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**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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**Interactions of design parameters**


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**CONTENT**

1. Background
2. Problematic
3. Case Study
4. Results
5. Exercise „What if...?“



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### Interactions of design parameters

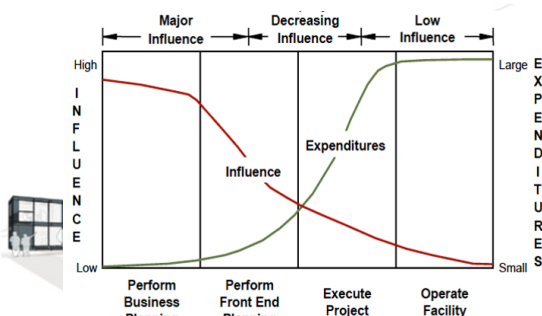
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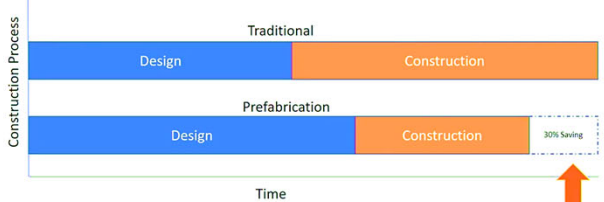
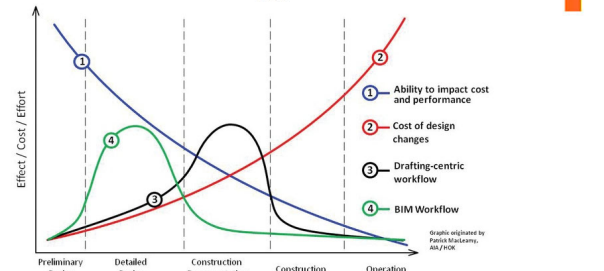



## BACKGROUND

- 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  
3



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### Interactions of design parameters

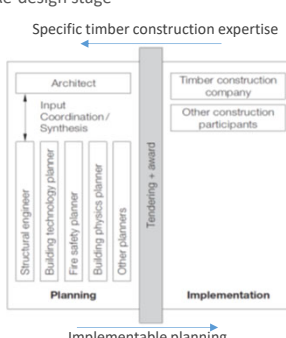
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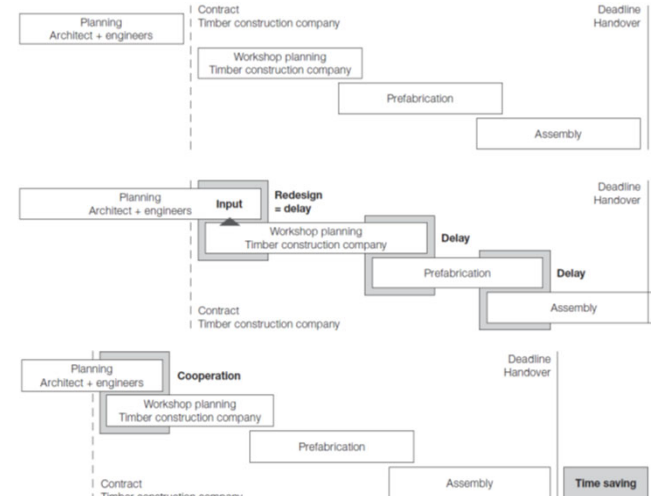



## PROBLEMATIC

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





Sources: Kaufmann 2018

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## PROBLEMATIC

Timber construction industry <-> Manufacturing <-> Automotive industry

|          |           |         |       |        |         |
|----------|-----------|---------|-------|--------|---------|
|          |           |         |       |        |         |
| Material | Component | Element | Modul | System | Product |
|          |           |         |       |        |         |
| Material | Component | Element | Modul | System | Product |
|          |           |         |       |        |         |
| Material | Component | Element | Modul | System | Product |

Sources: Wiki House

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## PROBLEMATIC

Structures and support Structures - From linear member to plane

|                                |  |  |  |  |  |
|--------------------------------|--|--|--|--|--|
| Vertical structural elements   |  |  |  |  |  |
|                                |  |  |  |  |  |
| Horizontal structural elements |  |  |  |  |  |








Sources: Kaufmann (2018)

6



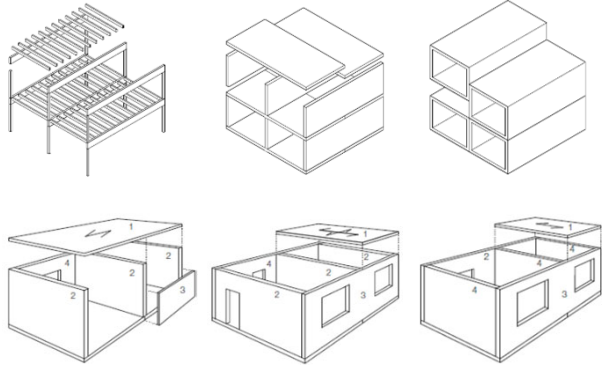
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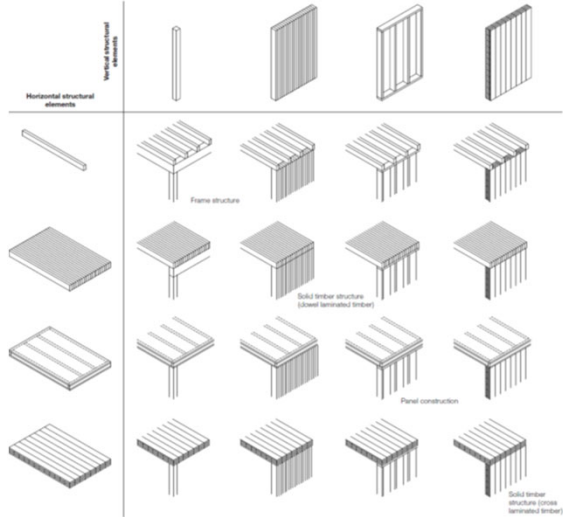
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## PROBLEMATIC


