Concrete for a Resilient and Sustainable Infrastructure

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Motivation

Existing Concrete Infrastructure:

Lacks Durability & Sustainability

ASCE's Assessment of US Infrastructure

2009 Grades

Aviation	D
Bridges	C
Dams	D
Drinking Water	D-
Energy	D+
Hazardous Waste	D
Inland Waterways	D-
Levees	D-
Public Parks and Recreation	C-
Rail	C-
Roads	D-
Schools	D
Solid Waste	C+
Transit	D
Wastewater	D-

America's Infrastructure GPA: **D**
Estimated 5 Year Investment Need: **$2.2 Trillion**

- 7% of the global GHG emissions (2009)
- 10 times more energy intensive than average GDP in the US

Cement Plant

Lacks Resilience

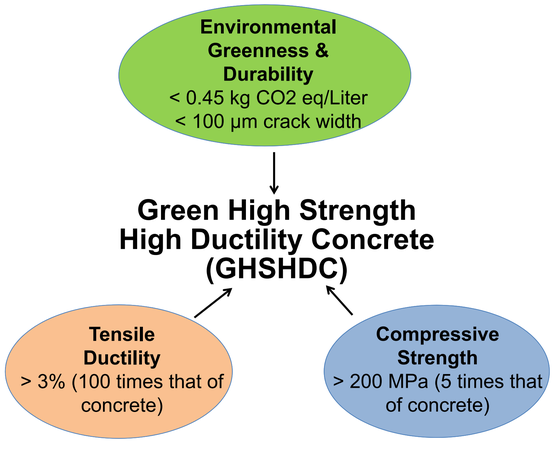
I-90 Truck Crash (2003)

Japan Tsunami (2011)

Proposed Material Solution

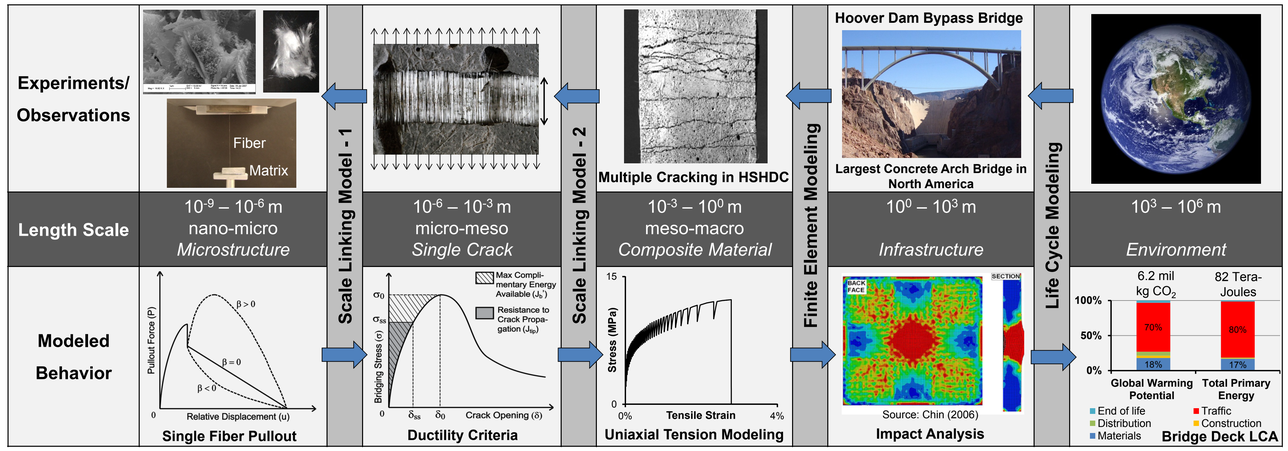
Green High Strength High Ductility Concrete

Integrating strength, ductility, durability, and greenness in one concrete material



Multi-scale Theoretical and Empirical Analysis Approach

To understand and design a resilient and sustainable infrastructure, the material behavior down to nano-micro length scales is investigated using carefully designed experiments.



Based on the micromechanical tailoring of GHSHDC, the performance of infrastructure in terms of its resilience and sustainability is predicted using a series of analytical and numerical models.

Results

Invention of High Strength High Ductility Concrete (HSHDC) [*US Patent Pending*]

Property	HSHDC	Concrete
Compressive Strength (MPa)	166	40
Ultimate Tensile Strength (MPa)	14	3
Tensile Strain Capacity	3.50%	0.01%
Modulus of Rupture (MPa)	30	4
Average Crack Width (μm)	110	Indefinite
CO_2 Footprint (kg CO_2 eq/L)	0.58	0.30
Primary Energy Intensity (MJ/L)	7	1.2

Conclusions

- Due to the combination of strength, ductility, and durability enabled by tight crack width, this invention has the potential to create a safer and less costly infrastructure in harmony with the natural environment
- The greener version of HSHDC: Green High Strength High Ductility Concrete (GHSHDC), which utilizes numerous industrial waste streams will further improve the sustainability of the built environment

Acknowledgements

Engineering Graduate Symposium