

Surface Settlement of SCC – How Critical is it on Concrete Performance?

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OUTLINE

- Workability functional requirements of SCC
- Measurement of surface settlement
- Selected factors affecting surface settlement
- Effect of surface settlement on SCC performance
 - Top-bar effect
 - Transport properties
- Recommendations

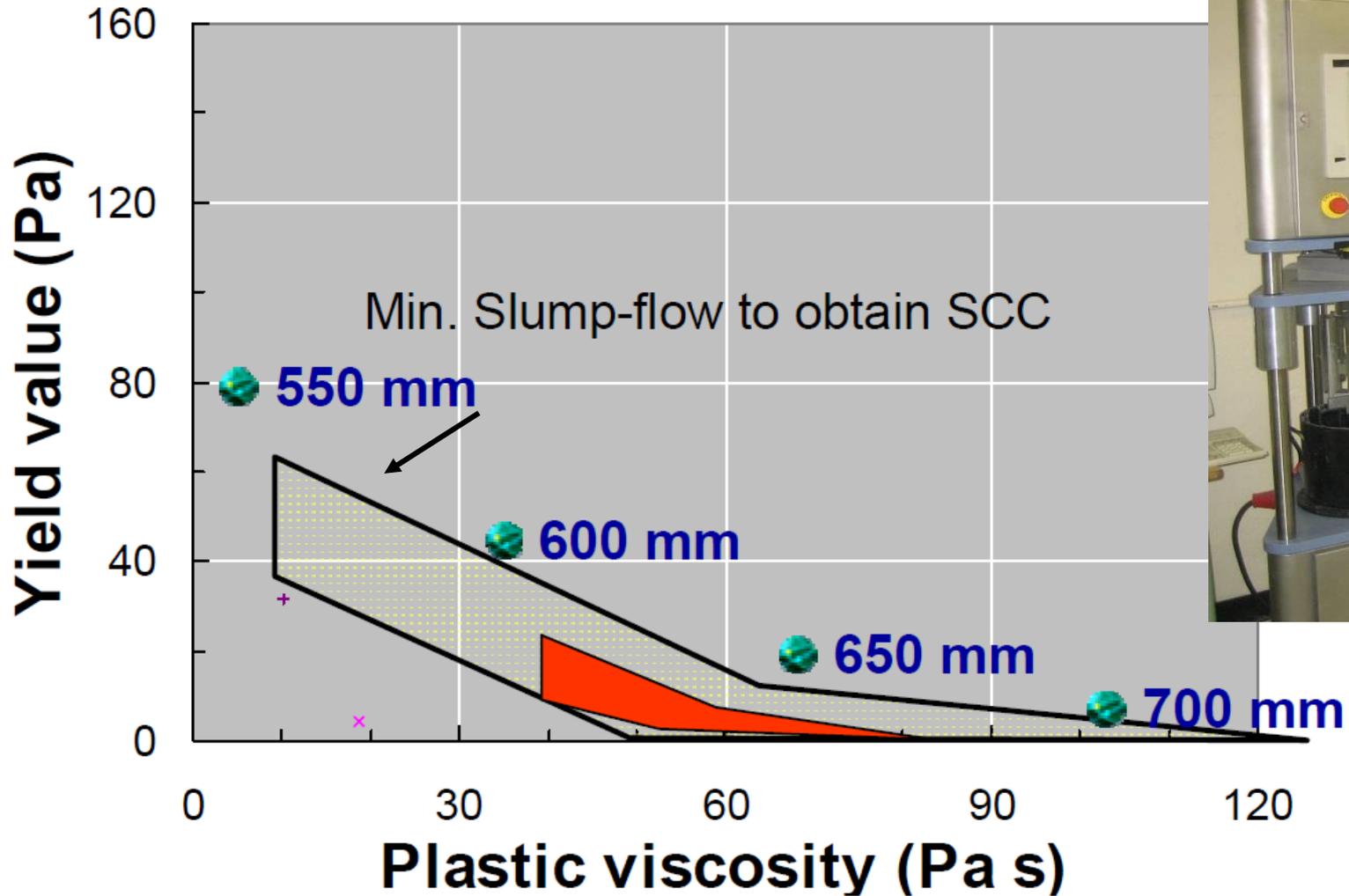
Flow behavior of SCC is complex and must be optimized to secure adequate performance

low resistance to flow (low τ_0)
high stability (moderate visc.)



high passing ability (low τ_0 + mod. visc.)

Rheological parameters of SCC



SCC Functional Requirements

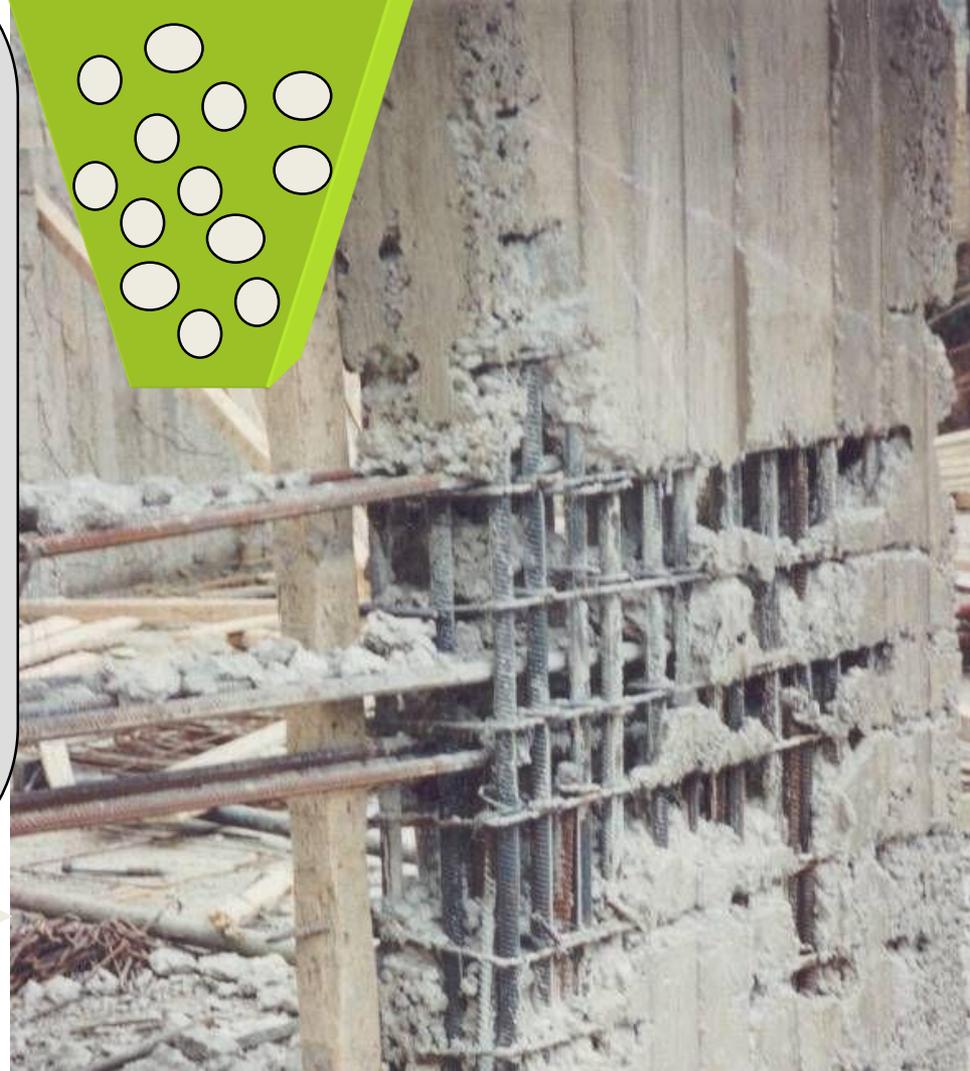
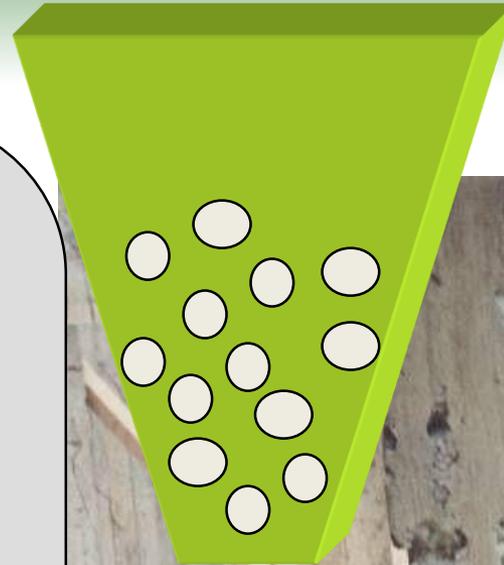
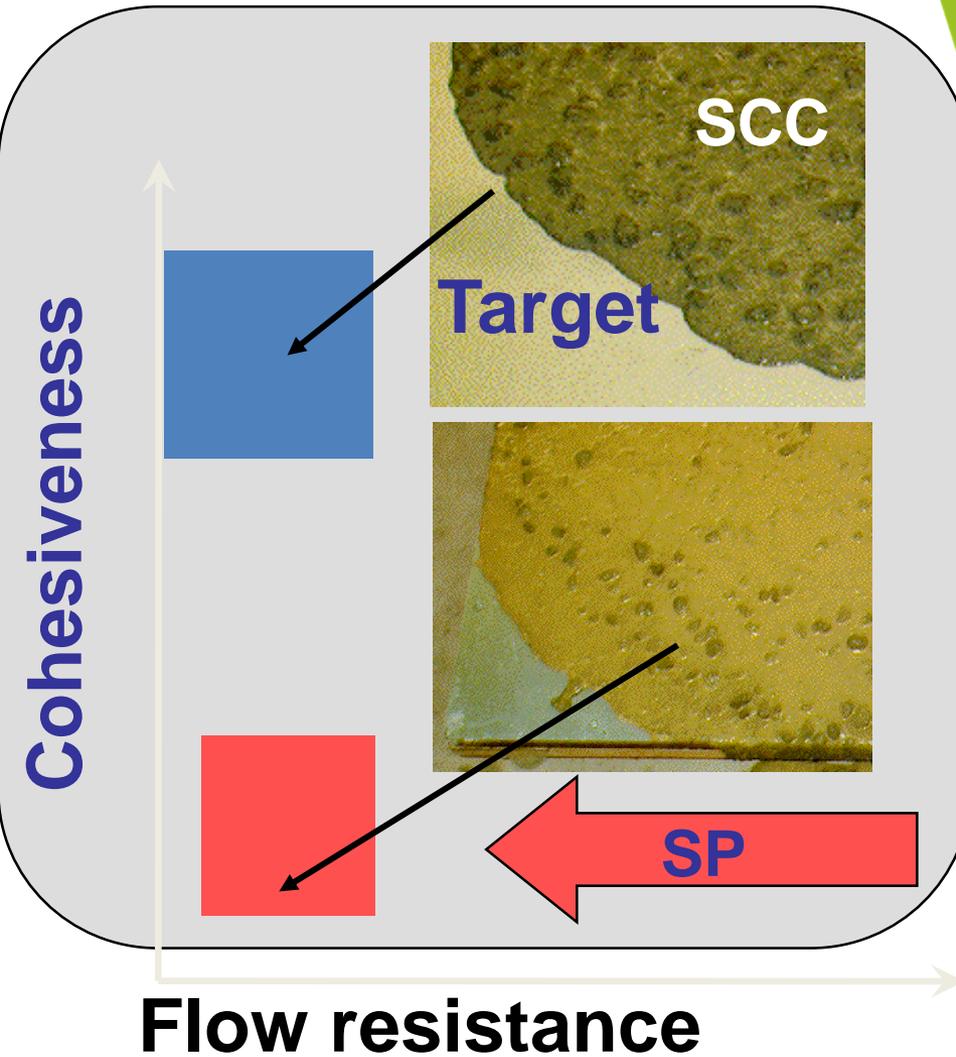
- Filling ability
 - Passing ability
- } Filling capacity
- Resistance to segregation
 - Static stability
 - Dynamic stability



Adequate Workability



Inadequate Workability



Inadequate Workability



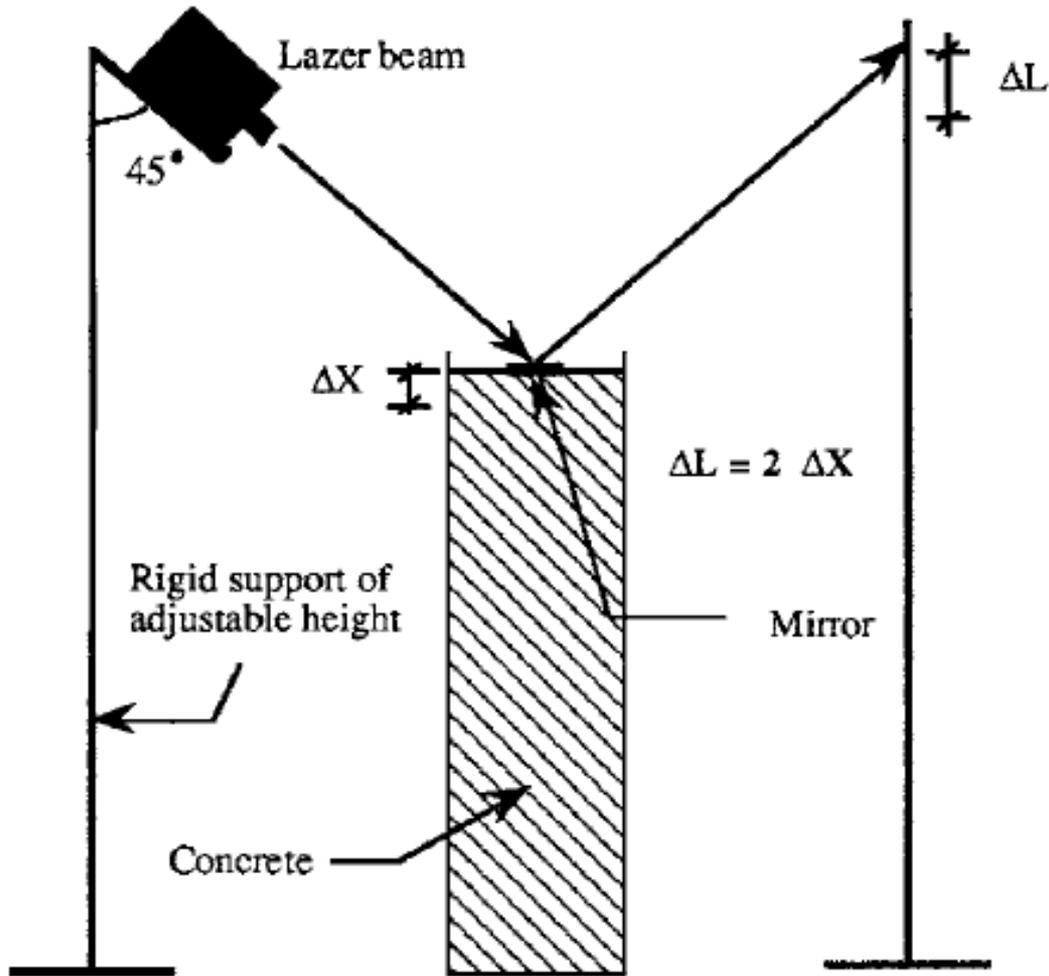
Static stability : resistance to segregation, bleeding, settlement following placement and until the onset of setting



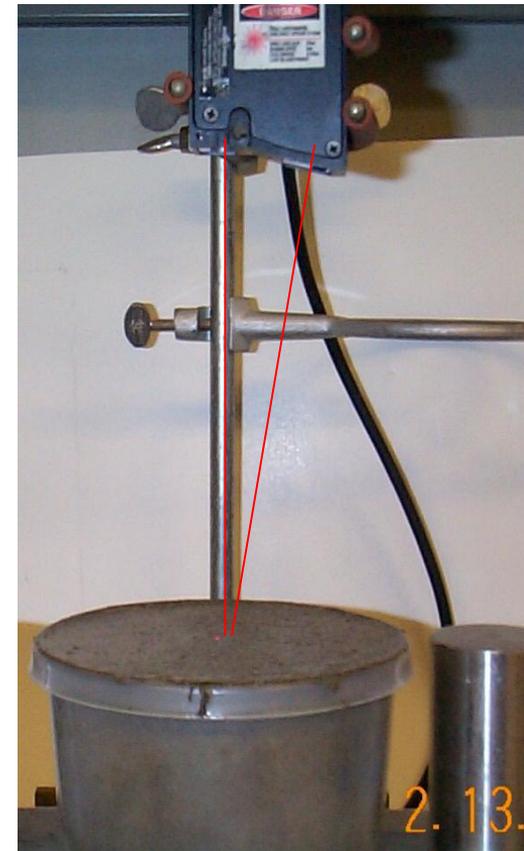
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Non-Contact Laser Measurement of Settlement

