



100% Circular Concrete

Concrete Trash = Cash

Koos Schenk

SCC bv

We close the concrete circle

&

SmartCrusher bv

We close the circle



How did we come to this

- The **inventor**: Koos Schenk from SCC BV (see www.scc-oss.nl)
- SmartCrusher Europe is **licensed** by SCC (see www.slimbreker.nl)
- Figured out SmartCrushing and **patented** this (2011 and 2015)
- Build the **laboratory version** of the crusher
- With that the principle was **proven** (photo →)
- First **Real Scale SmartCrusher 1.0** (2013)
- With that **scalability** was shown
- Now TRL 9 = Ready for the market



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SmartCrushers are intended to make traditional recycling plants "Smart" and profitable. SmartCrushers are an addition.

What is the trick of SmartCrushers

- Concrete is a composite:
Strength of Sand and Gravel: approx. **200 MPa**
Strength of Cement Hydrate in concrete: approx. **14 MPa**
- SmartCrushers Crush with forces between 50 and 150 Mpa.
The exact power can be set
 - Crushes cement hydrate but not gravel and sand
 - Gravel, sand stays unharmed (no sharp edges)
 - After SmartCrushing and sieving / classifying, the same PSD of the sand and gravel will be obtained
- A part of the Cement fines can be sucked out of the SmartCrusher
 - After sieving the sand fraction can be separated from the cement fraction with classifiers

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Revenue Calculator investing in SmartCrusher

SmartCrushers are very profitable compared to traditional recycling only

Note: The pay back period is calculated without the CO2.
The actual pay back period is therefor much shorter

[Download the calculator here](#)

	Total	Unit	Concrete**	Gravel	Sand	Cement	Hydrate	Waste
Composition of the waste:	%		100%	43%	34%	0%	23%	0%
Price materials (ex transport):	27,60	€/ton	2	24	14,5	0	45	0
** E.g. Concrete € 2, means that the bringer has to pay € 2,- as a gate fee to get rid of the concrete rubble.								
Revenue								
0-80 mm								
SmartCrusher 2.0 capacity (per hour)	40	Tons/hr		17,20	13,60	0,00	9,20	0,00
Hourly Revenue:	1104	€/hr	80	413	197	0	414	0
SmartCrusher operating hours	1800	hr/year						
Note: Based on the current information the capacity will probably be higher								
SmartCrusher 2.0 capacity (per year)	72.000	Tons/year						
Revenue per ton	27,60	€/ton						
Yearly Revenue	1.987.200	€/year	144000	743040	354960	0	745200	0
1104 €/hour								
Total Cost	461.900	€/year						
257 €/hour								
Profit/year	1.525.300	€/year						
pay back period	0,7	years						
COSTS								
License fee	72.000	€/year						
Yearly other costs	389.900	€/year						
5,42 €/ton								

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SmartCrusher cement fines as a replacement

SmartCrusher cement fines as a replacement for traditional CaCO_3 cement industry kiln feed.

- CaCO_3 consists of 44% CO_2 , SmartCrusher Cement Fines are virtually CO_2 free
- SmartCrusher cement fines is "pre-baked cement" that can be upgraded to new cement with over 50% less energy; thus much less CO_2 , thus much less costs.

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Calculation example savings

Calculation example savings cement industry on CO2 tax:

- Suppose at the time concrete rubble was composed with 15% cement. That can be harvested again for 95% by the SmartCrusher (resulting in 14% cement).
- Suppose a SmartCrusher processes 40 tons/hour.
 $2000 \text{ hours/year} \times 14\% = 11,000 \text{ tons of CO}_2 \text{ free cement fines for the cement kiln.}$
- Assume €80/ton CO2 tax.
 $11,000 \text{ tons/year} \times €80 = €880,000/\text{year savings in CO}_2 \text{ tax with only one SmartCrusher!!}$

