ANNA MARIA WORKSHOP XIII

UNCONVENTIONAL CONCRETE

CONCRETE SUSTAINABILITY

SIDNEY MINDESS
UNIVERSITY OF BRITISH COLUMBIA

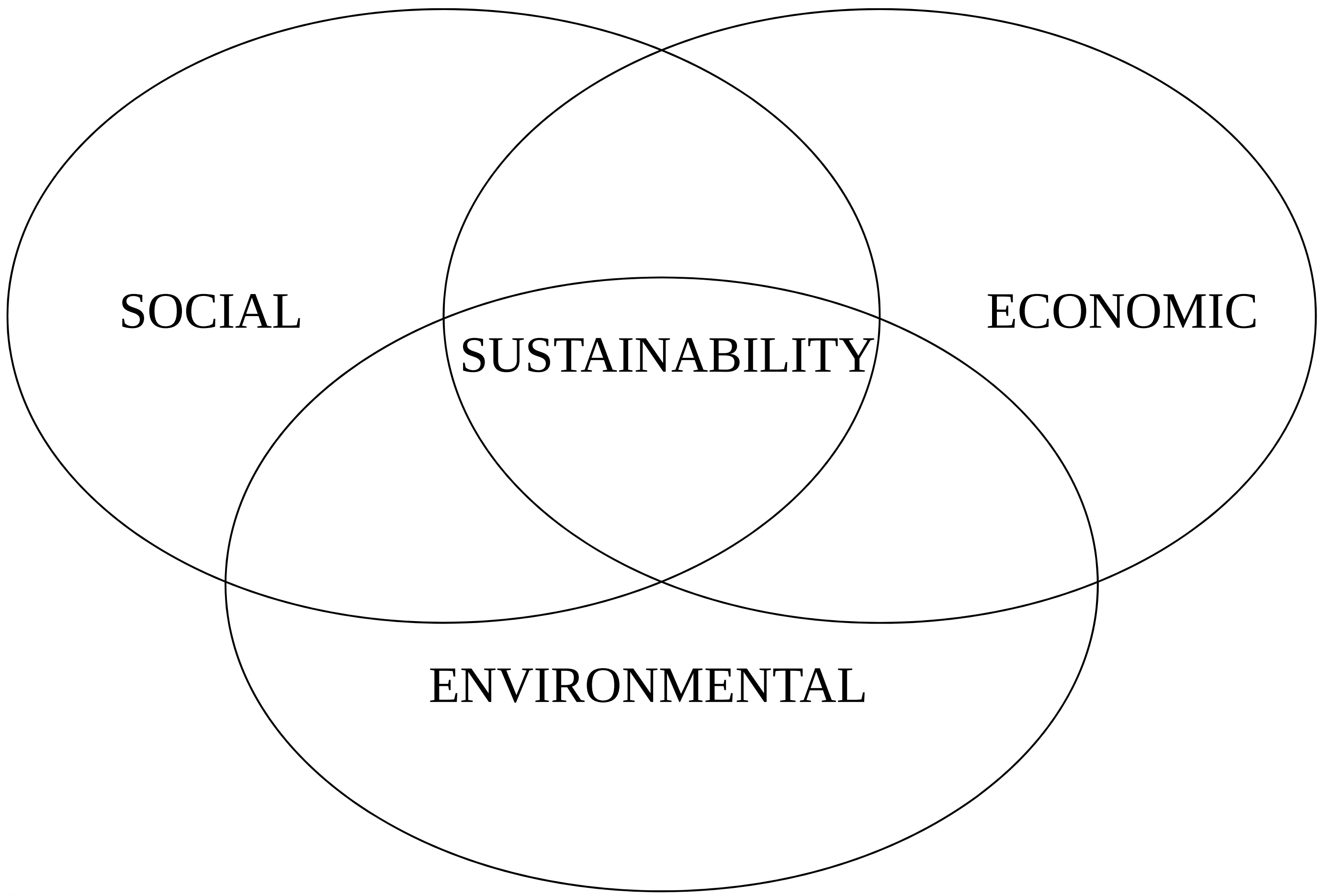

WELCOME
TO
CONCRETE
CROSSWALK
FUTURE HOME OF
