



Lightweight Self-Compacting Concrete (L-SCC): Systematic approach and case study

5th International RILEM Symposium on Self-Compacting Concrete (SCC2007)
3-5 september 2007, Ghent

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Introduction

Mix Design/Materials

Test Results

Case Study

Conclusion

- Why lightweight SCC?
 - Reduction in dead load
 - Transport weight
- Objectives research
 - Mix design method for precast plants
 - Flexibility:
 - basic materials
 - compressive strength and density

Density classes (D-class)	Requested compressive strength class (LC-class)
D 1.6 <i>(1400 < oven-dry density < 1600 kg/m³)</i>	LC 25/28
	LC 30/33
	LC 35/38
D 1.8 <i>(1600 < oven dry density < 1800 kg/m³)</i>	LC 30/33
	LC 35/38
	LC 40/44
D 2.0 <i>(1800 < oven dry density < 2000 kg/m³)</i>	LC 45/50
	LC 50/55



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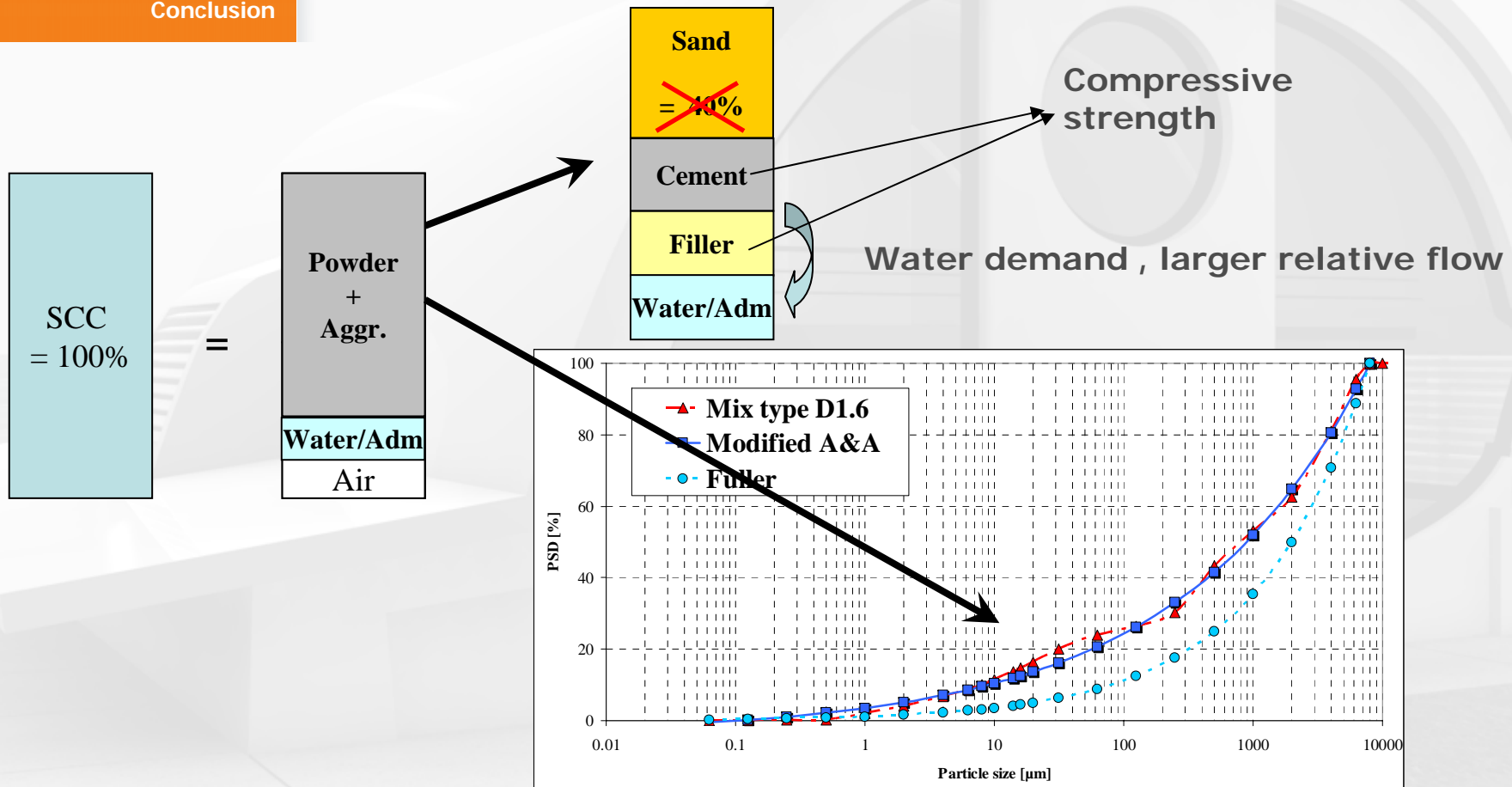
Test Results

