UV treated plastics used as an additive in cement to mitigate waste and improve mechanical performance

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Research question: Can UV treated microplastics be used to improve the mechanical performance of cement while reducing plastic waste?

Background Information and Motivation

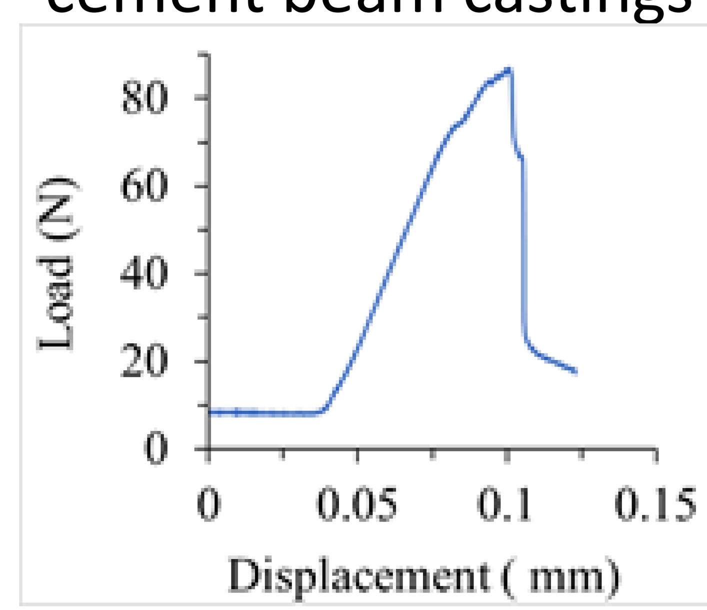
A large portion of the world's construction designs use steel reinforced concrete; a brittle material with low strength under forces in tension. However, production of both concrete and steel also contributes substantial carbon emissions to the environment, adding to the planet's pollution which includes plastic waste. If the mechanical properties of concrete could be improved, structures could require less steel used while mitigating plastic waste, it could prove to be economically viable in the construction industry. Treating plastic waste with UV light changes the surface properties, allowing it to bind with the cement mix, potentially bonding cracks and increasing the tensile strength of cement used in concrete production.

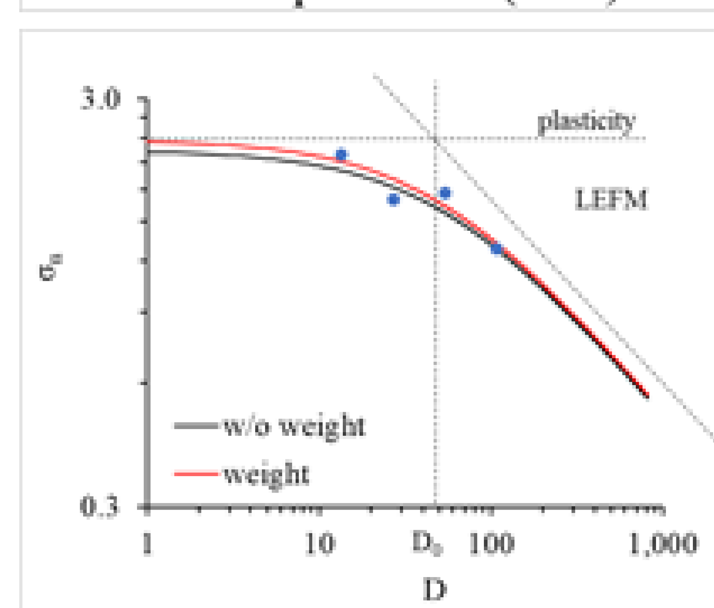
Procedure and Analysis

Originally, 32 individual plexiglass molds were constructed; 8 molds of 4 geometrically sized pieces with a span to depth ratio of 4 used to cast cement beams (see right). Issues arose with the larger molds, prompting the pieces used for all 8 larger molds to be consolidated into 2 large molds. The control group was a water/cement mixture, and the 2 test groups included water/cement combined with untreated plastic waste (PS) microparticles from and PS microparticles that had been treated in a UV chamber for 120 hours. The castings cured for 24 hours in a humid environment until removed from molds and cured further 28 days for the intial batch and 7 days for subsequent batches. Each beam had a notch cut into its edge prior to being subjected to 3-pt bend test.

