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Innovations for Sustainable Development and Resilient Infrastructure

Fabrication and Characterisation of Polyester-Fiberglass Manhole

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Figure 1: Cast Iron Manhole Cover

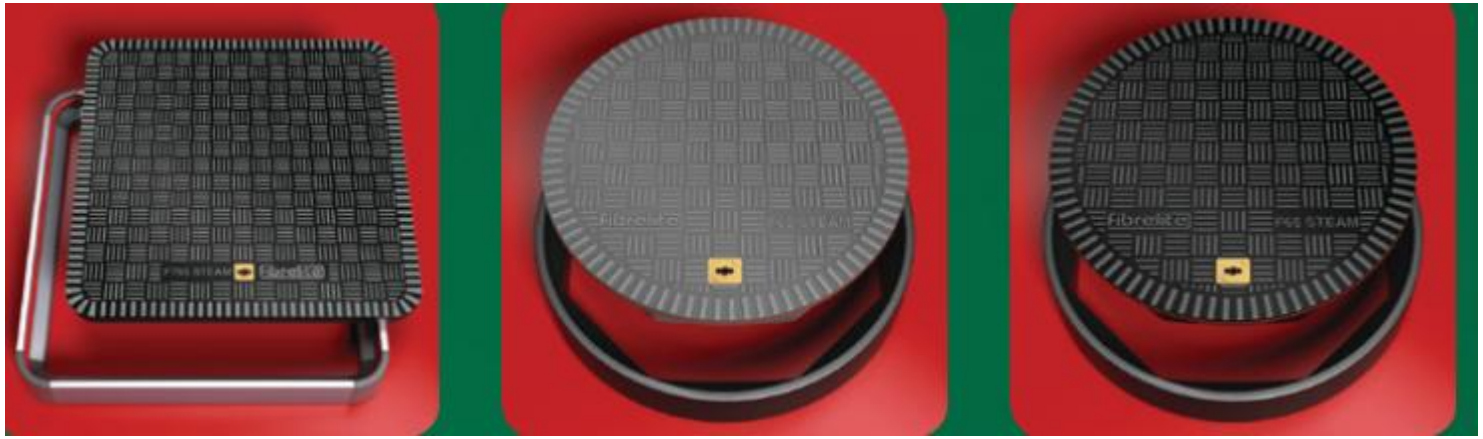


Figure 2: Composite Manhole covers

https://www.opwglobal.com/docs/libraries/opw-emea-retail-fueling/sales-literature/fibrelite/composite-steam-covers.pdf?sfvrsn=4df07ec7_4

Background of the Study

- Manhole covers come in different shapes and sizes and are made from different materials such as cast iron, concrete, steel, and composite materials
- **Cast iron** has been the dominant material for manufacturing manhole covers
- Its advantages include high load-bearing capacity, durability, recyclability, and Anti-Slip and Surface Patterns.
- Its disadvantages include high weight, lower corrosion resistance, and recyclability, leading to a high rate of theft

Table 1: Comparison of cast Iron and composite covers

Weight	corrosion	Production cost	Durability	Resistance to heavy load	Maintenance cost
79 to 136 kgs	vulnerable to H2S gases	high	over 30 years	from 1.5 tonnes to 90 tonnes	low
1/3 cast iron	impervious	Low to medium	about 10 years	limited	low

Statement of the Problem

- Although cast iron-based manhole covers are very good, the increasing rate of their theft by scavengers makes it necessary to research alternatives.
- On average, they weigh more than three times their counterparts made from composites
- Fibreglass-reinforced composites are increasingly being used for structural applications, including in manholes

Aim and Specific Objectives of the Study

Aim: to investigate the viability of using manhole covers from Fibreglass-reinforced composites to replace castiron-based manhole covers

The specific objectives include:

1. To procure the glass fibre and polymer raw materials to be used in the fabrication of the fibreglass-based manhole cover
2. To produce the fibreglass-based manhole covers with varying designs of the manhole cover.
3. To characterise the mechanical, physical and microstructural properties of the produced fibreglass manhole covers.
4. To compare the properties of the fibreglass-based manhole covers with those of Cast iron as reported in the literature

