Concrete flow and standards

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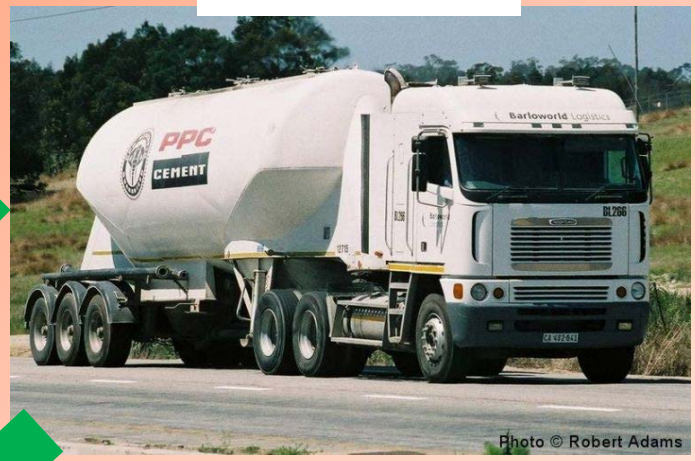
Raw Materials:
Limestone (lime), Sand and Clay (silica, alumina, iron)

Sintering raw materials by heating in kiln to 1600 °C.

Cement Truck



Concrete truck

Cement

Concrete

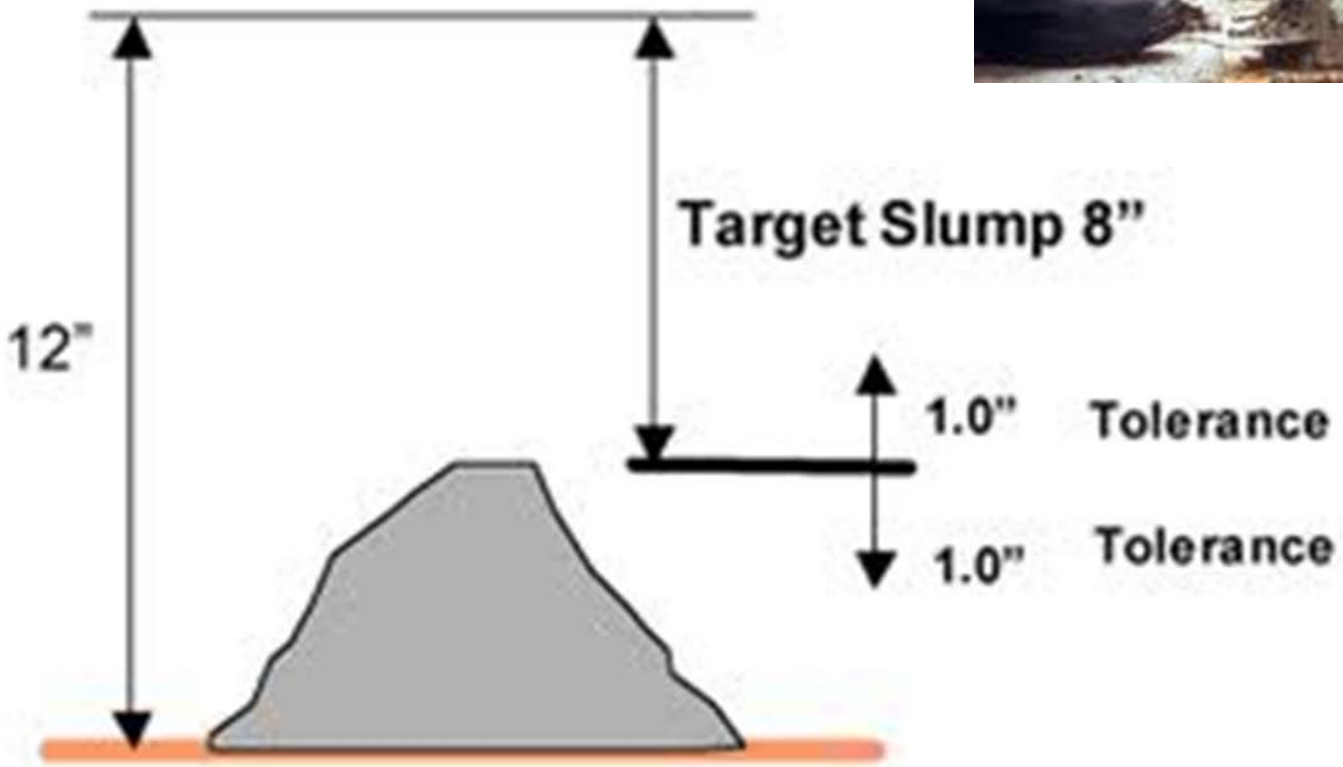
- Cement + Water + additives = **Paste**
- Paste + **Sand** = **Mortar**
- Mortar + **Aggregate** = **Concrete**

Why is Rheology important?

