstan
He2.Mineralwolle	He2	1,250
Skizze	Schichten (von oben nach unten)	[mm]
	Massivparkett	10
	Zementestrich	50
1	PE-Folie	0,2
2	TSDP Mineralwolle	30
3	Splittschüttung (ev. massereduziert)	50
4	PE-Folie	0,2
5	OSB-Platte	44
6	Holzträger	280
7	Dämmung (Glaswolle oder Schafwolle)	80
8	OSB-Platte	22
9	Holzlattung (verringert. Achsabst.max 40cm)	40
10, 11, 12	Dämmung (Glaswolle oder Schafwolle)	40
13	GKF (x2) / GKF (x3)	30





Sources: TU Wien (2020)

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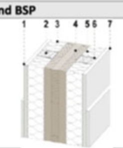
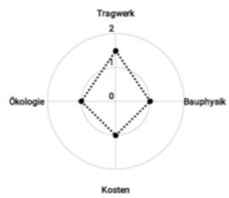
Interactions of design parameters
Aída Santana Sosa

Case study

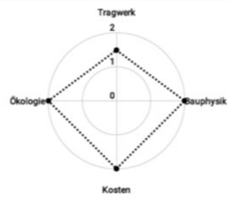
Results

TRENNWAND	BSP Lagen Aufbau variert je QS u. Brandschutzanforderung: 5lagig bessere Rest-R/ sch
TW tragend BSP	Lw2.3
Schichten (von links nach rechts)	[mm]
Gipsfaserplatte (2x)	25
Holzlattung auf Schwingbügel	70
Steinwolle	60
Brettsperrholz	90
Steinwolle	60
Holzlattung auf Schwingbügel	70
Gipsfaserplatte (2x)	25





TRENNWAND	
TW tragend BSP SICHT 2-schichtig	Lw2.3
Schichten (von links nach rechts)	[mm]
	0
Gipsfaserplatte	15
Brettsperrholz	80
Steinwolle (lagegesichert)	60
Brettsperrholz	120
	0
	0



Sources: TU Wien (2020)

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Interactions of design parameters

Aída Santana Sosa

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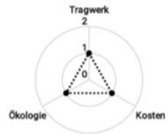
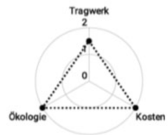
Results

INENNWAND		
IW tragend BSP		Lw2.3
Skizze	Schichten (von links nach rechts)	[mm]
	Gipsfaserplatte (2x)	25
	Brettsperrholz dreischichtig	100
	Gipsfaserplatte (2x)	25



INENNWAND		
IW tragend BSP SICHT		Lw2.3
Skizze	Schichten (von links nach rechts)	[mm]
	Brettsperrholz dreischichtig	120



Sources: TU Wien (2020)

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Interactions of design parameters

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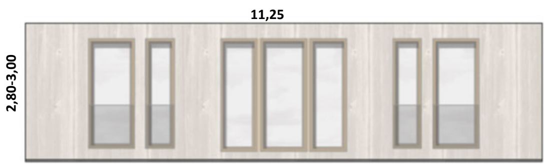
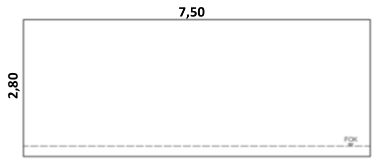
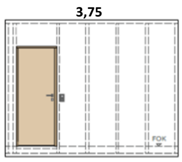
Exercise „What if…?“



