2026 NCBC WEBINAR SERIES

Stress–Strain Behavior and Bridge Performance of Concrete Containing Expanded Shale, Clay, and Slate Aggregates

April 15, 2026

Photo: HNTB, © Core-Visual as seen in *ASPIRE* Summer 2023.

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1

NCBC Webinar Series 2026

May 20: Anchoring to Concrete Updates for 2026-
Part 1: Screw Anchors

June 10: Overview of the new M-50 Tech Note on Unducted Post Tensioning with Epoxy Coated Strand

1:00 – 2:00 PM ET

July 15: Anchoring to Concrete Updates for 2026-
Part 2: Attachments with Shear Lugs

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2

Industry Events 2026

April 27-28: Concrete Materials for Bridges Training (CBEI)
May 4-7: PTI Convention, Long Beach, CA
May 19-21: Bridge Deck Construction Inspection Program (CBEI)
Jun 15-17: International Bridge Conference, National Harbor, MD
Jun 28- Jul 2: AASHTO COBS Annual Meeting, Charlotte, NC
Sep 9-12: PCI Committee Days, San Antonio, TX
Sep 30-Oct 2: PTI Committee Days, San Antonio, TX
Oct 11-14: ACI Convention, Atlanta, GA

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3

Continuing Education

NCBC is working with PCI to offer continuing education credits.

PCI has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net.

A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

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4

NCBC Members

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5

Acknowledgements

NCBC Acknowledges our webinar sponsors each month.

In February, the Silica Fume Association brought us the Life 365 App and how to estimate service life

In March, ASBI introduced the new ASBI Design Manual for concrete segmental bridges

This month ESCSI is discussing Stress–Strain Behavior and Bridge Performance of Concrete Containing Expanded Shale, Clay, and Slate Aggregates

Thank you to these, and to all the members who enable us to host this free webinar program.

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6

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7

Fariborz M. Tehrani, PhD, PE , ENV SP

- Full professor at California State University and Director Expanded Shale, Clay and Slate Institute
- Nearly four decades of experience spanning academia public agencies, and professional practice.
- Fellow of ASCE, voting member of ACI and ASTM committees
- Nationally recognized on the application of expanded shale, clay, and slate aggregates.

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8

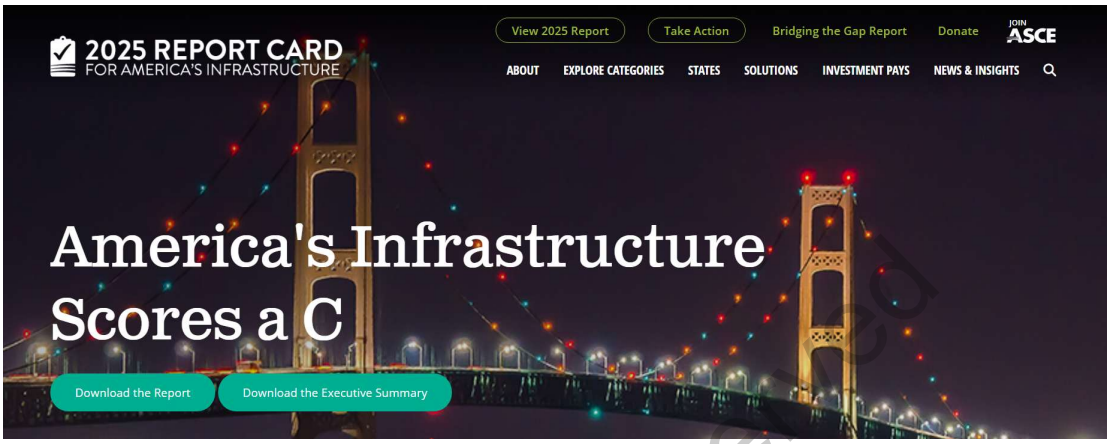
9

Stress–Strain Behavior and Bridge Performance of Concrete Containing Expanded Shale, Clay, and Slate Aggregates

Prof. Dr. Fariborz M. Tehrani
Ph.D., PE, ENV SP, PMP, SAP, F.ASCE

10

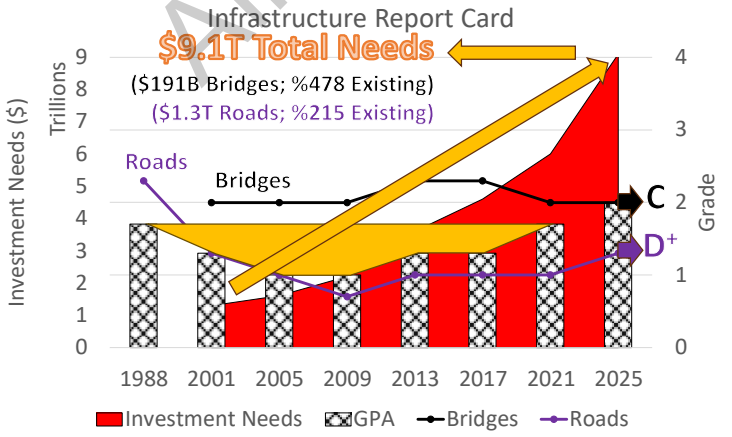
Infrastructure Report Card

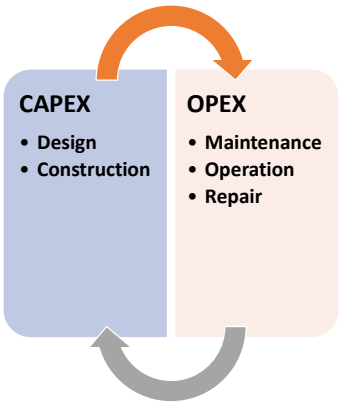


April 26 NCBC Webinar Series 11

11

Challenge: Infrastructure Grade



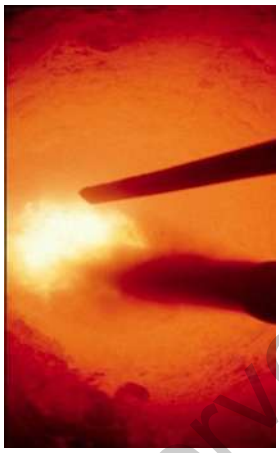


Data: ASCE, "Report Card for America's Infrastructure", 2021, https://infrastructurereportcard.org/

April 26 NCBC Webinar Series 12

12

Motivation

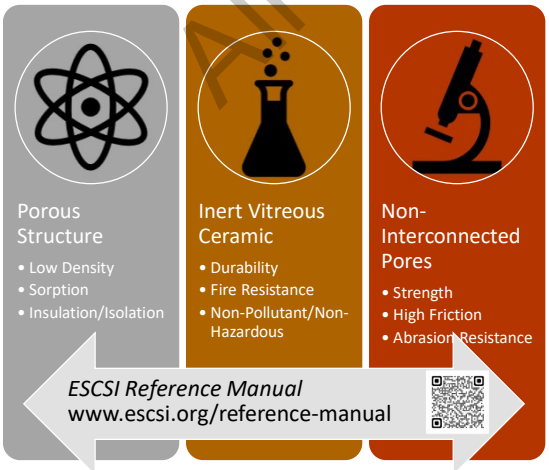


Kalantari et al. 2023. *Adapting the Built Environment for Climate Change*. Elsevier.
Tehrani. 2022. *Lifelines 2022*. UCLA, ASCE.
Davodijam et al. 2022. Leveraging Sustainable Infrastructure for Resilient Communities. ASCE.
Kalantari et al. 2021. *Airfield and Highway Pavements 2021*. ASCE.
Tehrani. 2021. *Airfield and Highway Pavements 2021*. ASCE.
Kalantari et al. 2021. *CRC 2021*. RILEM 31.
Tehrani. 2020. ESCSI 4363.

