gcp applied technologies

The rheology of control flow concrete

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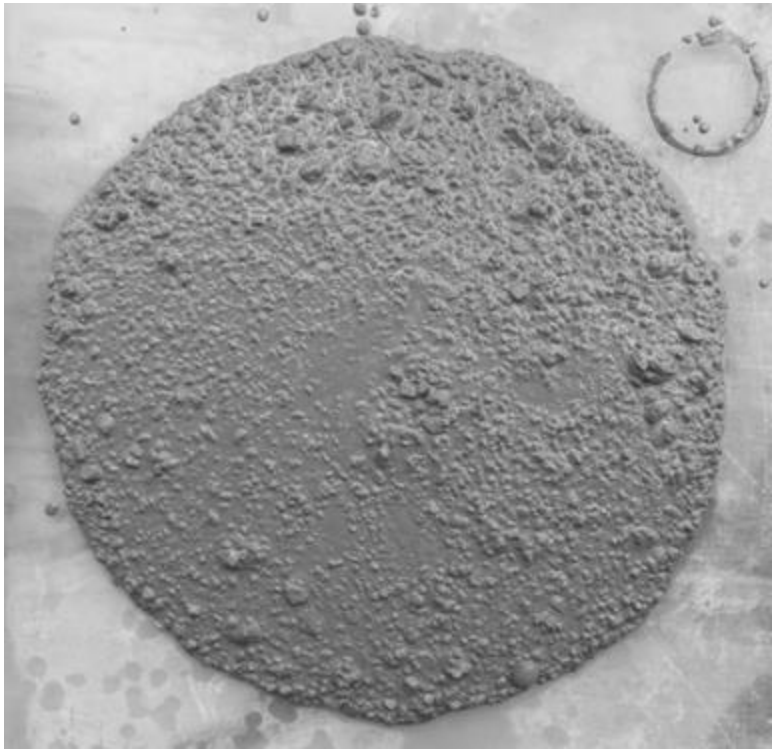
ACI 237R-07: Self-consolidating concrete

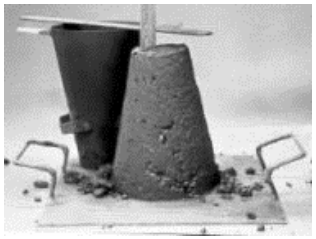
"…highly flowable, nonsegregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without any mechanical consolidation.

In general, SCC is concrete made with conventional concrete materials and, in some cases, with a viscosity-modifying admixture."

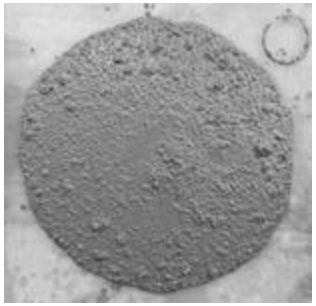


Mix proportioning

Conventional concrete



Self-consolidating concrete

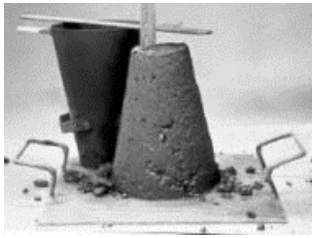


Challenges in producing ready-mix SCC

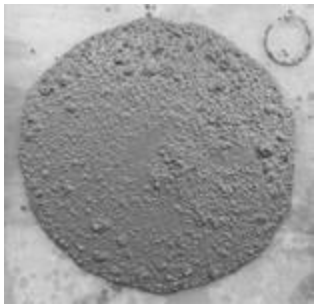
- **Mix proportioning is complicated**
- **High cementitious factor**
  - Significant cost increase
  - Difficult to finish
  - Increased shrinkage
- **Difficult to produce**
- **Limited applications**

To mitigate risk, you need an increase in both expertise/experience as well as material costs

What if we could have best of both worlds?

