International Association for Bridge and Structural Engineering

Monitoring carbon based structural design for building Paris Proof

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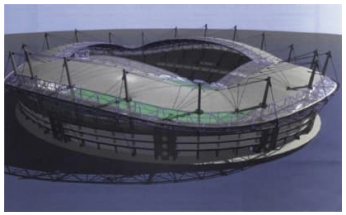

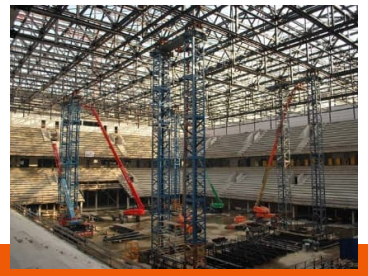

since 1953

250 employees, 6 headquarters, 3 countries
part Oosterhoff group

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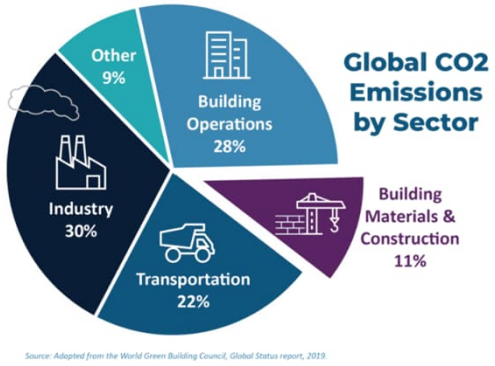
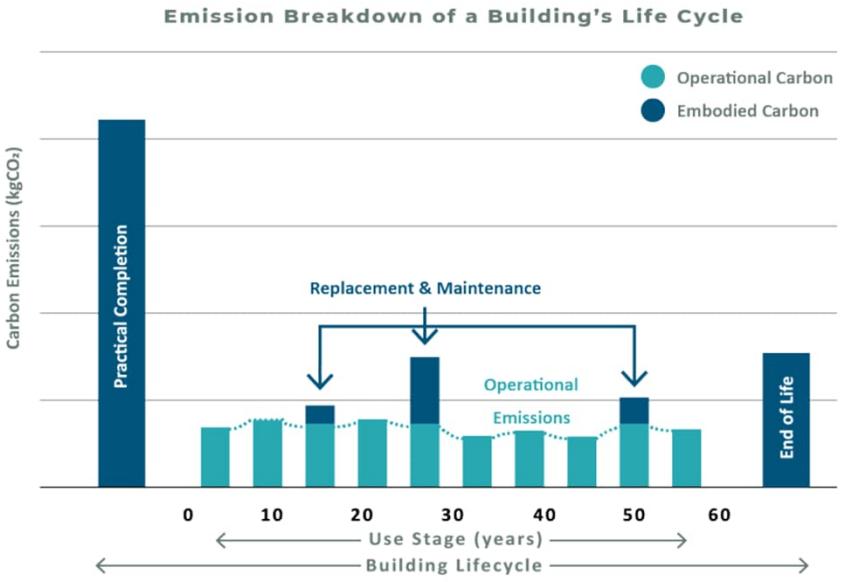
PARIS PROOF



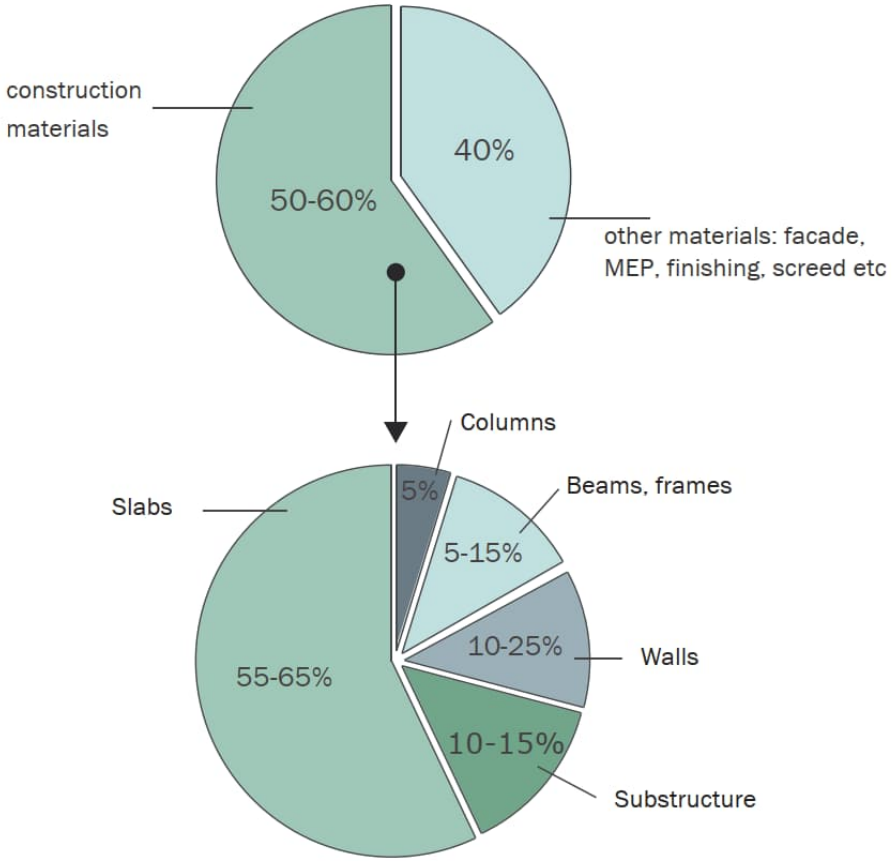


A decade of change!