CONCRETE
SILO
PARK

Basic Concrete Technology

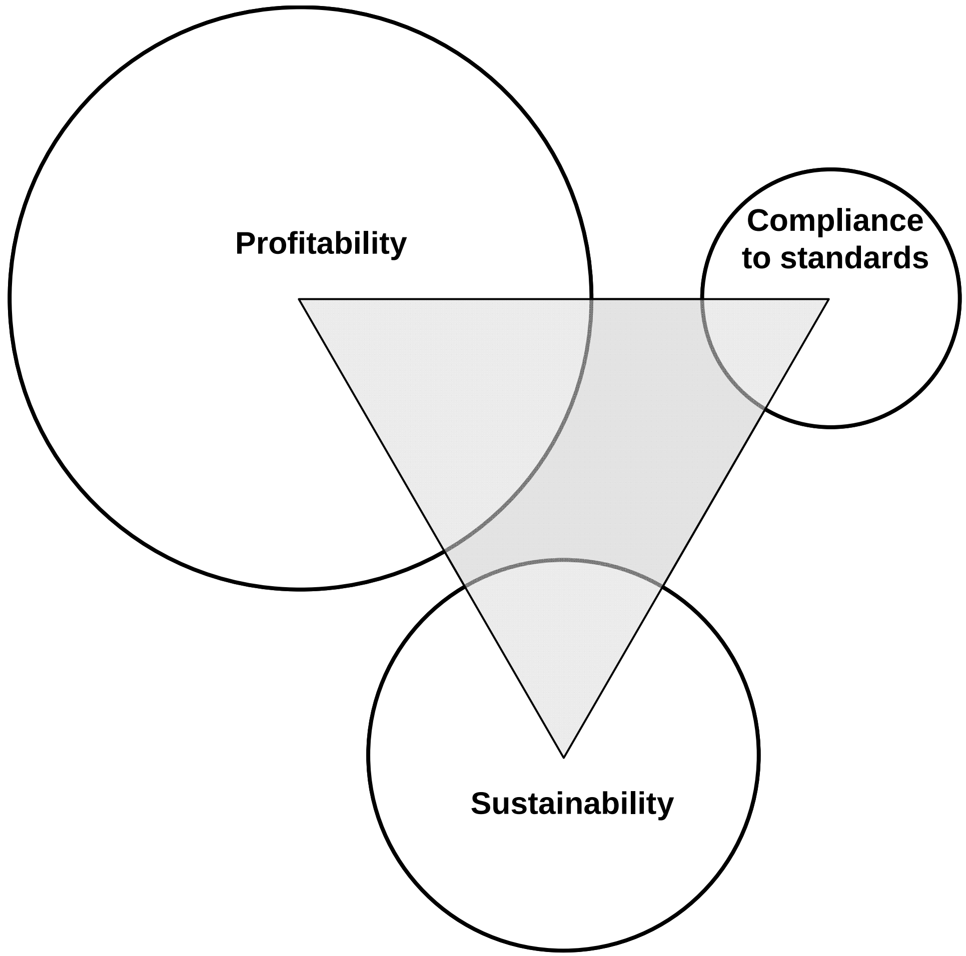
You mix together cement, water and aggregate, and it gets hard. What else is there to know about concrete?

