NP4007

From waste to building materials – an innovative sustainable solution for waste glass

Research Question

A batch of broken glasses (i.e. tempered glass, borosilicate glass, float glass etc.) have different melting point and properties which tend to cause recycling problem if they are mixed together. What are the recycling option to tackle this issue?

How to create an innovative sustainable low carbon product from waste glasses with minimal energy consumption?

What are the steps needed to create the product, namely polymeric glass composite (PGC)?

Is the product produced in this study comparable to the standard dimension stone product available in the market?

Objective

The objective of this study is to create a polymeric glass composite (PGC) panel that can serve as kitchen countertop, bathroom vanities, tiles for wall and floor.

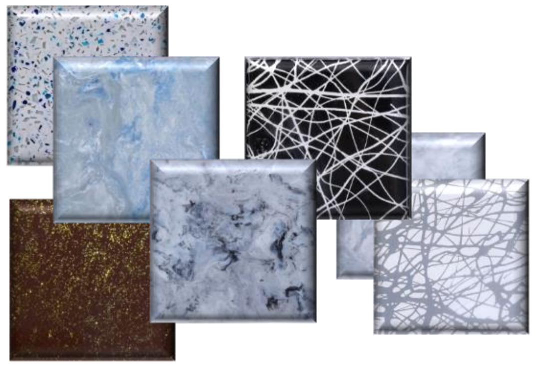


Figure 1. Polymeric glass composite (PGC) produced

Methodology

The production process of the PGC are shown in the schematic diagram below:

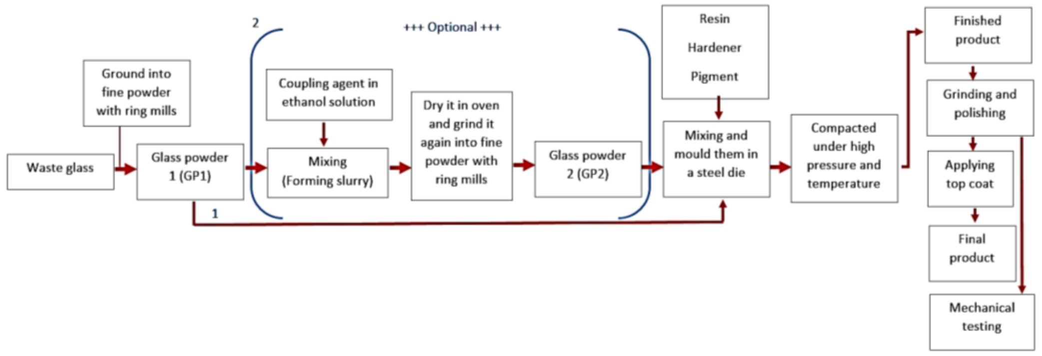
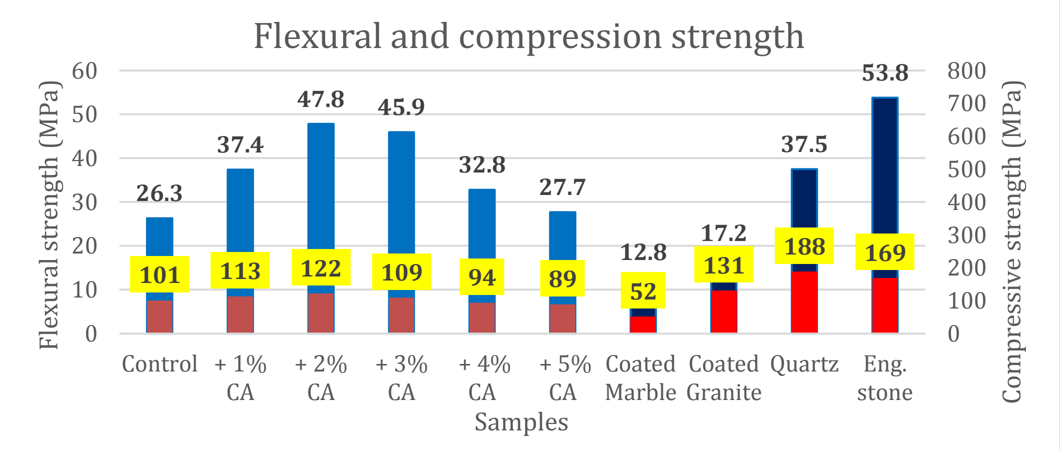


Figure 2. Schematic of the experimental procedure of PGC

Results

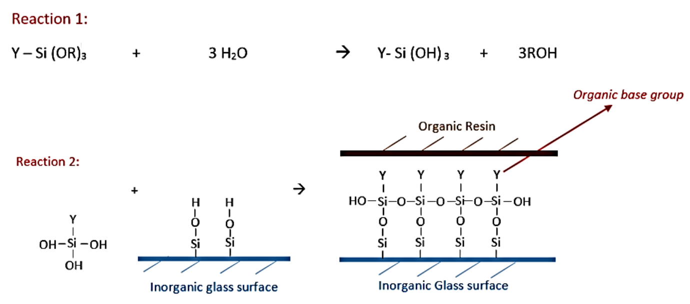
After the panels are produced, it is imperative that they meet the required mechanical properties for standard countertop. The mechanical properties of the PGCs produced and commercial standard dimension stones are compared and presented below. The "control" sample consist of glass powder and resin mixture with ratio of 80:20 respectively. The effect of coupling agent (CA) from 1-5% on the flexural strength will be the main focus in this segment of report.

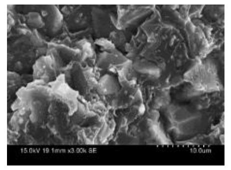


For all tested samples, water absorption <0.003%, density 2.0 – 2.8 g/cm^3, hardness >4.5, Stiffness (MOE) > 11 GPa (brittle).

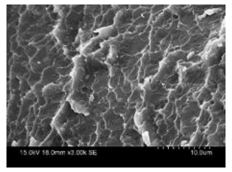
Flexural strength is defined as its ability to resist deformation under load. This property along with density and stiffness (MOE) are especially important when assessing the performance of dimension stone for countertop application or when beam system is applied. High flexural strength, reasonable density and high stiffness allow the countertop slab to be produced thinly with longer span. In contrast, for marble and granite, the slab tend to be produced thicker with shorter span due to its low flexural strength and relatively high density.

From the graph, the flexural strength of "control" samples are relatively low with value of 26.3 MPa due to poor wettability of inorganic (polar) glass powder with organic resin. To achieve better bonding adhesion capability, diluted silane coupling agent (Y-Si(OH)$_3$) are usually introduced with the organic base group (Y) being copolymerized with resin binder and the hydroxyl group binding with glass surface. The optimum ratio was found to be 2% with improvement to 47.8 MPa, nearly double compared to the control mix.





"No CA"



"+ CA"

Improvement in fracture surface can also be seen from the SEM analysis above which is done post mechanical testing of the samples. It was observed that a rough surface with several pores and air gaps occurred at the fracture surface when no coupling agent was added. The rough surface which is due to particle pull-out implies that the bonding between the powder filler and resin is relatively weak (delamination). In contrast, the fracture surfaces of the PGCs samples with the coupling agent shows massive shear deformation. The strong bonding among all components prevents delamination and encourages shear yielding before failure. More energy is absorbed by such shear deformation which leads to improvements in the flexural strength values.

Conclusion

This study has successfully manufactured high quality artificial construction slabs from waste glass powder filler. Addition of silane coupling agent was observed to give major improvement in the mechanical properties. Water absorption, stiffness, hardness are also comparable to the existing product in the market.

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