

Project Title: Bio-Inspired Functionally Graded Cementitious Composite Panels (BI-FGCCP) for Enhanced Impact Resistance

Duration: April 2023- March 2026

Objectives:

- Development of Bio-Inspired FGCC panels and corresponding material model
- Performance evaluation of the BI-FGCC panels under impact loading
- Formulation of guidelines to design Bio-Inspired advanced protective structures against impact loading

Deliverables: Know-How Development for the Analysis, design and development of impact resistant Bio-Inspired Functionally Graded Cementitious Composite Panels (BI-FGCCP)

Significant Achievements: Significant achievement may be considered as follows:

In recent years, bio-inspired concepts have gained prominence across diverse engineering domains. Yet, their translation into structural engineering for advanced protective systems has remained a challenge. This project successfully addressed that gap by developing Bio-Inspired Functionally Graded Cementitious Composite (BI-FGCC) panels with enhanced impact resistance, surpassing conventional single-phase and layered composites. Through a combination of computational modelling and experimental validation, the project demonstrated the clear advantages of functional gradation in cementitious composites. Steel slag aggregates were adopted as a sustainable alternative to conventional aggregates, optimized via packing density studies. Representative Volume Element (RVE) models and advanced constitutive simulations validated the performance of graded fiber distributions, showing up to 49% reduction in penetration depth compared to uniform fiber targets. Laboratory-scale demonstrations using high-velocity gas gun impact tests confirmed the superior energy absorption and structural integrity of BI-FGCC panels. Complementary finite element and mesh-free simulation frameworks further strengthened predictive capabilities for large deformation, high strain-rate loading, and fracture propagation.

Project Team:

Shri V. Rameshkumar (PI)
Dr. Amar Prakash (Co-PI)
Shri. Kanishka Bhattacharya
Dr. Mahesh M. J.
Dr. Nartu Manoj Kumar
Dr. J. Venkatesan
Dr. K. Senthil Kumar
Dr. Smitha Gopinath
Dr. N. Anandavalli
Dr. J. Rajasankar

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Damaged panels under ballistic impact