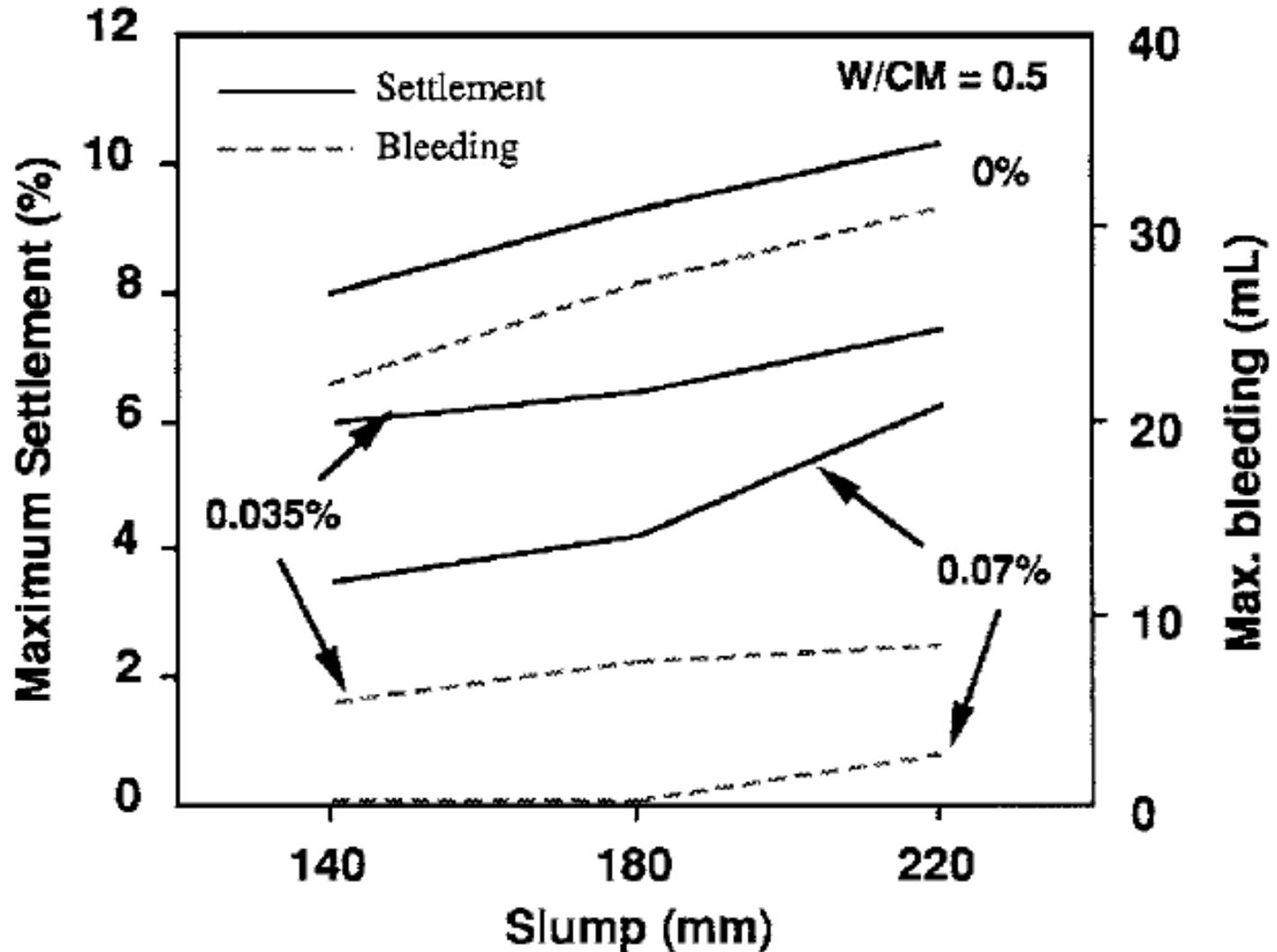


Khayat and Guizani, *ACI Mat. Jr.* July-Aug. 1997

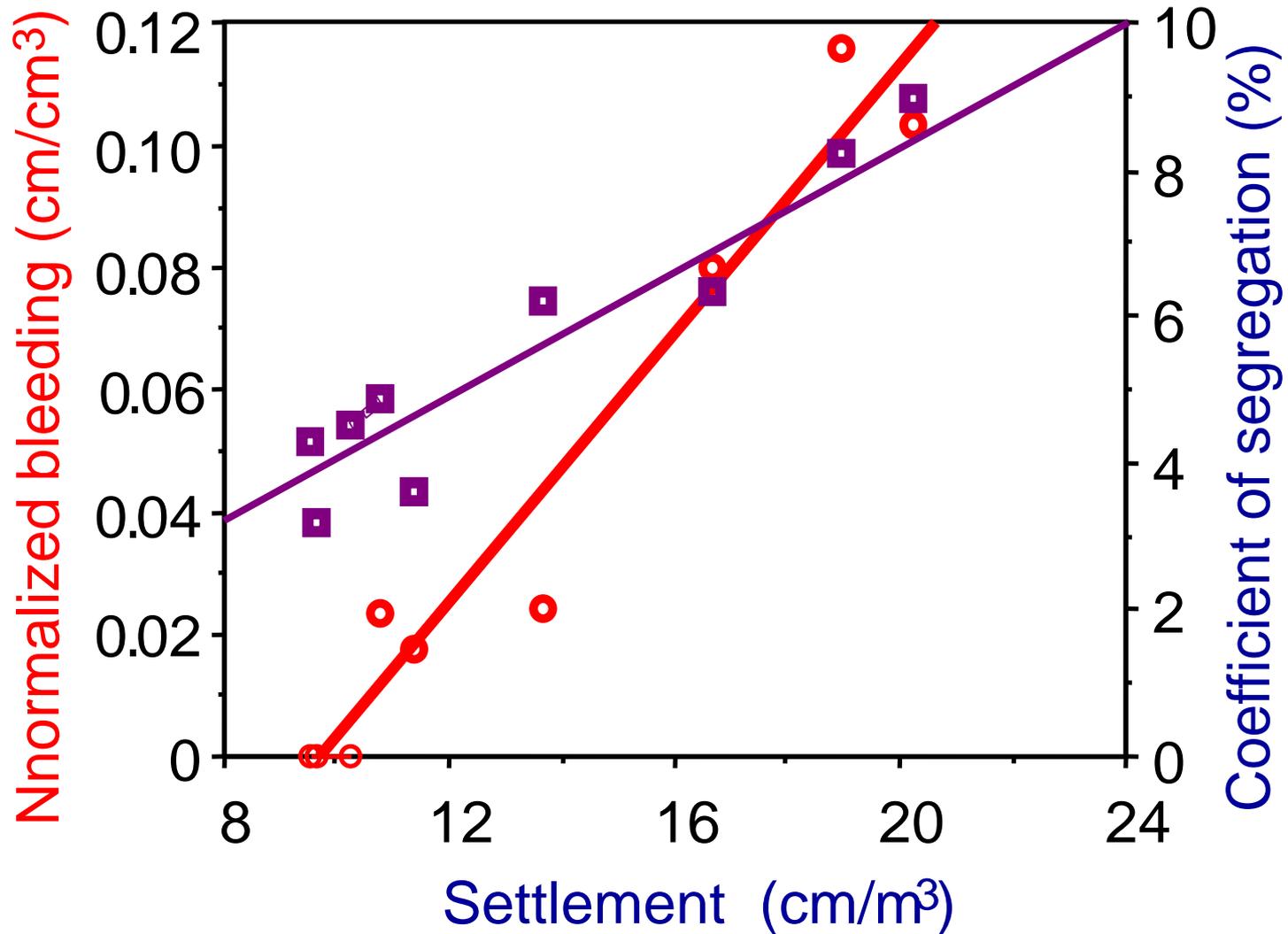


Weiss

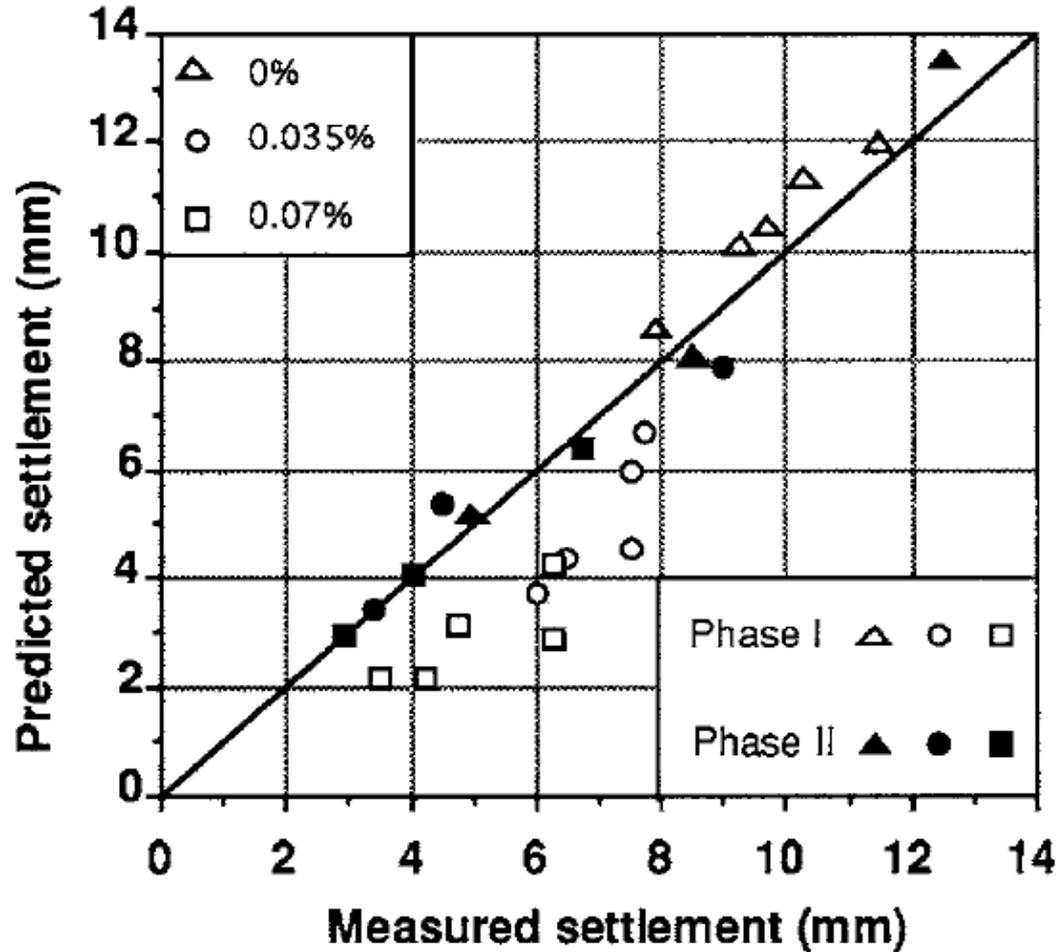
Effect of Welan Gum on Surface Settlement and Ext. Bleeding (H = 700 mm)



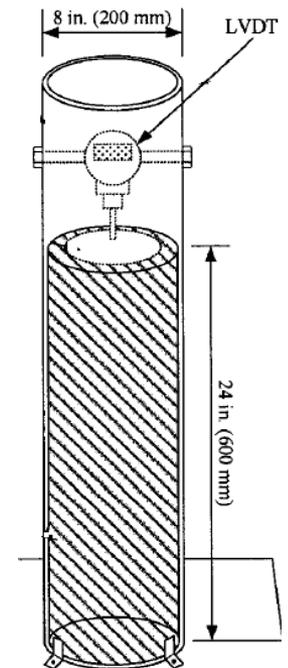
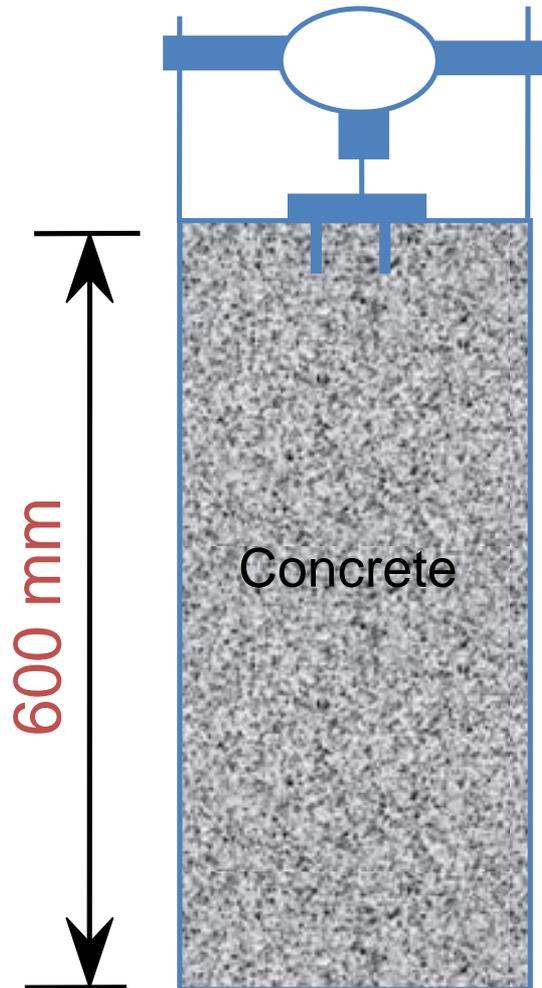
Surface Settlement