Literature Review

S/N3	Name of Authors	Title	Remarks
1	Khan and Ali, 2024	Sustainable Production of Manholes Covers with Fiber Concrete	Investigated the effect of locally available pine needle in concrete to improve its mechanical properties. Compressive strength was decreased while split tensile and flexural strengths increased with an increase in content of pine needle straw
2	Ayrilmis et al., 2024	Utilizing waste manhole covers and fibreboard as reinforcing fillers for thermoplastic composites	Used recycled manhole cover flour (CMC) and medium density fibreboard (MDF) sawdust as low-cost fillers for recycled polypropylene (PP) composites. increasing the filler content improved the bending strength and modulus, reaching 46.4 MPa and 3399 MPa, respectively, at 40 wt% loading. the tensile strength decreased slightly with the addition of 10 wt% filler and showed a slight decrease with the increase in filler content from 20 to 40 wt%.
3	Ishitsuka et al., 2023	Performance of manhole under severe conditions in Japan	A cover made of spheroidal graphite cast iron (cast iron cover) and a manhole bottom made of resin concrete have been developed to extend the life and performance of manholes

S/N3	Name of Authors	Title	Remarks
4.	Mónica et al., 2015	Exploring the Use of HPFRC AND GFRP Grids for the Production of Manhole Covers.	Experimental and FEM-based simulation studies showed that the Application of a fibre-reinforced polymer (FRP) system is an additional solution for increasing the load-carrying capacity of these elements without corrosion concerns.
5.	El Haggar and El Hatow, 2008	Reinforcement of thermoplastic rejects in the production of manhole covers	It was shown that with 10% foundry sand, 90% thermoplastic rejects, and a steel mesh reinforcement with a diameter of 12 mm, the manhole cover could withstand an average load of 112 kN. This value exceeds Grades A, AA, AAA, and B of the acclaimed standard BS EN 124 for manhole covers,
6.	Lin et al., 2012	Numerical Modelling of Composite Materials for the Alleviation of Manhole Decrement into Pavement	A 3-D finite element model is developed to analyse the mechanical behaviour of paving material surrounding the manhole under heavy traffic loads The results show that the fatigue damage of paving materials on a buried manhole is consistent with conventional theory. A combination of two-layer overlay material for manhole covers consisting of a modified asphalt concrete course as base and a dense-graded asphalt concrete as the surface course is recommended.

Materials and Methods

Raw Materials

- Unsaturated polyester resin
- Woven roving (fibre mat)
- Catalyst (methyl ethyl ketone peroxide - MEKP)
- Hardener
- Release agent

Equipment

- Mould
- Mixing containers and stirring rods
- Rollers/brushes
- Sandpaper or sander

