

Evaluating Crack-Reduction Technologies for Settlement Cracking in Concrete Bridge Decks

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Sponsors



The Concrete Convention and Exposition

Outline

- Research Background
- Laboratory Testing
- Results and Discussion
- Summary

Significance of Study

- Bridge Deck Cracking
 - Allows a direct path for corrosive materials
 - Compromised protection of reinforcing steel
 - Accelerates freeze-thaw damage / additional cracking

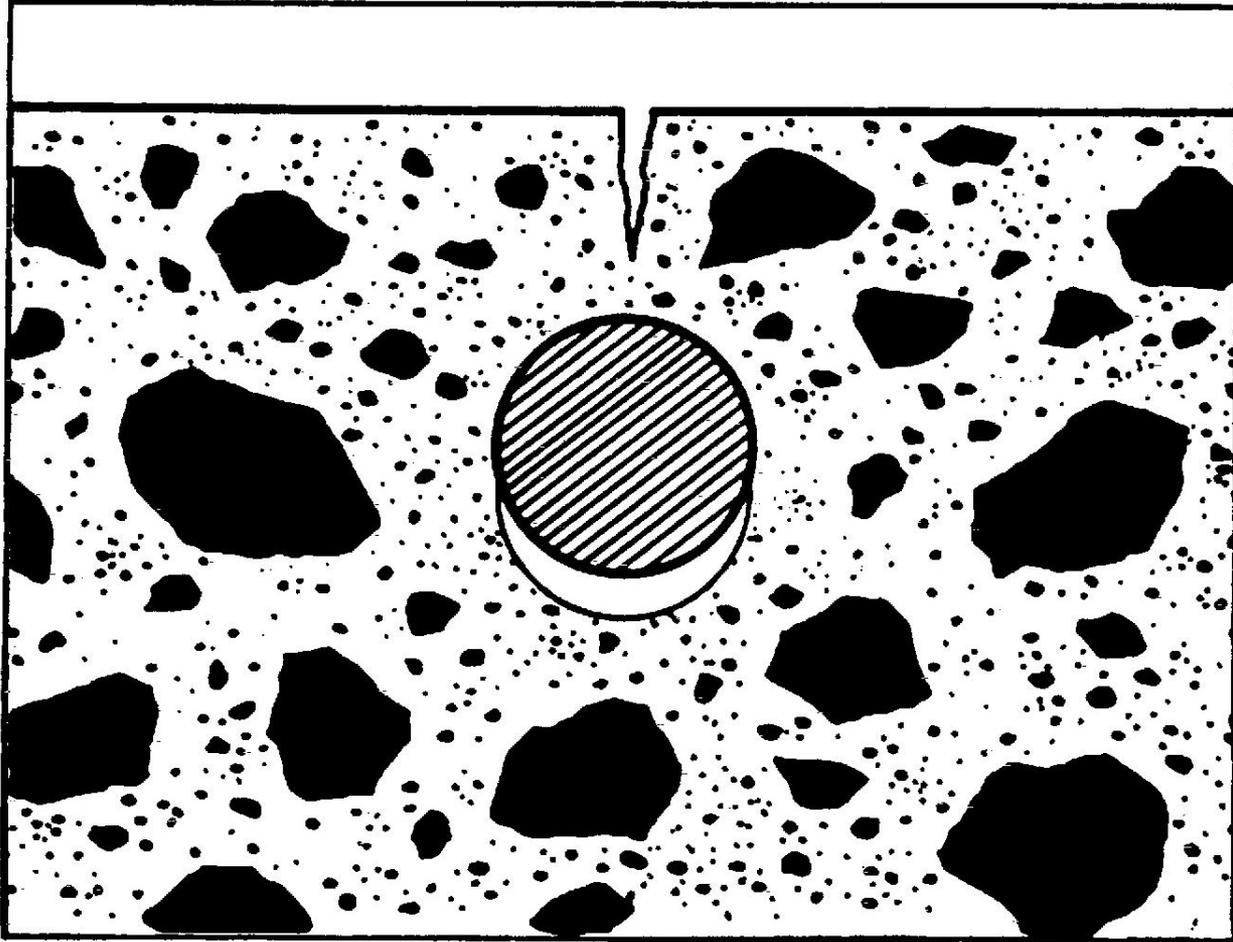
Cracking

- Plastic Concrete
 - Plastic Shrinkage
 - Settlement
- Hardened Concrete
 - Drying Shrinkage
 - Thermal

Cracking

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Settlement Cracking



Factors Affecting Settlement Cracking

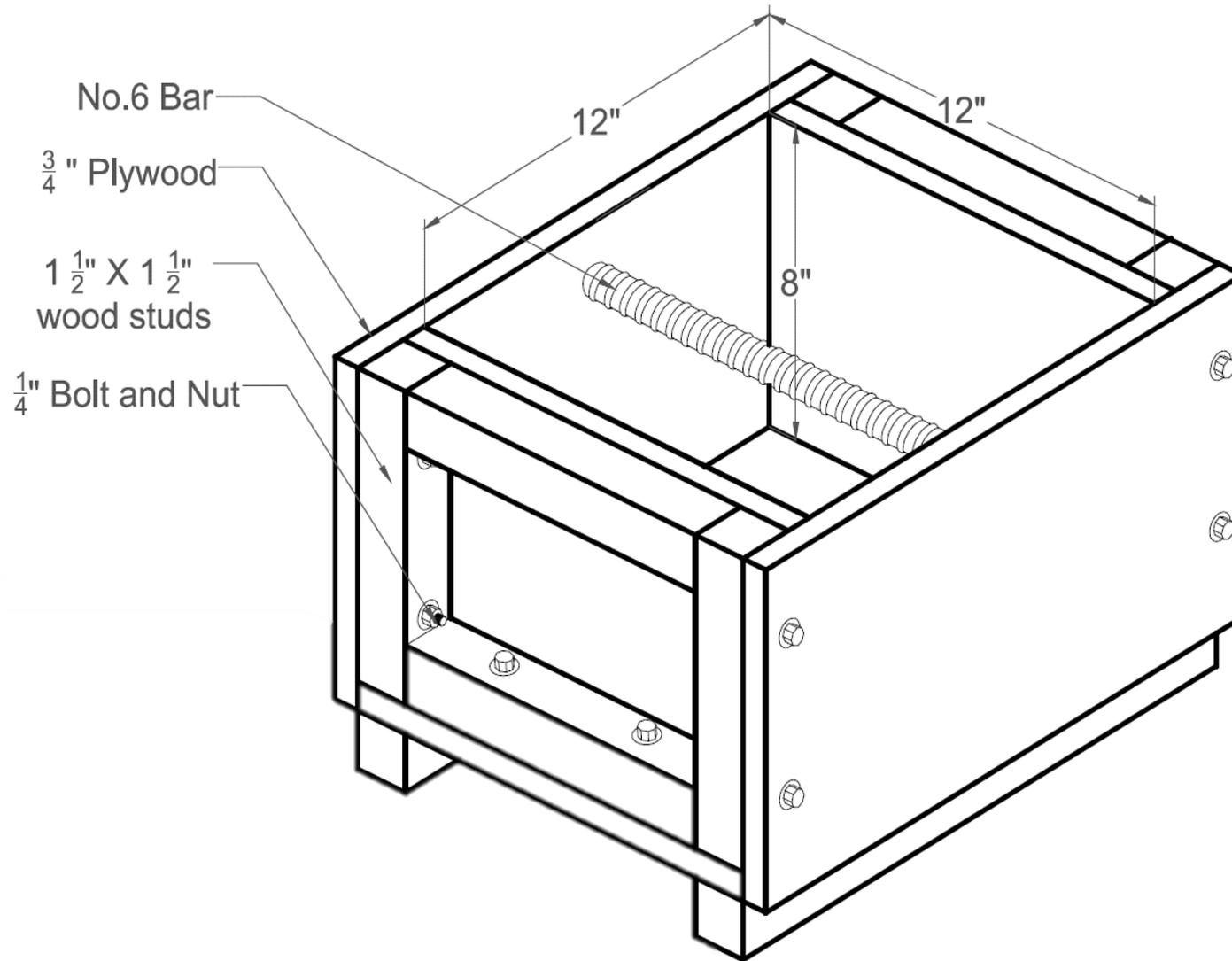
- Concrete Slump
- Cover
- Bar Size
- Combined Effects With Shrinkage