Combinations of various structural elements in timber construction












Sources: Kaufmann (2018)

7



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## PROBLEMATIC

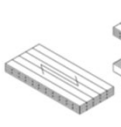
A comparison of slab elements

Beam ceiling

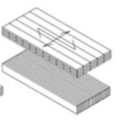


5 m

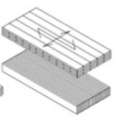
Cross laminated timber slab, uniaxial



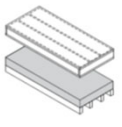
Cross laminated timber slab, biaxial



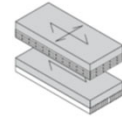
Cross laminated timber slab, Dowel laminated timber



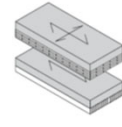
Box slab



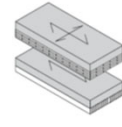
Composite timber-concrete beam ceiling



Composite cross laminated timber-concrete slab, biaxial



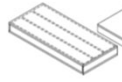
Composite timber-concrete Dowel laminated timber slab biaxial



Spans


5 m 10 m

Box slab

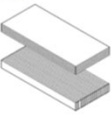


0.08 m<sup>3</sup>/m<sup>2</sup>

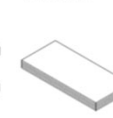
Beam ceiling



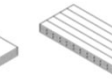
Beech laminated veneer lumber




Dowel laminated timber



Softwood laminated veneer lumber



Cross laminated timber




0.22 m<sup>3</sup>/m<sup>2</sup>

Material required

Sources: Kaufmann (2018)






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### Interactions of design parameters

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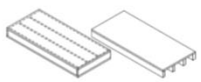






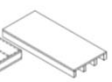
## PROBLEMATIC

### A comparison of slab elements

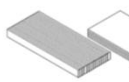
Box slab



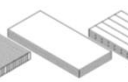
Beam ceiling




Dowel laminated timber



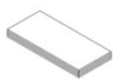
Softwood laminated veneer lumber



Cross laminated timber

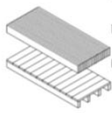


Beech laminated veneer lumber

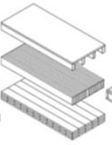


low CO<sub>2</sub> storage high

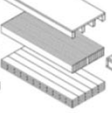
Dowel laminated timber, dowelled




Beam ceiling with OSB planking



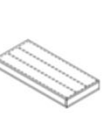
Dowel laminated timber, glued



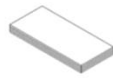
Cross laminated timber



Box slab




Laminated veneer lumber



0% Additives (glue ratios) 3%

Sources: Kaufmann (2018)






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### Interactions of design parameters

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## PROBLEMATIC

### A comparison of wall elements


Panel construction element




Panel construction element with continuous studs




Cross laminated timber



Laminated veneer lumber




Dowel laminated timber




low Load-bearing capacity high


Dowel laminated timber, dowelled




Panel construction element




Dowel laminated timber, glued



Cross laminated timber




Laminated veneer lumber




low Plate function high


Cross laminated timber, dowelled




Dowel laminated timber, dowelled




Panel construction element with diagonal planking




Dowel laminated timber, glued




Cross laminated timber



Panel construction element with OSB planking



Laminated veneer lumber



0% Additives (adhesives) 3%

Sources: Kaufmann (2018)

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## PROBLEMATIC

### Multi-Layer Character

Sources: Kaufmann (2018)

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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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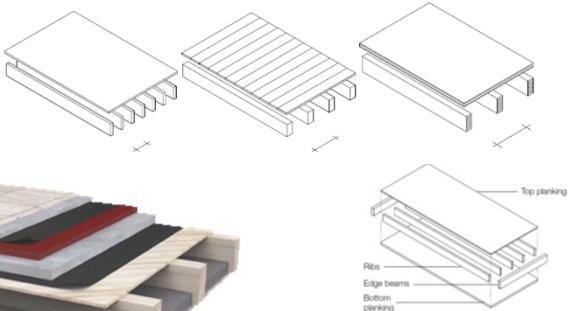
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## PROBLEMATIC


### 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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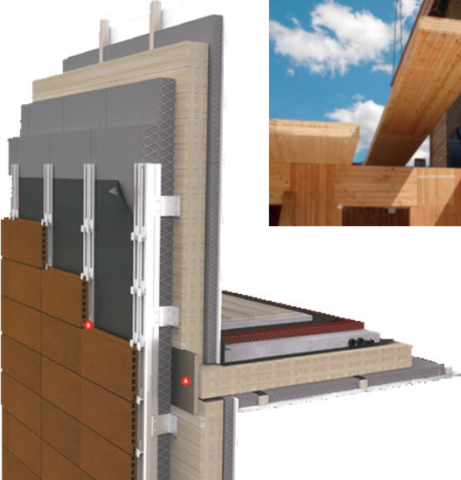