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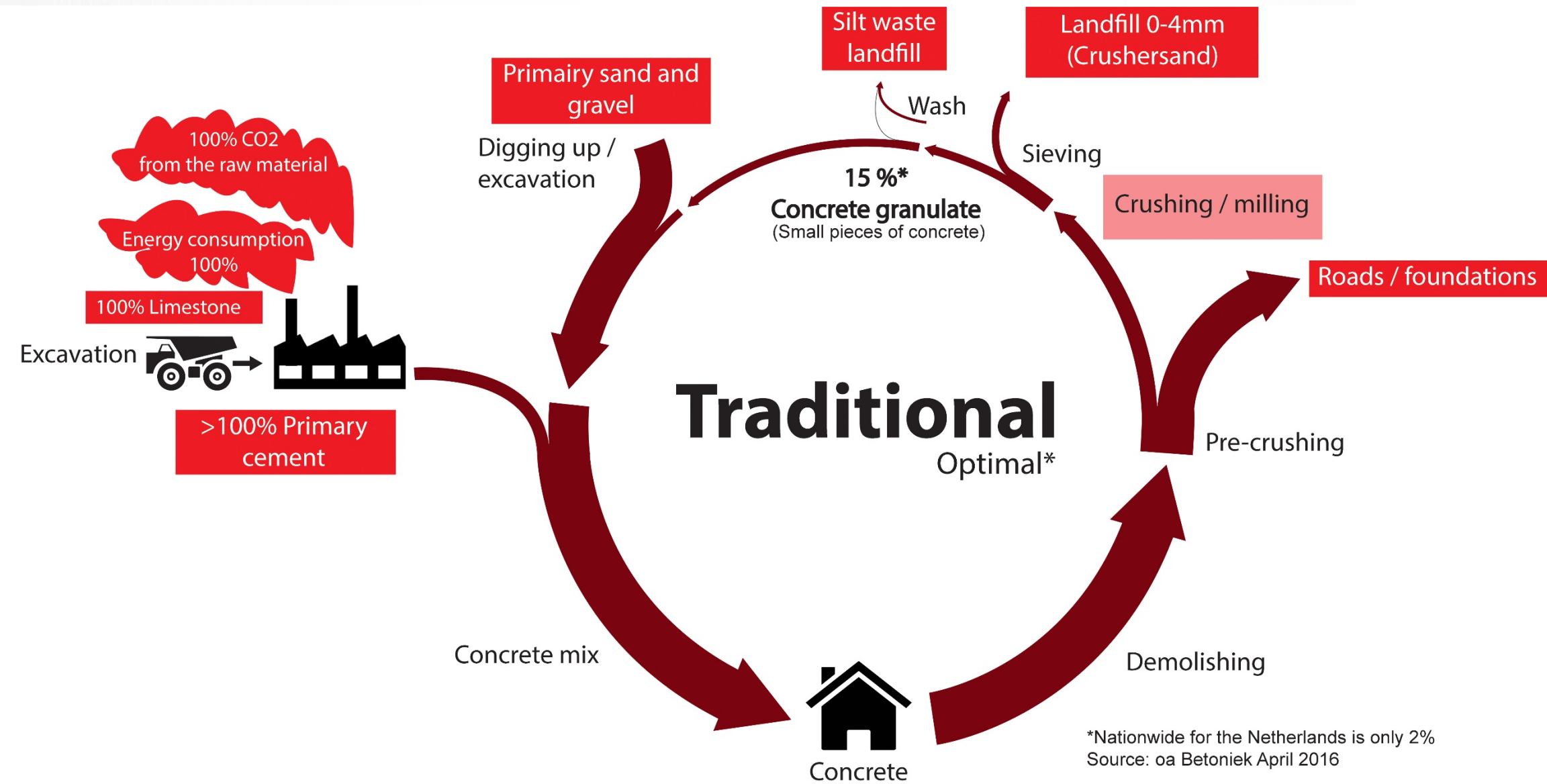