Why workability is essential?

State of the art since 1918
The slump cone

The slump cone (2)



Measurements for concrete

Classification of various tests introduced by NIST – adopted by ACI

- Confined flow (8 tests)
- Free flow (13 tests)
- Vibration (14 tests)
- Rotational rheometers (16 tests)

Note: more tests exist for mortar/paste and high yield concrete

Rheometers definition

The material is sheared between two surfaces, one or both of which are rotating

Concrete Rheometer types

Vane

Parallel plate

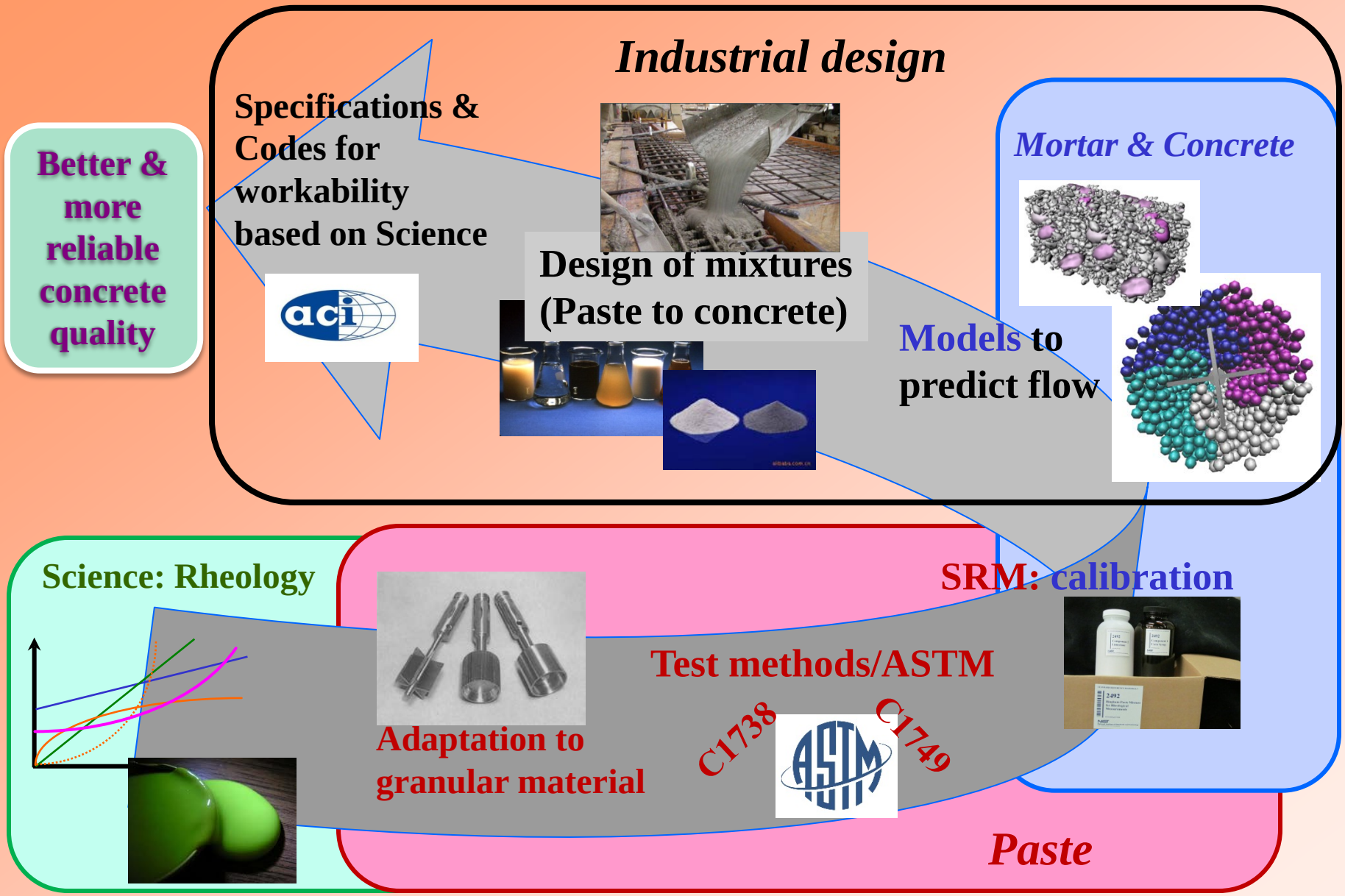
Coaxial

Industrial involvement: International testing of rheometers

- Mixtures:
  - Wide range of Yield stress and viscosity (up to SCC)
  - 12 mixtures (Phase I) and 23 mixtures (Phase II)
  - Phase II included also some mortars and more empirical tests
- Results:
  - High degree of correlation between rheometers
  - Ranking similar by all rheometers
  - ***Differences in absolute values***
  - Slump correlates with yield stress

✓ **Function to correlate pairs of rheometers were established**

✗ **Need a reference material**

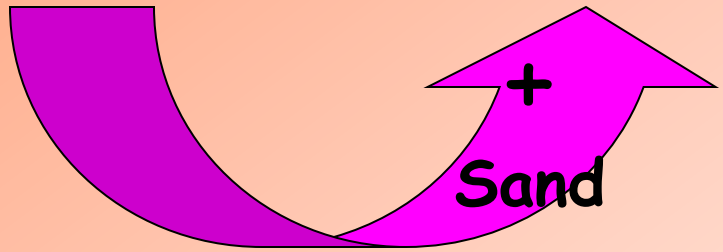

Better & more reliable concrete quality
Industrial design
Specifications & Codes for workability based on Science
Design of mixtures (Paste to concrete)
Mortar & Concrete
Models to predict flow
Science: Rheology
Adaptation to granular material
Test methods/ASTM
C1738
C1749
SRM: calibration
Paste