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• Approach (Brouwers)

- Chinese Method \approx Modified Andersen and Andreassen gradings
- No fixed ratios paste/sand/gravel





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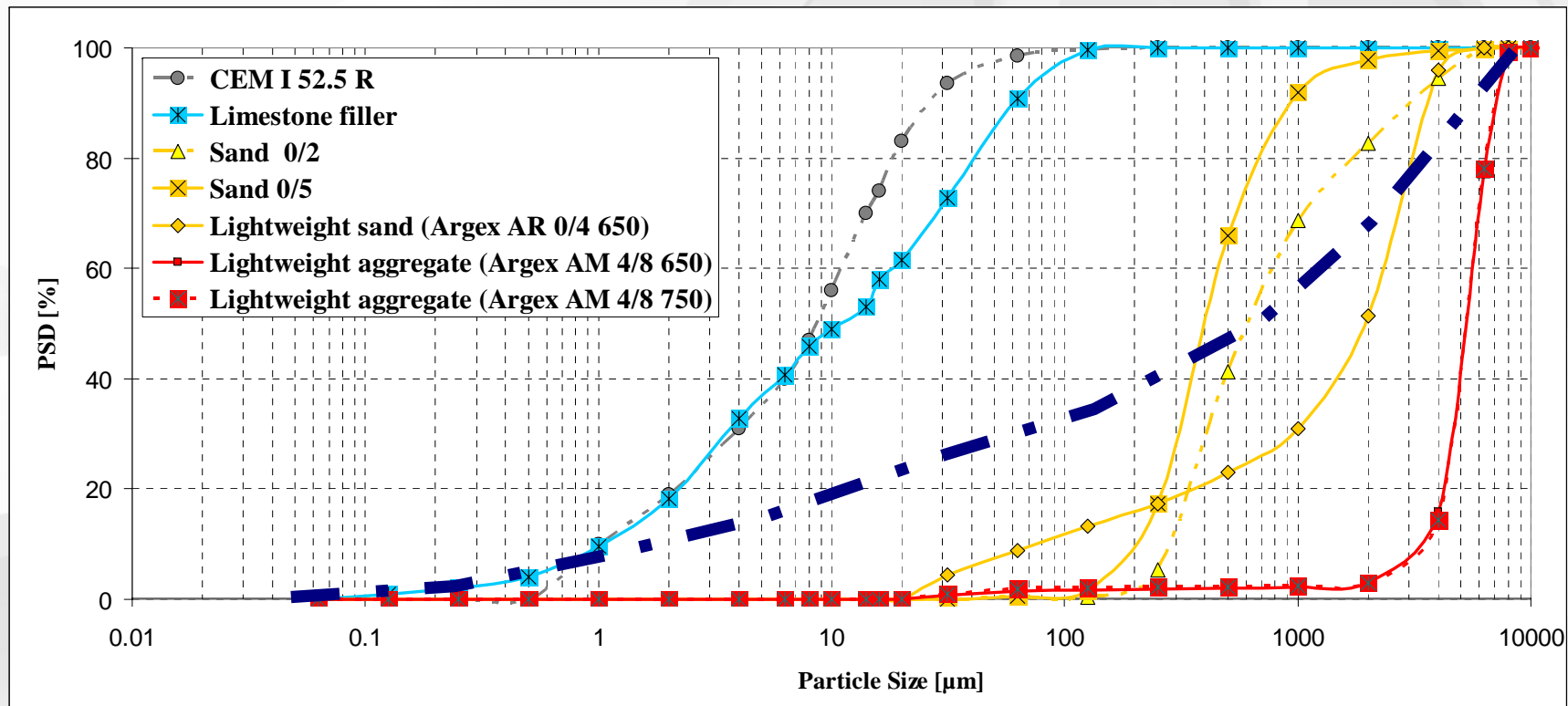
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- Approach (Brouwers)

