American Concrete Institute®
Advancing concrete knowledge

Field Measurements of Form Pressure Exerted by Self-Consolidating Concrete

ACI Spring 2013 Convention
April 14 - 16, Minneapolis, MN

ACI
WEB SESSIONS

Peter Billberg is Responsible for Concrete Development at Strängbetong, the largest precast company in Sweden and a company within Concolis. Peter, member of ACI since ten years serves as secretary of ACI 238 Workability and he is also the chairman of RILEM TC 233-FPC on form pressure.

ACI
WEB SESSIONS

Comparison of Various Approaches to the Prediction of Formwork Pressure of SCC

Peter Billberg

Strängbetong

Bakground

RILEM TC 233-FPC
"Form Pressure Generated by Fresh Concrete"

Committee started 2009 and chaired by P. Billberg and N. Roussel. 30 members

Deliverables:

- ✓ Committee report, state-of-the-art
- ✓ Evaluation of existing form pressure models
- ✓ Workshop

Work concluded at latest in 2015

Prediction Models Developed by

- Ovarlez/Roussel
- Perrot *et al*
- Proske (2 models)
- DIN 18218:2010-01 (2 models)
- Beitzel
- Khayat/Omran
- Gardner *et al*
- Lange/Tejeda-Dominguez

France

Germany

Canada

USA

Key Parameters for the Models

Pressure decay curve

$$P_h = \gamma R t \frac{C_0}{(at^2+1)^\alpha}$$

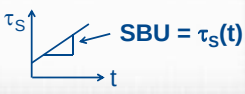
Undisturbed slump loss

$$P_h = wR\left(t_h - \frac{t_h^2}{2t_0}\right)$$

Σ = 10 models

Setting time

Structural build-up

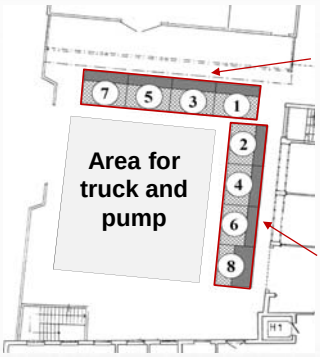


Test Area – CBI:s Backyard

→ 2 walls per day
→ 4 days in a row

Variables:
- proportioning
- casting rate
- wall geometry

Approximately 300 m²

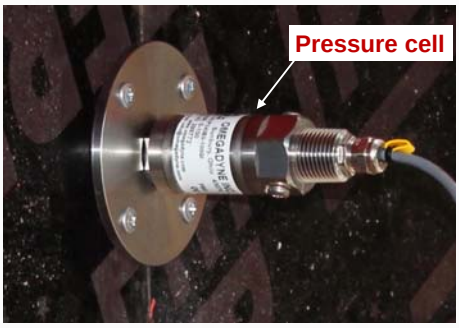


H=6.6 m
L=2.4 m
T=0.2 m

H=4.2 m
L=2.4 m
T=0.2 m
T_8=0.4 m

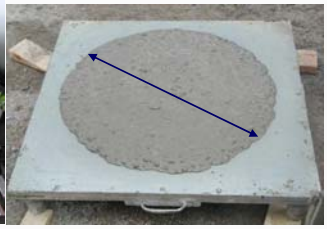
Test Area

Pressure Measurement



Concrete Fresh Properties

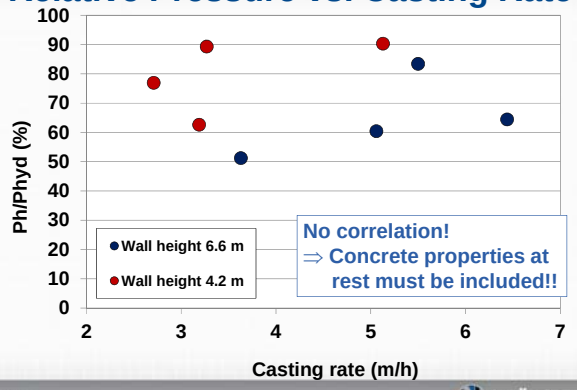
Stable SCC with slump-flow 600-700 mm (24-28")



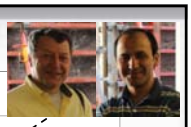
Adjusting Flowability

Characterization of Concrete

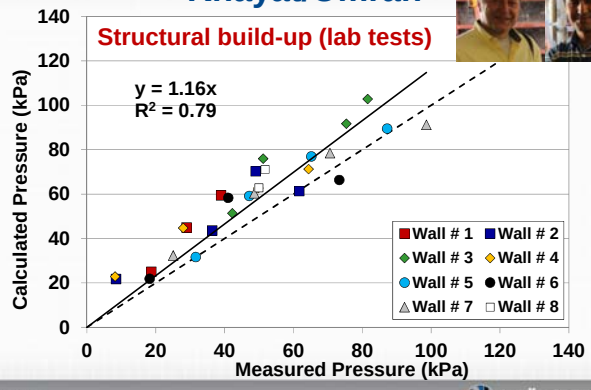
Relative Pressure vs. Casting Rate



Khayat/Omran

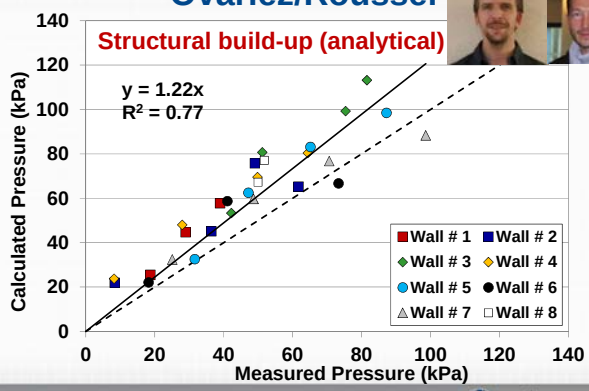


Structural build-up (lab tests)