Predicted Surface Settlement



Surface Settlement Column

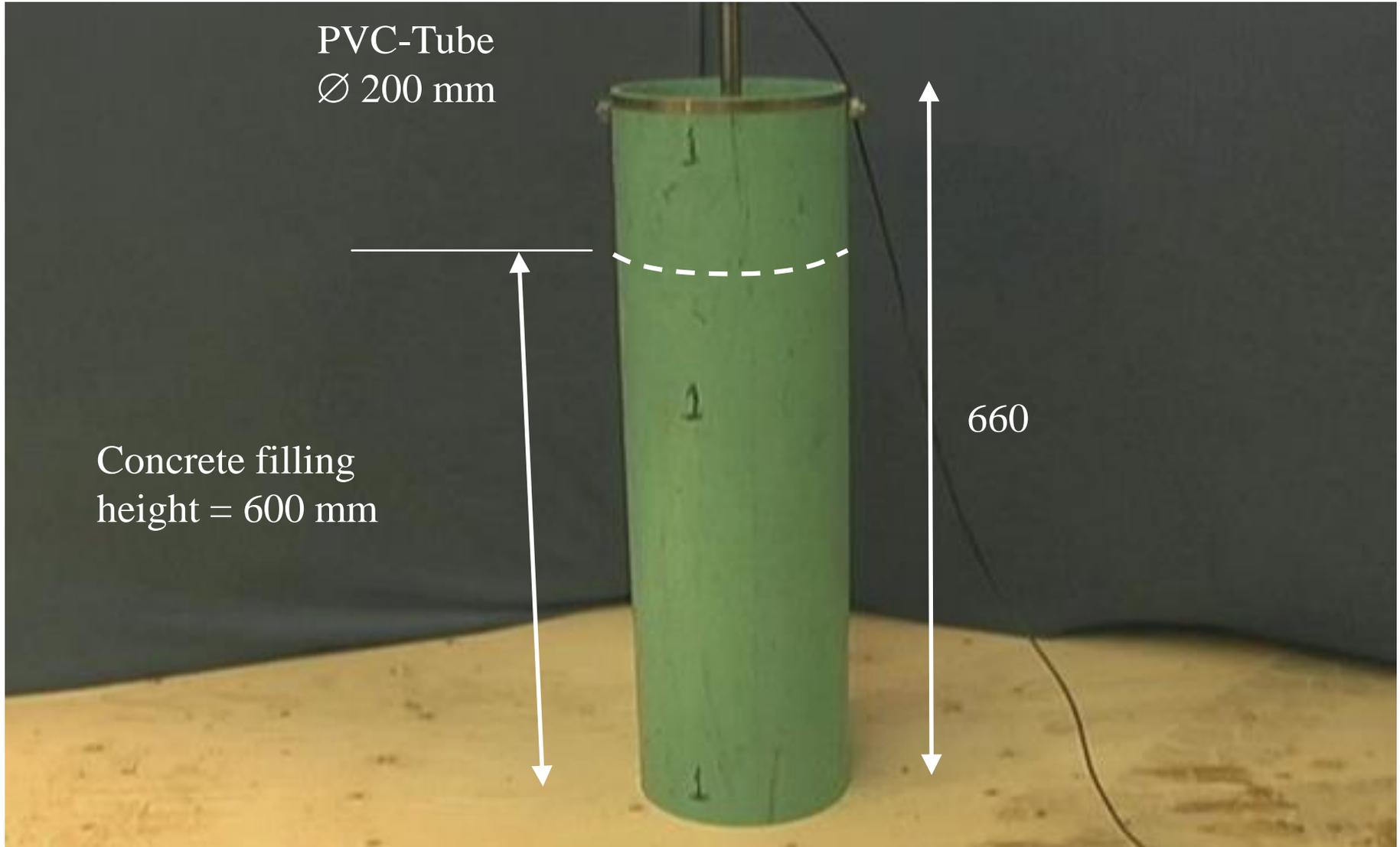


Surface Settlement

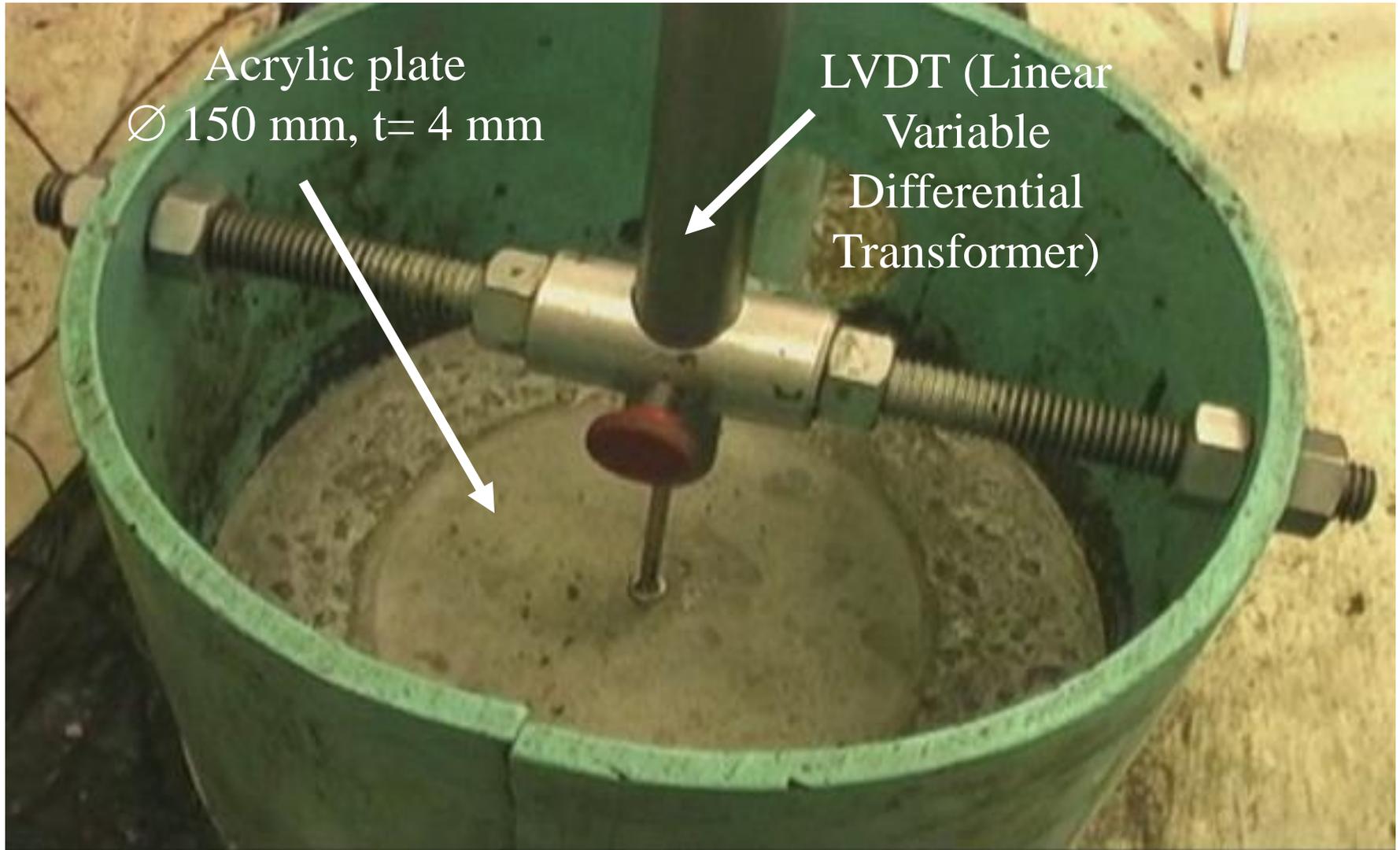
PVC-Tube
Ø 200 mm

Concrete filling
height = 600 mm

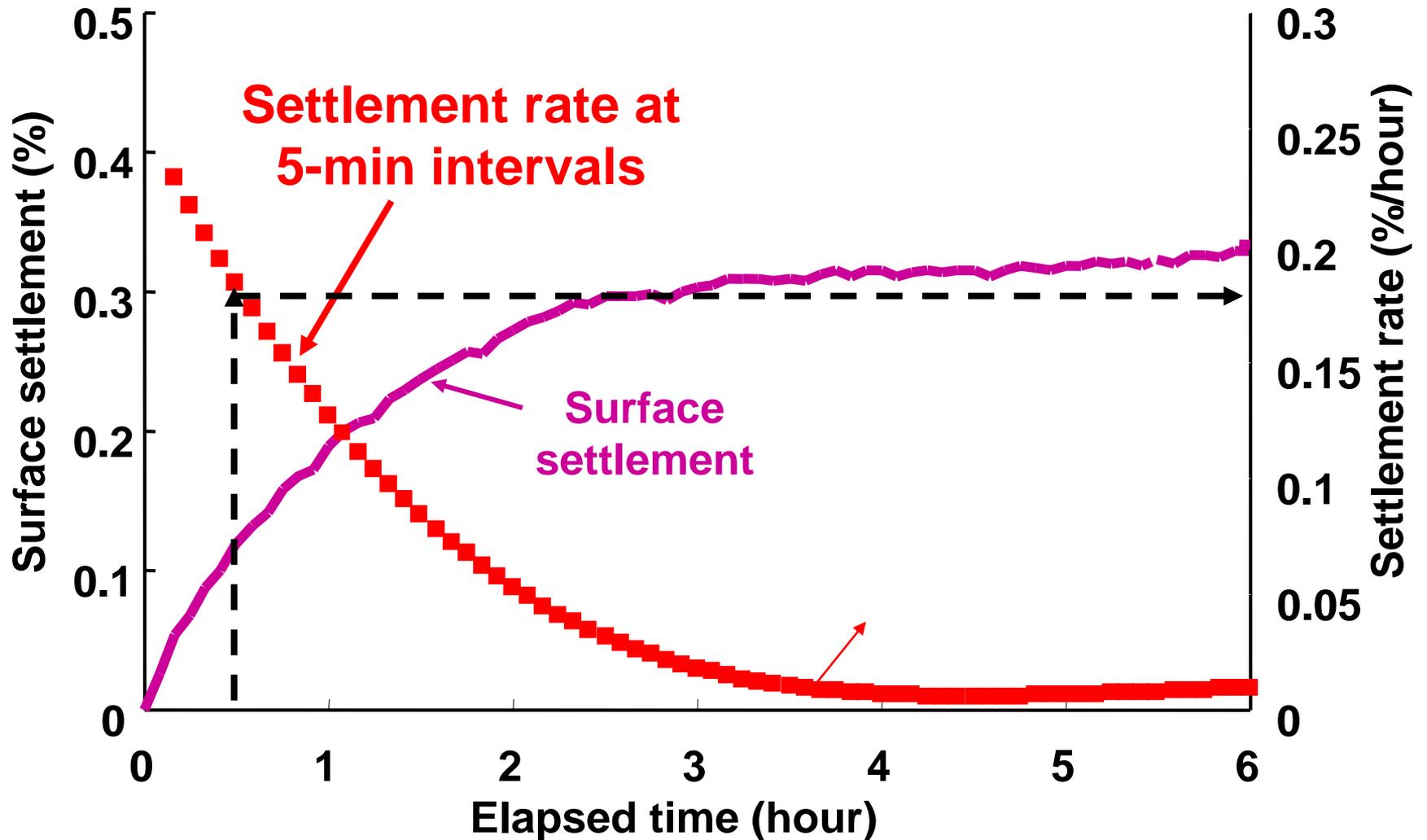
660



Surface Settlement



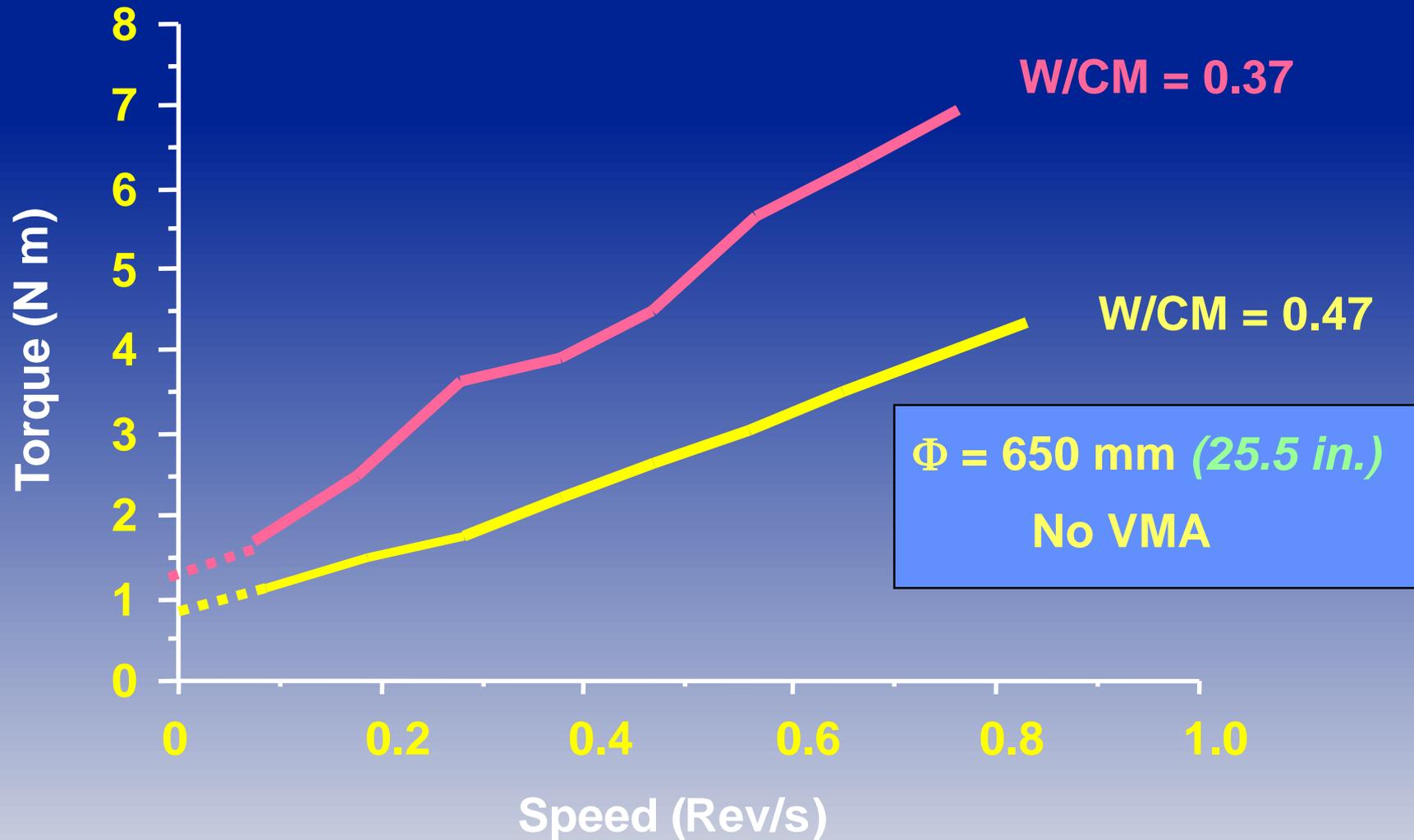
Surface Settlement and Rate of Settlement



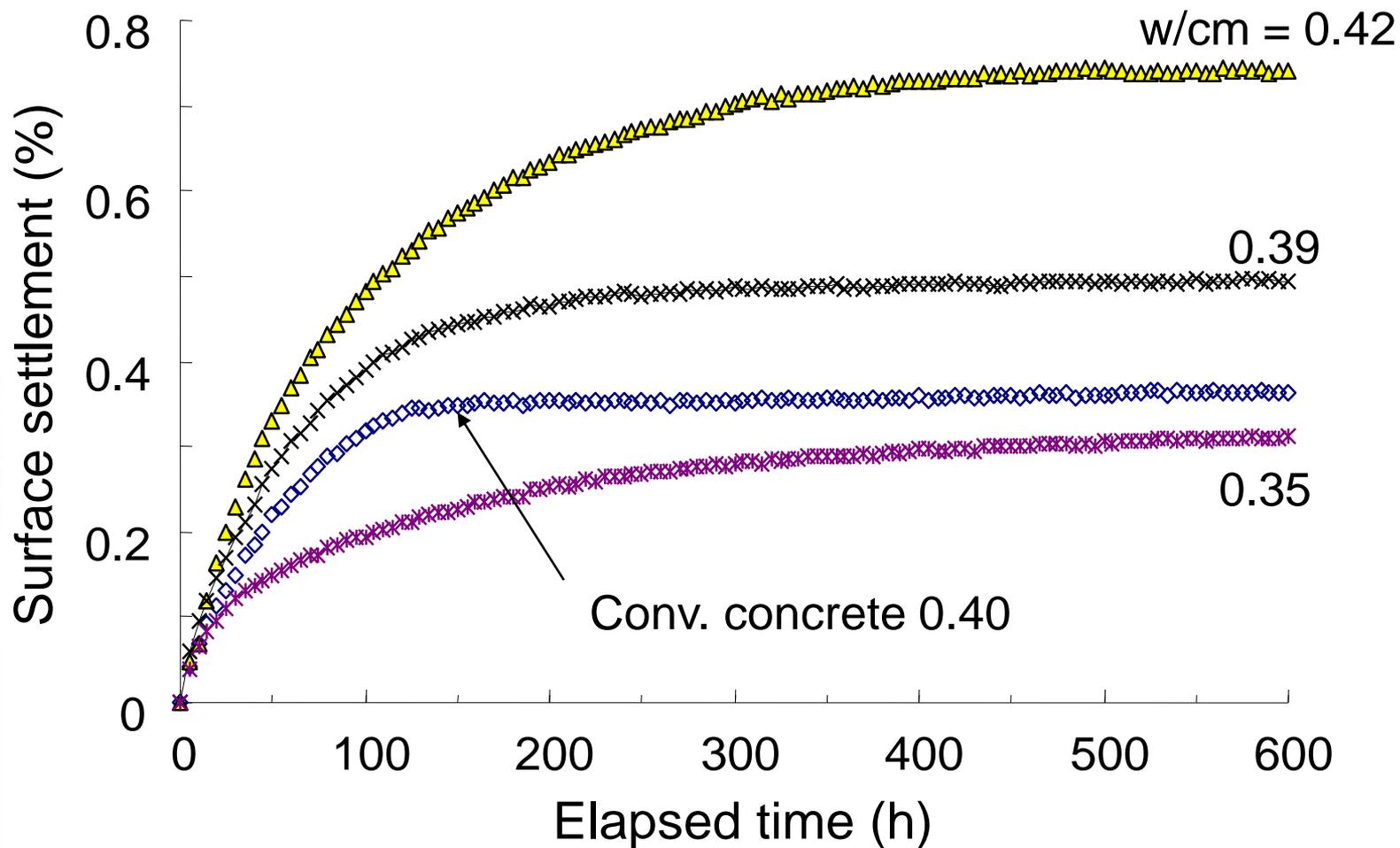
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Reduction in w/cm



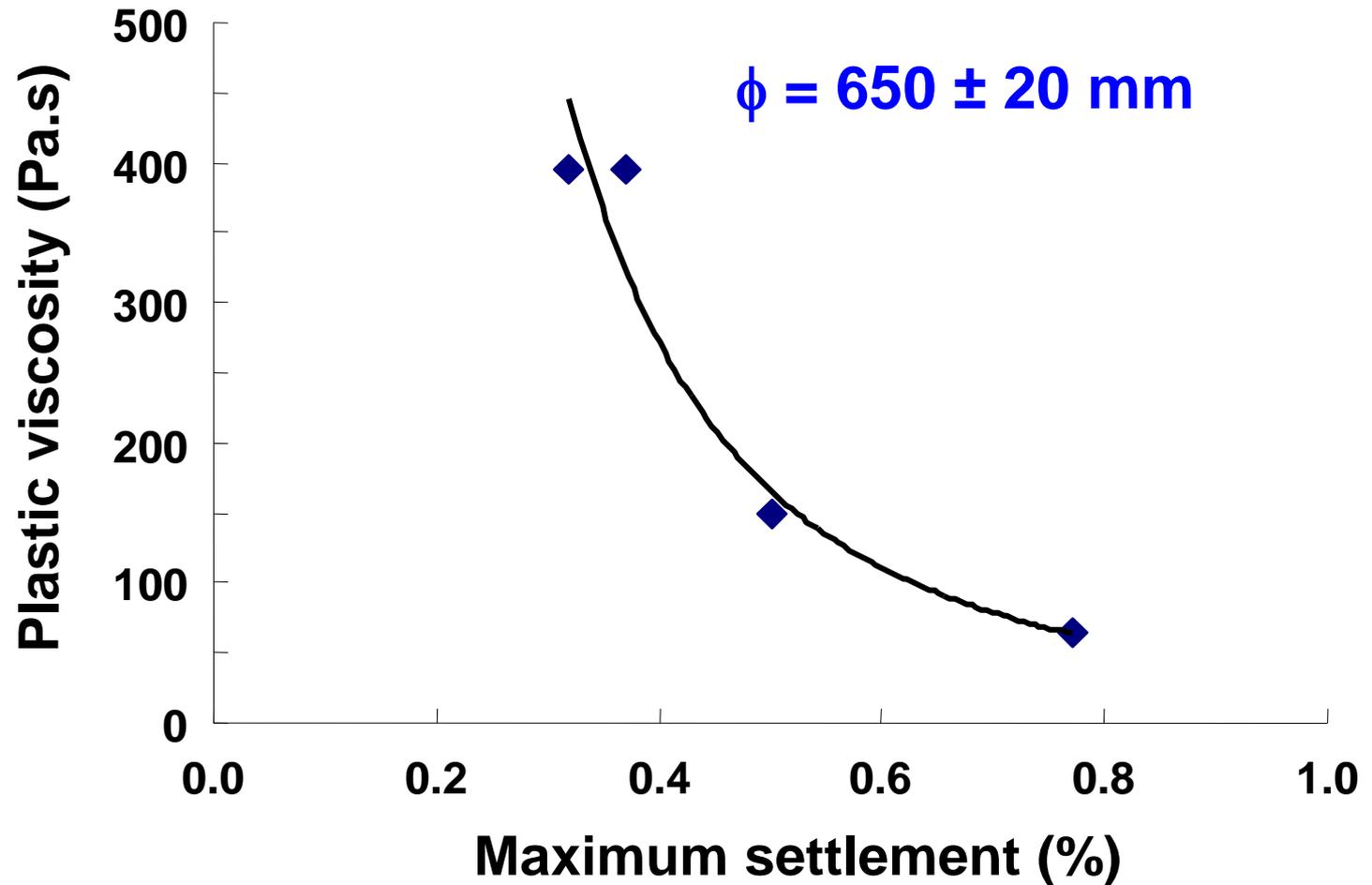
Effect of w/cm on Surface settlement of SCC



