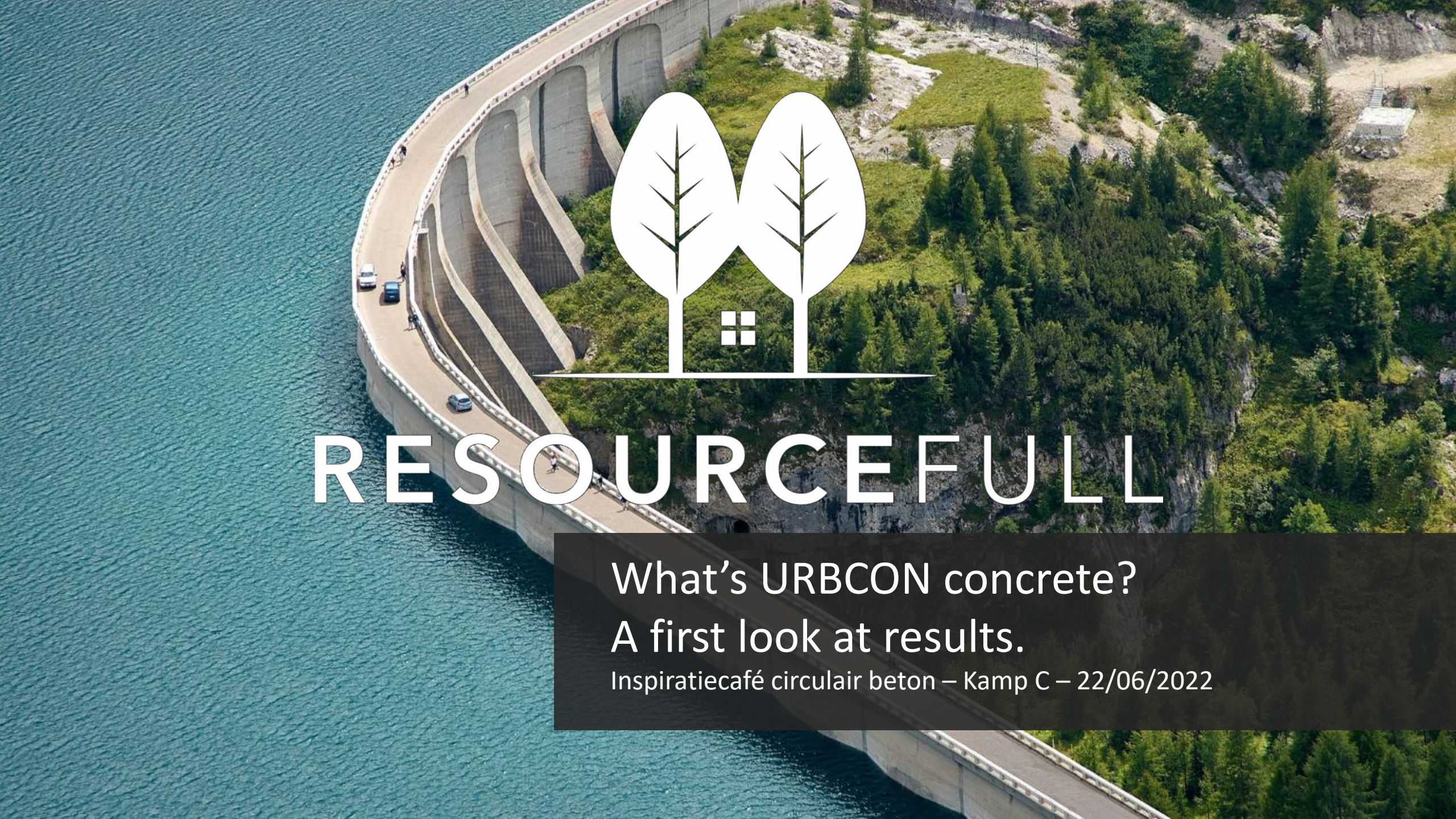


RESOURCEFULL

What's URBCON concrete?
A first look at results.

Inspiratiecafé circulair beton – Kamp C – 22/06/2022

Your engineering partner for low carbon concrete

- A young and vibrant company strongly motivated to reduce the ecological footprint of the construction industry
- Turning inorganic waste streams into low carbon concrete solutions
- Integrated in the network of large metallurgical companies as well as large construction groups
- 11 team members passionate about concrete innovation

Your engineering partner for low carbon concrete

Pre-treatment and analysis

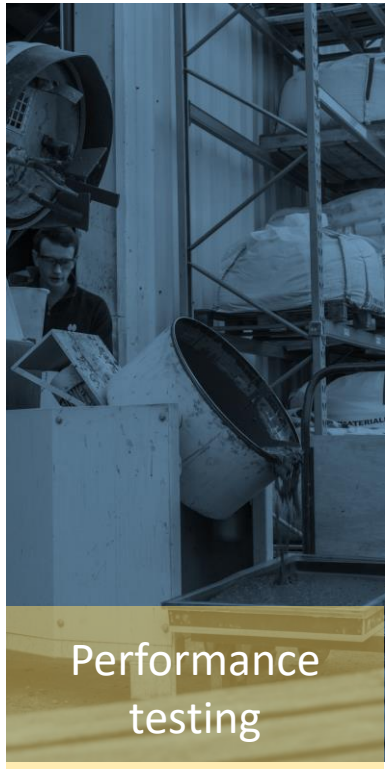
Chemical analysis
Mineral analysis
Crushing/grinding
Sizing and seperation
Thermal processing

Binder development

Alkali activation
Cement replacement
Acid activation
Carbonatation
Mg-cement

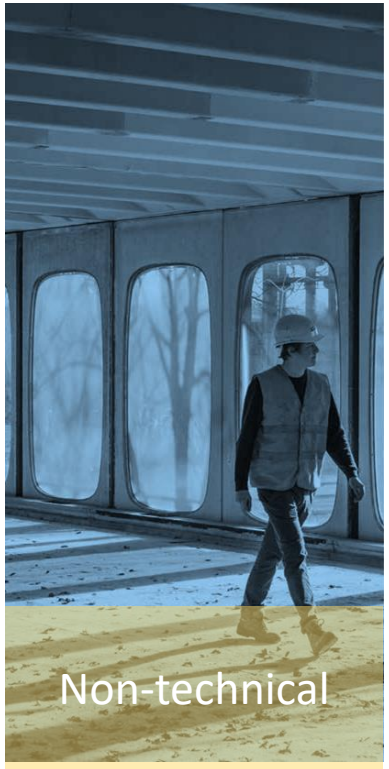
Product development

3D-printing mortar
Acid resistant mortar
Floor screed
Ready-mix concrete
UHPC



Performance testing

Aggregate testing
Workability
Strength testing
Freeze-Thaw
Carbonatation



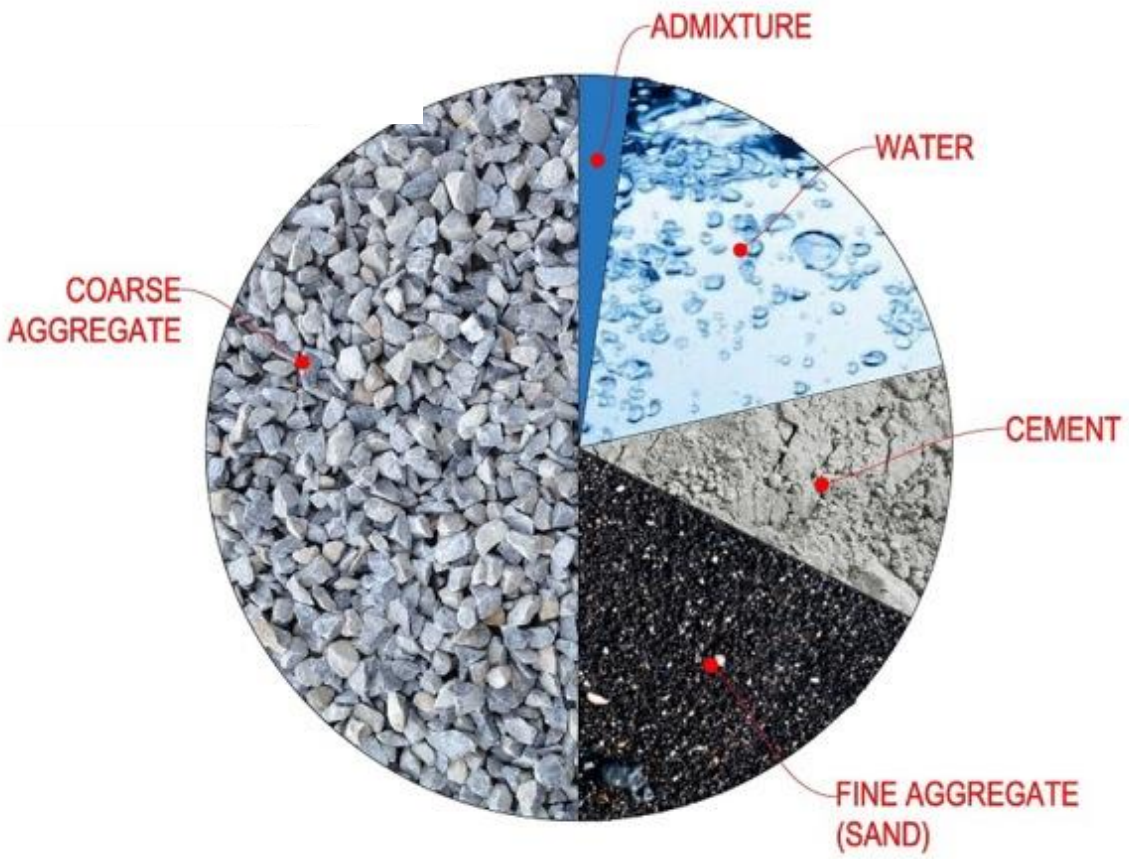
Non-technical

Industrial implementation
LCA
Waste legislation
Building legislation

RESOURCEFULL


RESOURCEFULL

What is concrete?



