Performance Concrete: Enhancing Durability, Cost Effectiveness and Reducing Carbon Footprint

VERMONT AGENCY OF TRANSPORTATION RESEARCH PROGRAM

University of Vermont

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Project Statement

Concrete is the backbone of transportation pavement and infrastructure, providing strength, durability, and safety. Meeting the performance targets outlined in specifications is crucial for ensuring the long-term success of construction projects. However, delays in obtaining approval for mix designs can hinder progress and escalate costs for regional concrete producers. This project aims to address this challenge by developing a generic mix design for Performance-Based Concrete that meets the performance specifications set by the Vermont Agency of Transportation. This generic concrete mix will be optimized to reduce cost and increase durability by employing the maximum packing density technique on locally sourced aggregates and partially replacing cement with supplementary cementitious materials.

Objectives

- Developing new concrete mixes using optimized binder compositions, aggregate skeleton, and selected shrinkage mitigation strategies.

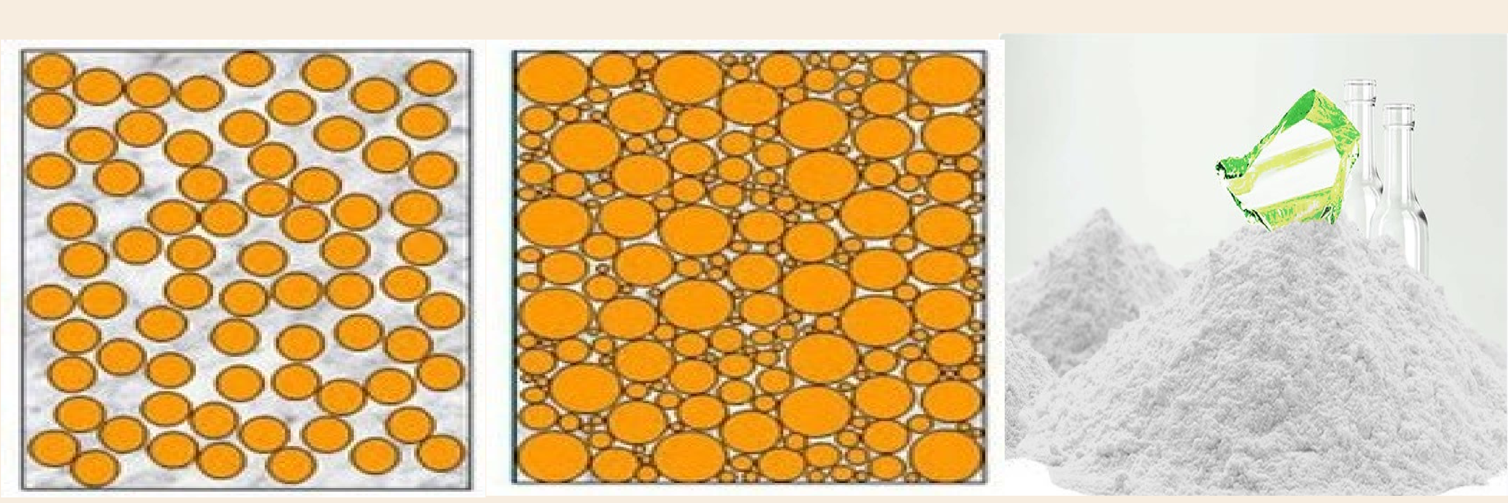


Figure 1. Poorly packed aggregates (left), well-packed aggregate with maximum packing density (middle) and SCM's as partial replacement of cement such as Ground glass pozzolan

