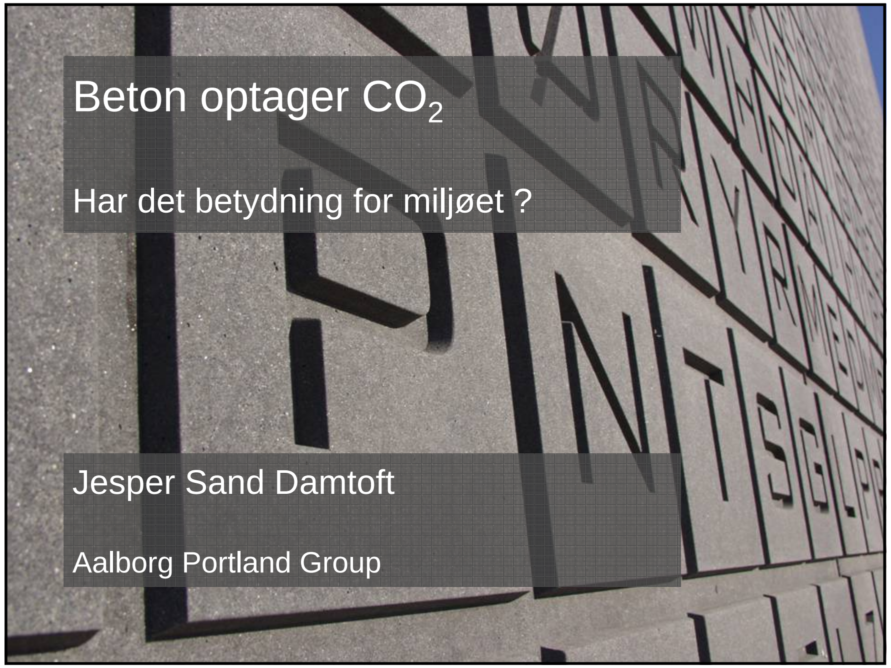
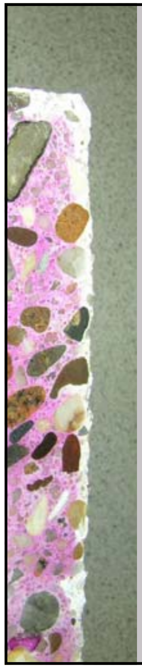

Beton optager CO_2
Har det betydning for miljøet ?
Jesper Sand Damtoft
Aalborg Portland Group