- Cement reacts with water and becomes a strong durable material
- Can be made with cheap and local raw materials
- Compatible with steel reinforcement
- From liquid to hard at room temperature

Most used man made material in the world

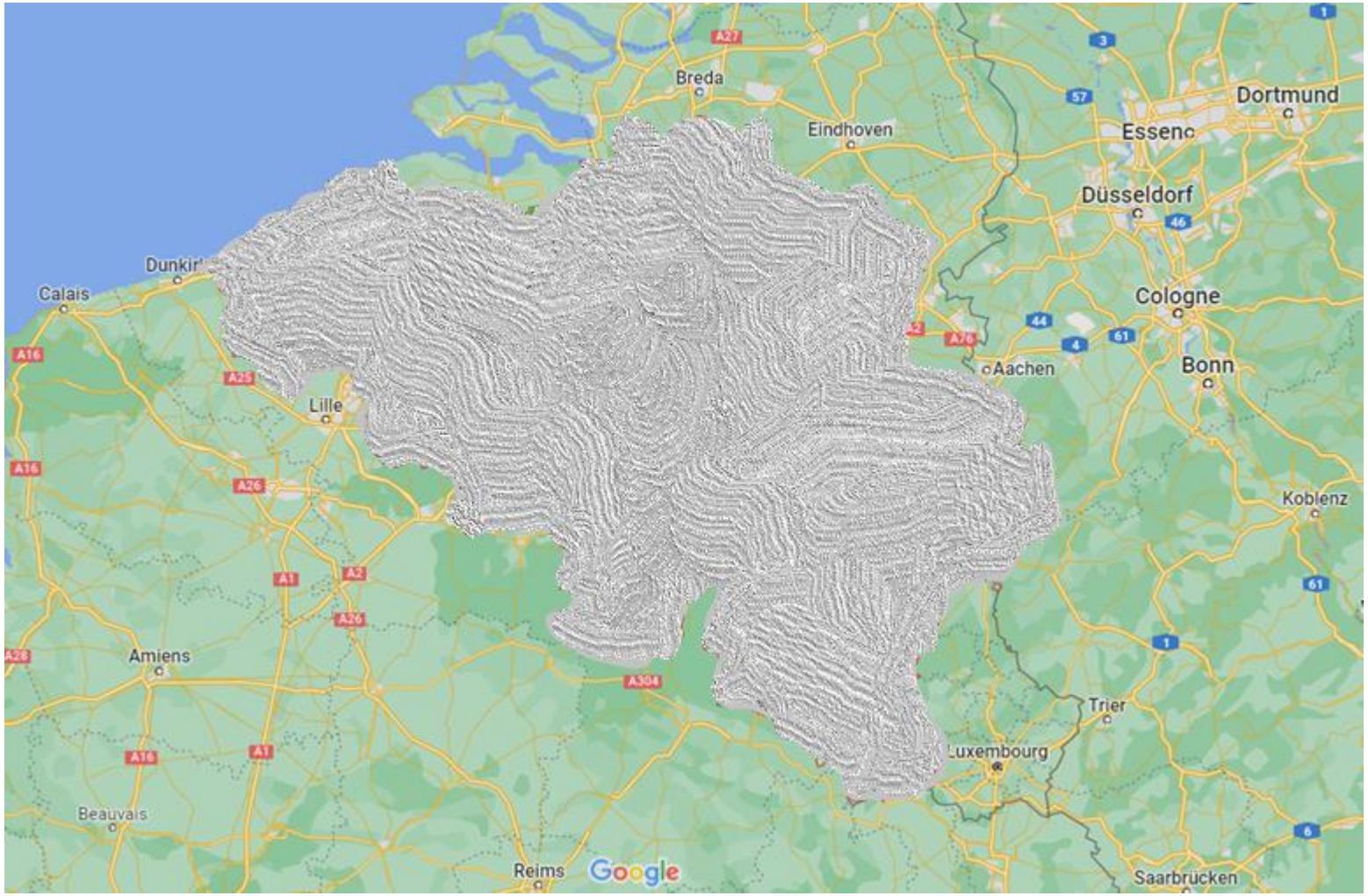
12.500.000.000 m^3 per year

RESOURCEFULL

12.500.000.000 m³ ?

RESOURCEFULL

12.500.000.000 m³ !



Belgium covered with 40 cm of concrete every year

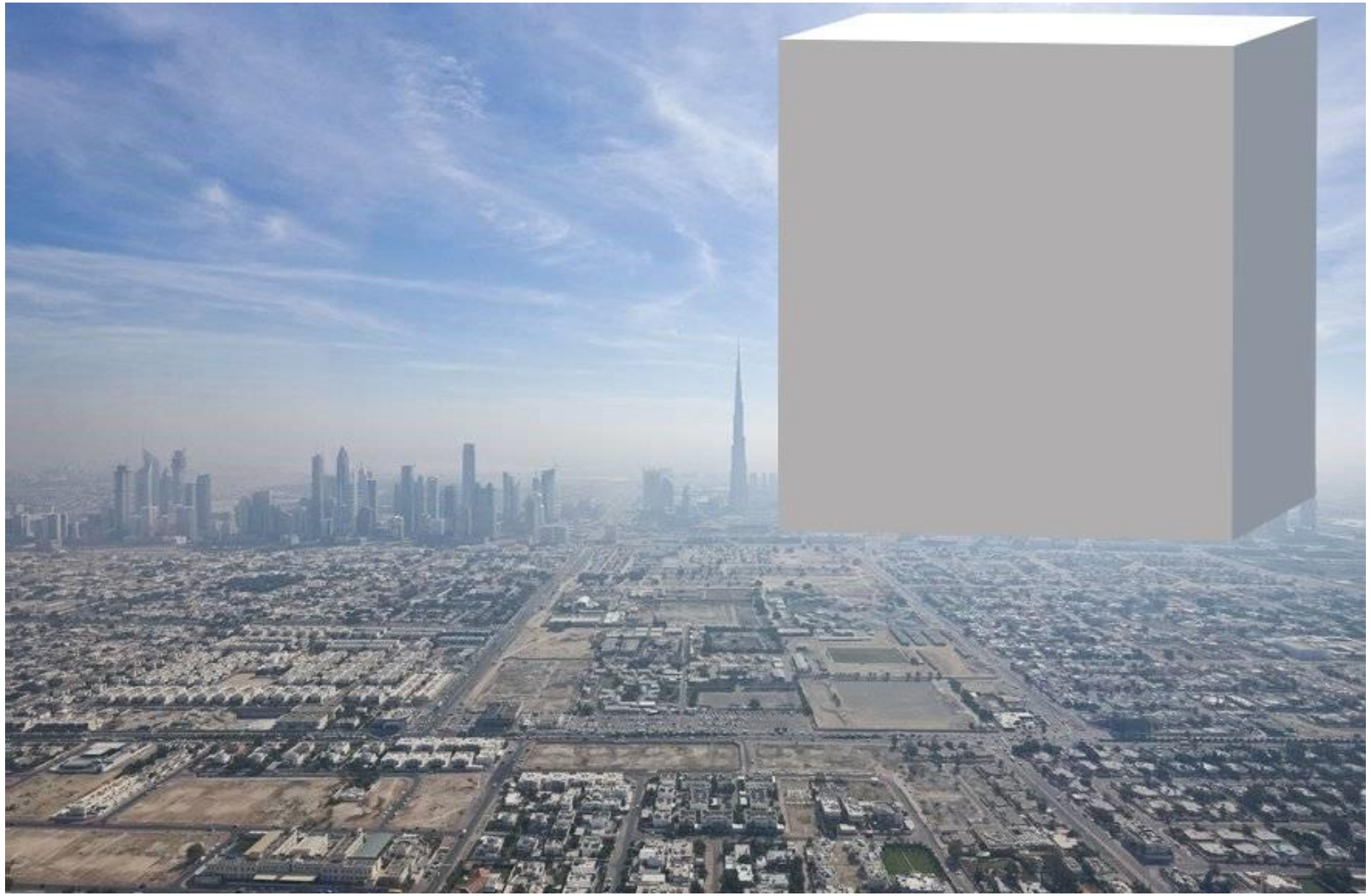
RESOURCEFULL

12.500.000.000 m^3 ?

RESOURCEFULL

12.500.000.000 m^3 ?

12.500.000.000 m^3 ?



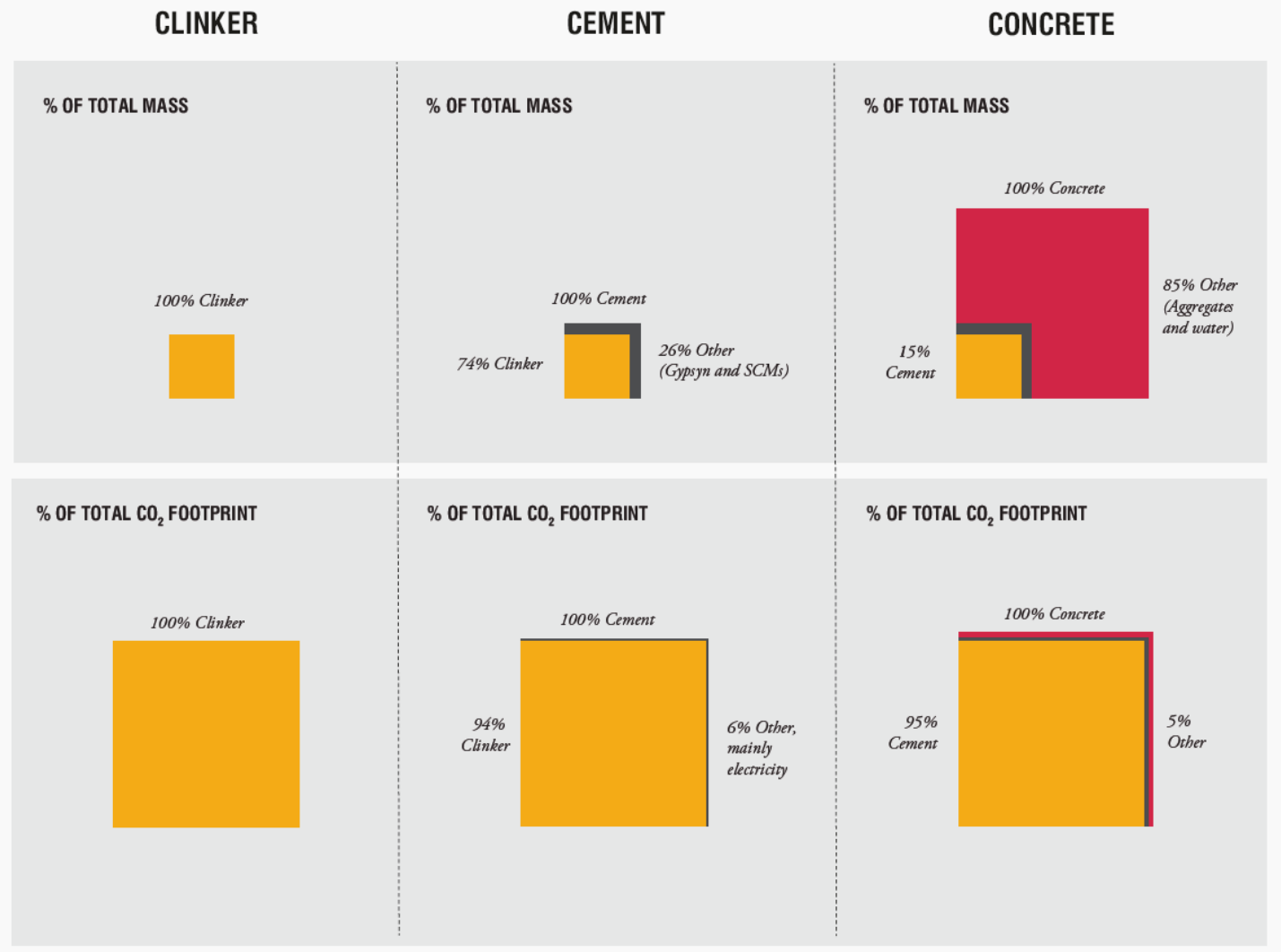
Solid concrete block of 2,3 x 2,3 x 2,3 km^3

Sustainable concrete: why?