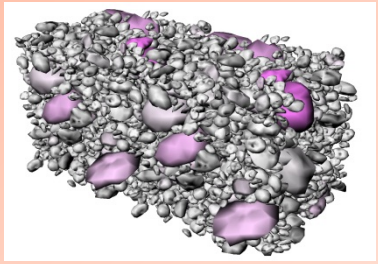
NIST Methodology

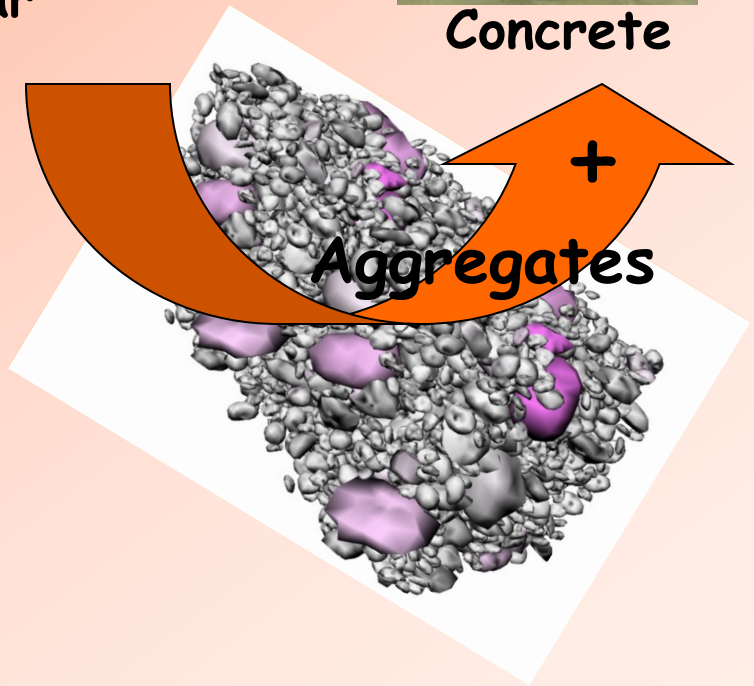
Cement paste

Mortar

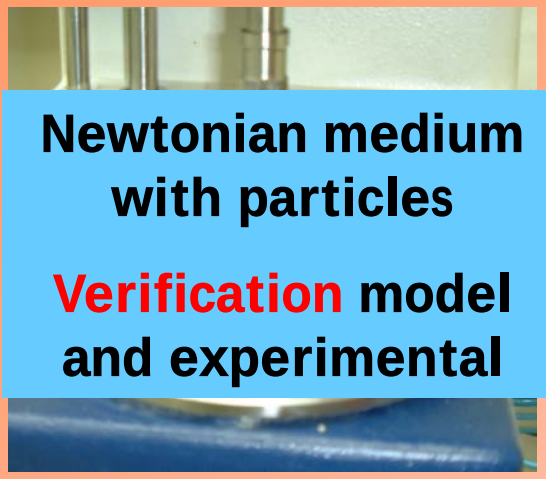
Concrete







NIST Methodology (2)



Newtonian medium with particles

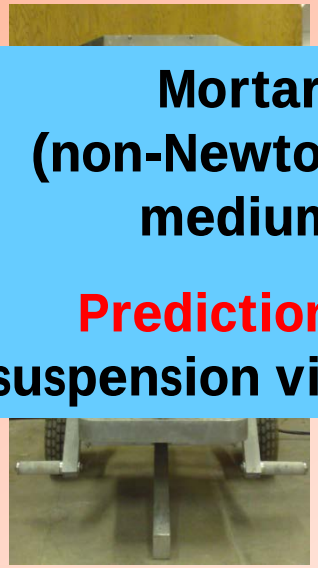
Verification model and experimental

Cement paste

Paste (non-Newtonian) medium

Prediction of suspension viscosity

Mortar

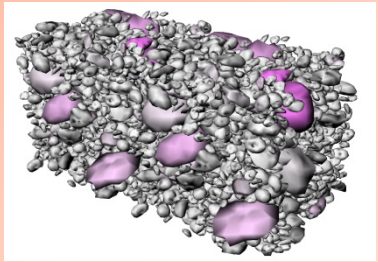


Mortar (non-Newtonian) medium

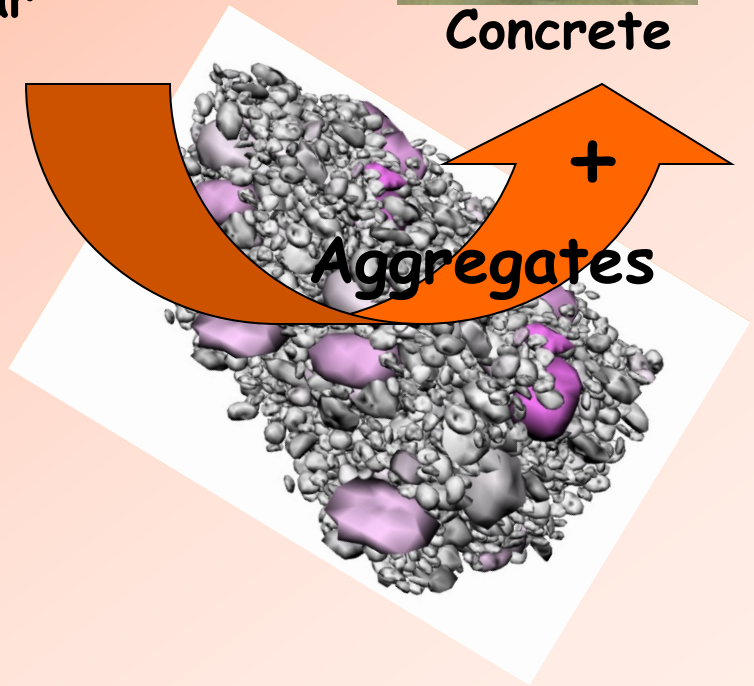
Prediction of suspension viscosity

Concrete

+ Sand



+ Aggregates



What do we already have?

