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FACADE DESIGN & EXECUTION

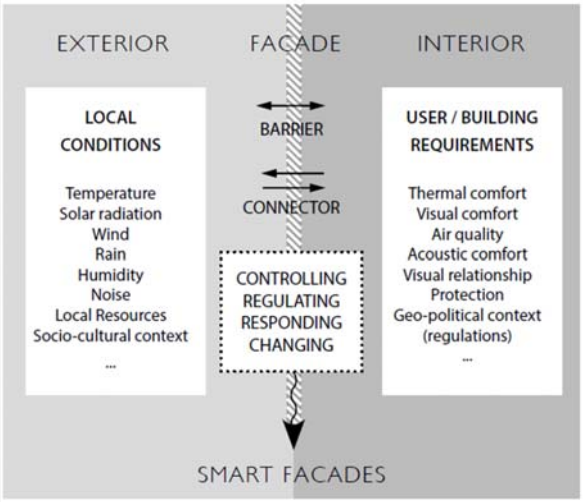
ARCHITECTS
& ENGINEERS

INFOSTEEL - PROFESSORENDAG - 2 FEB 2016

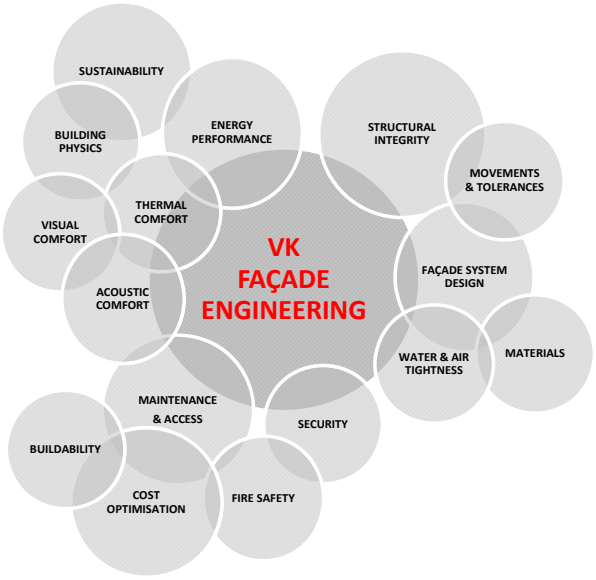
MAAIKE BERCKMOES & PIERRE LOMBA - VK FACADE ENGINEERING

- FACADE ENGINEERING
- STRUCTURAL ASPECTS
- BUILDING PHYSICS
- EXECUTION
- SPECIFIC APPLICATIONS

VK FACADE ENGINEERING

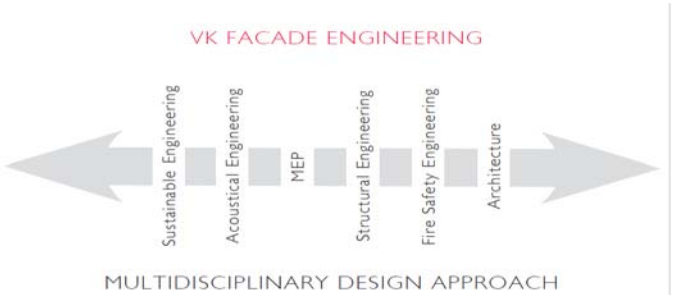


VK FACADE ENGINEERING

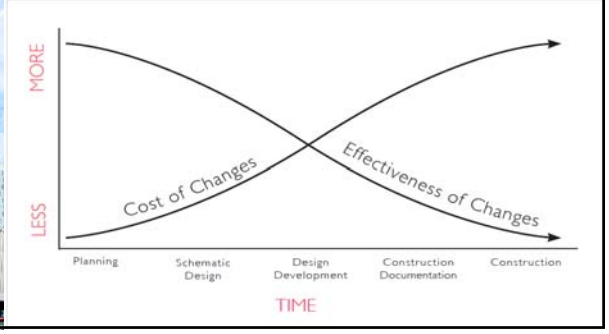


INTEGRATED BUILDING DESIGN

VK FACADE ENGINEERING



MULTIDISCIPLINARY DESIGN APPROACH



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STRUCTURAL FAÇADE REQUIREMENTS

