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Rate dependence of ultra high toughness cementitious composite under direct tension

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Key words: Ultra high toughness cementitious composite, Rate dependence, Direct tension, Strain hardening, Multiple cracking

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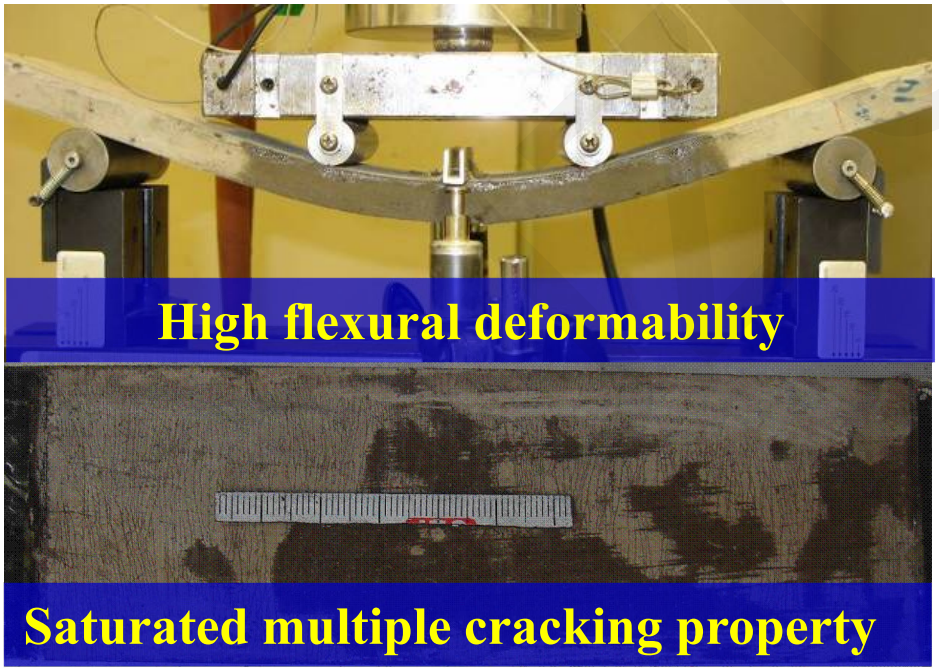
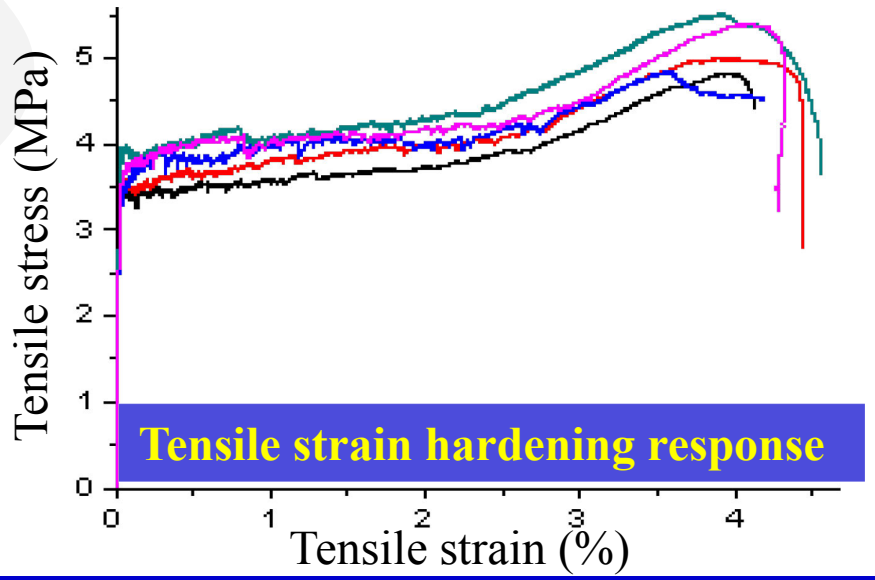
Background