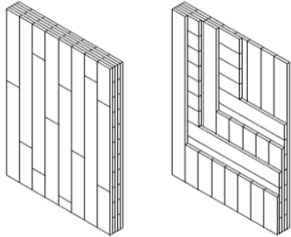
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## PROBLEMATIC

### Cross Laminated Timber - CLT

- Introduction in 1998 in AT. **Turning point** in 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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## PROBLEMATIC

| Requirements               | Cross Laminated Timber   | Timber Frame Construction  |
|----------------------------|--|--|
| <b>Moisture protection</b> | <ul style="list-style-type: none"> <li>Through a wind- and airtight completion. CLT can fulfil airtightness requirements.</li> <li>Higher risk of moisture penetration on site.</li> </ul> | <ul style="list-style-type: none"> <li>Via a wind- and airtight completion. Planking for airtightness necessary.</li> <li>Reduced risk of moisture penetration on site, due to high degree of prefabrication.</li> </ul> |

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### Case study

Sources: TU Wien (2020)

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### Case study

Catalogue of building elements

Sources: TU Wien (2020)

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### Case study

#### Selection of building elements

AW: 2,80-3,00 x 11,25

TW: 2,80 x 7,50

IW: 3,75

GD: 3,75 x 2,50

Sources: TU Wien (2020)

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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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## 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 → Swiss 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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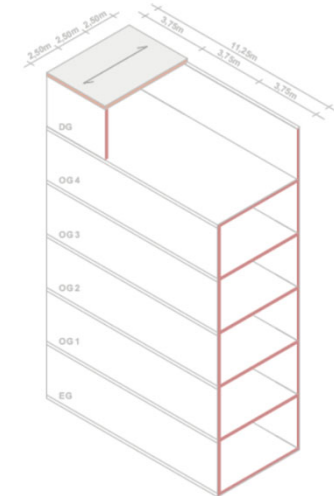
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## Case study

### Possible situations

Sources: TU Wien (2020)

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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 walkable 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)

**Structural component layers in a storey slab**

Floor covering oak on-edge lamella parquetry, glued 15 mm  
 Heated anhydride screed 53 mm  
 PE foil separating layer  
 Mineral wool footfall sound insulation 2x 20 mm  
 OSB 15 mm  
 Dowel laminated timber slab 180 mm  
 Gypsum fibreboard 18 mm  
 Installation cavity 30 mm  
 Suspended battens with spring clamps 25 mm  
 Cavity insulation between battens 50 mm  
 Plasterboard 15 mm

REI 60  
 $L_{n,w} < 53$  dB  
 $R_w > 52$  dB

**Protective functions of a storey slab**

- Protection from weather
- Airtightness
- Thermal insulation
- Protection from condensation
- Fire safety
- Sound insulation
- Acoustics

**Functional layers in a storey slab**

- Floor covering
- Screed/substructure
- Decoupling for sound insulation
- Separating layer
- (Additional mass)
- (Trickle protection)
- Airtight layer
- Load-bearing structure
- Installation layer
- Cavity insulation
- Ceiling lining

Sources: TU Wien (2020)

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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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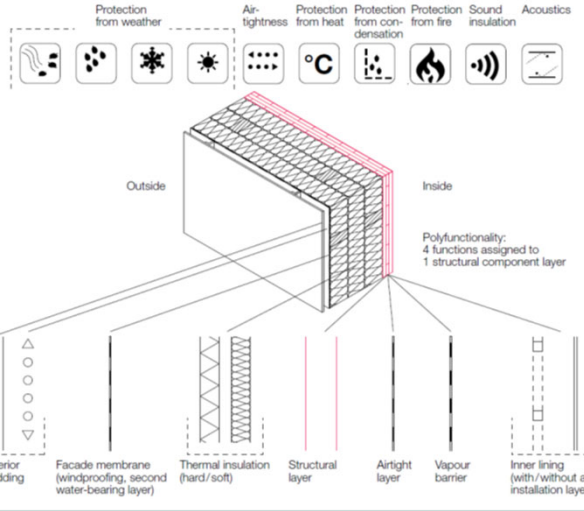



## Case study

### 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...



Protection from weather, Air-tightness, Protection from heat, Protection from condensation, Protection from fire, Sound insulation, Acoustics


Outside / Inside

Polyfunctionality: 4 functions assigned to 1 structural component layer

Exterior cladding, Facade membrane (windproofing, second water-bearing layer), Thermal insulation (hard/soft), Structural layer, Airtight layer, Vapour barrier, Inner lining (with/without an installation layer)