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Test Specimen

- Developed at KU
- Dimensions: 12 in. (305 mm) square
- Depth: 8 in. (203 mm)
- No. 6 (No. 19) Bars
- Top Bar Cover: $1 \frac{1}{8}$ in. (28.5 mm)
- Cured 24 hours:
50±5% humidity, 73±3°F (21-24°C) temperature



Concrete Mix Design Properties

- Air Content Range: 6.5 – 9.5%
- Temperature Range:

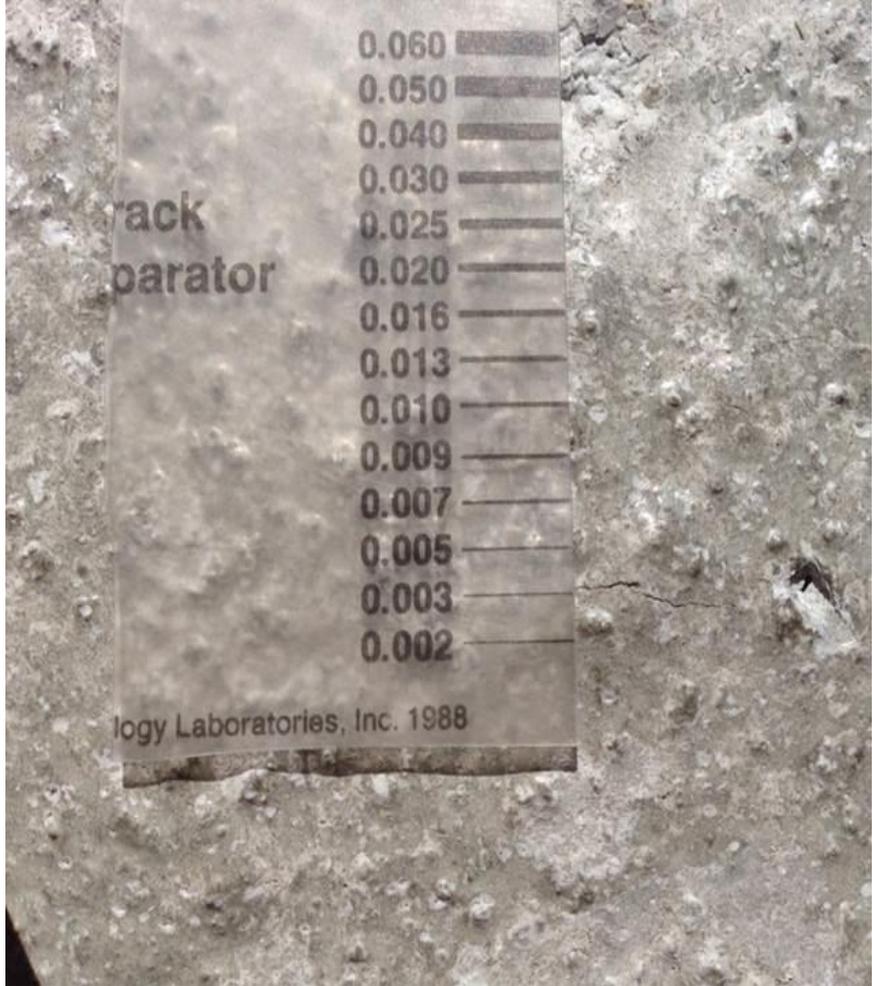
71 – 75°F (22 – 24°C)
- Vary slump between 2 – 9 in. (50 – 225 mm)
- Maintain constant finishing procedure
 - Fill forms in 2 lifts
 - Vibrate
 - Screed
 - Trowel