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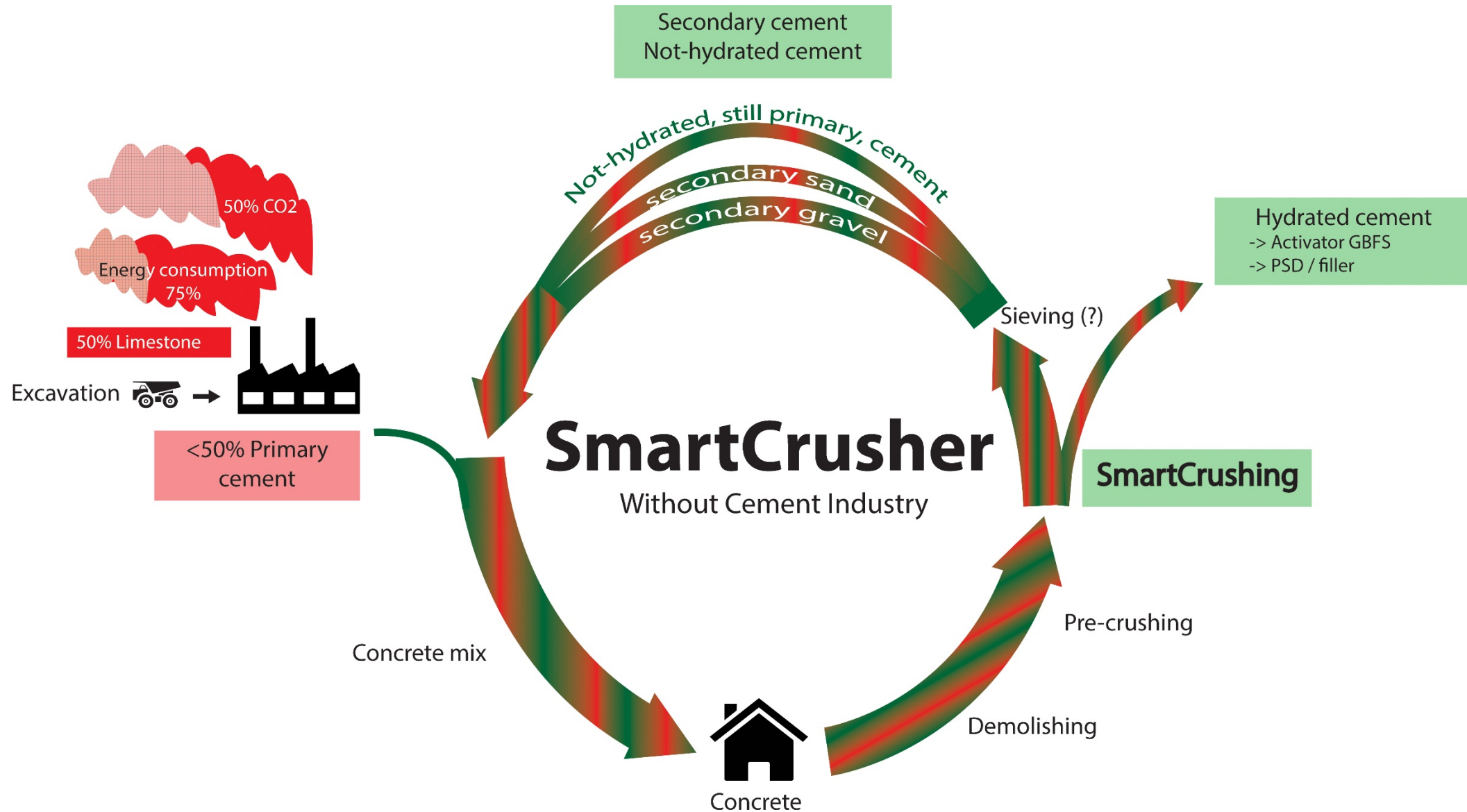
We close the circle