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



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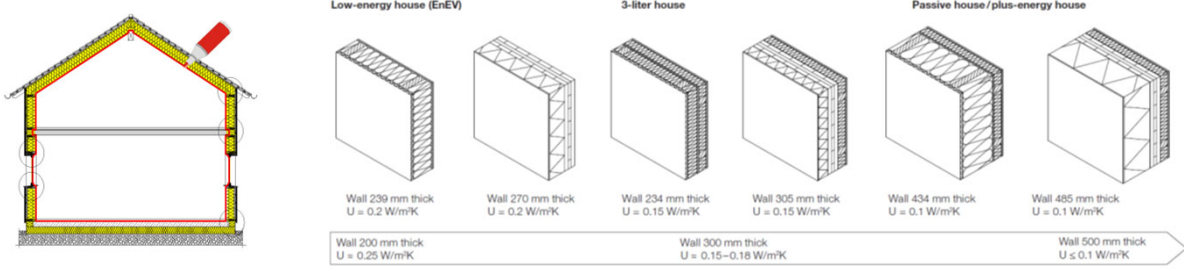
  

## Case study

### Building physics: slabs and walls

**U-value: External walls and roof [W/m<sup>2</sup>K]**

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




Low-energy house (EnEV), 3-liter house, Passive house / plus-energy house

Wall 239 mm thick U = 0.2 W/m<sup>2</sup>K, Wall 270 mm thick U = 0.2 W/m<sup>2</sup>K, Wall 234 mm thick U = 0.15 W/m<sup>2</sup>K, Wall 305 mm thick U = 0.15 W/m<sup>2</sup>K, Wall 434 mm thick U = 0.1 W/m<sup>2</sup>K, Wall 485 mm thick U = 0.1 W/m<sup>2</sup>K

Wall 200 mm thick U = 0.25 W/m<sup>2</sup>K, Wall 300 mm thick U = 0.15–0.18 W/m<sup>2</sup>K, Wall 500 mm thick U ≤ 0.1 W/m<sup>2</sup>K


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

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### Case study

**Building physics: slabs and walls**

**Airborne sound insulation: All elements  $R_w$  [dB]**

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

**Single walls in solid timber structures**

|  |  |   |  |  |  |
|--|--|---|--|--|--|
| Cross laminated timber 100 mm<br>REI 60<br>$R_w = 33$ dB | GF 15 mm<br>Cross laminated timber 100 mm<br>GF 15 mm<br>REI 90<br>$R_w = 38$ dB | GF 2x 12.5 mm<br>Battens on sound insulating clips 70 mm<br>Mineral wool 50 mm<br>Cross laminated timber 100 mm<br>REI 60/90<br>$R_w = 51$ dB | GF 2x 12.5 mm<br>Free-standing facing shell 85 mm<br>Mineral wool 50 mm<br>Cross laminated timber 100 mm<br>REI 60/90<br>$R_w = 48$ dB | GF 2x 12.5 mm<br>Battens on sound insulating clips 70 mm<br>Mineral wool 50 mm<br>Cross laminated timber 100 mm<br>Battens on 70 mm GF 2x 12.5 mm<br>REI 90<br>$R_w = 53$ dB | GF 2x 12.5 mm<br>Free-standing facing shell 85 mm<br>Mineral wool 50 mm<br>Cross laminated timber 100 mm<br>Free-standing facing shell 85 mm<br>GF 2x 12.5 mm<br>REI 60<br>$R_w = 68$ dB |
|--|--|---|--|--|--|


  

**Single panel construction walls**

|  |  |   |   |
|--|--|---|---|
| GFRP 15 mm<br>Studs 60/90 mm<br>Mineral wool 60 mm<br>GFRP 15 mm<br>EI 30<br>$R_w = 38$ dB | GFRP 2x 12.5 mm<br>Studs 60/90 mm<br>Mineral wool 60 mm<br>GFRP 2x 12.5 mm<br>EI 60<br>$R_w = 43$ dB | GFRP 2x 12.5 mm<br>OSB 15 mm<br>Studs 60/100 mm<br>Mineral wool 120 mm<br>OSB 15 mm<br>GFRP 2x 12.5 mm<br>REI 90<br>$R_w = 46$ dB | GFRP 2x 12.5 mm<br>OSB 15 mm<br>Studs 60/100 mm<br>Mineral wool 100 mm<br>OSB 15 mm<br>GFRP 2x 12.5 mm<br>REI 90<br>$R_w = 49$ dB |
|--|--|---|---|


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

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### Case study

**Building physics: slabs and walls**

**Airborne sound insulation: All elements  $R_w$  [dB]**

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

**Double walls in solid timber structures**

|   |  |  |   |   |  |
|---|--|--|---|---|--|
| Cross laminated timber 90 mm<br>Mineral wool 40 mm<br>Cavity 10 mm<br>Cross laminated timber 90 mm<br>REI 30<br>$R_w = 52$ dB | GF 2x 12.5 mm<br>Cross laminated timber 90 mm<br>Mineral wool 40 mm<br>Cavity 10 mm<br>Cross laminated timber 100 mm<br>GF 2x 12.5 mm<br>REI 60<br>$R_w = 58$ dB | GF 2x 12.5 mm<br>Battens on sound insulating clips<br>Mineral wool 50 mm<br>BSP 90 mm<br>Mineral wool 40 mm<br>Cavity 10 mm<br>Cross laminated timber 100 mm<br>REI 30/60<br>$R_w = 60$ dB | GF 2x 12.5 mm<br>Free-standing facing shell 85 mm<br>Mineral wool 50 mm<br>BSP 90 mm<br>Mineral wool 40 mm<br>Cavity 10 mm<br>Cross laminated timber 100 mm<br>REI 30/60<br>$R_w = 66$ dB | GF 12.5 mm<br>Cross laminated timber 90 mm<br>GF 2x 15 mm<br>Mineral wool 50 mm<br>Cavity 50 mm<br>GF 2x 15 mm<br>Cross laminated timber 100 mm<br>GF 1.5 mm<br>REI 60<br>$R_w = 70$ dB | GF 2x 12.5 mm<br>Cross laminated timber 90 mm<br>GF 2x 15 mm<br>Mineral wool 50 mm<br>Cavity 50 mm<br>GF 2x 15 mm<br>Cross laminated timber 100 mm<br>GF 2x 12.5 mm<br>REI 90<br>$R_w = 75$ dB |
|---|--|--|---|---|--|