my wife

Holistic View of Sustainability

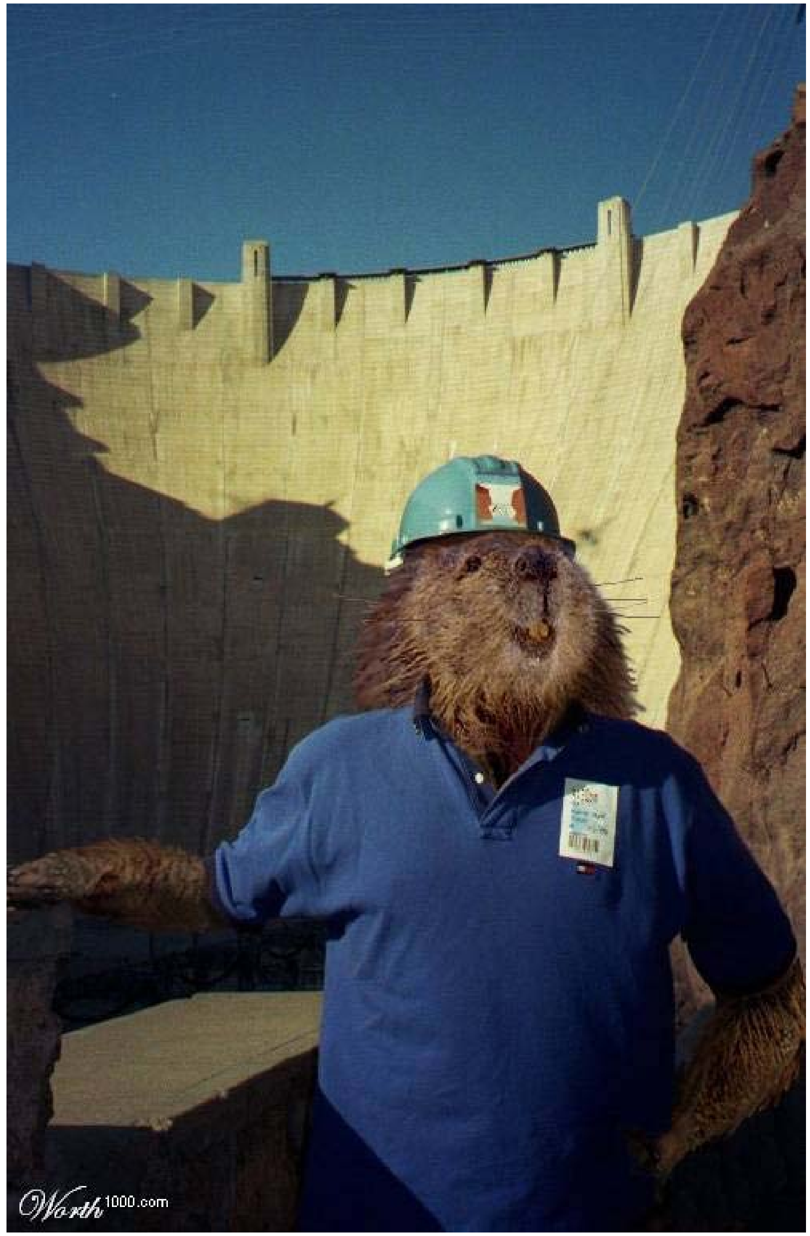


Issues for the cement/concrete industry



Energy Required Annually to Produce Portland Cement

Equivalent to about 26 days production of crude oil


Worth1000.com

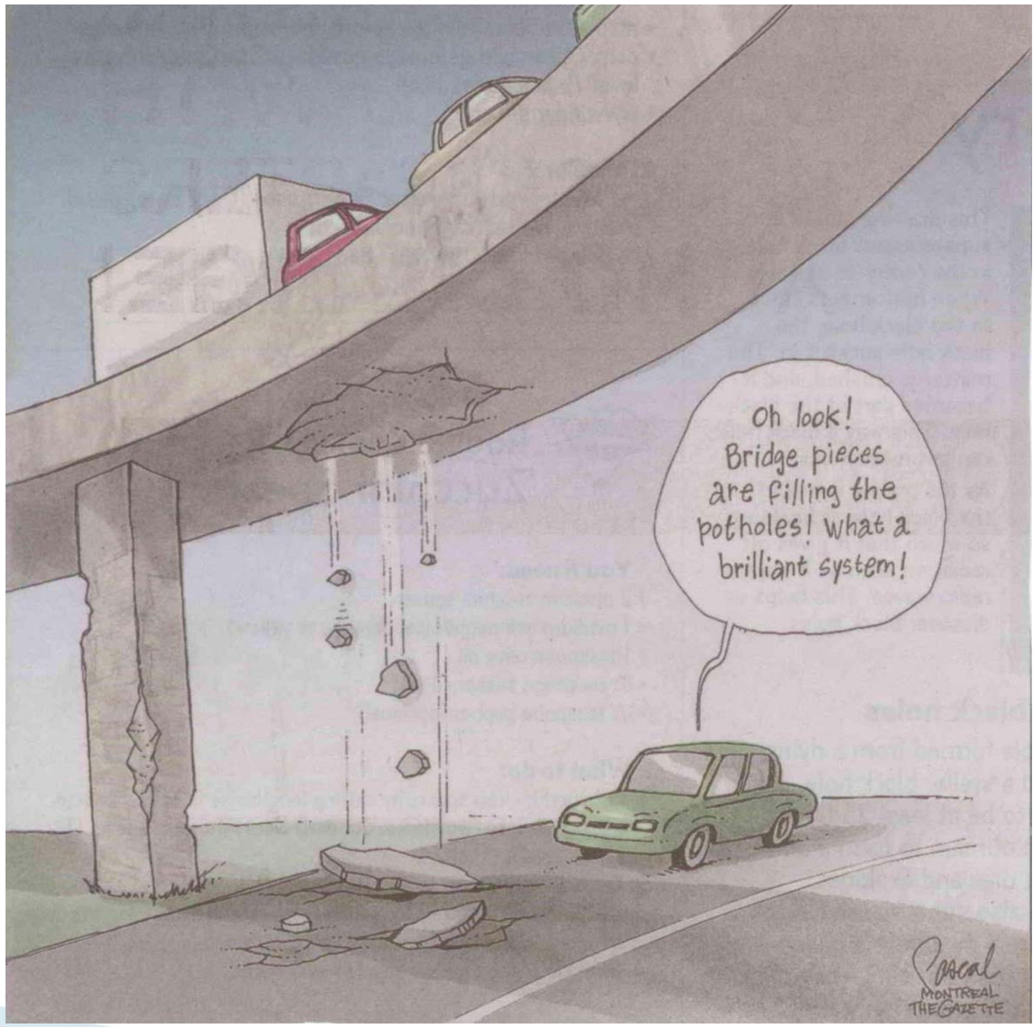
How Can We Make Concrete More Sustainable? (1)

