DEVELOPMENT OF SAND COMPOSITES FOR HIGH-IMPACT RESISTANCE

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CP302
CAPSTONE
PROJECT-1

ABSTRACT

Polymer Matrix Sand Composites (PMSCs) feature a graded structure with a brittle, abrasive impact layer combined with tensile and cushioning regions to effectively reduce energy and prevent backlash. Sand inclusions enhance hardness, adhesion, and load transfer. Mechanical testing confirms the potential of PMSCs as cost-effective, high-performance materials for advanced ballistic protection.

OBJECTIVE

- To enhance impact resistance of composite with graded sand reinforcement.
- To optimize key mechanical properties hardness, tensile strength, and energy dissipation—by varying sand types, fractions, and epoxy formulations.
- To create cost-effective, high impact resistant material for ballistic protection.

MATERIALS USED

- Epoxy – LY556; Hardener HY951
- Construction Sand
- GI Corrugated Sheet and Mesh

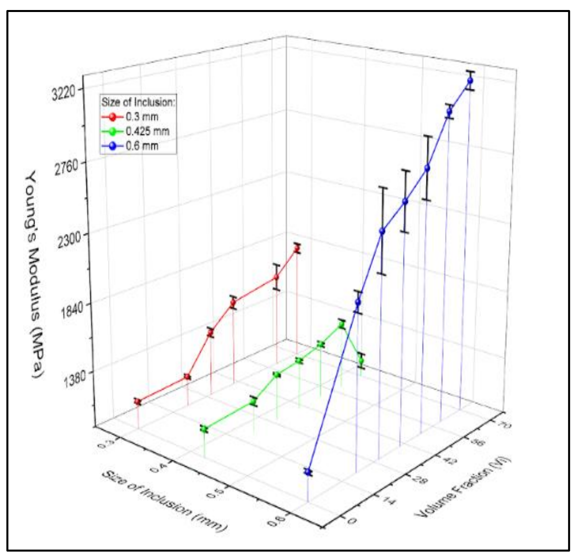
EQUIPMENTS USED

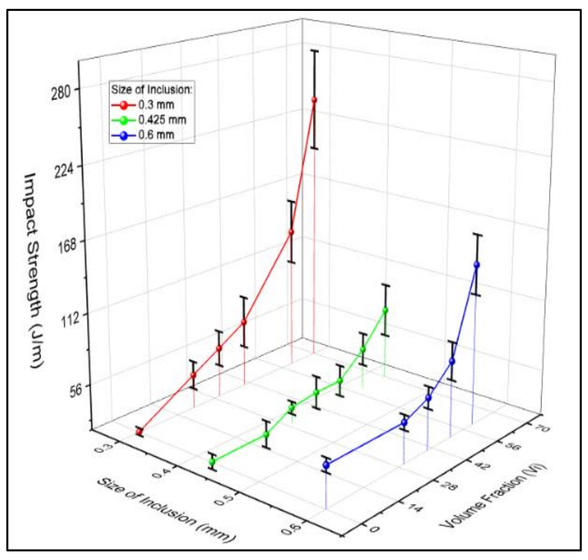
- Izod Impact Testing Machine
- Shore D Hardness Tester
- Polymer Tensile Testing Machine
- Olympus Base Microscope