Materials and Methods

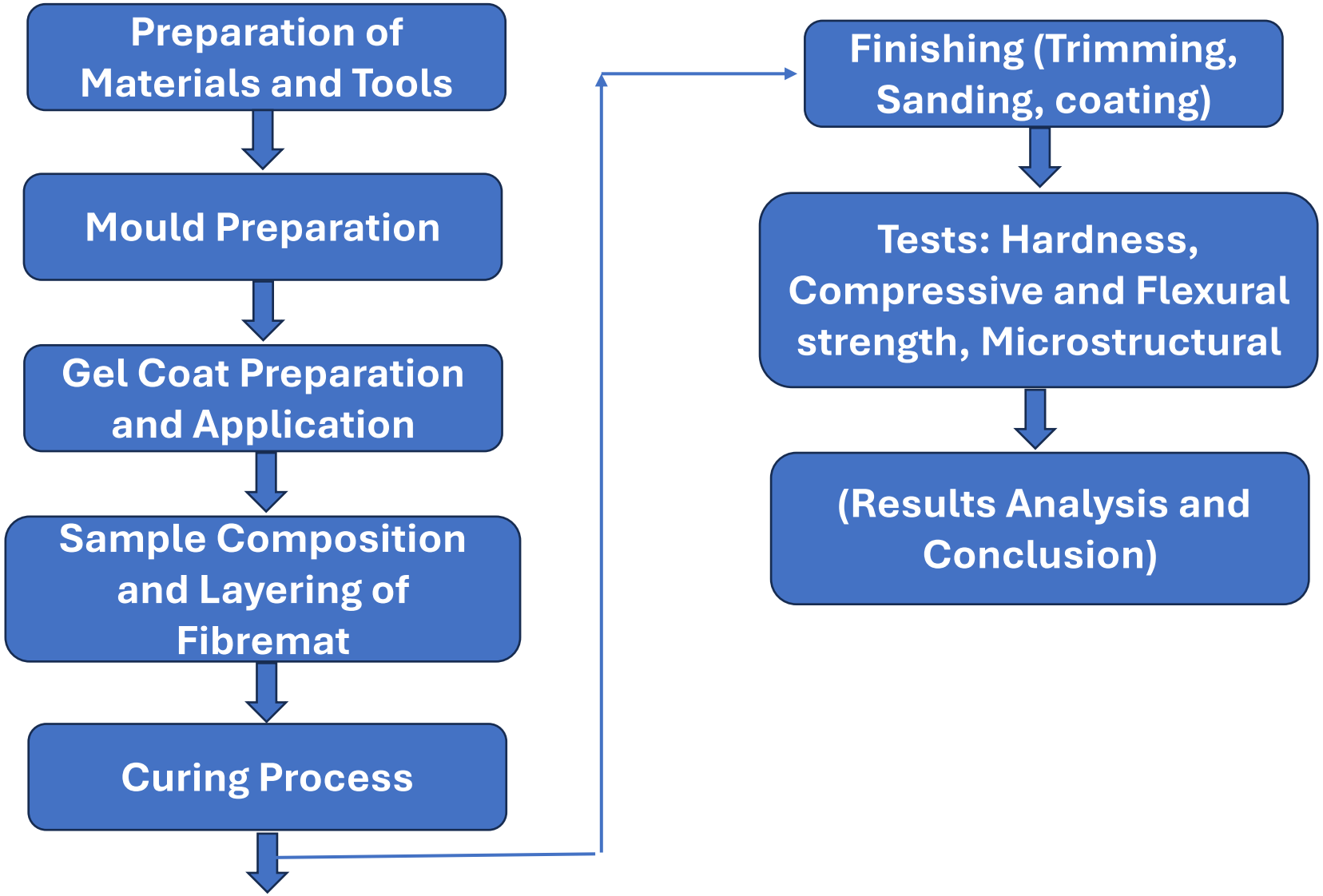
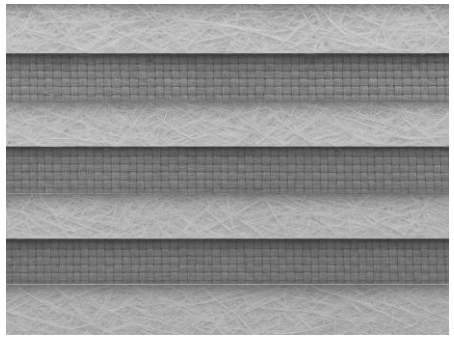


Figure 3: Flowchart of the Manhole Cover Production Process

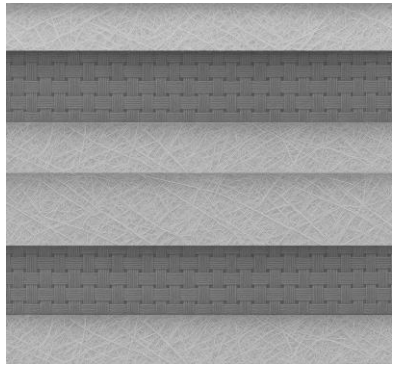
Layering Format of each SAMPLE

Sample A



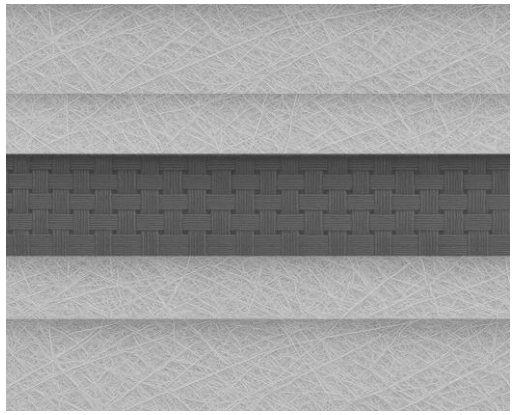
- chopped strand
- woven roven
- chopped strand
- woven roven
- chopped strand
- woven roven
- chopped strand

