

## 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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