- Manufacturing Portland cement more efficiently
- Replacing Portland cement with supplementary cementing materials (SCM's) and/or fillers
- Using High Performance Concretes (HPCs)
- Making concrete more durable

How Can We Make Concrete More Sustainable? (2)

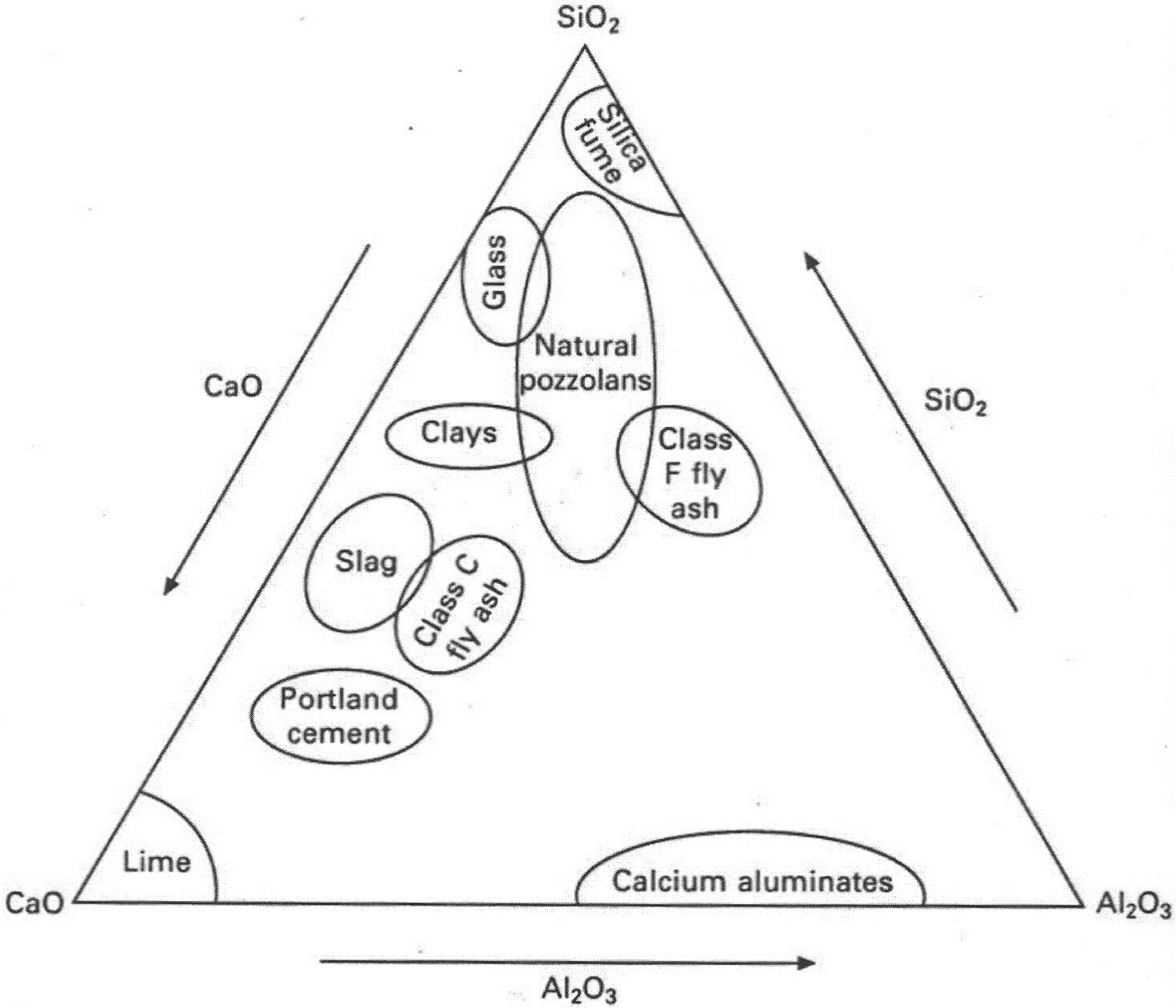
- Using waste materials as fuels
- Using recycled concrete, or other industrial wastes, as aggregate
- Capturing and storing CO_2 emissions
- Using less water
- Improving structural design and building codes (educating structural engineers???)