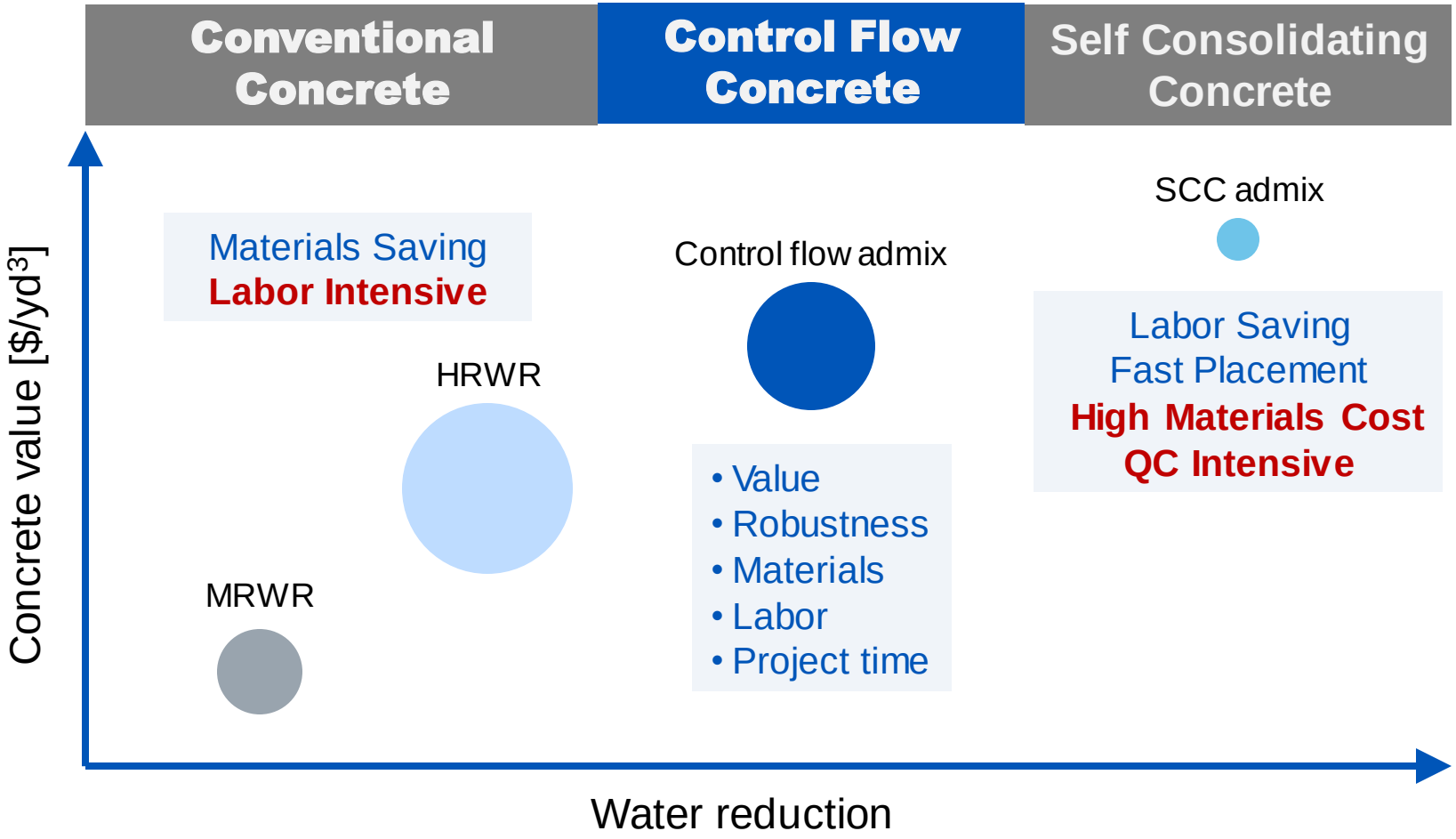


- **Typical mix proportioning**
  - Strength: 3500-6500 psi [25-45 MPa]
- **Lower cementitious content**
- **Superior moisture tolerance**
- **Higher segregation resistance**
- **Easier finishability**



- **Slump flows 16-25” [400 to 635 mm]**
- **Minimal vibration**
- **Excellent flowability retention for more than 1 hour**
- **Fast pumping, rapid placement**

Novel admixture formulation

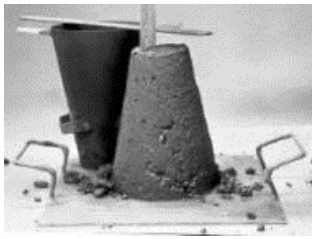


Control flow concrete

- ***Is*** Conventional Concrete with enhanced flow using novel blend of admixtures
- ***Is not*** Self Consolidating Concrete with reduced flow

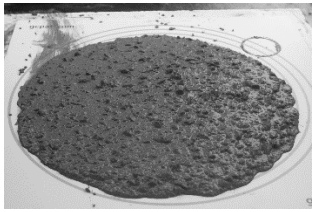
Control flow concrete

Conventional concrete



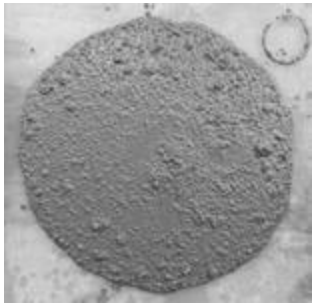
Slump: 6-8”

Control flow concrete



Slump flow: 18-22”

Self-consolidating concrete



Slump flow: 25-30”