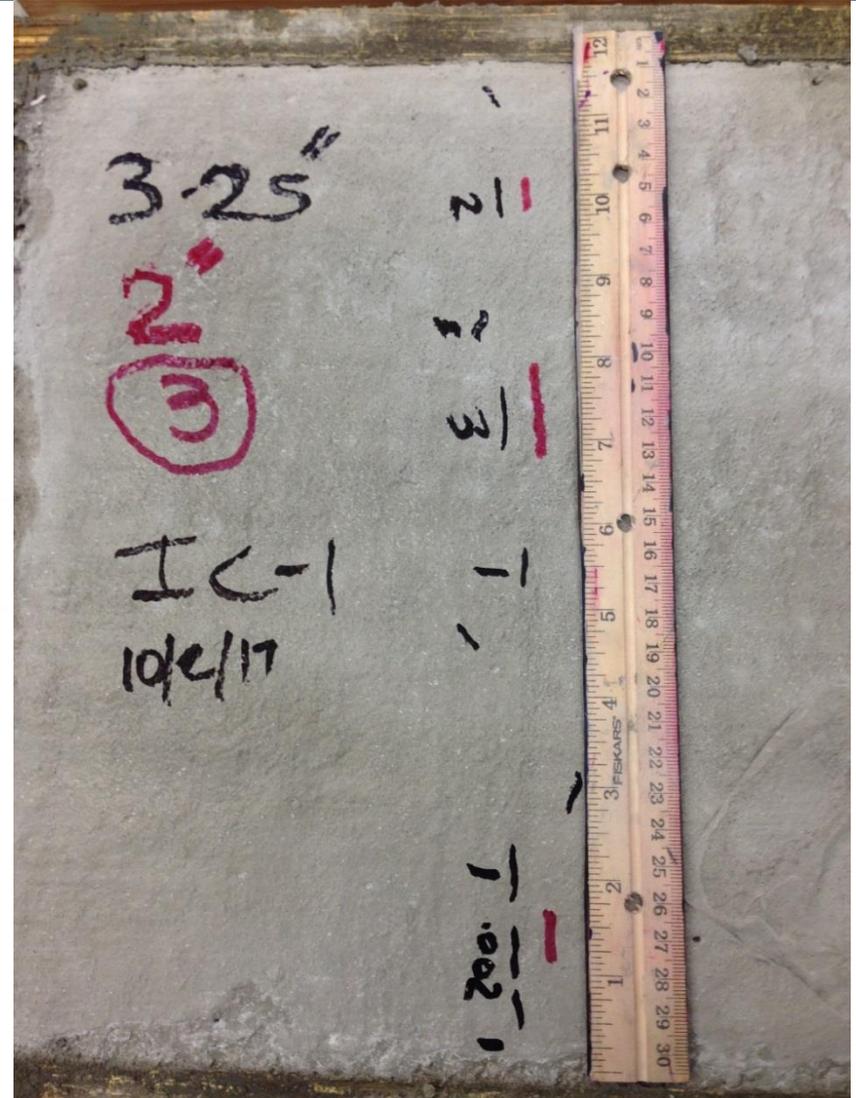
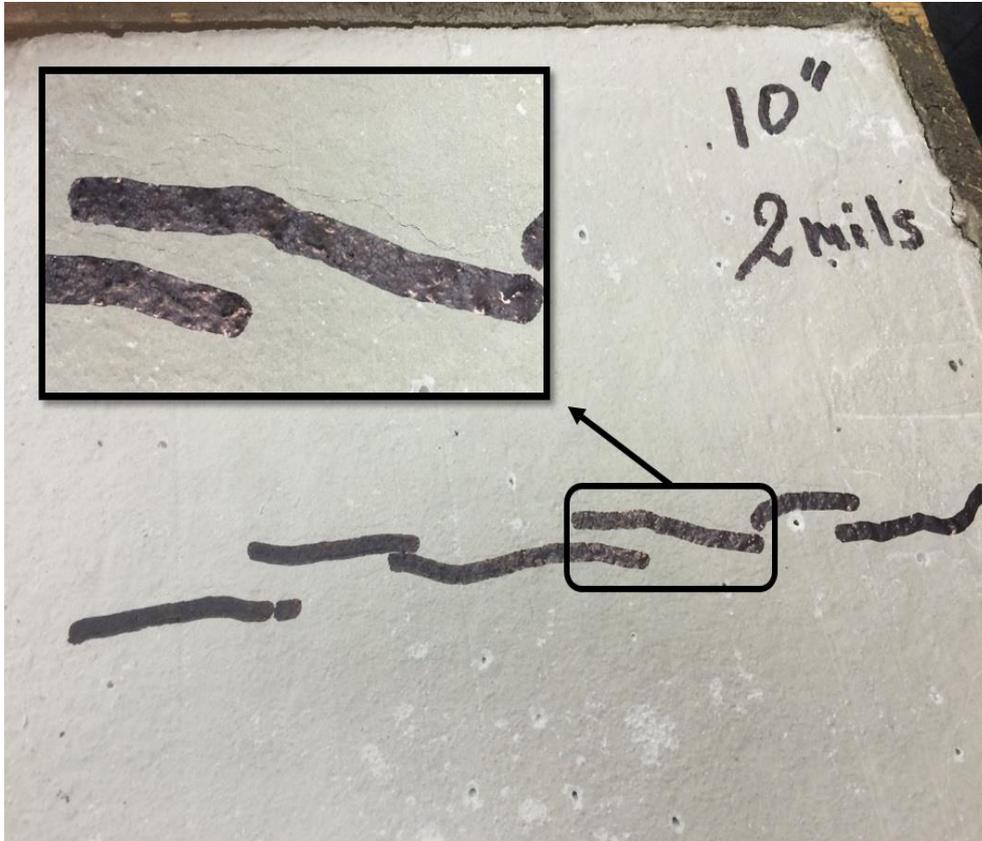




Test Specimen

- Isolate settlement cracking mechanism
 - Mitigate drying / plastic shrinkage cracking
- Separate cover from concrete surface
- Maintain high humidity until uncovering
- Verify with temperature / humidity sensors





Mixture Proportions

- $w/cm = 0.45$
- 27% paste content
 - 593 lb portland cement, 267 lb water
- Admixtures
 - Air entraining
 - High-range water reducer

Mixture Proportions (Control Mix)

- Portland cement
- Aggregate gradation based on optimized mix design → KUMix
 - 2 gradations of coarse – granite
 - Intermediate sized – pea gravel, LWA
 - Fine aggregate – Kansas River sand

Test Program

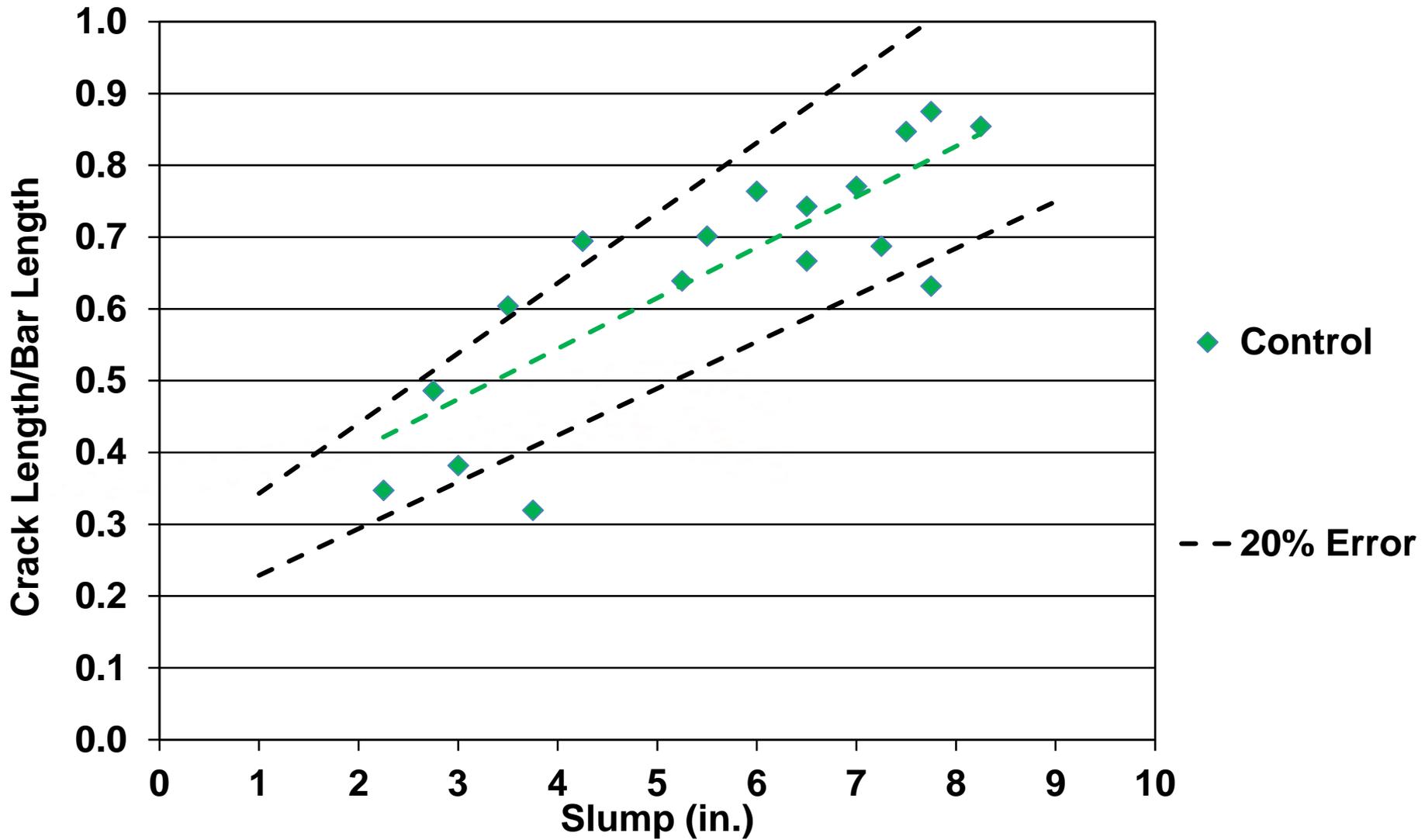
- Supplementary Cementitious Materials (SCMs)
 - Binary Mixes – 30% slag
 - Ternary Mixes – 30% slag + 3% silica fume
- Internal Curing
 - Pre-wetted lightweight aggregate
 - 7 lb/cwt
 - Combine with SCMs