Sample B



- chopped strand
- woven roven
- chopped strand
- chopped strand
- woven roven
- chopped strand

Sample C



- chopped strand
- chopped strand
- woven roven
- chopped strand
- chopped strand





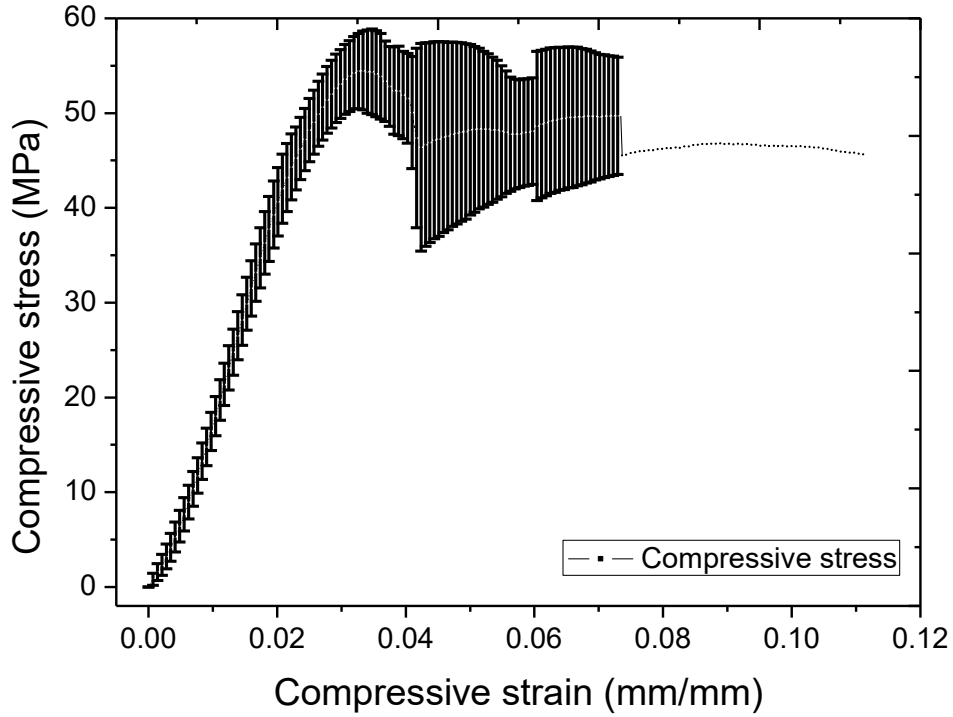