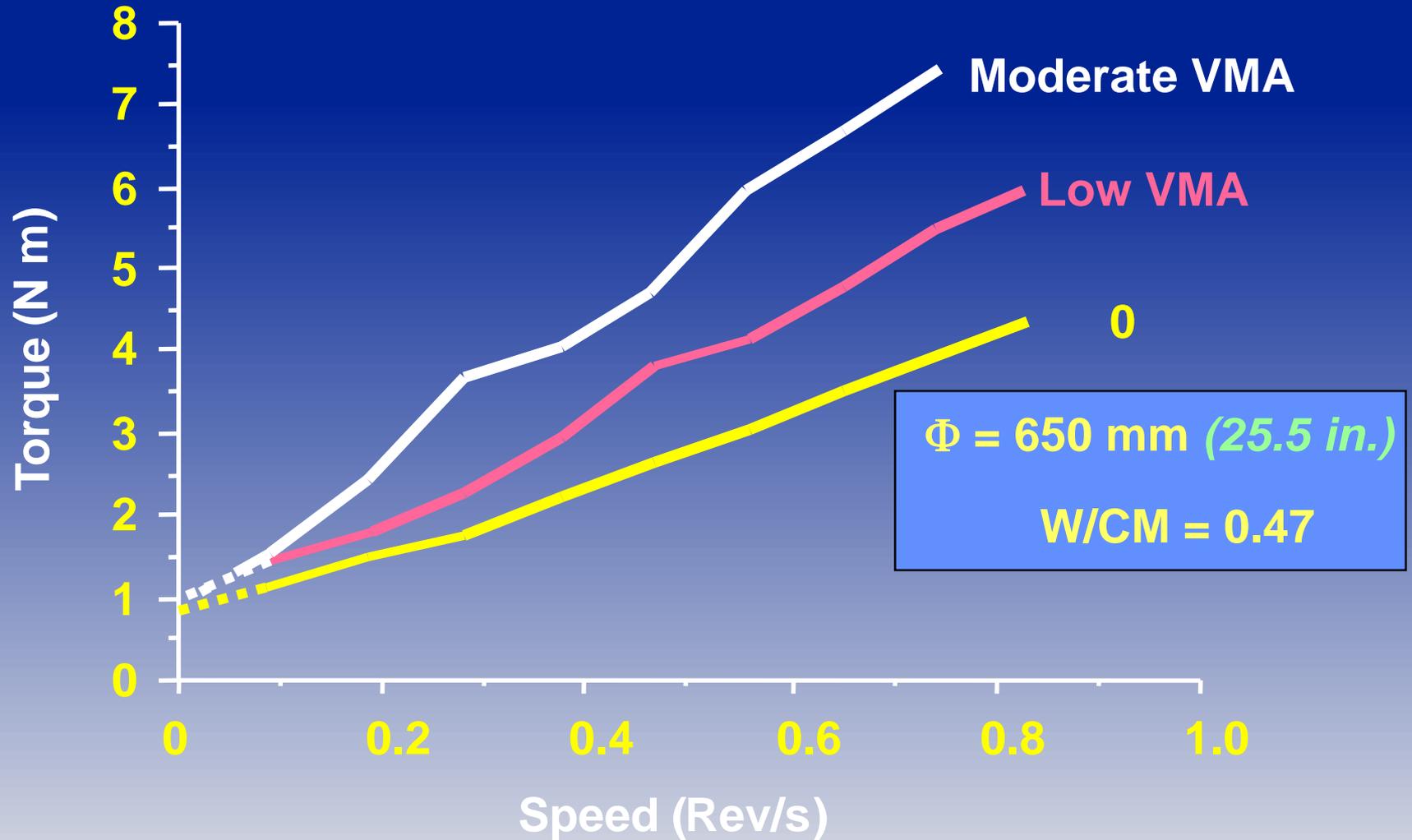
Khayat et al. 2005



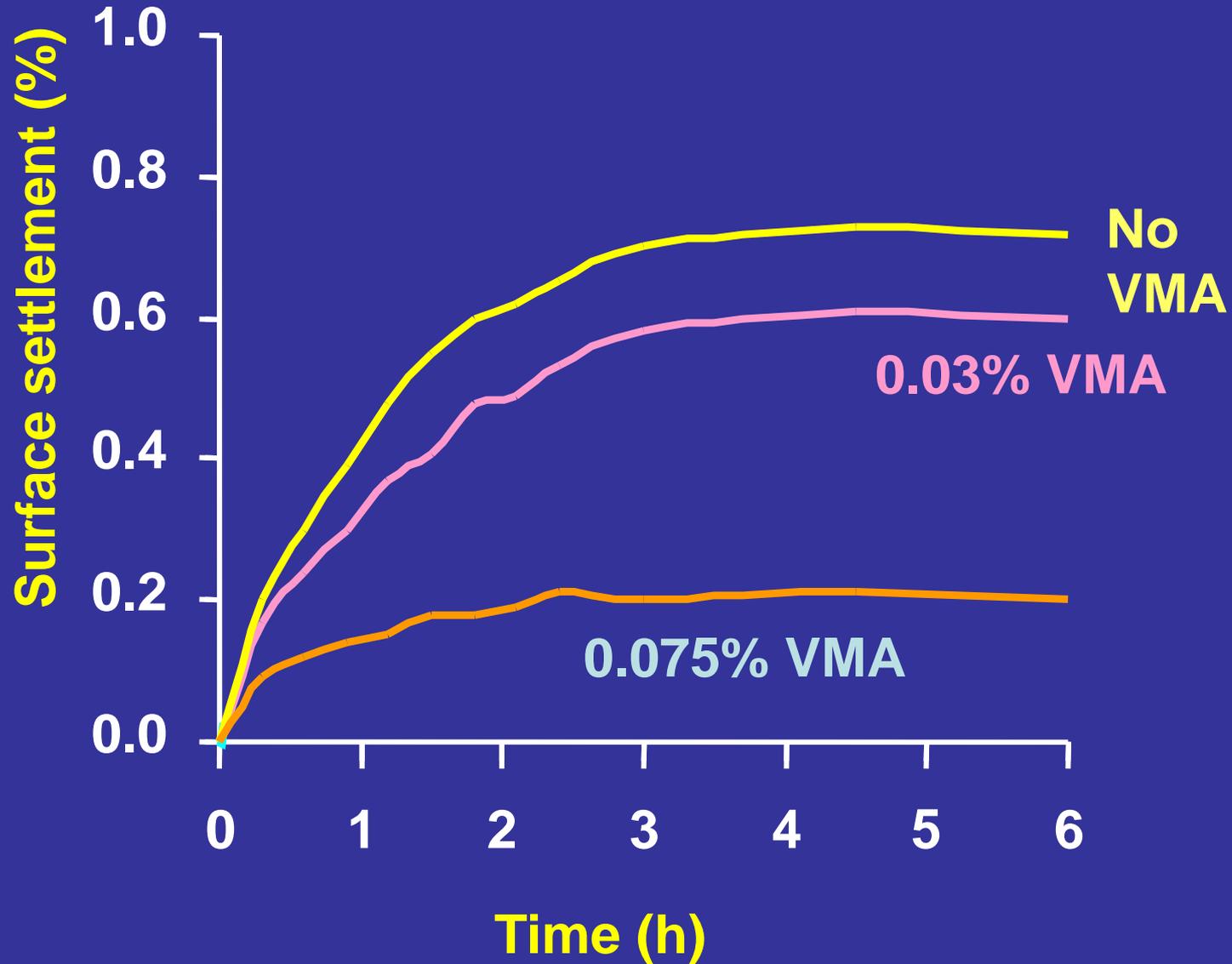
Surface Settlement vs. Plastic Viscosity of SCC



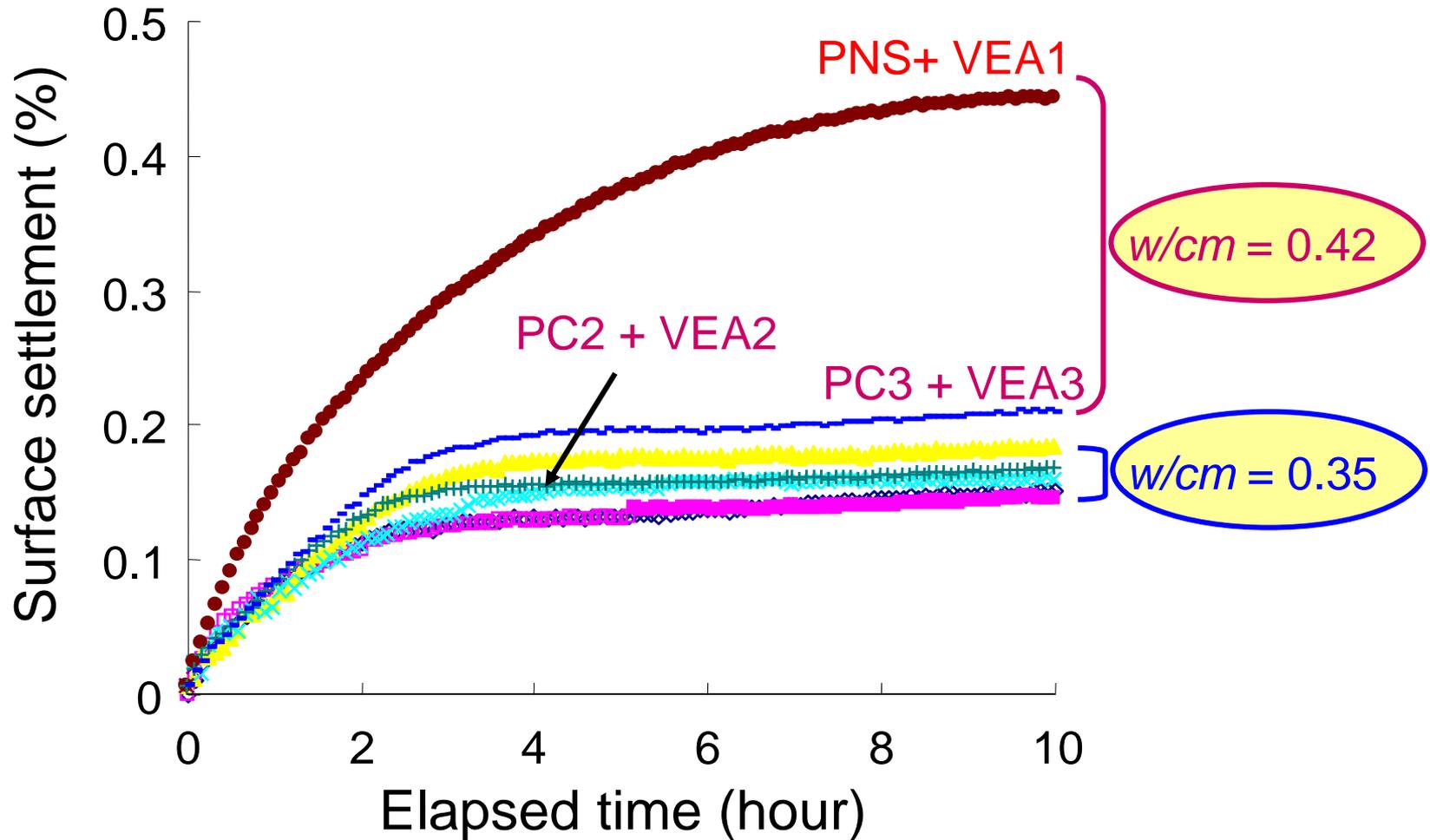
Incorporation of VMA



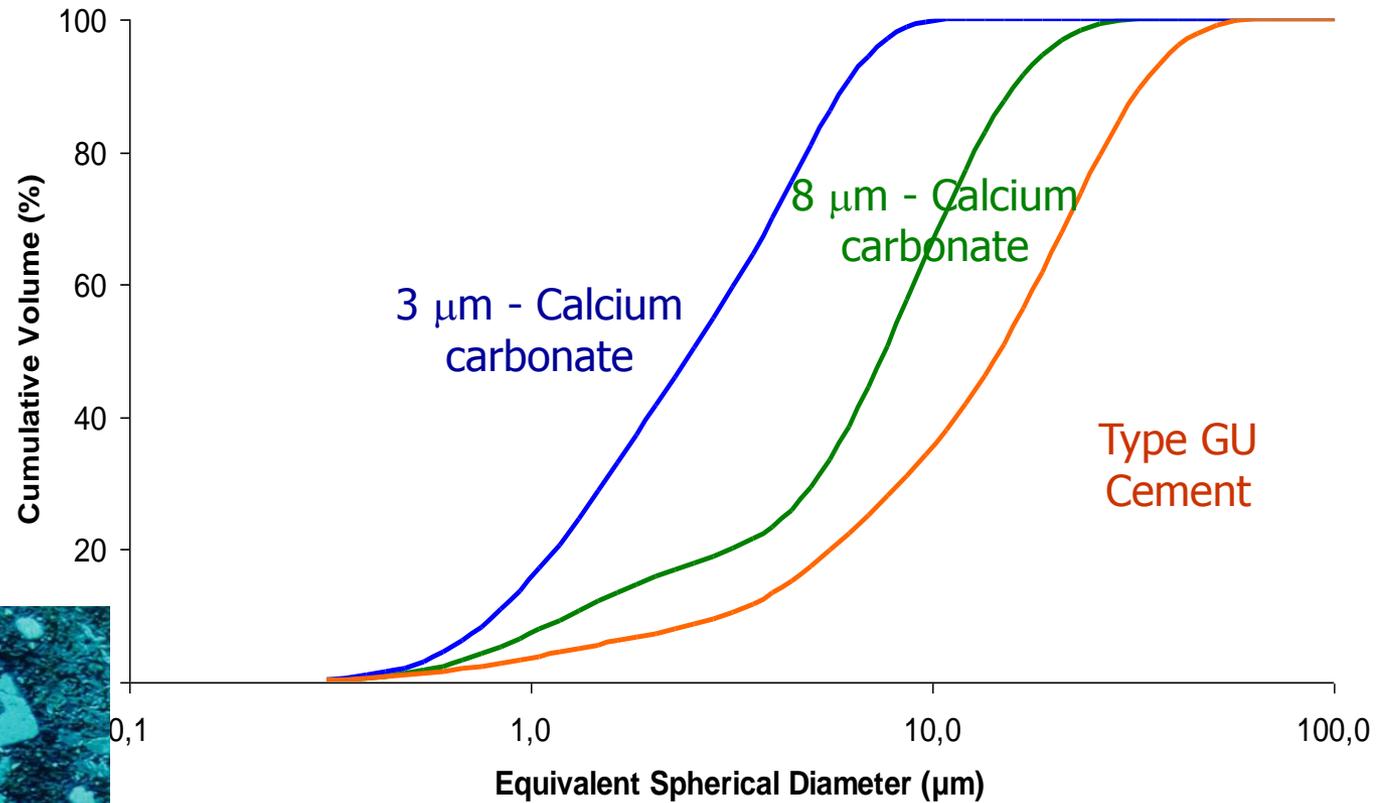
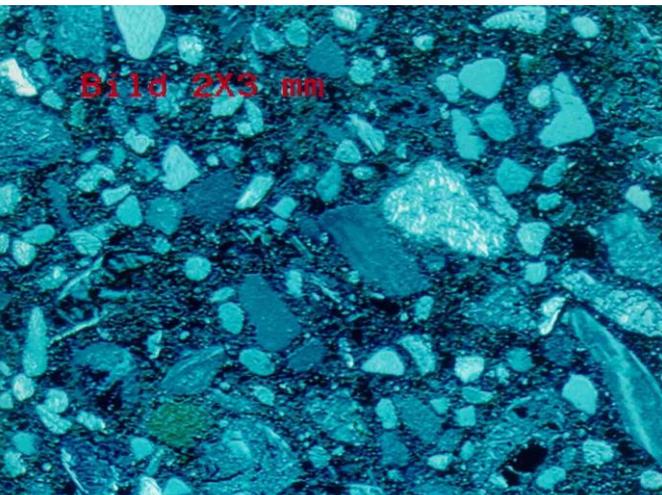
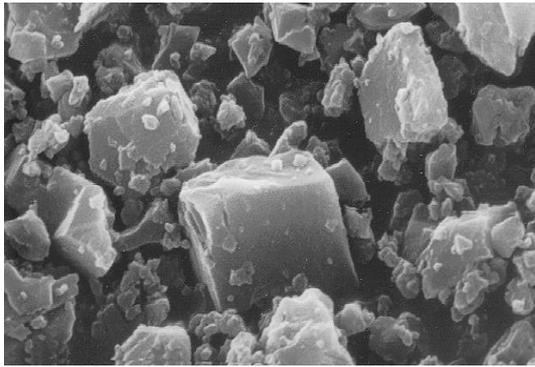
Effect of Welan Gum on Surface Settlement of SCC



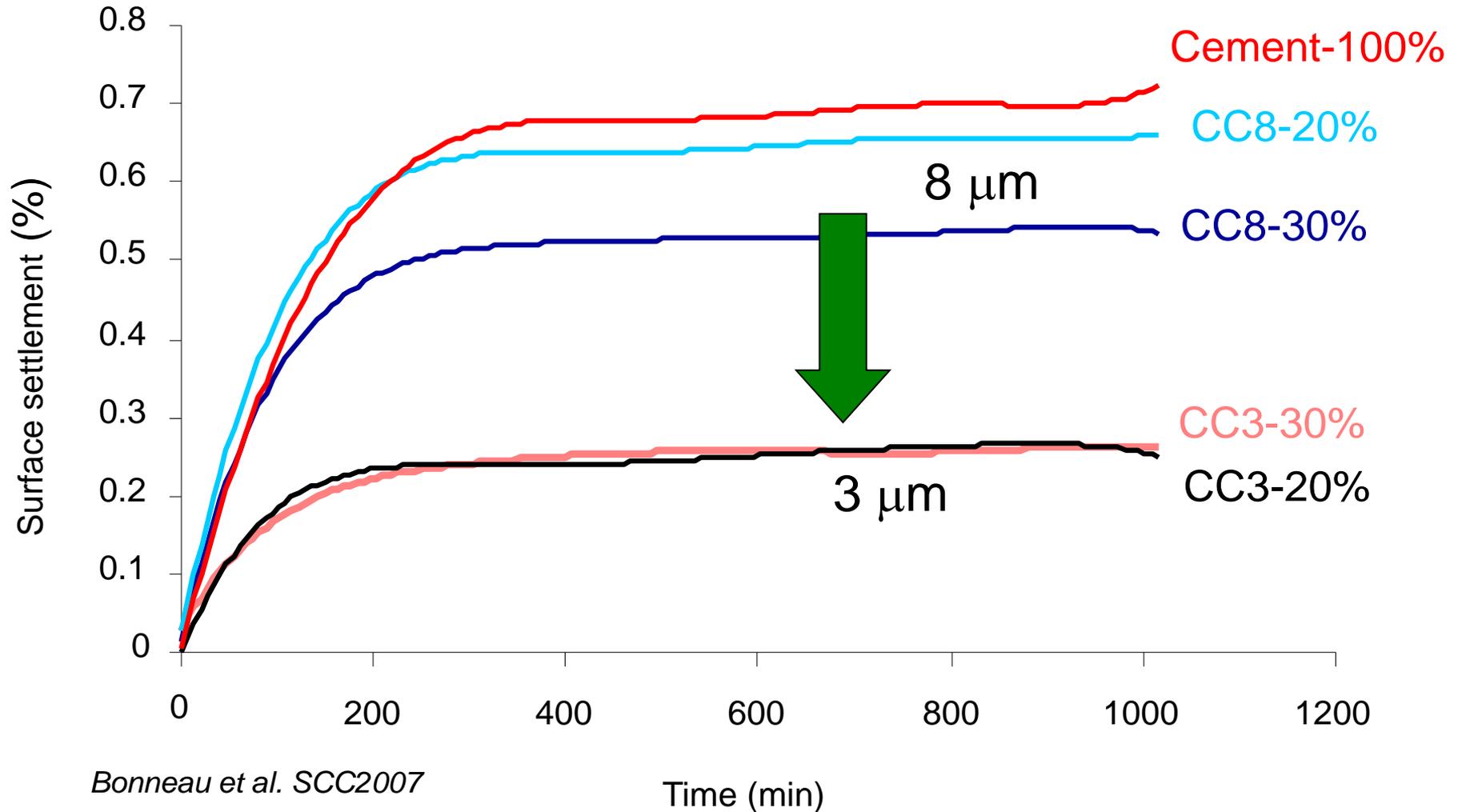
Surface Settlement



Enhanced Stability with Fine Fillers (w/p = 0.42)