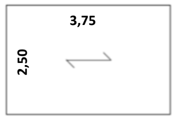
External Wall



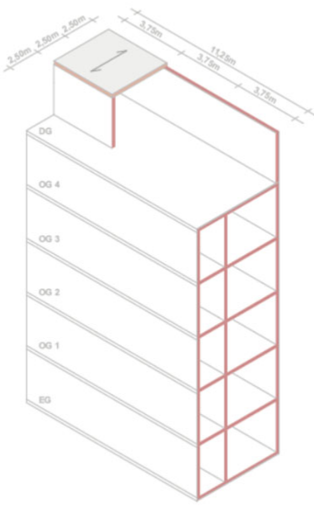
Separation Wall



Interior Wall



(External) Floor



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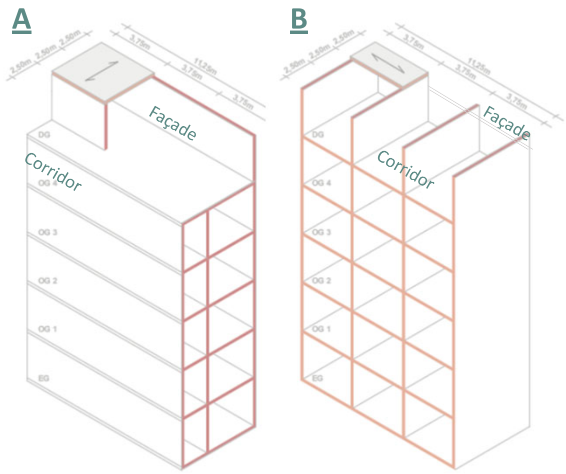
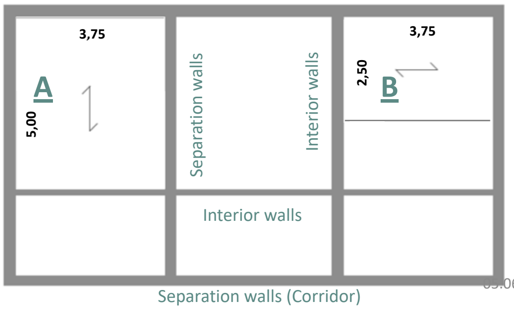
Exercise „What if…?“



- 6 Interdisciplinary teams (5-6 students)
- 2 Groups (A and B)
  - A. Load-bearing external walls and 5 m. spanwith
  - B. Lead-bearing separation walls and 3,75 m. spanwith
- 3 Teams/Group (A1, A2, A3, B1, B2, B3) with 3 specific target goals
  1. Architecture, building physics and technical services
  2. Ecology
  3. Economy



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Interactions of design parameters

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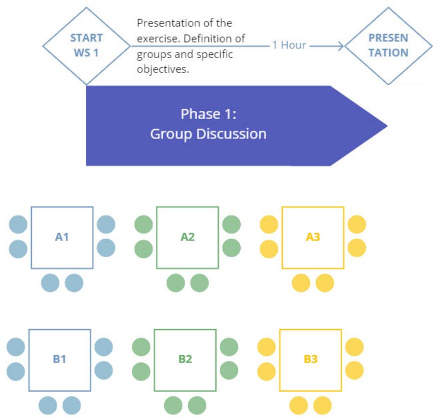
Exercise „What if…?“



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Interactions of design parameters

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Exercise „What if…?“

Aspects to consider regarding: Architecture, building physics, technical services

- Free facade design
- Moisture protection of external elements (walls and roof) – Prevention, conservation, mantainability, repairability
- Bio-based materials are specially sensitive against moisture
- Flexibility, adaptability (more/bigger rooms)
- Possible optmized positions of shafts for technical services
- Maintainance of services (accessibility)
- Airborne insulation
- Impact sound insulation
- U-value, thermal comfort (winter and summer)
- Surfaces and visual comfort

Sources:

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Interactions of design parameters

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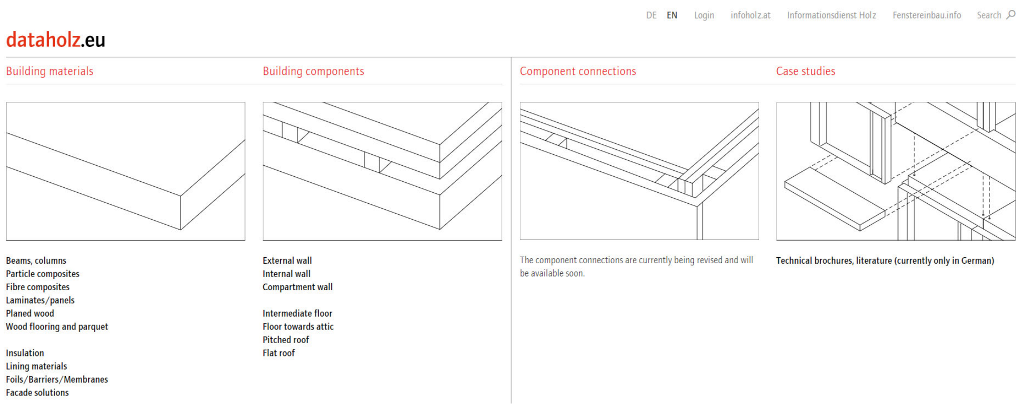
Exercise „What if…?“

Aspects to consider regarding: Architecture, building physics, technical services



Sources: dataholz.eu

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Interactions of design parameters

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Exercise „What if…?“

Aspects to consider regarding: Ecology

- Specific EPDs of building products
- Higher timber share means higher CO_2 storage, but may not be resource-efficient (REDUCE)
- Adhesives content
- Durability
- Interchangeability
- Dismantling
- Reusable (REUSE)
- Recyclable (RECYCLE)
- Embodied carbon emissions (Stage A1 to A5)
- Embodied energy

Sources:

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Interactions of design parameters

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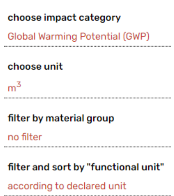
Exercise „What if…?“

Aspects to consider regarding: Ecology



Sources: https://www.materialepyramiden.dk/

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Interactions of design parameters
Aída Santana Sosa

Exercise „What if…?"