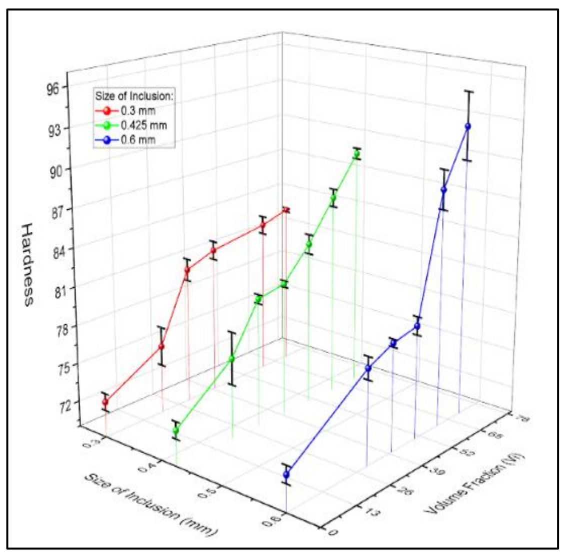
METHODOLOGY IMPROVEMENTS

- Materials Enhancement: Replaced ER099 epoxy and EH150 hardener with LY556 epoxy and HY951 hardener for improved performance.
- Mixing Process Refinement: Transitioned from hand stirring to overhead stirring at 800 rpm for 7-8 minutes, ensuring better uniformity.
- Curing Process: Reduced curing time from 24 hours at room temperature to 12 hours at 120°C in a hot-air oven for improved material properties.
- Polishing Improvement: Enhanced surface finishing by switching from sandpaper to a polishing machine for precision

RESULTS



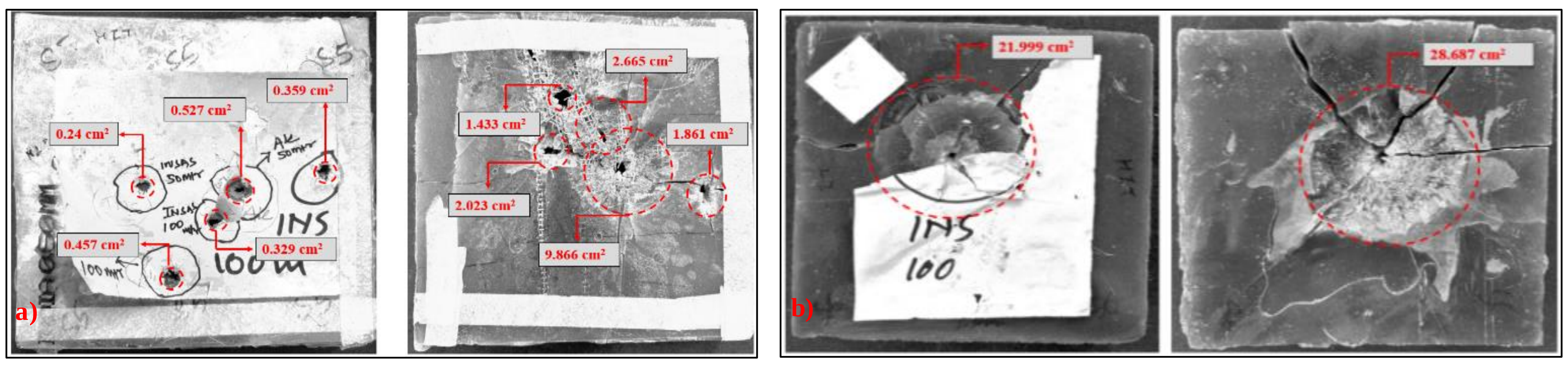




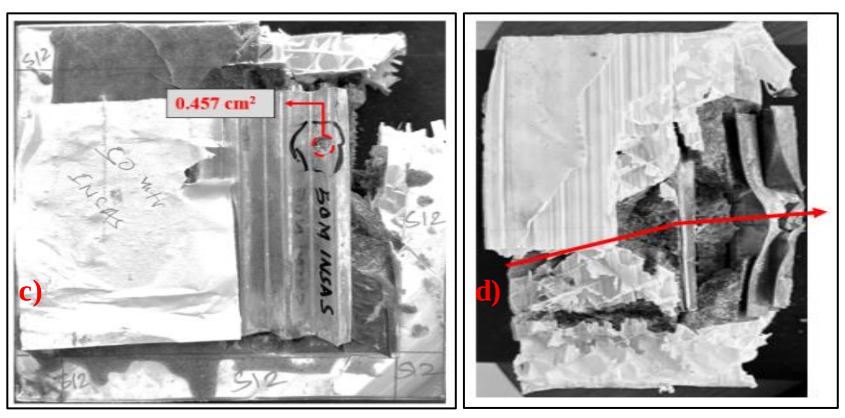
Observation:

- Modulus: Achieved 1810 MPa (121% increase) with 70% sand volume using 0.3 mm particles.
- Impact Strength: Reached 210 J/m at 70% sand volume with 0.3 mm sand size.
- Hardness: Shore-D hardness improved to 92.5, a 13.7% increase at 70% sand volume.