>

RESOURCEFULL

Sustainable concrete: why?

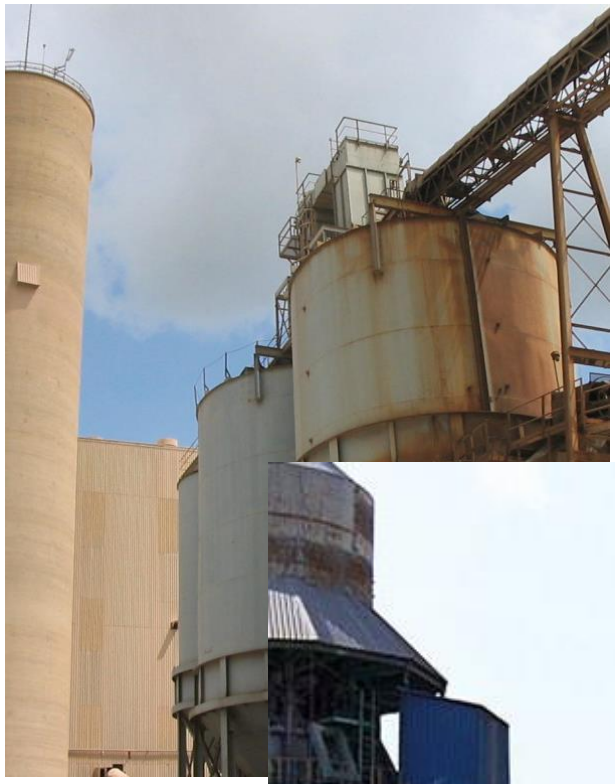


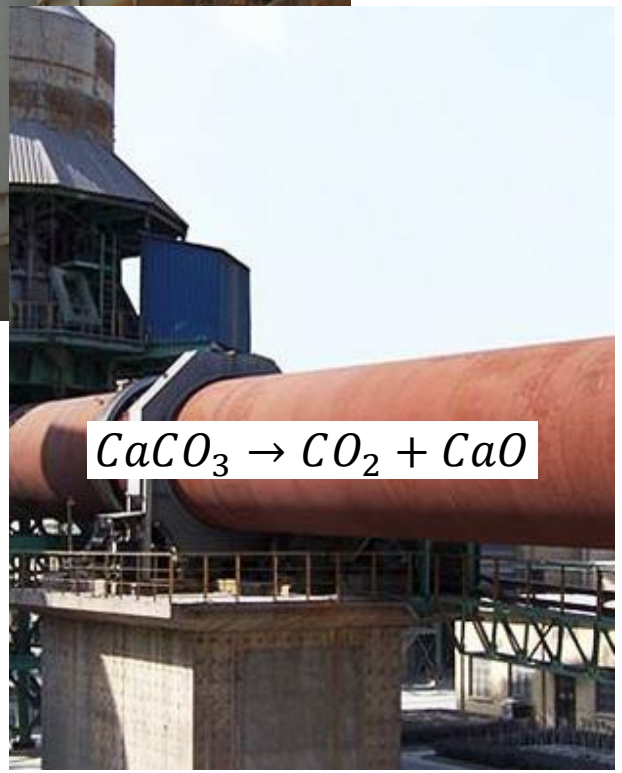
15% of the mass results in

95% of the Carbon Footprint

RESOURCEFULL

Cement Production Process



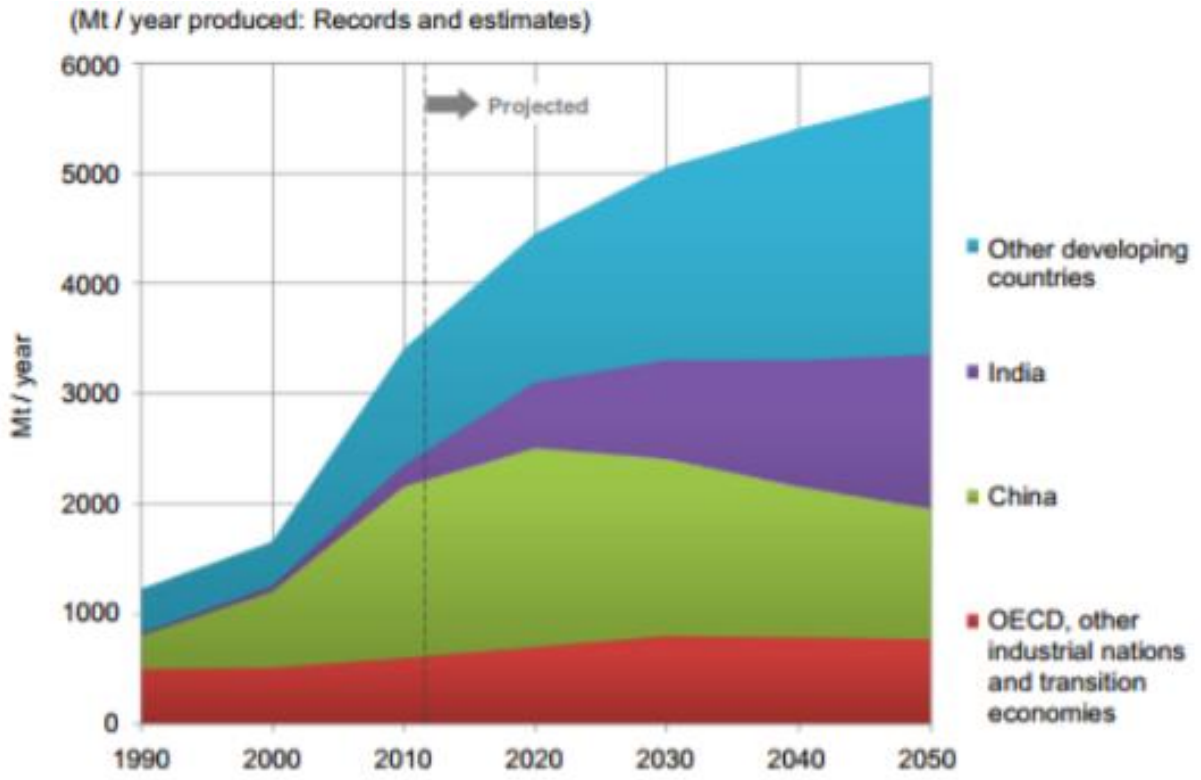


A **highly energy intensive** process, producing roughly 0,85 ton of CO_2 per 1 ton of cement produced *(vs. 2,5 ton of CO_2 per 1 ton of reinforcement steel)*

4.4 billion ton of cement is being produced each year, resulting in a contribution of **8 %** of worldwide **CO_2 emissions**.

RESOURCEFULL

Sustainable concrete: why?



Worldwide cement production

RESOURCEFULL

Sustainable concrete: how?

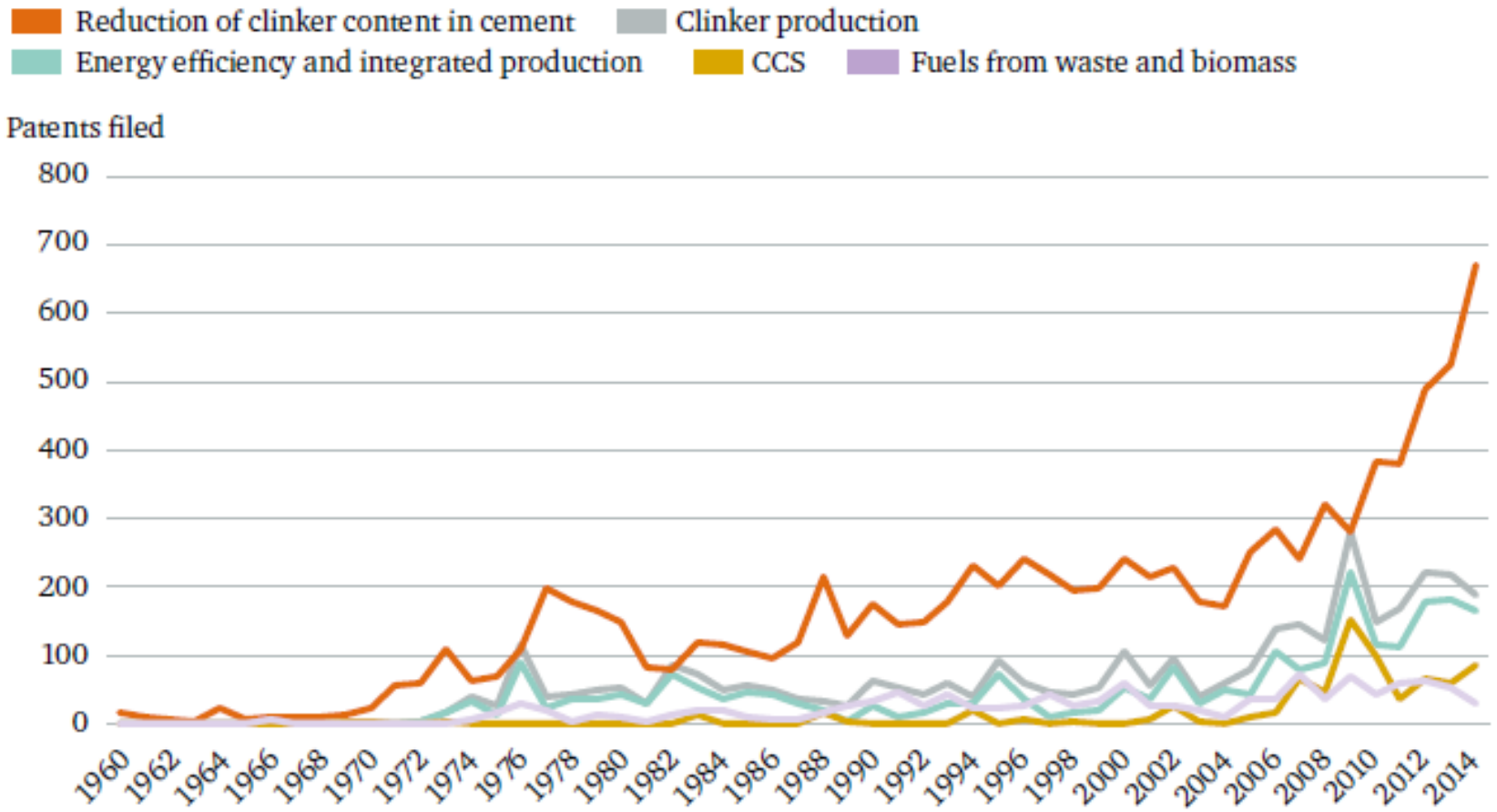
Technologies applicable at different levels

1. Clinker level
   - Energy efficiency
   - Alternative fuels
   - Carbon capture & storage
2. Cement level
   - Clinker ratio (SCMs)
   - Optimal grinding/blending of blended cements
   - Non-Portland binders
3. Concrete level
   - The right cement for the right application
   - ‘overdosing’
4. Structural level
   - Alternative building solutions to concrete
   - ‘overdesigning’
5. Recycling, circular economy
   - Recycling concrete
   - Recycling cement

RESOURCEFULL

Sustainable concrete: how?