Control flow concrete

Static and dynamic yield stresses

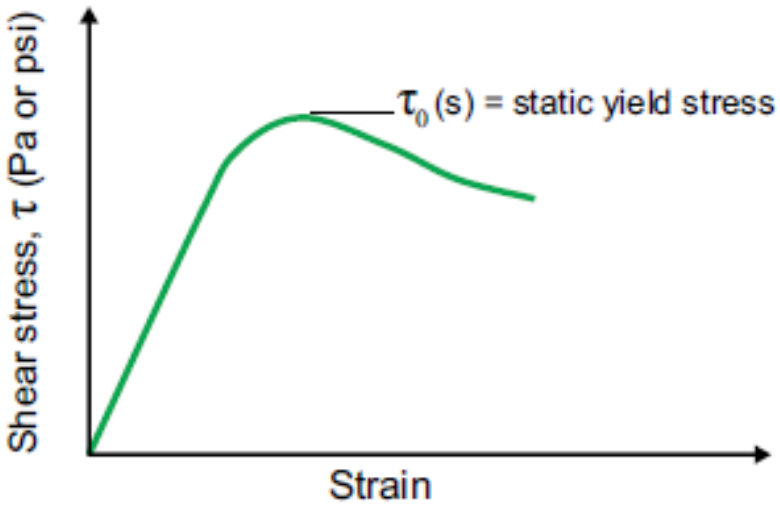


Fig. 3: The stress growth test is used to determine the static yield stress

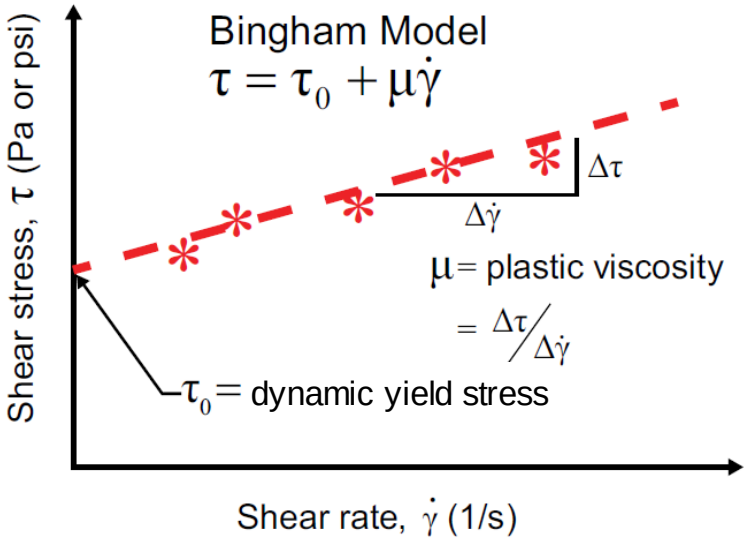


Fig. 1: Representation of Bingham model. The stars represent experimentally determined data points that are approximated using a straight line

Static yield stress:

- stress required to initiate flow
- (rest to flow)

A contribution from ACI Committee 238, Workability of Fresh Concrete

Role of Rheology in Achieving Successful Concrete Performance

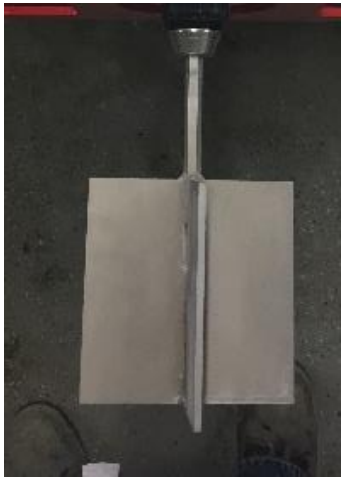
Properties must be balanced to manage segregation, surface finish, pumping pressure, or formwork pressure

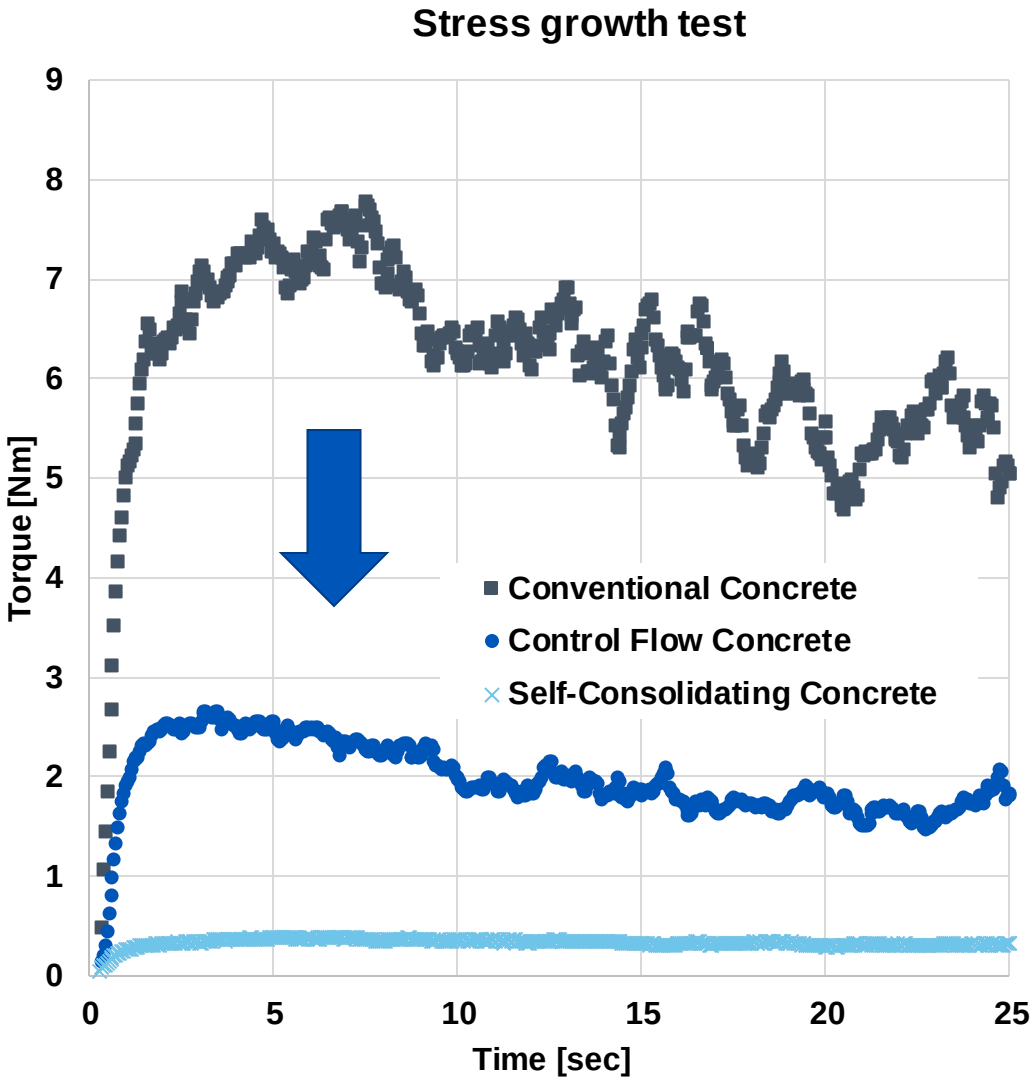
Dynamic yield stress:

