Recycled HDPE Plastic Paver Design

Tianyu Zhang[2], Sirri Neba Nforsoh[1], Korryn Naruaez[3], Rhea Panat[2], Jessica Smith[2], Jennifer Bissonnette[2], Vinka Oyanedel-Crauer[1]

[1] Department of Civil and Environmental Engineering, University of Rhode Island, Kingston, Rhode Island, United States
[2] Edna Lawrence Nature Lab, Rhode Island School of Design, Providence, Rhode Island, United States
[3] Department of Physics, Utah Valley University, Orem, Utah, United States

What is HDPE plastic?

- HDPE (High-Density Polyethylene)
- Widely used to make everyday items: milk jugs, detergent bottles.
- A significant portion of HDPE waste is not effectively recycled, preventing it from re-entering the circular economy.

Where does it come from?

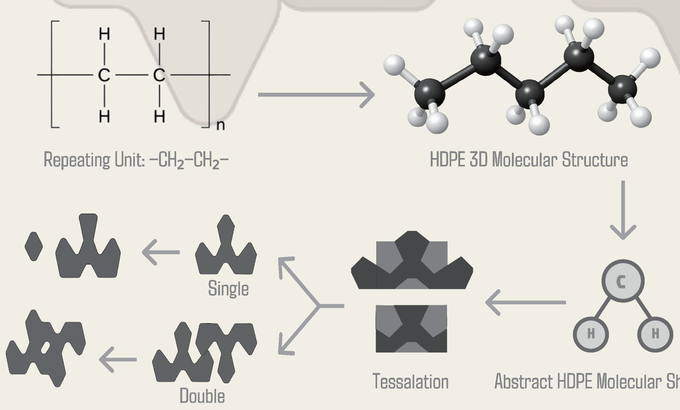
Our lab uses the HDPE plastic waste collected from the kitchen and ocean.



Why paver?

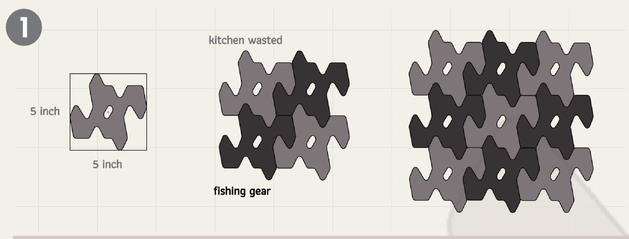
- Comparable compressive strength.
- Low water absorption and corrosion resistance.
- Opportunities for customized colors and surface finishes.
- Supports circular material use in landscape applications.