From energy neutral to carbon neutral!

After reducing operational emissions, the focus now shifts to tackling embodied emissions – a shift to material use and its environmental impact.

Achieving Paris Proof standards requires a Whole Life Carbon approach.



- 50–60% of all building materials in a construction project are structural
- the structural engineer plays a key role in influencing material use
- and thereby the structural engineer significantly impacts the embodied carbon associated with a building's structure!

Impact driven structural design

- futureproof design -
  extend lifespan by quality design
- circular design approach -
  maximize value retention
- use sustainable material -
  minimize environmental impact

creating optimum balance in structural design “green triangle”

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The road for building Paris Proof!

- Monitoring emissions of structural design is the key!

- Measuring emissions → brings awareness
  Awareness → leads to responsibility
  Responsibility → drives behavioral change
  Behavioral change → leads to action!

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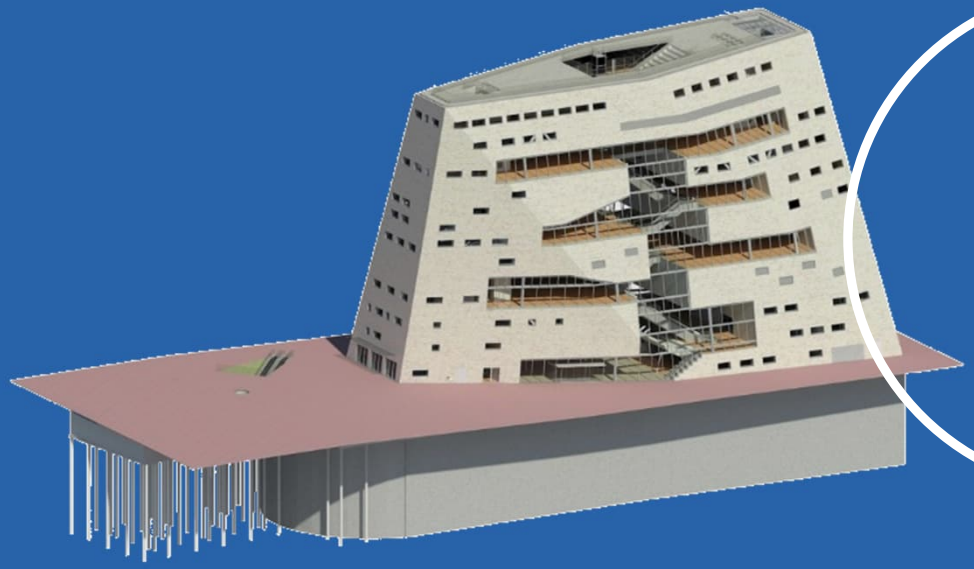
3D virtual BIM model



ABT MIM

Plugin

Environmental-database

ABT Environmental-Impact Monitor

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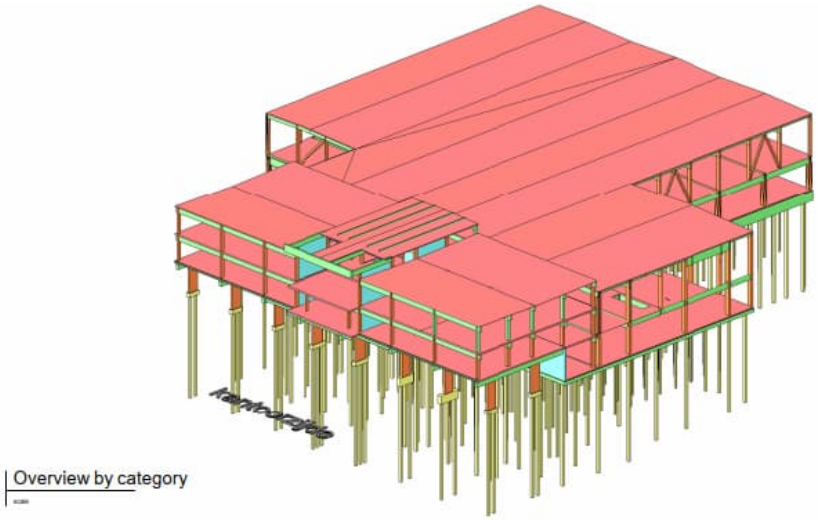
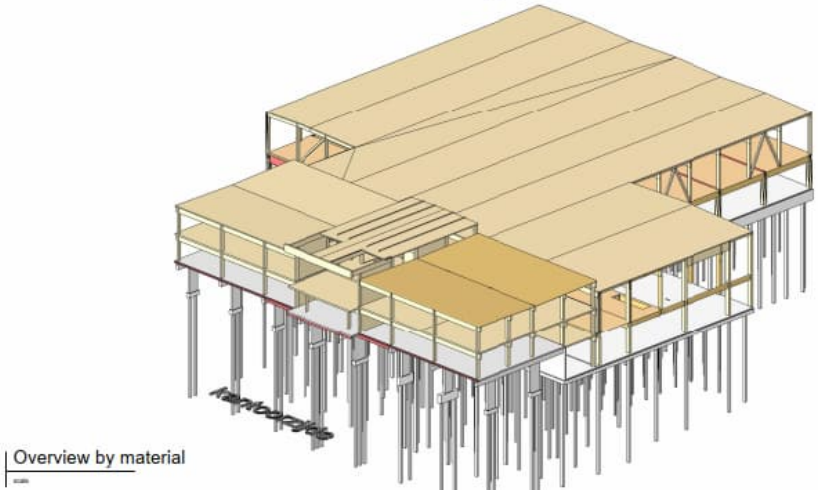
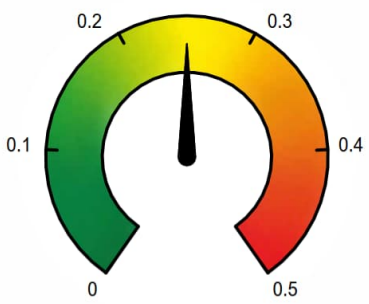