Circular concrete: Traditional



100% Circular concrete: SmartCrushing without Cement Industry



The most difficult thing about making cement is to ensure the right mix of Calcium, Silicate, Iron and Aluminum in the cement kiln. This mix ensures the correct chemical composition of the cement.

Cement hydrate from SmartCrushing is still the same mix, only now it contains some water

SmartCrusher cement hydrates can be seen as pre-baked cement which can be regenerated into new cement with about 50% less energy

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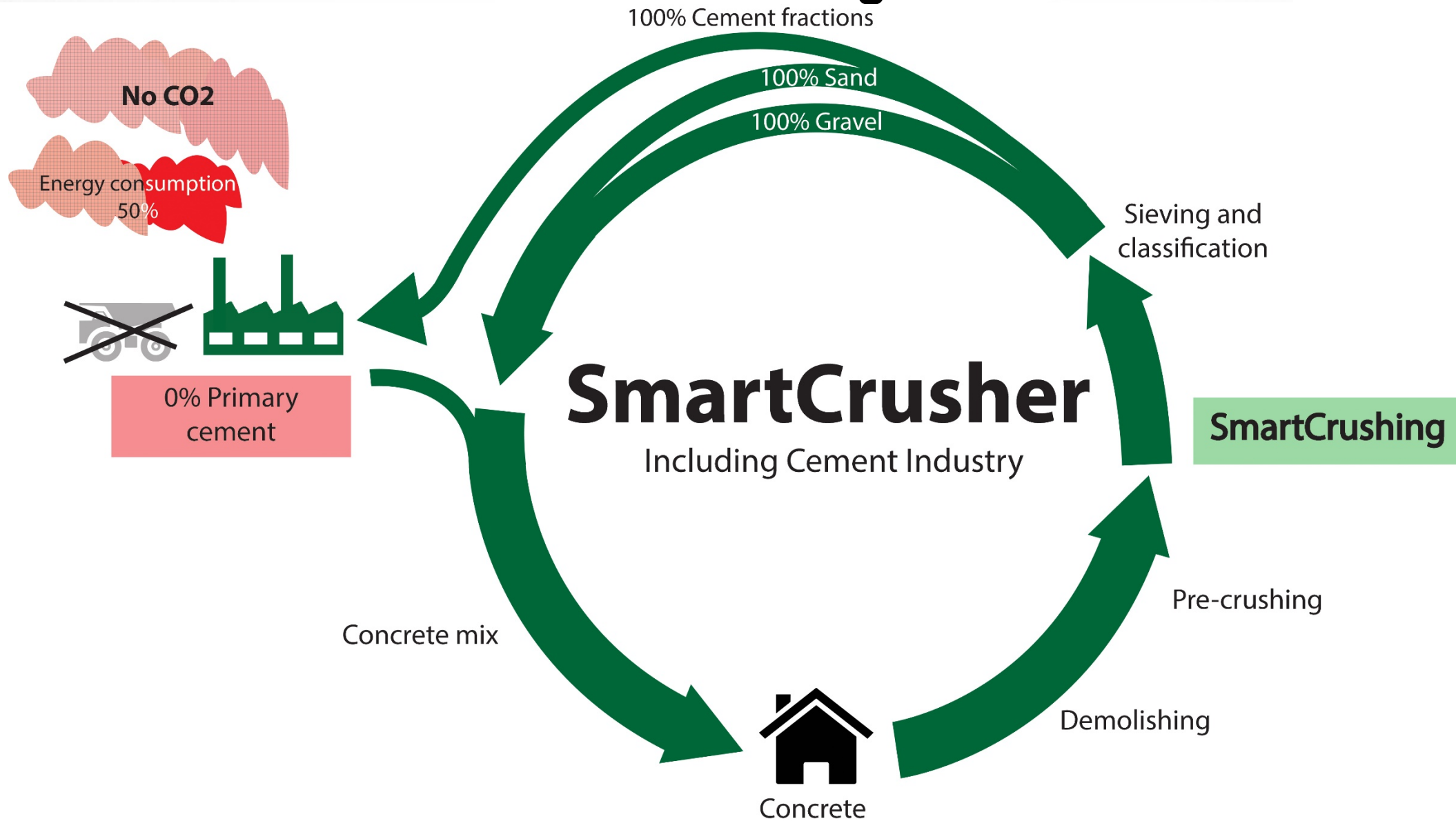
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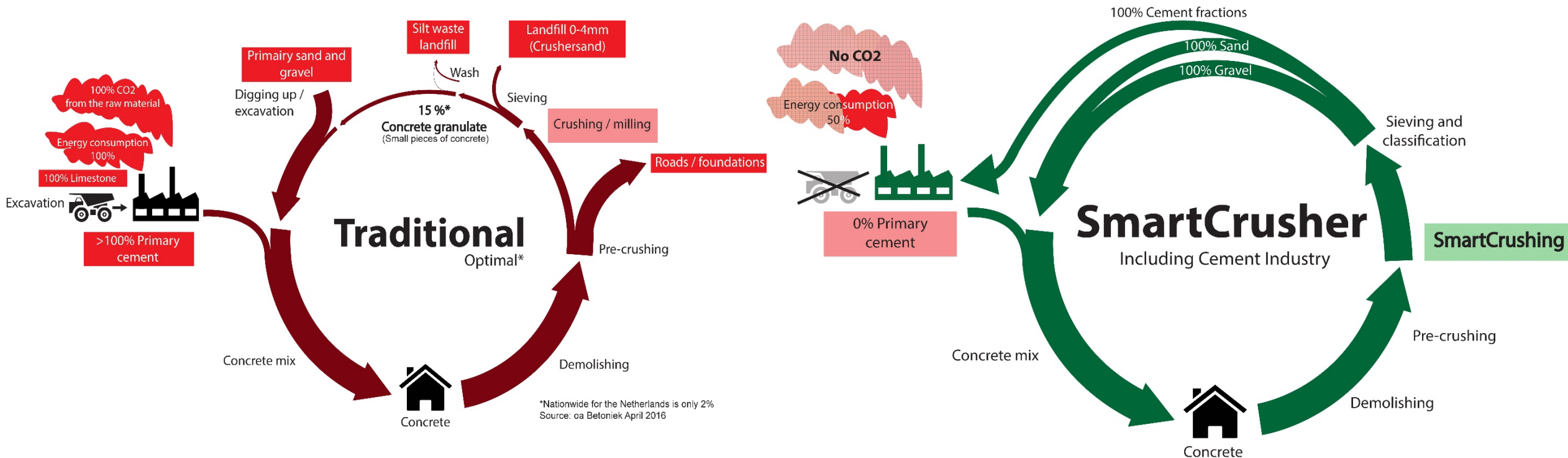
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100% Circular concrete: SmartCrushing with the Cement Industry