BALLISTIC SAMPLES



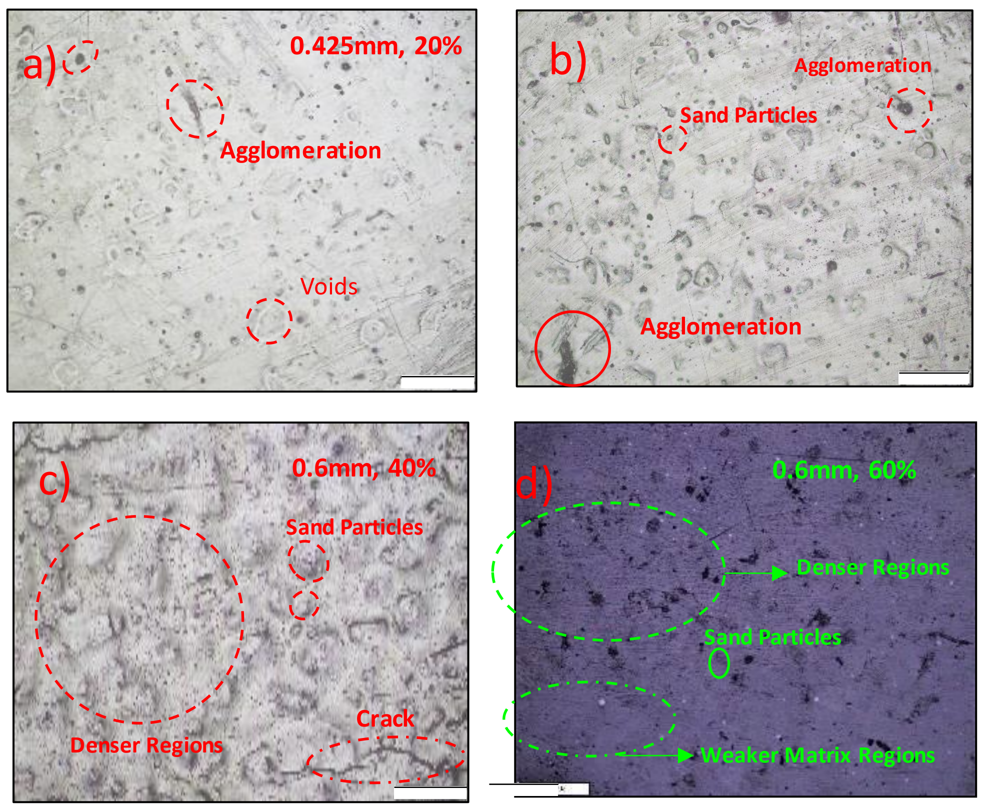
Front - LY25_06 | Back – LY25_06 | Front - ER40_06 | Back – ER40_06



LY80_04_1 | LY80_04_2

1. LY25_06: Larger bullet impact area due to LY556 epoxy's higher stiffness, indicating greater bullet deformation but visible cracks from higher energy absorption. (a)
2. Increased layer counts in samples caused delamination due to stress concentration at interfaces. (c)
3. LY80_04_1 sample showed bullet trajectory deviation from energy absorption across layers, but delamination weakened bonds despite good overall performance. (d)

MICROSTRUCTURAL ANALYSIS



Optical imaging using an Olympus microscope revealed that smaller sand sizes and lower volume fractions resulted in more uniform distribution with minimal agglomerations, while higher fractions caused clustering and uneven density. Under load, cracks formed primarily in weaker neat epoxy regions, while sand-reinforced areas showed greater structural integrity

CONCLUSION

1. Optimized sand inclusions reduced agglomeration, enhancing uniformity and structural performance.
2. Mechanical properties improved significantly, with modulus increasing by up to 125% and impact strength by 32% as the sand volume fraction increased.
3. LY-556 ballistic samples demonstrated greater impact absorption due to higher stiffness, resulting in larger impact areas compared to ER-099 samples.
4. Increased layering led to delamination from stress concentration at interfaces, as observed.

FUTURE WORK

The focus will be on incorporating rubber or new materials with sand and epoxy to improve strength and impact resistance. We will conduct simulation studies to understand material behavior under ballistic impact for varied compositions and inclusions along with sand. We will try to perform weathering tests to assess environmental resistance and long-term reliability.