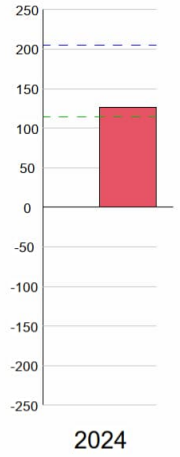


Material specification

Type	Embodied Carbon (A1-A5)
Cast-in-place concrete	<150 kg CO_2-eq/m^3
Precast concrete (25% CEMIII, 75% CEMI, standard)	325 kg CO_2-eq/m^3

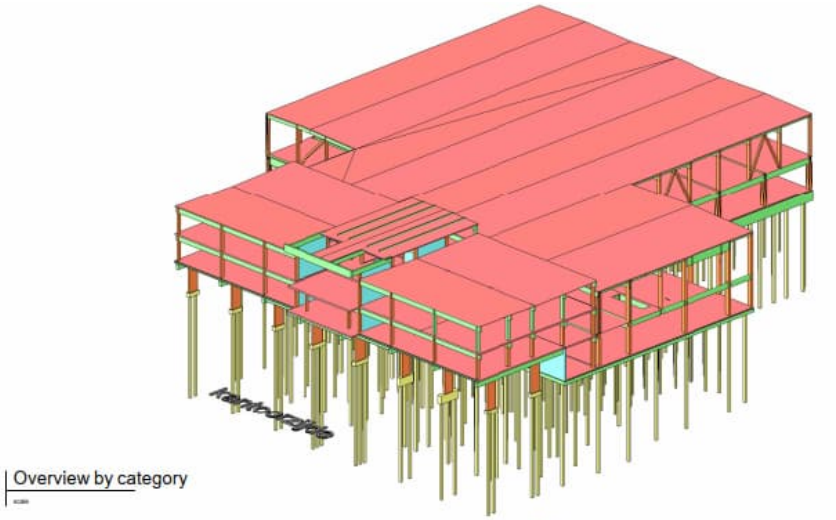


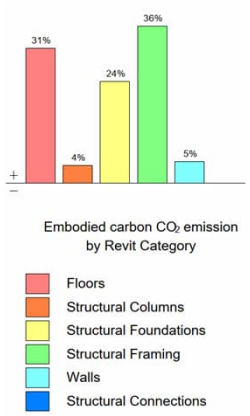
Shadow prices structures
per m² BVO/year

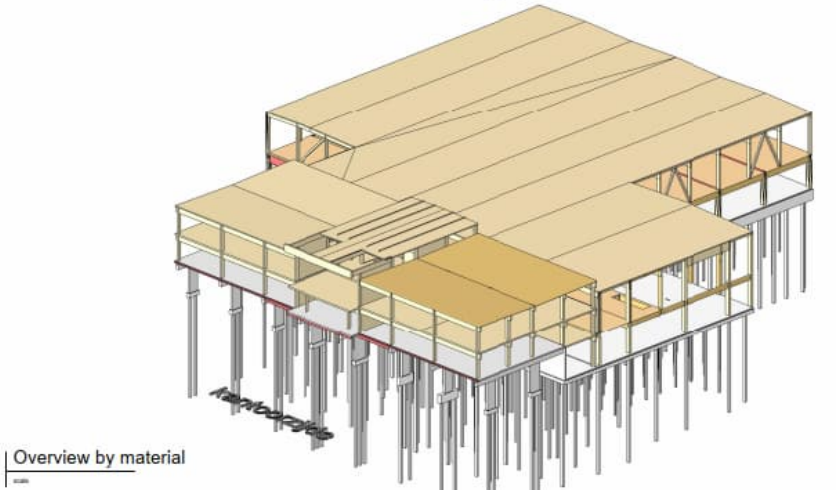


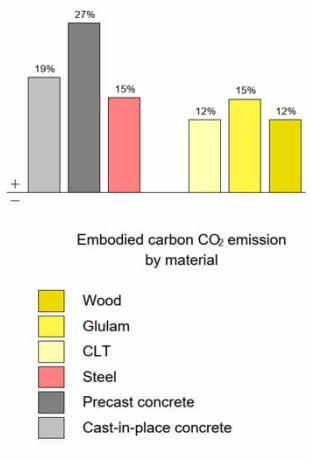
Embodied carbon design
related to limit values

- Paris Proof limit value total building
- Paris Proof limit value structures
- Embodied Carbon (A1-A5)

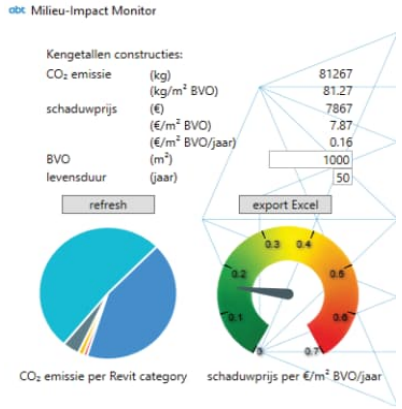


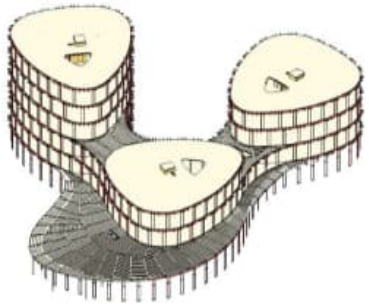






- monitoring MIM-tool by :
  - components substructure and superstructure
  - construction materials