Figure 10: Patenting trends for five low-carbon technology areas in the cement sector



RESOURCEFULL

Sustainable concrete: how?

cement

+

aggregates

+

water

=

concrete

alternative binders:

- Metallurgical slags
- Fly ashes
- Bottom ashes
- Waste clays
- Glass waste
- Vulcanic ashes
- …

Sustainable concrete: how?

cement

+

aggregates

+

water

=

concrete

alternative binders:
- Metallurgical slags
- Fly ashes
- Bottom ashes
- Waste clays
- Glass waste
- Vulcanic ashes
- …

secondary aggregates:
- Artificial aggregates
- Recycled aggregates

Less primary raw materials -> circularity

water
+ chemistry

=

ecological concrete

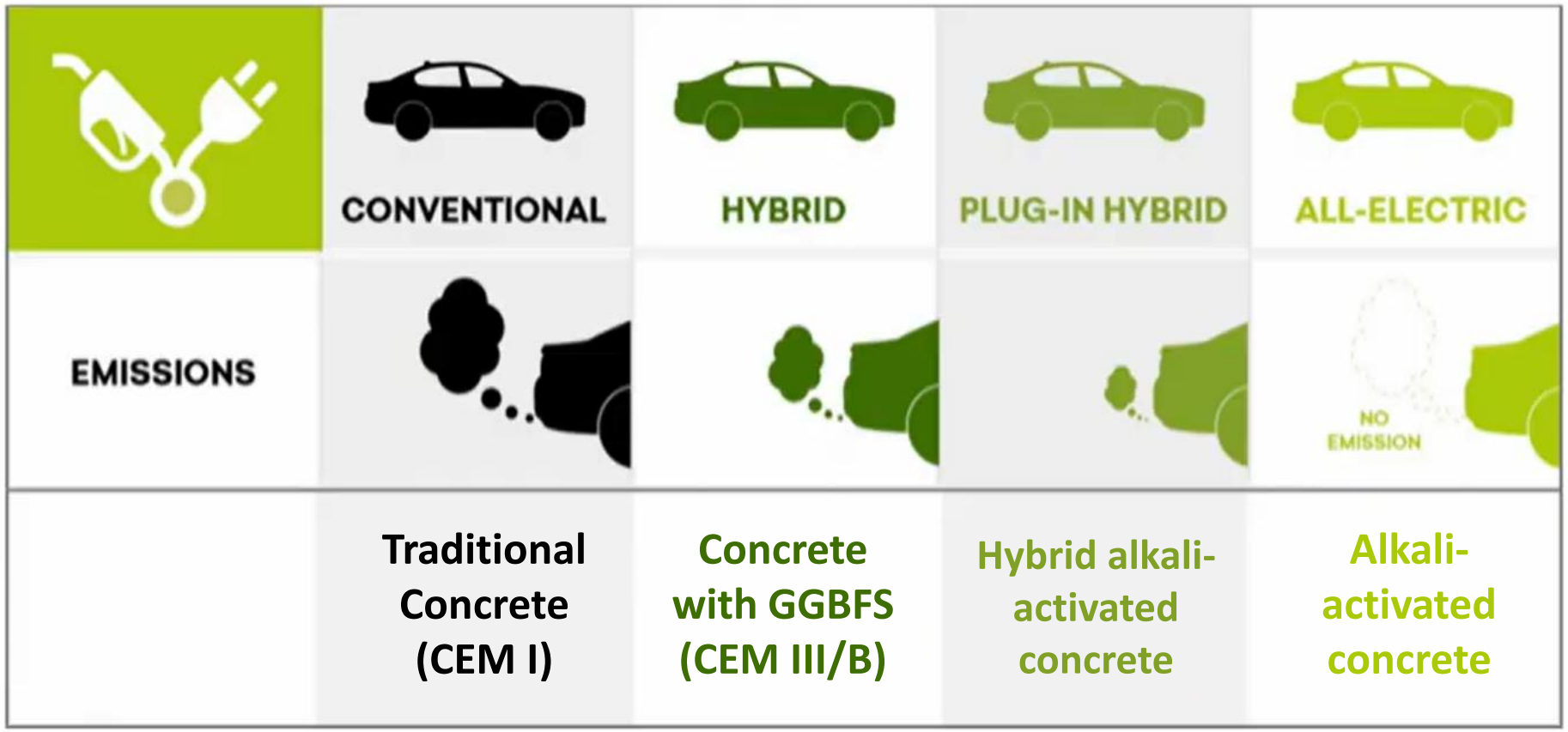
-

up to 90 % CO_2 -> sustainable

18

RESOURCEFULL

Cement vs. Cars



Source: after ABT- Studio beton 15/04/21 – Theo van Wolfswinkel

RESOURCEFULL

ResourceFull finds use for these by-products and transforms them into minerals suitable for the production of a **new generation of concrete**.

Metal and mining industry
Huge waste piles with low value or non-existing applications

Concrete industry
OPC dependency

Eco-friendly alternative: up to 90% CO_2 reduction

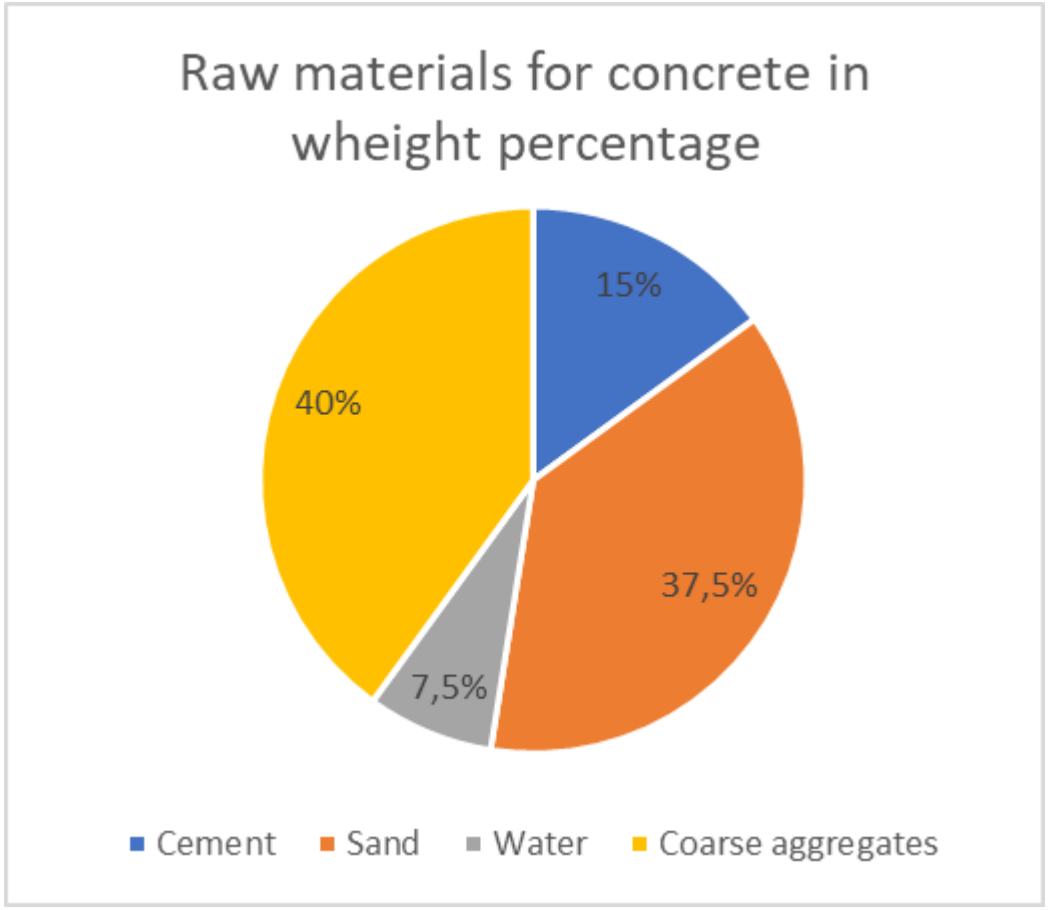
Europe & world
Dependancy on primary raw materials

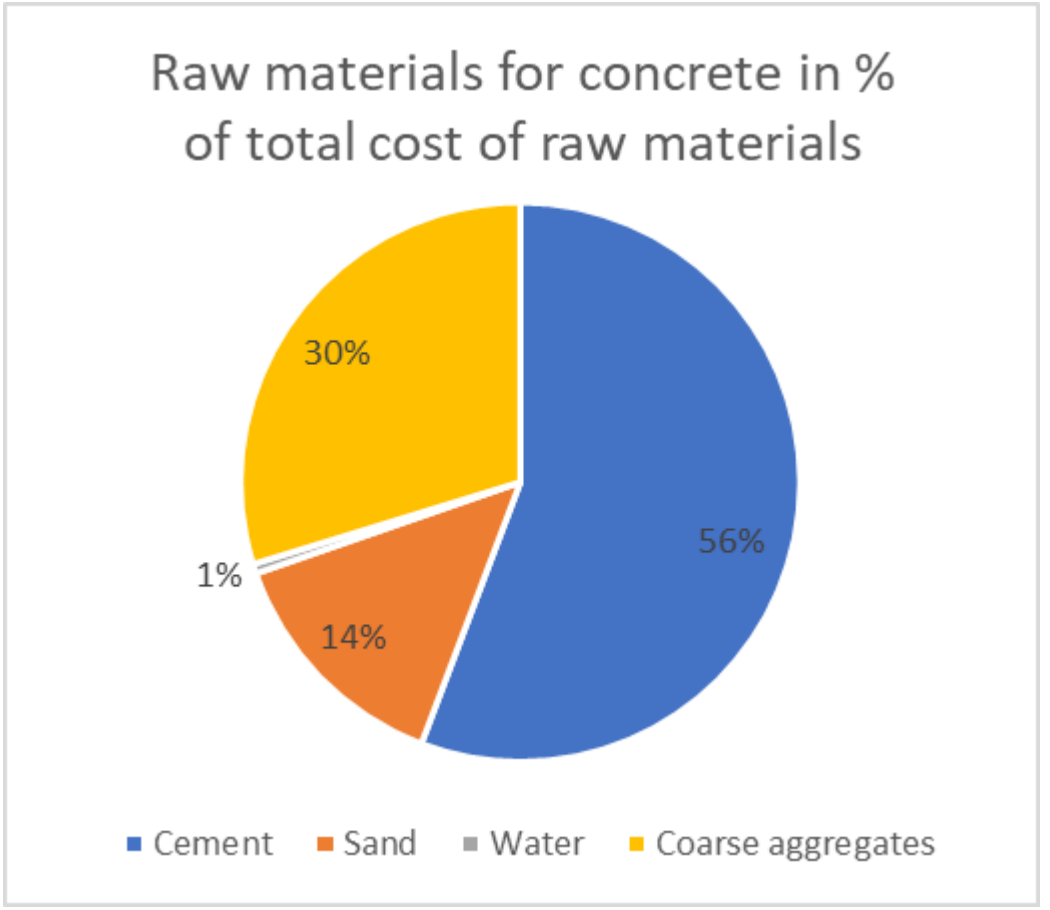
CO_2 reduction of construction industry

RESOURCEFULL

What about cost?