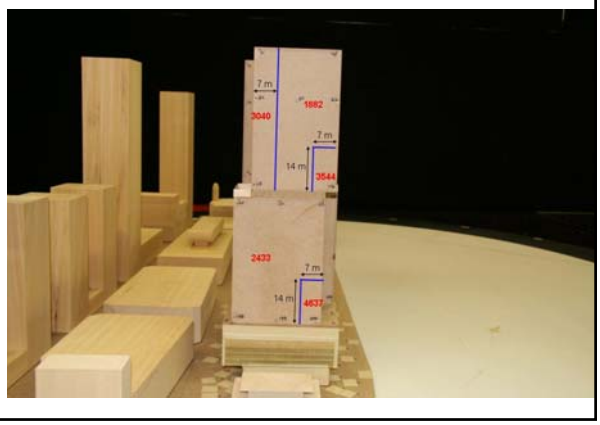
Estimation of wind load on façade element:

- Standard EN1991-1-4 for European countries
- ASCE 7-10
- Wind tunnel testing

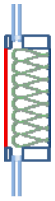
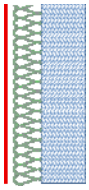
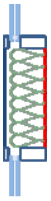
Example – De Rotterdam – H = 150m

$$\frac{Measurement}{Norm} = \frac{4637}{1{,}4 \times 1860} \sim 1{,}8$$

De Rotterdam – Rotterdam – the Netherlands – Architect OMA

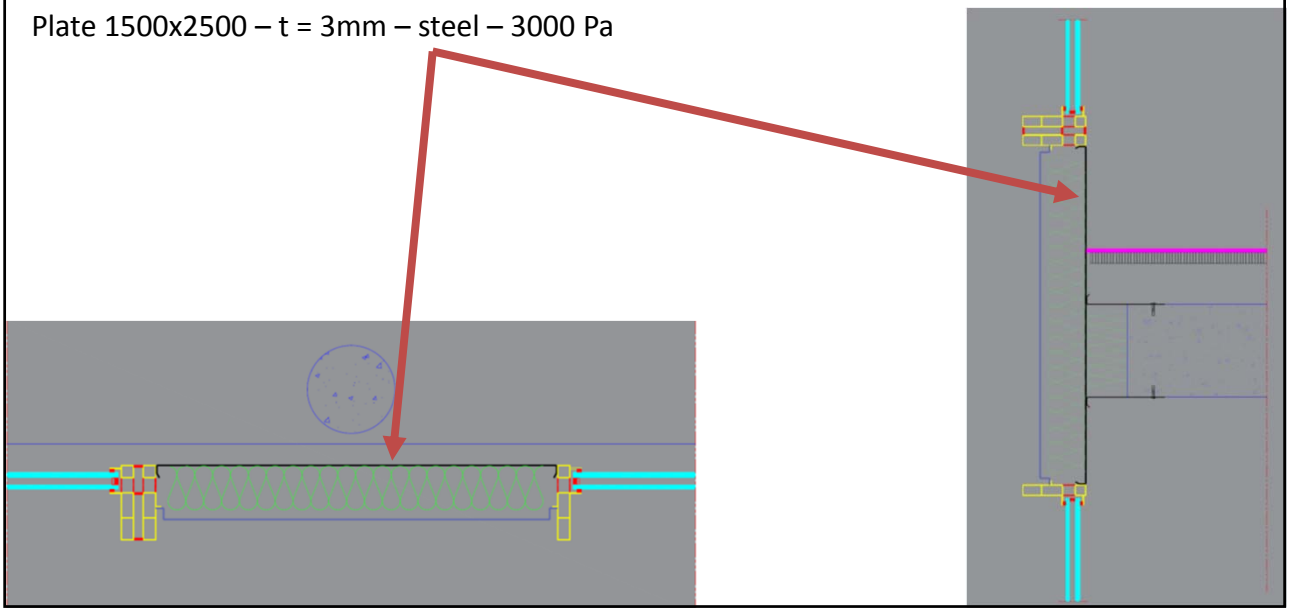


APPLICATION OF STEEL IN FAÇADE ELEMENTS

Applications of steel in façade elements			
	Spandrel panel Front sheet	Rain screen application	Spandrel panel Back sheet
Function	Esthetic finishing facade element First rain barrier		Fire barrier (1m) Vapour/Air/Acoustic barrier
Requirements	Alloy : AISI 304/316 Thickness: 1,0-3,0mm/layered composite Typical dimensions: 1800mm x1200mm Wind loading: External pressure with possible reduction		Alloy : DX51D+Z Thickness: 1,5-3,0mm Typical dimensions: 1800mm x1200mm Wind loading: external plate not airtight ! full Cpe+Cpi to be applied to the plate
Attention points	Corrosion; Flatness Thermal movements Calculation: Non-linear effects, eigen frequency Glued reinforcements		Calculation: basic plate theory can't be applied d > t calculation shall be carried out by FEM software must take non-linear geometry into account
		Connections: bolts in bending	

