

Impact of GNPs on the Buildability of Fiber Reinforced Concrete for Additive Manufacturing

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Buildability of Cement-Based Mixtures



- Rheological experiments: Oscillation-time \checkmark sweep tests were employed to analyze the evolution of storage modulus.
- early age which is an indication of material's stiffness.
- ✓ For additive manufacturing applications, high green strength and modulus are highly desired.







Concrete with insufficient buildability

*Y.Chen et al., Cement and Concrete Research 149 (2021) 106553



Polyethylene (PE) Fiber Reinforced Concrete for Additive Manufacturing **Advances and Challenges**

High Buildability

- ✓ High Storage Modulus
- ✓ High Green Strength and Modulus

High Buildability



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Nozzle --Fresh Cementitious Mixture





(c)

Layer failure

Polyethylene (PE) Fiber Reinforced Concrete for Additive Manufacturing Advances and Challenges

High Buildability

- ✓ High Storage Modulus
- ✓ High Green Strength and Modulus

High Buildability



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Low Buildability

Nozzle — Fresh Cementitious Mixture





Agglomerated PE fibers

Layer failure

Objective:

To Improve the dispersion of the PE fibers within the cementitious mixture and enhance the flowability, storage modulus and overall buildability

Optimize the mixing procedure



Shear Mixing time Optimum time

Shear Mixing Speed

Optimum speed

Materials and Mixing protocol



Effect of shear mixing time on the Storage modulus

w/c =0.30 @ 800rpm



Effect of shear mixing time on the Storage modulus

w/c =0.30 @ 800rpm



Effect of shear mixing speed on Storage Modulus

w/c=0.30 @ 60sec



- ✓ Shear mixing speed from 0 to 1800rpm
- ✓ Optimum shear mixing speed at 800rpm



Effect of shear mixing speed on Storage Modulus

w/c=0.30 @ 60sec





- ✓ Shear mixing speed from 0 to 1800rpm
- ✓ Optimum shear mixing speed at 800rpm

SEM images of PE fibers at different mixing times

w/c =0.30 @800rpm

CP reinforced with shear mixed PE fibers 60sec



CP reinforced with shear mixed PE fibers 120sec



Effect of Few-layer/Exfoliated GNPs on the Storage Modulus of PE-Cement paste

w/c=0.30 @ 800rpm, 60sec



Effect of Few-layer/Exfoliated GNPs on the Storage Modulus of PE-Cement paste

w/c=0.30 @ 800rpm, 60sec



Effect of PE +SP and Bulk GNPs on the Storage Modulus of PE-Cement paste

w/c=0.30 @ 800rpm, 60sec



Effect of PE +SP and Bulk GNPs on the Storage Modulus of PE-Cement paste

w/c=0.30 @ 800rpm, 60sec

197 nm

<u>0 nm</u>

100 nm

134nm

200.0 nm

37nm

(15-20 layers)

Green Strength and Modulus of Mortars reinforced with PE and PE+GNPs

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Thank you!

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