ASTM- C1738 (mixing)

ASTM C-1749 (measuring)

SRM 2492

Cement paste

Idea: Add of Beads

Some measurements techniques

Mortar

Idea: Add of Beads

Concrete

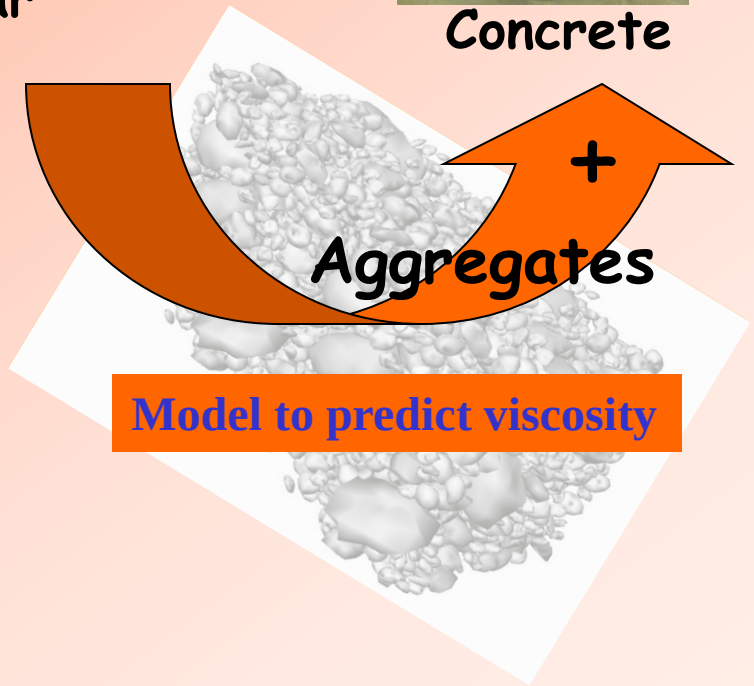
+

Sand

Model to predict viscosity

+

Aggregates



Model to predict viscosity

What does the industry need?

ASTM- C1738 (mixing)

ASTM C-1749 (measuring)

