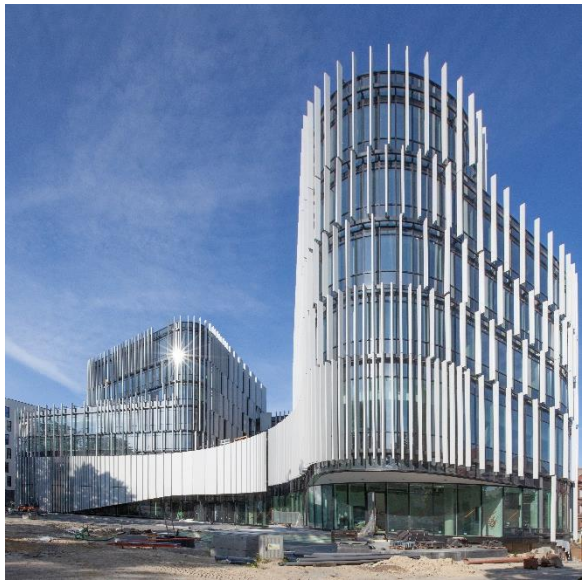
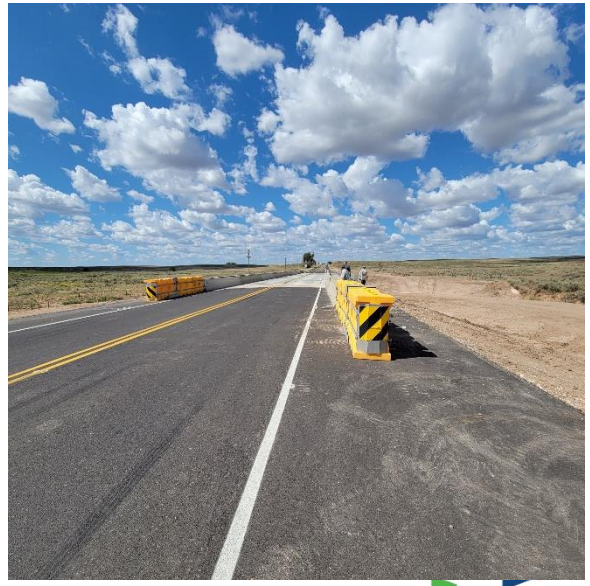
UHPC as an Environmentally-Friendly Concrete Material

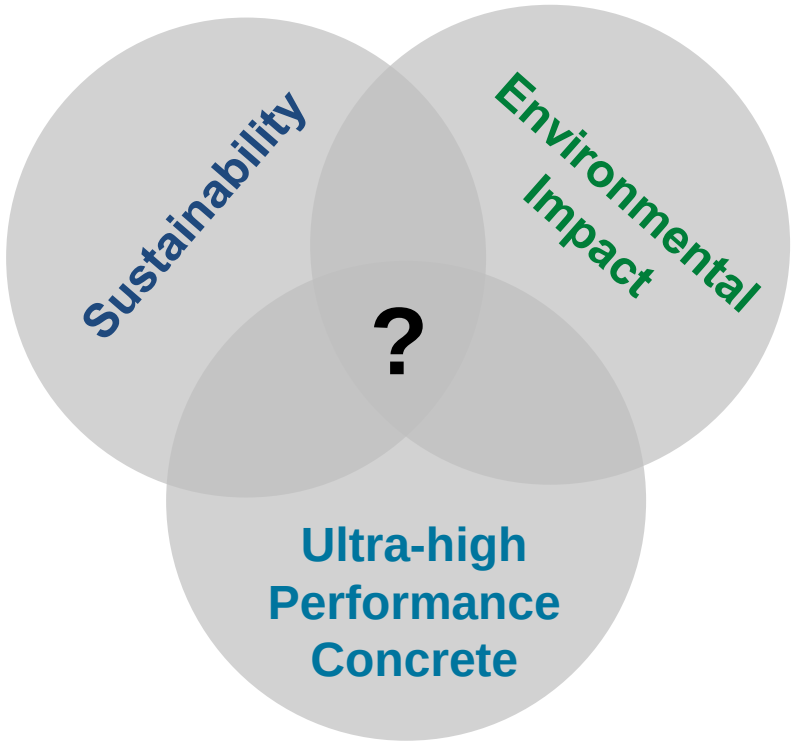


Hannah Tzabari
Engineer for National Cement Company
March 2022

Key topics in concrete today

- Sustainability
  - Design life and durability
  - Repurposing structures
- Environmental impact
  - Alternative cementitious materials
  - Recycled aggregates
  - Carbon capture
- Concrete technologies
  - Continuous fiber reinforcement
  - Ultra-high performance concrete