Image courtesy of Norlite (Left: Rotary Kiln Production) FMTehrani
(Right: Expanded Shale, Clay and Slate Aggregates)

13

Manufactured Physics, Chemistry, and Mechanics



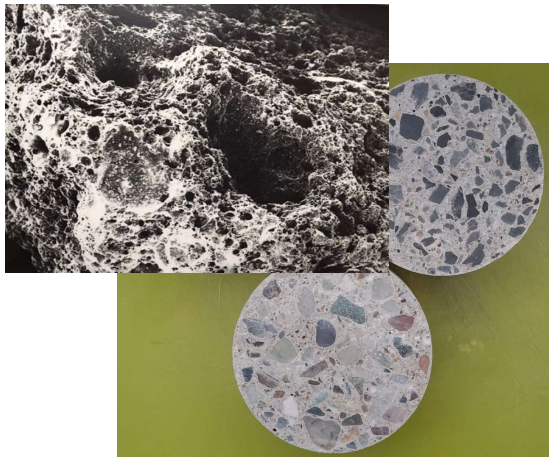
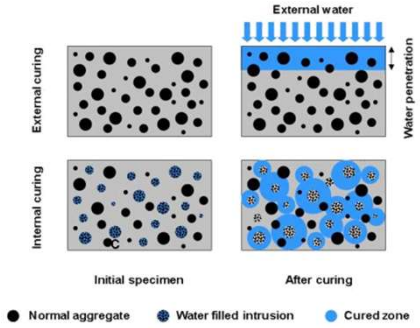


Image Courtesy of ESCSI; FMTehrani

14

Contact Zone



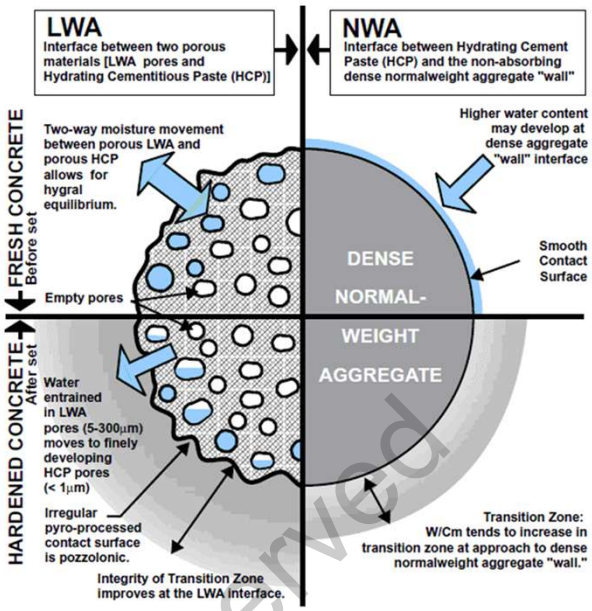


Image Courtesy of ESCSI

Image Credit: Lura 2003; Courtesy of ESCSI 2006

15

Background: Bridge Structures


Benicia-Martinez (CA)


Bay Bridge (CA)


11th St Corridor (DC)


Wabash River (IN)

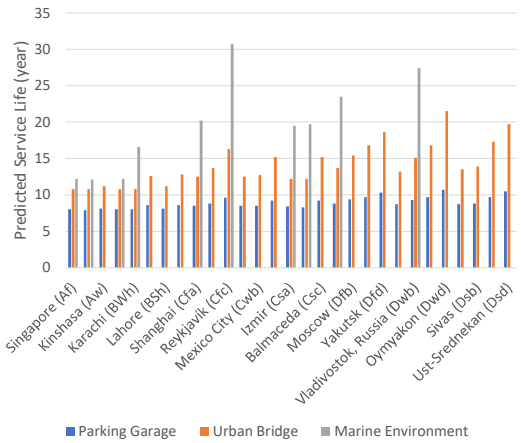

I-84 at Taggart (UT)

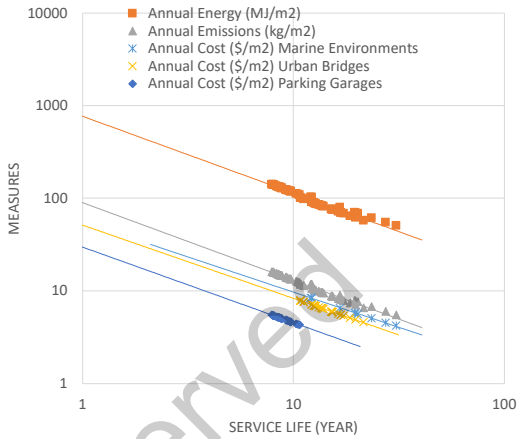

Hartsfield Jackson APM (GA)

Images Courtesy of Aspire Magazine; ESCSI

16

Background: Concrete Service Life

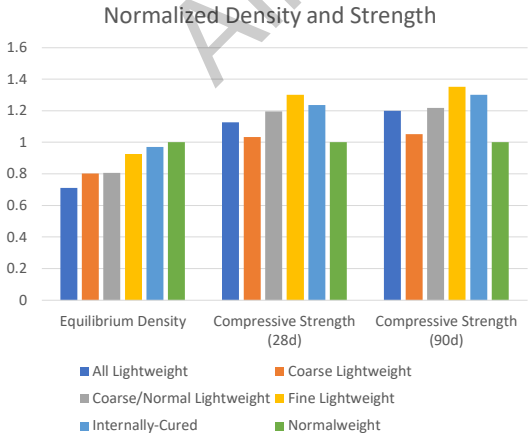


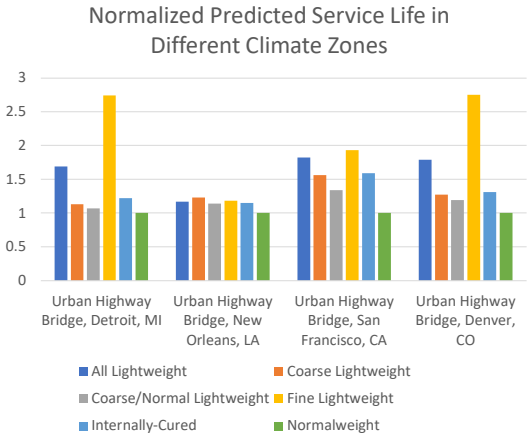


Kalantari et al. 2023. *Adapting the Built Environment for Climate Change*. Elsevier.

