

# Geopolymeren op basis van lokale grondstoffen: wat is mogelijk, wat (nog) niet?

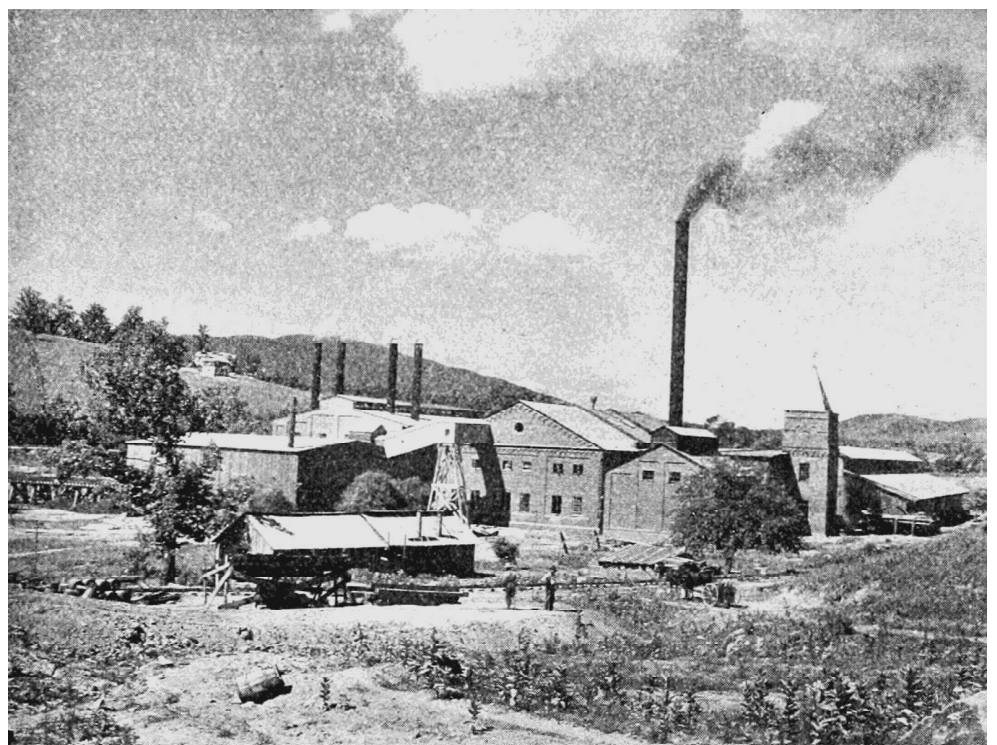
Een nieuw circulair bindmateriaal



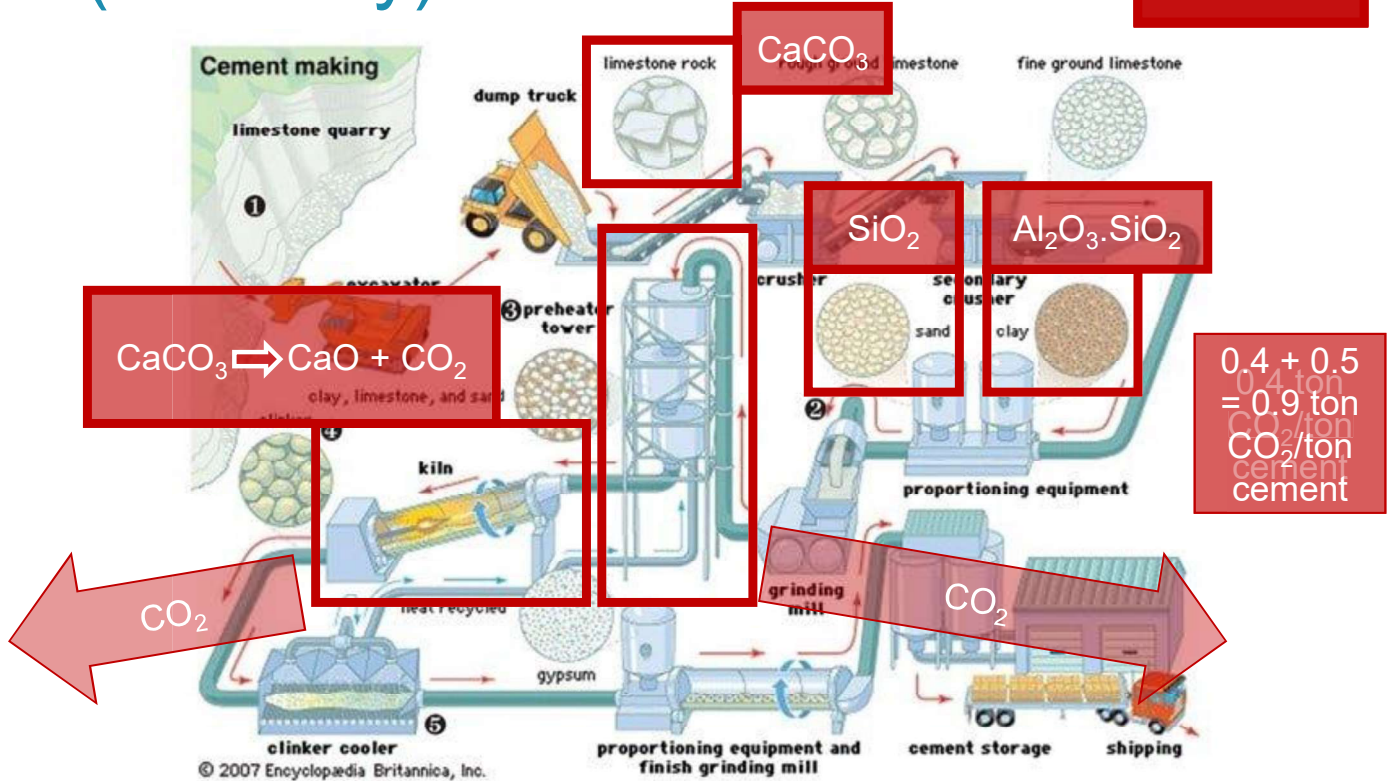
Arne Peys

SREMat group, prof. Yiannis Pontikes (sremat.be)