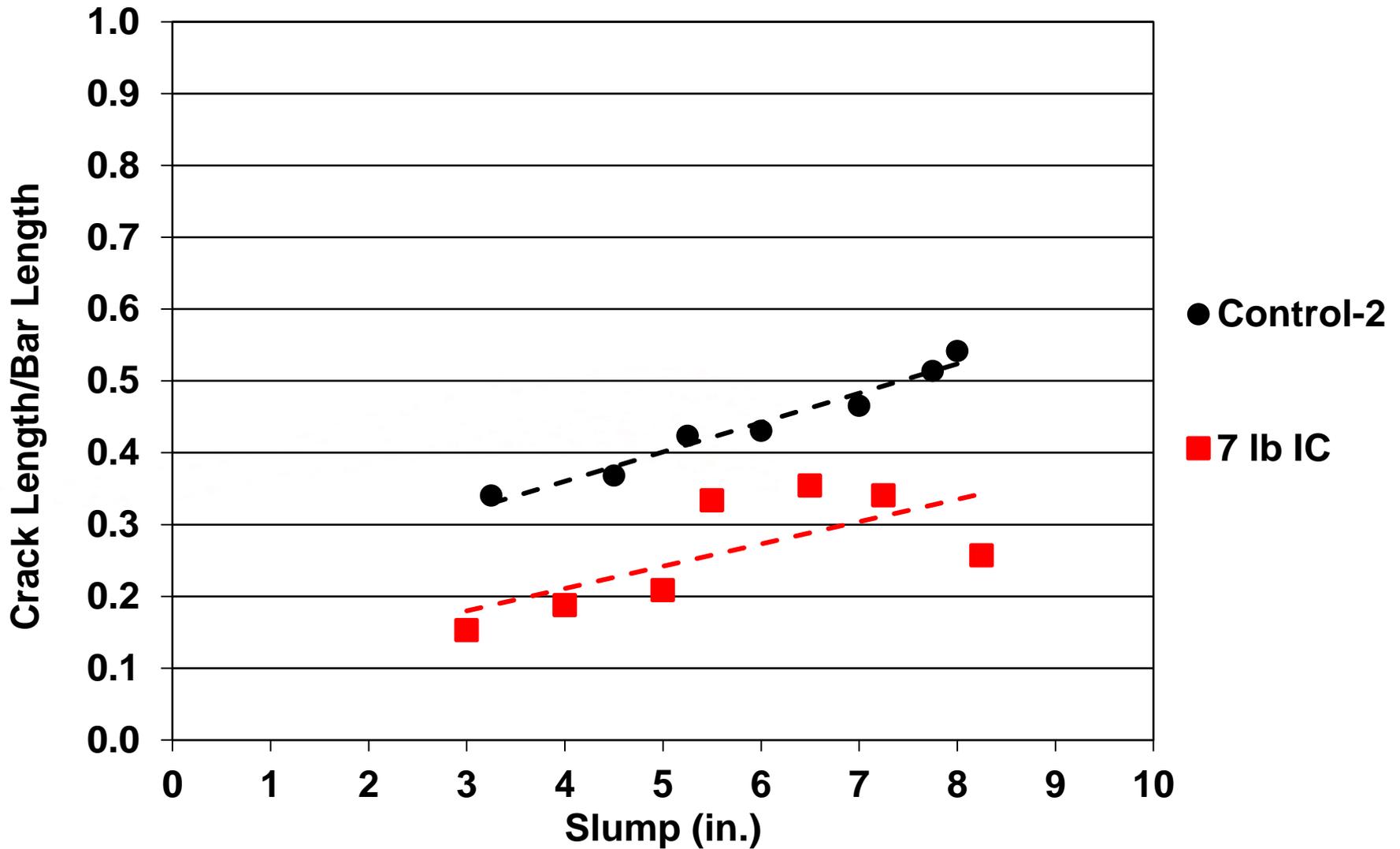
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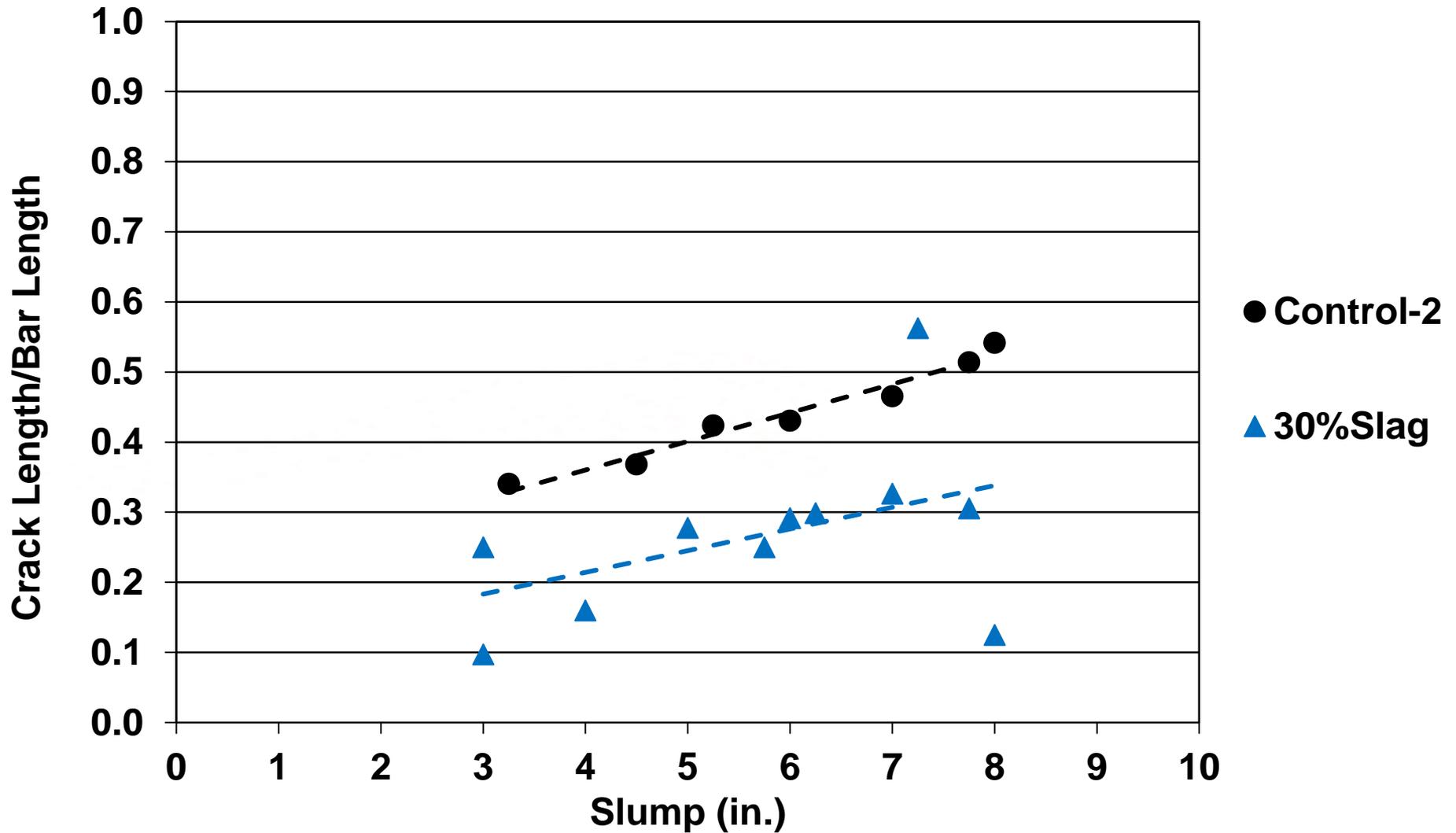
- Additional Study Parameters
 - Viscosity modifying admixture (VMA)
 - Shrinkage reducing admixture (SRA)
 - 3 types of macrofibers
 - 1 type of microfiber
 - One with varied dosage