Figure 4: The Layering format for the composites

Results and Discussion

Compressive Strength Test



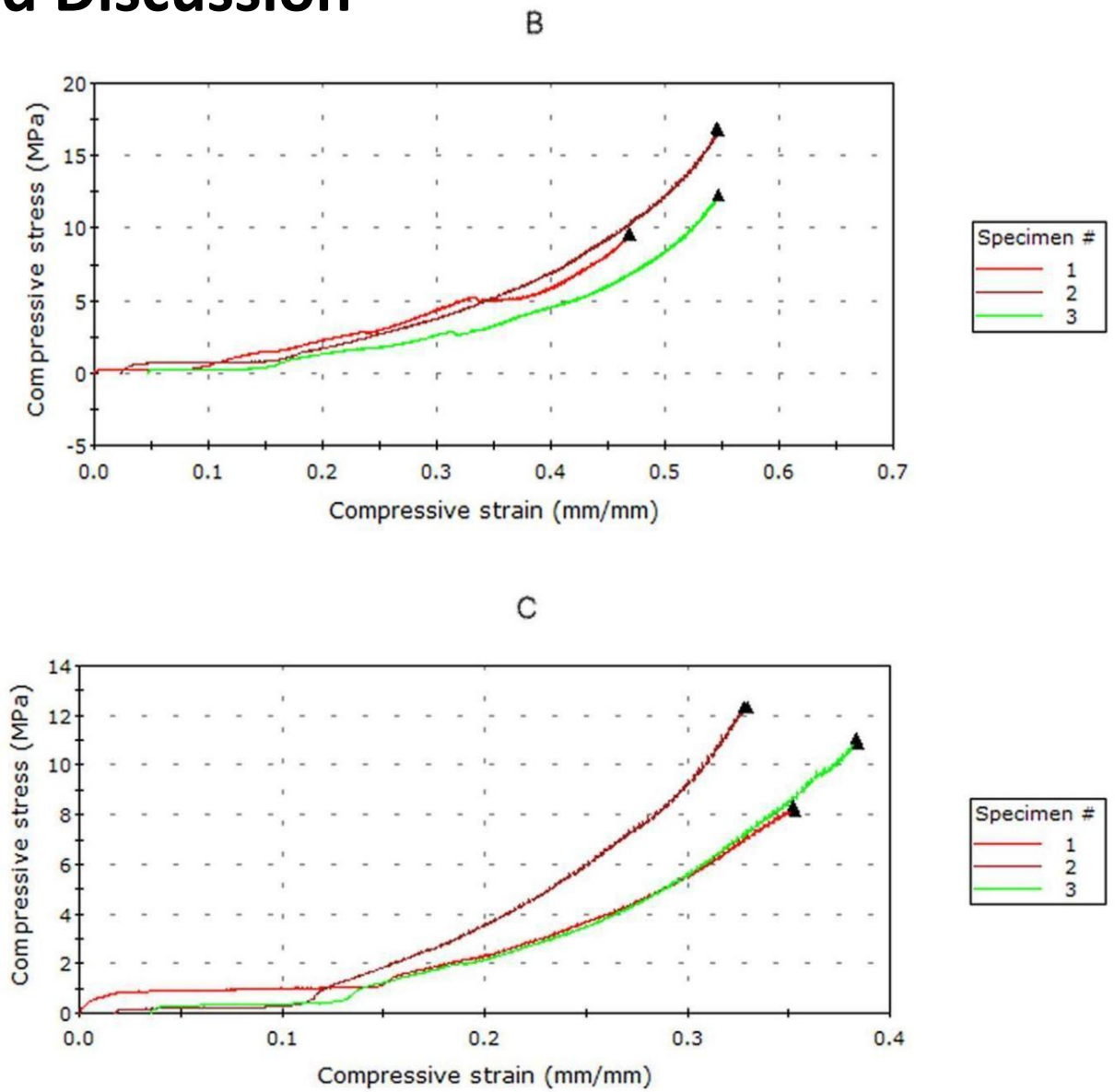
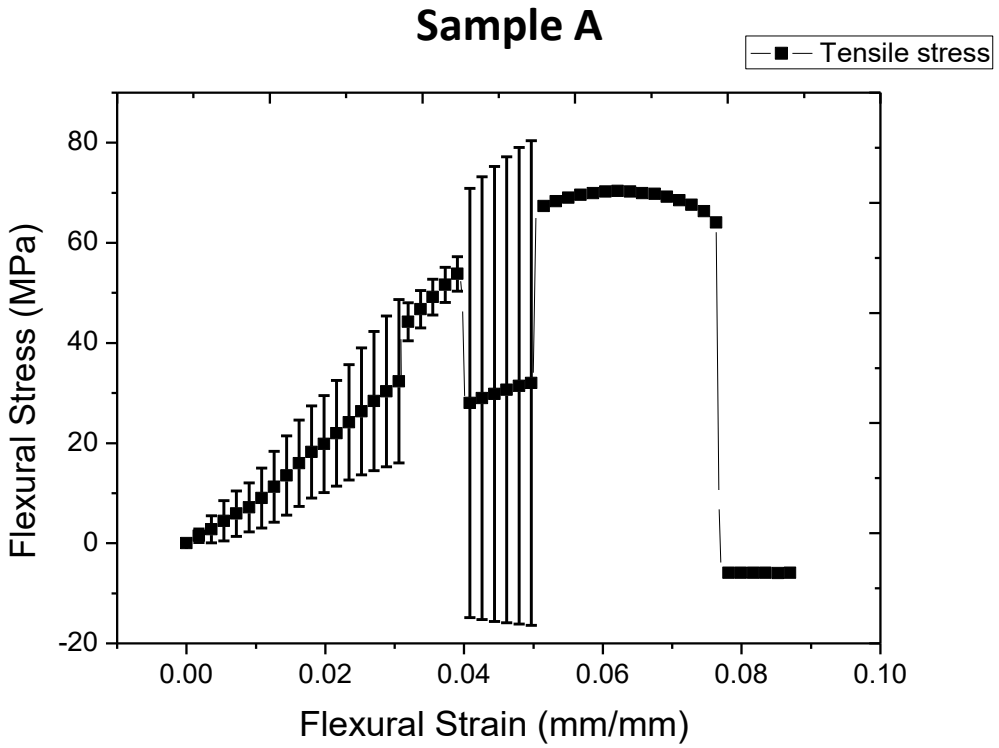
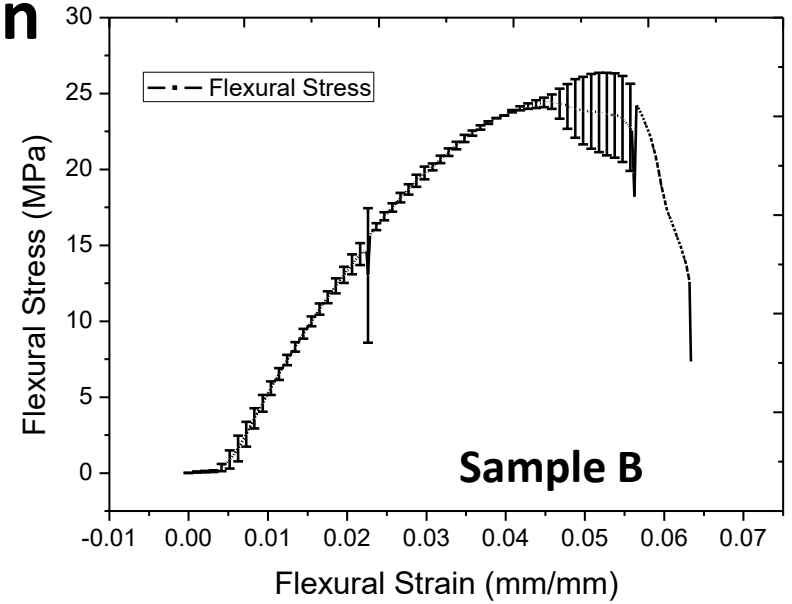