STRUCTURAL FAÇADE REQUIREMENTS

Plate 1500x2500 – t = 3mm – steel – 3000 Pa

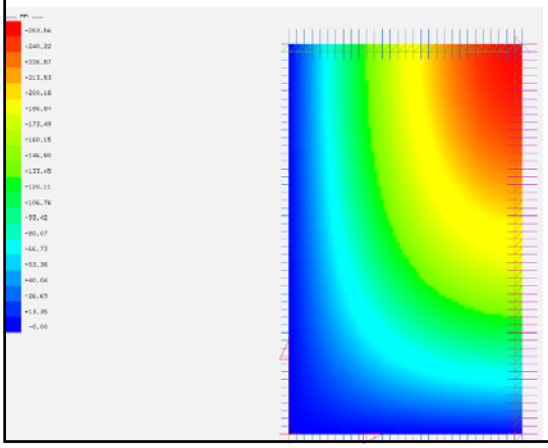


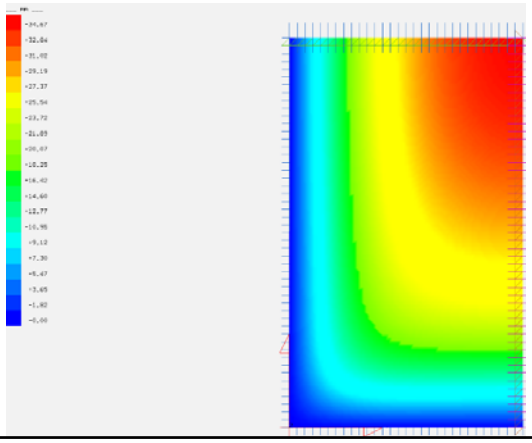
STRUCTURAL FAÇADE REQUIREMENTS

Plate 1500x2500 – t = 3mm – steel – 3000 Pa

$D_{center.linear}$ = 254mm

$D_{center.nonlinear}$ = 35mm





STRUCTURAL FAÇADE REQUIREMENTS

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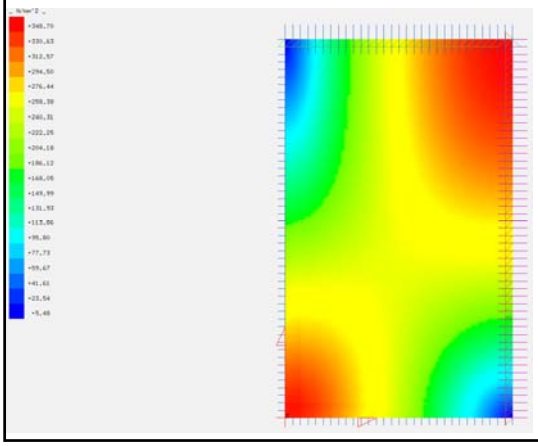
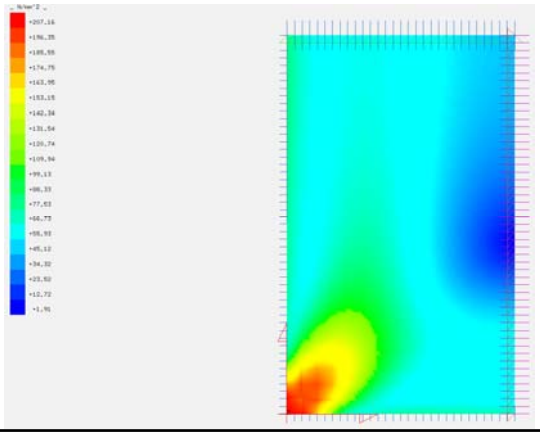
Plate 1500x2500 – t = 3mm – steel – 3000 Pa