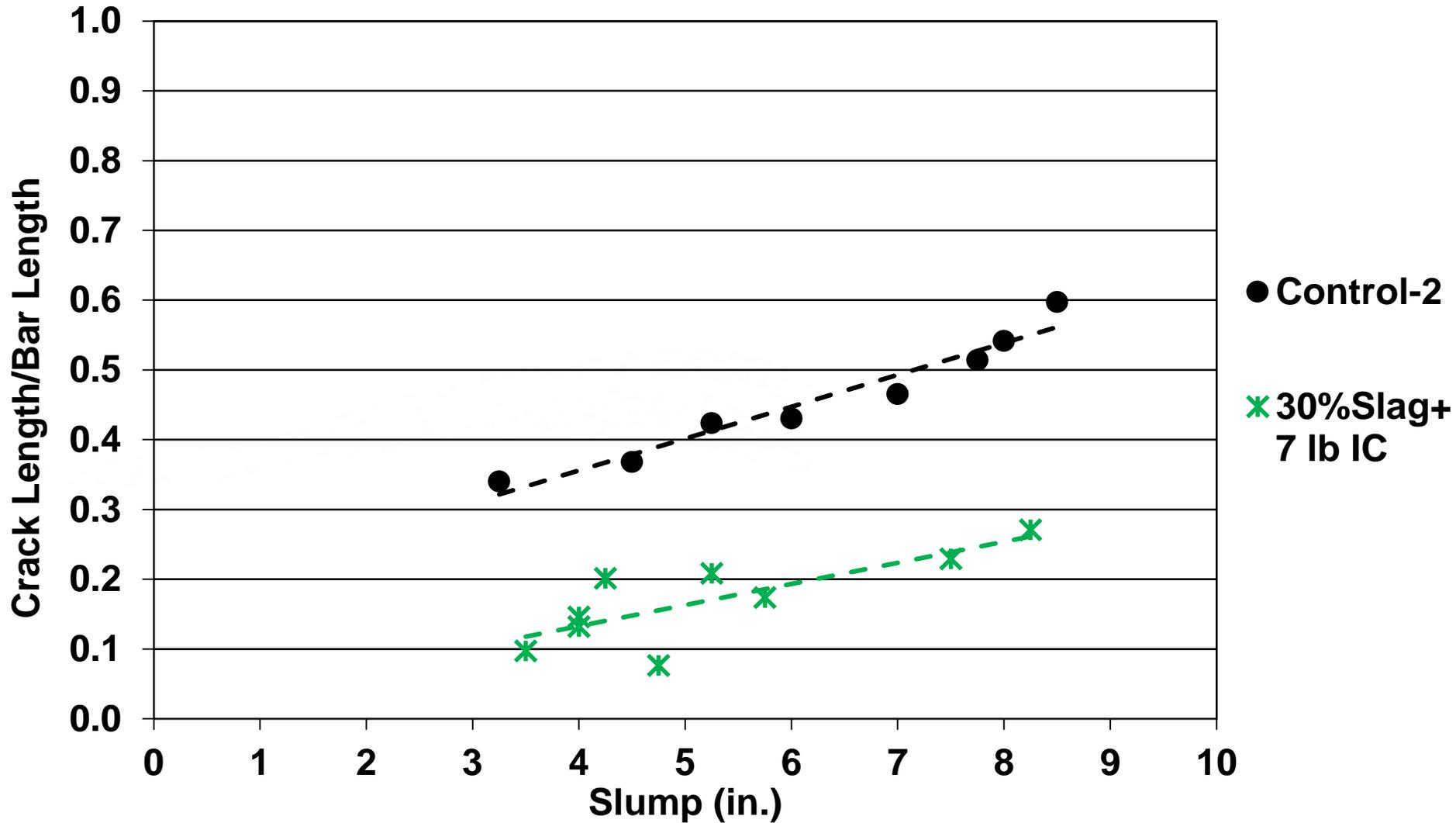
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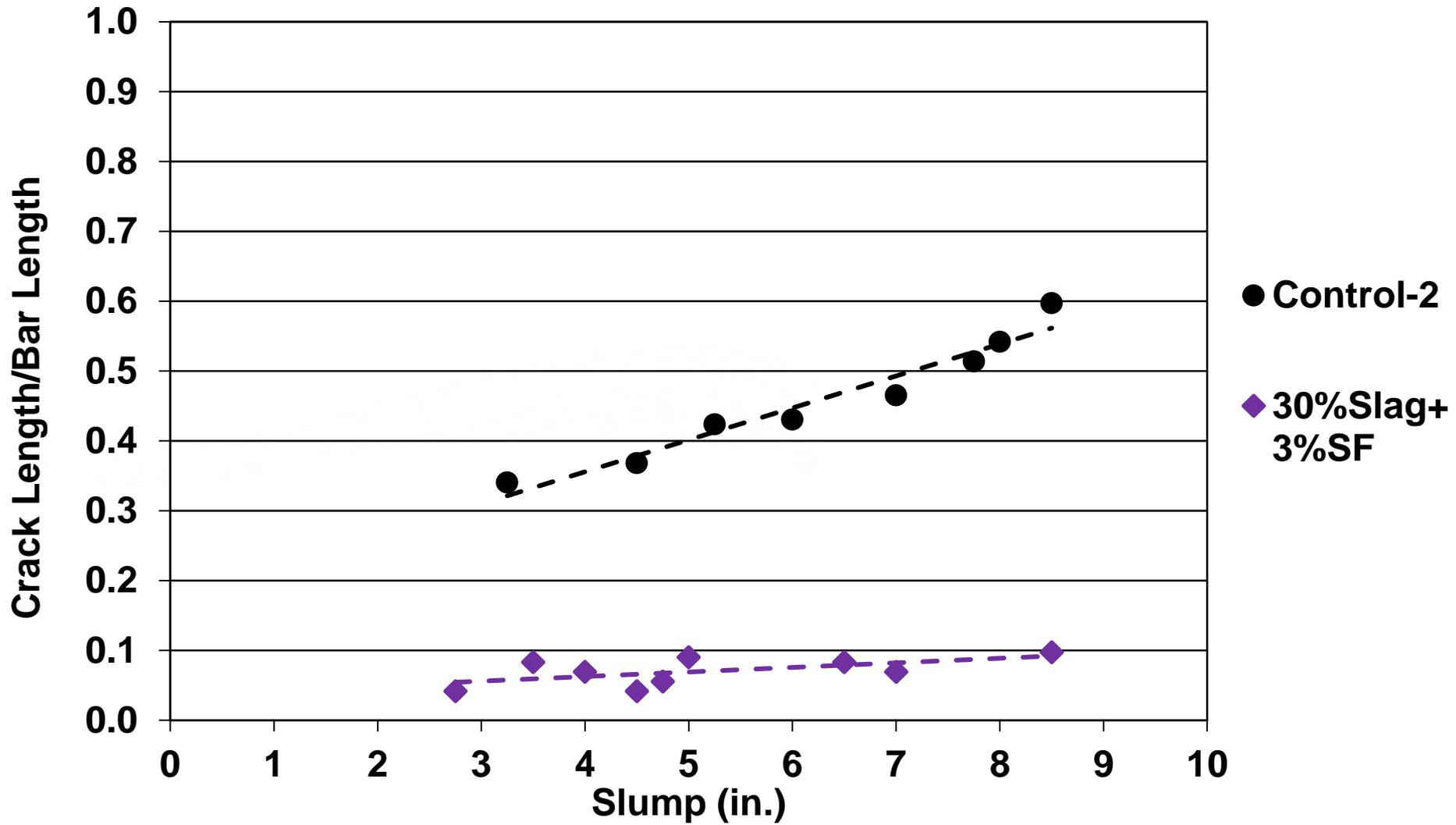