Figure 5: A graph of compressive stress as a function of compressive strain for (a) sample A, (b) sample B, and (c) sample C

Results and Discussion

Flexural Strength Test





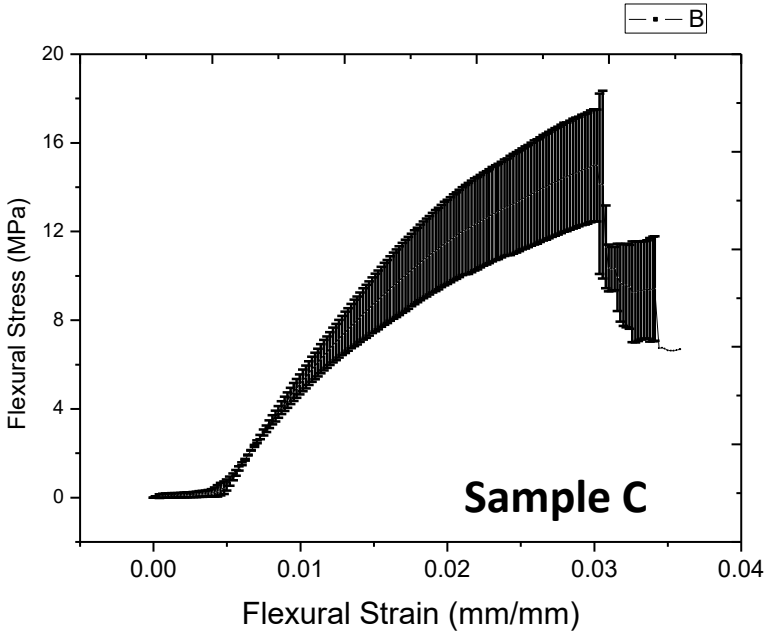


Figure 6: Flexural Stress-Strain Curves for configurations (a) Sample A, (b) Sample B, and (c) Sample C.