Methodology

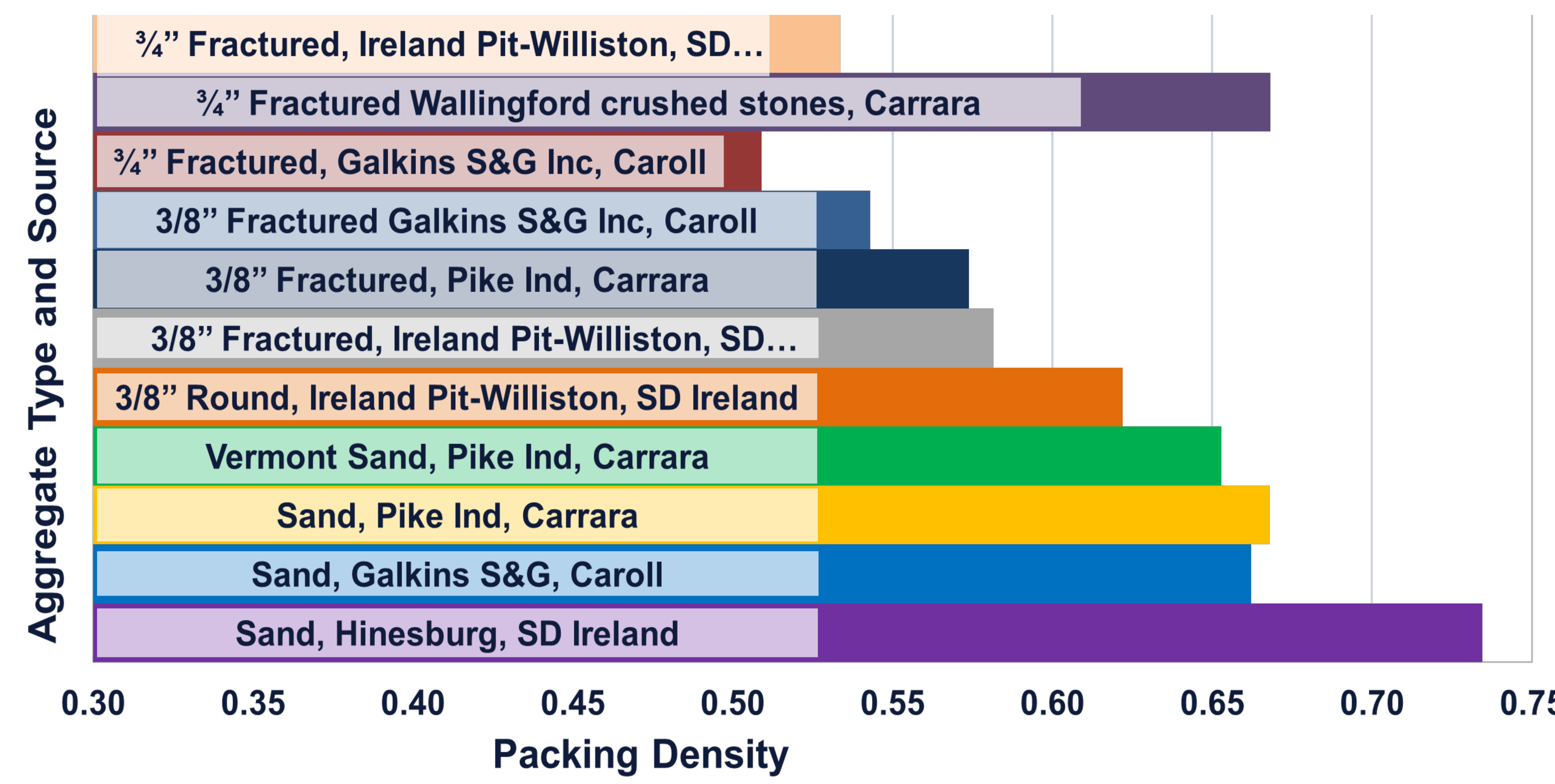