17

Background: Materials Investigations

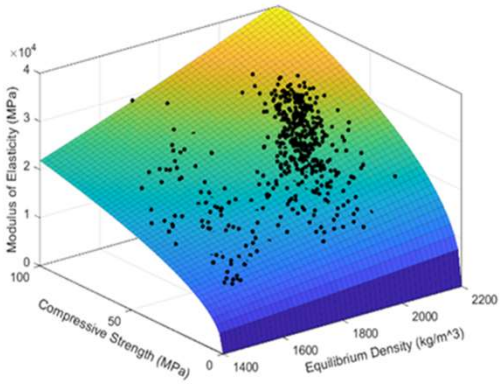


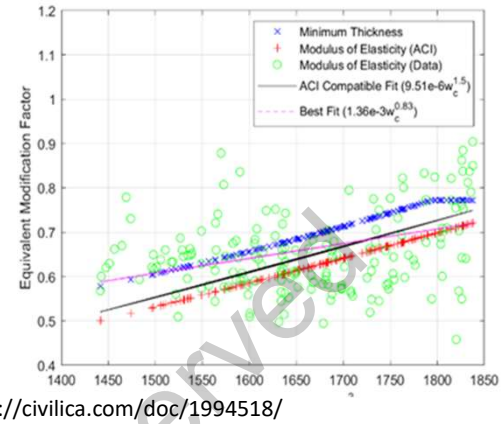


Tehrani, F. M. (2020) ESCSI 4363. <https://www.escsi.org/structural-lightweight-concrete/latest-papers>.

18

Background

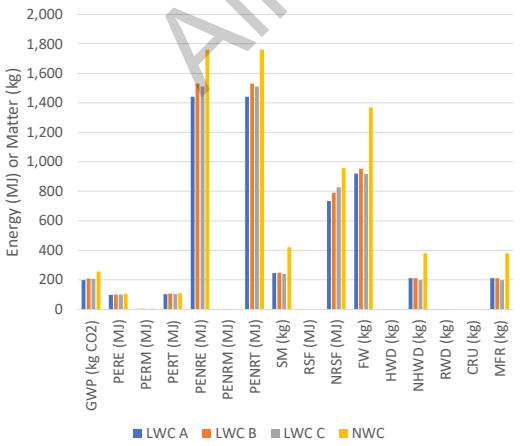


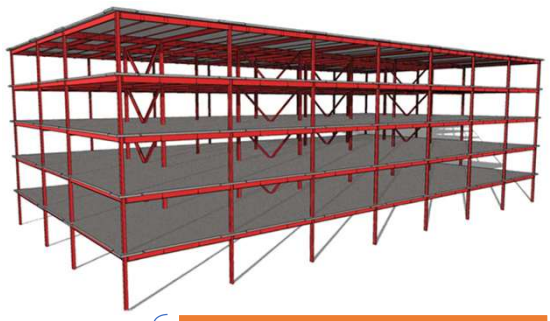


Ghavami, Kadkhodaie, Kalantari, and Tehrani. 2024. https://civilica.com/doc/1994518/
Kadkhodaie, Kalantari, Ghavami, and Tehrani. 2024. https://civilica.com/doc/1994519/

19

Background: Building Case Studies





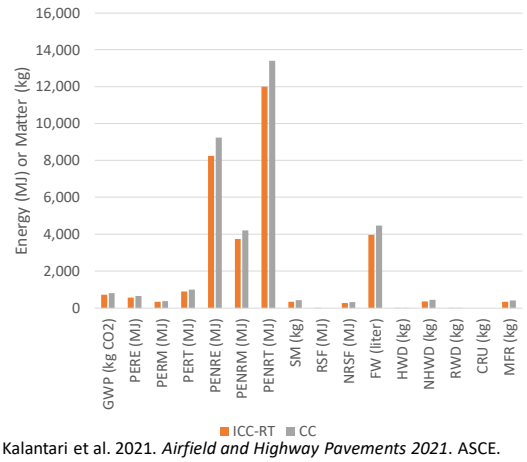
1 m³ ESCS Savings

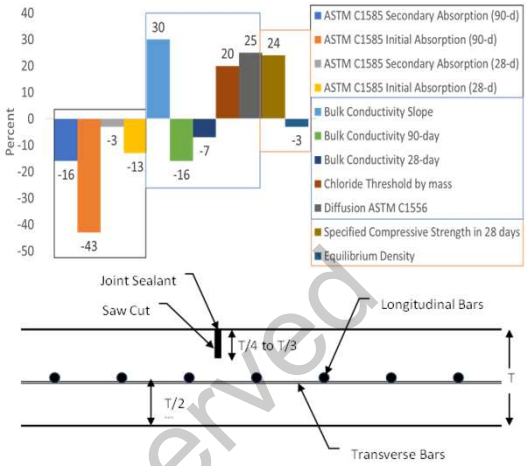
- 60 kg Hot Rolled Steel
- 50 kg Cold Formed Steel
- 7 kg Reinforcing Steel
- 35 kg Cement
- 45 kg Fly Ash
- 2000 kg Gravel
- 300 kg Sand

Walter P. Moore and Associates 2012

20

Background: Pavement Case Studies





Kalantari et al. 2021. *Airfield and Highway Pavements 2021*. ASCE.
Tehrani. 2021. *Airfield and Highway Pavements 2021*. ASCE.

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21

Highlights

- Importance of lightweight concrete in transportation infrastructure
- Focus on bridge decks and high-performance pavements
- Need for better understanding of stress-strain behavior and modulus of elasticity

→ Significance
→ Framework
→ Application
→ Outcomes

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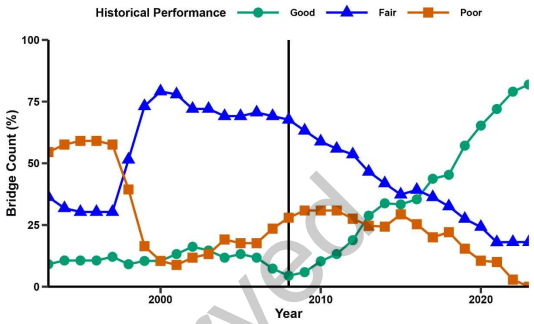
22

Significance

- Establish stress-strain relationships for lightweight concrete
- Examine lifecycle effects on service life of bridges
- Perform lifecycle analysis including GHG emissions
- Align with:
  - FHWA Every Day Counts Innovations
  - ASCE Infrastructure Report Card



Images courtesy of FHWA. 2024. *EDCNews*, June 27, 2024.