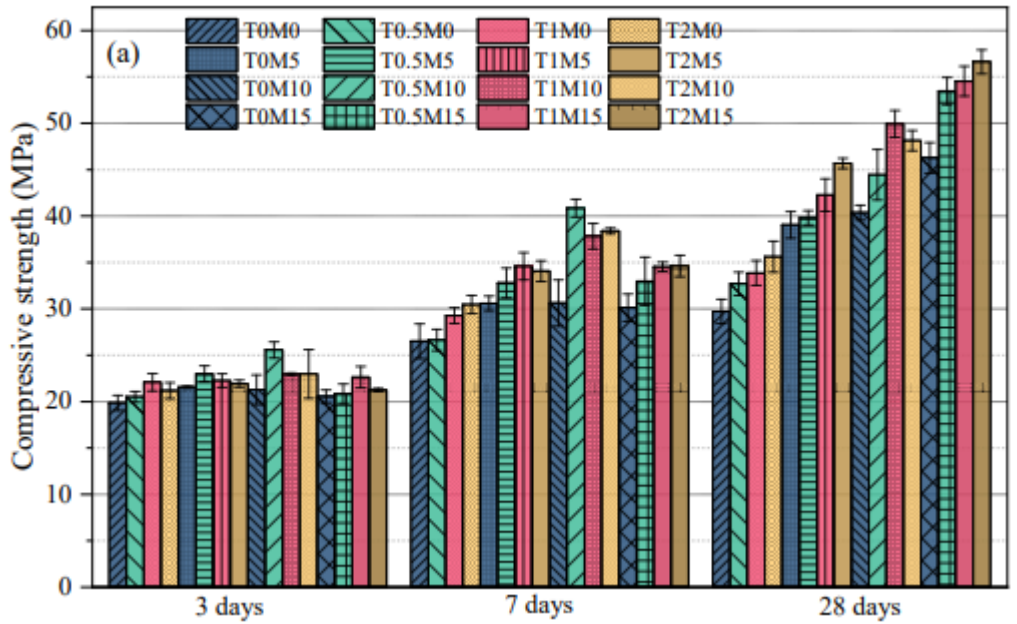
Bio-based Admixture: Black Tea Extraction

Rationale

- Metakaolin proven as a SCM
  - High pozzolanic reactivity
  - Can impair microstructure and workability
- To counteract these issues
  - Superplasticizers (harmful chemicals)
  - Pure, processed plant polyphenol molecules (high production cost and waste)
- Extract the molecules from tea leaves via boiling?

Conclusions

- Tea water used in mortar samples functioned as expected
  - Rich in polyphenols
  - Improved workability
  - Increased strength from more nucleation sites and smaller/fewer pores
- Cost-competitive and eco-friendly

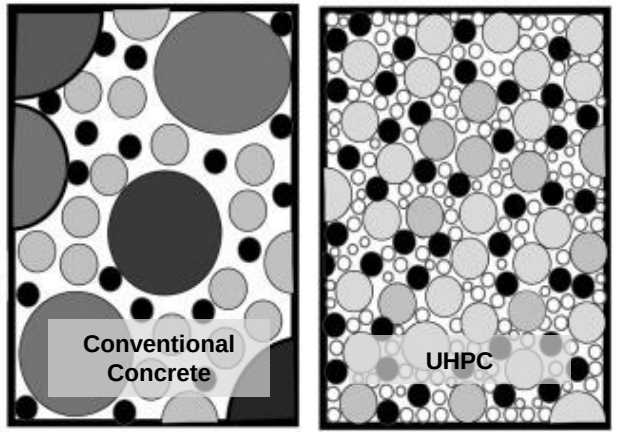


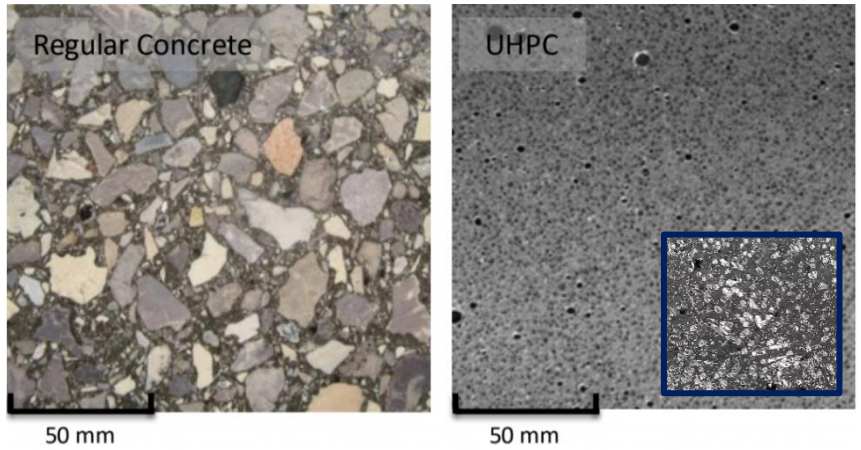
Dr. Jialai Wang and Yi Fang
The University of Alabama (2022)