$\sigma_{vonMises.linear}$ = 349 MPa

$\sigma_{vonMises.nonlinear}$ = 207 MPa





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ENERGY REGULATIONS

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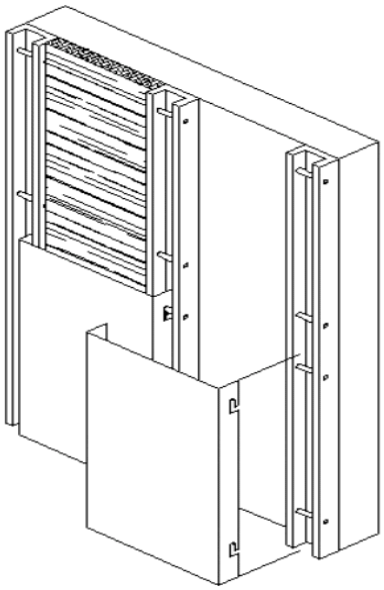
		2016	2017	2018	2020	2021 - NZEB	2051 - ZEB
FLANDERS	All buildings	K40 + max U-values → Up ≤ 0.24W/m²K					Energy - & CO_2 neutral
	Residential	E50	E50	E40	E35	E30	
		+ requirements on overheating, net demand, renewable energy					
	Non-residential: Function dependent: Offices/School	E55	E55	E50	E45	E40	
		+ requirements on renewable energy					
	Industry	-	~~Spec! (function dependent)~~ No E_{level}				
BRUSSELS	All buildings (Incl. Industry)	max U-values → Up ≤ 0.24W/m²K					
	Residential	Brussel Passief (Requirements on net heating, primary energy & overheating)				NZEB	
				+ air tightness			
	Offices/School	Brussel Passief (Requirements on net heating, primary energy)				NZEB	
			+ overheating	+ air tightness			
WALL.	Residential + Offices + School	K35 (K55 for Industry) + max U-values → Up ≤ 0.24W/m²K					
		E80 (No E_{level} for Industry)					

Requirements for U value of opaque wall: Up < 0.24W/m²K:

- Rockwool: λ = 0.035W/mK t ~ 140mm
- PIR/PUR: λ = 0.025W/mK t ~ 100mm

ENERGY REGULATIONS



U value of opaque wall ≤ 0.24WMm²K

1D value of opaque wall (centre value)

+

Thermal bridging connections

Heat loss through Linear & Point connections

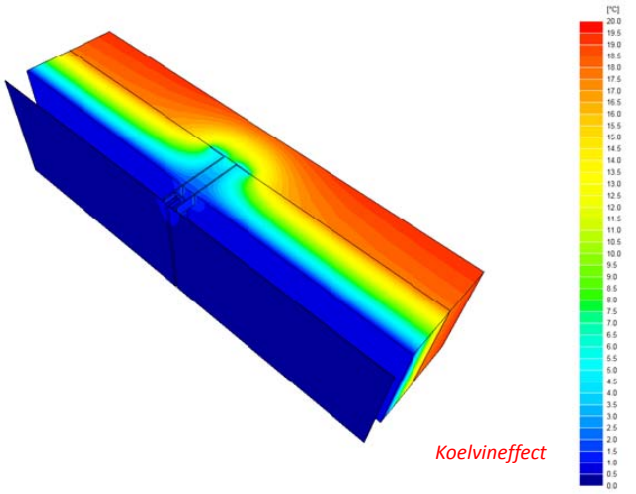
ψ- & χ-values

Simplified method:
according to EPB
transmissiereferentiedocument

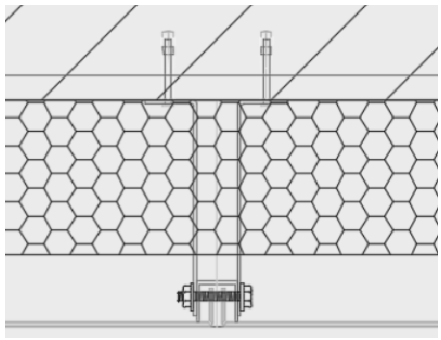
Detailed Simulations:
according to EN ISO 10211

HEAT LOSS - EXAMPLE

Uwall = U1D + χ (3D analyse, TRISCO (Physibel) conform EN ISO 10211)