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23

Framework

- **Mobilization**: Materials, tools, software
- **Experimental Investigations**: Mix design, specimens, mechanical properties
- **Analytical Investigations**: Data analysis, surveys, lifecycle performance
- **Dissemination**: Final report, presentation, publication

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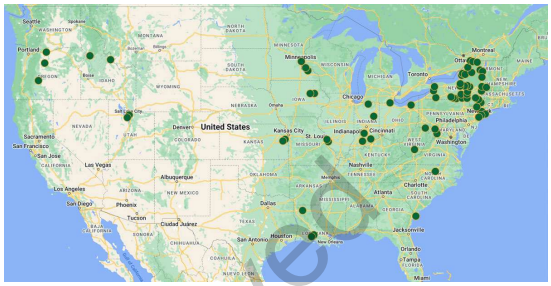
24

Application

- Factors affecting modulus of elasticity:
  - Aggregate type and proportion
  - Cementitious matrix
  - Additives and fibers
- Use of ACI and ESCSI guidelines for estimation
- Importance in structural design

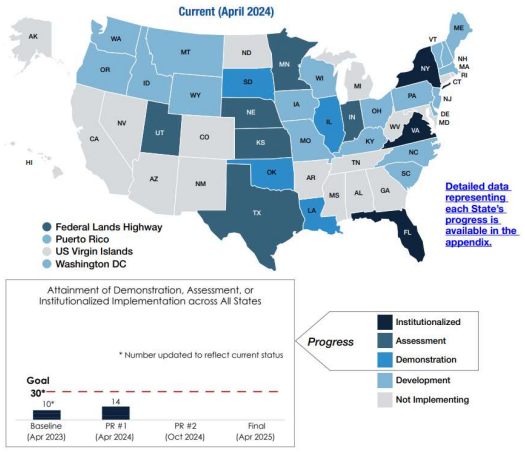


ESCSI Internal Curing Map.

25

Outcomes

- Updates to LRFD Bridge Design Specifications
- Empirical expressions for modulus of elasticity
- Insights into shrinkage and creep
- Relevance to high-strength and lightweight concrete



Images courtesy of FHWA. 2024.

26

Methodology

Four Material Sources

- Pairs of LWA and NWA

Eight Mixtures

- ALW, SLW, ICC, HSSLWC-6, HSSLWC-8
- NWC, HSNWC-6, HSNWC-8

Three Standard Tests

- Static (Longitudinal)
- Dynamic (Longitudinal, Transverse, Torsional)
- Compressive Strength (Longitudinal)

April 26 NCBC Webinar Series 27

27

Results

Variability in aggregate modulus of elasticity

Statistical analysis of structural lightweight concrete

Implications for design and lifecycle performance

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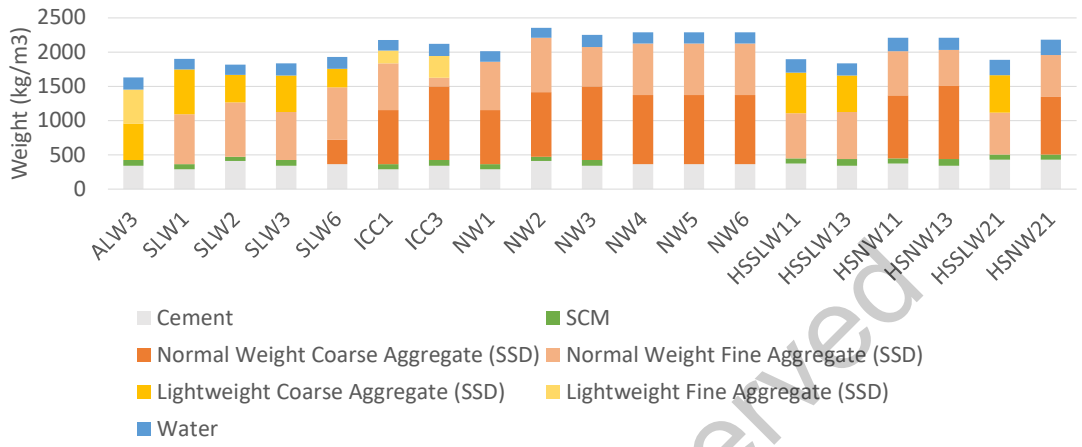
28

