CONCRETE SOLUTIONS FOR HIGH TEMPERATURES

Effects of elevated temperatures on concrete and cementitious materials

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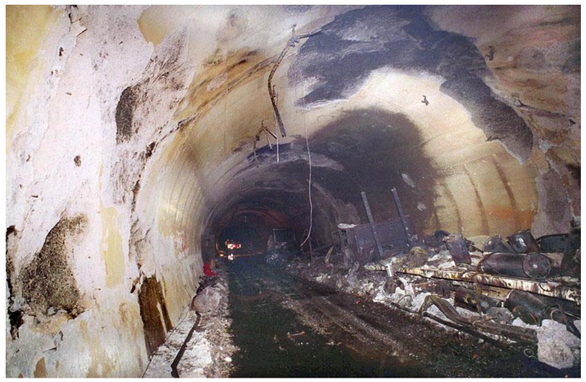
Motivation

Concrete at high temperatures suffers loss in strength, which has led to catastrophic failures.

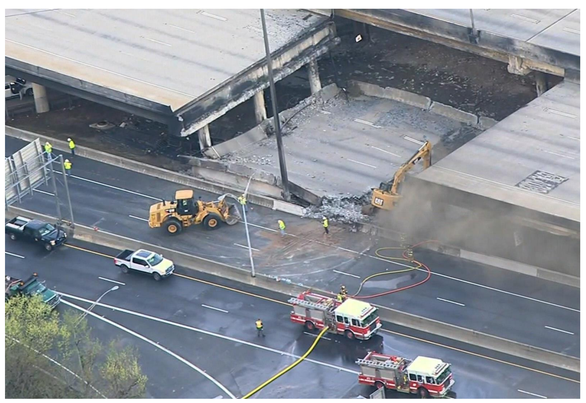
Objectives

- Improve understanding of effects of elevated temperatures on concrete materials
- Develop new construction materials to better withstand elevated temperatures

Research significance



Tunnels (Mont Blanc, 1999)

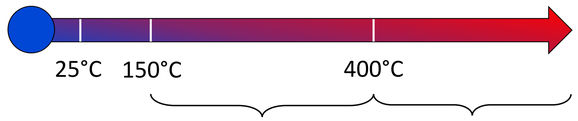


Bridges (I-85 near Atlanta, 2017)

https://www.tunneltalk.com/images/Mont-Blanc/The-aftermath-of-the-1999-fire.jpg
https://tribktla.files.wordpress.com/2017/03/s077272674-300.jpg?quality=85&strip=all&strip=all

Material development

Inspired by the thermal changes within concrete



Microcracking

Solution: use polymer fibers!
melting = steam escape pathways

PVA-ECC

… as a starting point

PVA-ECC is a ductile fiber-reinforced concrete containing polyvinyl alcohol (PVA) fibers at volume fraction of 2%

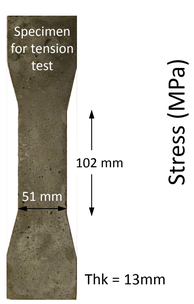
Main drawback:
Fiber melting = loss in strain-hardening (ductility)

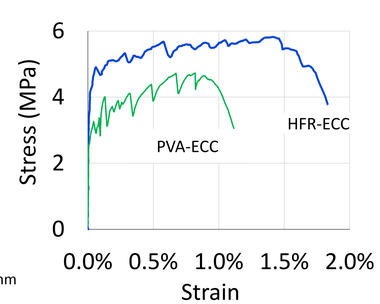
Solution: Use steel fibers

Multi-objective optimization of f_c' & tensile strain capacity

Hybrid fiber reinforced ECC
HFR-ECC

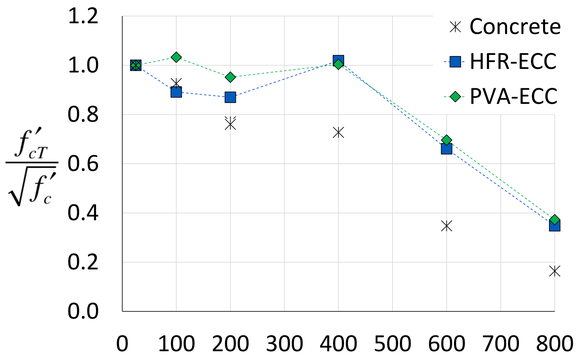
2% PVA fibers + 1% steel fibers
f_c' = 44 MPa
1.6% strain capacity in tension





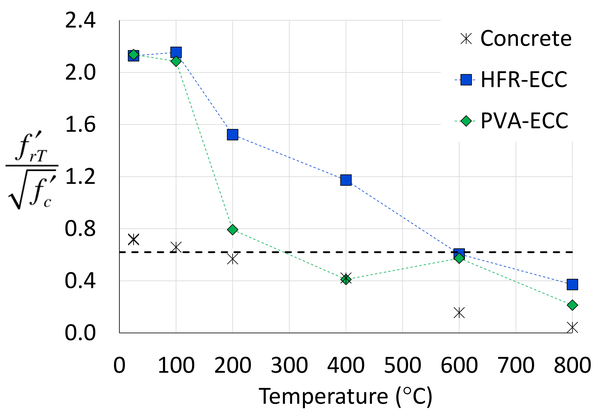
Results

Residual compression strength:



- 2% PVA fibers → strength retention up to 400°C
- Conventional concrete ~35% loss @ 400°C
- Loss beyond 400°C similar in all concretes

Residual flexural (tensile) strength:



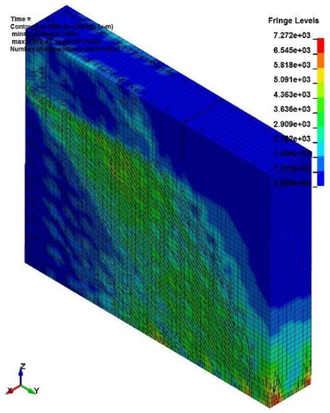
- Overall, superior performance of HFR-ECC compared to both concrete and PVA-ECC
- 2% PVA fibers only → similar to concrete after 200°C (melting of fibers)
- HFR-ECC retains ~70% strength @ 200°C
- HFR-ECC performs better up to 600°C than conventional concrete @ 25°C

Summary

Successful development HFR-ECC:

- Strain-hardening behavior @ 25°C
- Compression strength retention @ 400°C
- Superior tension strength @ 600°C

Future work



Effects of elevated temperatures on seismic behavior of RC walls and bridge piers

Rebar-concrete bond at elevated temperatures

References

Deshpande, A., Kumar, D., Mourougassamy, A. & Ranade, R. (2017). "Development of a Steel-PVA Hybrid Fiber SHCC." In Proc. of 4th RILEM Conference on SHCC, 18-20 September, 2017, Dresden, Germany, pp. 195-202.

Sahmaran, M., Ozbay, E., Yucel, H.E., Lachemi, M., & Li, V.C. (2011). "Effect of fly ash and PVA fiber on microstructural damage and residual properties of engineered cementitious composites exposed to high temperatures." Journal of Materials in Civil Engineering 23(12), 1735-1745.