DEVELOPING A COMPOSITE WALL TILE USING TEXTILE WASTE

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The generation of textile waste has increased rapidly during the last few decades, and it has become a significant problem in the countries where apparel manufacturing is a major industry. The main objective of this research study was to develop a novel composite material for wall tile applications using textile waste.

Textile waste, appropriate composite size was 12 inches x 12 inches, and the thickness was 8 mm. Four (04) composite samples were fabricated for each selected weight ratio of textile resin type, weight ratios of textile waste to resin, suitable composite manufacturing method and evaluation tests were selected to conduct the study. The selected sample waste to resin, amounting to a total of twelve (12) samples. The developed composite samples were evaluated for water absorption, modulus of rupture and impact resistance to determine the suitability for wall tile applications. According to the results, with the increase in the textile waste component, the water absorption of composite samples increased. Water absorption values show that the results are acceptable for using the developed samples as wall tiles. During the modulus of rupture testing, no failures were observed in any of the developed composite samples. As there were no failures, it can be suggested that the samples have a higher modulus of rupture. All the developed composite samples, regardless of their different material compositions, exhibited no visible cracks during the impact resistance tests. Therefore, all the developed composite samples showed a satisfactory level of impact resistance. The overall experimental results indicated that the developed composite samples showed encouraging results in water absorption, modulus of rupture and impact resistance, suggesting their potential for use in wall tile applications.

As per the findings, all the test results were within the acceptable range for the tested parameters. Further studies should be carried out to determine the optimum range for the textile waste to resin weight ratio using an increased number of textile waste-to-resin weight ratios.

Keywords: Textile waste, Textile reinforced composites, Wall tile, Water absorption, Modulus of rupture, Impact resistance

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INTRODUCTION

As a result of the development of the textile and apparel industry, global population growth, rising living standards, technological boom and the fast trends in the international fashion sector, the creation of textile waste has increased. Globally, approximately 75% of textile waste ends up in landfills and the rest is reused or recycled (Juanga-Labayen et al., 2022). The annual generation of textile waste in Sri Lanka is around 30, 000,000 kilograms. As there are no substantial recycling practices available in Sri Lanka, the textile waste is generally dumped in open areas or incinerated (University of Cambridge, 2017). Therefore, at present, the need for an innovative solution for the rising textile waste crisis has become increasingly urgent.

Given the low rate of reuse and recycling of textile waste, researchers have actively focused on developing novel technologies and products for various end-use applications, and the textile waste- reinforced composite materials have become a prominent area of various research studies. In one of the research studies, garment waste and fly ash reinforced polymer composite material was developed to be used as an alternative material for ceiling panels, sound barrier panels, roofing tiles and building insulation materials (Khot & Kumar, 2018). In another study, cotton and polyester textile cutting waste were used to produce composites for ceiling sheets and separation boards **(**Priyakumari & Perera, 2019**)**.

An impact-absorbing composite panel was developed by incorporating denim waste and bio-based epoxy resin (Öztemur et al., 2021). A research study concerning the reinforcement of natural fibres for the development of composites for tiles was reported in the literature. In another study (Abate et al., 2019), flax, jute, and sisal fibres were used as reinforcement material to produce a composite for tile application using waste polypropylene as the matrix material.

The main objective of this study was to develop a novel composite material for wall tile applications using textile waste to address the growing environmental, social and economic challenges.

METHODOLOGY

1. The required information was gathered through a thorough literature review.
2. The types of textile waste materials, appropriate resin type, weight ratios of

textile waste to resin, suitable composite manufacturing method and types of tests were selected to conduct the investigation. The size and thickness of the composite samples were selected by considering the dimensions of the commercially available wall tiles.

3. A mould was prepared in accordance with the desired size and the thickness of the planned composite material.
4. Four (04) composite samples were fabricated for each selected weight ratio of textile waste to resin amounting to a total of twelve (12) samples.
5. The test results of the developed composite samples were compared with the selected two commercial products to check the suitability for wall tile application.

RESEARCH DESIGN

The research design comprises four major parts namely, selection of materials, preparation of a mould, fabrication and testing of composite samples.

PART A: Selection of materials

Reinforcing material

Textile waste materials from the cutting department of a garment factory were selected as the reinforcement component of the composite samples. The collected textile waste materials were not separated according to fibre type to ensure that any fibre type can be used for this purpose. They were cut into small pieces randomly to mix them properly with resin.

Resin material

Epoxy resin and its corresponding hardener were mixed at a 3:1 weight ratio to prepare the polymer matrix. The selected weight ratios of textile waste material and resin, as well as the number of samples developed for this study, are given in Table 1.

Table 1: Selected material compositions for composite sample development

Sample designation	Weight ratio (Textile waste: Resin) (%)	Number of samples developed
T30R70	30:70	04
T40R60	40:60	04
T50R50	50:50	04

PART B: Preparation of a mould

A mould was prepared using stainless steel to develop the composite wall tile samples.

PART C: Fabrication of composite samples

The samples were fabricated using the hand lay-up method. The selected size was 12 inches x 12 inches with a thickness of 8 mm. Figure 1 shows three (03) developed composite samples.