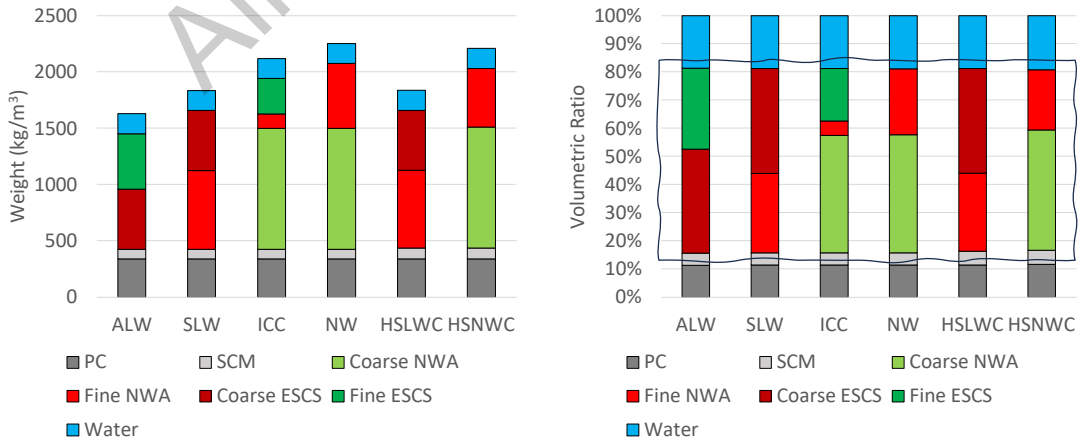
Results: Material Properties



April 26 NCBC Webinar Series 29

29

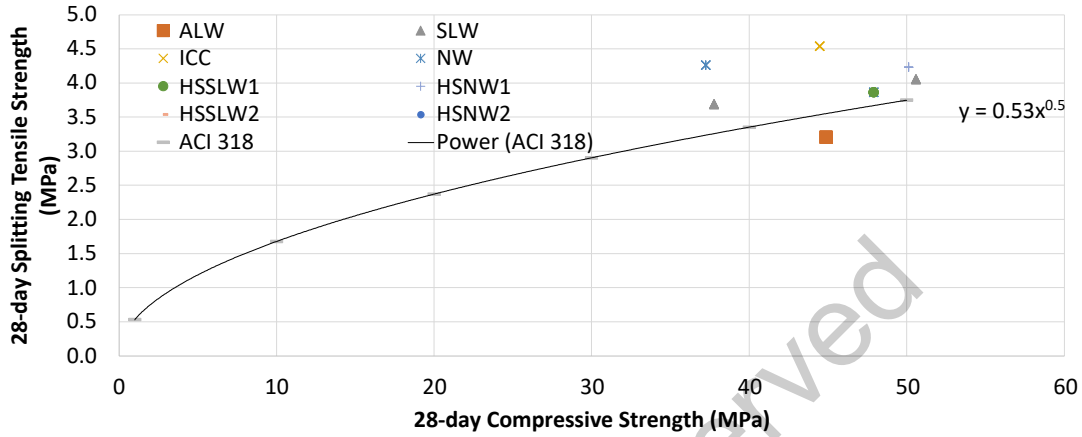
ESCS Concrete Mixtures



April 26 www.fmtehrani.com 30

30

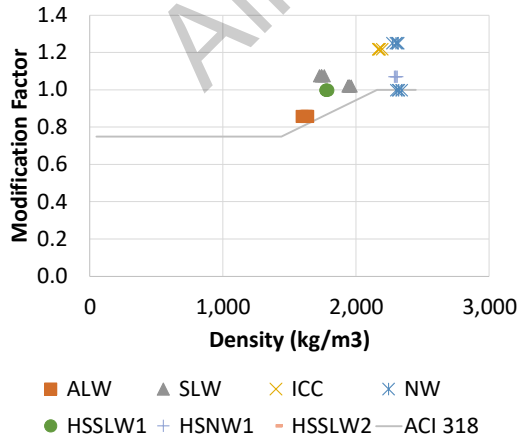
Results: Mechanical Strengths

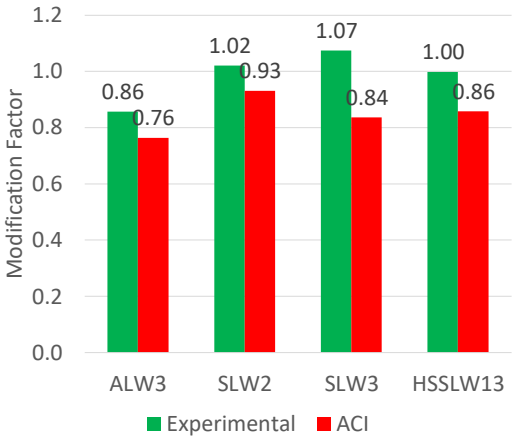


April 26 NCBC Webinar Series 31

31

Results: Modification Factors

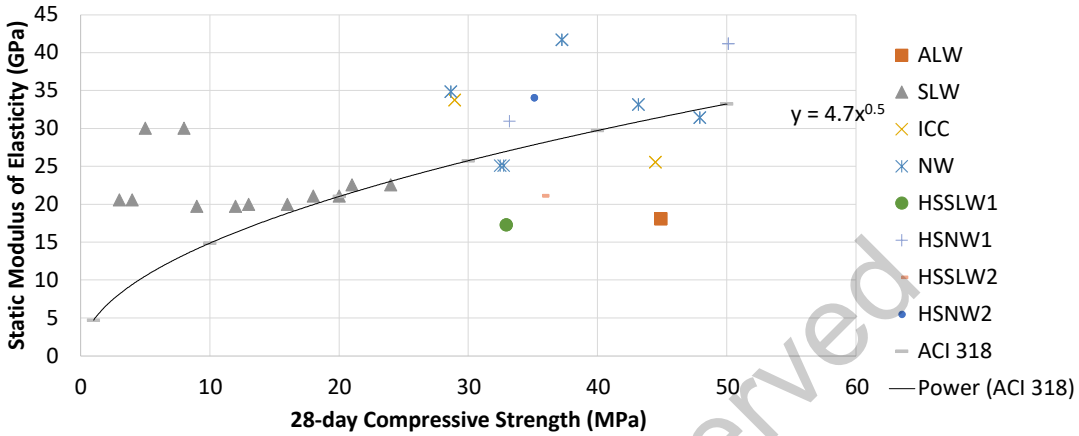




April 26 NCBC Webinar Series 32

32

Results: Static Modulus of Elasticity



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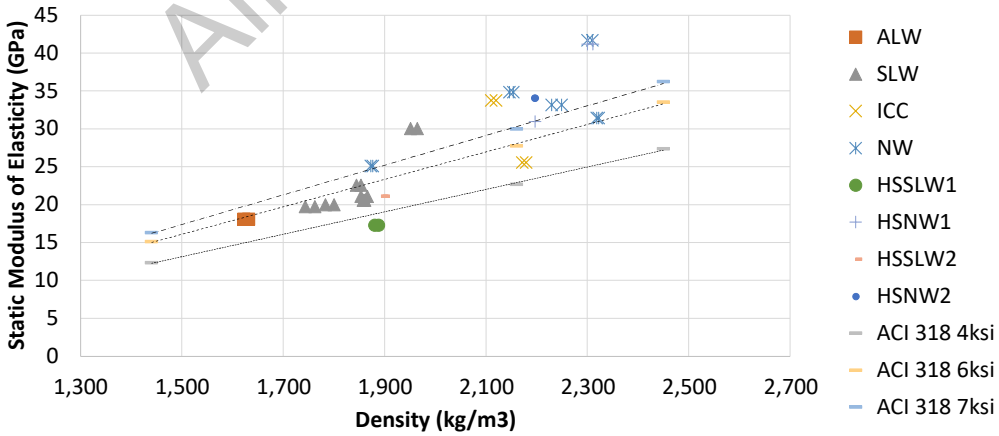
33

Results: Static Modulus of Elasticity



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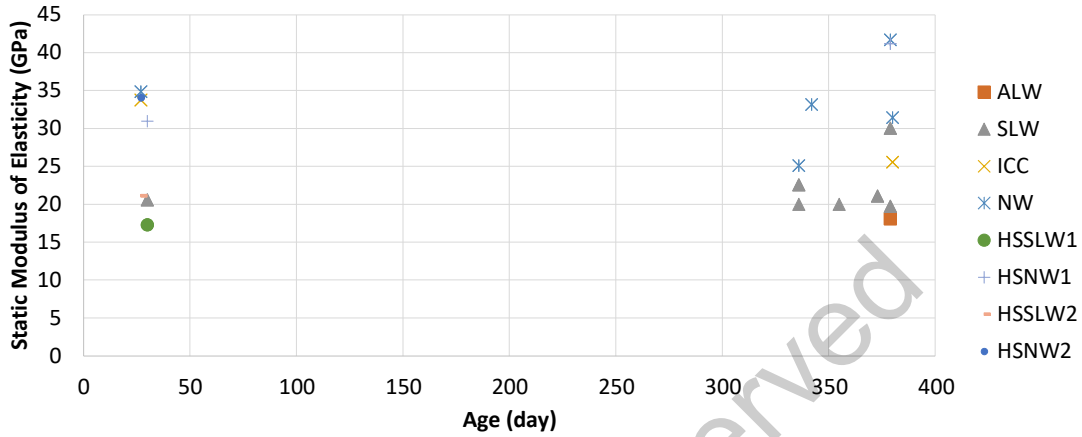
34

Results: Static Modulus of Elasticity



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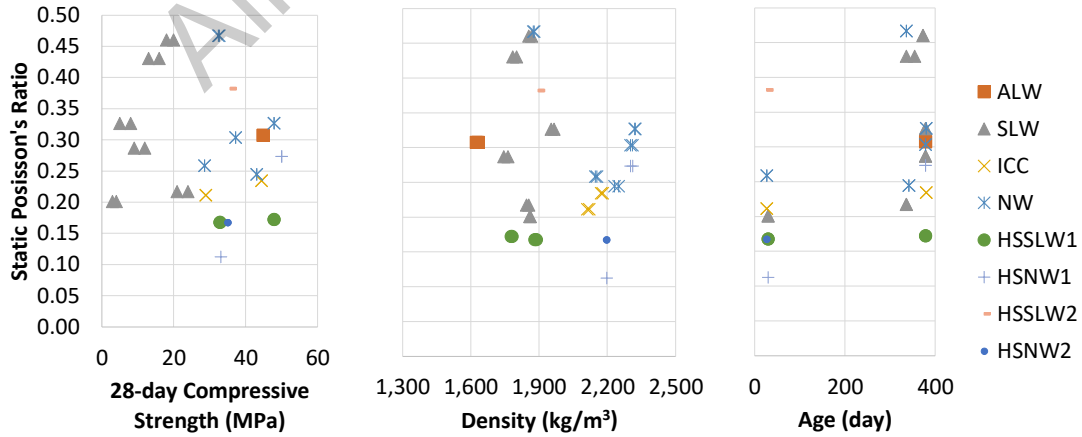
35