- stress at which flow stops
- (flow to rest)

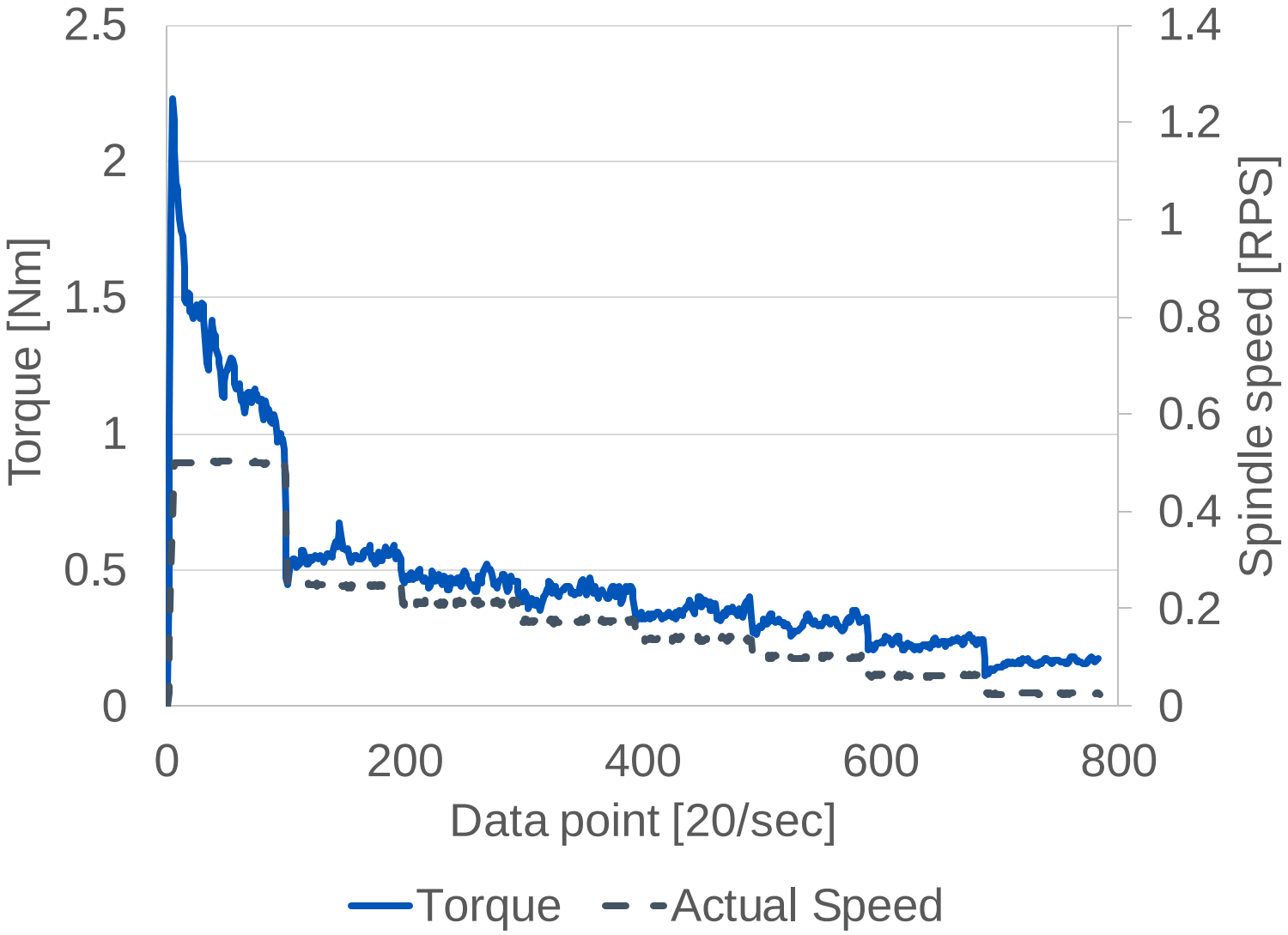
CI June 2007, ACI 238

Static yield stress

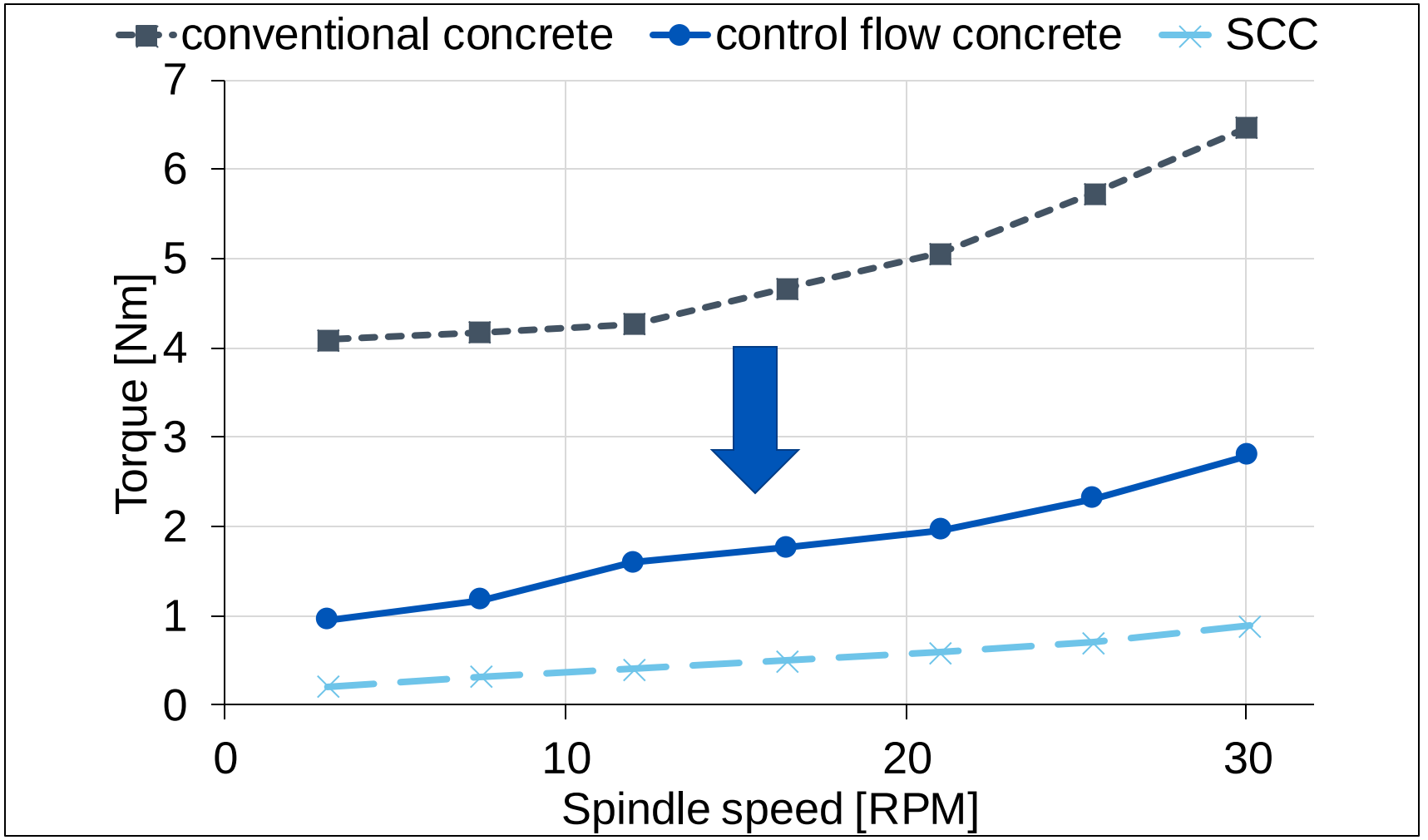