## 1824: Wat is gebeurd?



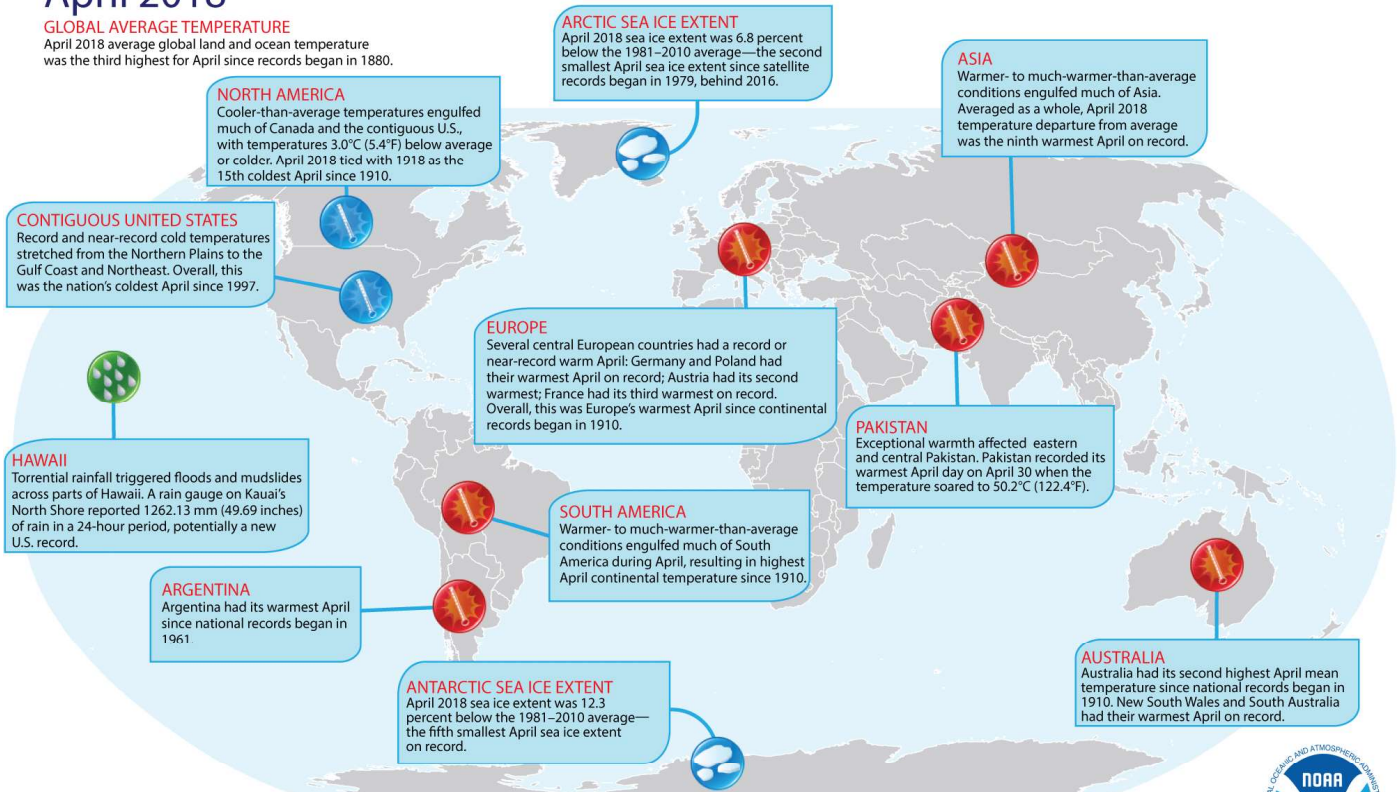
# (Ordinary) Portland cement



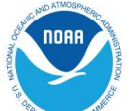
## Selected Significant Climate Anomalies and Events April 2018

### GLOBAL AVERAGE TEMPERATURE

April 2018 average global land and ocean temperature was the third highest for April since records began in 1880.



Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: <http://www.ncdc.noaa.gov/sotc>



# Selected Significant Climate Anomalies and Events

## May 2018

### GLOBAL AVERAGE TEMPERATURE

May 2018 average global land and ocean temperature was the fourth highest for May since records began in 1880.

### NORTH AMERICA

Warmer-than-average temperatures engulfed much of North America during May 2018, with the exception of Alaska and northeastern Canada. As a whole, North America had its highest May temperature since 1998 and the second highest since continental records began in 1910. The contiguous U.S. had its warmest May since records began in 1895.

### SUBTROPICAL STORM ALBERTO

(May 25–31, 2018)  
Maximum winds - 100 km/h  
Alberto brought heavy rain to parts of the southeastern contiguous U.S., triggering flash floods and mudslides.

### ARGENTINA

Argentina had its seventh highest May temperature since 1961. Several regions in northern Argentina had a May temperature that ranked among the five highest Mays on record.

### ANTARCTIC SEA ICE EXTENT

May 2018 sea ice extent was 8.6 percent below the 1981–2010 average—the third smallest May sea ice extent on record.

### ARCTIC SEA ICE EXTENT

May 2018 sea ice extent was 8.1 percent below the 1981–2010 average—the second smallest May sea ice extent since satellite records began in 1979, behind 2016.

### EUROPE

Europe had its warmest May since records began in 1910. Several European countries had a record or near-record warm May.

### AFRICA

May 2018 tied with 2005 as the ninth highest May temperature on record.

### ASIA

Warmer-than-average conditions were present across much of Asia, with cooler-than-average conditions across central Russia and Far East Russia. Overall, this was the coolest May since 2009.