Enhanced Stability with Fine Fillers (w/p = 0.42)

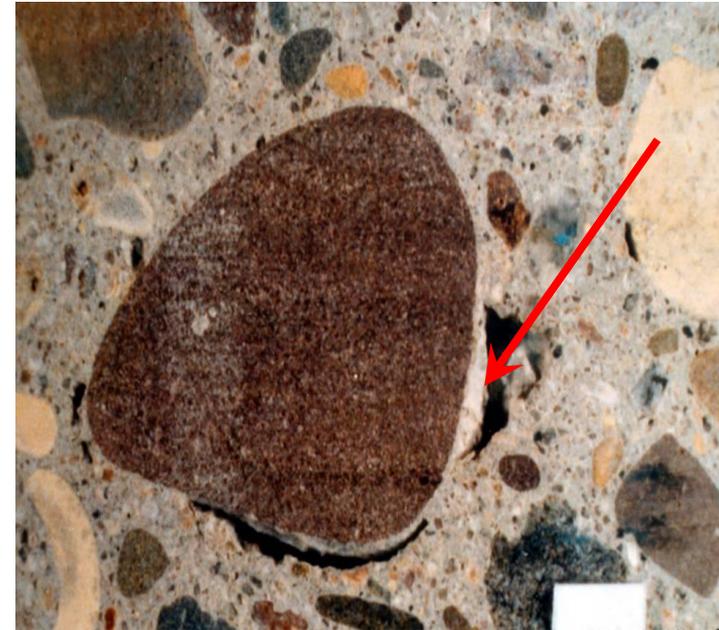


OUTLINE

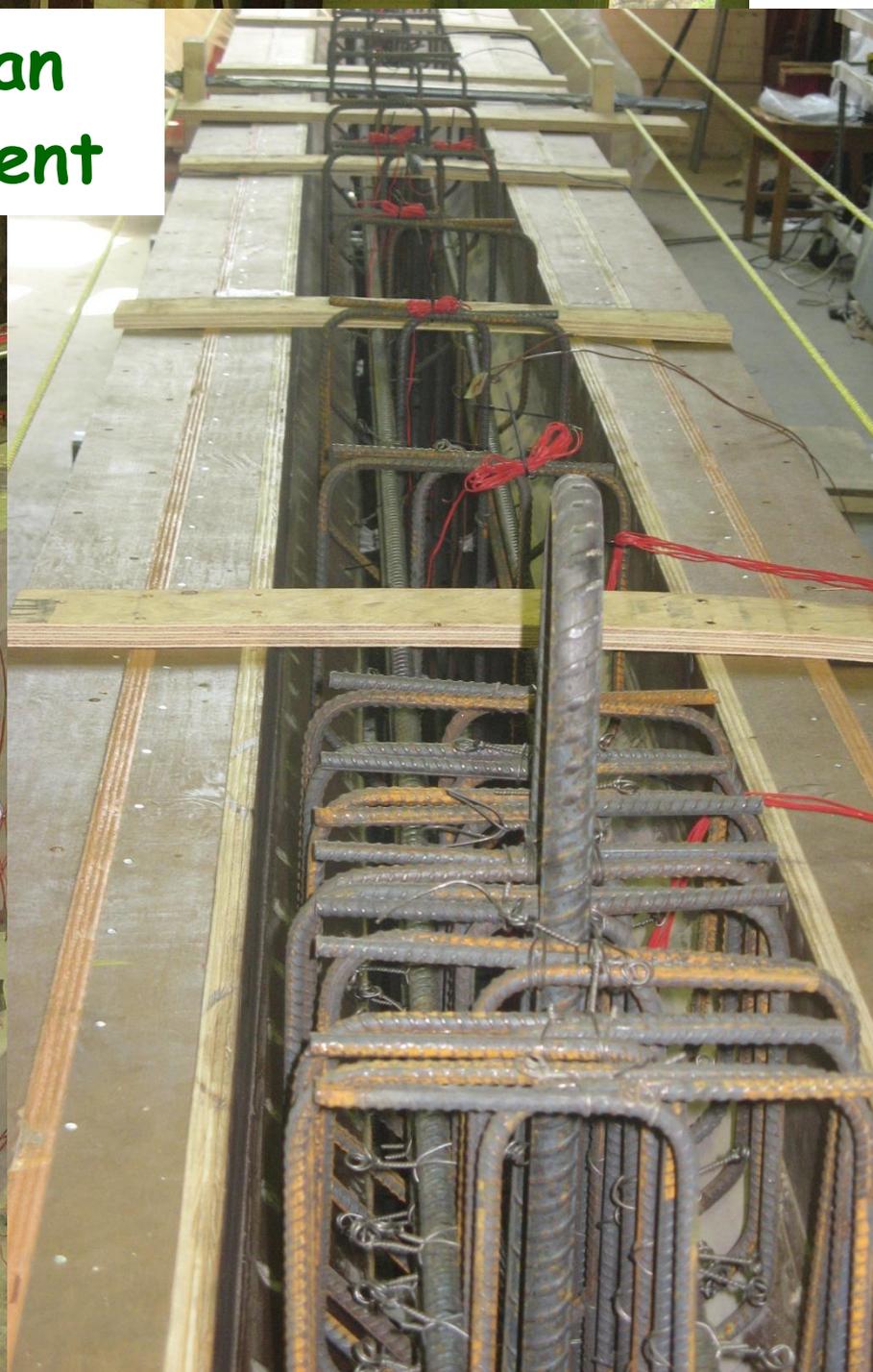
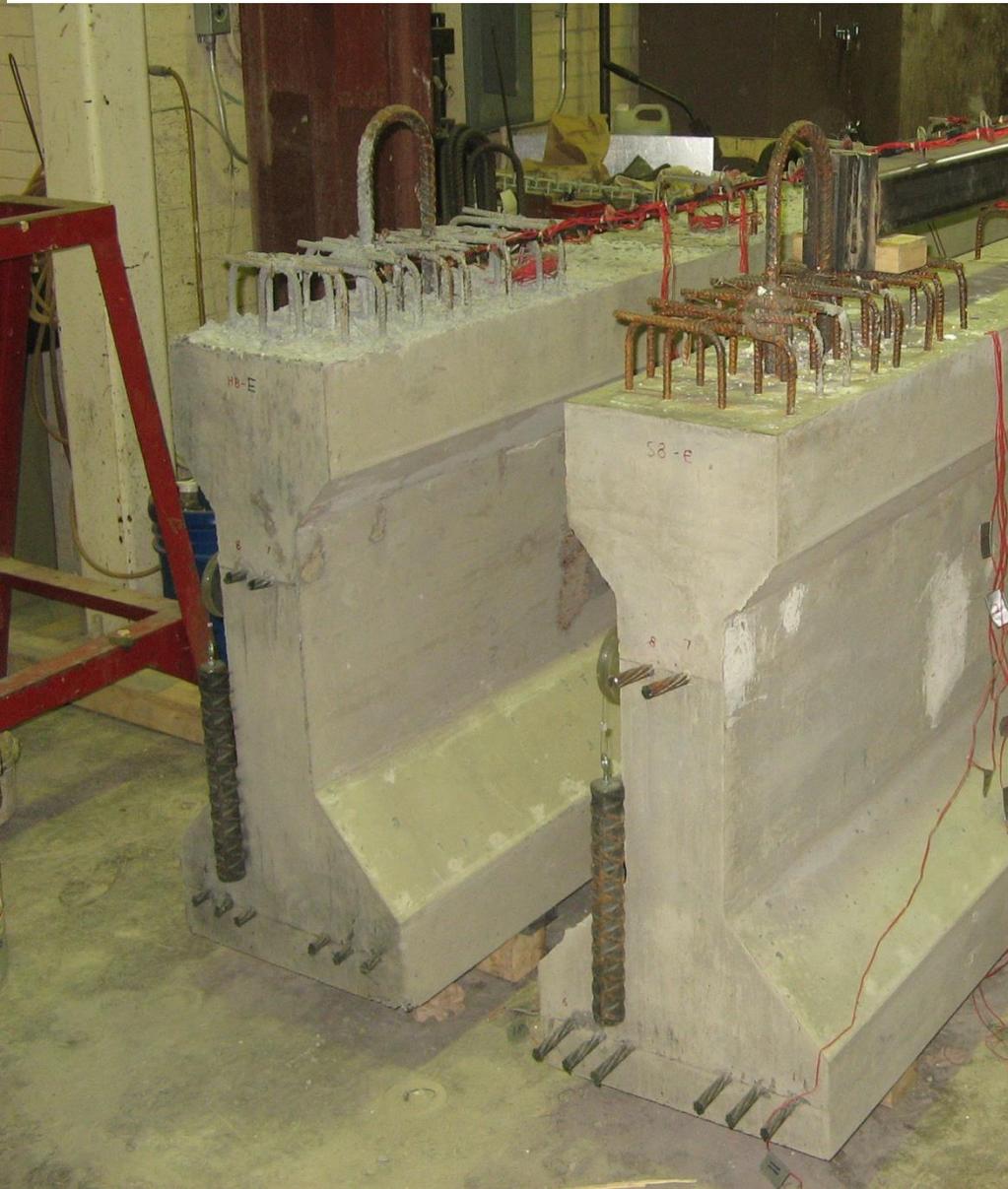
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Importance of stability of SCC

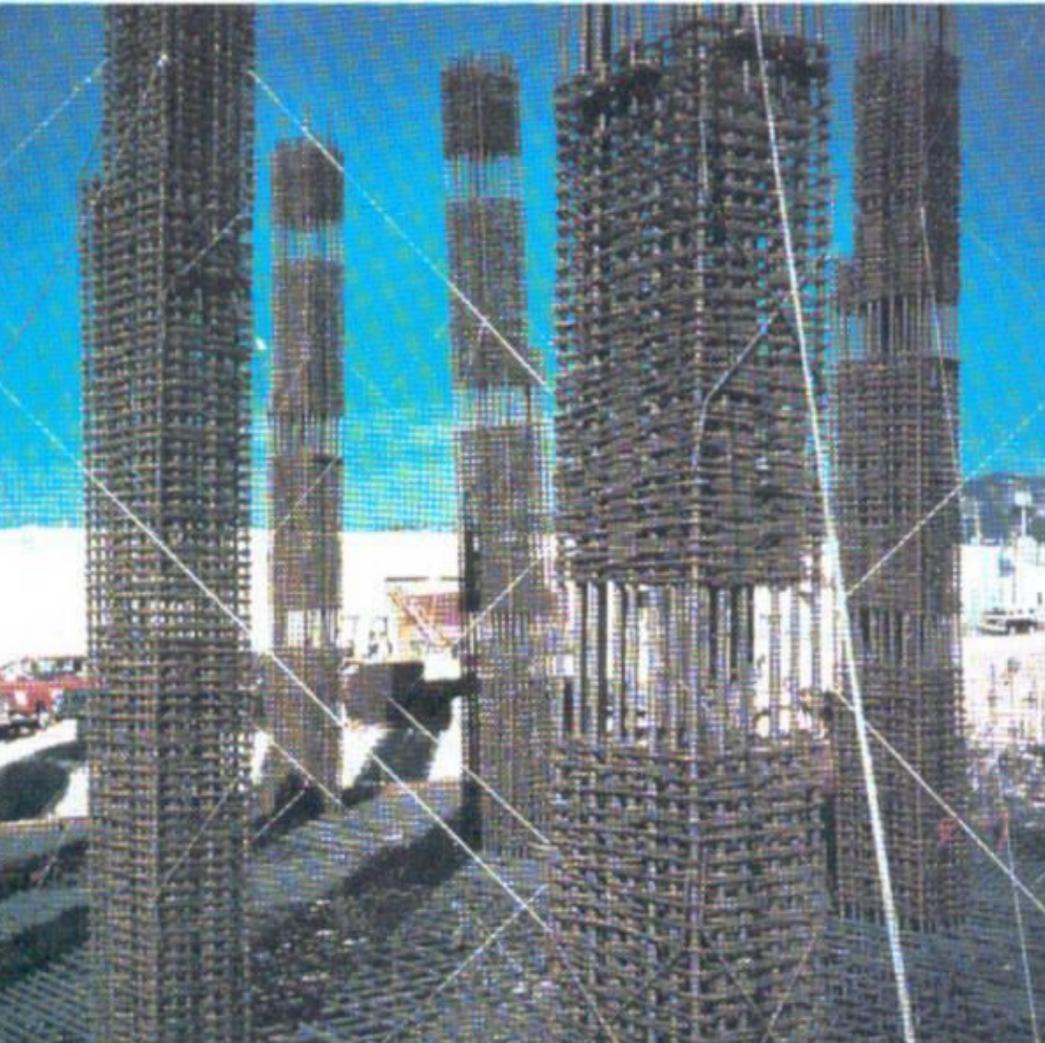
- **Lack of stability** can result in greater risk of bleeding, segregation, and surface settlement leading to porous ITZ under coarse aggregate and reinforcement
- **Lack of stability** can adversely affect bond strength, mechanical properties, and transport properties



Lack of mixture stability can weaken bond to reinforcement



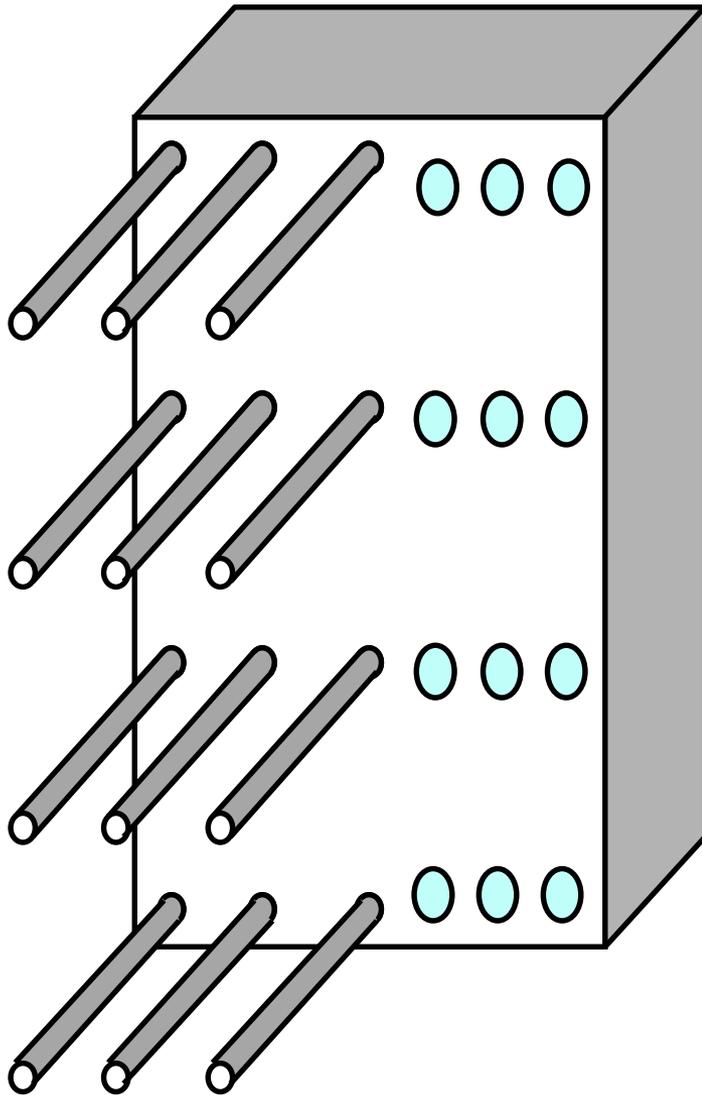
Special care is needed to produce stable SCC mixtures, especially in deep elements



Wall Elements

$1.5 \times 0.95 \times 0.2 \text{ m}$

$w/\text{cm} = 0.41$



$d = 142 \text{ cm}$

$d = 97$

$d = 52$

$d = 7$

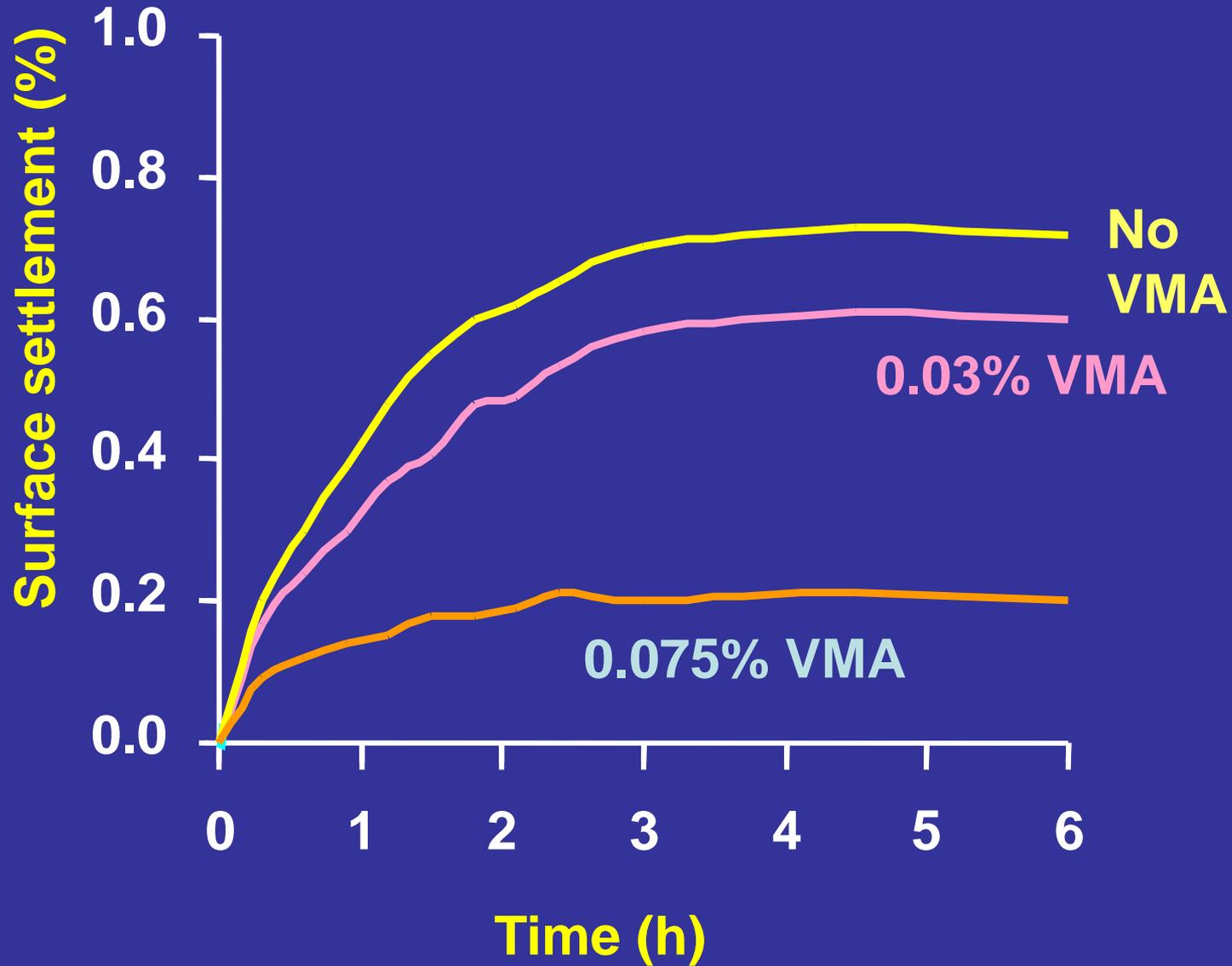
$\Phi = 625 - 650 \text{ mm}$

0% VMA

0.03% VMA (125 ppm)