This is *NOT* sustainable construction



Supplementary Cementing Materials

- Fly ash: A by-product of coal-fired production of electricity
- Slag: A by-product of iron production
- Silica Fume: A by-product of silicon and ferro-silicon production
- Metakaolin: from the calcination of kaolin (china clay)



SiO2
Silica fume
Glass
Natural pozzolans
CaO
SiO2
Clays
Class F fly ash
Slag
Class C fly ash
Portland cement
Lime
Calcium aluminates
CaO
Al2O3
Al2O3

Fillers

Fillers are finely divided materials that are (more or less) inert:

- Pulverized limestone
- Pulverized silica

According to current codes, they may be added at substitution rates of up to 5% by weight of cement, though higher addition rates (up to 12%) have been found not to be harmful.

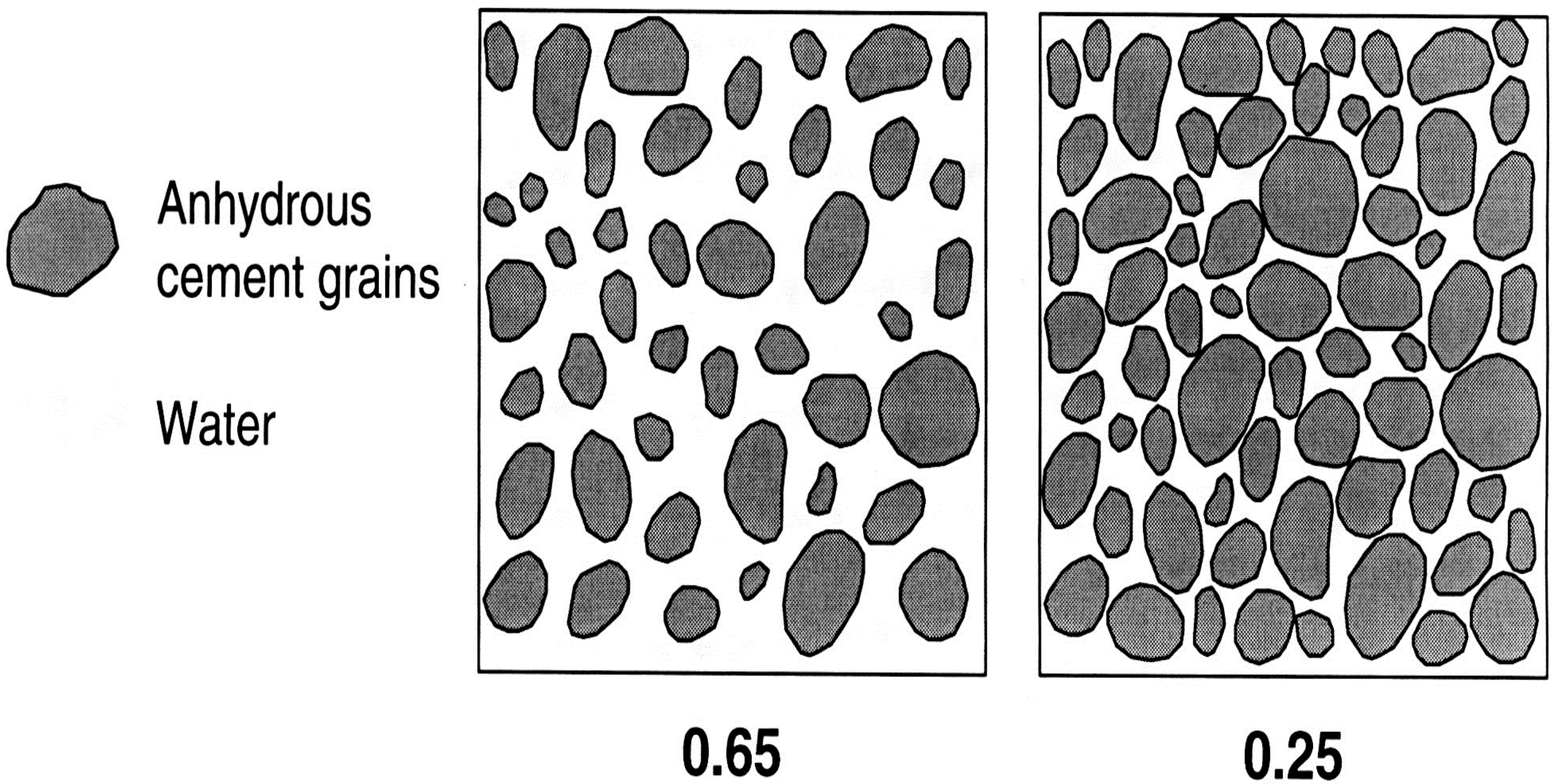
High Performance Concrete

- HPCs are made with w/b ratios well below 0.42. That is, they contain significantly *less* water than is necessary to fully hydrate the cement. *If properly cured*, they are not only stronger, but much less permeable than ordinary concrete. Result: greatly enhanced durability and sustainability.

W/B Ratio

- The w/b ratio is in *direct* relation to the average distance between cementitious particles in the fresh cement paste.

W/B Ratio



W/B ratio

- The smaller the spacing between cement particles, the more rapidly the hydration products can fill the space between cement particles, and the stronger the interparticle bonds thus formed; hence, the higher the concrete strength, and the lower the permeability.

Tricks

- However, the cement producer can use various "tricks" (increased fineness, increased amounts of C_3S and C_3A, …..) to maintain the same short term (28-day) strength.

- The result is a less durable concrete, even though the apparent strength remains the same.