UHPC – a “New” Technology

Composition

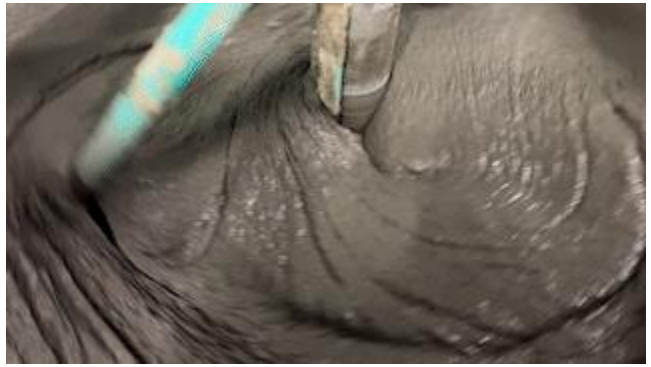
- Particle packing theory
  - SCMs and fine fillers
  - No coarse aggregates
- Additional improvements
  - Continuous microfiber reinforcement
  - Superplasticizers and accelerators





Properties

- Compressive strengths over 21 ksi
- Tensile strengths over 1 ksi
- Extremely low permeability (chlorides, free-thaw, ASR, AAR)



Advantages

- Smaller cross sections
- Extended service life and sustainability
- Complex shapes and textures

UHPC Panels under Tornado Impact Loads

<u>Rationale</u>

- Tornado fatalities happen nationwide yet are preventable
  - Most occur inside homes
  - Shelters exist but are inaccessible, intrusive, or expensive
- UHPC Literature
  - Exceptional impact resistance
  - Versatile casting options (shape and texture)
- Test UHPC panels against ICC / NSSA 500 tornado shelter design requirements

<u>Conclusions</u>

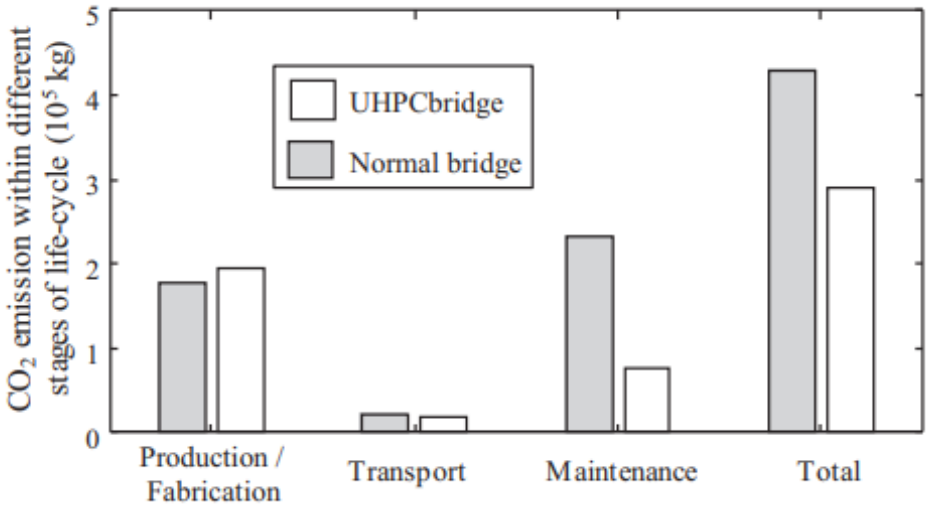
- 1.25-inch panel “passes” due to high ductility
  - Encourage flexural failure rather than punching shear
  - Verify dynamic models for UHPC
- Cost-competitive for full-sized structure

Work with National Cement and Smart-Up

- UHPC Project Support
  - Planning stages
  - On site
  - Outreach
- Environmental Reporting
  - Capture existing data
  - New collection methods
  - Identify opportunities

Can UHPC be a sustainable, environmentally-conscious solution?