### CYCLONE MEKUNU

(May 21–27, 2018)  
Maximum winds - 185 km/h  
Mekunu, the 10th tropical cyclone in the Arabian Sea in the last 11 years, ranked as the fourth strongest cyclone over the Arabian Sea. Salalah, Oman, received over twice the annual average precipitation for the city in a 36-hour period.

### AUSTRALIA

Drier-than-average conditions plagued much of Australia, giving way to the driest May since 2008 and the third driest since records began in 1900.

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# Selected Significant Climate Anomalies and Events

## June 2018

### GLOBAL AVERAGE TEMPERATURE

June 2018 average global land and ocean temperature was the fifth highest for June since records began in 1880.

### NORTH AMERICA

June 2018 ranked as the sixth warmest June since continental records began in 1910. The contiguous U.S. had its third highest June temperature since national records began in 1895.

### HURRICANE BUD

(June 9–15, 2018)  
Maximum winds - 215 km/h  
The second major hurricane in the Eastern North Pacific Hurricane basin in 2018. Bud brought heavy rain and floods to northern Mexico and parts of the southwestern contiguous U.S.

### SOUTH AMERICA

Warmer-than-average temperatures were present in the northern half of South America, while southern South America had near- to cooler-than-average conditions during June 2018. Averaged as a whole, South America had its smallest June temperature departure from average since 2008.

### ANTARCTIC SEA ICE EXTENT

June 2018 sea ice extent was 3.8 percent below the 1981–2010 average—the eighth smallest June sea ice extent on record.

### ARCTIC SEA ICE EXTENT

June 2018 sea ice extent was 9.0 percent below the 1981–2010 average—the fourth smallest June sea ice extent since satellite records began in 1979.

### EUROPE

Europe had its highest June temperature since 2003. Several European countries had a June temperature that ranked among the six warmest Junes on record.

### AFRICA

Africa had its fourth highest June temperature since 1910.

### ASIA

Record warm temperatures were observed across much of central Russia. Overall, Asia had its seventh highest June temperature on record.

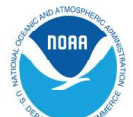
### OMAN

Oman recorded its highest minimum temperature on June 26 when temperatures only dropped to 42.6°C (108.7°F) in Quriyat.

### AUSTRALIA

Drier-than-average conditions were present across much of Australia. Regionally, Northern Territory had the most notable precipitation deficit at 90% below average.

Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: <http://www.ncdc.noaa.gov/sotc>



# Selected Significant Climate Anomalies and Events July 2018

## GLOBAL AVERAGE TEMPERATURE

July 2018 average global land and ocean temperature was the fourth highest for July since records began in 1880.

### NORTH AMERICA

July 2018 ranked as the ninth warmest July since continental records began in 1910. The contiguous U.S. had its 11th highest July temperature (tied with 1998) since national records began in 1895. The state of California had a record warm July. Death Valley had the hottest month on record observed anywhere.

### ARCTIC SEA ICE EXTENT

July 2018 sea ice extent was 13.2 percent below the 1981–2010 average—the ninth smallest July sea ice extent since satellite records began in 1979.

### ASIA

Record warm temperatures were observed across parts of southern Asia. Overall, Asia had its sixth highest July temperature on record.

### EUROPE

Europe had its second highest July temperature departure from average. Several European countries had a July temperature that ranked among the six warmest Julies on record.

### SOUTH KOREA

South Korea had its second warmest mean and maximum July temperatures on record.

### SOUTH AMERICA

Warmer than average conditions were present across northern South America, while near to cooler-than-average conditions were present across southern South America. Averaged as a whole, South America had its smallest July temperature departure from average since 2012.

### AFRICA

Africa had its second highest July temperature since 1910. On July 5 the city of Ouargla in Algeria recorded a maximum temperature of 51.3°C (124.3°F)—possibly the highest temperature on record in Algeria.

### ANTARCTIC SEA ICE EXTENT

July 2018 sea ice extent was 1.9 percent below the 1981–2010 average—the eighth smallest July sea ice extent on record.

### AUSTRALIA & NEW ZEALAND

Australia and New Zealand had their fifth highest July temperature on record.

Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: <http://www.ncdc.noaa.gov/sotc>



# Selected Significant Climate Anomalies and Events in 2018

### ARCTIC SEA ICE EXTENT

During its growth season, the Arctic had its second smallest annual maximum extent. During its melt season, the Arctic reached its sixth smallest minimum extent on record (tied with 2008 and 2010).

### ALASKA

Alaska had its second warmest year on record, trailing behind 2016.

### EUROPE

Much-warmer-than-average conditions engulfed much of Europe for most of 2018, resulting in the warmest year on record. Several countries had a record or near-record warm year. France, Germany, and Switzerland had a record warm year; while, Denmark and the Netherlands had their second warmest year on record.

### HAWAII

Heavy rain in April triggered floods and mudslides across parts of Hawaii. A rain gauge on Kauai's North Shore reported 1262.13 mm (49.69 inches) of rain in a 24-hour period, a new U.S. national record.

### CONTIGUOUS UNITED STATES

The yearly precipitation total across the contiguous U.S. was the third wettest year on record. The years 1973 and 1983 were wetter.

### ATLANTIC HURRICANE SEASON

Above average activity  
15 storms, 8 hurricanes

### ASIA

Iraq, United Arab Emirates, Qatar, Turkmenistan, Pakistan, Uzbekistan, and Tajikistan set new national March temperature records. Asia set a new continental maximum temperature record for March when temperatures across Pakistan soared to 45.5°C (113.9°F).

### EASTERN NORTH PACIFIC HURRICANE SEASON

Above average activity  
23 storms, 13 hurricanes

### HURRICANE MICHAEL

(October 7–12, 2018)  
Maximum winds - 250 km/hr  
Michael was the third most intense hurricane to make landfall in the contiguous U.S. based on central pressure and the fourth most intense based on wind speed.

### HURRICANE FLORENCE

(August 31–September 17, 2018)  
Maximum winds - 220 km/hr  
Florence brought record rainfall and caused significant damage to the Carolinas.