3 point bend test set up

Plexiglass molds used for cement beam castings

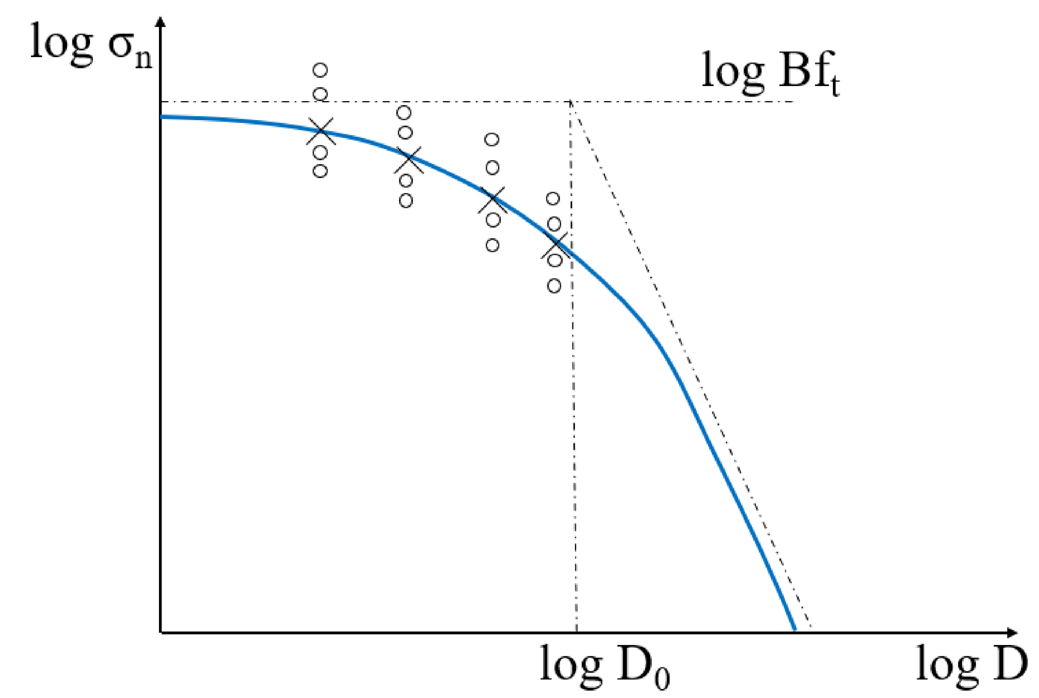




Preliminary results

Procedure and Analysis continued

Depth (mm)	Span (mm)	Length (mm)	Thickness (mm)	Ligament (mm)	Notch Length (mm)
13.50	54.00	74.52	13.50	9.45	4.05
27.00	108.00	149.04	13.50	18.90	8.10
54.00	216.00	298.08	13.50	37.80	16.20
108.00	410.00	569.16	13.50	75.60	32.40



Type 2 Size Effect Law (SEL)

Size Effect

Dependence of σ_{nu} on D when comparing geometrically similar structures:

$$\sigma_{nu} = \frac{B\, f_t'}{\sqrt{1+\frac{D}{D_0}}}$$

$B\, f_t'$ and transitional structure size D_0 obtained by optimum fitting of measured nominal stress (σ_{nu}) values.

$$\sigma_{nu} = \sqrt{\frac{E'\, G_f}{g(\alpha_0) + g'(\alpha_0) c_f}}$$

Gf (initial fracture energy) measures of resistance to crack propagation; E' is the Young's modulus; $g(\alpha_0)$ dimensionless energy release rate function; c_f the characteristic length.

SEL type 2, is the typical behavior of a structure containing a preexisting notch, where crack propagation occurs until maximum load is reached. Fracture energy evaluation will help determine if UV treated PS microparticles improves cement's ductility.

Conclusion

Results gathered are limited due to COVID-19 restrictions and testing is ongoing.

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