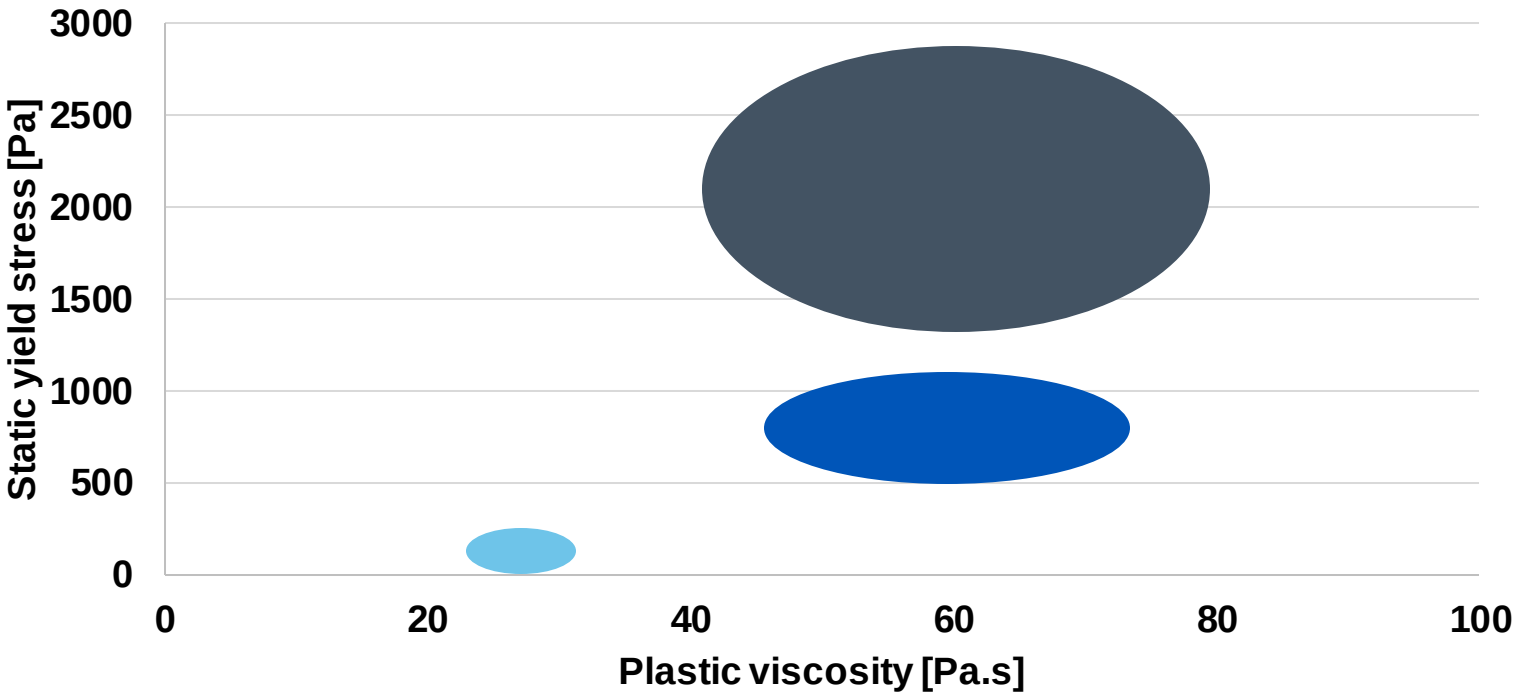
Flow curve data example



Flow curve results



Balancing rheology



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