### ALGERIA

On July 5, the city of Ouargla recorded a maximum temperature of 51.3°C (124.3°F), the highest temperature ever recorded in Algeria.

### CYCLONE MEKUNU

(May 21–27, 2018)  
Maximum winds - 185 km/hr  
The fourth strongest cyclone in the Arabian Sea. Salalah, Oman, received over twice its annual average precipitation for the city in a 36-hour period.

### NORTH INDIAN OCEAN CYCLONE SEASON

Above average activity  
8 storms, 4 cyclones

### WESTERN PACIFIC OCEAN TYPHOON SEASON

Above average activity  
29 storms, 13 typhoons

### TYPHOON YUTU

(October 21–November 2, 2018)  
Maximum winds - 285 km/hr  
Yutu was the strongest typhoon to affect the Mariana Islands on record.

### ARGENTINA

Argentina had its ninth warmest year since national records began in 1961.

### SOUTH INDIAN OCEAN CYCLONE SEASON

Below average activity  
8 storms, 7 cyclones

### AUSTRALIAN CYCLONE SEASON

Average activity  
11 storms, 3 cyclones

### AUSTRALIA

Had its third warmest year since national records began in 1910.

### SOUTHWEST PACIFIC OCEAN CYCLONE SEASON

Below average activity  
6 storms, 3 cyclones

### ANTARCTIC SEA ICE EXTENT

During its growth season, the Antarctic had its fourth smallest annual maximum extent. During its melt season, the Antarctic reached its second smallest minimum extent on record.

### NEW ZEALAND

The 2018 national temperature for New Zealand tied with 1998 as the second highest temperature on record, behind 2016.

Please Note: Material provided in this map was compiled from NOAA's NCEI State of the Climate Reports and the WMO Provisional Status of the Climate in 2018. For more information please visit: <http://www.ncdc.noaa.gov/sotc>

# Selected Significant Climate Anomalies and Events January 2019

## GLOBAL AVERAGE TEMPERATURE

January 2019 average global land and ocean temperature tied with 2007 as the third highest for January since records began in 1880.

## ARCTIC SEA ICE EXTENT

January 2019 sea ice extent was 6.0 percent below the 1981–2010 average—the sixth smallest January sea ice extent since satellite records began in 1979.

## NORTH AMERICA

Much of northern North America had near- to cooler-than-average conditions, while parts of western North America had warmer-than-average conditions. North America's average temperature for January was the coolest since 2011.



## HAWAIIAN REGION

The Hawaiian region had its fifth warmest January on record.

## SOUTH AMERICA

South America had its fifth warmest January on record. Warmer-than-average conditions were present across much of South America, with parts of southern Brazil experiencing record warm January temperatures.

## CARIBBEAN ISLANDS

The January 2019 temperature across the Caribbean Islands was the 13th highest on record.

## AFRICA

Much of the southern half of Africa had much-warmer-than-average temperatures during January. Africa as a whole had its eighth highest (tied with 1985) January temperature on record.

## ASIA

Much of Asia had warmer-than-average conditions during January. The most notable temperature departures from average were present across parts of northeastern and southwestern Asia, where temperatures were 4.0°C (7.2°F) above average or higher.

## AUSTRALIA

Australia had its warmest January on record. The national mean temperature for January was 0.99°C (1.78°F) higher than the previous record set in 2013.

## NEW ZEALAND

New Zealand had its third warmest January since national records began in 1909.

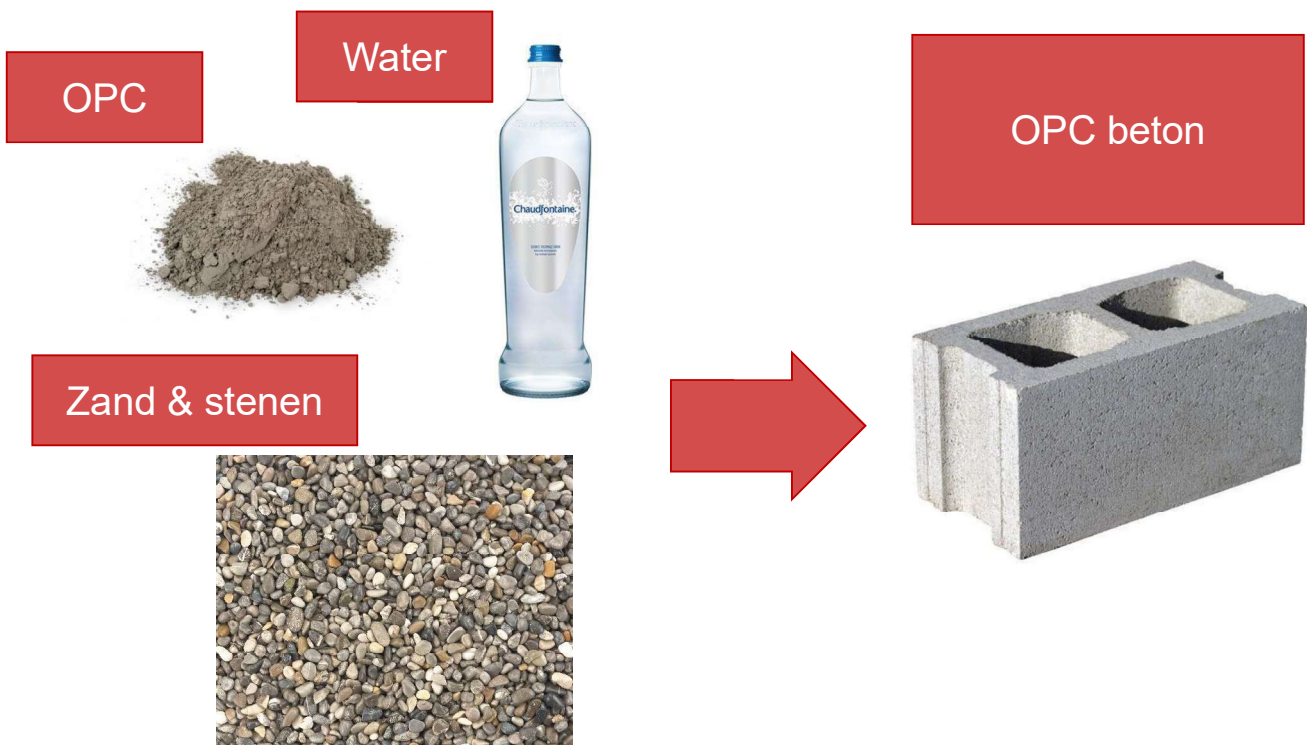
## ANTARCTIC SEA ICE EXTENT

January 2019 sea ice extent was 23.4 percent below the 1981–2010 average—the second smallest January sea ice extent on record, behind 2017.