- No fixed ratios paste/sand/gravel
- Less cement/filler, more (fine) sand
- Input PSD: optimal packing, robust mixtures, good rheology, more sand, cheaper





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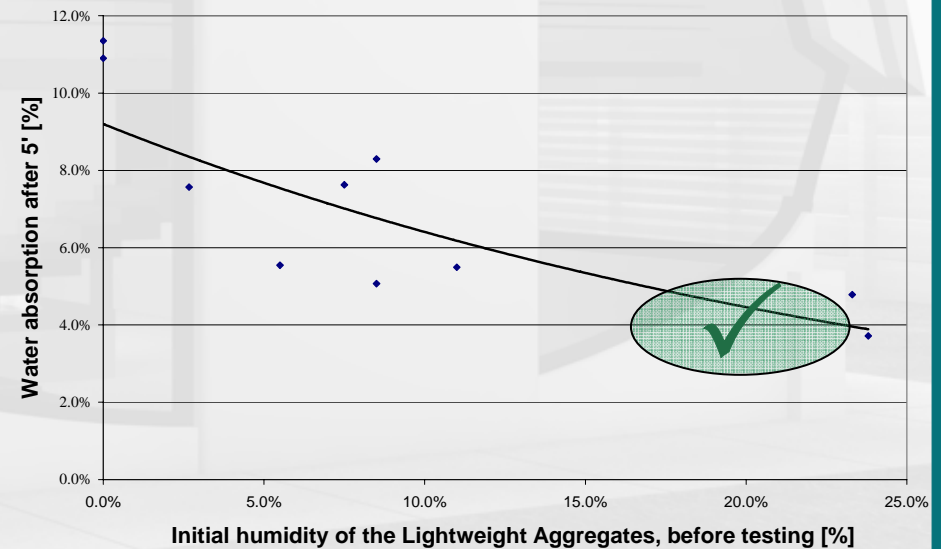
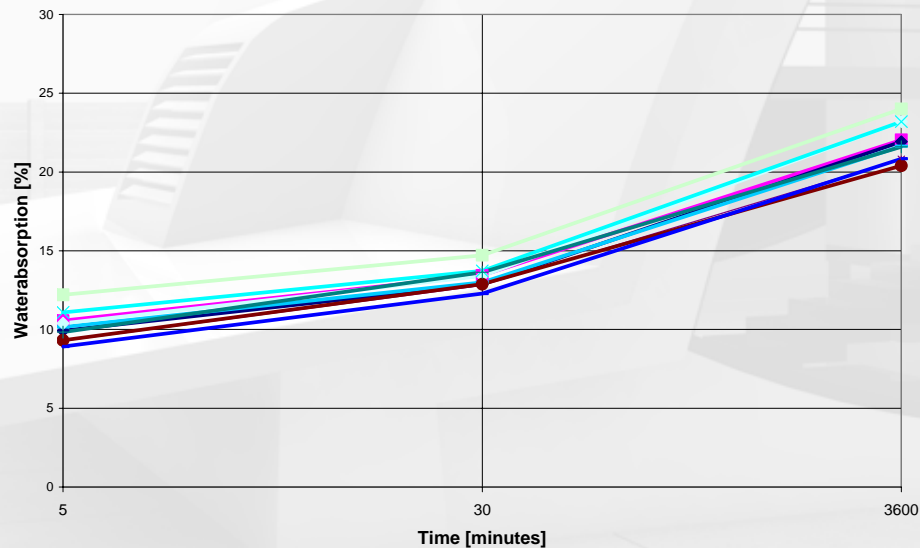
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- Lightweight aggregates