**Double walls in timber panel structures**

|   |   |   |
|---|---|---|
| GFRP 2x 12.5 mm<br>Studs 60/100 mm<br>Mineral wool 100 mm<br>GFRP 2x 12.5 mm<br>Mineral wool 20 mm<br>REI 60<br>$R_w = 59$ dB | GFRP 2x 12.5 mm<br>OSB 15 mm<br>Studs 60/100 mm<br>Mineral wool 100 mm<br>OSB 15 mm<br>GFRP 2x 12.5 mm<br>Mineral wool 20 mm<br>REI 90<br>$R_w = 60$ dB | GFRP 2x 12.5 mm<br>OSB 15 mm<br>Studs 60/100 mm<br>Mineral wool 100 mm<br>OSB 15 mm<br>GFRP 2x 18 mm<br>Mineral wool 50 mm<br>REI 90<br>$R_w = 64$ dB |
|---|---|---|

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

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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

**Hollow box slab**

Cement screed 50 mm  
Footfall sound insulation 40 mm  
Hollow box element 200 mm

$L_{n,w} = 62$  dB  
 $R_w = 60$  dB

Cement screed 50 mm  
Footfall sound insulation 40 mm  
Honeycomb infill 60 mm  
Hollow box element 200 mm

$L_{n,w} = 45$  dB  
 $R_w = 67$  dB

Cement screed 50 mm  
Footfall sound insulation 40 mm  
Honeycomb infill 60 mm  
Hollow box element 200 mm  
with infill 100 kg/m<sup>2</sup>

$L_{n,w} = 39$  dB  
 $R_w = 74$  dB

**Cross laminated timber slab**

Cement screed 50 mm  
Footfall sound insulation 20 mm  
Cross laminated timber 80 mm  
Mineral wool insulation  
Flexibly mounted rails  
Plasterboard 2x 18 mm

$L_{n,w} = 47$  dB  
 $R_w = 58$  dB  
REI 60

Cement screed 50 mm  
Footfall sound insulation 20 mm  
Elastically bonded infill 25 mm  
Cross laminated timber 80 mm

$L_{n,w} = 48$  dB  
 $R_w = 58$  dB  
REI 60

Screed element 25 mm  
Footfall sound insulation 20 mm  
Honeycomb infill 60 mm  
Kraft paper trickle protection  
Cross laminated timber 140 mm  
Plasterboard 12.5 mm

$L_{n,w} < 51$  dB  
 $R_w > 51$  dB  
REI 90

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

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## Case study

### Life cycle Analysis

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

**PERT:** Primary Energy Renewable, Total [MJ]

**GWP:** Global Warming Potential [kg CO<sub>2</sub>-Äq.]

**AP:** Acidification potential of the component layer [kg SO<sub>2</sub> äqui./m<sup>2</sup>]

...

| PRODUCT STAGE       |           |              | CON-STRUCTION PROCESS STAGE |                                     | USE STAGE               |             |        |             |               |                        |                       | END OF LIFE STAGE |           |                  |          | POTENTIAL BENEFITS & LOADS           |
|---------------------|-----------|--------------|-----------------------------|-------------------------------------|-------------------------|-------------|--------|-------------|---------------|------------------------|-----------------------|-------------------|-----------|------------------|----------|--------------------------------------|
| A1                  | A2        | A3           | A4                          | A5                                  | B1                      | B2          | B3     | B4          | B5            | B6                     | B7                    | C1                | C2        | C3               | C4       | D                                    |
| Raw material supply | Transport | Manufaturing | Transport                   | Construction – installation process | Use, installed products | Maintenance | Repair | Replacement | Refurbishment | Operational energy use | Operational water use | Deconstruction    | Transport | Waste processing | Disposal | Recovery, reuse, recycling potential |

Sources: TU Wien (2020)

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## Case study

### Life cycle Analysis

Database search

OKOBAUDAT according to EN 15804+A1    OKOBAUDAT according to EN 15804+A2    Additional data

These OKOBAUDAT datasets (current release 2021-II as of 25.06.2021) are compliant to EN 15804+A1 and have been generated based on **GaBI background data**. All EPD datasets are compliant with the „Principles for acceptance of LCA data in OKOBAUDAT“.

Accepted EPD programme operators can constantly transfer datasets to OKOBAUDAT. A new OKOBAUDAT release is published approx. once a year with the update of the generic datasets. On-going minor additions or corrections are dated and documented in a correction list.