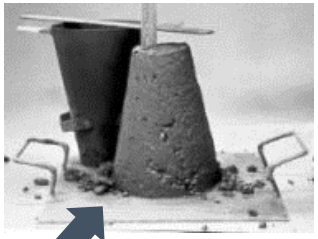

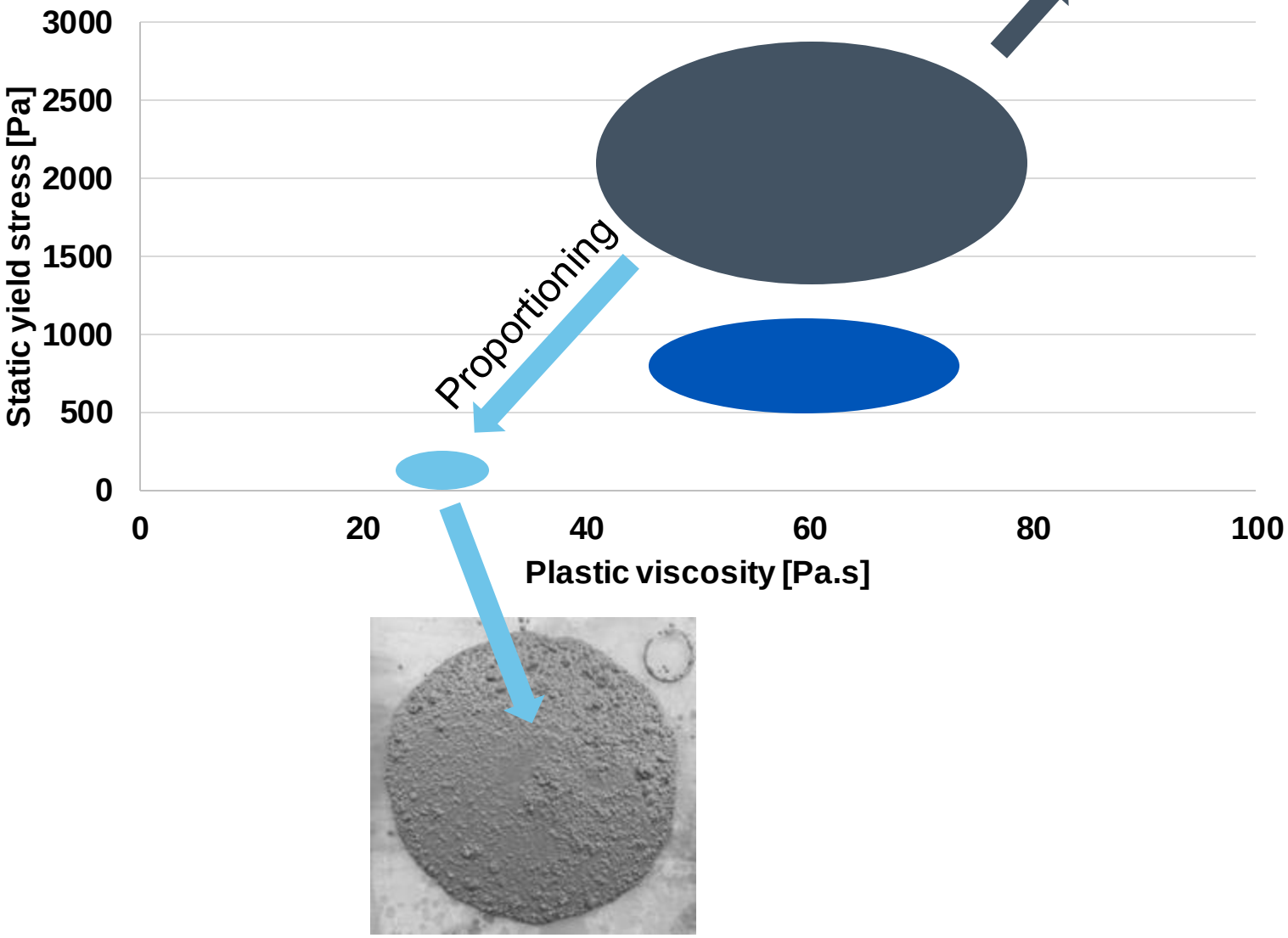

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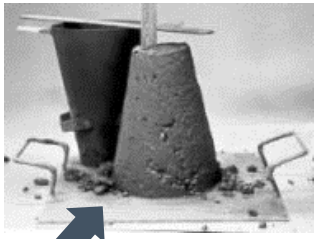