165 kg CO_2/m^2

77 kg CO_2/m^2

281kg CO_2/m^2

Monitoring for giving insights in carbon emissions of structural design

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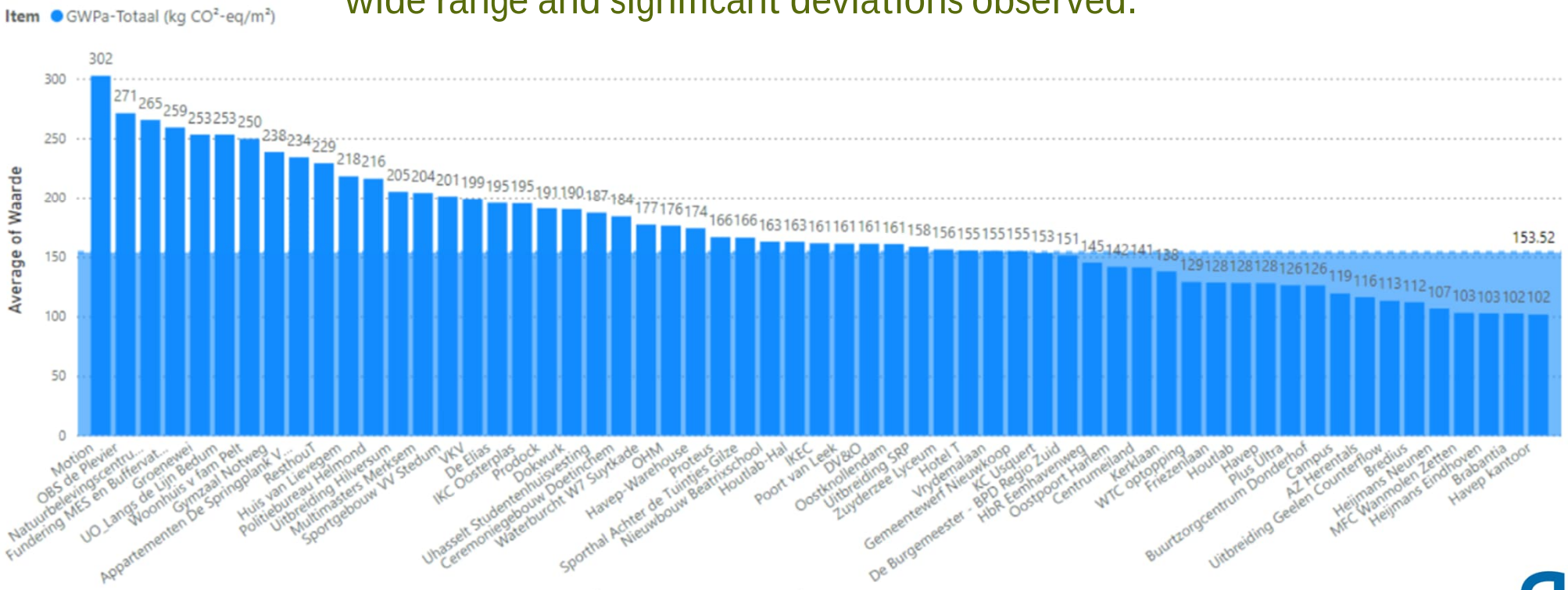
Overview projects in ecosystem Oosterhoff monitoring embodied carbon: wide range and significant deviations observed.

Oosterhoff
consultants & engineers



Materiaal GWPa per project (in kg CO_2-eq./m² BVO)

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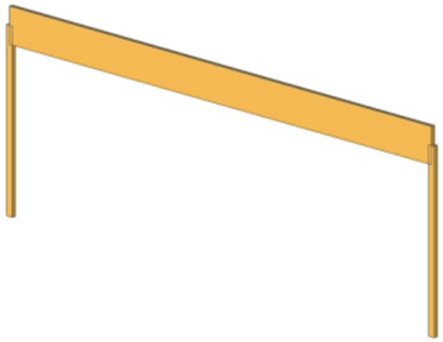
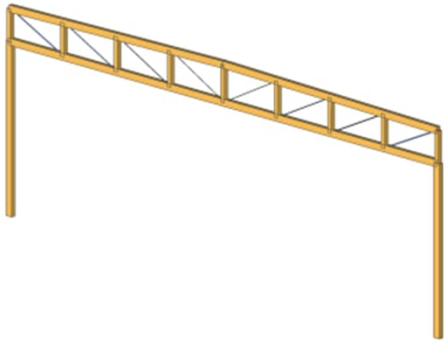
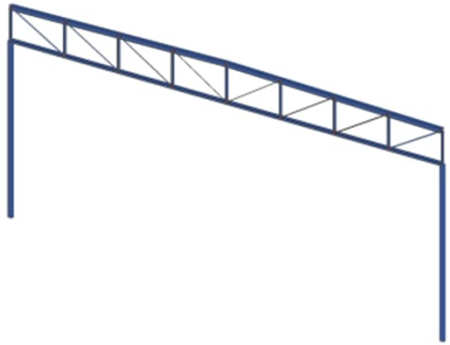
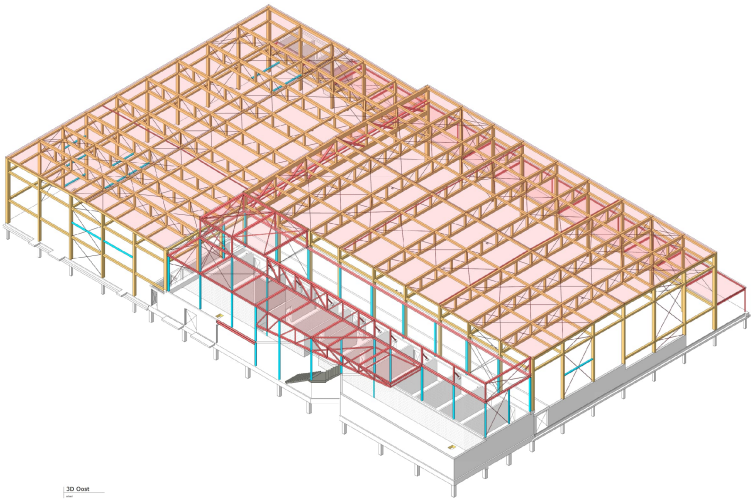
WRZV-sports halls Zwolle