OKOBAUDAT datasets according to EN 15804+A1 currently serve as mandatory data source within the Assessment System for Sustainable Building (BNB).

List datasets (Total number of entries: 1140 of 1140) (Page: 1 of 57)

| Name II   | Languages | Classification II  | Location II | Valid Until II | Type II                | Owner II                          |
|---|-----------|--|-------------|----------------|------------------------|-----------------------------------|
| 3- und 5-Schicht Massivholzplatte (Durchschnitt DE)   | de        | 3.2.01 Holz / Holzwerkstoffe / 3- und 5-Schichtplatten   | DE          | 2025           | representative dataset | Thünen-Institut für Holzforschung |
| Shutters - claus markisen Projekt GmbH - Fire curtain | de        | 7.11.03 Komponenten von Fenstern und Vorhangfassaden / Zubehör für Fenster, Fassade, Türen und Tore / Feuer-Rauchschutzsysteme | RER         | 2025           | specific dataset       | claus markisen Projekt GmbH       |

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

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## 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**

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### Case study

#### Results

**AUSSENWAND** Var. bez. auf Kombination Achaabstände 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 (Lx/Zx)                              |  | 15   |

**AUSSENWAND** Var. bez. auf Kombination Achaabstände 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 (Lx/Zx)                              |  | 15   |

Sources: TU Wien (2020)
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**Interactions of design parameters**

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### Case study

#### Results

**DACH** Trügerabstände

**V1.He1b.Zellulose** Rahmenbau 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   |
| KVH / Keilpfosten  |  | 220  |
| Dämmung (Zellulose oder Steinwolle)                        |  | 220  |
| Dampfbremse  |  | 0,2  |
| OSB  |  | 15   |
| Dämmung (Steinwolle oder Zellulose) + Metall-UK entkoppelt |  | 50   |
| GKF (x2)   |  | 25   |
|  |  | 11   |

**DACH** Trügerabstände

**V1.He1b.Steinwolle** Rahmenbau 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   |
| KVH / Keilpfosten  |  | 220  |
| Dämmung (Zellulose oder Steinwolle)                        |  | 220  |
| Dampfbremse  |  | 0,2  |
| OSB  |  | 15   |
| Dämmung (Steinwolle oder Zellulose) + Metall-UK entkoppelt |  | 50   |
| GKF (x2)   |  | 25   |
|  |  | 11   |

Sources: TU Wien (2020)
05.06.2023

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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 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   |
|        | Holzlatting (Querlatting)                | 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   |
|        | Holzlatting (Querlatting)                | 40   |
|        | Dämmung (Steinwolle oder Zellulosefaser) | 40   |
|        | GFP (1x/2x)                              | 15   |

Sources: TU Wien (2020) 05.06.2023

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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   |
|        | Holzlatting (Querlatting)                | 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   |
|        | Holzlatting (Querlatting)                | 40   |
|        | Dämmung (Steinwolle oder Zellulosefaser) | 40   |
|        | GFP (1x/2x)                              | 15   |

Sources: TU Wien (2020) 05.06.2023


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### Interactions of design parameters

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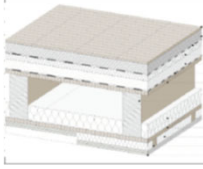



## Case study

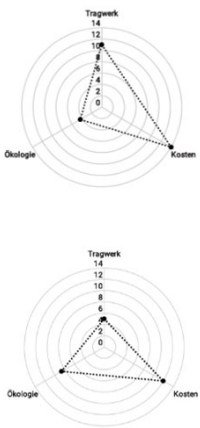
**Results**

He1 = 62,5 cm  
He2 = 125 cm

| DECKE   |  | Rahmenbau  |    | Trägerabstand |
|---|--|------------|----|---------------|
| <b>He1.Mineralwolle</b>   |  | <b>He1</b> |    | <b>0,625</b>  |
|  | Schichten (von oben nach unten)            |            |    | [mm]          |
|   | Massivparkett                              |            |    | 10            |
|   | Zementestrich                              |            |    | 50            |
|   | PE-Folie                                   |            |    | 0,2           |
|   | TSDP Mineralwolle                          |            |    | 30            |
|   | Spülschichtung (ev. massereduziert)        |            |    | 50            |
|   | PE-Folie                                   |            |    | 0,2           |
|   | OSB-Platte                                 |            |    | 18            |
|   | Holzträger                                 |            |    | 240           |
|   | Dämmung (Glaswolle oder Schafwolle)        |            |    | 80            |
|   | OSB-Platte                                 |            |    | 18            |
|   | Holzlatung (verringert, Achsabst.max 40cm) |            |    | 40            |
|   | Dämmung (Glaswolle oder Schafwolle)        |            |    | 40            |
| GKF (x2) / GKF (x3)   |  |            | 30 |               |