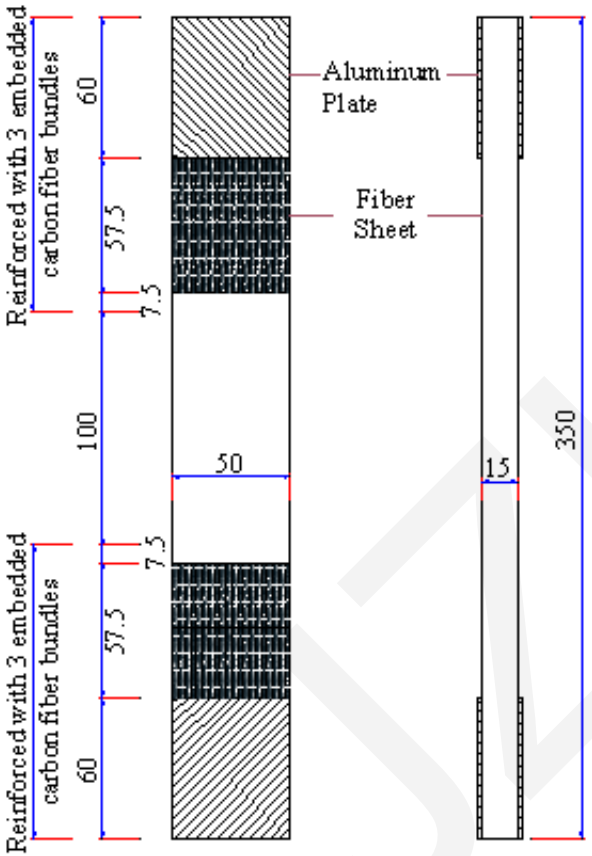
- Most cementitious composites are strain-rate dependent.
- However ultra high toughness cementitious composite (UHTCC) possesses excellent static mechanical properties, what determines its effects in seismic application is its properties under high strain rates.
- There are limited researches conducted on the rate dependence of this type of multiple cracking strain hardening composites, and parts of their conclusions are different and even conflicting to each other.