You can produce 1 m³ of traditional concrete for roughly 100€.





RESOURCEFULL

Ecology can not be the only driver

Driver	Property
Ecological	- Less CO_2 - Less primary raw materials - Less landfill
Economical	- **Cost competitive** - CO_2 taxation - Green push policy makers
Technical	- Chemical resistance - Acid resistance - Fireproof (>1000 °C) - Strength(development) - Bonding to traditional cement/concrete - Bonding to ceramics, glass, metal - Low permeability - Low sensitivity degradation ASR

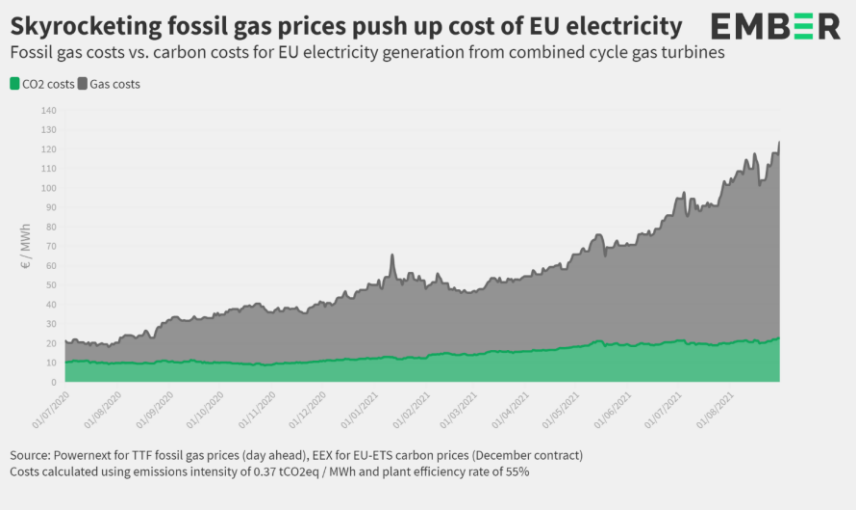
The use of industrial by-products and/or waste (= low value products) opens opportunities.

But have to factor in:

- Pre-treatment: washing, drying, milling…
- Cost of “activation”
- Transport

Ecology can not be the only driver

Driver	Property
Ecological	- Less CO_2 - Less primary raw materials - Less landfill
Economical	- **Cost competitive** - CO_2 taxation - Green push policy makers



Cement will become more expensive

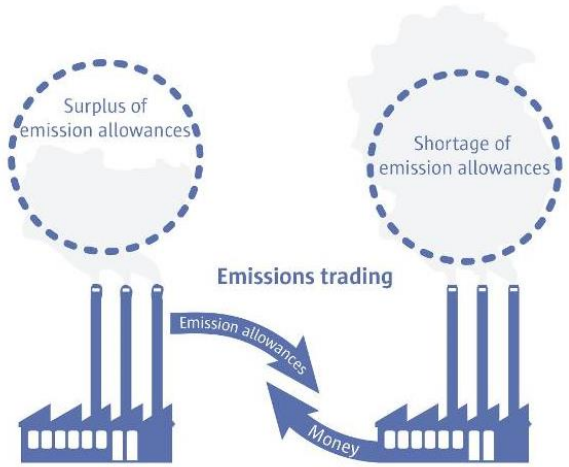
Lack of primary resources
+ Increasing cost of transport
→ Average increase of 3-6% materials costs in the construction sector

Gas prices went through the roof in 2021
→ Energy-intensive building materials (e.g. cement) are undoubtably going to rise.

RESOURCEFULL

Ecology can not be the only driver

Driver	Property
Ecological	- Less CO_2 - Less primary raw materials - Less landfill
Economical	- **Cost competitive** - **CO_2 taxation** - Green push policy makers



Cement will become more expensive

Europe's Emissions Trading System (ETS) has been te centerpiece of the EU's climate policy to reduce greenhouse gas emissions from EU's industrial and power sector.

Until today, CO_2 allowances have been received for free by sectors such as steel and cement.

Under the 2030 Climate Target Plan, the EU has agreed to accelerate the pace: reforming the ETS by phasing out free allowances.

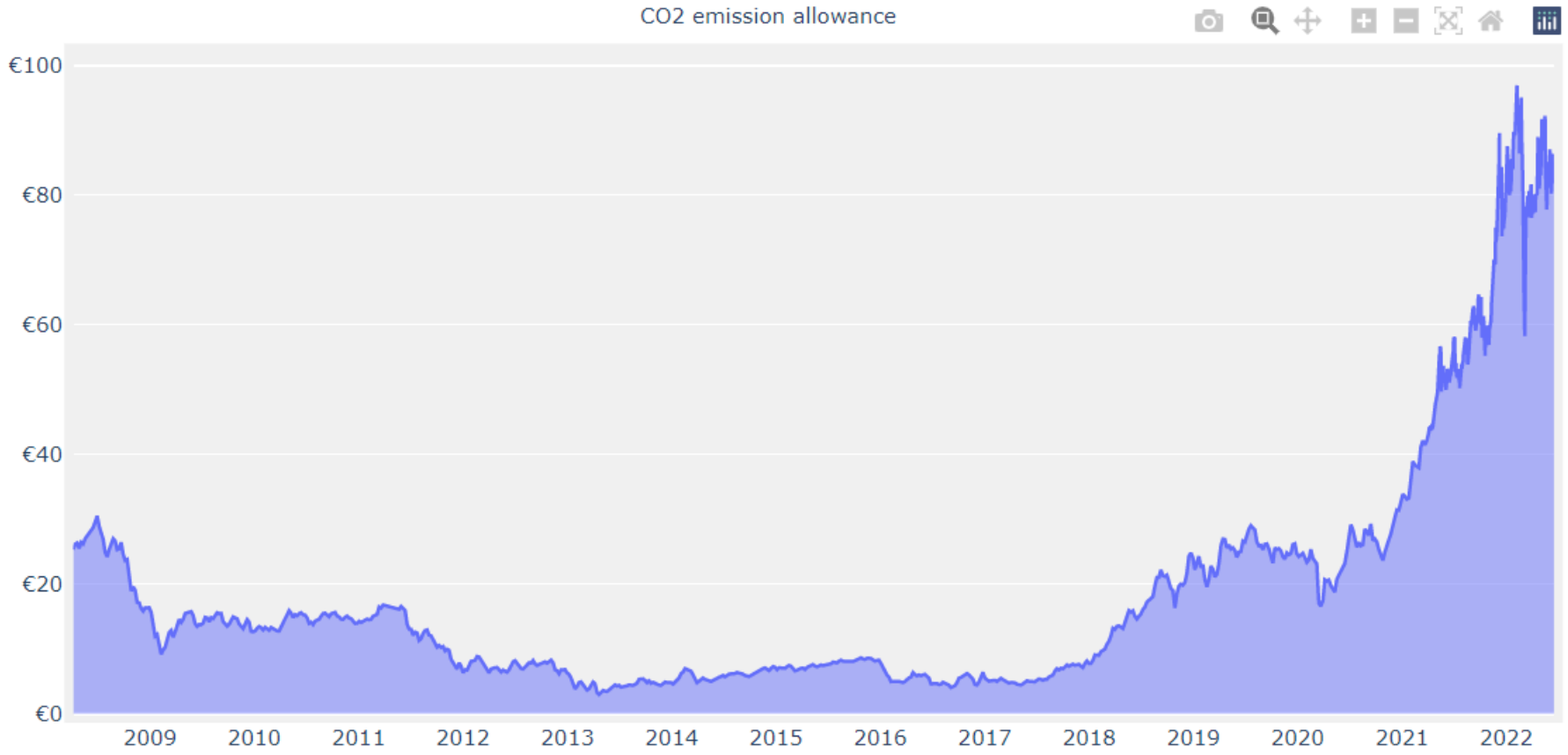
RESOURCEFULL

Ecology can not be the only driver

EUA Futures 20/06/2022

€82.12

Source



https://sandbag.be/index.php/carbon-price-viewer/

RESOURCEFULL

Ecology can not be the only driver

Driver	Property
Ecological	- Less CO_2 - Less primary raw materials - Less landfill
Economical	- **Cost competitive** - **CO_2 taxation** - Green push policy makers

Cement will become more expensive

Major cement players have announced the price rise for cement over 2021: **30 (!) %**

Since it is uniformal, switching supplier is out of the question and the price rise is basically non-negotiable.

→ **Opportunities for low carbon binders and technologies**

Ecology can not be the only driver

Driver	Property
Ecological	- Less CO_2 - Less primary raw materials - Less landfill
Economical	- Cost competitive - CO_2 taxation - **Green push policy makers**

Policy makers favoring green products

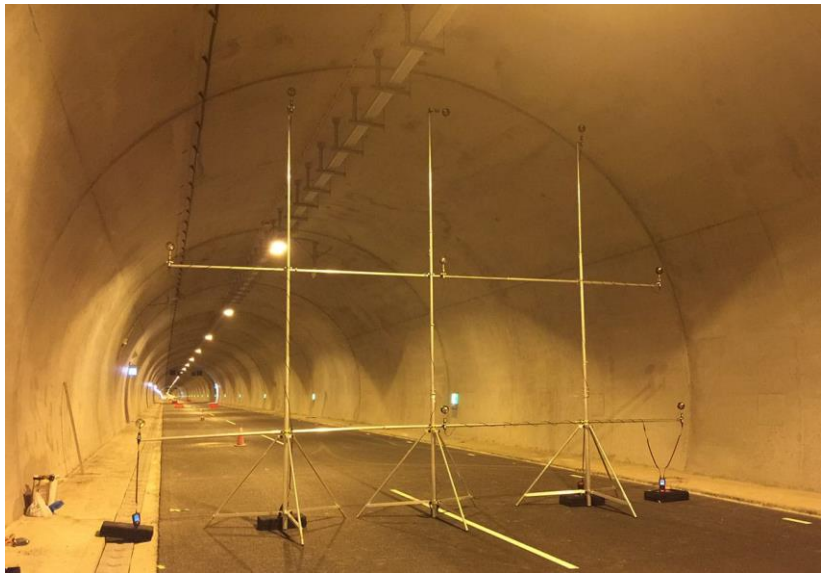
NL: Environmental Cost Indicator (MKI-score)

Impact categorie	**Unit**	**Weighting Factor** (€/unit)
Global Warming	kg CO_2-eq	0,05 €
Ozon depletion	kg CFC-11-EQ	30,00 €
Ecidification of soil and water	kg SO_2-eq	4,00 €
Eutrophication	kg PO_4^{3-}-eq	9,00 €
Depletion of Abiotic Resource Elements	kg SB-eq	0,15 €
Depletion of abiotic resources – fossil fuels	kg SB-eq	0,15 €
Human Toxicity	kg 1,4 DB-eq	0, 09 €
Freshwater ecotoxicity	kg 1,4 DB-eq	0,03 €
Marine water ecotoxicity	kg 1,4 DB-eq	0,0001 €
Terrestrial ecotoxicity	1,4 DB-eq	0,06 €
Photochemical oxidant creation (Smog)	kg C_2H_4	2,00 €

RESOURCEFULL

Ecology can not be the only driver

Driver	Property
Ecological	- Less CO_2 - Less primary raw materials - Less landfill
Economical	- Cost competitive - CO_2 taxation - Green push policy makers
Technical	- **Chemical resistance** - **Acid resistance** - **Fireproof (>1000 °C)** - **Strength(development)** - **Bonding to traditional cement/concrete** - **Bonding to ceramics, glass, metal** - **Low permeability** - **Low sensitivity degradation ASR**



So what's holding us back?