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# Tijd voor een nieuw soort cement



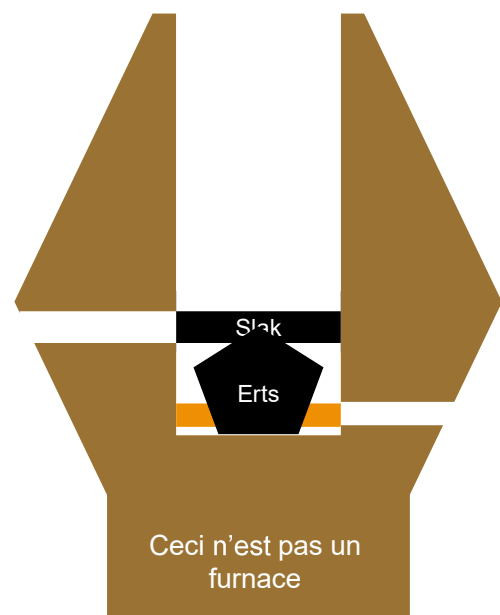
# Tijd voor een nieuw soort cement



## Wat is een slak?

- Slak = residu uit metaalproductie
  - “minder waardevolle” elementen
  - Ca, Si, (Al, Fe) – oxiden
- ⇒ Staalproductie (hoogovenslak): Calcium (alumino)silicaat slak
- ⇒ Koper/lood/non-ferro industrie: Fe-silicaat slak

*Ja, er is meer dan hoogovenslak!*



# Waarom worden non-ferro slakken nu niet gebruikt in (de reactieve fractie van) beton?

- Lage pozzolane activiteit (reageert niet met  $\text{Ca}(\text{OH})_2$ )  
⇒ Kleine substitutie van cement

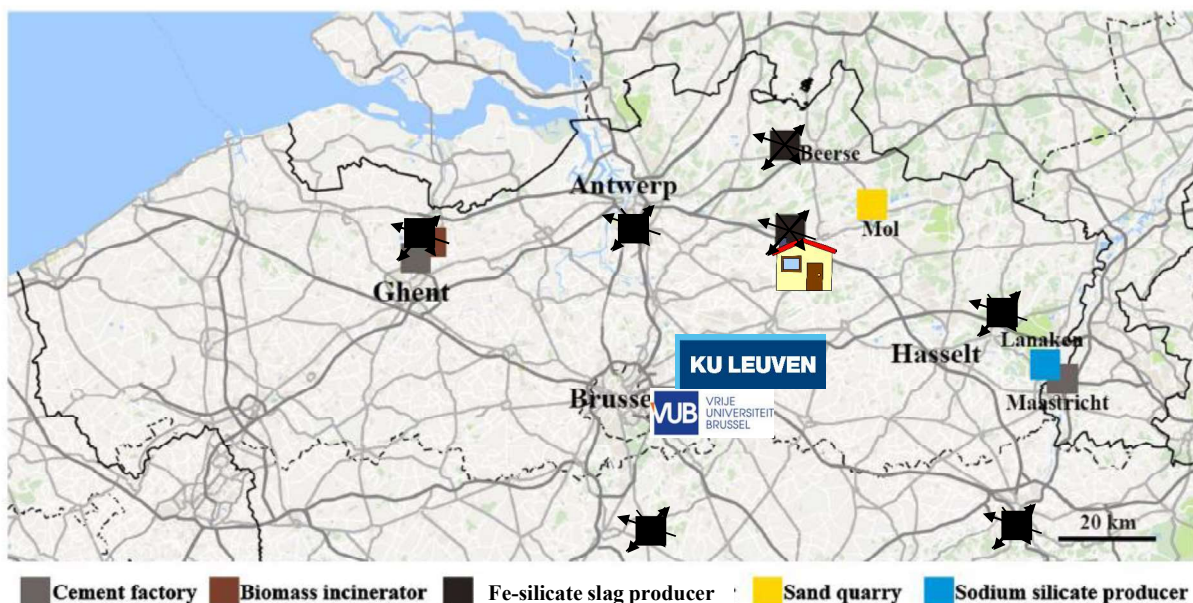
*Jammer, want zeer groot volume in België*

13

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## Hoge densiteit slakproducenten