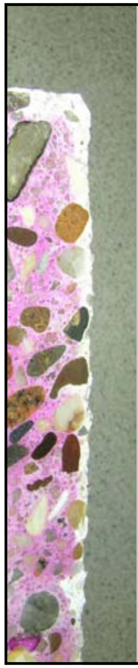


CO_2 emission fra cementproduktion

aalborg portland group

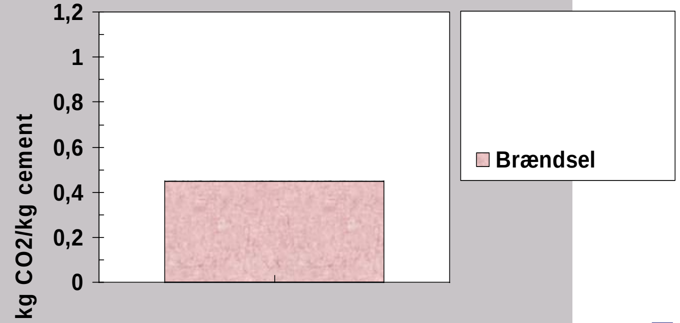
Baggrund

Research and Development Centre



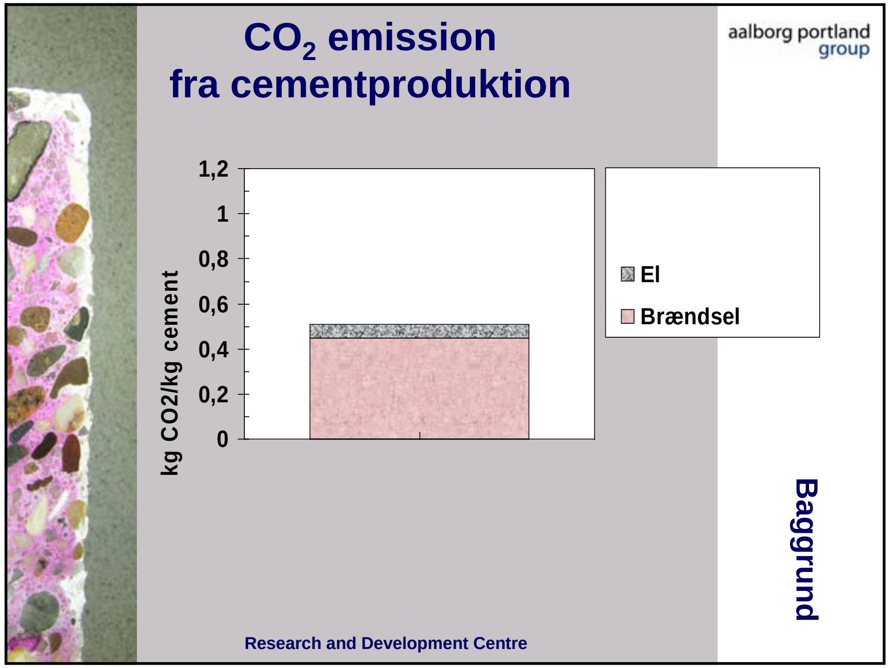
CO_2 emission fra cementproduktion

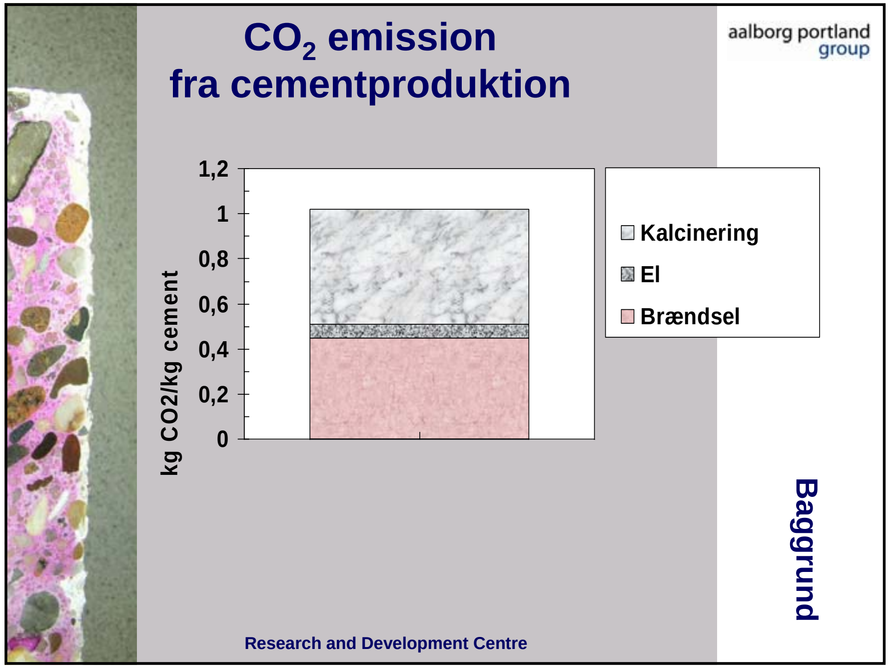
aalborg portland group

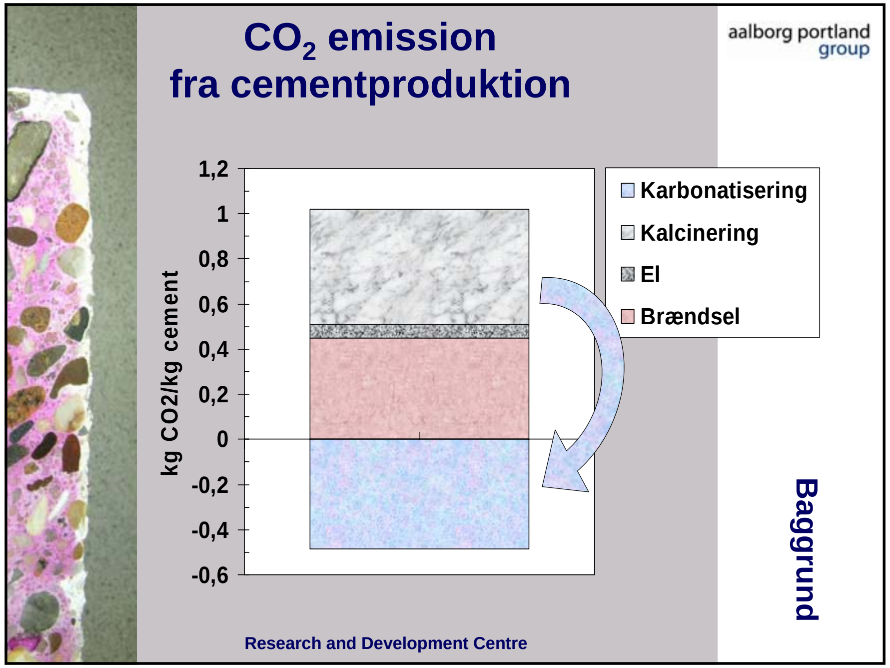


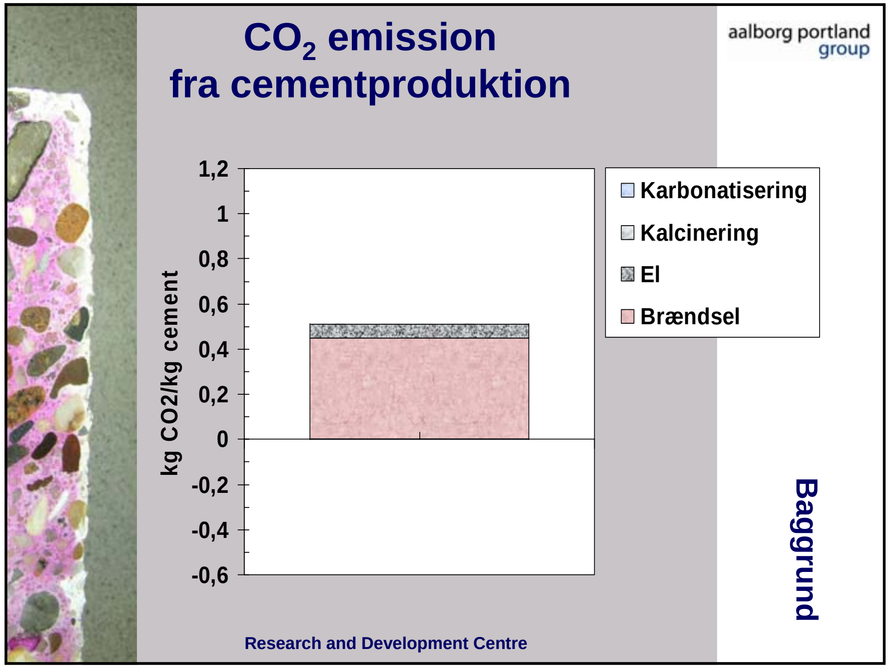
Baggrund

Research and Development Centre

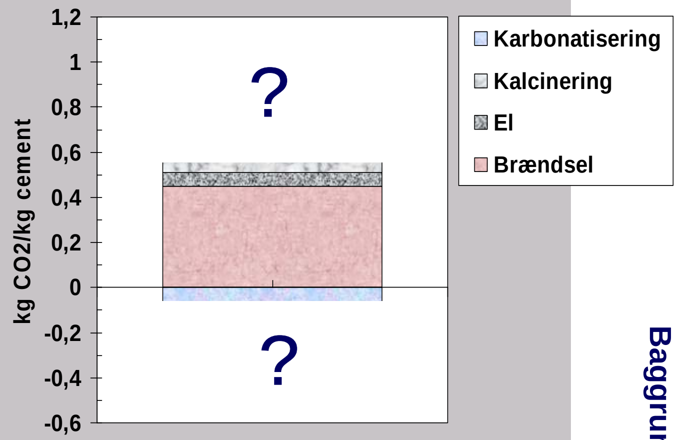

CO_2 emission
fra cementproduktion
aalborg portland group
1,2
1
0,8
0,6
0,4
0,2
0
kg CO2/kg cement
El
Brændsel
Baggrund
Research and Development Centre


CO_2 emission
fra cementproduktion
aalborg portland group
1,2
1
0,8
0,6
0,4
0,2
0
kg CO2/kg cement
Kalcinering
El
Brændsel
Baggrund
Research and Development Centre


CO2 emission
fra cementproduktion
aalborg portland group
1,2
1
0,8
0,6
0,4
0,2
0
-0,2
-0,4
-0,6
kg CO2/kg cement
Karbonatisering
Kalcinering
El
Brændsel
Baggrund
Research and Development Centre