- Need for standardisation on different levels
  - The development and introduction of such documents is a gradual process at best
- The unanswered questions about the durability of AAM concrete
  - Structural concrete must last several decades
  - Data on such time scales is simply not available for a newly developed material

But, we're working on it:

- RILEM Technical Committees: C224-AAM; 247DTA; 281-CCC; 283-CAM; MPA
  - Global technical committees with the aim of promoting scientific knowledge regarding building materials, systems and structures and stimulating market uptake.
- Collaboration with multiple research institutes across EU
  - European collaborations with large-scale research into sustainability
    - H2020, Horizon Europe, EIT Raw Materials, VLAIO …
  - Putting it to the test: selecting the right applications
- In Belgium (2022): WGAAM in the commission E-104
  - Workgroup with purpose of constructing a norm for alternative binders in collaboration with BE-CERT

Alternative cements/binders: new?

a

UNITED STATES PATENT OFFICE.

HANS KÜHL, OF BLANKENESE, NEAR HAMBURG, GERMANY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE ATLAS PORTLAND CEMENT COMPANY, OF NEW YORK, N. Y., A CORPORATION OF PENNSYLVANIA.

SLAG CEMENT AND PROCESS OF MAKING THE SAME.

No. 900,939. Specification of Letters Patent. Patented Oct. 13, 1908.

Application filed July 3, 1907. Serial No. 381,980.

b

THE ACTION OF ALKALIS ON BLAST-FURNACE SLAG

By A. O. PURDON

Although slag may be considered to be a cement in itself, hydration proceeds with such extreme slowness that it cannot be used alone as such. The reactions are usually accelerated by incorporation with the slag of lime, Portland cement clinker, or anhydrite. The resulting cements, compared with Portland, are characteristically slow-hardening but attain great strength with time. A relatively small quantity of an alkali is a much more efficient accelerator. The resulting cement has greater strength, both initial and final, than Portland. The optimum quantity of caustic soda is 5—8% of the mixing water. The same effect is produced by incorporation of lime plus a sodium salt in such quantities as to produce a like quantity of nascent soda. Cements made in this way, apart from their characteristically high early strength, have the following advantages over Portland: (a) Heat of hydration is extremely low. (b) Concrete is practically watertight. (c) Low solubility in pure or aggressive waters.

c

First patent in 1908

Lower in Ca
Higher in alkalis, Si en Al

>3M m³ in 80-90's
in Soviet Union

Parking 58 in 50's
in Brussels by
'Le Purdociment'

RESOURCEFULL

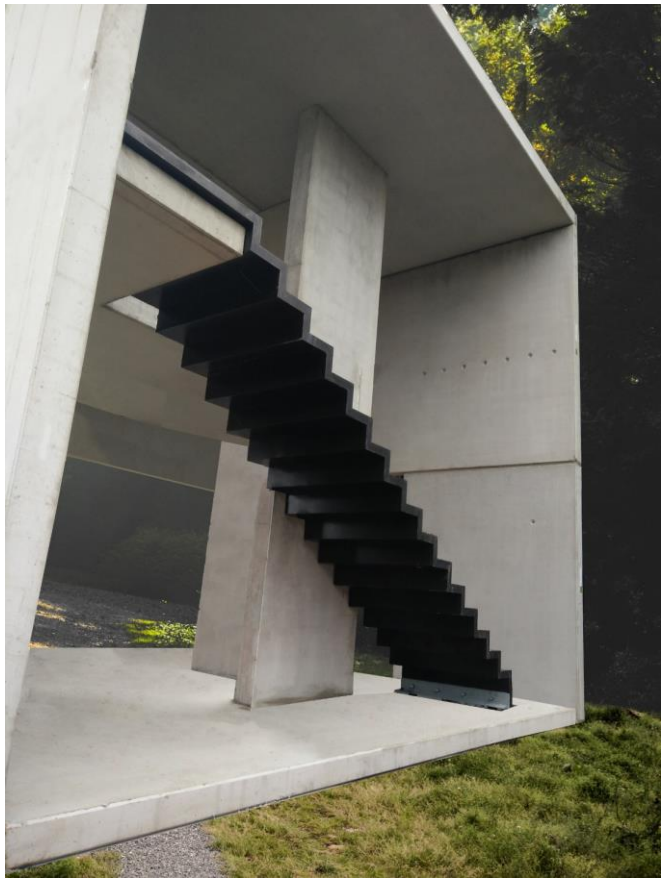
Alternative cements/binders: new?

Landing strip in Brisbane, Australia
40 000 m³ (2014)

Geopolymer bicycle lane
Zeewolde, NL (2016)

Geopolymer roundabout
Enschede, NL (2017)

Completed by ResourceFull



UHPC staircase,
Lier, BE (2017)

Public infrastructure 22m³
Leuven, BE (2020)

61 m³ of foundations
Kamp C, Westerlo BE (2021)

Public infrastructure
Gent, BE (2021)

RESOURCEFULL

The story of the foundations

https://www.nweurope.eu/projects/project-search/urbcon-by-products-for-sustainable-concrete-in-the-urban-environment/

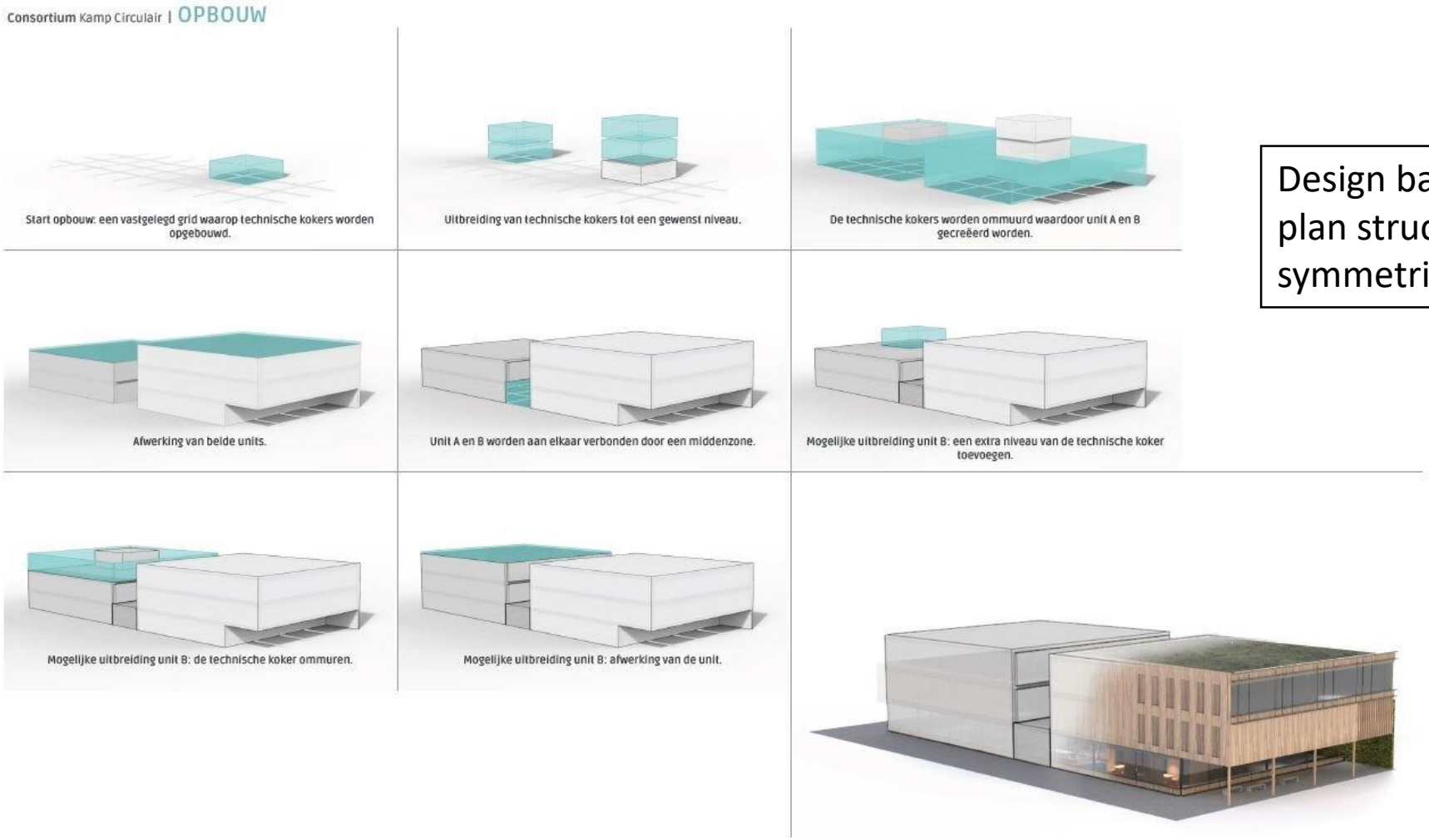
URBCON demonstrators

Stairs in school building
+ public infrastructure

Two pedestrian bridges

Foundation for ‘t Centrum

‘t Centrum – Kamp C



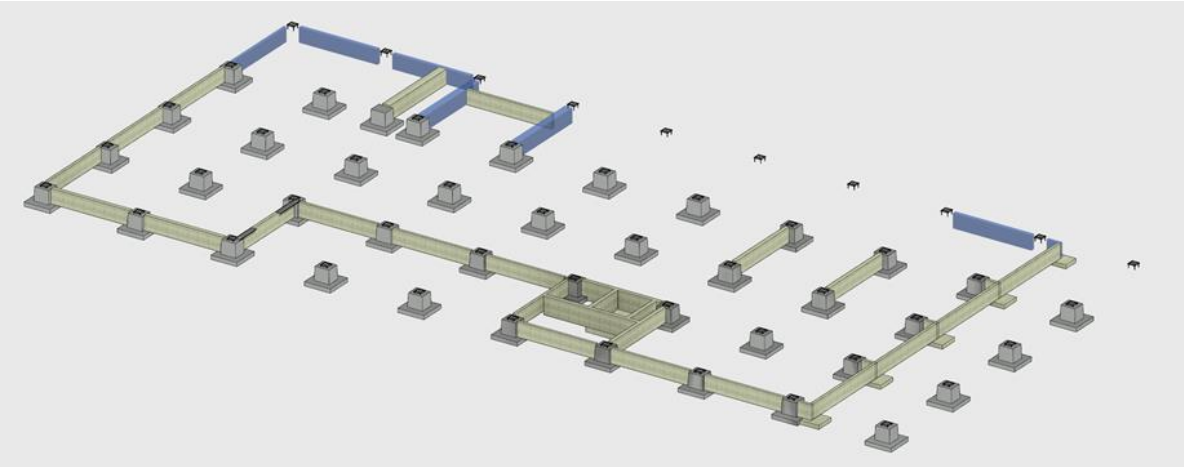
Design based on open plan structure with a symmetrical grid.