- Veel keus in leverancier
- Logistiek interessant

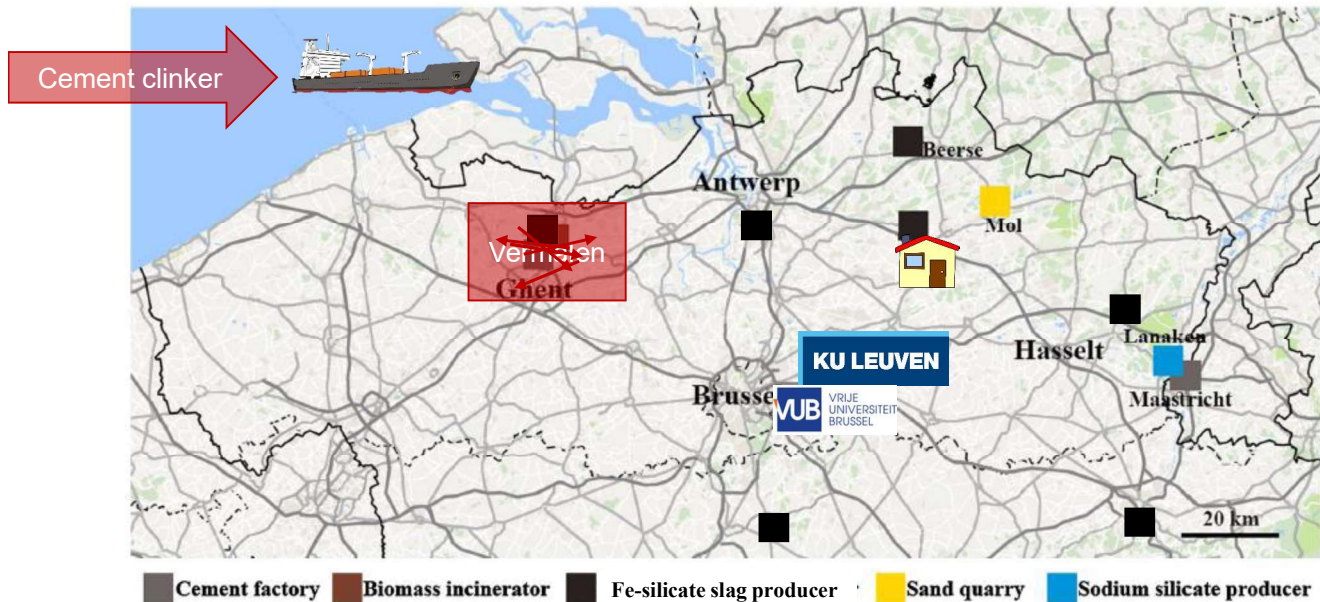


14

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# Weinig aanleveringsmogelijkheden cement

- Clinker wordt per boot aangebracht, vermalen en verdeeld



15

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## Waarom worden non-ferro slakken nu niet gebruikt in (de reactieve fractie van) beton?

- Lage pozzolane activiteit  
(reageert niet met  $\text{Ca}(\text{OH})_2$ )  
⇒ Kleine substitutie van cement

Jammer, want zeer groot volume in België

16

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# Waarom werkt ons cement dan wel?

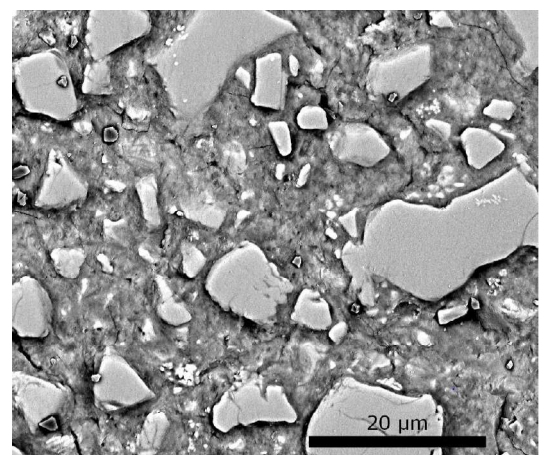
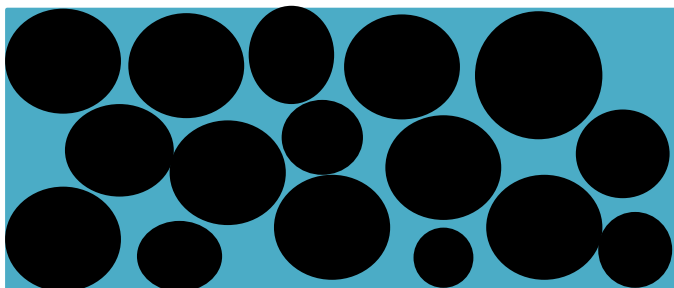


17

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## Hoe werkt dat dan (ongeveer)?

- Reactiemechanisme
  - Slak lost op in alkalische vloeistof + maakt binder
  - Resulterende microstructuur = binder & niet gereageerd slak