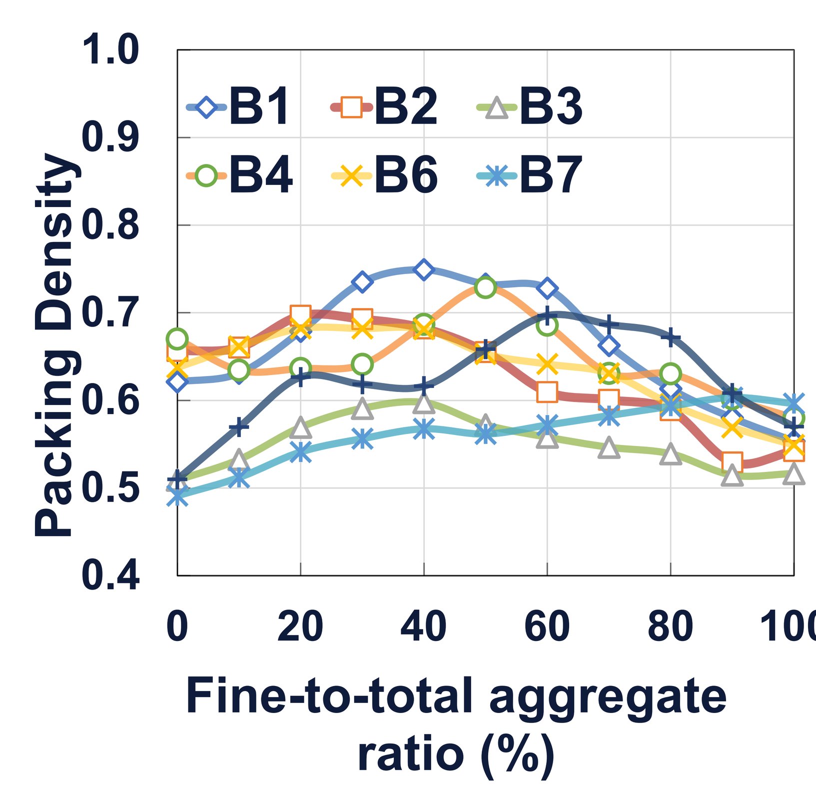