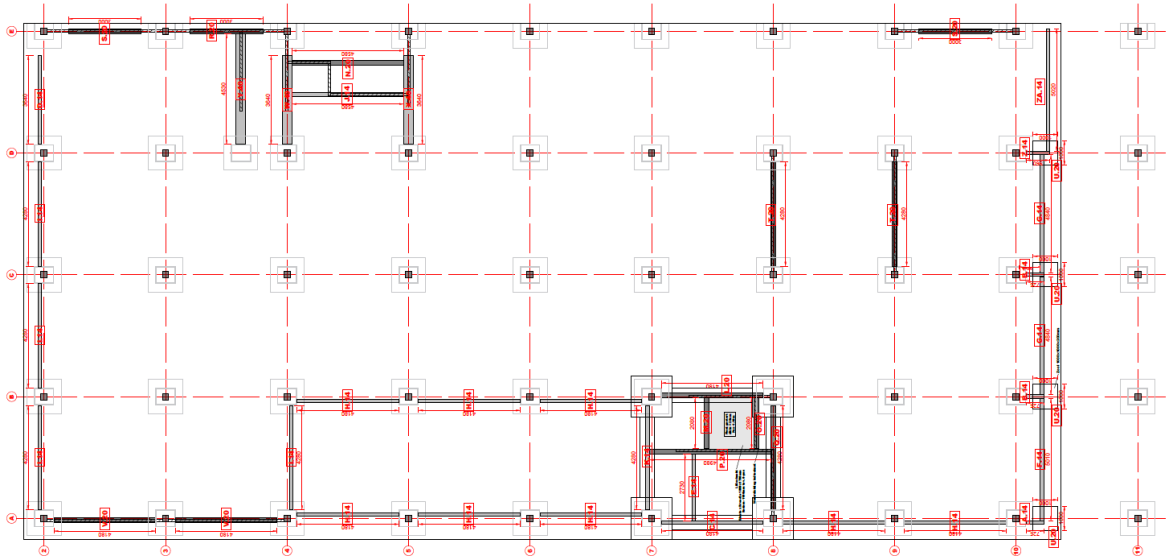
RESOURCEFULL

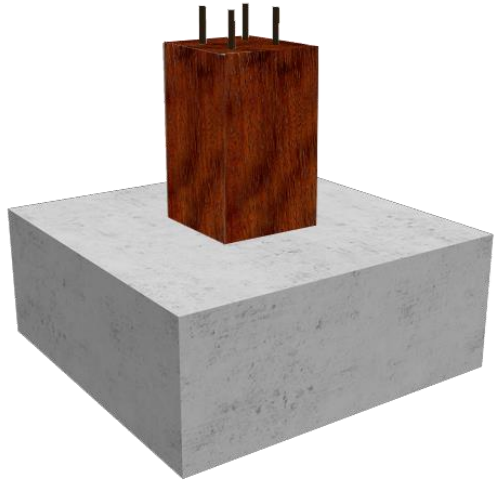
‘t Centrum – Kamp C

RESOURCEFULL

‘t Centrum – Kamp C







- 40 foundation blocks (36 m³)
  - C20/25 EE2 S5 (60 min stability)
- 37 beams (20 m³)
  - C30/37 EE3 SCC (60 min stability)