You Dong
The Hong Kong Polytechnic University (2018)

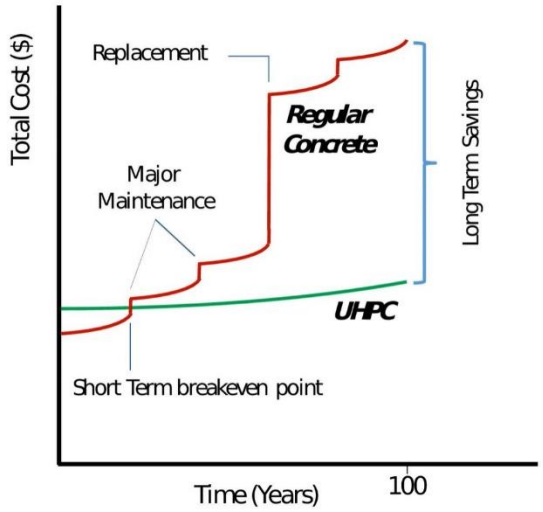


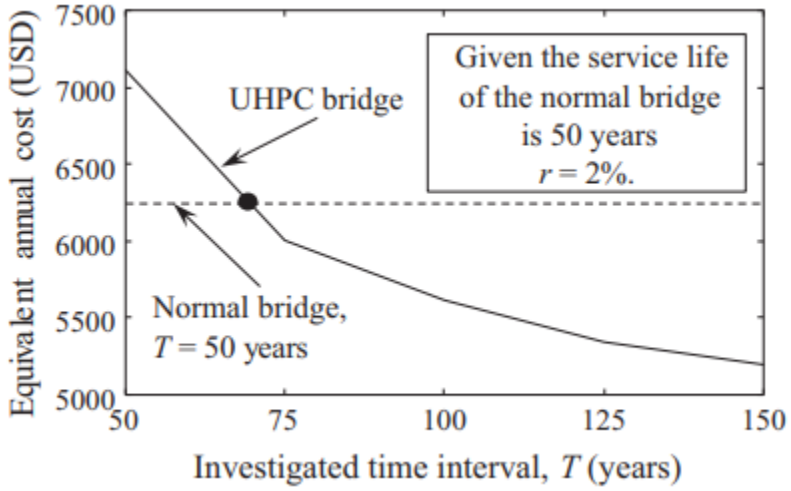
Fewer CO2 emissions and fewer materials consumed throughout service life.

Still relies on components with high production costs and emissions

- Cement
- Admixtures
- Refined SCMs

Long-term material and cost savings, little maintenance required, and overall higher quality throughout service life.

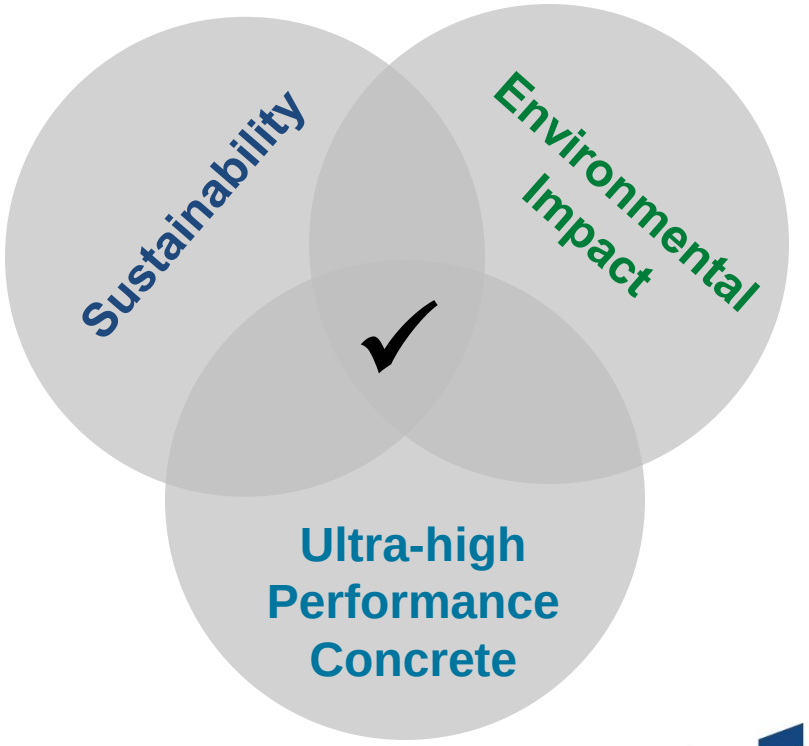




Takeaways

As a professional…

- UHPC has demonstrated promising performance as a sustainable, environmentally-friendly engineering material
- Potential to transform the scope of infrastructure rehabilitation and management
- Future improvements still necessary



As a student…

- It’s never too late to pivot!
- Integrate your interests
- Get comfortable with the unknown