Results: Poisson's Ratio



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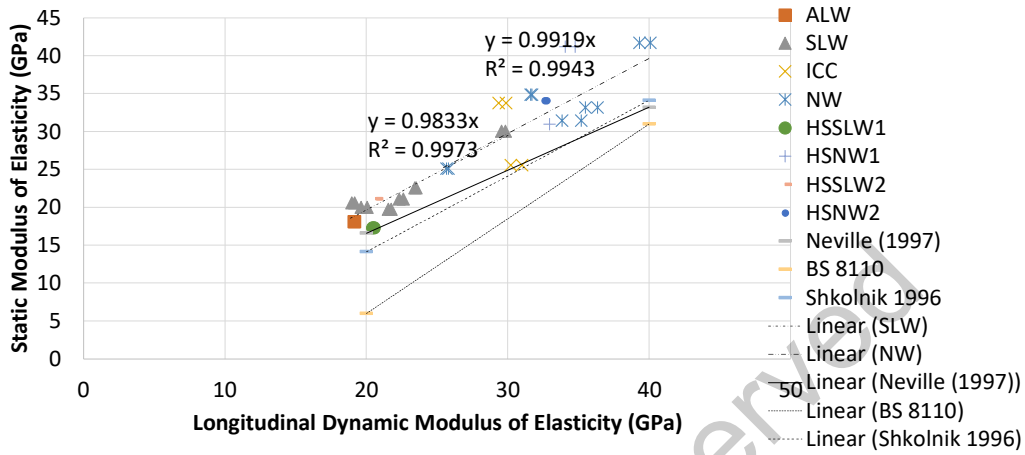
36

Results: Dynamic Modulus of Elasticity



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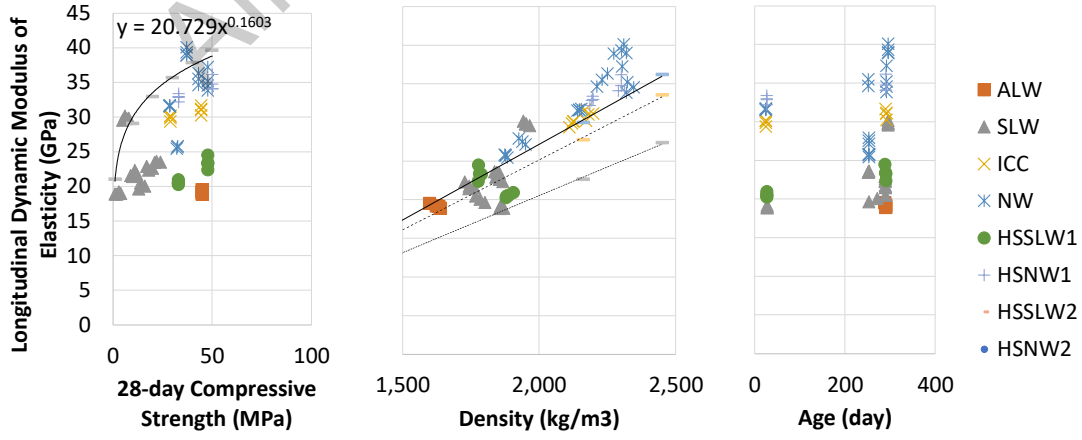
37

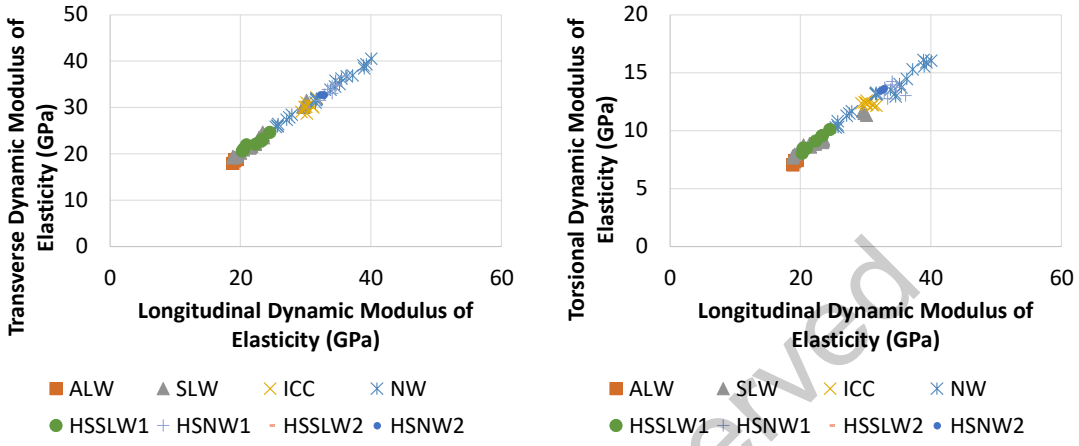
Results: Dynamic Modulus of Elasticity



April 26 NCBC Webinar Series 38

38

Results: Dynamic Modulus of Elasticity



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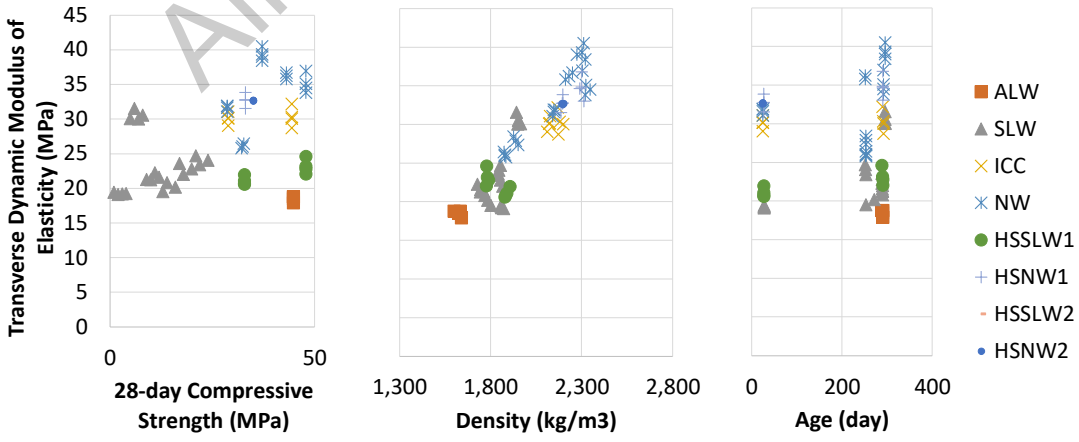
Results: Dynamic Modulus of Elasticity