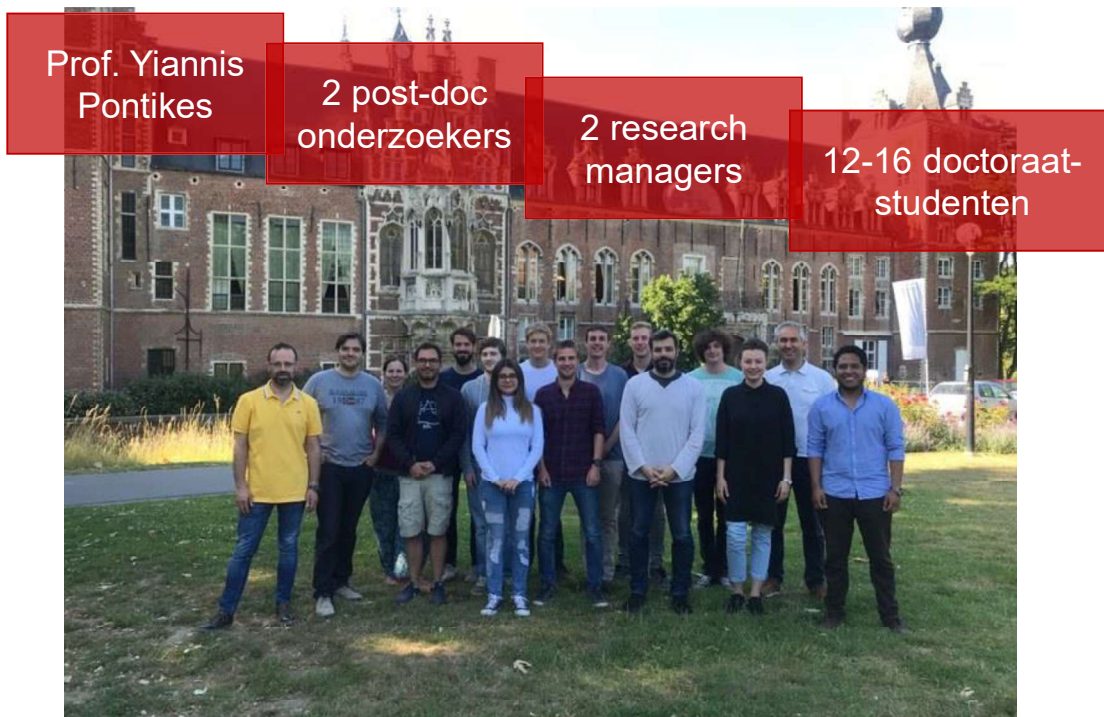
18

SEM image from master thesis Vincent Hallet

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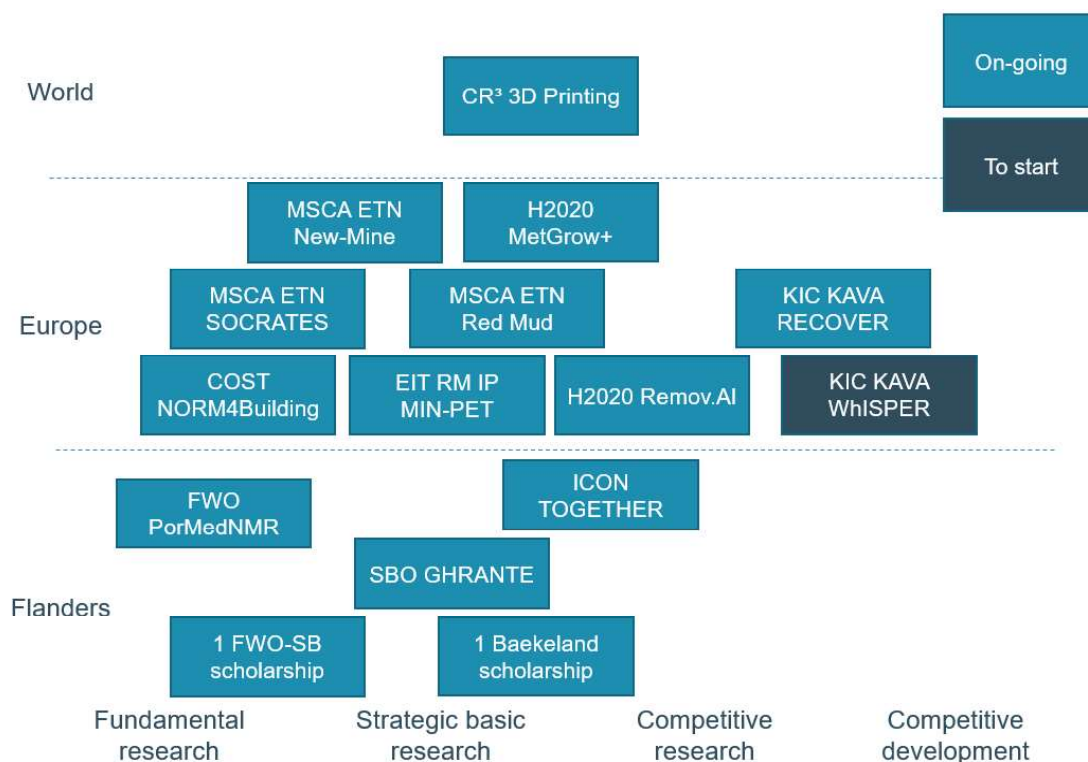
# SREMat onderzoeksgroep

<https://www.youtube.com/watch?v=0kpwPIEluX8>



meer informatie: [sremat.be](http://sremat.be)

# SREMat onderzoeksprojecten



# Voorbeelden projectresultaten



Picture from redmud.org

Pyro  
treatment

Milling



- Tobias Hertel
- ETN-MSCA Red Mud, funded by European Commission
- Valorization of red mud in inorganic polymers by pyro-treatment

21

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# Voorbeelden projectresultaten

- Lukas Arnout
- SIM ICON SuperMEX, funded by IWT/VLAIO, in collaboration with Ergon (CRH), Lier
- Ultra high performance concrete development
  - 160 MPa compressive strength, 36 MPa flexural (200 and 40 in lab)

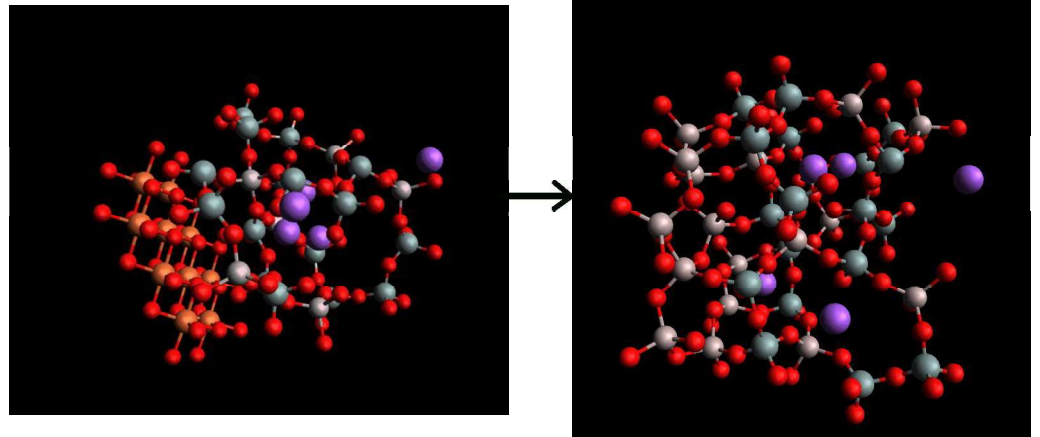


22

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# Voorbeelden projectresultaten

- Arne Peys
- FWO-SB



Fe same as slag

$\text{VIFe}^{2+}$  in binder

$\text{IVFe}^{3+}$  in binder



# Digitalisering: een nieuwe motor

- Vlottere acceptatie als online tool eigenschappen kan voorspellen?
- Begint bij database van residus