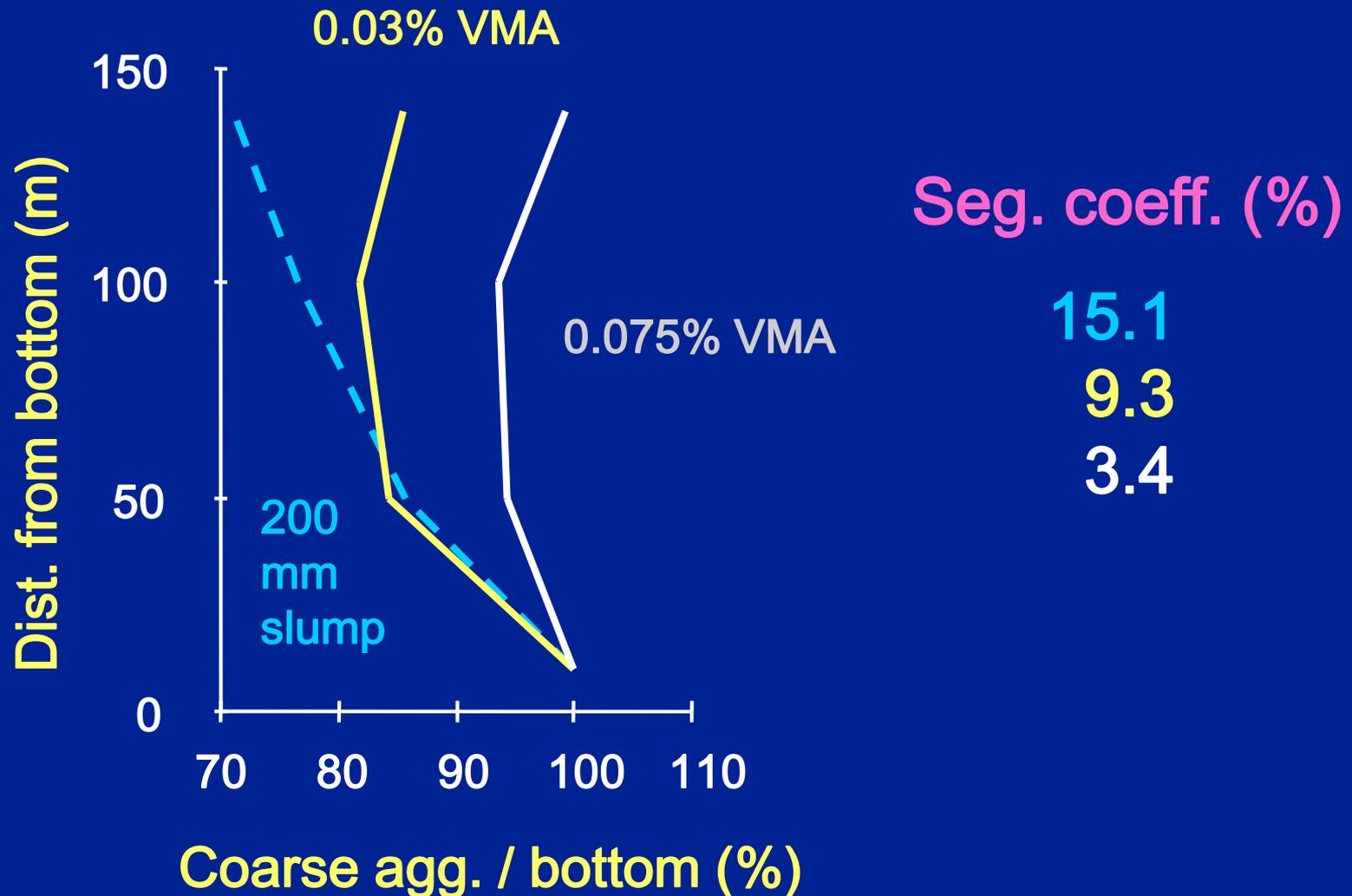
0.075% VMA (300 ppm)

Effect of VMA dosage on surface settlement of SCC

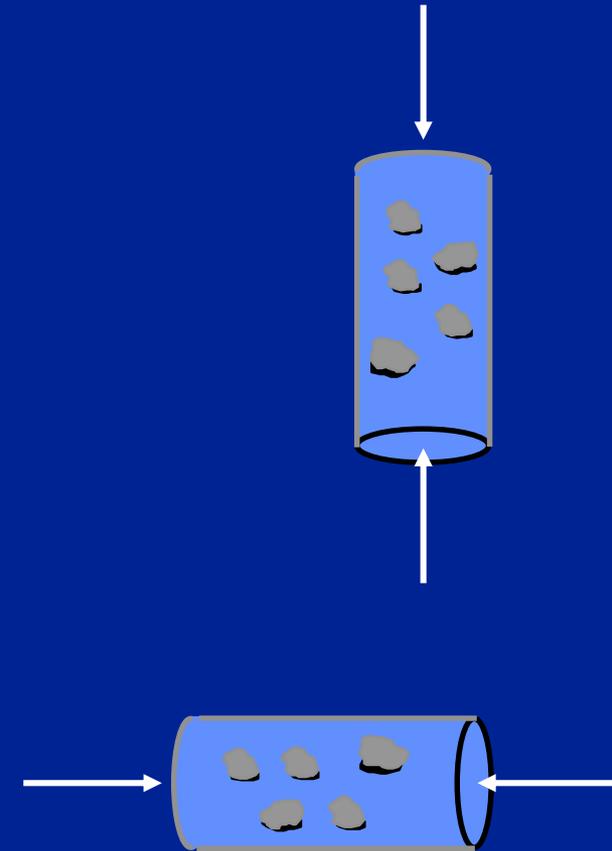
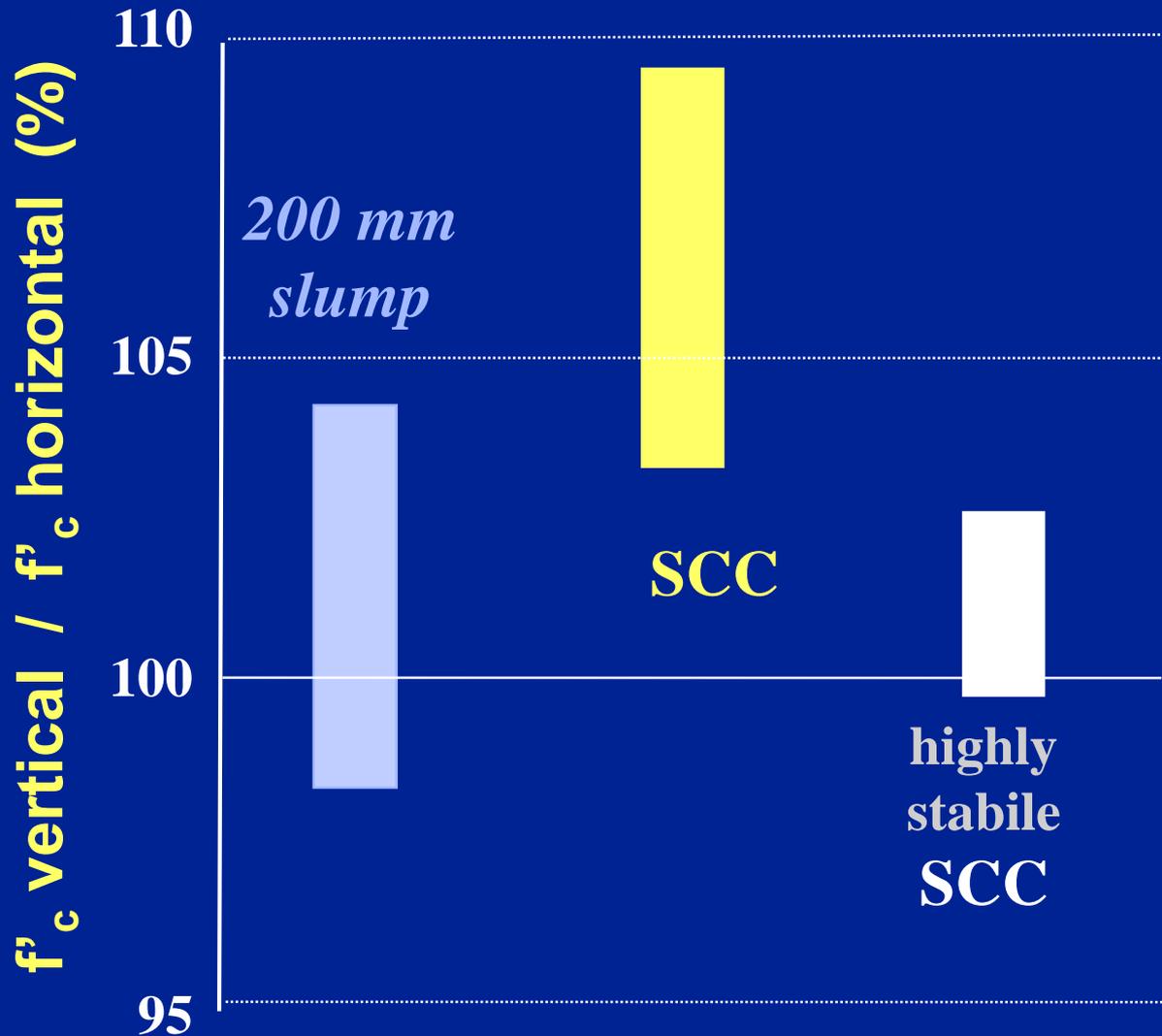




Effect of VMA Dosage on Coarse Aggregate Distribution



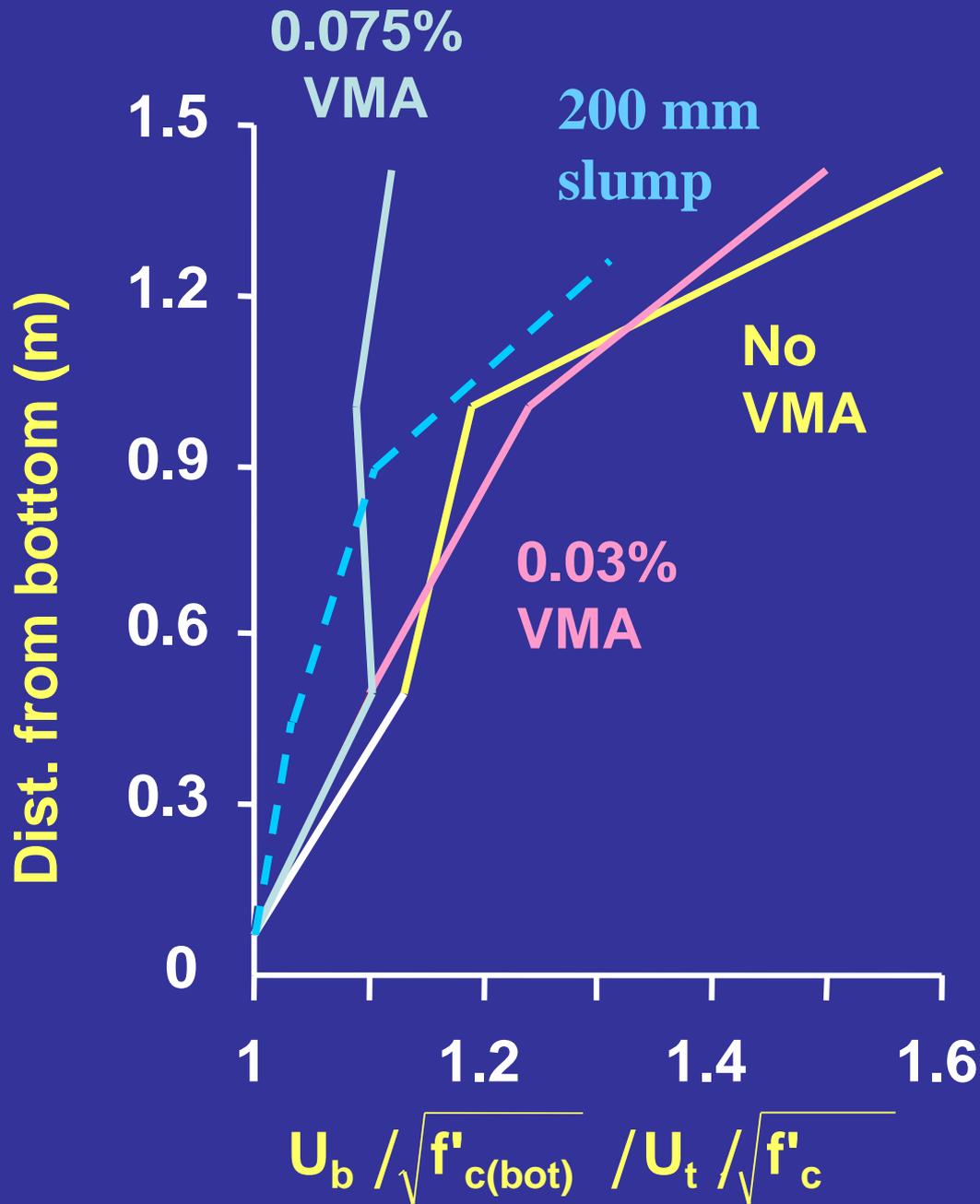
Effect of VMA Dosage on Coarse Aggregate Distribution