- expanded clay, porous, cellular structure
- 0/4 mm (650) and 4/8 mm (650 or 750)
- water absorption!
 - > prewetting





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- Typical mix design
 - 3 classes

Mixture design [kg/m ³]	LD 1.6	D 1.8	D 2.0
	LC 30/33	LC 35/38	LC 45/50
Cement (CEM 1 (52.5 R LA))	330	350	350
Limestone filler	260	172	172
Sand 0/2	164	140	78
Sand 0/5	0	648	886
Lightweight aggr. 0/4 650	524	0	0
Lightweight aggr. 4/8 650	220	450	0
Lightweight aggr. 4/8 750	0	0	360
Water	159	170	170
SP	4.3	4.1	4.2
VMA	2.3	2.3	3.7
Theoretical density [kg/m ³]	1773	1934	2023
W/C [-]	0.50	0.50	0.50
W/P [-]	0.27	0.32	0.32

SP and VMA dosage:

- stability of the mixture (water variations)
- inhibits floating of the lightweight aggregates (« inverse segregation »)
- surface finish



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- Typical test results

- 3 classes

Characteristics fresh concrete	LD 1.6	D 1.8	D 2.0
Slump flow [mm]	655	730	690
T50 mm [s]	4	5	3
Funnel time [s]	15	25	10
J-Ring (slump flow) [mm]	675	640	700
with blocking step (h1/h2)	6	10	4
L-Box (ratio)*	0.86	0.70	0.80
Air-ratio [%]	2.0	3.0	1.6
Fresh density [kg/m ³]	1766	1834	2070
Characteristics hardened concrete			
f _{cm_cube} 1d [N/mm ³]	-	32	-
f _{cm_cube} 7d [N/mm ³]	37	-	54
f _{cm_cube} 28d [N/mm ³]	42	46	62
f_{ck_cube} 28d [N/mm²]	40	39	56
Resulting LC-class	LC 30/33	LC 35/38	LC 45/50
Oven-dry density 28d [kg/m ³]	1544	1780	1817
E-modulus [N/mm ²]	19350	23000	27100