CO2 emission
fra cementproduktion
aalborg portland group
1,2
1
0,8
0,6
0,4
0,2
0
-0,2
-0,4
-0,6
kg CO2/kg cement
Karbonatisering
Kalcinering
El
Brændsel
Baggrund
Research and Development Centre

CO_2 emission fra cementproduktion

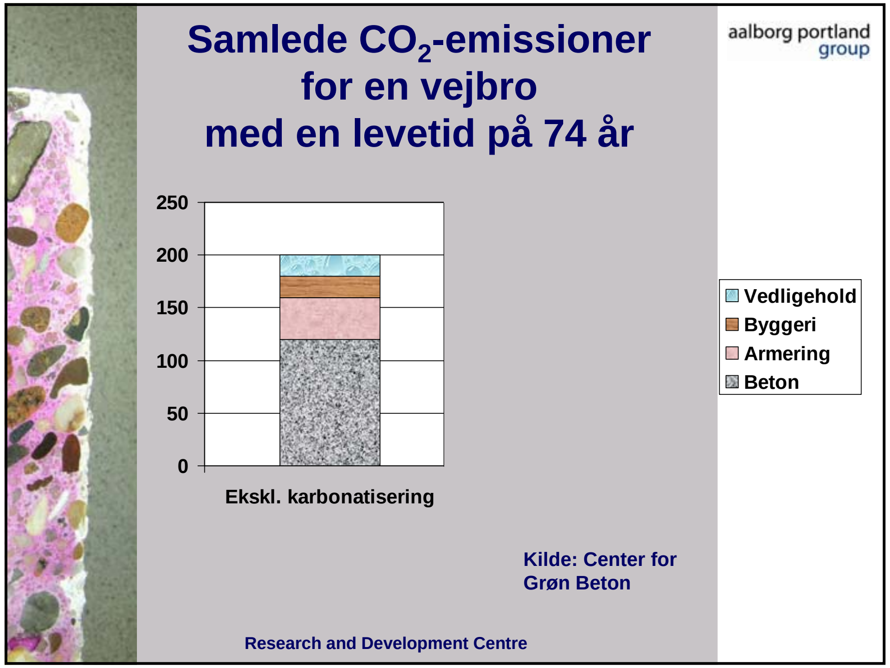


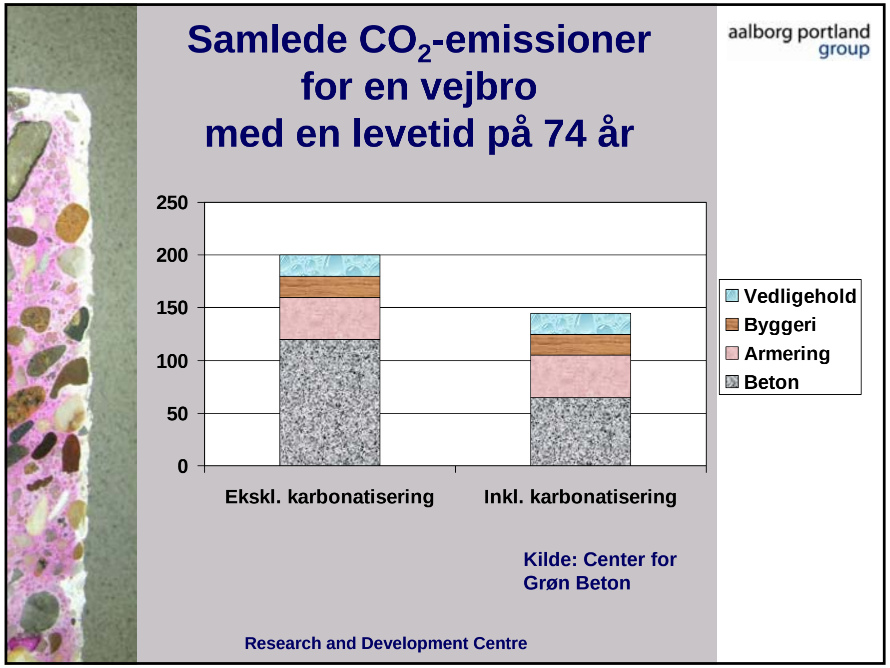
Baggrund

Research and Development Centre

Samlede CO_2-emissioner for en vejbro med en levetid på 74 år

Research and Development Centre


Samlede CO_2-emissioner
for en vejbro
med en levetid på 74 år
aalborg portland group
250
200
150
100
50
0
Ekskl. karbonatisering
Vedligehold
Byggeri
Armering
Beton
Kilde: Center for Grøn Beton
Research and Development Centre


Samlede CO_2-emissioner
for en vejbro
med en levetid på 74 år
aalborg portland group
250
200
150
100
50
0
Ekskl. karbonatisering
Inkl. karbonatisering
Vedligehold
Byggeri
Armering
Beton
Kilde: Center for Grøn Beton
Research and Development Centre

aalborg portland group

Mål

Mål

Dokumentere miljøeffekten af betons karbonatisering, dvs. CO_2-optag i de Nordiske lande.

Budget

2,6 mill. kr.

Projektperiode

December 2003 – december 2005

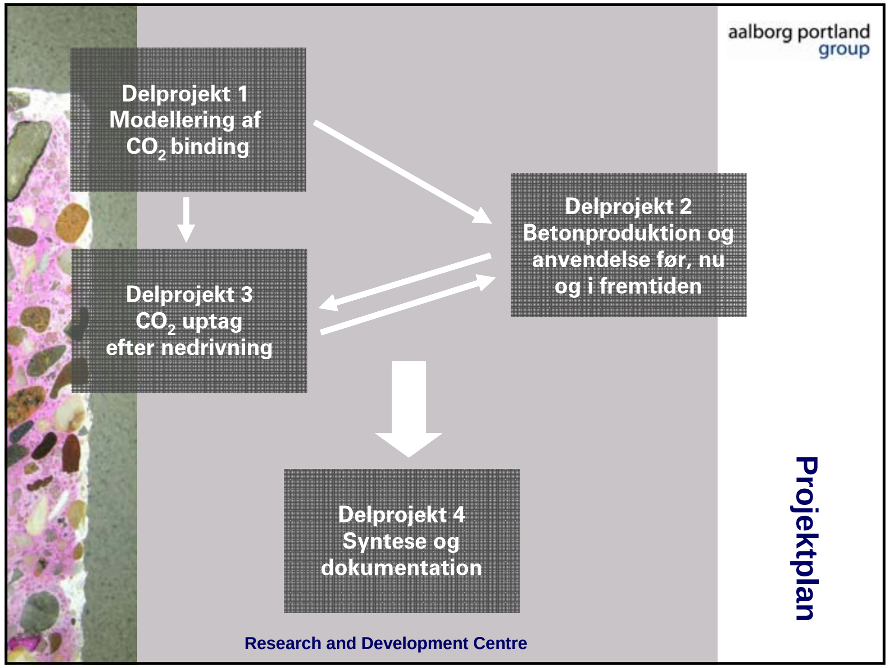
Research and Development Centre

aalborg portland group

Partnere

Teknologisk Institut, DK
Aalborg Portland A/S, DK
Betonindustriens Fællesråd, DK
Cement och Betong Institutet, S
Cementa AB, S
Byggforsk, NO
Norcem A/S, NO
Elkem ASA Materials, NO
Icelandic Building Research Institute, IS