AGS Architecten

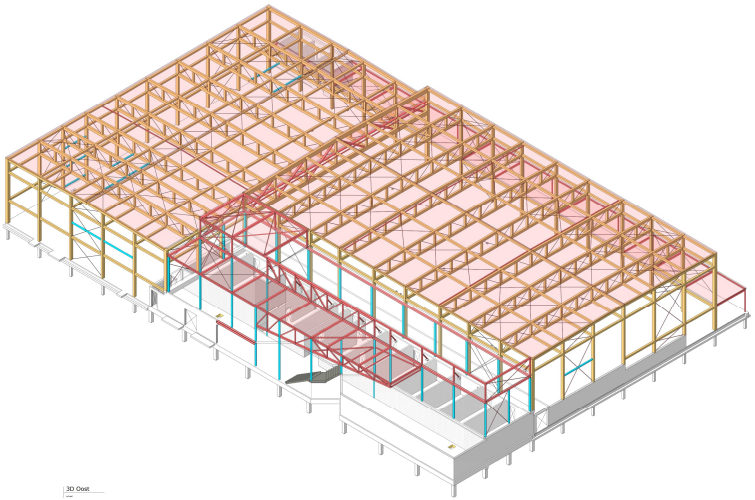
Comparison environmental impact of construction variants of roof beams W.R.Z.V. sports halls in Zwolle.

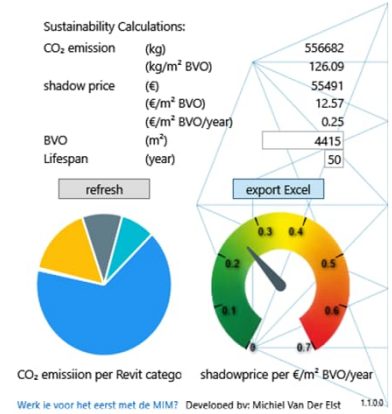
Starting points:
span 30m
hth 5,3m
total 15 beams in 2 halls

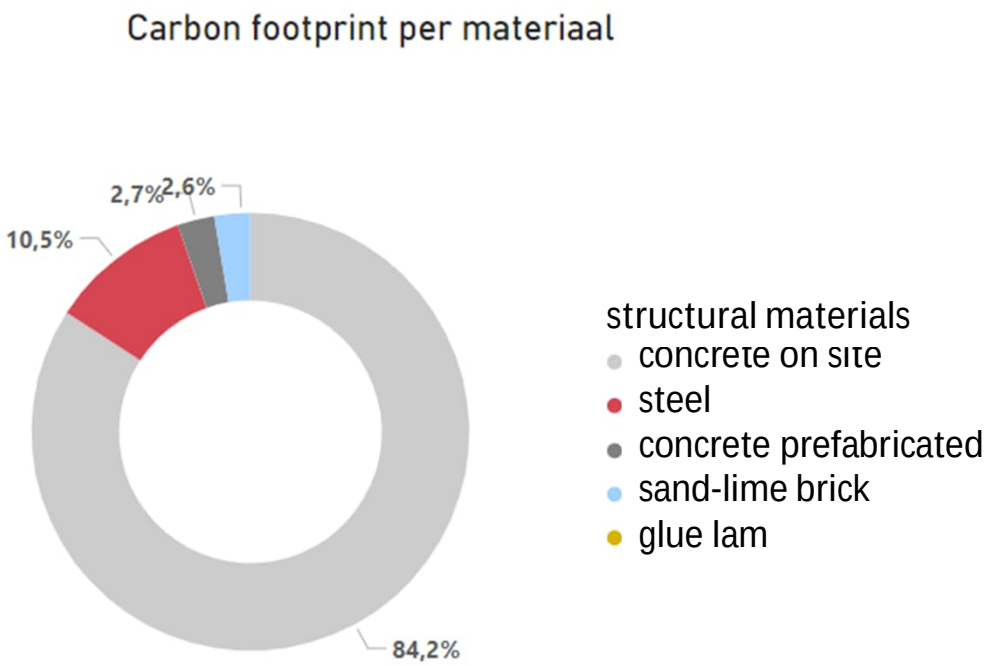
	solid timber wall beam	timber truss beam	steel truss beam
			
results for 2 halls	101.625 kg; -20.880 kgCO₂eq; 3210	52.230 kg; - 8.520 kgCO₂eq; 1665	76.425 kg; 32.220 kgCO₂eq; 2700