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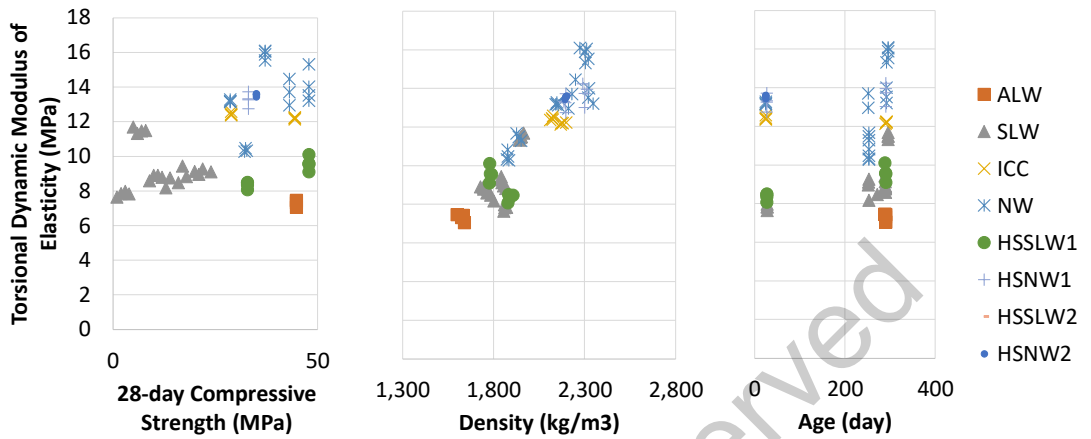
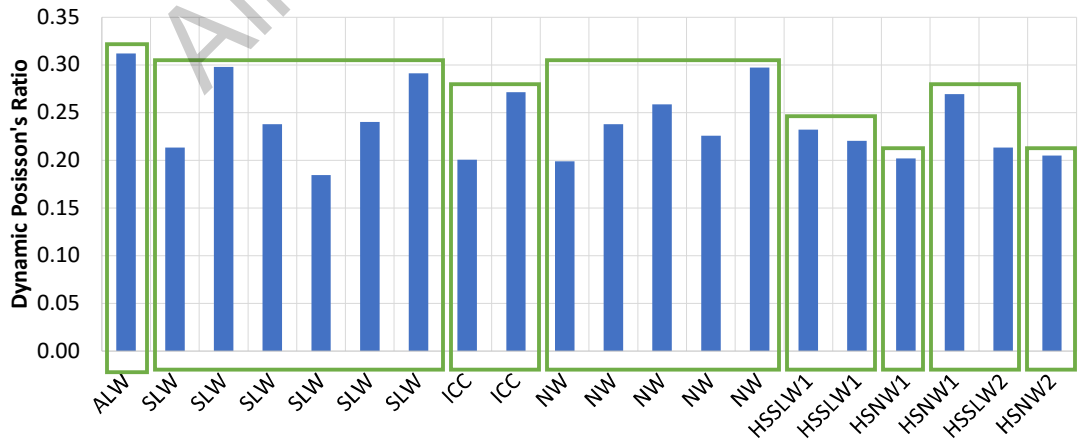
Results: Dynamic Modulus of Elasticity