Research and Development Centre



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CO_2-optag

Karbonatiseringsdybde

$d_c = k \cdot (t)^{0.5}$

k - Hastighedsfaktor
t - Tid

CO_2-optag

$0.75 \cdot C \cdot CaO \cdot (M_{CO2}/M_{CaO})(kg/m^3)$

C - masse af Portland-cement klinker pr. m^3 beton
CaO – andel af CaO i cement-klinkerne (masse)
M - molmasse af hhv. CO_2 og CaO

Modeller

Research and Development Centre

Hastighed af CO_2-optag

	< 15 MPa	15-20 MPa	25-35 MPa	> 35 MPa
Eksponeret	5	2.5	1.5	1
Beskyttet	10	6	4	2.5
Indendørs	15	9	6	3.5
Vådt	2	1	0.75	0.5
Begravet	3	1.5	1	0.75

$mm/year^{0.5}$

Modeller

Research and Development Centre

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Betonproduktion i Norden

- Mængde beton produceret i 1950 og 2003
- Betontyper
- Gennemsnitlig tykkelse af hver betontype
- Eksponering

Statistik

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Betonproduktion i Norden

- Mængde beton produceret i 1950 og 2003
- Betontyper
- Gennemsnitlig tykkelse af hver betontype
- Eksponering

Ready-mixed concrete		Pre-cast elements		Pre-cast products	
	Thickness (mm)		Thickness (mm)		Thickness (mm)
Walls	180	Hollow-core slabs	300	Paving	60
Slabs	200	Other slabs	120	Blocks	160
Foundations	240	Roof	120	Elements	120
Civil eng. structures*	400	Walls	220	Pipes and others	60
		Facades	70+150		
		Columns/Beams	300x300		
		Other	150		

Statistik

Research and Development Centre

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Affald fra nedrivning

	Betonaffald (tons)
Norge	650.000-975.000
Danmark	800.000-1.200.000
Sverige	1.080.000-1.200.000
Island	52.000
Finland	630.000-720.000

Genanvendelse af beton

Research and Development Centre

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Genanvendelse af beton

- % af betonaffald, der genanvendes
- Partikelstørrelsesfordeling af nedknust beton
- Eksponering

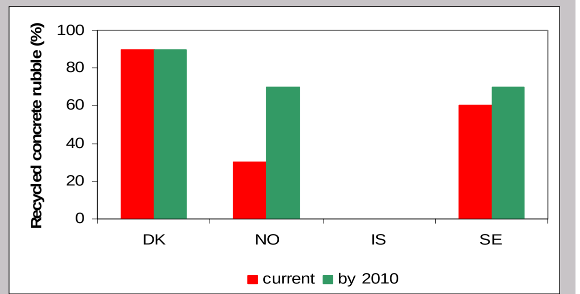
Genanvendelse af beton

Research and Development Centre

aalborg portland group

Genanvendelse af beton

- % af betonaffald, der genanvendes
- Partikelstørrelsesfordeling af nedknust beton
- Eksponering



Genanvendelse af beton

Research and Development Centre

Betydning af partikelstørrelse

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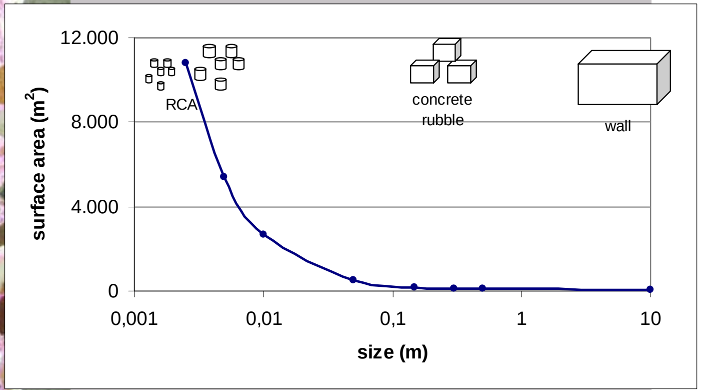

Genanvendelse af beton

Research and Development Centre

Beregnet CO_2-optag i nedknust beton

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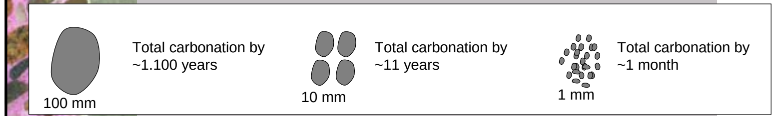
Particle sizes	%	Volume (m3)	Volume carbonated after 5 years (m3)
<1mm	21	140.252	**140.252**
1 -10mm	30	200.360	**200.360**
10-30mm	44	293.861	155.238
>30mm	5	33.393	7.056