Results and Discussion

Vickers Hardness

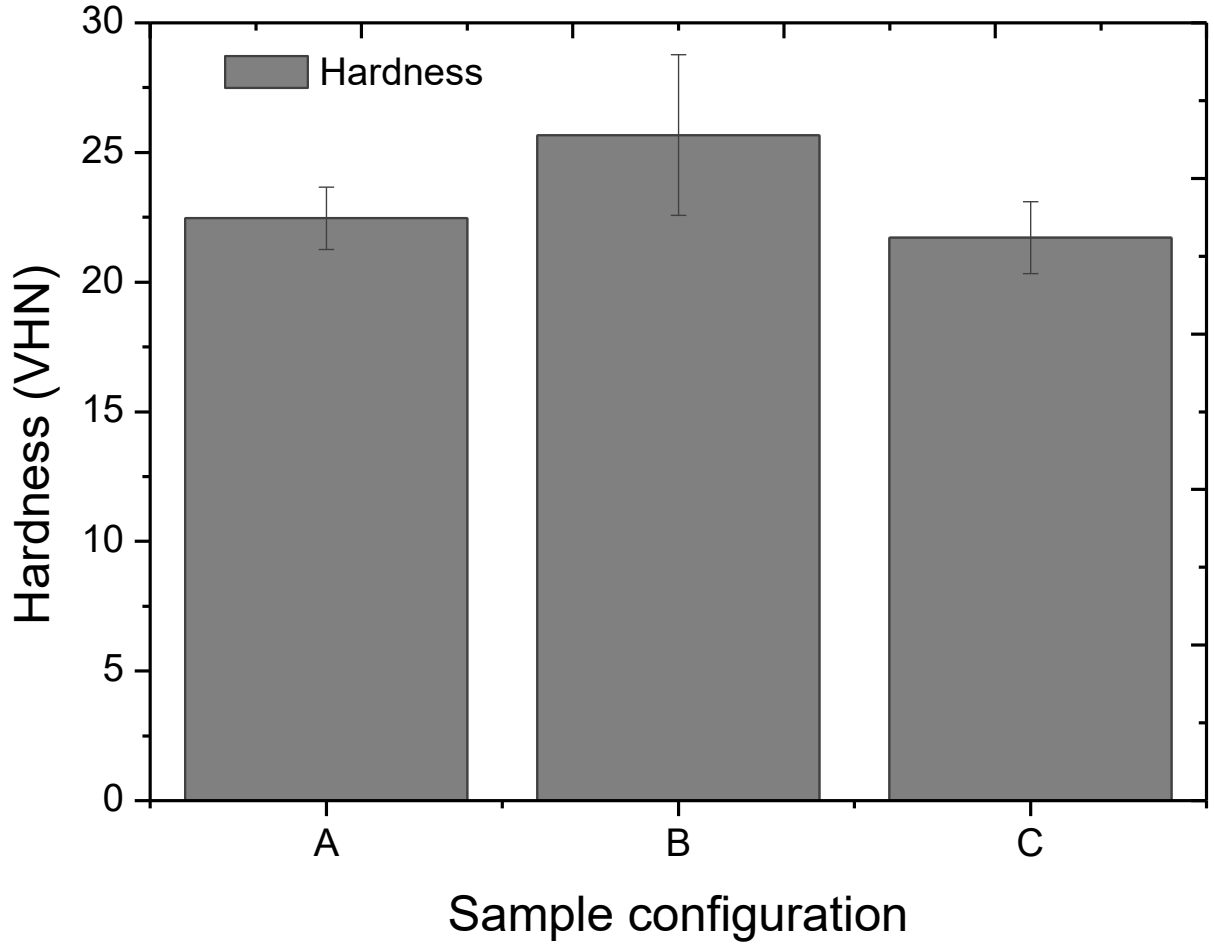


Fig. 7: A graph showing the hardness of Samples A, B, and C.