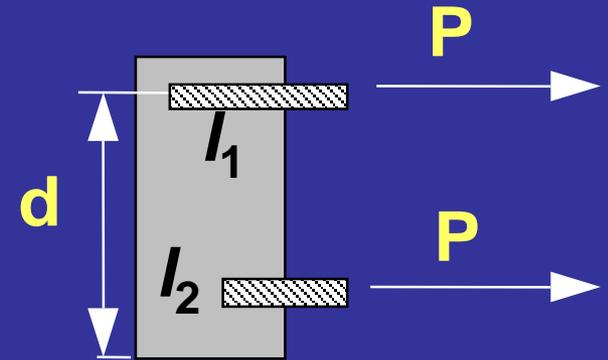


H = 1.5 m



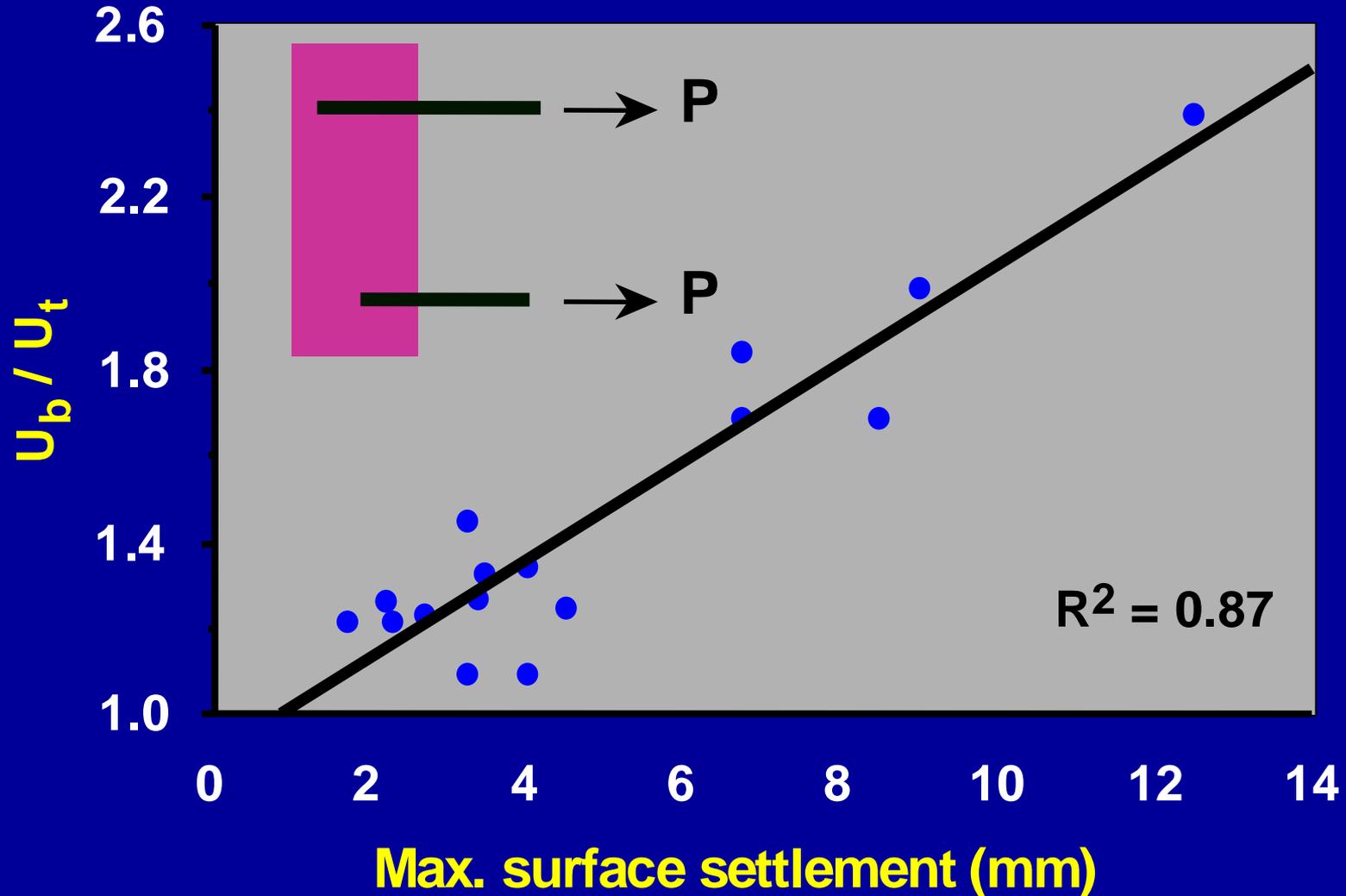


Top-bar effect



Uniform P
 l_1 vs. l_2

Max. Settlement vs. Top-Bar Effect



Rheological properties affect bond to reinforcement

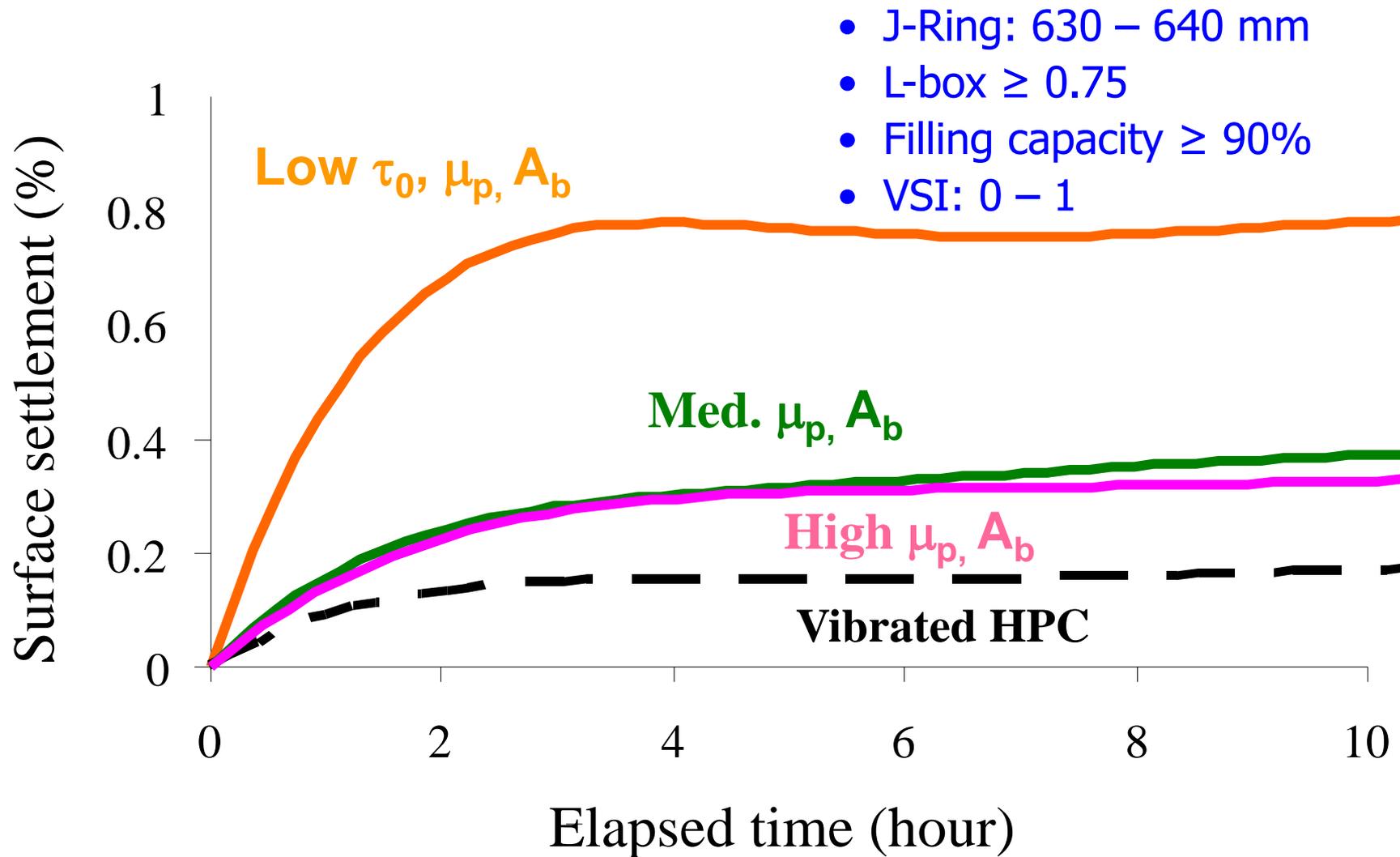
Homogeneity of bond strength



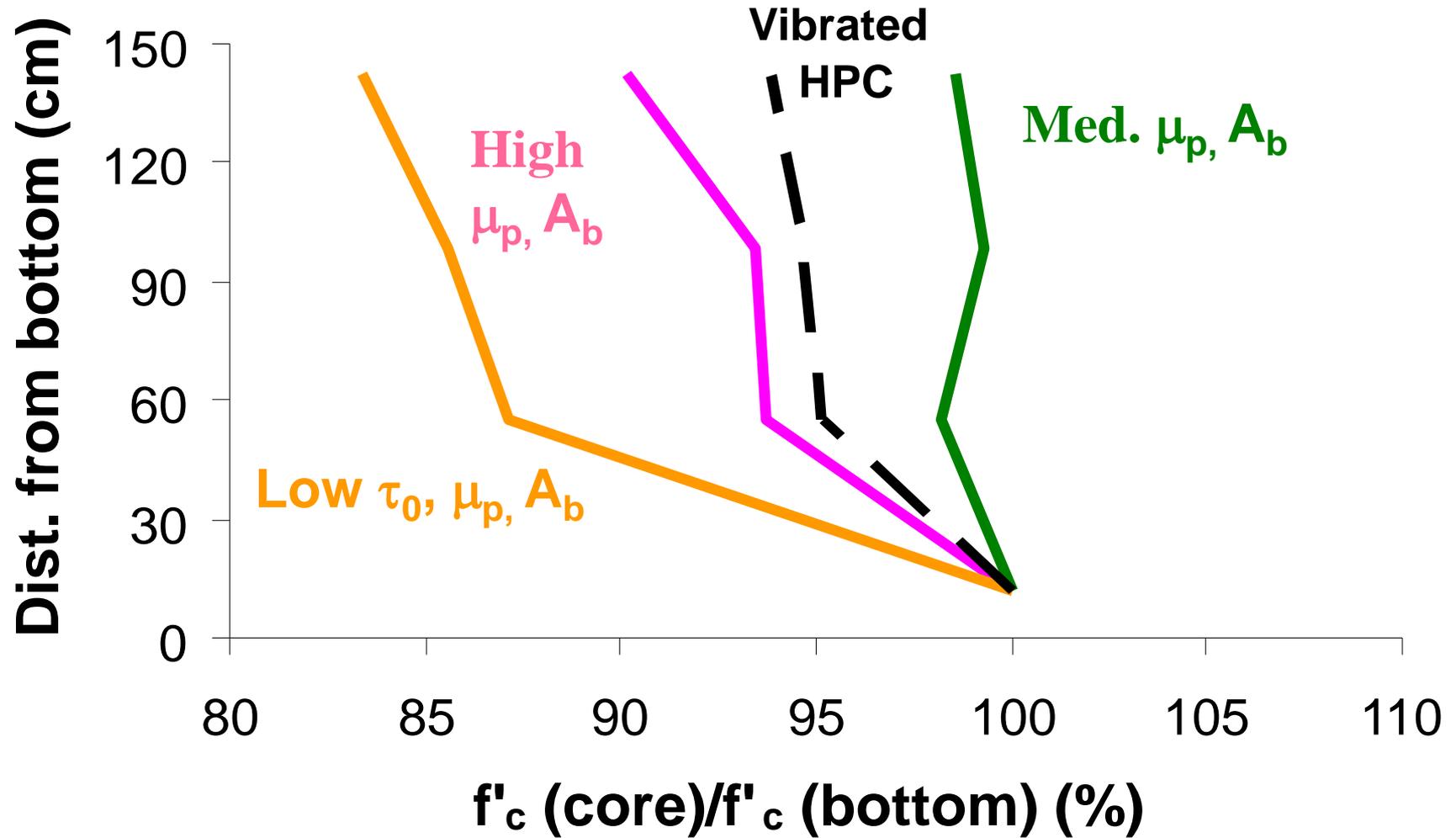
H = 1.5 m



Rheological properties affect performance of hardened concrete

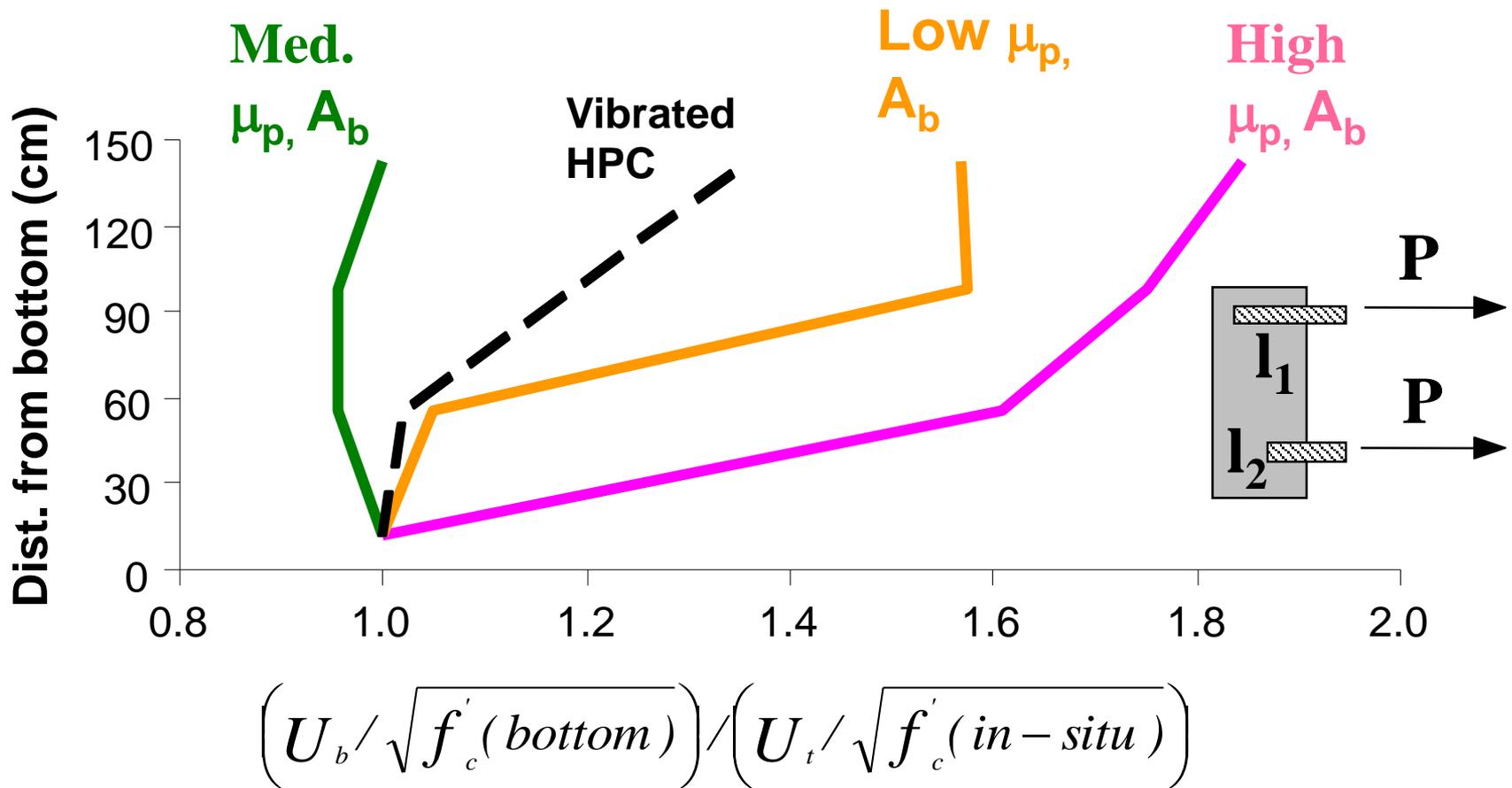


In-situ compressive strength



Rheological properties vs. top-bar effect

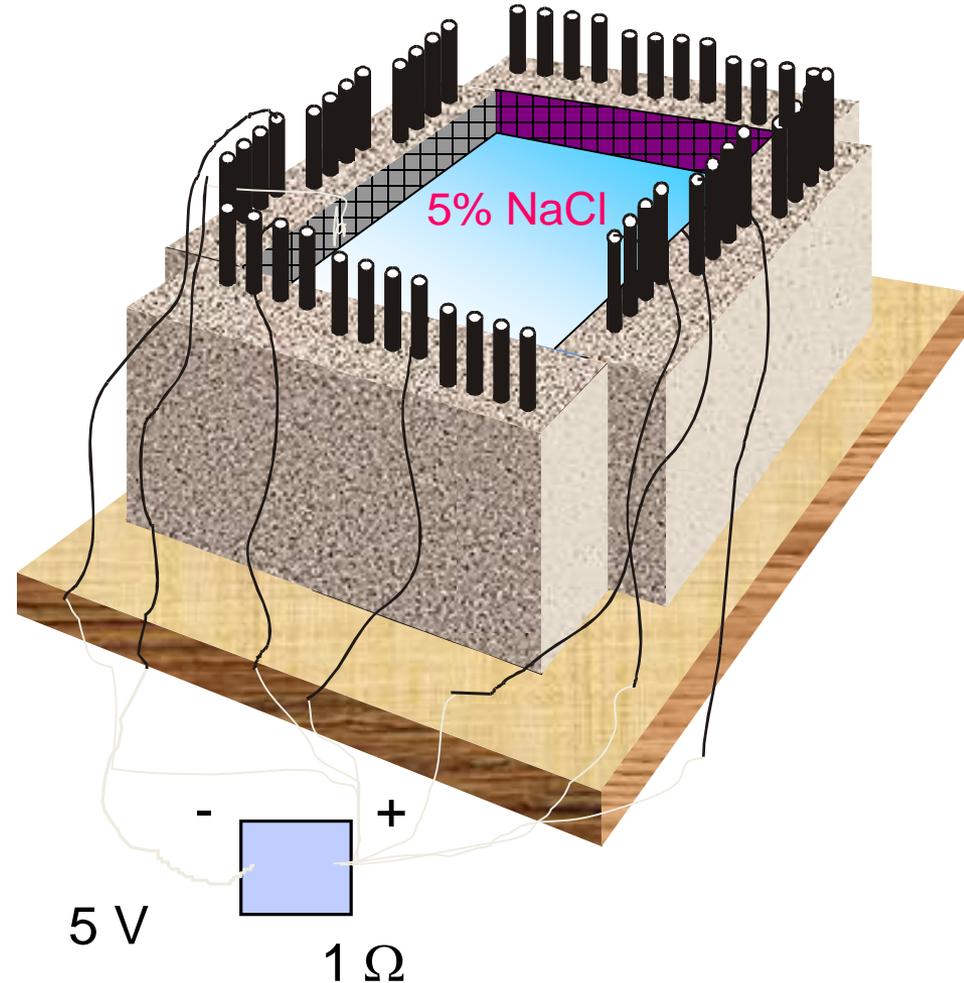
- J-Ring: 630 – 640 mm
- Filling capacity $\geq 90\%$
- L-box ≥ 0.75
- VSI: 0 – 1