Internal Water Curing

- Introduce some “hidden” water into the concrete mix, *i.e.*, water that is not used as part of the regular mixing water. This water can be introduced by
  - Saturated coarse lightweight aggregate
  - Saturated lightweight sand
  - Superabsorbent polymers

- During hydration of low w/b concretes, when any dessication occurs within the concrete, this “extra” water can be sucked up by the hydrating paste both to continue the hydration, and to fill the porosity created by self-dessication.

Curing concrete according to its w/c

w/c > 0.42	fogging + external curing **or** curing membrane
w/c < 0.42	fogging + evaporation retarder + external curing + internal curing

- Cement producers should optimize their cements in terms of their fineness and their rheological properties (in combination with a suitable superplasticizer) for the first 90 minutes after contact with water, rather than in terms of their cube strengths.


THE
END
IS
AT HAND

Concluding Remarks

There are many strategies that must be followed to make concrete a truly sustainable material. Of course, those listed earlier are not all of equal importance, but in sum they would reduce the carbon footprint of concrete, reduce the consumption of raw materials, and result in a much more durable material.

The production of more durable and sustainable concrete is likely to lead to higher *initial costs* (superplasticizers, better curing, etc.).

However, the *life cycle cost* should be considerably reduced, because of the enhanced durability and longer effective life of the structure.

We already know how to do all of the things have been discussed here. What is necessary is to better educate the industry, and encourage them to make the necessary changes in how cement and concrete are produced.