Aspects to consider regarding: Economy

- Material costs
- Production costs (in the factory):
  - Workload
  - Labour costs
  - Machine labour
- Storage costs (stocks)
- Transport costs
  - Exploitation of loading capacity of the trucks (Volume)
  - Number of transport journeys
  - Loading of the trucks (Weight)
  - Distance between the factory and the site
- On site costs:
  - Assembly costs
  - Crane work and lifting
  - Building site equipment
  - Completion
  - Personnel expenses
- Rentable areas: Net floor area / room height / building height
- Reusability (Leasing)
- Protection of building elements and site against moisture (envelopes)

Sources:

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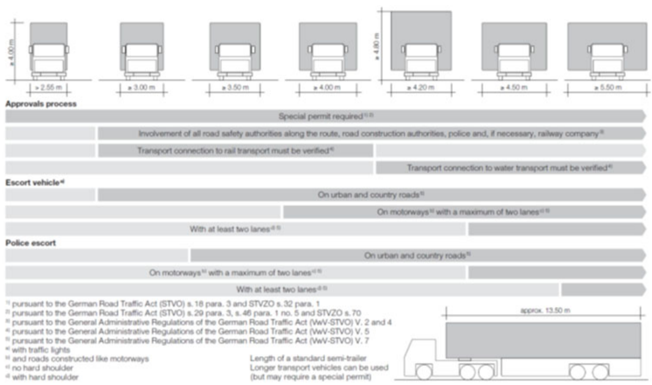
Exercise „What if…?"

Aspects to consider regarding: Economy



Sources: Kaufmann (2018)

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Interactions of design parameters

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HAMK

Hi Bi WOOD

Exercise „What if…?“

Aspects to consider regarding: Economy

				Production costs (factory)					On site costs					
			Material costs €/m²	Workload h/m²	Labour costs €/h	Machine labour	**Production costs €/m²**	Transport €/km	Assembly costs €/h	Crane work and lifting €/h	Completion work	Labour costs	**On site costs €/m²**	**COST (without Tranport)**
Walls	CLT (REI 90)	Non exposed-quality	183,00 €/m²	2,00 h/m²	45 €/h	10,00 €/m²	**283,00 €/m²**	2,50 €	55 €/h	160 €/h	0,35 h/m²	165 €/h	**113,75 €/m²**	**396,75 €/m²**
Walls	CLT (REI 90)	Exposed quality	201,00 €/m²	1,50 h/m²	45 €/h	10,00 €/m²	**278,50 €/m²**	2,50 €	55 €/h	160 €/h	0,30 h/m²	165 €/h	**97,50 €/m²**	**376,00 €/m²**
Walls	Frame (REI90)	Without installation layer	120,00 €/m²	2,40 h/m²	45 €/h		**228,00 €/m²**	2,50 €	55 €/h	160 €/h	0,20 h/m²	165 €/h	**65,00 €/m²**	**293,00 €/m²**
Walls	Frame (REI90)	With installation layer	155,00 €/m²	2,80 h/m²	45 €/h		**281,00 €/m²**	2,50 €	55 €/h	160 €/h	0,25 h/m²	165 €/h	**81,25 €/m²**	**362,25 €/m²**
Slabs	CLT (REI 90) 140mm	Non exposed-quality	85,00 €/m²		45 €/h	10,00 €/m²	**95,00 €/m²**	2,50 €	55 €/h	160 €/h	0,45 h/m²	165 €/h	**146,25 €/m²**	**241,25 €/m²**
Slabs	CLT (REI 90) 140mm	Exposed quality	103,00 €/m²		45 €/h	10,00 €/m²	**113,00 €/m²**	2,50 €	55 €/h	160 €/h	0,40 h/m²	165 €/h	**130,00 €/m²**	**243,00 €/m²**
Slabs	Frame (REI90)	Without double ceiling	25,00 €/m²	1,50 h/m²	45 €/h		**92,50 €/m²**	2,50 €	55 €/h	160 €/h	0,35 h/m²	165 €/h	**113,75 €/m²**	**206,25 €/m²**
Slabs	Frame (REI90)	With double ceiling	60,00 €/m²	2,80 h/m²	45 €/h		**186,00 €/m²**	2,50 €	55 €/h	160 €/h	0,40 h/m²	165 €/h	**130,00 €/m²**	**316,00 €/m²**

Sources: Kaufmann (2018)

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Interactions of design parameters

Aída Santana Sosa

HAMK

Hi Bi WOOD

Exercise „What if…?“

GO!

ENJOY!

Sources:

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