100% Circular concrete: SmartCrushing



“Overall, the results show that recycling concrete can reduce the impact by more than 50% for each of the impact categories. Moreover, the CO₂ emission can even be reduced by almost 75% When the concrete is recycled.”

(from Closed-loop Economy University Leiden and TU Delft)

SmartCrusher sand and gravel is better than New

- **SmartCrusher sand** compared to Norm sand has better properties in concrete
- **SmartCrusher sand and gravel can be immediately reused in new concrete**
- **Traditional crusher sand** is not suited to be re-used in concrete

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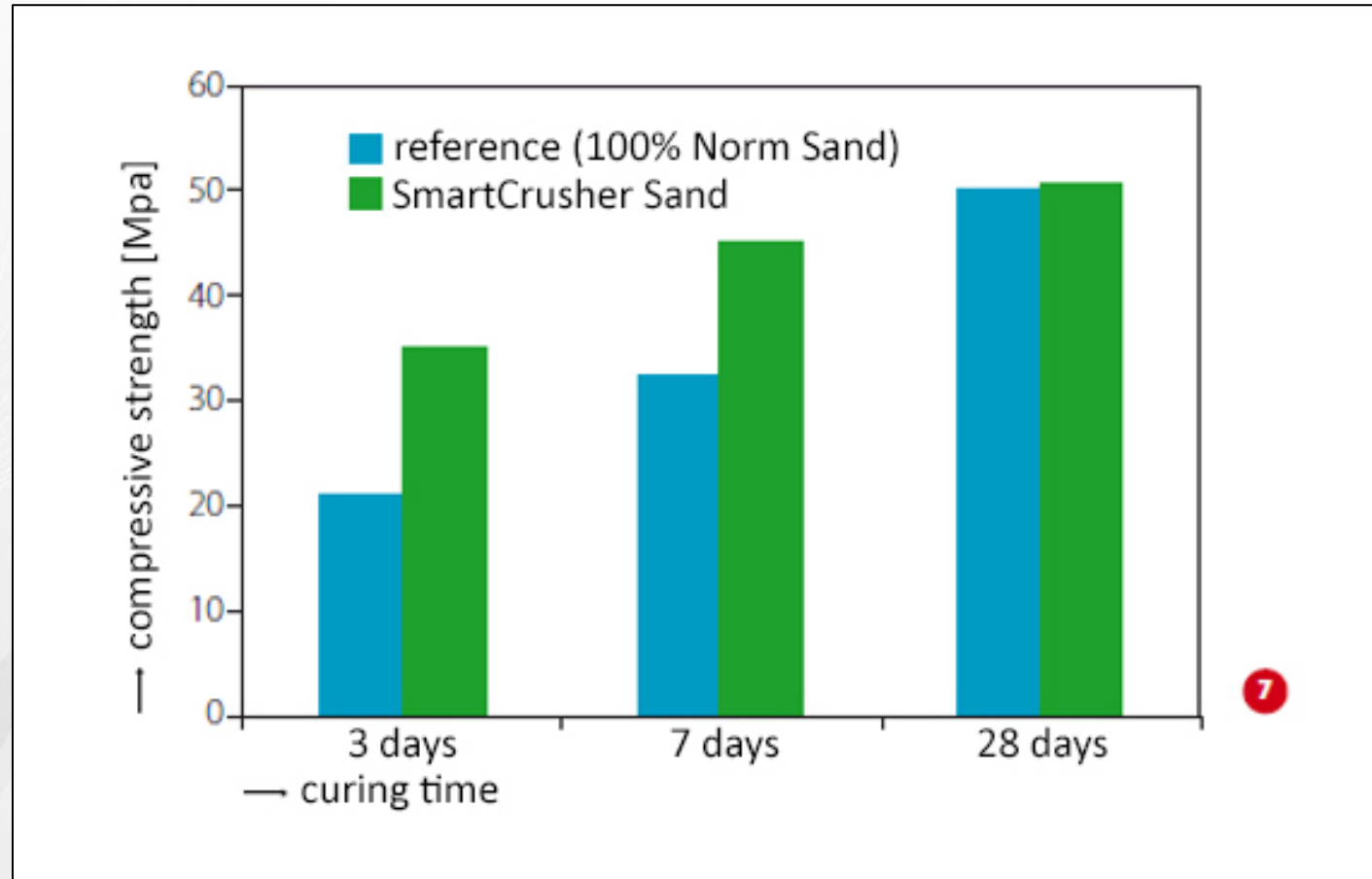
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“SmartCrushing closes the material circle” (Source: Bouwstenen 192 TU/e)