  

| DECKE   |  | Rahmenbau  |    | Trägerabstand |
|---|--|------------|----|---------------|
| <b>He2.Mineralwolle</b>   |  | <b>He2</b> |    | <b>1,250</b>  |
|  | Schichten (von oben nach unten)            |            |    | [mm]          |
|   | Massivparkett                              |            |    | 10            |
|   | Zementestrich                              |            |    | 50            |
|   | PE-Folie                                   |            |    | 0,2           |
|   | TSDP Mineralwolle                          |            |    | 30            |
|   | Spülschichtung (ev. massereduziert)        |            |    | 50            |
|   | PE-Folie                                   |            |    | 0,2           |
|   | OSB-Platte                                 |            |    | 44            |
|   | Holzträger                                 |            |    | 280           |
|   | Dämmung (Glaswolle oder Schafwolle)        |            |    | 80            |
|   | OSB-Platte                                 |            |    | 22            |
|   | Holzlatung (verringert, Achsabst.max 40cm) |            |    | 40            |
|   | Dämmung (Glaswolle oder Schafwolle)        |            |    | 40            |
| GKF (x2) / GKF (x3)   |  |            | 30 |               |



Sources: TU Wien (2020) 05.06.2023  
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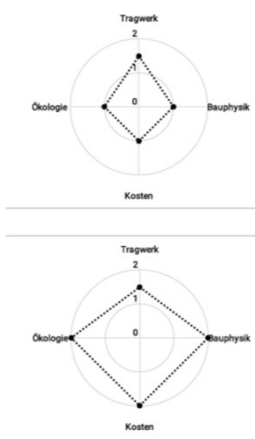
## Case study

**Results**

| TRENNWAND   |                             | BSP Lagen Aufbau variiert je OS u. Brandschutzanforderung: Slagig bessere Rest-R/sch |    | Lw2.3 |
|---|-----------------------------|--|----|-------|
| <b>TW tragend BSP</b>   |                             | Schichten (von links nach rechts)  |    |       |
|  |                             |  |    | [mm]  |
|   | Gipsfaserplatte (2x)        |  |    | 25    |
|   | Holzlatung auf Schwingbügel |  |    | 70    |
|   | Steinwolle                  |  |    | 60    |
|   | Brettsper Holz              |  |    | 90    |
|   | Steinwolle                  |  |    | 60    |
|   | Holzlatung auf Schwingbügel |  |    | 70    |
| Gipsfaserplatte (2x)  |                             |  | 25 |       |

| TRENNWAND   |                            | BSP Lagen Aufbau variiert je OS u. Brandschutzanforderung: Slagig bessere Rest-R/sch |   | Lw2.3 |
|---|----------------------------|--|---|-------|
| <b>TW tragend BSP SICHT 2-schichtig</b>   |                            | Schichten (von links nach rechts)  |   |       |
|  |                            |  |   | [mm]  |
|   | Gipsfaserplatte            |  |   | 0     |
|   | Brettsper Holz             |  |   | 15    |
|   | Steinwolle (lagegesichert) |  |   | 80    |
|   | Brettsper Holz             |  |   | 120   |
|   |                            |  | 0 |       |
|   |                            |  | 0 |       |



Sources: TU Wien (2020) 05.06.2023  
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### Case study

**Results**

**INENNWAND**  
IW tragend BSP Lw2.3

| Skizze | Schichten (von links nach rechts) | [mm] |
|--------|-----------------------------------|------|
|        | Gipsfaserplatte (2x)              | 25   |
|        | Brettspertholz dreischichtig      | 100  |
|        | Gipsfaserplatte (2x)              | 25   |

**INENNWAND**  
IW tragend BSP SICHT Lw2.3

| Skizze | Schichten (von links nach rechts) | [mm] |
|--------|-----------------------------------|------|
|        | Brettspertholz dreischichtig      | 120  |
|        |                                   |      |

Sources: TU Wien (2020)
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### Exercise „What if...?“

11,25

External Wall

7,50

Separation Wall

3,75


Interior Wall

3,75

(External) Floor



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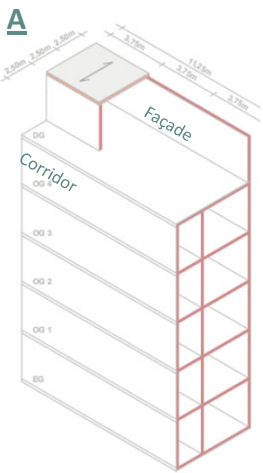
**Interactions of design parameters**  
Aida Santana Sosa

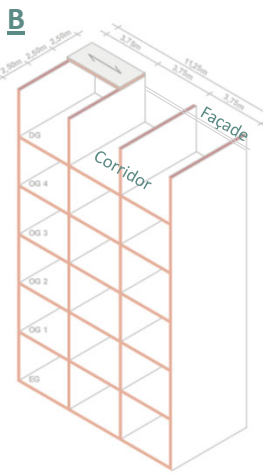
  

### Exercise „What if...?“

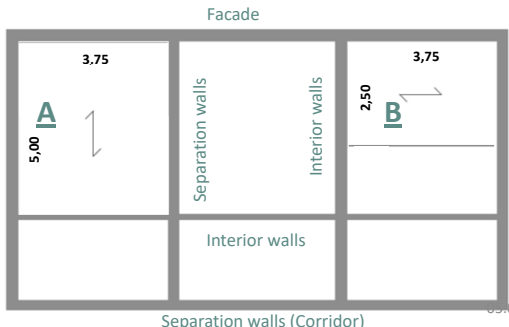
**A**



**B**




- 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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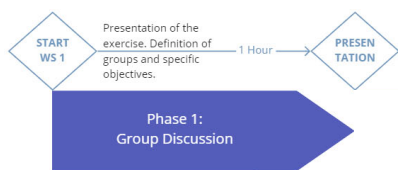
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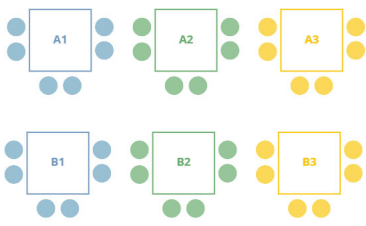
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### Exercise „What if...?“





