Longevity of 3D printed polymer composite materials for culvert diffuser application

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Abstract

Culverts are installed in highways to control water flows. Culverts deteriorate with age due to corrosion and cracking and need repairs. Current culvert retrofit technology includes the use of slip-liners, which reduces the cross-section and hence the capacity of the culvert. A culvert outlet diffuser increases the culvert capacity and compensates for losses due to liner retrofit, which in addition, reduces outlet flow velocity and minimizes erosion.

Large-scale polymer extrusion-based 3D printing allows for rapid prototyping and cost-effective manufacturing of customized culvert outlet diffusers.

Outlet diffusers can be 3D printed using different types of polymer matrix composite materials. The materials selected for this study include synthetic and bio-based materials. The synthetic materials are CF-ABS (Carbon fiber - Acrylonitrile Butadiene Styrene), and GF-PETG (Glass fiber - Polyethylene Terephthalate Glycol). The bio-based material is WF-aPLA (Wood fiber – amorphous Polylactic Acid). Previous research work showed that exposure to moisture and freeze thaw cycles can reduce the strength of 3D printed polymer composite materials. The objective of this research work is to understand the longevity of 3D printed polymer composite materials for culvert diffuser applications. The change in mechanical properties with time for different accelerated environmental exposures are evaluated experimentally.

Tests were conducted in accordance with ASTM standards to generate material properties. Mechanical property retention after accelerated exposure times was evaluated to characterize the longevity of the materials. The mechanical properties determined though tensile tests are ultimate tensile strength, ultimate strain, modulus of elasticity and Poisson's ratio.

Finally, witness panel installed at the site of the culvert at NH will be tested. Accelerated exposure in lab will be correlated with test results of witness panel and based on this correlation the longevity of different materials under study will be accessed.

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References

[1] Bhandari, S., Lopez-Anido, R.A., Anderson, J. and Mann, A. "Large-scale extrusion-based 3D printing for highway culvert rehabilitation," ANTEC 2021, Society of Plastic Engineers, Hybrid Edition, Mar. 22-23, 2021.