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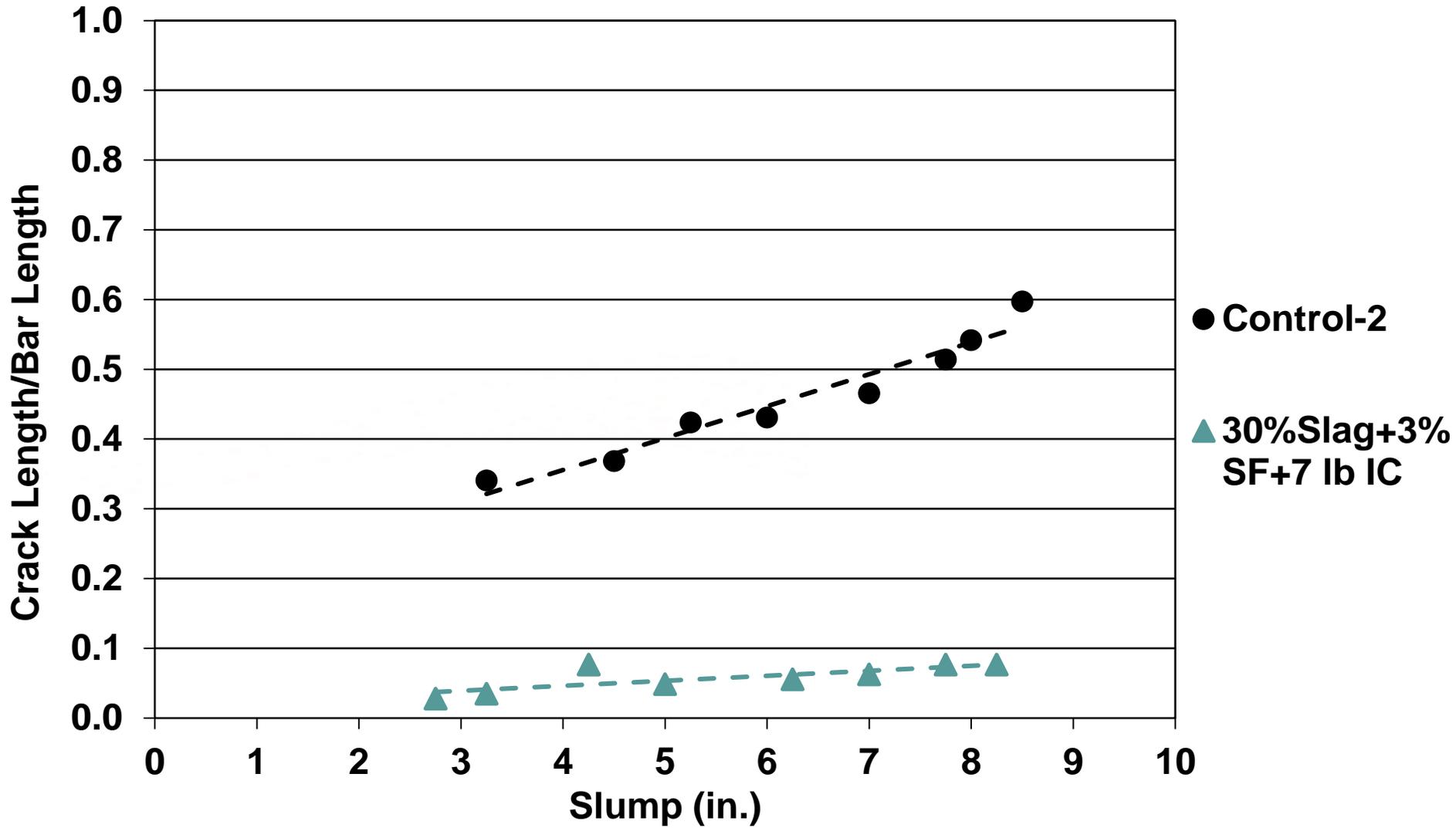