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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, maintainability, reparability
- Bio-based materials are specially sensitive against moisture
- Flexibility, adaptability (more/bigger rooms)
- Possible optimized positions of shafts for technical services
- Maintenance 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**

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dataholz.eu

| Building materials   | Building components  | Component connections   | Case studies   |
|--|--|---|--|
| <ul style="list-style-type: none"> <li>Beams, columns</li> <li>Particle composites</li> <li>Fibre composites</li> <li>Laminates/panels</li> <li>Planned wood</li> <li>Wood flooring and parquet</li> <li>Insulation</li> <li>Lining materials</li> <li>Foils/Barriers/Membranes</li> <li>Facade solutions</li> </ul> | <ul style="list-style-type: none"> <li>External wall</li> <li>Internal wall</li> <li>Compartment wall</li> <li>Intermediate floor</li> <li>Floor towards attic</li> <li>Pitched roof</li> <li>Flat roof</li> </ul> | <p style="font-size: 0.7em; margin: 5px 0;">The component connections are currently being revised and will be available soon.</p> | <p style="font-size: 0.7em; margin: 5px 0;">Technical brochures, literature (currently only in German)</p> |

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<sub>2</sub> 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



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## Exercise „What if...?“

**Aspects to consider regarding: Ecology**

**BYGGERIETS MATERIALEPYRAMIDE**  
HUSK LÆVETIDER



**choose impact category**  
Global Warming Potential (GWP)

---

**choose unit**  
m<sup>3</sup>

---

**filter by material group**  
no filter


---

**filter and sort by "functional unit"**  
according to declared unit

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

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## 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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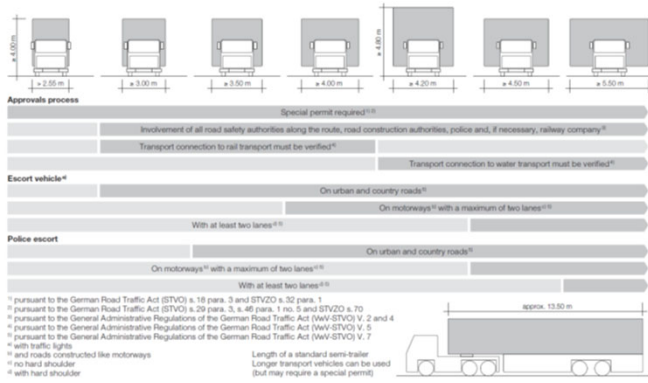
### Interactions of design parameters

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## Exercise „What if...?“

**Aspects to consider regarding: Economy**



| Approvals process  | Special permit required <sup>1)</sup> |
|--|---------------------------------------|
| Involvement of all road safety authorities along the route, road construction authorities, police and, if necessary, railway company <sup>2)</sup> |                                       |
| Transport connection to rail transport must be verified <sup>3)</sup>  |                                       |
| Transport connection to water transport must be verified <sup>4)</sup>   |                                       |
| Escort vehicle <sup>4)</sup>   |                                       |
| On urban and country roads <sup>5)</sup>   |                                       |
| On motorways <sup>6)</sup> with a maximum of two lanes <sup>7)</sup>   |                                       |
| With at least two lanes <sup>8)</sup>  |                                       |
| Police escort  |                                       |
| On motorways <sup>6)</sup> with a maximum of two lanes <sup>7)</sup>   |                                       |
| On urban and country roads <sup>5)</sup>   |                                       |
| With at least two lanes <sup>8)</sup>  |                                       |

<sup>1)</sup> pursuant to the German Road Traffic Act (StVO) § 18 para. 3 and STVZO § 32 para. 1

<sup>2)</sup> pursuant to the German Road Traffic Act (StVO) § 29 para. 3, § 46 para. 1 no. 5 and STVZO § 70

<sup>3)</sup> pursuant to the General Administrative Regulations of the German Road Traffic Act (Vw-StVO) V. 2 and 4

<sup>4)</sup> pursuant to the General Administrative Regulations of the German Road Traffic Act (Vw-StVO) V. 7


<sup>5)</sup> with traffic lights

<sup>6)</sup> and roads constructed like motorways

<sup>7)</sup> no hard shoulder

<sup>8)</sup> with hard shoulder

Length of a standard semi-trailer  
Longer transport vehicles can be used  
(but may require a special permit)



Sources: Kaufmann (2018)

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Interactions of design parameters  
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RIGA BUILDING COLLEGE  
HAMK  
FH CAMPUS WIEN  
KLAIPĖDOS VILSTYBINĖ MOKSLO

Hi Bi WOOD

### Exercise „What if...?“

Aspects to consider regarding: Economy

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

Sources: Kaufmann (2018)

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### Exercise „What if...?“

GO!  
ENJOY!

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