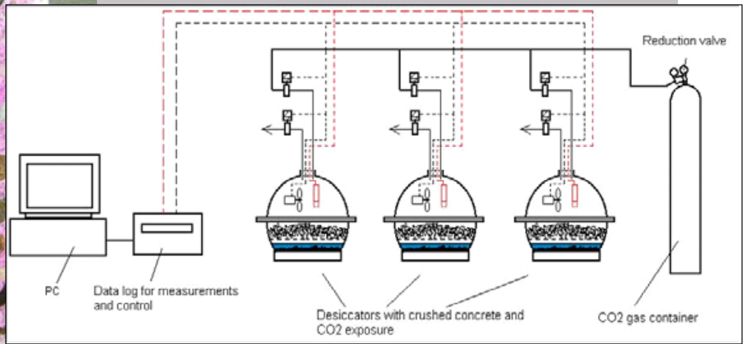


Beregning: **75%** karbonatiseret efter 5 år

Genanvendelse af beton

Research and Development Centre

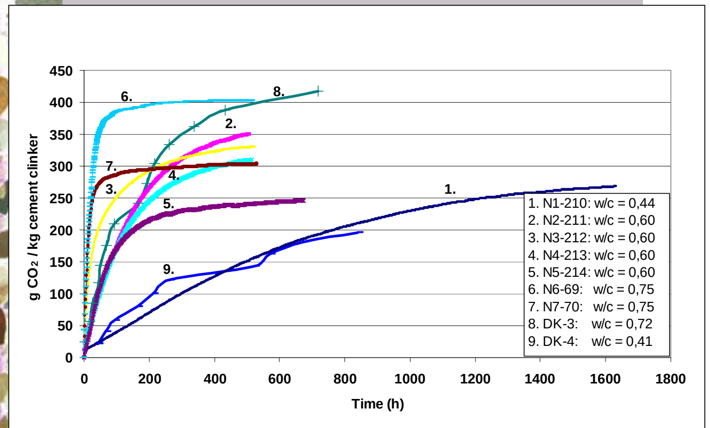
Accelereret prøvning



Genanvendelse af beton

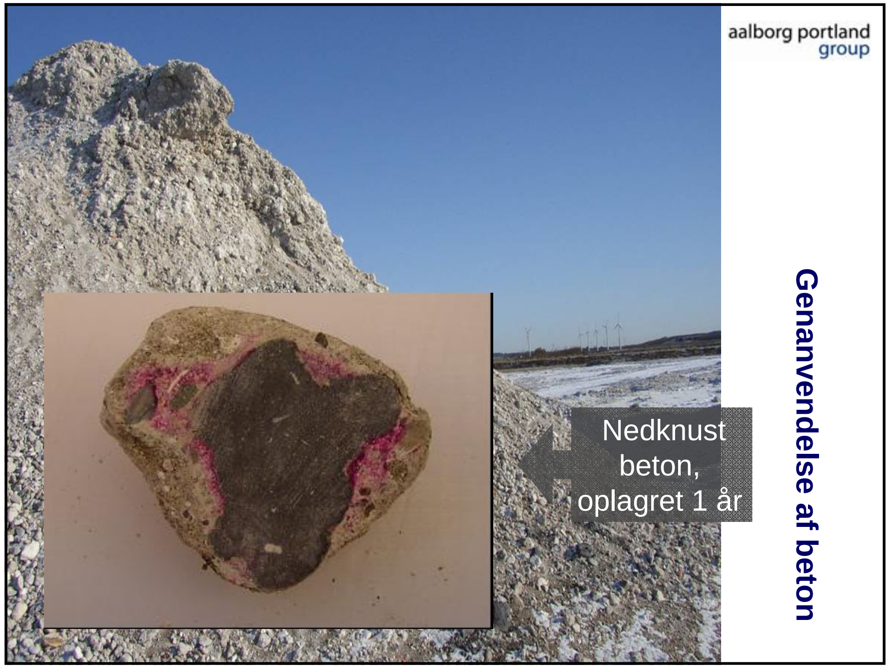
Research and Development Centre

Accelereret prøvning



Genanvendelse af beton

Research and Development Centre



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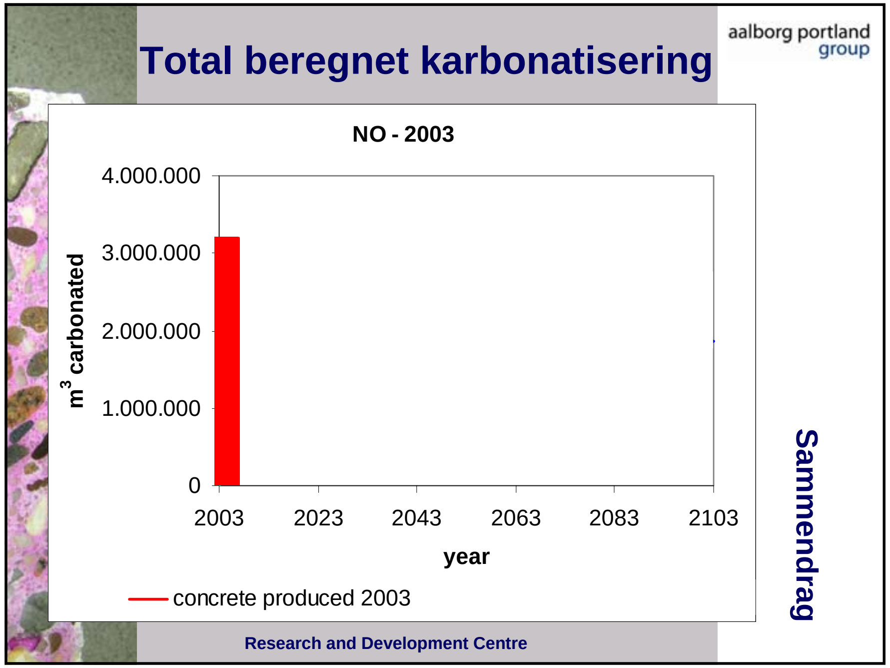
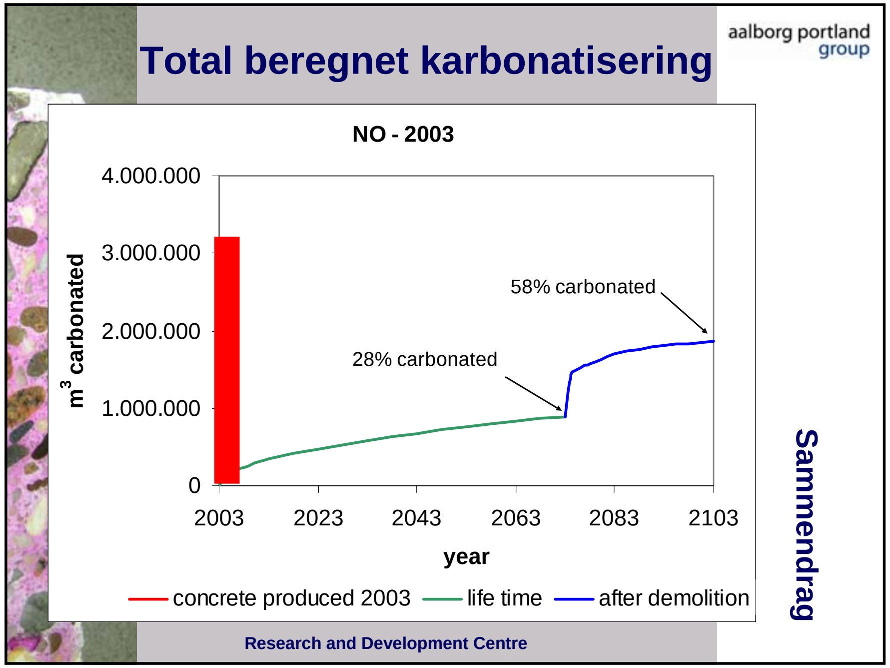
Vigtigste antagelser