# SReDat: centraal punt voor info

- Online beschikbaar
- Vrij up- en downloaden van informatie
  - Kritisch beoordeelde database zal later tegen betaling beschikbaar worden



## Search the Secondary-Resource Database

Resource-Category Type  
--- Select Resource-Category Type ---

Resource Name

SREWay code

Location

Source

Elements Included

Elements Excluded

## SReDat: voorbeeld

Home / Secondary Resources / Jorn S4

### Jorn S4



#### Basic Information

<b>Name</b>	Jorn S4
<b>Critically Assessed</b>	No
<b>Resource Category</b>	WASTES RESULTING FROM EXPLORATION, MINING, QUARRYING, AND PHYSICAL AND chemical processing of non-metalliferous minerals / wastes not otherwise specific

# SReWay: berekeningen

Describe your mixture for analysis

## Activating Solution

Alkali Atom

Please select Alkali atom

SiO<sub>2</sub>/M<sub>2</sub>O

H<sub>2</sub>O/M<sub>2</sub>O

## Mixture Mass Ratios

Solution/Slag

wt.% aggregates

Clear

Calculate Cost

Calculate Eco Impact

Back

## Slag Specifics

Price of Slag (€/ton)

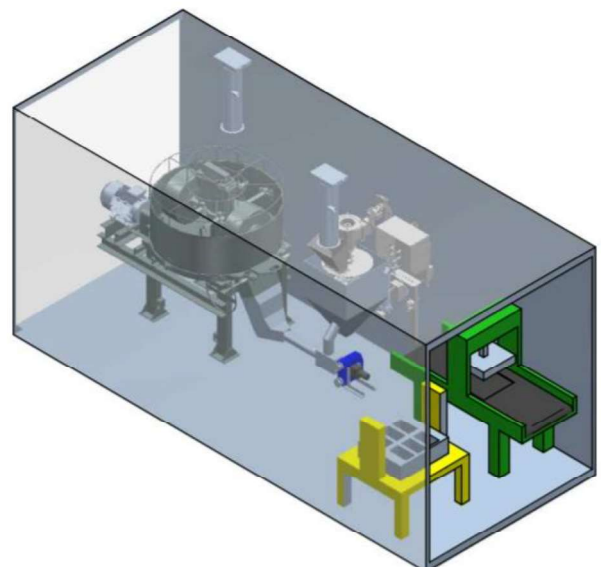
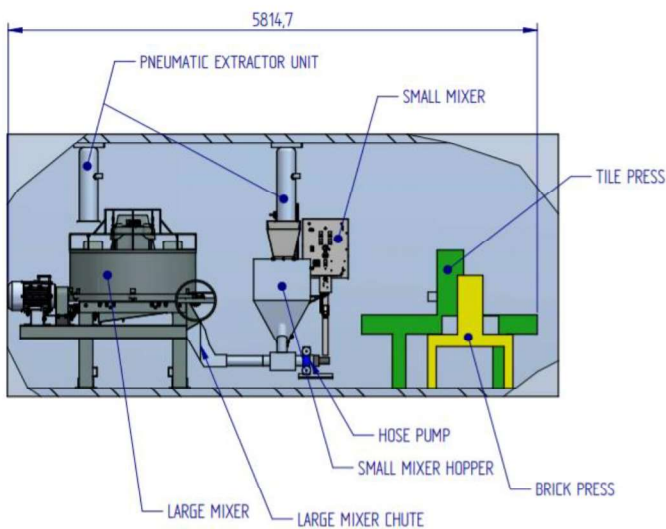
Price of Aggregates (€/ton)

27

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## Upscalen

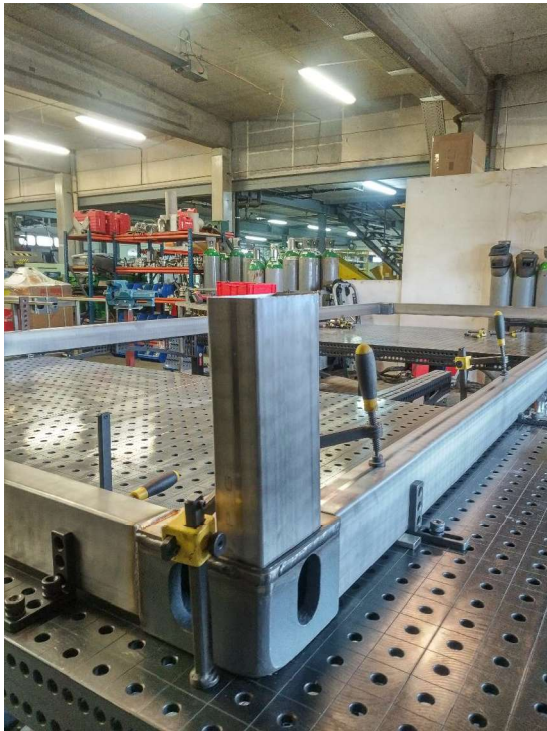
- We stoppen niet op labo-schaal
- Mobiele containers voor upscale trials



28

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# Mobiele containers: work in progress



29

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## Wat is nog niet mogelijk?

- Een zak ELCe kopen
- Een m<sup>3</sup> ready-mix ELCe bestellen
- Waarom?
  - Standaarden op basis van OPC chemie
  - Sociale acceptatie van een nieuwe binder

30

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# Want to know more about slags?

slag-valorisation-symposium.eu

## 6<sup>th</sup> International Slag Valorisation Symposium



Science, Innovation & Entrepreneurship  
in Pursuit of a Sustainable World

1-5 April 2019

Mechelen, Belgium

# Hartelijk dank!

# Vragen?

Het lijkt wel magie  
Als ik dat hard worden met water zie  
Het laat me niet kou  
Als ik die sterkte aanschouw  
Maar een echte vent  
Maakt beton zonder Portland cement

*Freddy Fayalite*