Ovarlez/Roussel

Structural build-up (analytical)

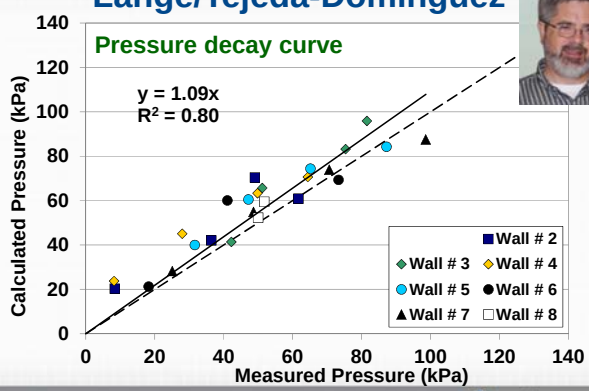


Perrot *et al*

Structural build-up (incl. rebars)

Lange/Tejeda-Dominguez

Pressure decay curve

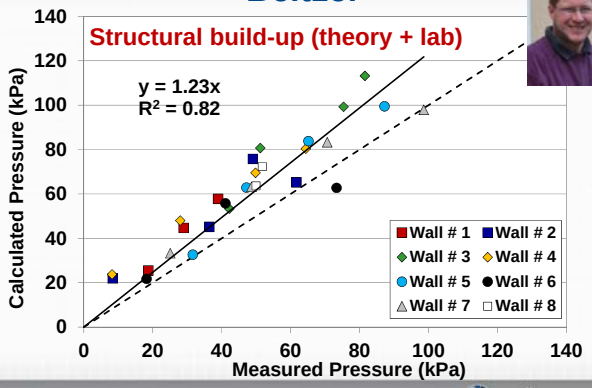


Gardner *et al*

Undisturbed slump loss

Beitzel

Structural build-up (theory + lab)



Proske mean values

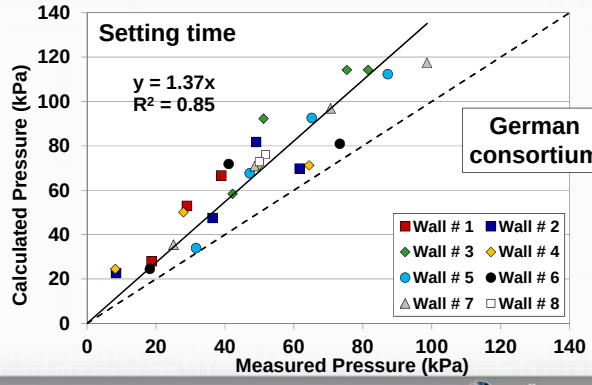
Setting time

Proske design values

Setting time

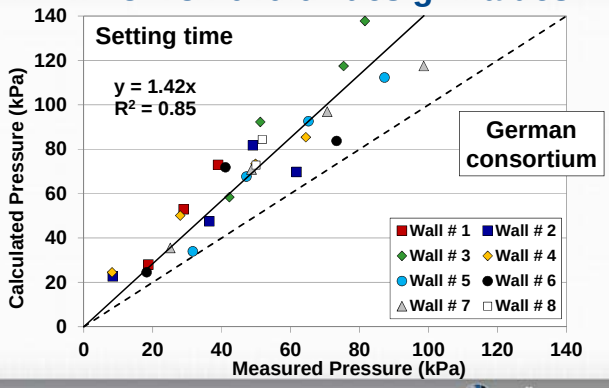
DIN 18218:2010-01 mean values

Setting time



DIN 18218:2010-01 design values

Setting time



Summary of Regressions

Model by	Slope	R²
Khayat/Omran	1.16	0.78
Ovarlez/Roussel	1.22	0.77
Lange/Tejeda-Dominguez	1.09	0.80
Perrot et al	1.20	0.81
Gardner et al	1.30	0.86
Beitzel	1.23	0.82
Proske mean	1.23	0.69
Proske design	1.40	0.85
DIN 18218 mean	1.37	0.85
DIN 18218 design	1.42	0.85

Conclusions (1/2)

- ✓ **Knowing the casting height, form geometry, concrete density and casting rate is not enough in order to calculate the form pressure. Concrete properties at rest must be accounted for. However, NOT the recipe or fresh properties such as slump-flow or T_{500}!**
- ✓ **All evaluated models are based on key parameters relating to the concrete behavior at rest (structural build-up, pressure decay, setting time or undisturbed slump-loss)**

Conclusions (2/2)

- ✓ **The models are all satisfactory in that they are conservative with good precision (R^2 = 0.69-0.86). None can be singled out as best and none can be excluded. Choice of model should be based on how to capture the key parameter in the easiest and most reliable (accurate) way.**
- ✓ **More field studies are needed in order to statistically define the reliability and confidence of the model chosen.**

Acknowledgements

Moral support from ACI and financial support from ACI Concrete Research Council (CRC)

Moral support from RILEM

Financial support from the Swedish Consortium for Financing Basic Research in the Concrete Field

Financial support from the Development Fund of the Swedish Construction Industry

THANKS!