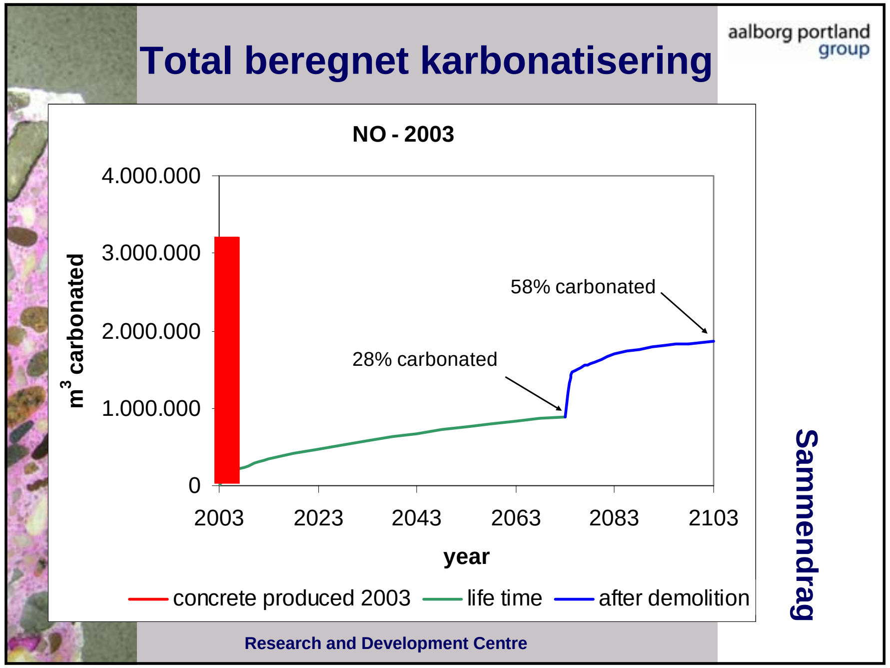
1. 75% a CaO i cement kan karbonatisere [100% CH + 50% (CSH + Afm + Aft)]
2. Karbonatisering beregnet for 100 år = 70 års levetid + 30 år efter nedrivning
3. Ca. 85% af al beton nedrives efter 70 år (dvs. alt beton, der ikke er våd eller begravet
4. 50 til 90% nedrevet beton genanvendes som nedknust beton
5. Kun den del af betonen, der nedknuses forventes at karbonatisere efter nedrivning
6. Karbonatiseringshastigheder blev anslået ud fra et litteraturstudium og er derfor formodentlig til den høje side
7. Karbonatiseringsmekanismen for nedknust beton antages at tilsvare den for stående betonkonstruktioner (dvs. udvaskning af calcium blev ikke taget med i regning)

Research and Development Centre

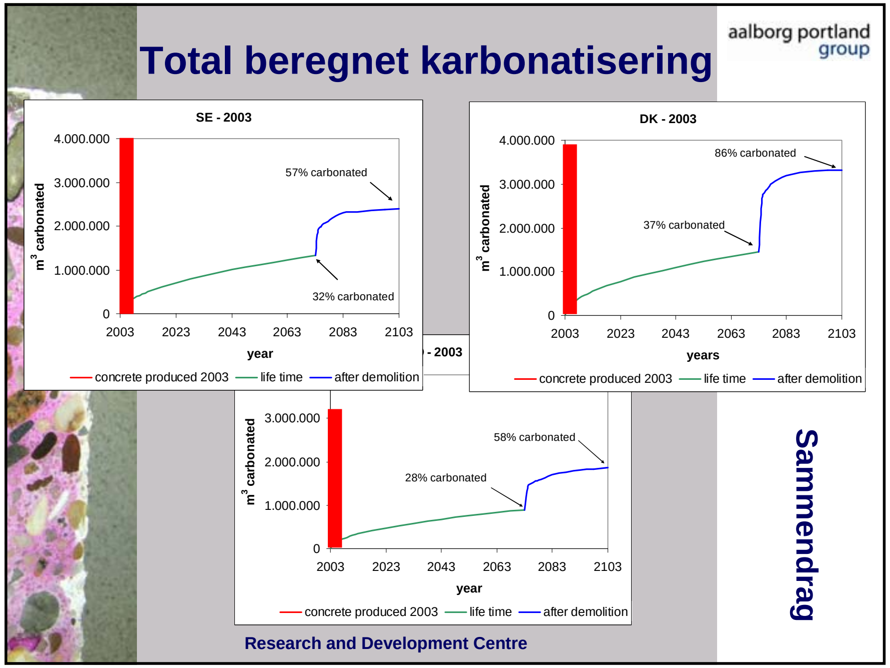
Sammendrag


Total beregnet karbonatisering
aalborg portland group
NO - 2003
m3 carbonated
4.000.000
3.000.000
2.000.000
1.000.000
0
2003
2023
2043
2063
2083
2103
year
concrete produced 2003
Sammendrag
Research and Development Centre

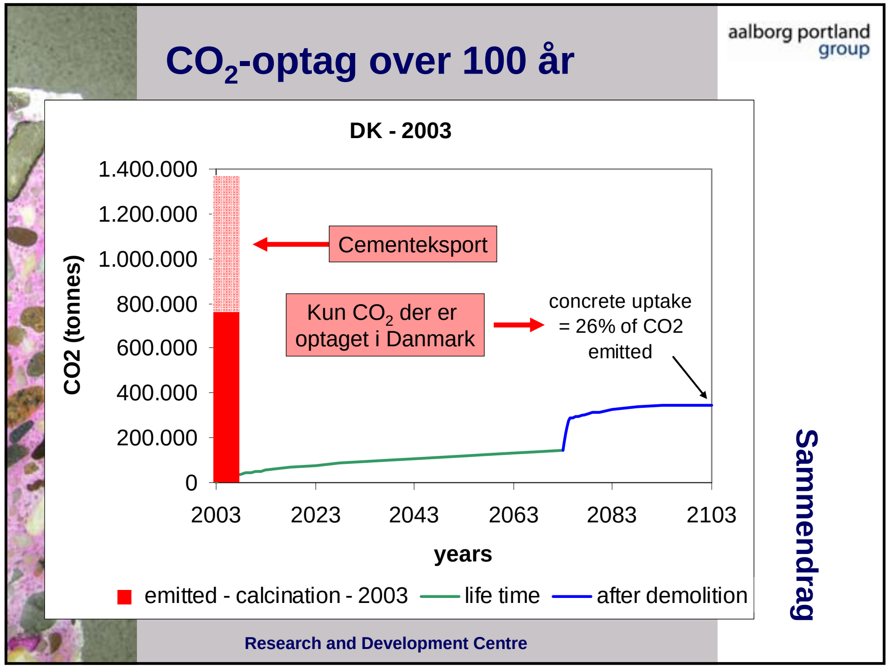

Total beregnet karbonatisering
aalborg portland group
NO - 2003
m3 carbonated
4.000.000
3.000.000
2.000.000
1.000.000
0
58% carbonated
28% carbonated
2003
2023
2043
2063
2083
2103
year
concrete produced 2003
life time
after demolition
Sammendrag
Research and Development Centre