Bill of materials





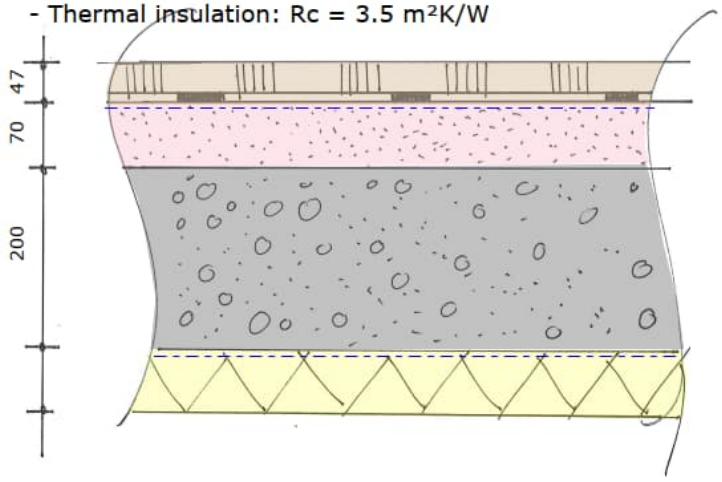


By monitoring the construction elements, it is clear which components contribute most to the environmental impact.

Ground floor sports hall

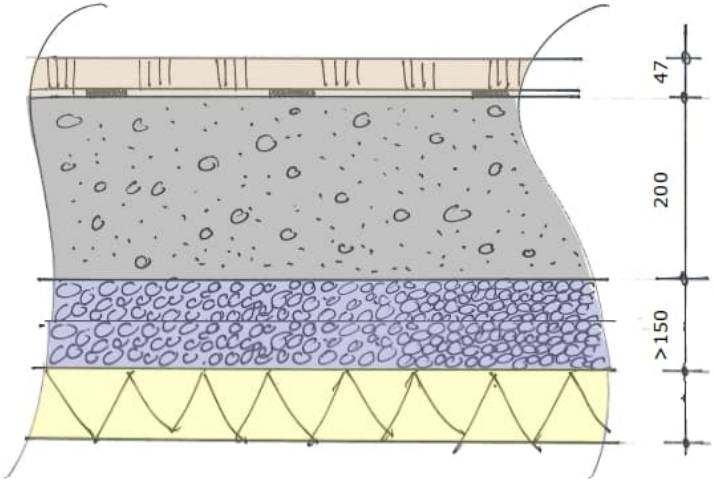
FINAL DESIGN -variant

- Sports floor: Pulastic Elite Performance 90 Eco
- PE foil
- Sand-cement screed
- In-situ concrete floor, with the following specifications:
  - o Concrete mix based on CEM III
  - o Strength class: C30/37, exposure class XC1
  - o 40% recycled concrete aggregate
  - o Finished under screed level
  - o CSC-certified
- PE foil
- Thermal insulation: Rc = 3.5 m²K/W

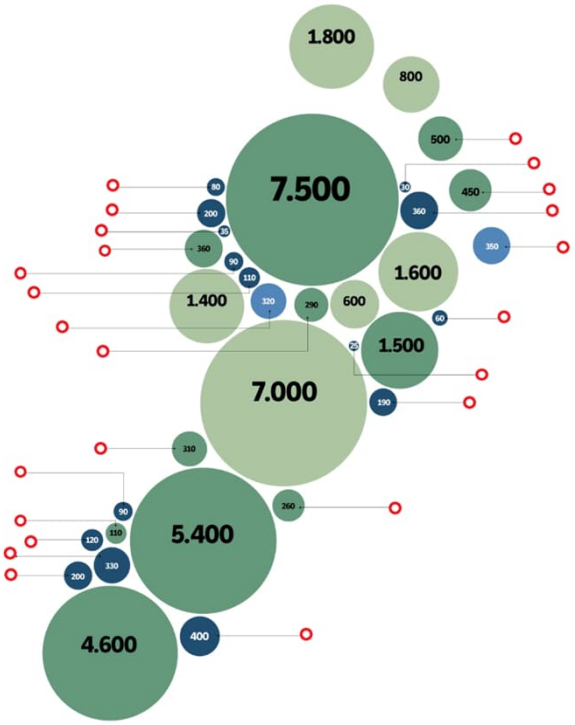


DETAILED DESIGN -variant

- Sports floor: Pulastic Elite Performance 90 Eco
- In-situ concrete floor, with the following specifications:
  - o AAM concrete mix
  - o Strength class: C20/25, exposure class XC1
  - o 100% circular aggregates (sand + gravel)
  - o Power-trowelled finish
  - o CSC-certified
- Blinding layer with mixed granulate – 100% circular
- Thermal insulation: Rc = 3.5 m²K/W



refuse redundant screed, go for low carbon concrete and a circular approach



Environmental data is valuable for…

- a full insight into the environmental performance of our buildings
- knowing the decisive buttons for impact-driven design decisions at an early stage of the design process
- quickly reflect on target values for structural design makes ambitions come true