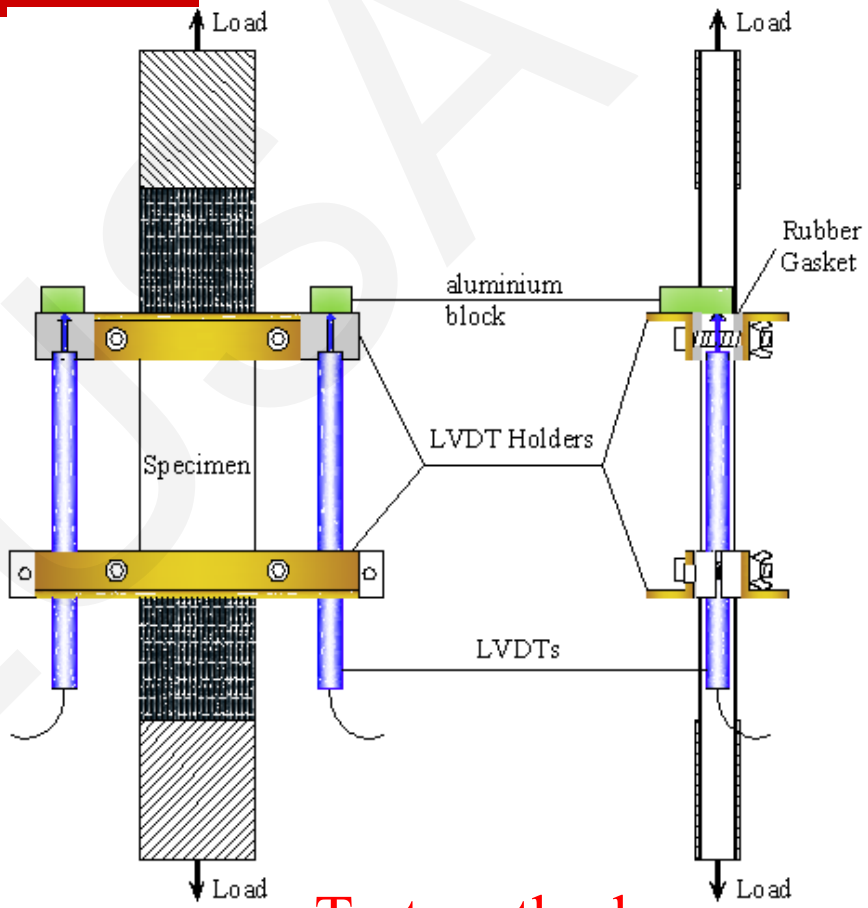


Quasi-static tensile and flexural properties of UHTCC.