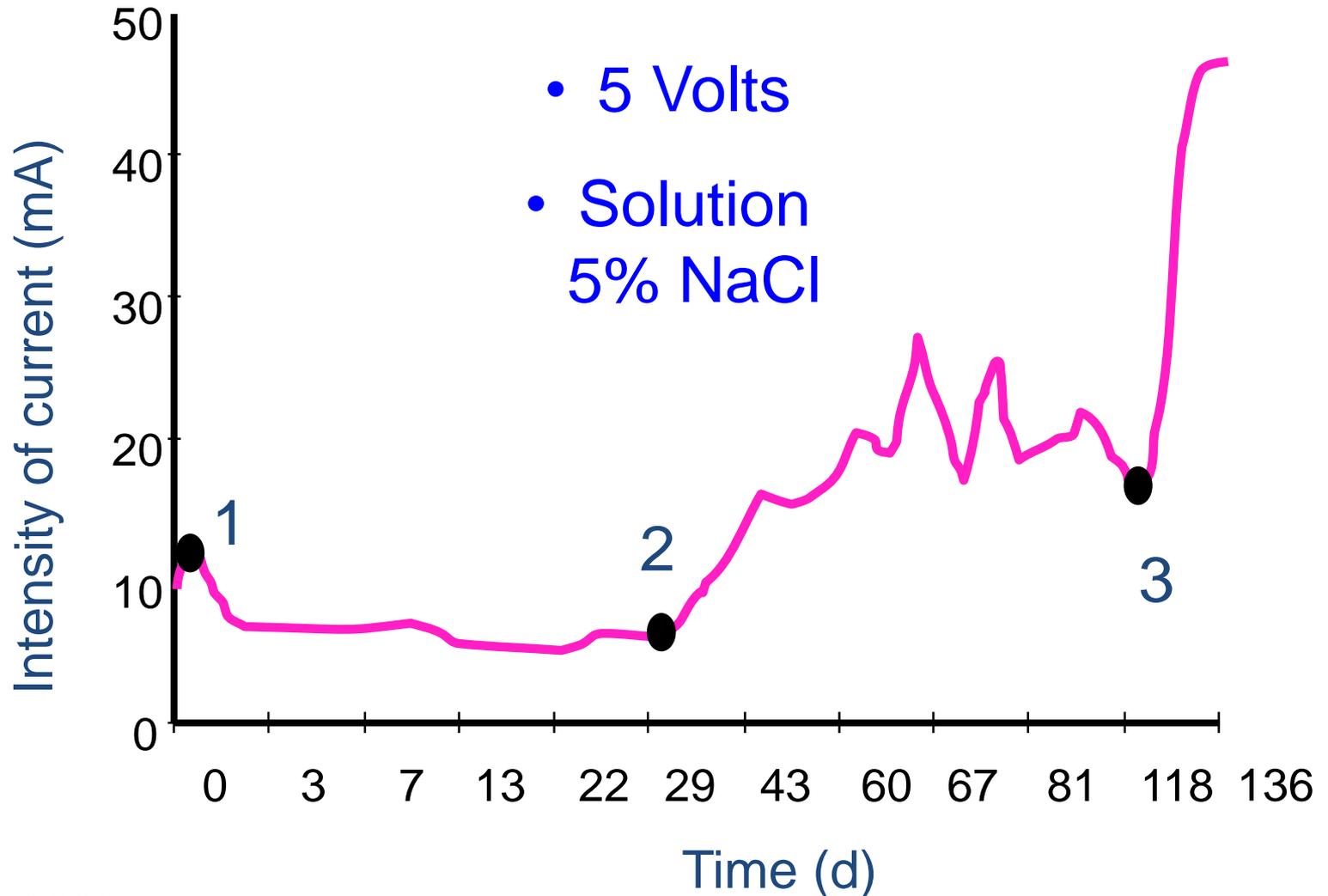
Lack of Stability Affects ITZ Quality



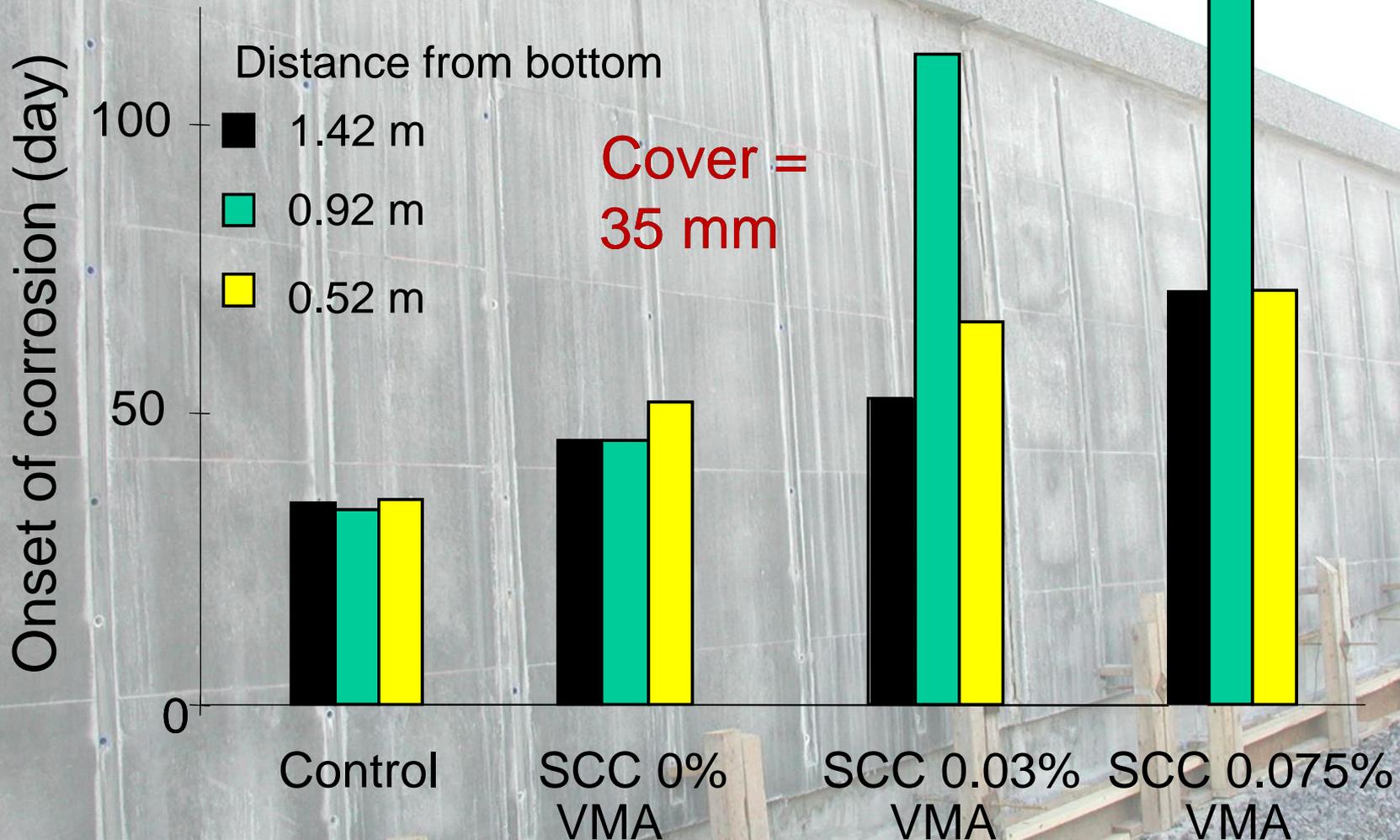
H = 1.5 m



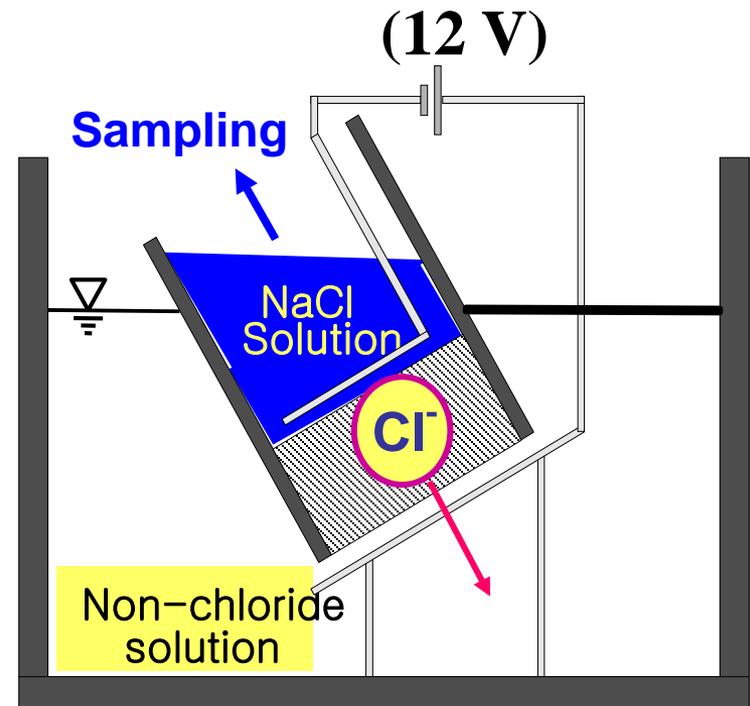
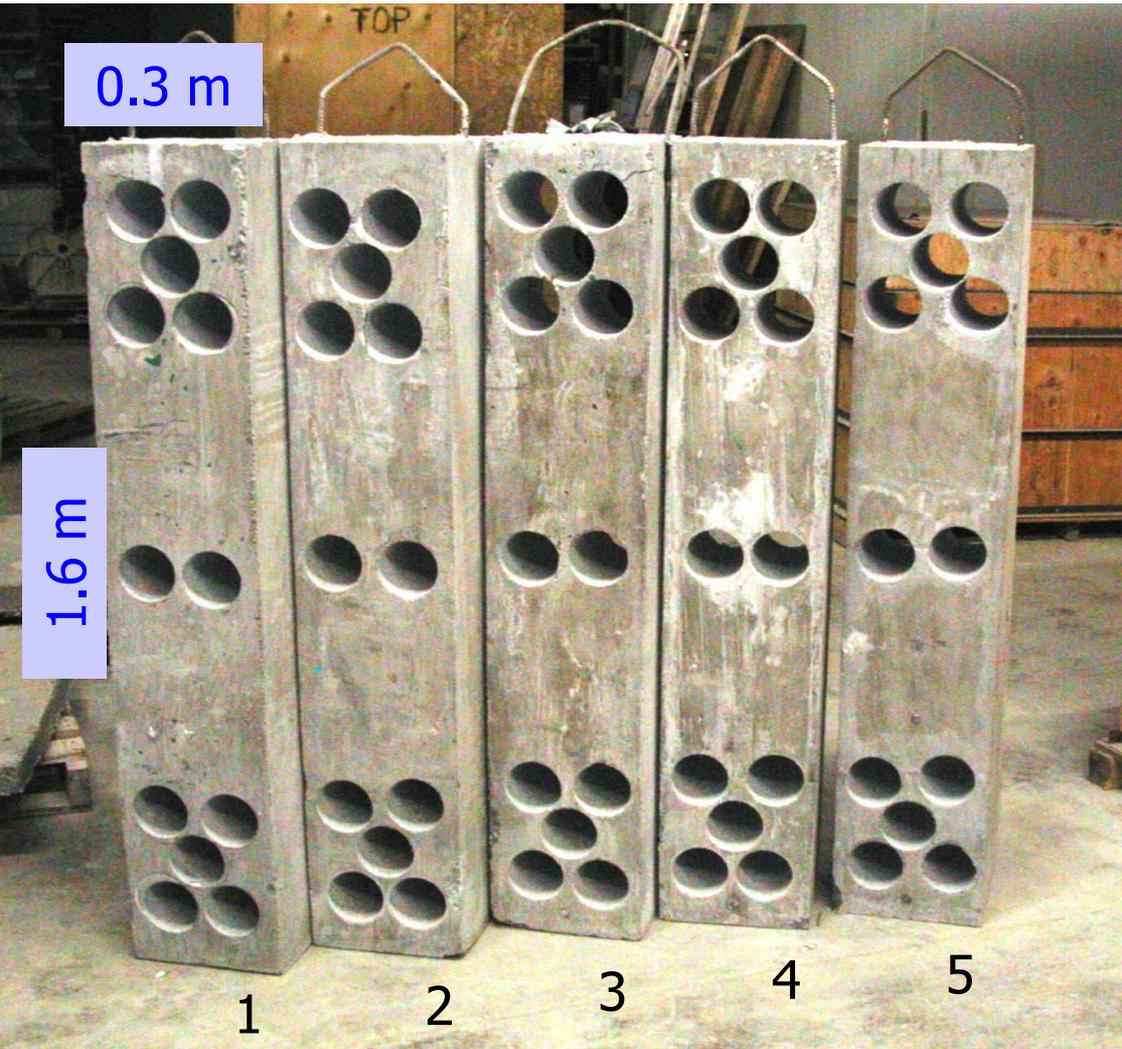
Resistivity, $R = \text{Voltage} / \text{Intensity of current}$



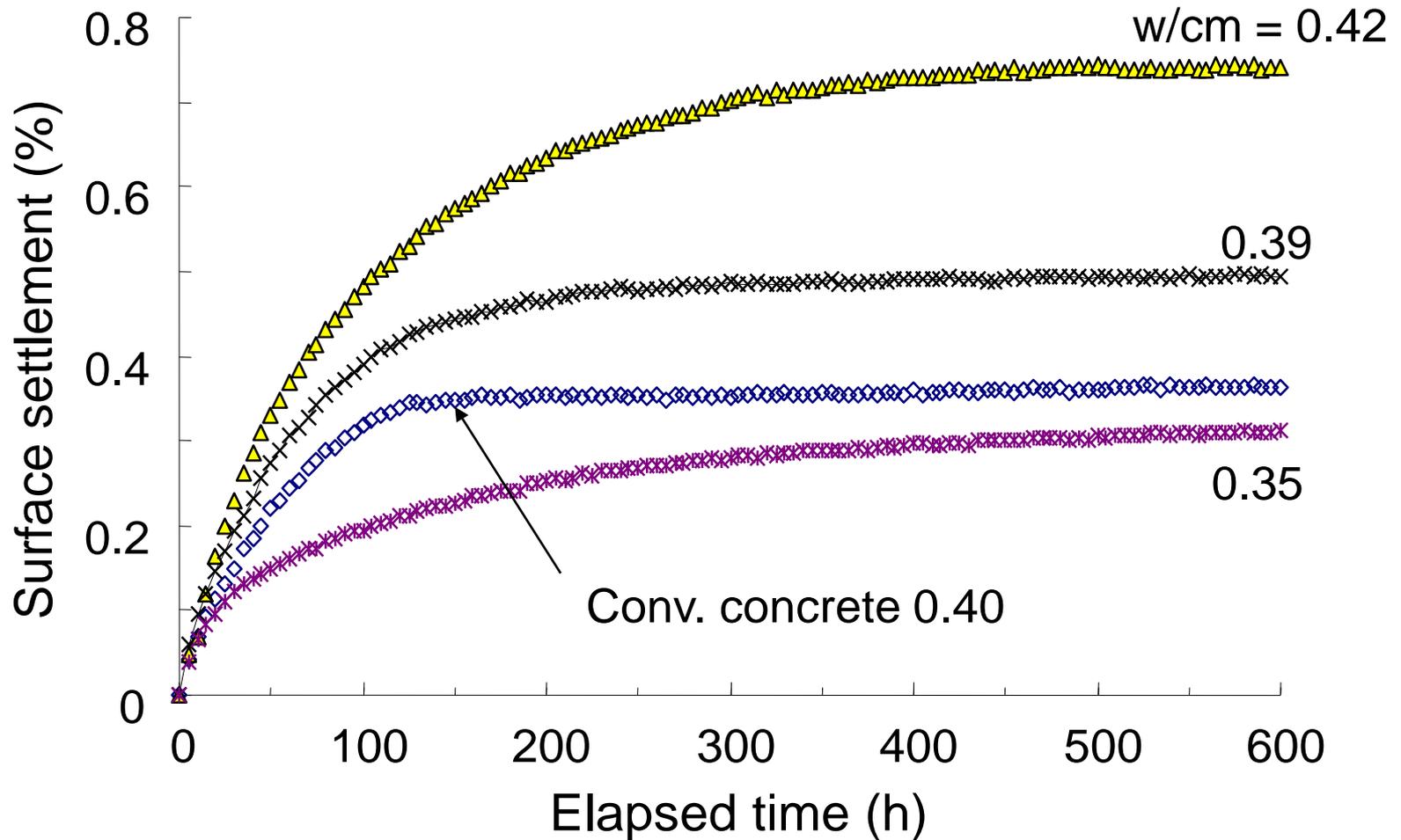
Time before onset of corrosion of rebars is influenced by **stability** of fresh concrete (affecting quality of ITZ)



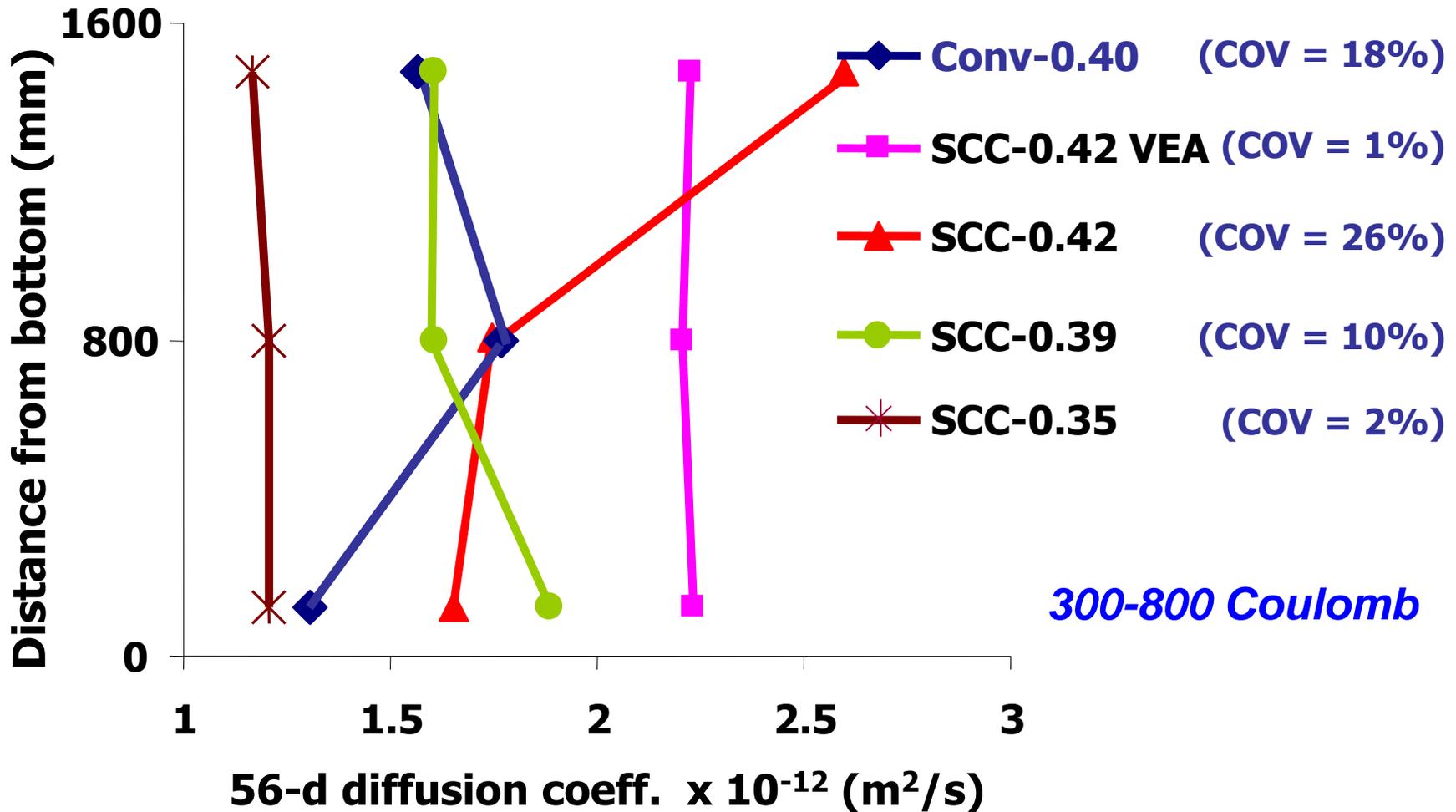
Homogeneity In-Situ Durability



Effect of w/cm on Surface settlement of SCC



In-situ diffusion coefficient (m^2/s)



Recommendations

Static stability	<p>MSA 9.5, 12.5 mm Surface settlement $\leq 0.5\%$ Settlement rate at 25-30 min $\leq 0.27\%/h$</p> <p>MSA 19 mm Surface settlement $\leq 0.3\%$ Settlement rate at 25-30 min $\leq 0.12\%/h$</p> <p>Column segregation index (Iseg) $\leq 5\%$ Percent static segregation (S) $\leq 15\%$</p> <p>VSI 0 – 1 (0 for deep elements)</p>
Plastic viscosity	Plastic viscosity $\leq 80\text{ Pa}\cdot\text{s}$
In-situ mechanical properties	<p>Core-to-cylinder compressive strength $\geq 90\%$ Bond strength modification factor ≤ 1.4</p>