Design Inspiration

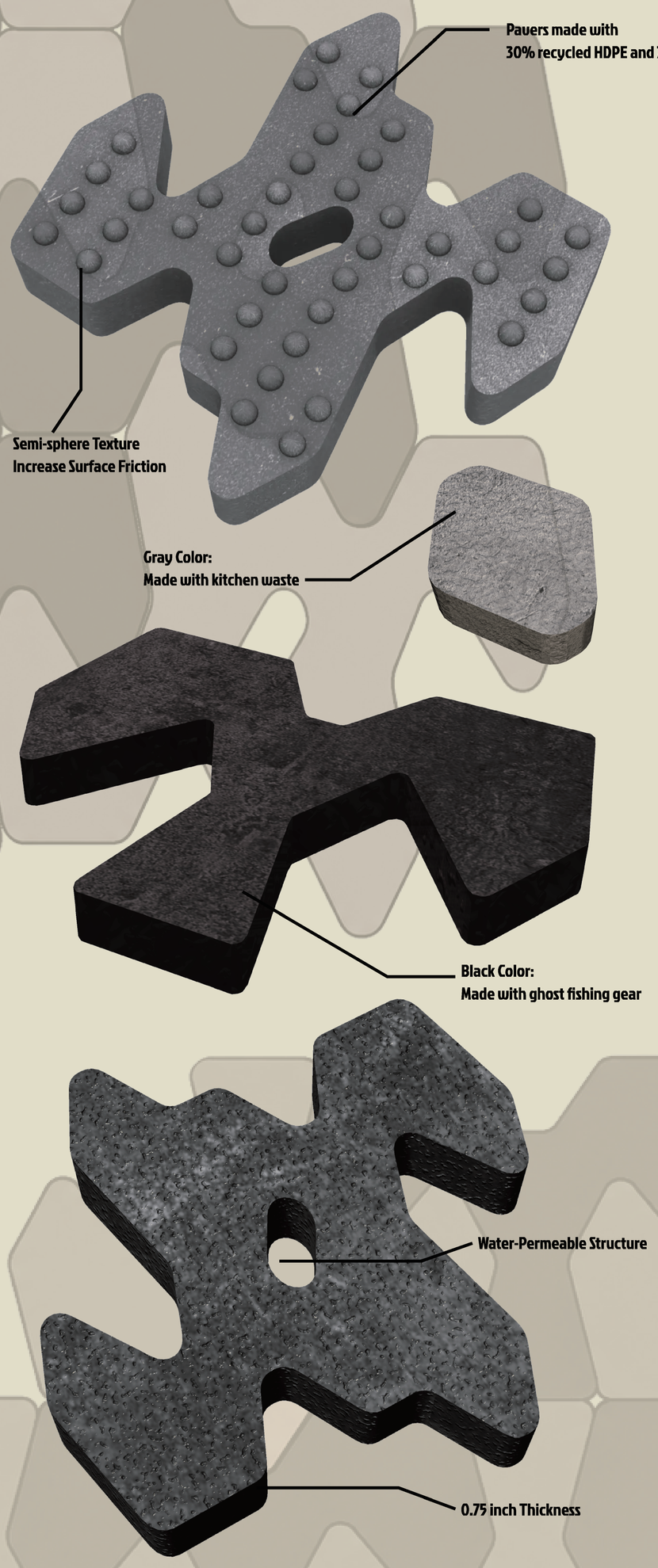


Inspired by the molecular structure of HDPE, the paver's form was developed by abstracting its two-dimensional molecular geometry and transforming it through cutting and recombination into a new geometric configuration.

Three Different Paver Designs



* Design Option 3 was not pursued because combining the permeable design with the dual-shape concept would make the overall geometry unnecessarily complex.



Surface Finishes



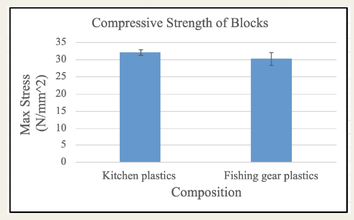
Glass fragment decoration

Different color HDPE as material

Material Tests

Compressive Strength Test

- Test Method ASTM C109 (SHIMADZU)
- Fishing gear HDPE: 32.15 ± 0.90 MPa
- Kitchen HDPE: 30.19 ± 1.86 MPa
- Both compositions exceeded 30 MPa, demonstrating the feasibility of recycled HDPE as a paving material.

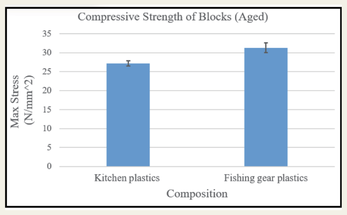


UV Weathering Test

UV weathering Method

- Kitchen waste plastic: Blocks were exposure UV for a duration of ~500 hours at 35°C to 40°C.
- Fishing gear waste plastics: Aged in accordance with ASTM 155 cycle 1, coupled with freeze thaw cycles for a duration of 1000 hours.

Before

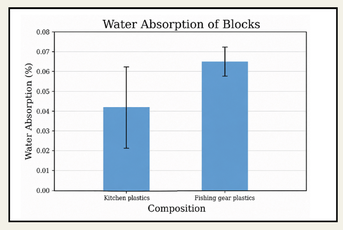


After

- Both recycled HDPE composites maintained high compressive strength after aging, indicating good long-term durability.
- Fishing gear HDPE exhibited higher retained compressive strength than kitchen HDPE.

Water Absorption Test

- Test Method ASTM D570
- Fishing gear HDPE: 0.065 ± 0.007 %
- Kitchen HDPE: 0.042 ± 0.021 %
- Both recycled HDPE composites exhibited negligible water absorption (<0.1%), demonstrating excellent moisture resistance and suitability for outdoor paving applications.



Applications: Garden & Home

* Visualization based on authors' 3D model, enhanced using generative AI.

Brick Fabrication Process

CNC Machine Application

Conclusions

- Sand–HDPE composite pauers are a promising pauing material due to their excellent wear resistance and water resistance.
- Recycled HDPE in different base colors provides strong aesthetic flexibility, allowing customizable color combinations.
- The pauer geometry promotes water permeability, making it suitable for garden applications.
- The perforated design enables easy removal and replacement of individual pauers.

Next Steps

- Increase the current 5 × 5 in pauer size to improve weight and interlocking stability.
- Evaluate post-abrasion surface friction and the environmental impact of wear particles.
- Assess the environmental impact of pigments used in different colored pauers.

Acknowledgements

This work is supported in part by the U.S. National Science Foundation under EPSCoR Cooperative Agreements #OIA-2433276 and in part by the RI Commerce Corporation via the Science and Technology Advisory Council (STAC). [Additional funding sources, if applicable.] Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the U.S. National Science Foundation, the RI Commerce Corporation, STAC, our partners or our collaborators.

We sincerely thank Dr. Sirri Neba Nforsoh and Dr. Vinka Oyanedel-Crauer (University of Rhode Island), Dr. Jennifer Bissonnette and Prof. Jessica Smith (RISD Nature Lab), and Dr. Louise Manfredi (Brown University) for their invaluable guidance, expertise, and collaboration. We also acknowledge the University of Rhode Island for providing the research facilities and technical resources that supported this project.