Strength class C(ompression) cylinder/cube

Environmental Exposure Class

Flow class

RESOURCEFULL

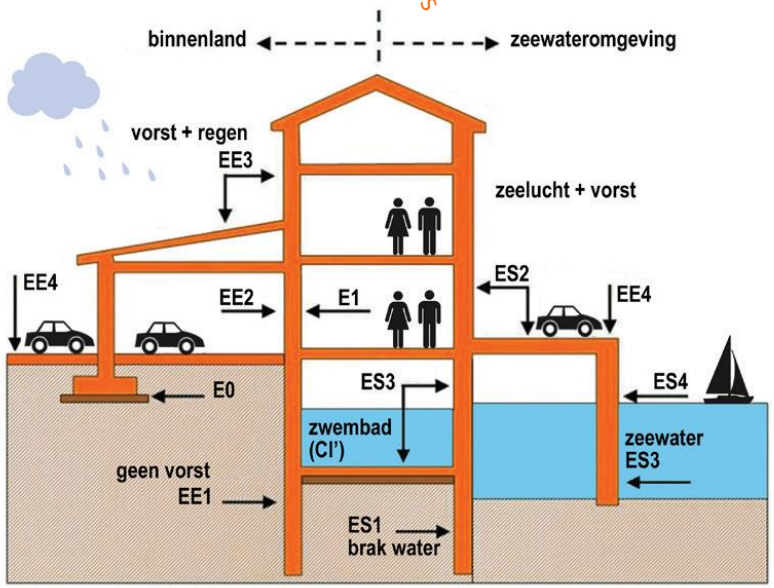
Intermezzo: concrete notation

C20/25 EE2 S5

Strength class

Environmental Exposure class

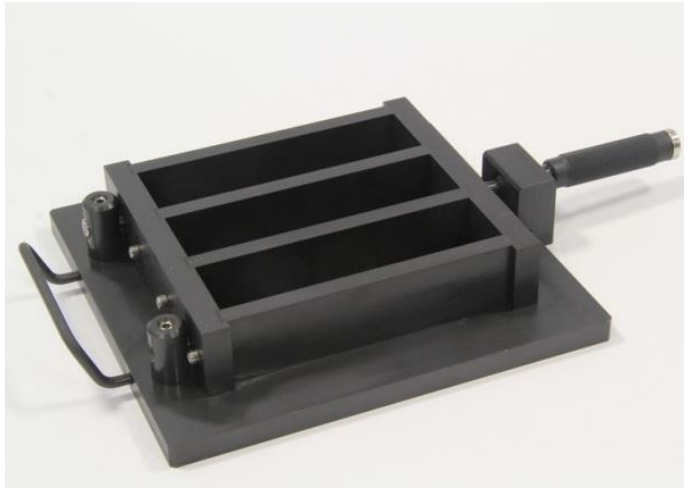
Slump Flow Class



RESOURCEFULL

The stages in bringing technology to market

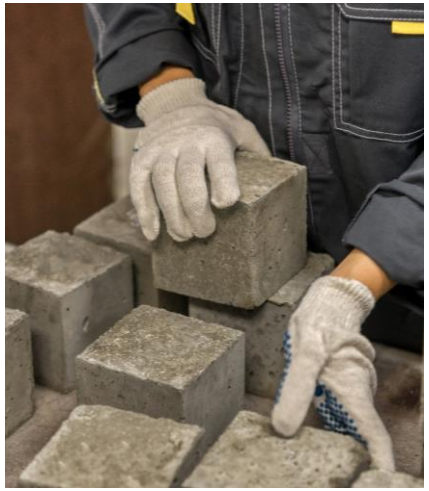
Binder development





Concrete development






RESOURCEFULL

The stages in bringing technology to market

Durability testing





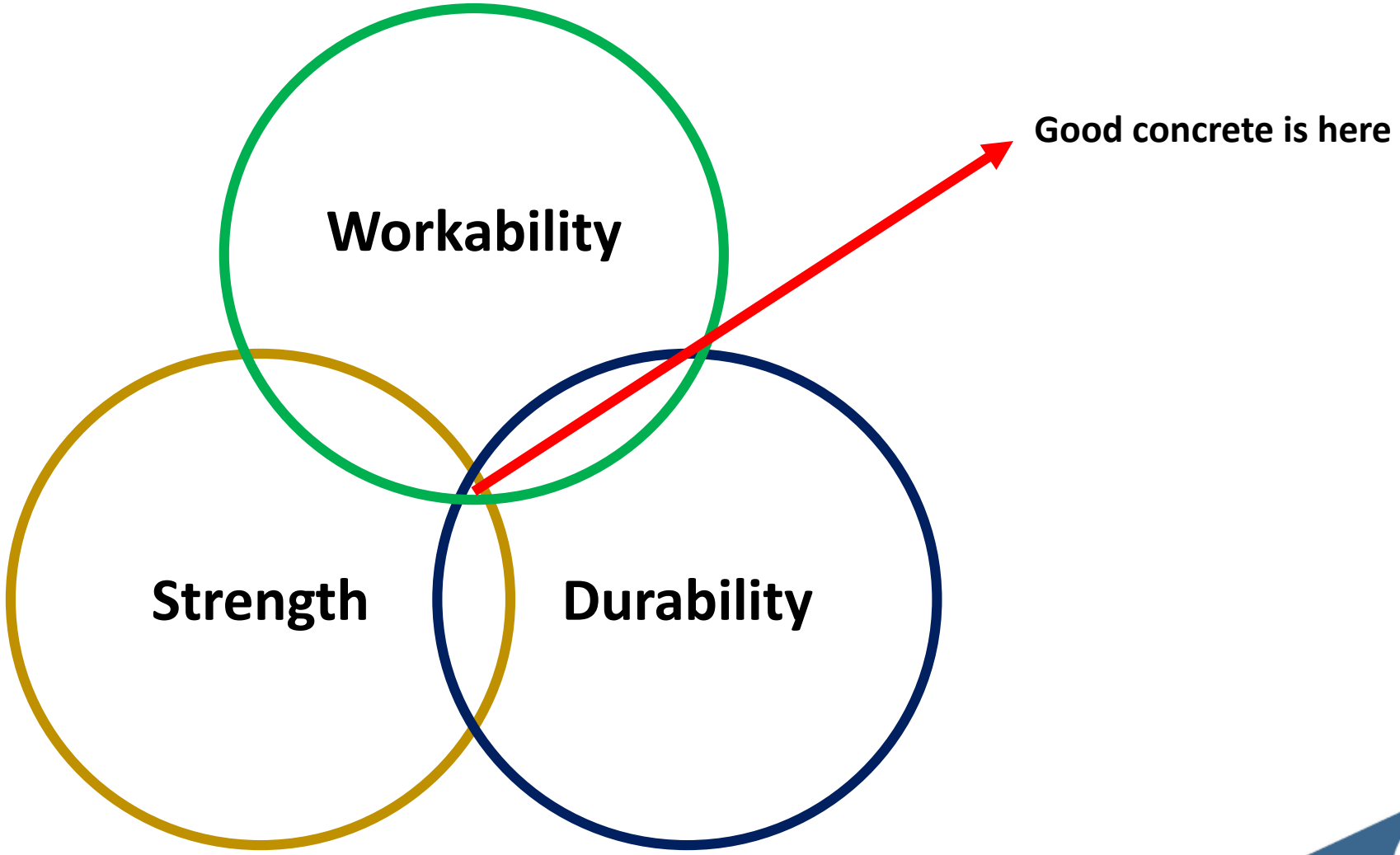
Large scale testing and monitoring





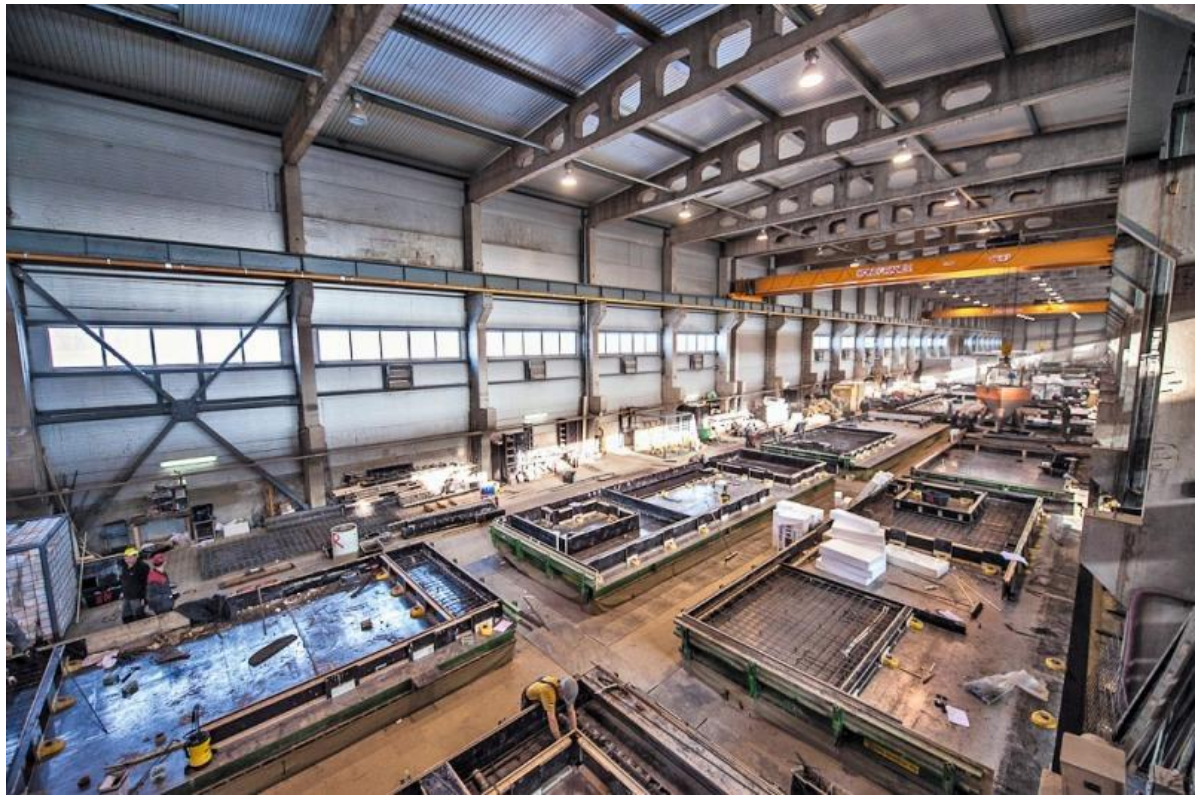
RESOURCEFULL

Holy trinity of concrete theology



RESOURCEFULL

…and now for real.



Production partners for the pilot

WILLY NAESSENS CONSTRUCT

Wanden in prefabbeton • Parois en béton préfabriqué

Willy Naessens

Construct

Bedrijvenpark de Coupure 15

9700 Oudenaarde

J. Janssens & ZN

BOUWMATERIALEN

& BETON

RESOURCEFULL

Production of the precast elements

Two different kind of concrete were developed with respectively 0 and 95kg CEM I per m^3 of concrete. The foundations were produced during 4 production days and quality control measures were used every two pours.

- Cubes to measure strength
- Water/cement analysis

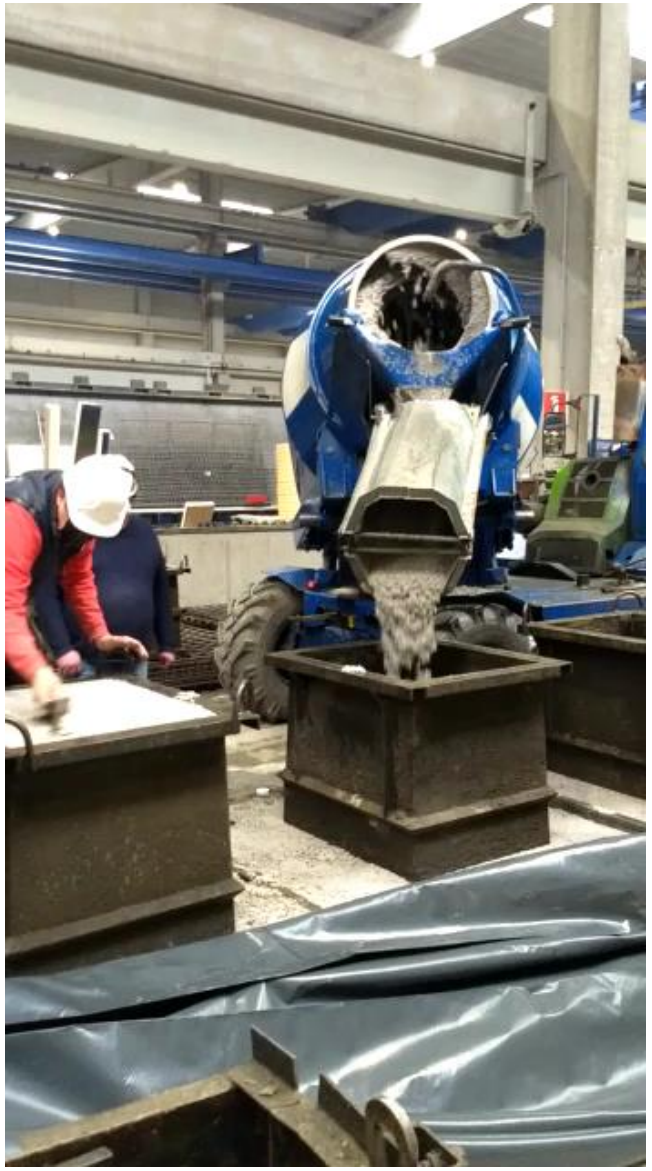
In the standard recipe, the granular skeleton was completely preserved and only the binder was replaced.





RESOURCEFULL

RESOURCEFULL



RESOURCEFULL

Production of the ready-mix concrete

RESOURCEFULL

RESOURCEFULL

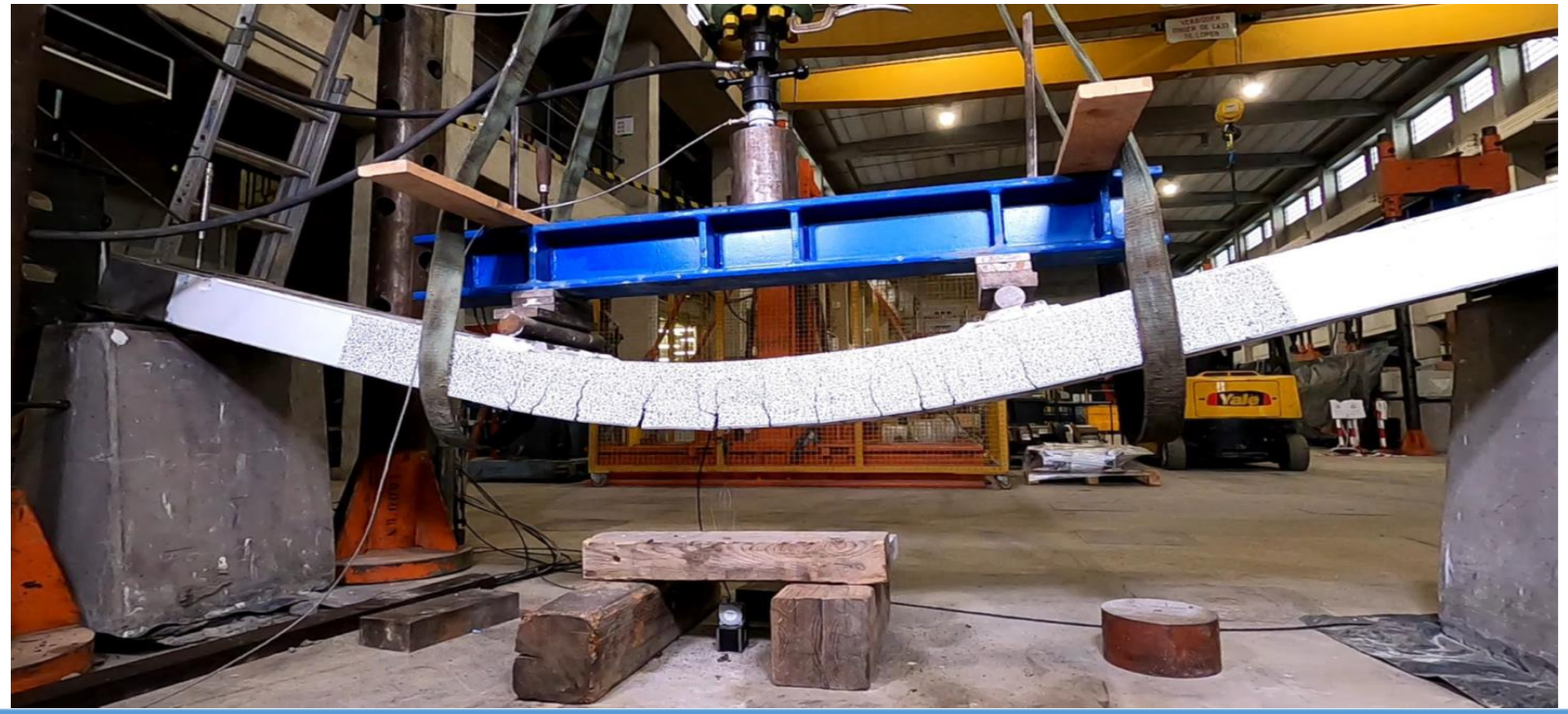
URBCON demonstrators

Stairs in school building
+ public infrastructure

Two pedestrian bridges

Foundation for ‘t Centrum

Test	standard	
Slump stability	EN 12350-2	Fresh properties
Fresh density	EN 12350-6	
Air content	EN 12350-7	
Compressive strength	EN 12390-3	Mechanical properties
Flexural strength	EN 12390-5	
Splitting tensile strength	EN 12390-6	
Elastic modulus	EN 12390-13	
Chloride Migration	NT Build 492	Durability properties
Carbonation	EN 12390-12	
Water absorption		
Freeze and thaw - salt	EN 12390-9	
Reinforcement corrosion		
Creep and shrinkage	EN 12390-17	Structural Properties
Pull out (steel rebars)	EN 10080	
Flexural strength - slab		
Shear capacity - slab		



RESOURCEFULL

ResourceFull
Centrum Zuid 3060
3530 Houthalen
Belgium

www.resourcefull.eu

Lukas Arnout
lukas.arnout@resourcefull.eu

Wouter Crijns
wouter.crijns@resourcefull.eu

Thomas Lapauw
thomas.lapauw@resourcefull.eu

Building a greener future, together