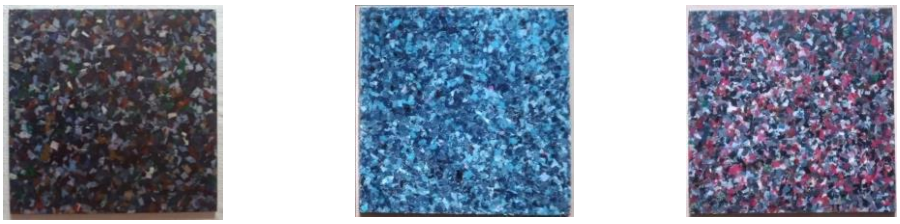

Figure 1: Developed composite wall tile samples

PART D: Testing of composite samples

Due to the cost of production of composite wall tile samples, the number of samples developed and tested was limited to 6, 3, and 3 for water absorption, modulus of rupture and impact resistance, respectively. The performed tests and testing standards are shown in Table 2.

Table 2: Tests performed to evaluate the developed composite wall tile samples

Test	**Standard**	**Number of samples tested**
Water absorption	ASTM D570	06
Modulus of rupture	ASTM C1505-15	03
Impact resistance	ASTM C1870-18	03

RESULTS AND DISCUSSION

The summary of the test results of the three (03) selected parameters is given in Table 3.

Table 3: Summary of test results of the developed composite wall tile samples

Sample designation	Weight ratio (Textile waste: Resin) (%)	Water absorption (%)	Modulus of rupture (N/mm^2)	Impact resistance (mm)
T30R70	30:70	0.23	No failure	No effect
T40R60	40:60	0.42	No failure	No effect
T50R50	50:50	0.78	No failure	No effect

It was found that water absorption has been increased with the increase of the textile waste component. The composite sample made with 30% of textile waste composition showed the lowest water absorption of 0.23% among the tested composite samples.

During the modulus of rupture testing, no failures were observed in any of the developed composite samples made using three different material compositions of textile waste and resin. Notably, the developed composite samples showed substantial bending deformation without any observable signs of failure such as breakage, fracture, delamination or permanent deformation throughout the loading process. Due to the absence of a distinct failure point, definitive modulus of rupture values could not be obtained. As there were no failures, it can be suggested that the samples have a higher level of modulus of rupture.

All the developed composite samples, regardless of their different material compositions, exhibited no visible cracks during the impact resistance tests for the standard steel ball dropped from the heights of 0.91 m and 1.2 m as per the selected standard. As no cracks, it can be suggested that the samples demonstrated a satisfactory level of impact resistance for the intended use.

COMPARISON OF TEST RESULTS WITH THE SELECTED TWO COMMERCIALLY AVAILABLE PRODCUTS

Ceramic and porcelain wall tiles are the most popular and widely used wall tiles in the construction industry in Sri Lanka. The test results of the developed composite samples were compared with two commercially available ceramic and porcelain wall tiles of the same size and thickness. The commercial products were tested using the same testing procedures used for the developed composite wall tile samples. The test results are shown in the Table 4.

Table 4: Comparison of the developed composite samples with the selected commercial products

Sample type		Water absorption (%)	Modulus of rupture (N/mm^2)	Impact resistance (mm)
Developed composite sample	T30R70	0.23	No failure	No effect
	T40R60	0.42	No failure	No effect
	T50R50	0.78	No failure	No effect
Ceramic wall tile		14.67	14.55 (Broken)	Cracked (At ball drop height of 0.91 m)
Porcelain wall tile		0.00413	16.03 (Broken)	Cracked (At ball drop height of 0.91 m)

As per test results, the developed composite samples showed a significantly lower water absorption in comparison to the tested ceramic wall tile samples. However, the developed composite samples possess higher water absorption values than the tested porcelain wall tile samples. According to the standards accepted by the tile industry, the water absorption of the tested composite samples is at a satisfactory level. Therefore, the test results of the water absorption of composite wall tile samples were in accordance with recommended values for both commercially available ceramic and porcelain tiles. The comparative data clearly demonstrate that the developed composite samples exhibited significantly greater modulus of rupture and impact resistance properties than the tested porcelain and ceramic wall tile samples. Accordingly, it can be concluded that the developed composite samples exhibited excellent properties compared to the commercially available products in performance and quality.

CONCLUSION

This research study was carried out as a preliminary study to provide a solution to the crisis of textile waste. The composite wall tile samples were produced using three different weight ratios of textile waste to resin and tested for water absorption, modulus of rupture and impact resistance properties. According to the results, with the increase in the textile waste component, the water absorption of composite samples increased. The composite sample made with 30% of textile waste composition showed the lowest water absorption of 0.23% among the tested composite samples. As per the results, no failures were found in any of the developed composite samples. As there were no failures, it can be suggested that the samples have a higher modulus of rupture. All the developed composite samples regardless of their different material compositions, exhibited no visible cracks during the impact resistance tests. Therefore, all the developed composite samples showed a satisfactory level of impact resistance.

Water absorption values show that the results are acceptable for using the developed samples as wall tiles. The overall experimental results indicated that the developed composite wall tile samples possessed significantly higher impact resistance and modulus of rupture than the selected commercially available products, suggesting their potential for use in wall tile applications. It is difficult to determine the optimum textile waste to resin weight ratio with the selected material compositions as all the test results are within the acceptable range. It is necessary to conduct further studies to determine the optimum range for the textile waste to resin weight ratio using an increased number of textile waste to resin weight ratios. Future studies could investigate wider range of properties and characteristics, including abrasion resistance, thermal stability and chemical resistance, etc.

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