

Resource recovery of granite-processing sludge for extrusion-based 3D printing of ceramic products

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INTRODUCTION

- Granite processing generates large quantities of mineral sludge, an underutilised secondary raw material commonly disposed of as waste.
- Valorising granite sludge reduces environmental impacts while replacing virgin ceramic raw materials.
- This study investigates its incorporation into ceramic formulations for extrusion-based additive manufacturing (Slurry Deposition Modeling).

RESULTS

RHEOLOGICAL ASSESSMENT AND PRINTABILITY

Water content strongly influenced paste rheology and printability. At 25 wt% water, Gallenkamp values increased to 29 - 32°, entering the operational print window and enabling stable extrusion. Therefore, 25 wt% water was selected for all subsequent printing trials.

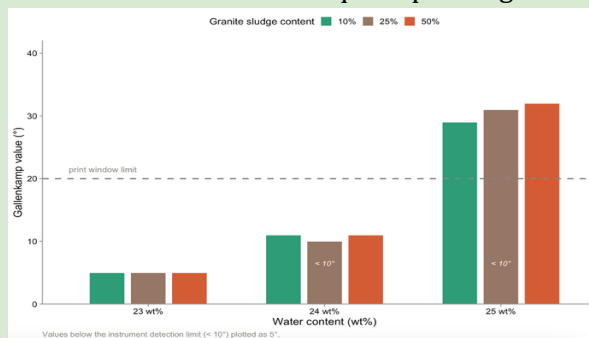


Figure 2. Effect of water content on paste rheology.

WATER ABSORPTION

Water absorption after sintering decreased by approximately 44%, from 5.3% to 3.0%, as granite sludge content increased. The parts increase in bending strength and reduction in water absorption indicate progressive densification through liquid-phase sintering. The 50 wt% formulation combined the highest strength with the lowest water absorption.

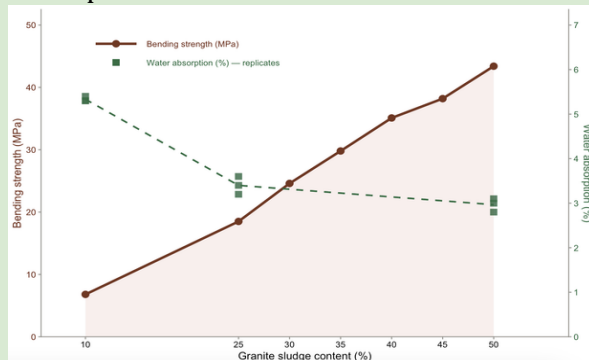


Figure 3. Bending strength against water absorption.

CONCLUSIONS AND NEXT STEPS

- Granite sludge was successfully incorporated into printable mineral formulations.
- Selected formulations achieved the ≥ 20 MPa mechanical performance target.
- Local clays demonstrated potential to replace conventional raw materials.
- SDM reduced machining waste from $\sim 45\%$ to $\sim 6\%$.
- Further optimization will focus on low-temperature and firing-free formulations.

METHODOLOGY

Raw material characterization: Granite sludge and selected clays were characterized.

Formulation development: Granite/clay ratios, additives and water content were optimized.

Printability assessment: Pumpability, rheology and SDM extrusion behaviour were evaluated.

3D printing trials: Selected formulations were printed and assessed for buildability and stability.

Performance testing: Mechanical strength, shrinkage and water absorption were evaluated.

Optimization: Best-performing formulations were selected for further development.

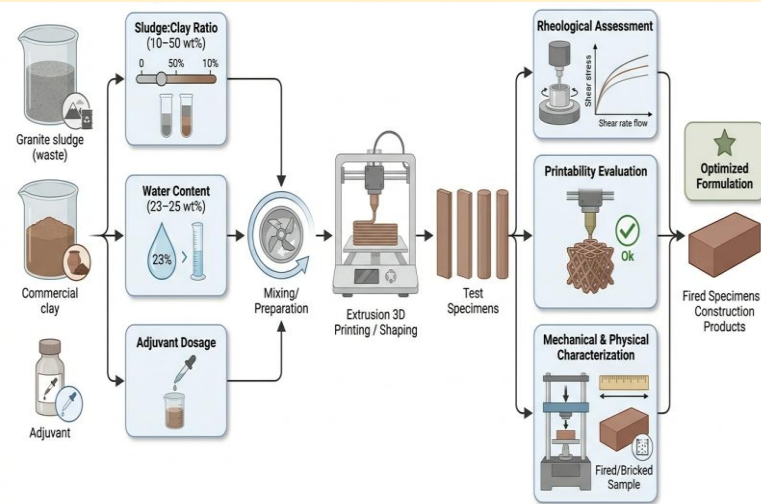


Figure 1. Process diagram

MECHANICAL PERFORMANCE

Bending strength increased from 6.8 to 43.4 MPa with increasing granite sludge content. The 20 MPa construction target was exceeded from 30 wt% sludge onward. 50 wt% granite sludge provided the highest strength and was selected as the optimum formulation.

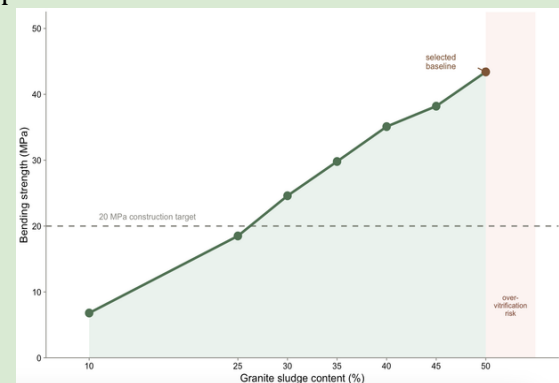


Figure 4. Effect of Granite Sludge Content on Bending Strength

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