Results and Discussion

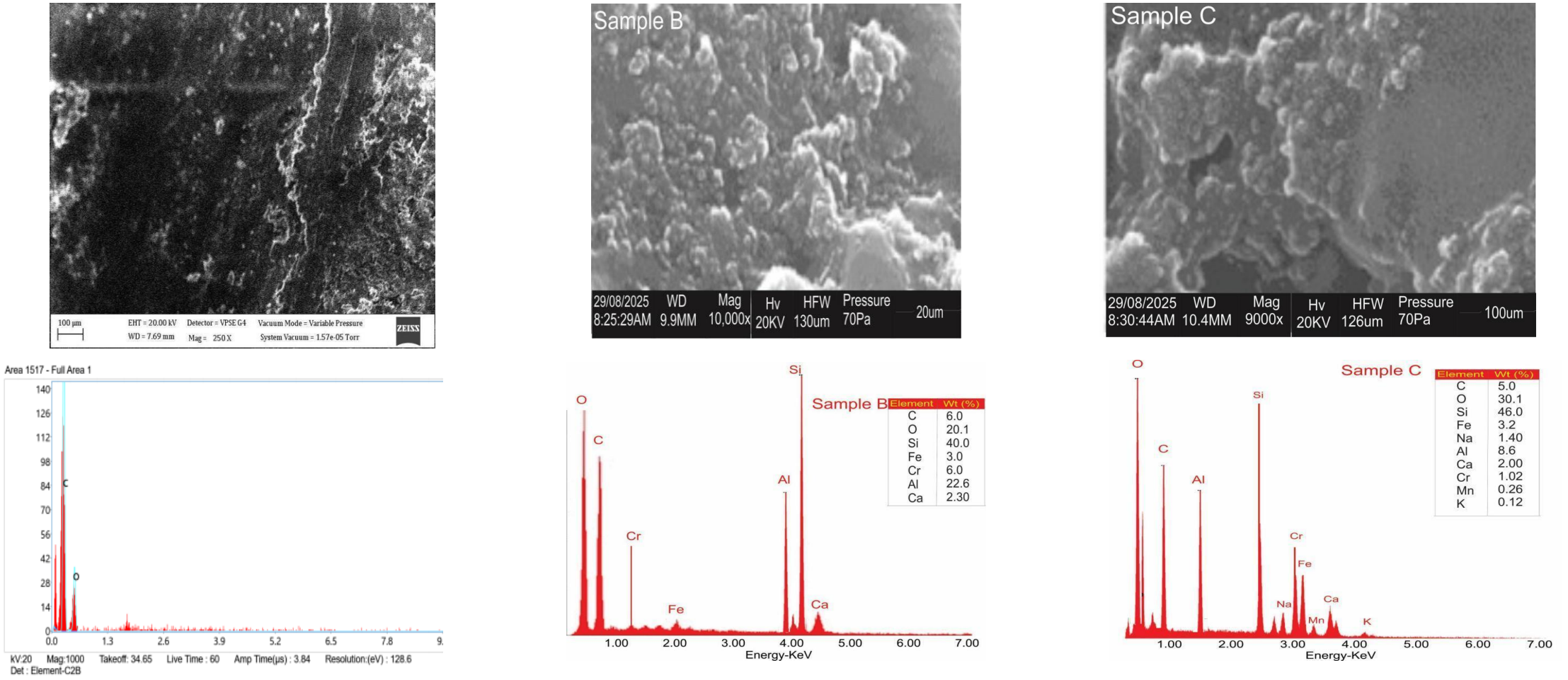


Fig. 8: Scanning Electron Micrograph and Energy Dispersive Spectroscopy (EDS) of (a) sample A, (b) sample B, and (c) sample C.

Conclusion

- Sample A, with alternating layers of chopped strand and woven roven, exhibited the highest compressive strength (~55–60 MPa), while Sample C recorded the lowest values (8–12 MPa).

- Flexural performance was most impressive in Sample A, with values (60–70 MPa) far exceeding cast iron's range (10–20 MPa), while Sample C (10–15 MPa) was comparable.

- Sample B showed the highest hardness value of ~25.5 VHN, but it is far below that of cast iron.

- The microstructure showed that Sample A displayed a resin-rich structure with minor voids. Sample B showed denser reinforcement with fibre pull-outs, indicating stronger but brittle fracture tendencies. Sample C exhibited a porous and fragmented morphology, which explains its weaker performance.

- More research is required to produce composite-based manhole covers that can replace cast iron in heavy load-bearing applications.