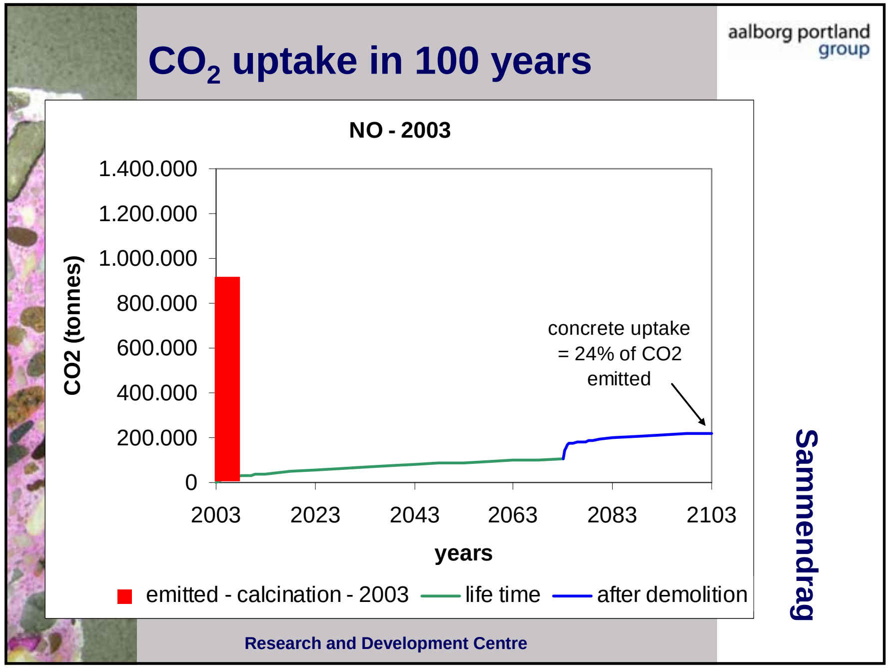
Total beregnet karbonatisering
aalborg portland group
NO - 2003
4.000.000
3.000.000
2.000.000
1.000.000
0
m3 carbonated
58% carbonated
28% carbonated
2003
2023
2043
2063
2083
2103
year
concrete produced 2003
life time
after demolition
Sammendrag
Research and Development Centre



Total beregnet karbonatisering
aalborg portland group
SE - 2003
4.000.000
3.000.000
2.000.000
1.000.000
0
m3 carbonated
57% carbonated
32% carbonated
2003
2023
2043
2063
2083
2103
year
concrete produced 2003
life time
after demolition
DK - 2003
4.000.000
3.000.000
2.000.000
1.000.000
0
m3 carbonated
86% carbonated
37% carbonated
2003
2023
2043
2063
2083
2103
years
concrete produced 2003
life time
after demolition
- 2003
3.000.000
2.000.000
1.000.000
0
m3 carbonated
58% carbonated
28% carbonated
2003
2023
2043
2063
2083
2103
year
concrete produced 2003
life time
after demolition
Sammendrag
Research and Development Centre



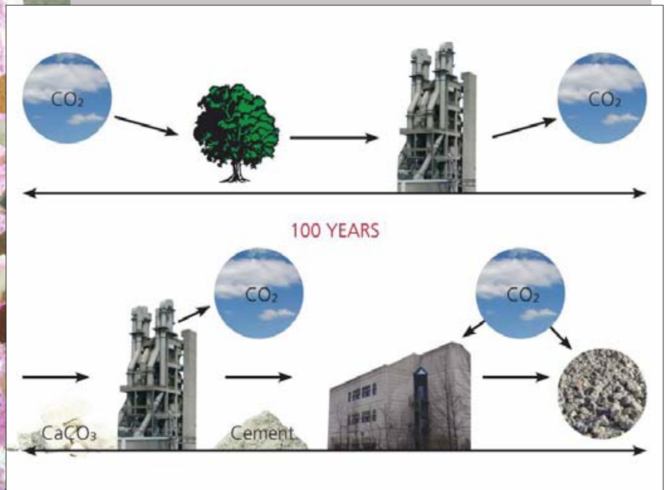
CO_2-optag over 100 år
aalborg portland group
DK - 2003
CO2 (tonnes)
1.400.000
1.200.000
1.000.000
800.000
600.000
400.000
200.000
0
Cementeksport
Kun CO_2 der er optaget i Danmark
concrete uptake = 26% of CO2 emitted
2003
2023
2043
2063
2083
2103
years
emitted - calcination - 2003
life time
after demolition
Sammendrag
Research and Development Centre



CO_2 uptake in 100 years
aalborg portland group
NO - 2003
CO2 (tonnes)
1.400.000
1.200.000
1.000.000
800.000
600.000
400.000
200.000
0
concrete uptake = 24% of CO2 emitted
2003
2023
2043
2063
2083
2103
years
emitted - calcination - 2003
life time
after demolition
Sammendrag
Research and Development Centre

Hvad viser undersøgelsen?

aalborg portland group



Konklusion

Research and Development Centre

Hvad viser undersøgelsen?

aalborg portland group

- Betons CO_2 cyklus svarer til biobrændsler, med undtagelse af at kun en andel af CO_2 emissionen optages i løbet af de første 100 år

Konklusion

Research and Development Centre

Hvad viser undersøgelsen?

aalborg portland group

- Betons CO_2 cyklus svarer til biobrændsler, med undtagelse af at kun en andel af CO_2 emissionen optages i løbet af de første 100 år
- Denne andel varierer fra land til land afhængig af hvorledes beton håndteres efter nedrivning

Konklusion

Research and Development Centre

Hvad viser undersøgelsen?