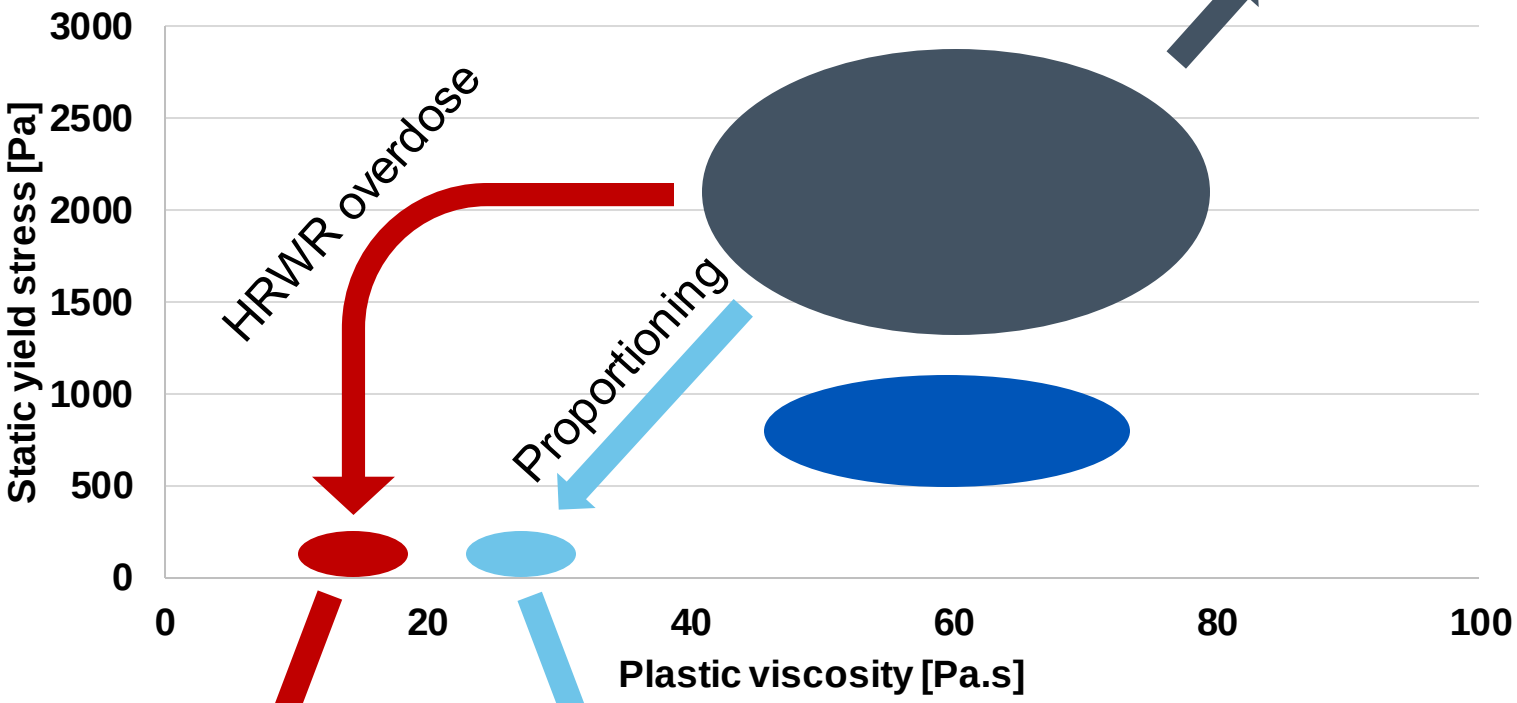

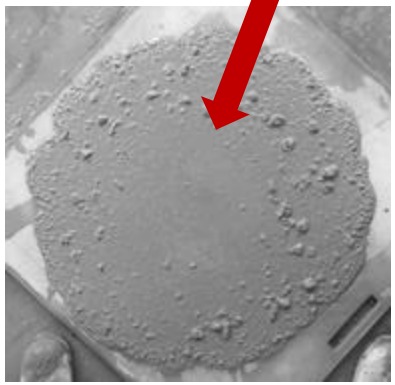

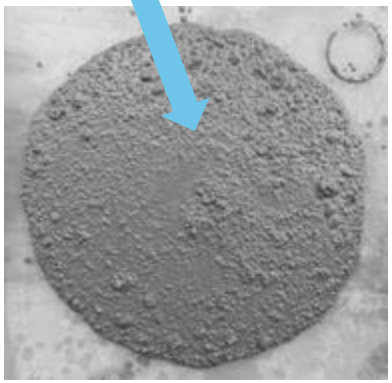

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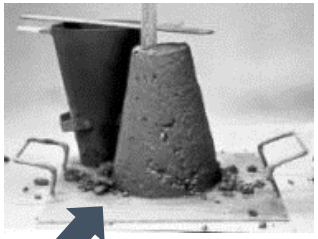

