

## Efficient Strengthening of Concrete Cylinders Using Additively Manufactured Auxetic TPU Metamaterials

Bolaji Oladipo, Sumanta Das, Civil and Environmental Engineering, University of Rhode  
Island

### Abstract

As the need for the rehabilitation of dilapidating concrete columns in aging civil structures from the early 20<sup>th</sup>-century rapid development in infrastructure increases [1], researchers continue to devise strengthening methods for these structures to mitigate the effects of failure. PyAuxetic python scripts of four geometrical features in batches are loaded into Abaqus scripting to generate 8096 non-self-intersecting honeycomb reentrant geometries. Displacement loading was applied to the generated auxetic geometries and their Poisson's ratios were evaluated. The percentage deviation of a validating tensile test and Digital Image Correlation (DIC) result from the finite element analysis result was less than 3%. A neural network model was developed, and an optimum combination of reentrant unit cell parameters for an auxetic cylinder jacket was achieved. A Concrete cylinder and Thermoplastic Polyurethane (TPU) auxetic cylinder with the optimized reentrant unit cell parameters were modeled on SolidWorks software and imported into Abaqus CAE as shown in Fig. 1. A uniaxial compressive load is applied on the concrete cylinder jacketed with TPU auxetic cylinder. Results showed that the TPU auxetic cylinder delayed the catastrophic failure that is expected in a compressed and failing concrete cylinder without a reinforcing jacket. 3D DIC will be utilized to inspect the reduction in the dilation concrete jacketed with the auxetic cylinder.

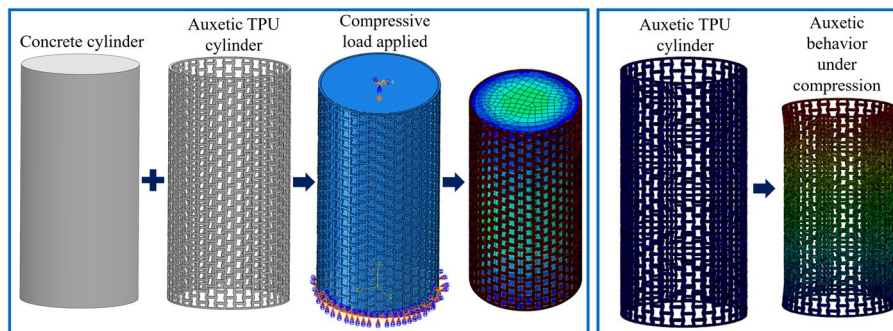


Figure 1: External jacketing of the concrete cylinder with an auxetic TPU cylinder.

**Acknowledgments:** Funding for this research is provided by the Transportation Infrastructure Durability Center under grant 500-2302-0000-0009495 from the U.S. Department of Transportation.

### References

- [1] W.L. Baloch, H. Siad, M. Lachemi, M. Sahmaran, A review on the durability of concrete-to-concrete bond in recent rehabilitated structures, *Journal of Building Engineering*. 44 (2021) 103315. <https://doi.org/10.1016/j.job.2021.103315>.