SmartCrusher sand with the same PSA as standard test sand.
So less cement is needed for the same strength! == So less CO₂

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Comparison of materials

Comparison between **traditional crushed** concrete aggregate, **new gravel** and **SmartCrusher gravel**

	100% Traditional & ADR cf Reference	Reference = Primary	100% SmartCrushing cf Reference
Compr.strength - Begin	↓↓	=	= up to ↑↑
Comp.strength – End	↓↓	=	= up to ↑↑
Stifness – E modulus	↓↓	=	Equal to reference = primary
Permeability	↓↓	=	Equal to reference = primary
Processability	↓↓↓↓	=	Equal to reference = primary

In short:

Cement needed	↑↑ !	=	↓ !
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Source: [Betoneiek November 2011](#) and April 2016; the most right column is an addition by SmartCrusher bv

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SMARTCRUSHER SC2



Questions?

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Portland Cement without limestone

The cement chemical story summarised as dry CEM1, CEM1 with water and 30+ years experience and (CEM1) cement hydrate after dehydration through heating at about 500 °C

Cementminerals			The reaction of CEM1 with water (H)			After dehydration		
Before reaction with water and after dehydration								
C ₃ S	55%	-	2C ₃ S + 6H	->	C ₃ S ₂ H ₃ + 3Ca(OH) ₂	will C ₃ S ₂ H ₃	->	C ₂ S + CS
C ₂ S	15%	28%	2C ₂ S + 4H	->	C ₃ S ₂ H ₃ + Ca(OH) ₂	will Ca(OH) ₂	->	CaO
C ₃ A	10%	16%	C ₃ A + 6H	->	C ₃ AH ₆	C ₃ A		
C ₄ AF	10%	-	C ₄ AF + 2Ca(OH) ₂ + 10H	->	C ₃ AH ₆ + C ₃ FH ₆	C ₃ A + C ₃ F		
C ₃ F	-	7%	C ₃ A + 3CaSO ₄ + 32H	->	C ₃ A <u>S</u> H ₃₂	C ₃ A + SO ₂		
CS	-	19%						
C	-	21% = CaO = quicklime						
<u>S</u>	2%	2%						

After 24 hours the C₃ASH₃₂ will partly transfer into C₃ASH₁₄ (mono sulphate). Depending on the cement class (A, B or C) and the watercementfactor (wcf), there will always remain new, unhydrated cement, in addition to the minerals mentioned above.

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SmartCrusher Cement fines CO2-Free

The traditional raw material CaCO_3 consists of 44% CO_2 that is released when making cement. SmartCrusher cement fines are free of CO_2 .

SmartCrusher cement fines are therefore a CO_2 -free feed for the cement kiln.

Cement stone from concrete rubble can be seen as "pre-baked cement", in which all ingredients, such as C_2S , $\text{Ca}(\text{OH})_2$, Aluminum and iron are present in the right amount.

The SmartCrusher cement fines only need to be fired again in the cement kiln.

The difference in CO_2 emissions compared to CaCO_3 is huge.

Traditionally, the high-energy CaCO_3 has to be extracted, crushed, dried and ground from a quarry with expensive crushers and dump trucks, mixed with SiO_2 and alm and iron before it can be transferred into the cement.

First of all, a lot of energy is needed in the cement kiln to decarbonize the CaCO_3 into CaO and CO_2 . After that, it takes a lot of energy to turn "C" and "S" into " C_2S ". Cement fines from concrete rubble is mainly C_2S hydrate!!

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