April 26 NCBC Webinar Series 41

41

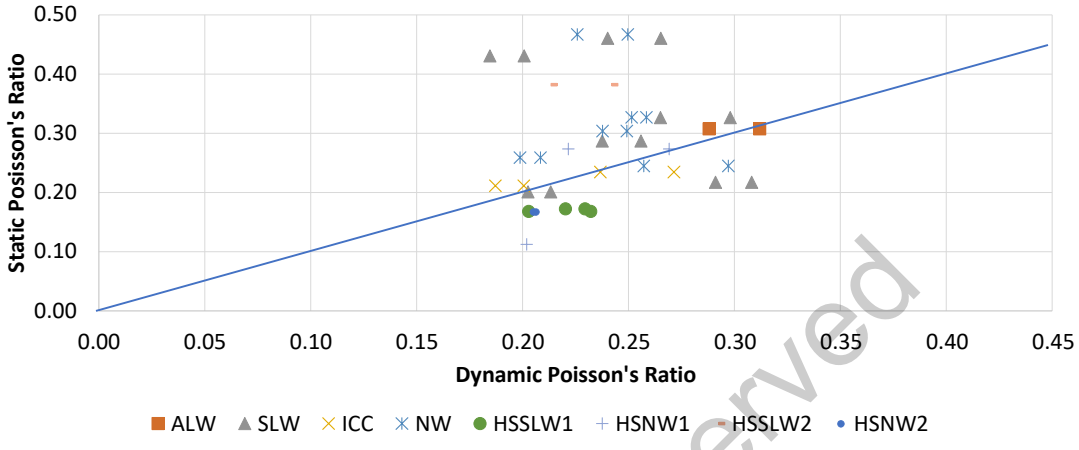
Results: Dynamic Poisson's Ratio



April 26 NCBC Webinar Series 42

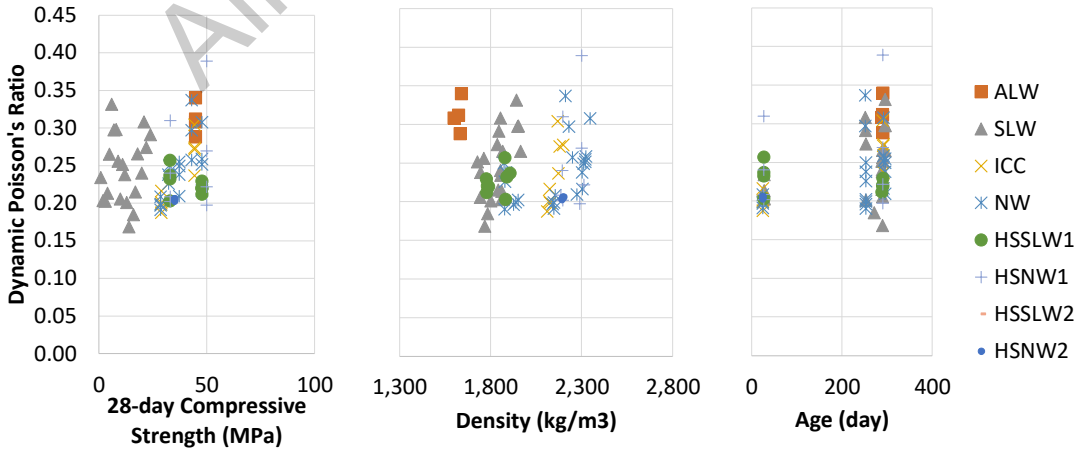
42

Results: Dynamic Poisson's Ratio



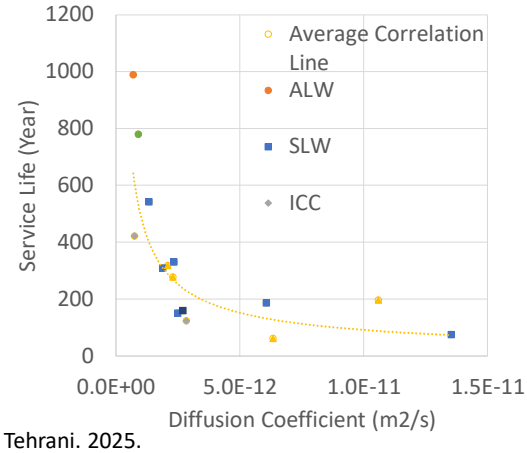
43

Results: Dynamic Poisson's Ratio

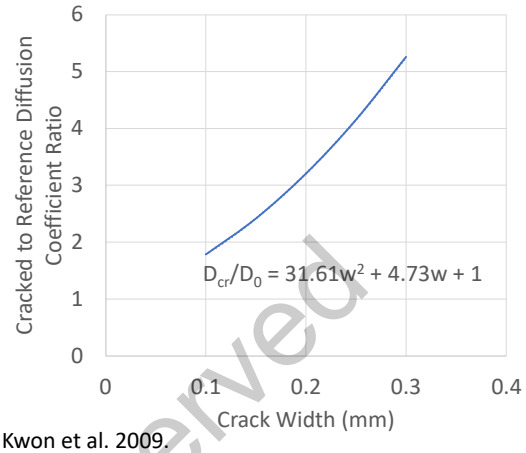


44

Results: Service Life



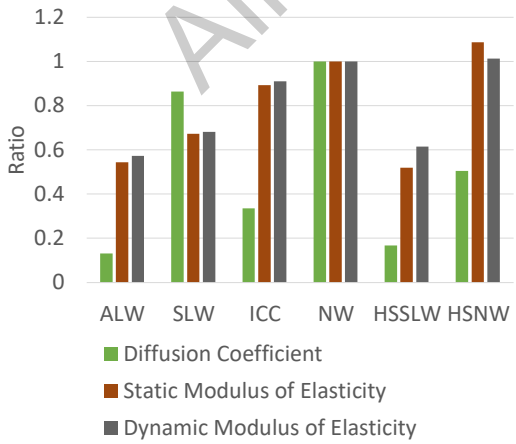
Tehrani. 2025.
https://doi.org/10.31979/mti.2025.2447

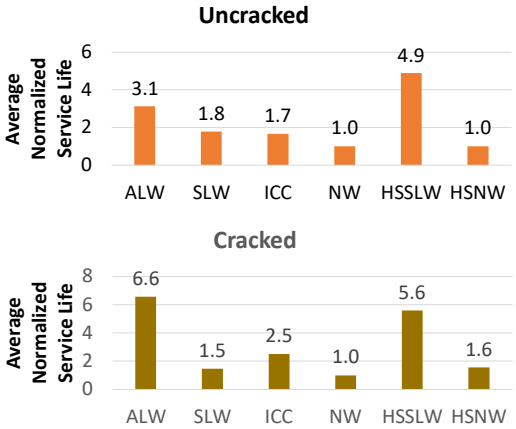


Kwon et al. 2009.
https://doi.org/10.1016/j.strusafe.2008.04.001

45

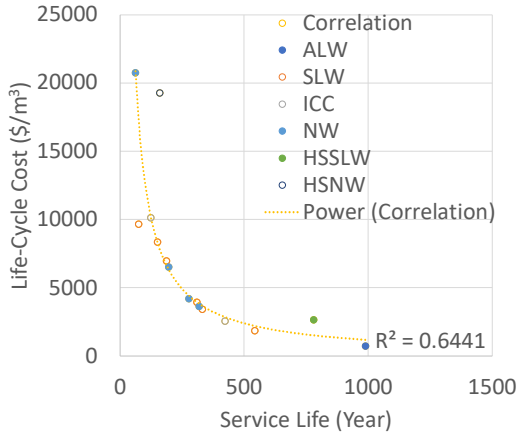
Results: Service Life

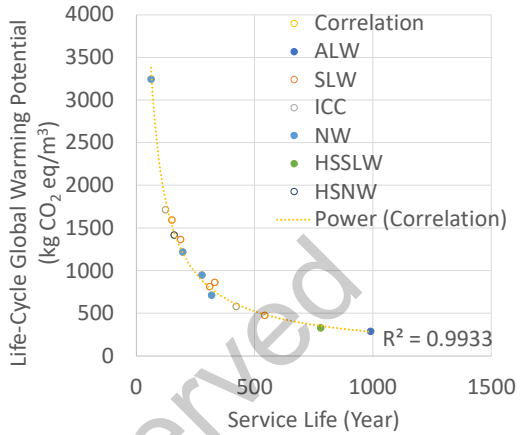




46

Results: Service Life

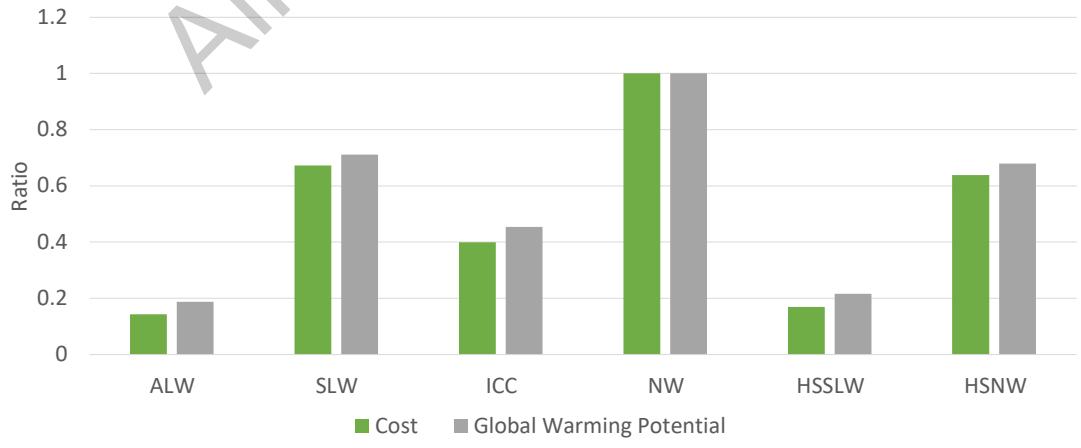




Tehrani. 2025. https://doi.org/10.31979/mti.2025.2447

47

Results: Lifecycle Analyses



48

Conclusions

Structural Efficiency
- Structural Demands
- Mechanical Strength
- Modulus of Elasticity
- Deformations and Cracking

Durability and Sustainability
- Chloride Diffusion
- Service Life

Economic and Environmental Feasibility
- Lifecycle Cost
- Lifecycle Emissions

Design Recommendations
- Modification Factors
- Design for Durability

April 26 NCBC Webinar Series 49

49

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- Editor-in-Chief
  - Journal of Civil Engineering and Materials Application
- Sustainability Professional/Trainer
  - Institute for Sustainable Infrastructure

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50

Questions
Key Takeaways

51

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52