Method



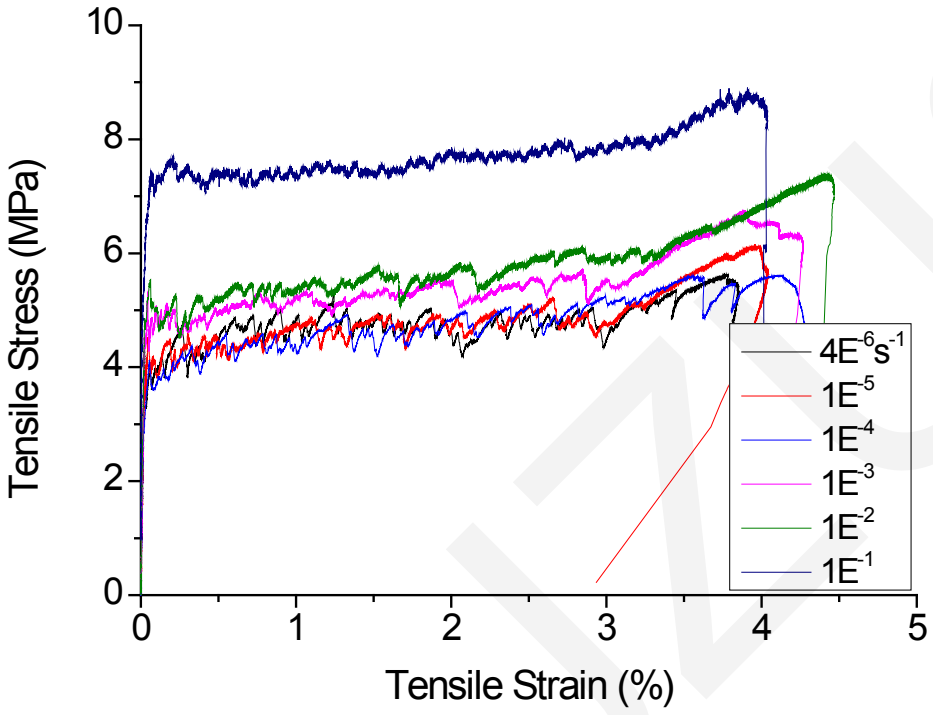
Specimen geometry

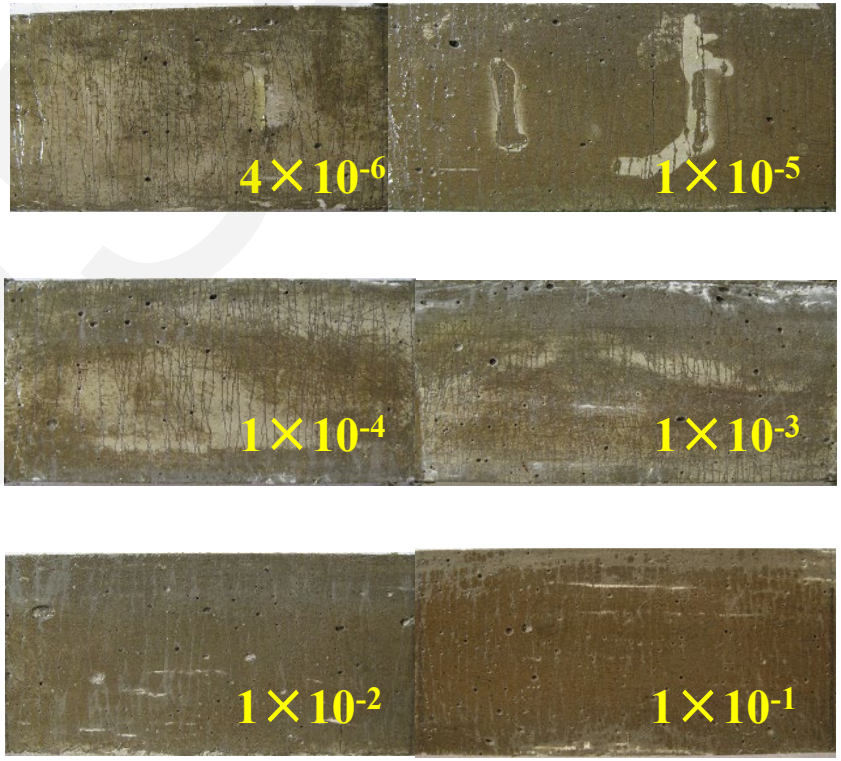


Test method

Loading rates: 4×10^{-6} s^{-1}, 1×10^{-5} s^{-1}, 1×10^{-4} s^{-1}, 1×10^{-3} s^{-1}, 1×10^{-2} s^{-1} ,1×10^{-1}, and 4×10^{-6} s^{-1} is considered as the quasi static rate.