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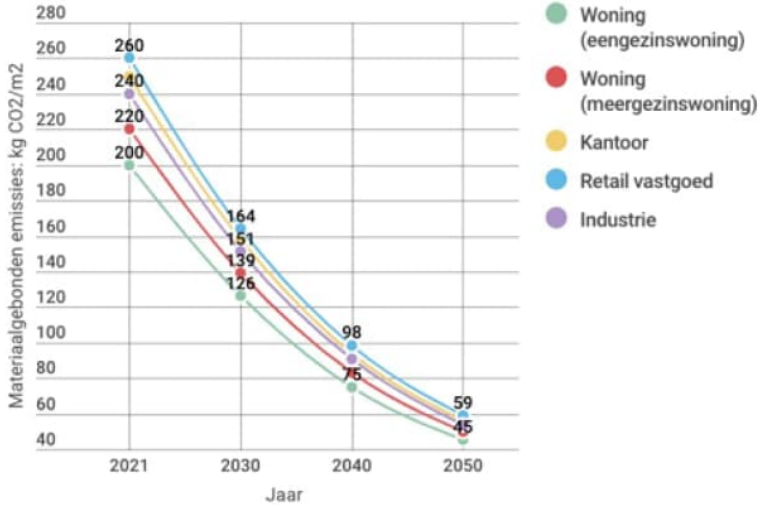
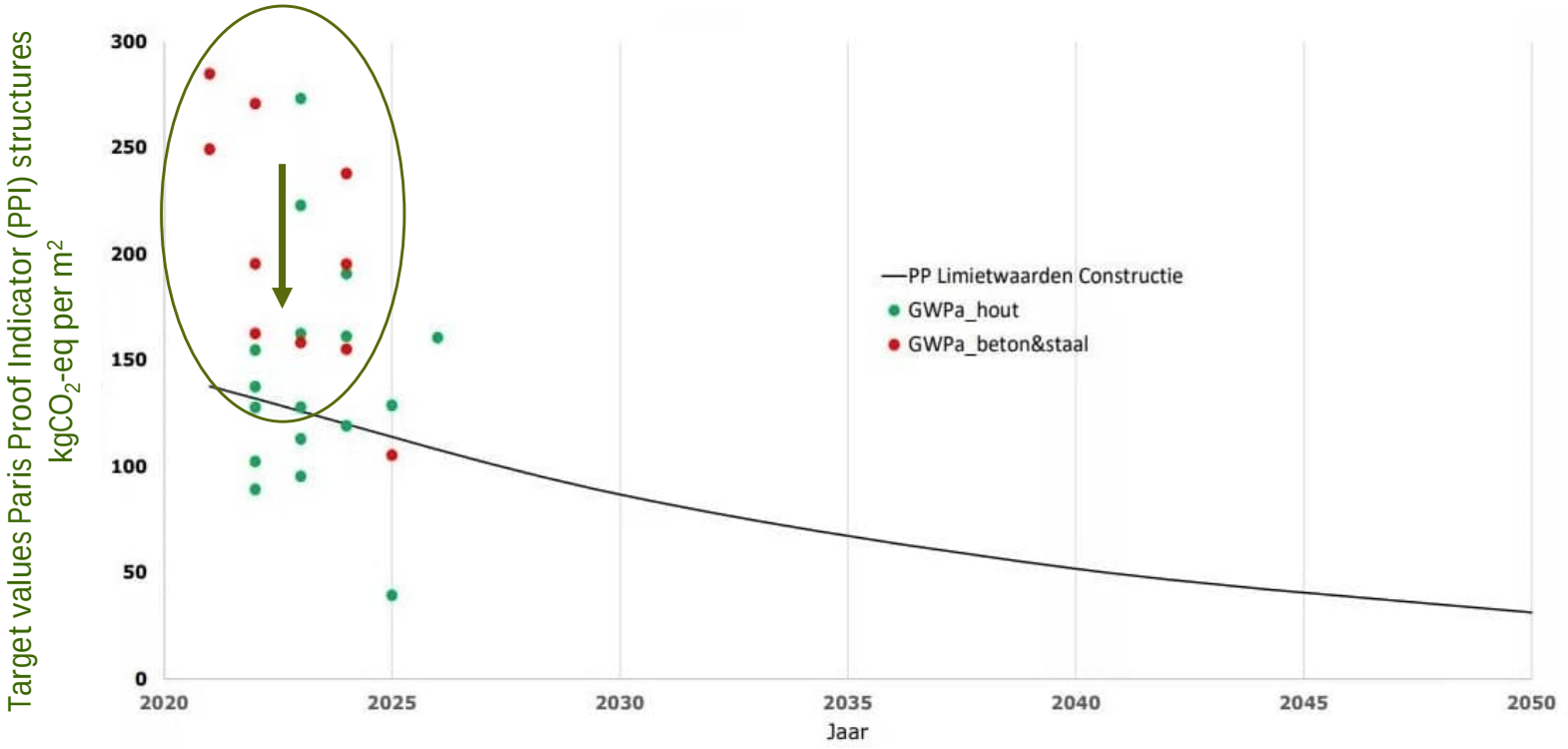
Limit values for new construction



Paris Proof limit values	embodied carbon kg CO_2-eq. per m^2			
	2021	2030	2040	2050
Residence (single-family home)	200	126	75	45
Residence (multi-family home)	220	139	83	50
Office	250	158	94	56
Retail real estate	260	164	98	59
Industry[5]	240	151	91	54

Benchmarking the target values for Paris-proof construction!

CO_2 emissions production and construction phase (GWPA) completed projects Oosterhoff



Cutting carbon emissions in structural design is urgent!

Overview of the CO2 emissions in the production and construction phase (GWPa) of Oosterhoff projects (green dots: wooden constructions; red dots: concrete and steel constructions) and the increasingly strict limit value for Paris Proof Constructions.)