Figure 2. Packing density of fine and coarse aggregates sourced from different aggregate pit sites in Vermont.



	Aggregate 1	Aggregate 2
B1	3/4'' stones, SD Ireland	Sand, SD Ireland
B2	3/4" stones, Carrara	Vermont Sand, Carrara
B3	3/4'' Stones, Caroll	Sand, Galkins
B4	¾" Stones, Carrara	3/8" Stones SD Ireland
B5	3/8" Stones, Carrara	3/4" Stones, Carroll
B6	¾" Stones, Carrara	Sand, Carrara
B7	¾" Stones, Caroll	3/8" R. stones, SD Ireland

Figure 3. Packing density of locally sourced binary aggregates

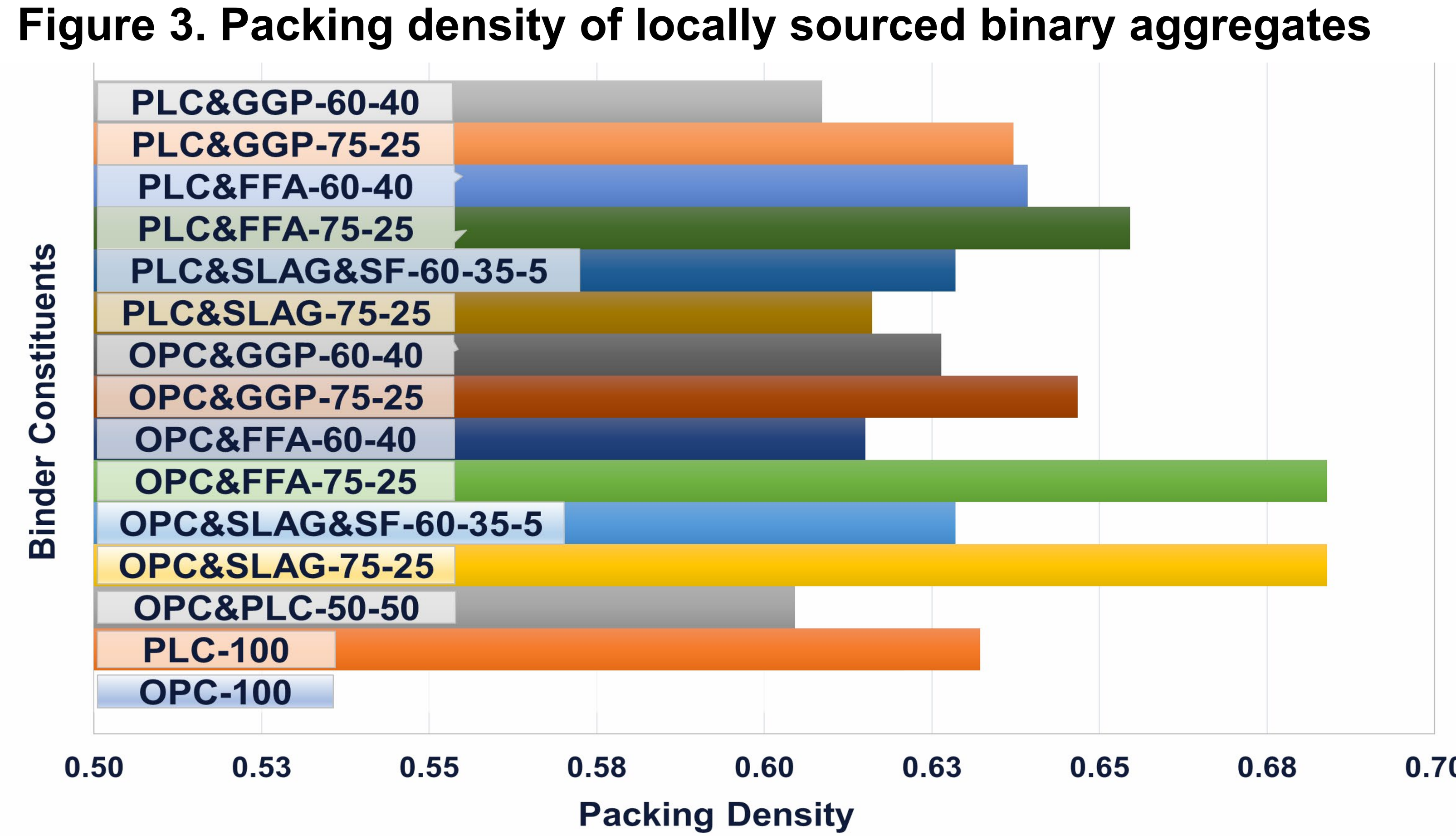
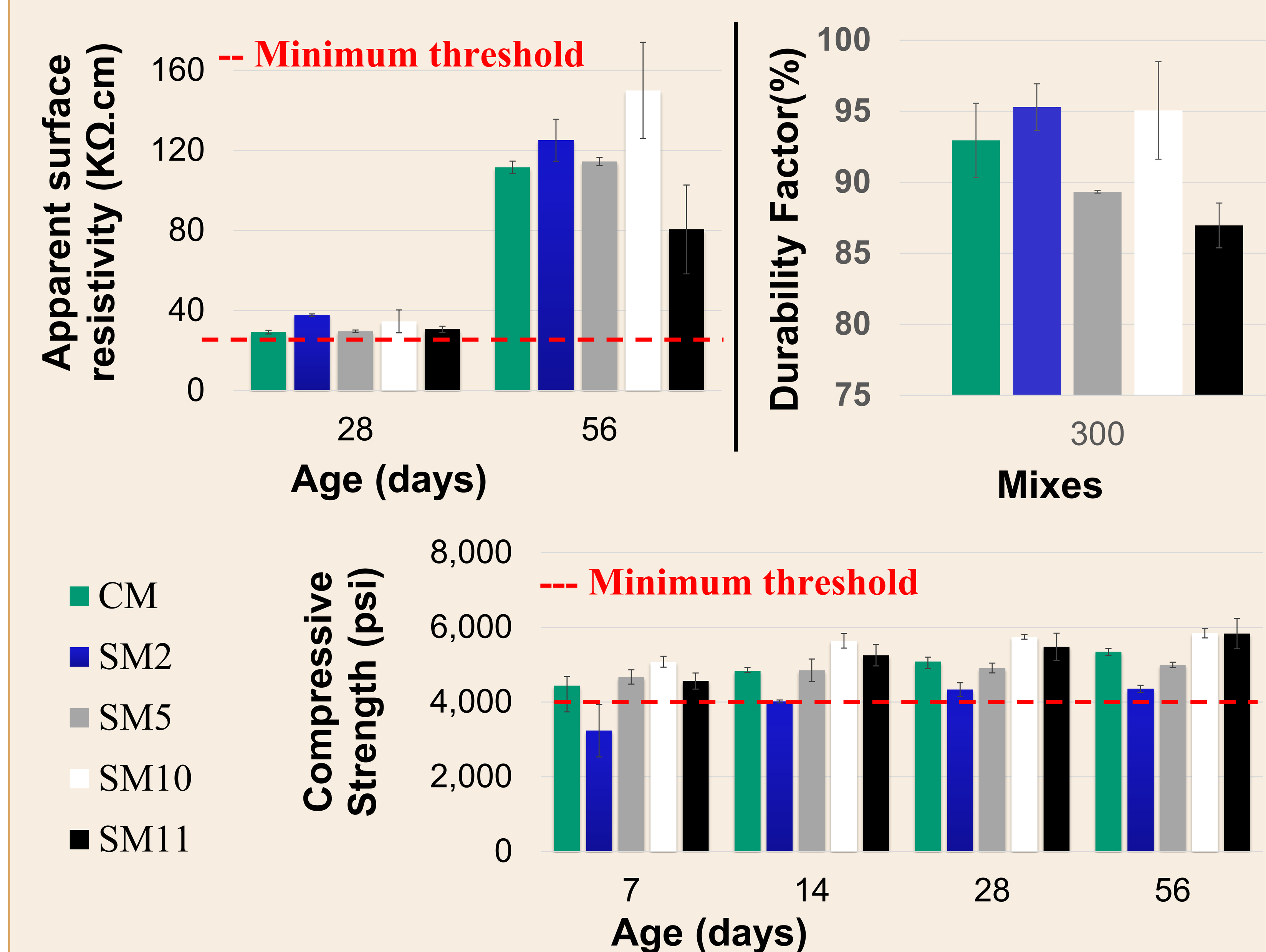


Figure 4. Packing density for individual, binary and ternary cement blends.

Results



SM2: PLC&GGP-75-25 | SM5: PLC&FFA-75-25 | CM1: Tercem
SM10: PLC&SLAG-75-25 | SM11: PLC&SLAG-75-25

Figure 5. surface resistivity of final four concrete mixes (top left). Durability factor after 300 freeze-thaw cycles (top right). Compressive strength of the cylindrical concrete mixes (bottom).

28th Day compressive strength (psi) Min: 4,000	Durability factor (%) Min: 60	Surface resistivity (KΩ.cm) Min: 22	Max. 28th Day drying shrinkage (%) PCD: 0.032 PCS: 0.042
SM10 (5,845)	SM10 (95)	SM10 (149.95)	SM10 (0.027)
SM11 (5,833)	SM2 (95)	SM2 (125.06)	SM2 (0.030)
SM5 (4,995)	SM5 (89)	SM5 (114.43)	SM11 (0.032)
SM2 (4,354)	SM11 (87)	SM11 (80.48)	SM5 (0.034)

Figure 7. Summary of the performance of the different mixes.

Acknowledgements

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