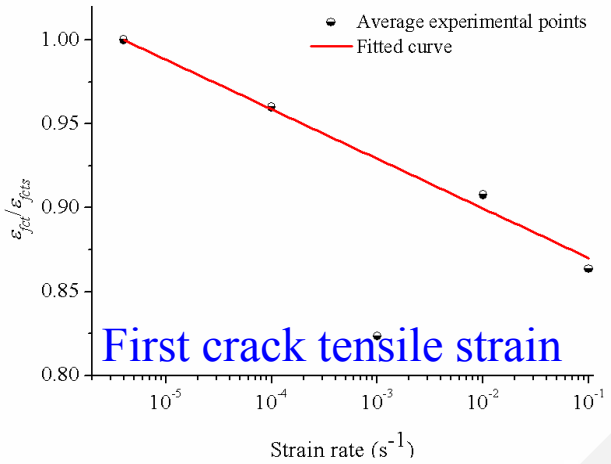
Results and conclusions

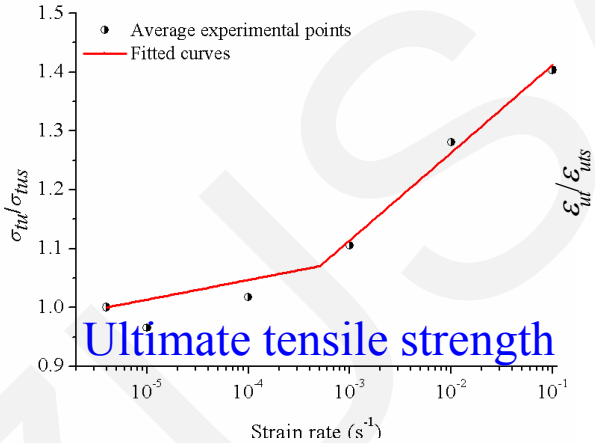


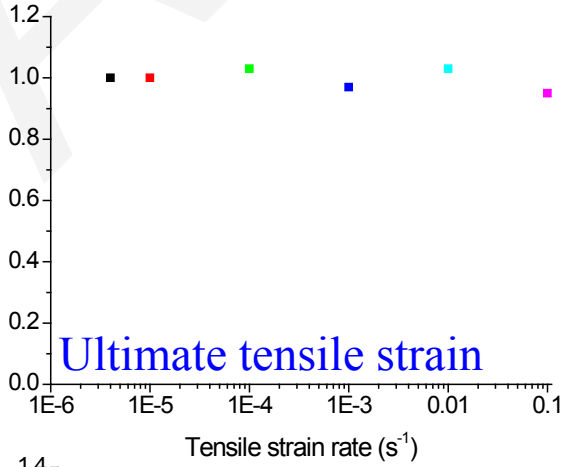


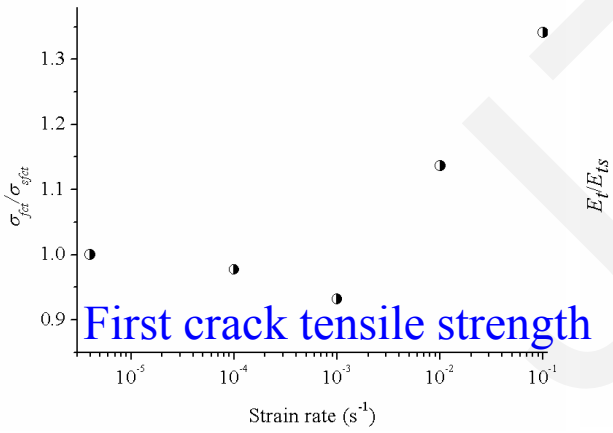
Uniaxial tensile stress-strain curves and multiple cracking properties under different strain rates

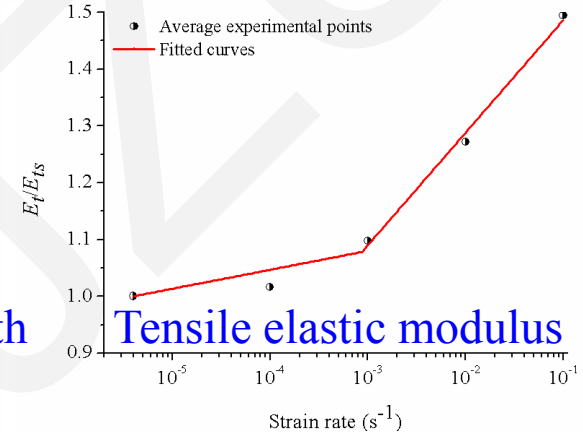
Results

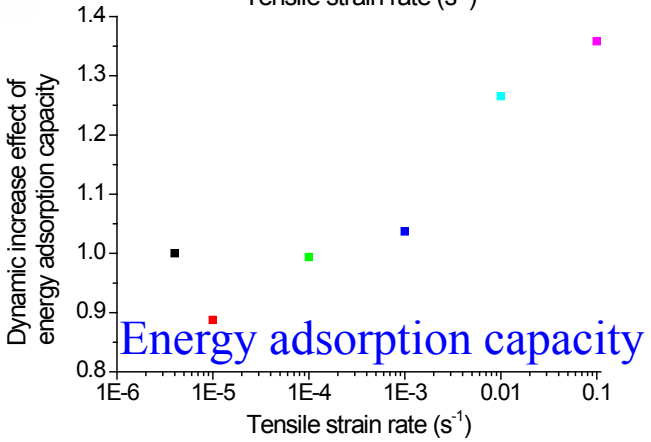












Dynamic effects of tensile properties of UHTCC

Conclusions

Based on uniaxial tensile tests on thin plate specimens of UHTCC with strain rates ranging from 4×10^{-6} s^{-1} to 1×10^{-1} s^{-1}, the following conclusions can be drawn:

- The first crack tensile strain, first crack tensile strength, elastic modulus, ultimate tensile strength and energy absorption capability of the UHTCC were all rate dependent. Except for the first crack tensile strain which showed a dynamic decrease effect, all others showed significant dynamic increase effects.
- The multiple cracking modes and ultimate tensile strain capacity of the UHTCC were both rate independent.
- The strain rate of 1×10^{-3} s^{-1} seems to be the threshold for dynamic increase effects of first crack tensile strength, elastic modulus, ultimate tensile strength and energy absorption capacity of UHTCC. Their dynamic increase effects were not pronounced until the strain rate was higher than 1×10^{-3} s^{-1}.
- UHTCC shows a great advantage over concrete in energy absorption capacity. Under seismic loads, the energy absorption capacity of UHTCC is about 1000 times that of C20 concrete.