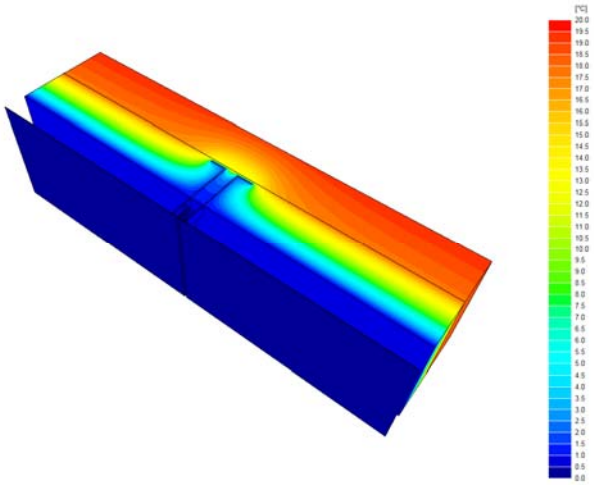
Koelvineffect

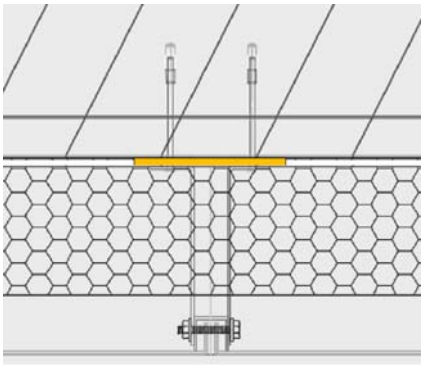


U $_{\text{wall no thermal bridge}}$ = 0.20W/m²K → **U $_{\text{wall with thermal bridge}}$ = 0.26W/m²K** (χ = 0.064W/K)

HEAT LOSS - EXAMPLE

Uwall = U1D + χ (3D analyse, TRISCO (Physibel) conform EN ISO 10211)





$U_{\text{wall no thermal bridge}} = 0.20 W/m^2K$ → **$U_{\text{wall with thermal bridge}} = 0.23 W/m^2K$** (χ = 0.031W/K)

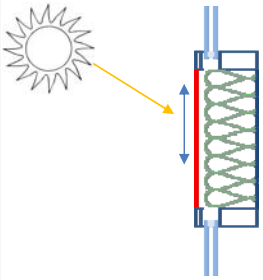
CONDENSATION RISK + TEMP DISTRIBUTION

Condensation risk: (Surface & interstitial condensation)

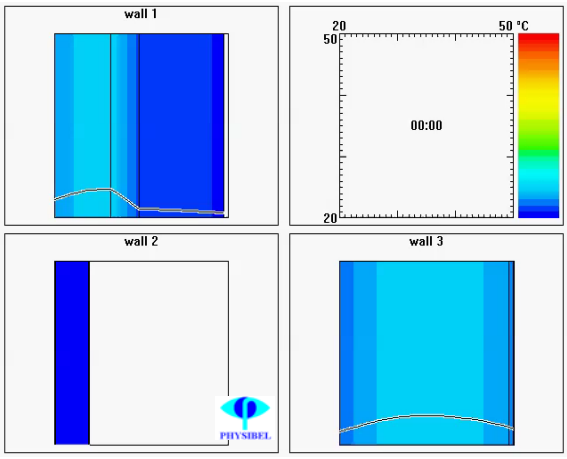
- **Possible risks:** Corrosion, Mould growth, Dust marking, Degradation of materials (insulation)
- **Solutions:** Correct positioning of vapour barrier, Modifying connections, Adding weep holes

Dynamic behaviour under Te + Solar Radiation:

- Movements due to temperatures: Thermal expansion
- Material requirements ifo facade system:
  panels: bond of components;
  displacement of closers; damage seals/gaskets



External surface temperatures:	
Heavyweight, light colour	-20°C to +50°C
Heavyweight, dark colour	-20°C to +65°C
Lightweight (insulated), light colour	-25°C to +60°C
Lightweight (insulated), dark colour	-25°C to +80°C



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ARCHITECTURAL REQUIREMENTS

1. **Freedom in design** (dimensions, coatings, colors, …)
2. **Perfect flatness** (high rise / differences in reflection directly visible)



3. **Avoid corrosion** (edge cuts, contact corrosion, delamination coating, staining, degradation…)



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SPECIFIC APPLICATIONS

- Improving acoustic performance of facades
- Integrated in double skin facades (primary structure or other steel elements)
- Solar shading elements
- Heated facade
- Research on integration of Solar absorber in double skin facade / renewable systems
- …


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