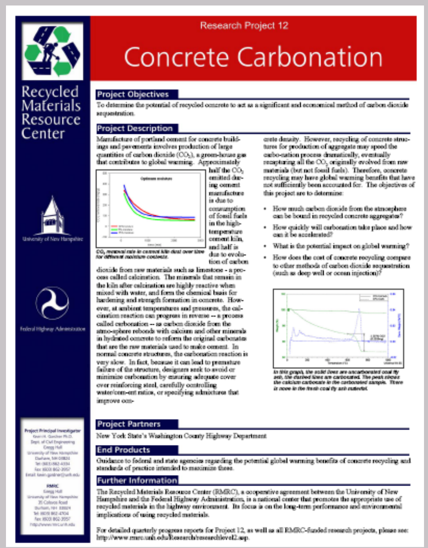
aalborg portland group

- Betons CO_2 cyklus svarer til biobrændsler, med undtagelse af at kun en andel af CO_2 emissionen optages i løbet af de første 100 år
- Denne andel varierer fra land til land afhængig af hvorledes beton håndteres efter nedrivning
- Man bør derfor tage effekten af karbonatisering med i vurderingen af de samlede CO_2 emissioner fra cementproduktionen – specielt når betonen genanvendes efter nedknusning

Konklusion

Research and Development Centre

Andre har tilsvarende ideer !



Recycled Materials Resource Center

Research Project 12

Concrete Carbonation

Project Objectives

To determine the potential of recycled concrete to act as a significant and economical method of carbon dioxide sequestration.

Project Description

Manufacture of portland cement for concrete buildings and pavements involves production of large quantities of carbon dioxide (CO_2), a green-house gas that contributes to global warming. Approximately half the CO_2 emitted during cement manufacture is due to consumption of fossil fuels in the high-temperature cement kiln, and half is due to evolution of carbon dioxide from raw materials such as limestone - a process called calcination. The minerals that remain in the kiln after calcination are highly reactive when mixed with water, and form the chemical basis for hardening and strength formation in concrete. However, at ambient temperatures and pressures, the calcination reaction can progress in reverse -- a process called carbonation -- as carbon dioxide from the atmosphere rebonds with calcium and other minerals in hydrated concrete to reform the original carbonates that are the raw materials used to make cement. In normal concrete structures, the carbonation reaction is very slow. In fact, because it can lead to premature failure of the structure, designers seek to avoid or minimize carbonation by ensuring adequate cover over reinforcing steel, carefully controlling water/cement ratios, or specifying admixtures that improve concrete density. However, recycling of concrete structures for production of aggregate may speed the carbonation process dramatically, eventually recapturing all the CO_2 originally evolved from raw materials (but not fossil fuels). Therefore, concrete recycling may have global warming benefits that have not sufficiently been accounted for. The objectives of this project are to determine:

CO_2 removal rate in cement kiln dust over time for different moisture contents.

- How much carbon dioxide from the atmosphere can be bound in recycled concrete aggregates?
- How quickly will carbonation take place and how can it be accelerated?
- What is the potential impact on global warming?
- How does the cost of concrete recycling compare to other methods of carbon dioxide sequestration (such as deep well or ocean injection)?

In this graph, the solid lines are uncarbonated coal fly ash, the dashed lines are carbonated. The peak shows the calcium carbonate in the carbonated sample. There is none in the fresh coal fly ash material.

Project Partners

New York State's Washington County Highway Department

End Products

Guidance to federal and state agencies regarding the potential global warming benefits of concrete recycling and standards of practice intended to maximize these.

Further Information

The Recycled Materials Resource Center (RMRC), a cooperative agreement between the University of New Hampshire and the Federal Highway Administration, is a national center that promotes the appropriate use of recycled materials in the highway environment. Its focus is on the long-term performance and environmental implications of using recycled materials.

For detailed quarterly progress reports for Project 12, as well as all RMRC-funded research projects, please see: http://www.rmrc.unh.edu/Research/researchlevel2.asp.

University of New Hampshire

Federal Highway Administration

aalborg portland group

Konklusion

Research and Development Centre

Men………

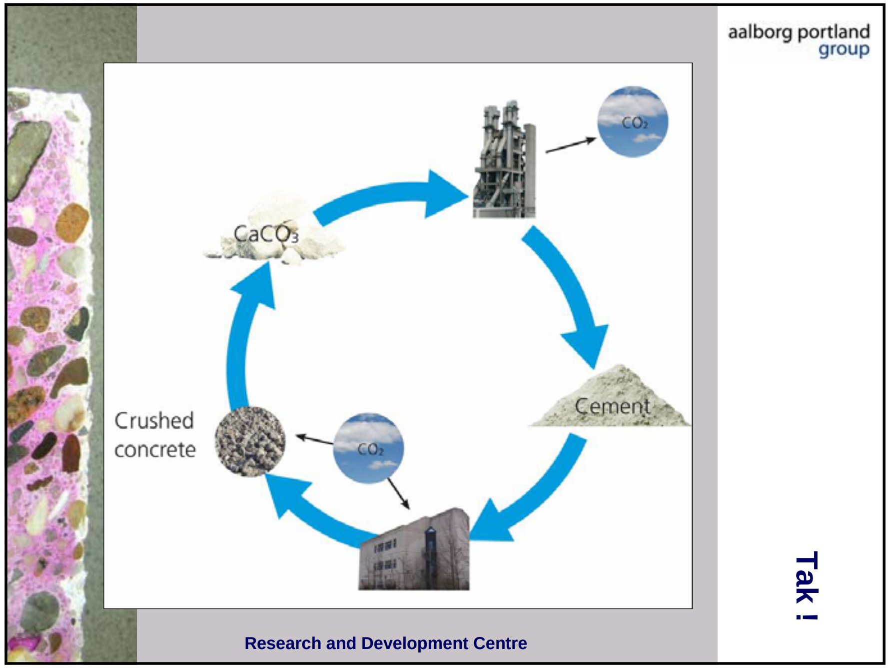
DETTE ER FORELØBIGE RESULTATER !

- Vi er sikre på, at CO_2-optag i beton har en positiv miljøeffekt, men vi kender ikke det eksakte tal
- Det er nødvendigt at underbygge resultaterne:
  - Alle antagelser skal underbygges
  - Flere feltstudier af nedknust beton er nødvendige

aalborg portland group

Konklusion

Research and Development Centre


aalborg portland
group
$CaCO_3$
CO_2
Cement
Crushed
concrete
CO_2
Tak !
Research and Development Centre