SRM 2492

Cement paste

SRM for mortar rheometers

Mortar

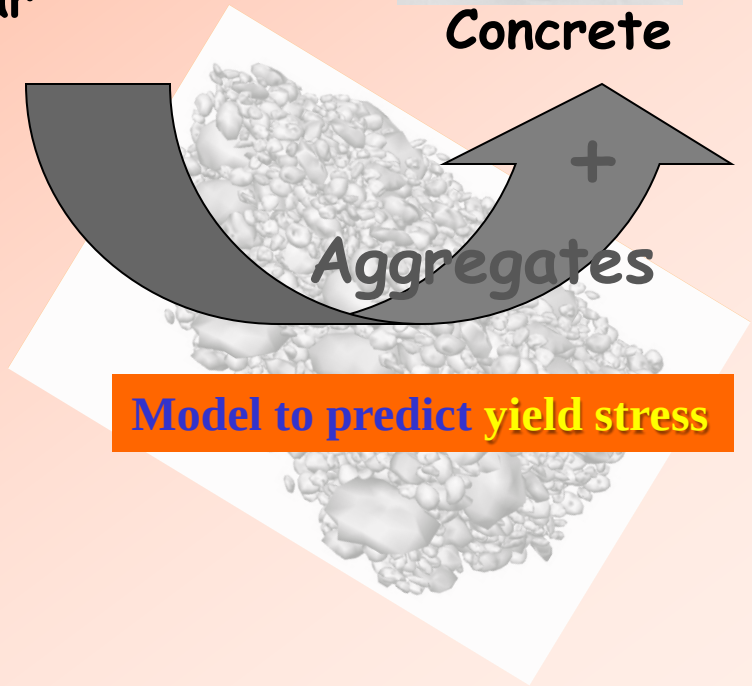
SRM for concrete rheometers

Concrete

+ Sand

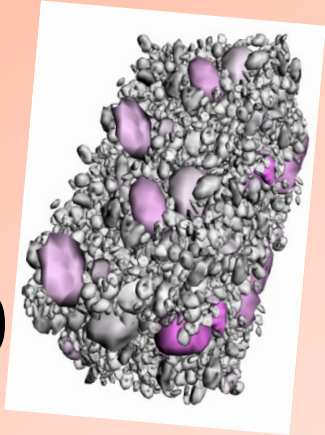
Model to predict yield stress

+ Aggregates

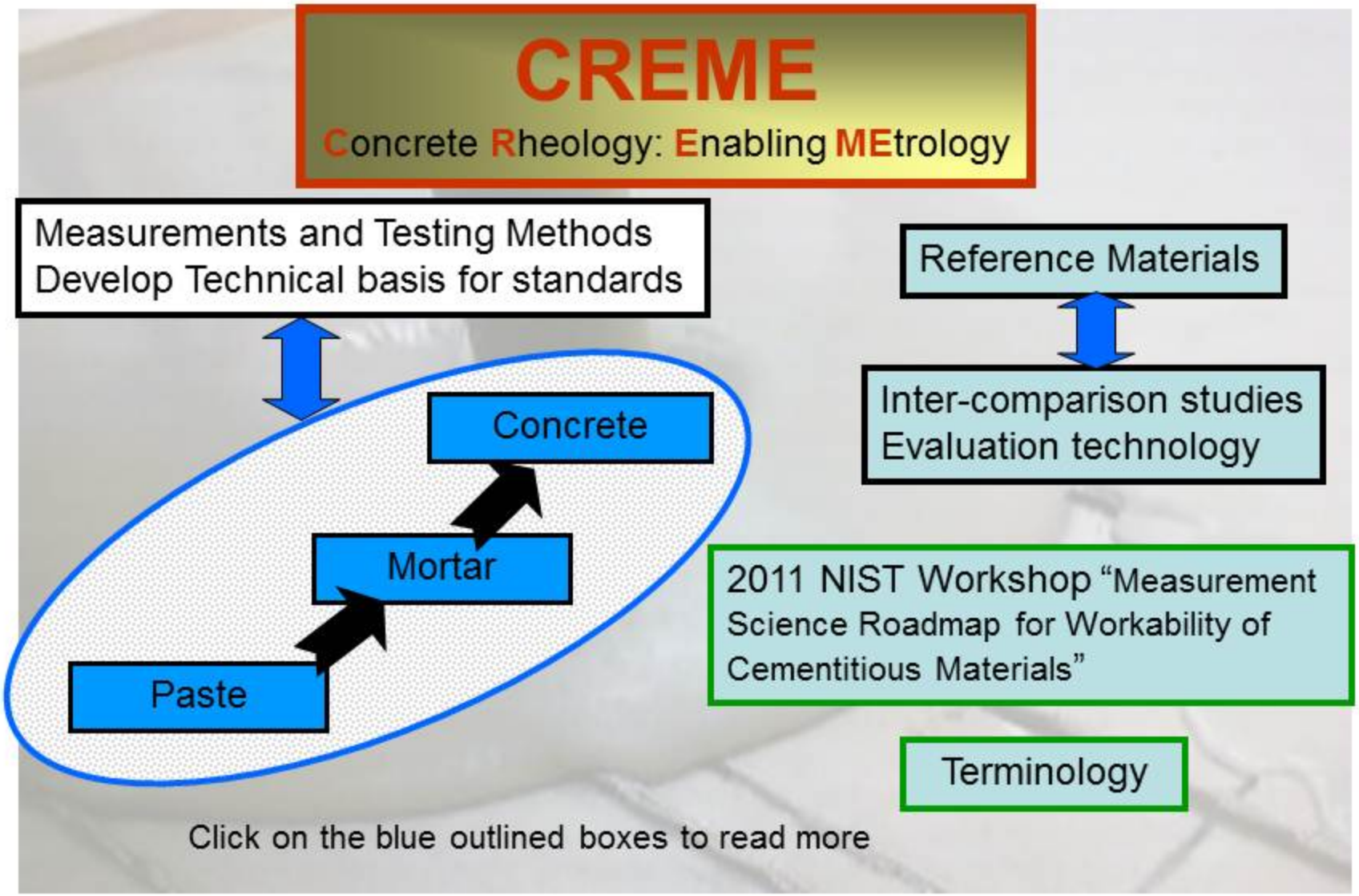


Model to predict yield stress

Applications - conformity



- **Model and measure mixture** with non-spherical aggregates: Real concrete (not just calibration)
- Create information for designer to specify rheological properties instead of slump: **Codes and specifications.**
- **Relate to real world application** such as pumping



http://concrete.nist.gov/CREME.html

Acknowledgements

- **Dr. Nicos Martys**: simulation model
- Various collaboration throughout the years (see cited papers)

CREME

Concrete **R**heology: **E**nabling **ME**trology

Thank you