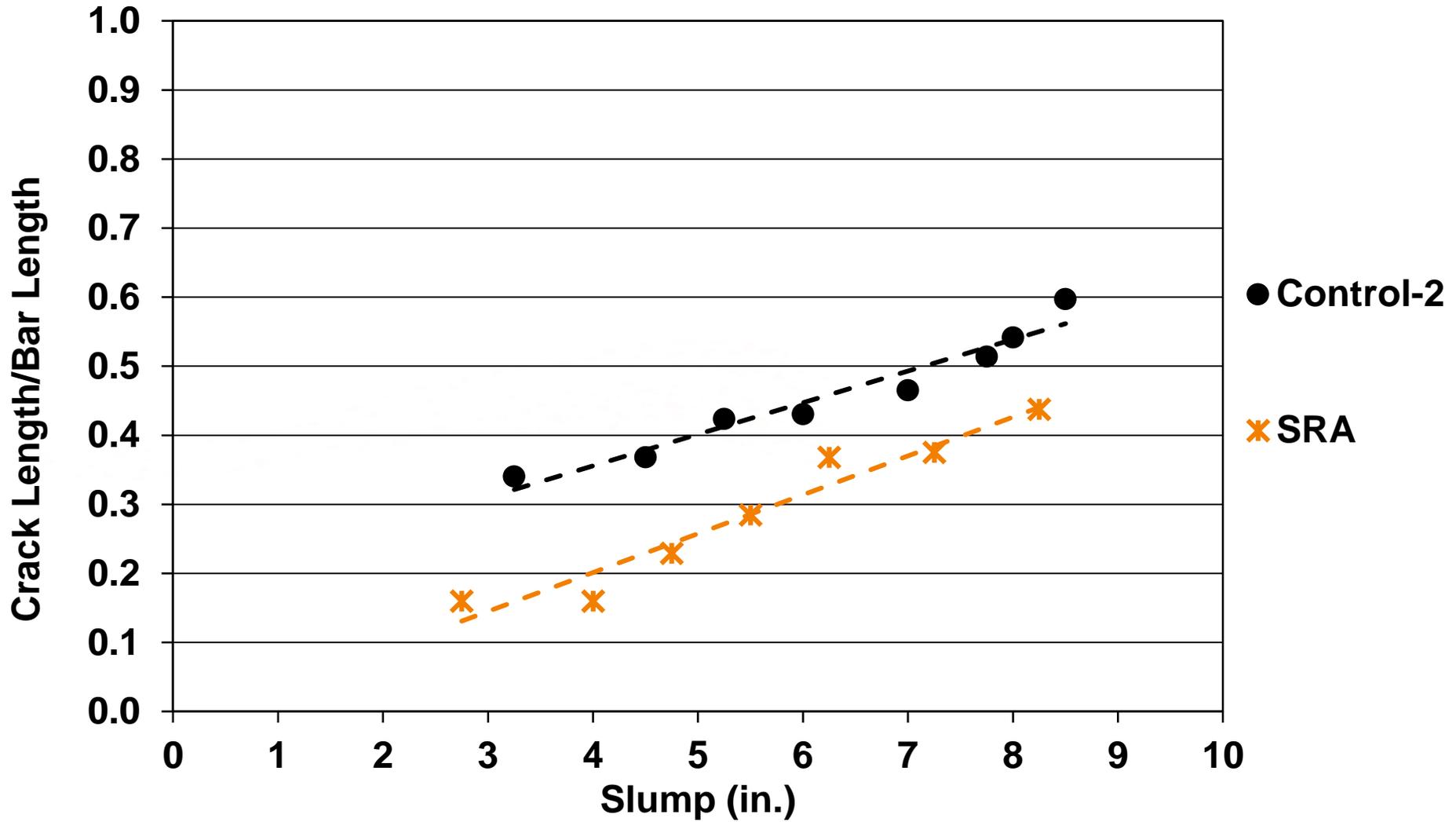


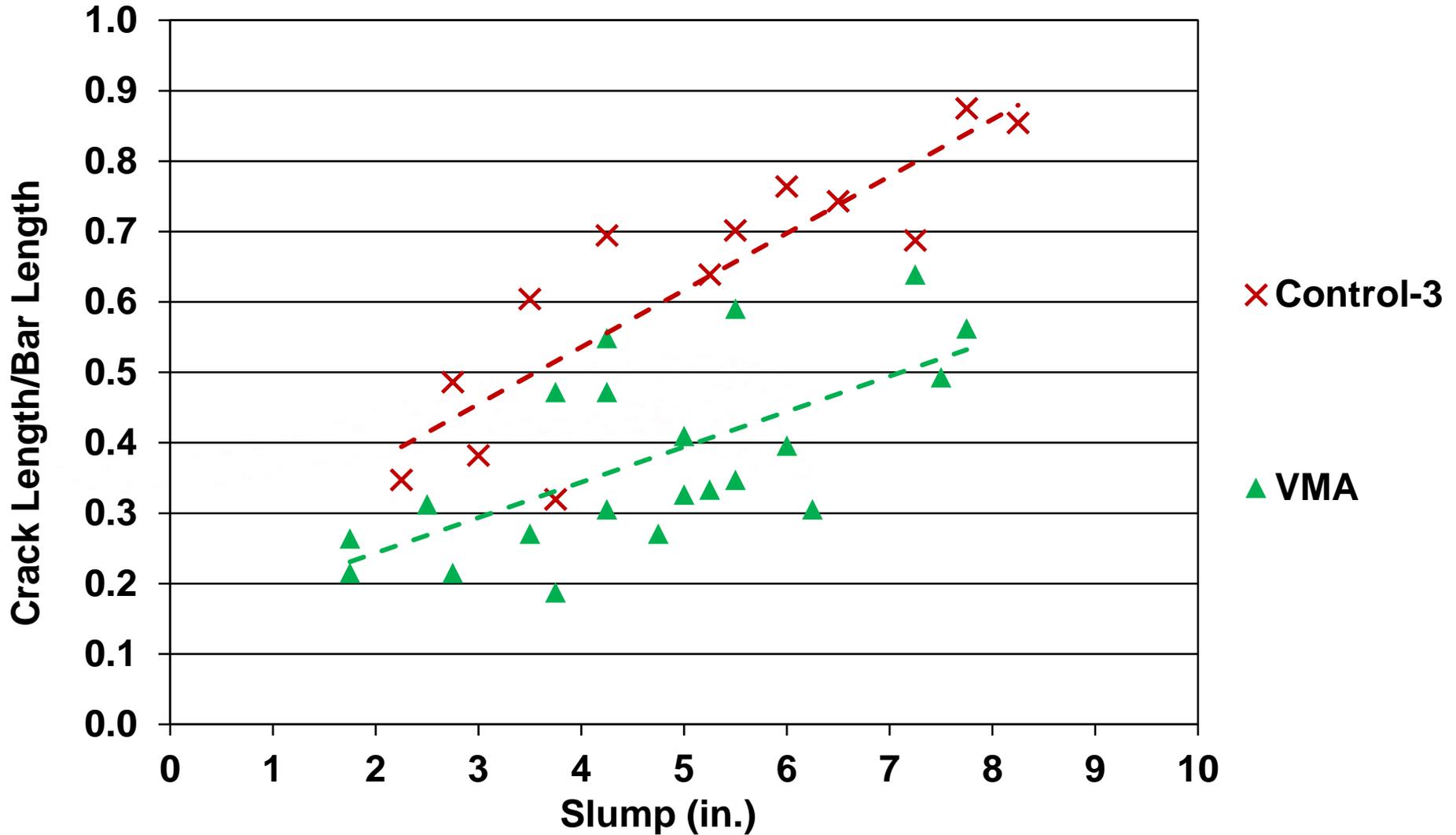


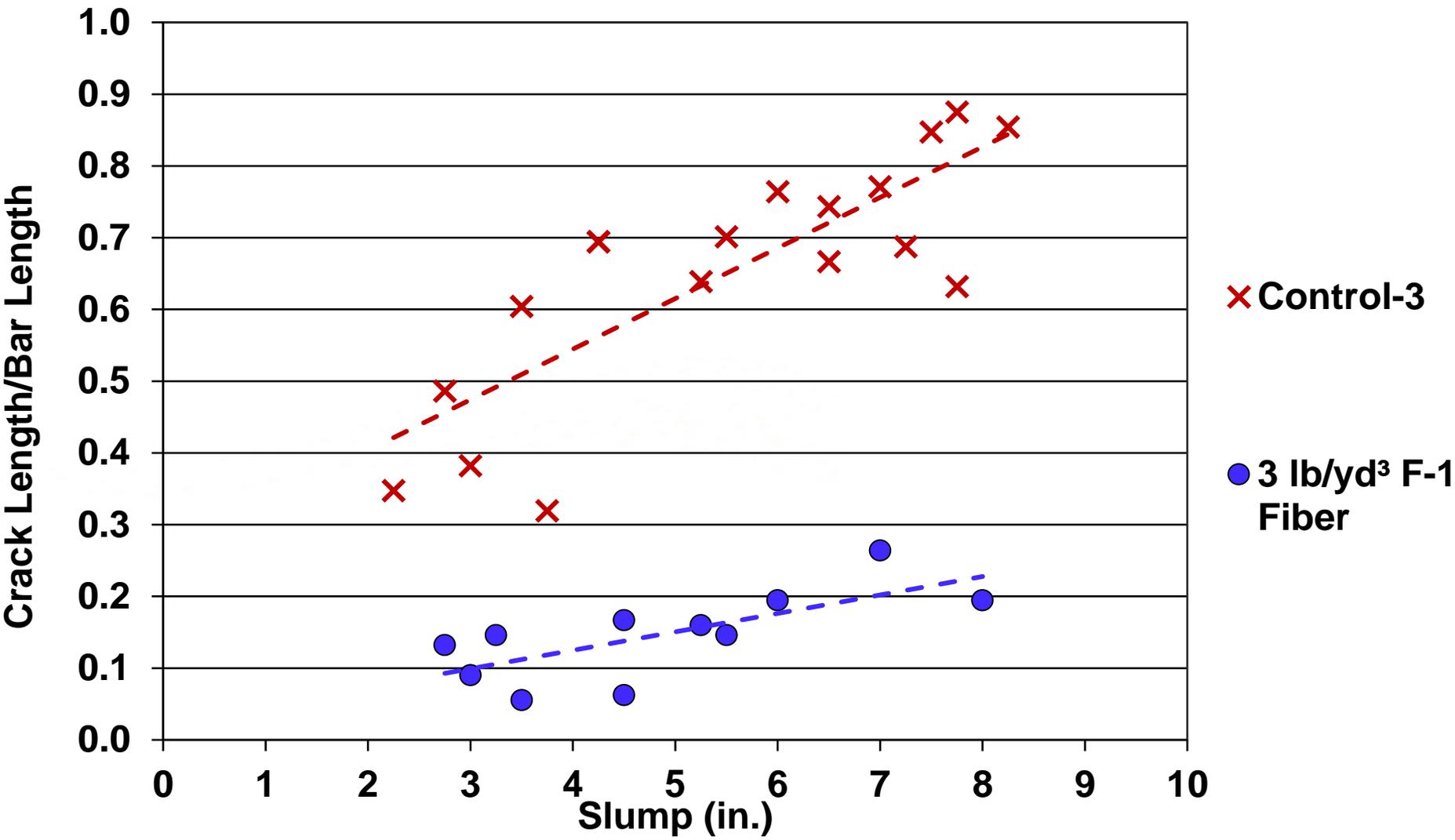


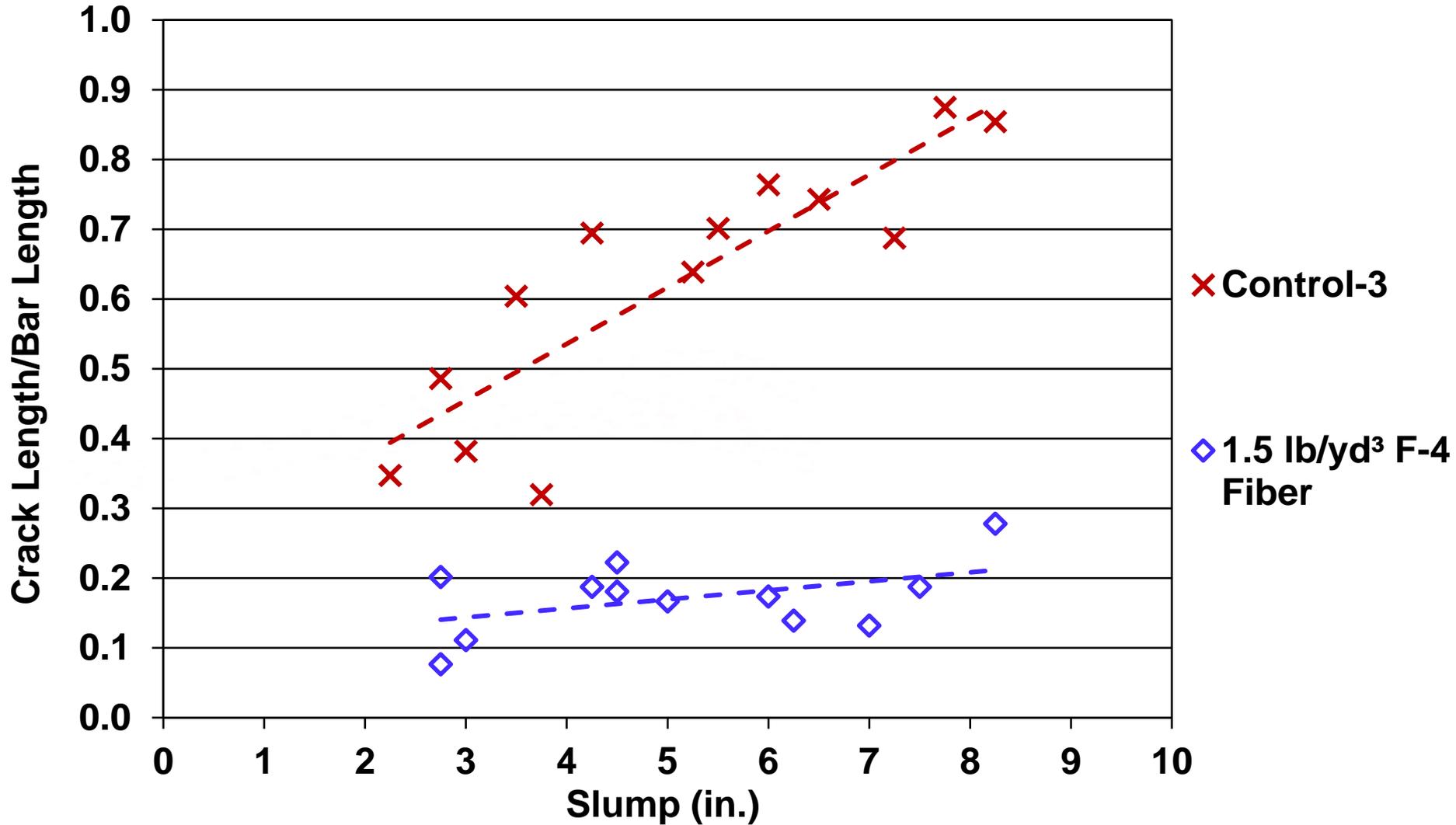












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Summary

- Settlement cracking increases with slump
- Doubling the recommended dosage of one fiber had no significant effect on settlement cracking
- Combined effects with SCMs and internal curing
- Many of the technologies that reduce shrinkage cracking also reduce settlement cracking

Questions?

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