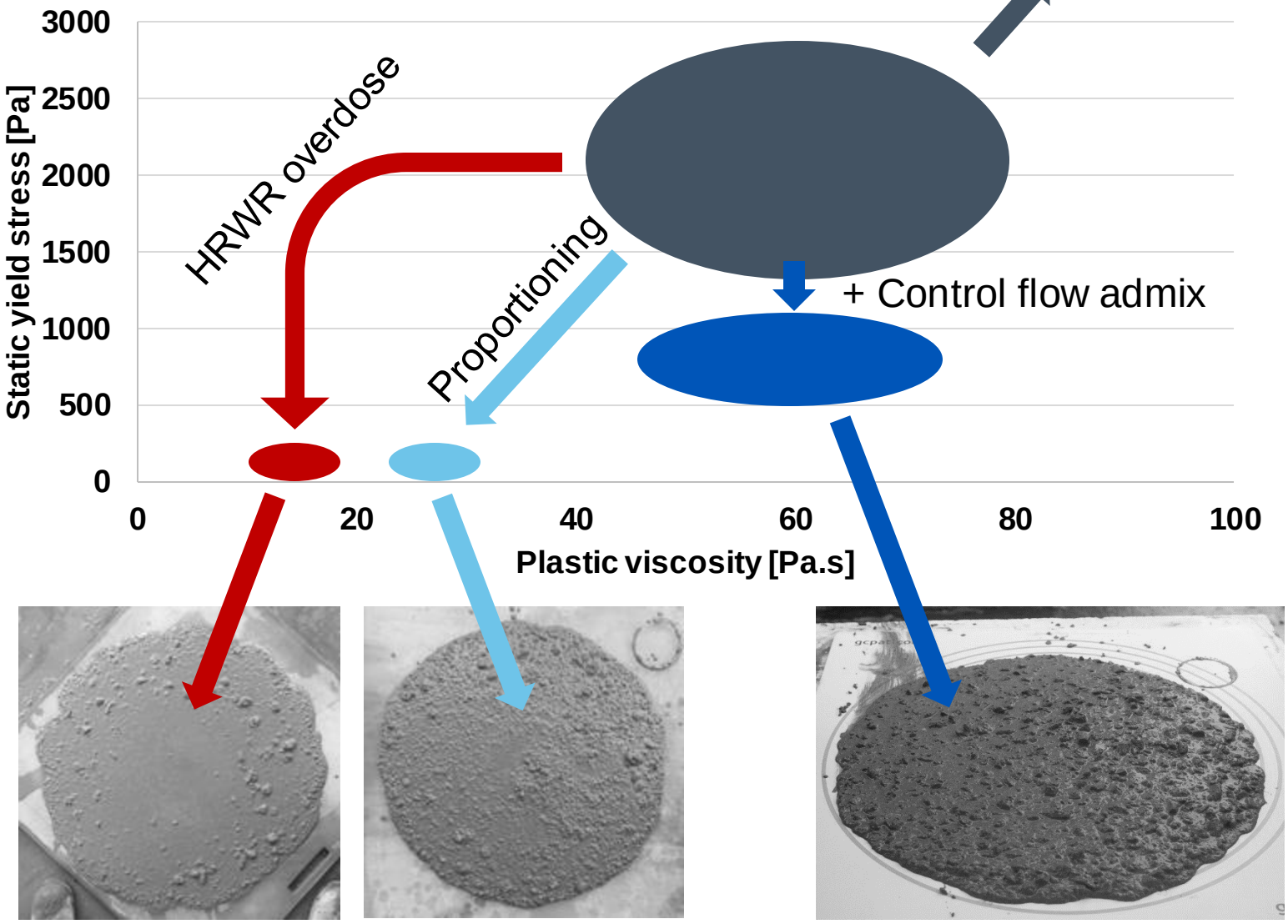

Performance comparison example

	3500 PSI ready mix with HRWR (Conventional)	3500 PSI ready mix with Control Flow Admixture	Self Consolidating Concrete (SCC)
Self-consolidating	No	Semi-consolidating	Yes
Placement	Difficult	Easy	Easy
Labor demand	High	Low	Low
Segregation risk	Low	Low	High
Powder content	500-600 lbs/yd³	500-600 lbs/yd³	>700 lbs/yd³
Mix design adjustments	None	None or Minimal (robust to manufactured Sand)	Yes (high quality fine aggregates and Needs more powder)
Moisture tolerance	Tolerant	Tolerant	Needs very close QC
QC need	Routine	Routine	Extra effort
Drying shrinkage	OK	OK	Higher

Conventional Mix Design with Unconventional Performance

Project highlights with control flow concrete

My Home Vihanga Apartments
Hyderabad, India

Landmark 81
Ho Chi Minh City, Vietnam

Mayo Clinic & MD Anderson Cancer Center
Jacksonville, FL

Tanjong Pagar Centre
Singapore

Landmark 81: Ho Chi Minh City

Tallest building in Vietnam

11th Tallest building in the world

GCP's Dr. Jiang Jiabiao

Final pour, at 400m


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