Docket #: S25-133

Engineered Biopolymer Composite: A near structural-grade, carbon-negative cement alternative

Stanford University's Lepech Research Group has developed an Engineered Biopolymer Composite (EBC): a recyclable, carbon-negative alternative to lightweight concrete and non-structural masonry, made by binding soil aggregate with lignin (a hydrophobic biopolymer) and a plant-based additive. Building on prior research (Stanford docket 23-551), the plant-based additive enhances the biopolymer's binding capability, significantly increasing the strength of this three-phase composite. Compaction during desiccation further improves strength by reducing shrinkage cracks and flaw size, making EBC up to 400% stronger than comparable composites. Sourced from low-cost, carbon-rich waste feedstocks, EBC is cement-free and carbon-negative overall. Ongoing optimization of additives, compaction, and solvent chemistry offers a roadmap toward semi-structural and structural-grade performance as a carbon-negative alternative to Portland cement.

Stage of Development – Prototype
The Lepech Research Group have produced standard clay-fired size bricks that meet strength requirements for certain construction applications as defined by ASTM standards.

Applications

- Near structural-grade building materials and modular construction components:
  - Bricks
  - Precast/modular construction
  - Cast-in-place construction
  - Roofing tiles
  - Construction pavers

Advantages

- Carbon-negative plus CO? sequestration with end-of-life recyclability
- Structural strength (up to 35 MPa)
- Enhanced moisture resistance and reduced cracking
- Faster manufacturing and lower cost
- Low-cost waste stream feedstock - utilizes waste material rather than mined/processed raw materials
- Lower processing temperatures and lower energy use
- Scalable

Publications

- Miao, B.H., et al. Development of biopolymer composites using lignin: A sustainable technology for fostering a green transition in the construction sector. Cleaner Materials (2024).
- Miao, B.H., et al. Life cycle assessment and design of LignoBlock: A lignin bound block on the path towards a green transition of the construction industry. Journal of Cleaner Production (2024).
- Miao, B.H., et al. Recycling of lignin-based biocomposites: Improving sustainability and enhancing material strength. Resources, Conservation and Recycling (2025).
- Miao, B.H., et al. Solvent selection enables sustainable and affordable lignin biocomposite for cement-free construction. Cleaner Materials (2026).
- Miao, B.H., et al. AI-powered non-destructive testing for smart manufacturing of carbon-negative biopolymer-bound soil composite. Communications Engineering (2026).

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