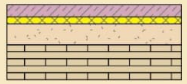
- integral approach ensures a full representation
- use of sustainable materials pays off

Comparison of Paris Proof Indicator (PPI) for residential floor constructions

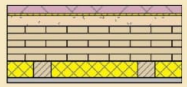
abt van de laar adviseur in bouwconstructies

Timber construction

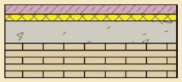
CLT wet screed — CO_2 41|-3* — 34% | 66%
390 | 385 | € 235
- Screed anhydrite 70 mm
- Insulation 20 mm
- Sand/gravel 100 mm
- Foil
- CLT 200 mm



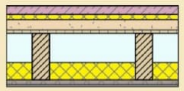
CLT dry screed — CO_2 54|10* — 50% | 50%
410 | 250 | € 305
- Fermacell 25 mm
- Insulation 20 mm
- Sand/gravel 60 mm
- Foil
- CLT 200 mm
- Insulation 75 mm
- Gypsum fiberboard 30 mm



CLT foam concrete — CO_2 59|15* — 54% | 46%
390 | 385 | € 240
- Screed anhydrite 70 mm
- Insulation 20 mm
- Foam concete 100 mm
- Foil
- CLT 200 mm

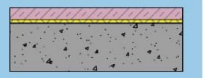


Timber beam — CO_2 52|40* — 54% | 46%
480 | 305 | € 230
- Screed anhydrite 70 mm
- Foil
- Insulation 30 mm
- Sand/gravel 40 mm
- Foil
- Underlayment 18 mm
- Wooden beams + insulation 270 mm
- Cladding + framework 27 mm
- Gypsum fiberboard 2x12,5 mm

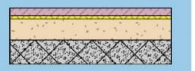


Sustainable concrete

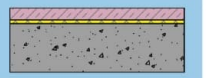
Sustainable on site cast concrete — CO_2 58 — 22% | 78%
340 | 745 | € 200
- Anhydrite screed 70 mm
- Insulation 20 mm
- On situ concrete 250 mm C30/37, XC1, CEM III B (ecocem)
- Reinforcement 60 kg/m³



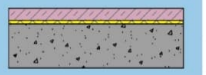
Hollow core slab — CO_2 58 — 26% | 74%
390 | 605 | € 155
- Anhydrite screed 70 mm
- Insulation 20 mm
- Sand/ gravel 100 mm
- Hollow core slab 200 mm



Eco friendly concrete — CO_2 43 — 30% | 70%
now possible, but deviates from the norm
340 | 745 | € 205
- Anhydrite screed 70 mm
- Insulation 20 mm
- Sustainable concrete 250 mm (AACM/ Urban Mine/ geopolymer)
- Basalt/fiberglass reinforcement 20 kg/m³

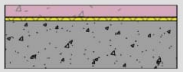


CO_2-neutral concrete — CO_2 23 — 57% | 43%
possible in the future
340 | 745 | € 215
- Anhydrite screed 70 mm
- Insulation 20 mm
- Concrete CC(S)U technology 250 mm, C30/37, XC1
- Basalt/fiberglass reinforcement 20 kg/m³

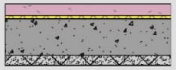


Traditional

On site cast concrete — CO_2 95 — 34% | 66%
340 | 745 | € 180
- Cement screed 70 mm
- Insulation 20 mm
- On site cast concrete 250 mm C30/37, XC1, NL average. mixture
- Reinforcement 70 kg/m³



Wide slab flooring — CO_2 101 — 32% | 68%
340 | 745 | € 190
- Cement screed 70 mm
- Insulation 20 mm
- On site concrete 190 mm C20/25, XC1, NL gem. mengsel
- Wide slab 60 mm C30/37, XC1, prefab snel
- Reinforcement 70 kg/m³



Precast floor slab — CO_2 107 — 30% | 70%
350 | 650 | € 150
- Cement screed 70 mm
- Insulation 20 mm
- Precast floor slab 260 mm

PPI budget 2030: 50-55 kg CO_2-eq/m²

CO_2 PPI [kg CO_2-eq/m²] (LCA fase A1-A5)
* 30% biogenic CO_2 storage included [kg CO_2-eq/m²]
% | % share PPI: architectural | structure
thickness floor package [mm]
weight [kg/m²]
€ direct construction costs [€/m²]
60 minutes fire resistance

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Key Strategies for Designing Paris Proof Structures

1. **Rethink structural design -** Design with simplicity and efficiency and integral - avoid large column grids, excessive transfer structures, deep basements with underwater concrete.

2. **Futureproof and adaptable design -** Design for change by incorporating adaptability into the design. Apply the layers principle of Stewart Brand to decouple building layers.

3. **Repurpose existing structures and circular material use and building components -** Renovate and reuse existing buildings wherever feasible.Integrate recycled materials and reuse of building components into new construction (e.g., recycled reinforcement steel). Design for disassembly and reuse.

4. **Use of low-carbon and innovative materials –** low-carbon steel e.g. XCarb®, low-carbon/carbon neutral concrete.

5. **Incorporation of biobased materials -** sustainably sourced timber, biocomposites

6. **Advanced structural engineering –** Use advanced calculations and optimization tools to minimize material usage and enable the reuse of existing structures and building components in a sustainable and efficient way.

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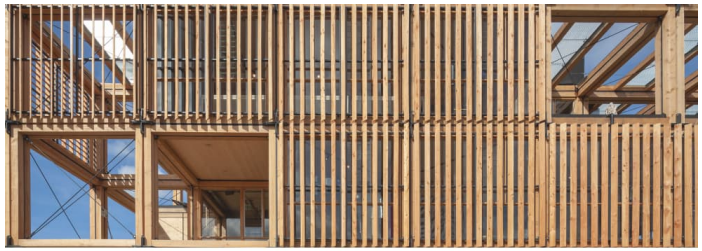

MILIEU-IMPACT GESTUURD ONTWERPEN

BOUWEN AAN EEN DUURZAME TOEKOMST

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PARIS PROOF

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THANKS!

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