~ Target value

> Wide range

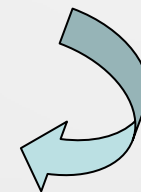
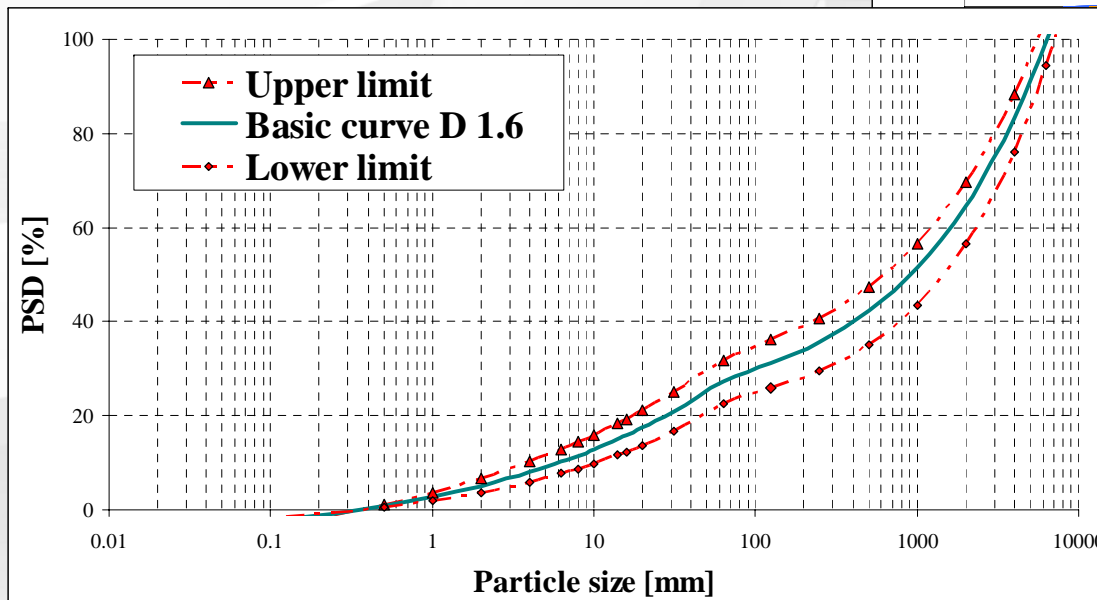
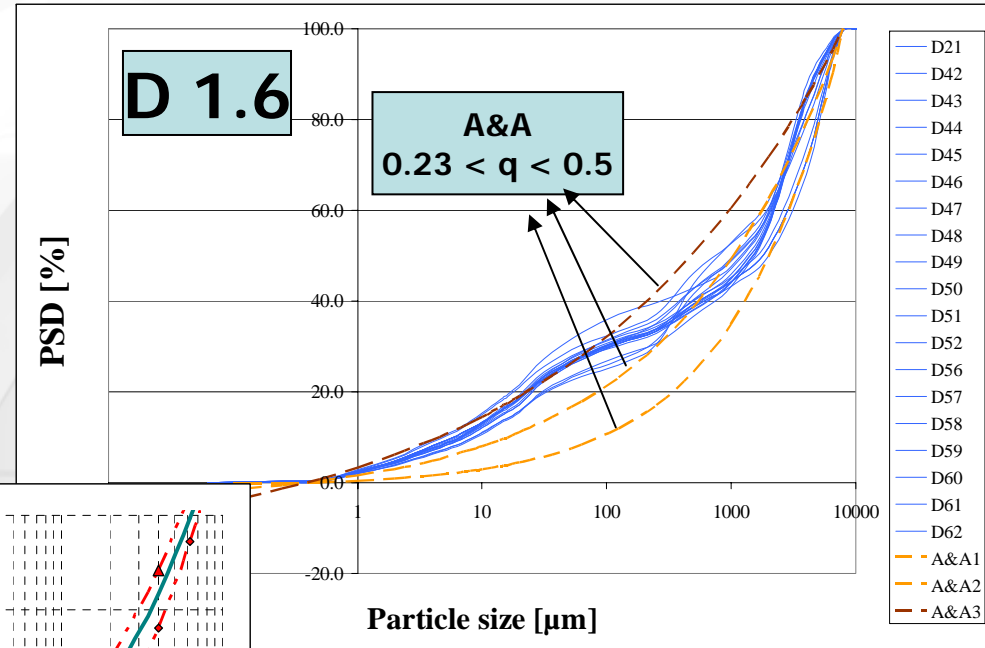
~ Eurocode 2

Shrinkage: 300 to 400 μm/m at 2 months measurements ongoing



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- Theory -> empirical curves





Case study: first industrial tests

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- Large-scale tests (precast plant)
 - housing elements (120·700·15 mm³)

Mixture design [kg/m ³]	
Cement	354
Limestone	225
W/C [-]	0.59
Characteristics fresh concrete	
Slump flow [mm]	675
Funnel time [s]	13
Fresh density [kg/m ³]	2059
Characteristics hardened concrete	
f _{cm_cube} 28d [N/mm ²]	51
Oven-dry density 28d [kg/m ³]	1800





Conclusions

- Mix design method
 - Chinese method, modifications by Brouwers and empirical adaptations
 - ↳ Including effect of PSD's
 - Optimal packing, robust mixtures
- Resulting mixtures
 - Slump flow 700 – 750, funnel time 5 – 25 s
 - Density range, oven-dry: 1400 – 2000 kg/m³
 - Compressive strength: LC 20/22 – LC 50/55
- Implementation in precast plants: more industrial tests are planned
- Surface finish: some work to be done



Thank you very much for your attention!

Questions?

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