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Development of hybrid yarn-based woven textile structures for textile-reinforced concrete applications

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Abstract: Textile-based structures are now being widely used in civil engineering applications. The non-corrosive nature, higher specific strength and ductile behaviour of textile structures have made it suitable to be used as a reinforcing component for producing lightweight durable structural components often recognized as textile-reinforced concrete (TRC). This study is a first attempt to produce a novel hybrid yarn-based woven textile structure for possible application as reinforcement in TRC components. The Dr. Ernst Fehrer (DREF-3) friction spinning and filament wrapping technique has been used to form hybrid yarn structure. The hybrid yarn has been subjected to heat treatment to stabilize the yarn structure and maintain its structural integrity during weaving operation. The plain woven fabrics are formed with a grid type open structure having two different grid spacings: 6 mm × 7 mm and 16 mm × 17 mm. The fabric composite was formed using a compression moulding machine. The cross-section was prepared for the yarn structures and analysed using a microscope. The microscopic images show DREF spun yarn has less-dense packing of polypropylene fibres over basalt filaments. However in heat-treated-DREF yarn, the polypropylene melt has encapsulated and uniformly covered the basalt filament core. There was no impregnation of the polypropylene matrix inside the basalt roving bundle. The tensile test was carried out for the yarn, hybrid yarn, heat-treated hybrid yarn, fabric and fabric composite specimens. The hybrid yarn and hybrid yarn-based fabrics were found superior compared to the parent basalt yarn and basalt fabric in terms of load-bearing ability and ductility. Hybrid yarns as compared to basalt roving have exhibited higher load bearing ability by a factor of 106–156%, yarn tenacity by 56–95% and ductility behaviour (elongation) by 82–105%. Moreover, hybrid yarn-based fabric and composites have shown higher load bearing ability (46–66%) and ductility behaviour elongation (20–63%). It was also observed that under tensile loading, the fabric composites exhibit multiple failure behaviour. The tensile results of hybrid yarn (basalt–polypropylene–polyester) and hybrid yarn-based fabric samples were encouraging as compared to the parent basalt roving and basalt fabric samples, respectively. This study has

13 Flexible Towpregs and Thermoplastic Composites for Civil Engineering Applications

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Textile structures in concrete reinforcement

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ABSTRACT

Traditional steel-based reinforcements face corrosion issues that compromise the durability of concrete structures. Large concrete covers are recommended to mitigate corrosion of steel reinforcements, resulting in thicker, heavier structures with increased material consumption and costs, making them less sustainable. Textile reinforced concrete (TRC), with its corrosion resistance, high tensile strength, drapeability, formability, and lightweight nature, offers a sustainable alternative. It necessitates less concrete cover, thereby reducing costs and material consumption, making it suitable for lightweight and durable structural components. Various combinations of textile structures achieved through selective adjustments to fibre, yarn, and fabric geometry present significant potential for developing customized TRC elements. This issue of Textile Progress delves into the environmental impact of construction materials, TRC composition and manufacturing, mechanical testing techniques, and the influence of textile (yarn, braided fabric, woven fabric, knitted fabric, 3-D spacer fabric, nonwoven fabric) structural parameters on TRC behaviour. Additionally, the effects of textile coatings, filler incorporation, and discrete fibre integration on TRC properties are also explored. Overall, textile reinforcement in concrete enhances properties such as tensile strength, ductility, strain hardening behaviour, flexural strength, impact resistance, toughness, multiple cracking behaviour, and reduced crack width and spacing, whilst also bolstering resistance to environmental factors.

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Textile reinforced concrete (TRC); textile reinforced mortars (TRM); fabric reinforced cementitious composite (FRCC); reinforced concrete (RC); yarn geometry; fabric geometry; strain-hardening; pull-out behaviour; tensile properties; flexural properties; ductility; durability

1. Introduction

Concrete possesses high compressive strength but low tensile capacity, leading to brittle failure once its tensile strength is exceeded. To ensure adequate structural behaviour, reinforcement is required. Traditional steel reinforcement demands a minimum concrete cover thickness (typically between 20 and 50 mm relying on structural characteristics), limiting the creation of thin shell structures (Lee, Mata-Falcón, Popescu, Block, & Kaufmann, 2020) and raising concerns about durability due to its interaction

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Improving Performance of Concrete Structures with Textile Reinforcements

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Abstract The application of fabric as a reinforcement and strengthening material for building elements has gained significant attention in recent times. The unique characteristics of fabric structures, such as light weight, tensile strength, flexibility, and durability, have been widely acknowledged. The development of textile reinforced concrete (TRC) requires a comprehensive understanding of fabric parameters to enable engineers to design and construct TRC structures that meet specific end use requirements. The most commonly used fabrics in TRC are 2-D woven, 2-D knitted, and 3-D spacer fabric structures. This chapter reviews important fabric parameters, including fiber type, weave design, reinforcement ratio, embedment length, yarn fineness, pick density, loop size, inlay yarn, grid opening, resin-coated fabric, and hybrid fabric. These fabric parameters significantly impact the mechanical behaviour of TRC in terms of pull-out load, tensile strength, ductility, strain hardening behaviour, flexural strength, impact resistance, toughness, multiple cracking behaviour, crack width, and crack spacing. Woven fabrics are generally deemed more suitable due to the stable fabric structure, which provides mechanical anchoring and resistance against pull-out force inside the concrete matrix through warp-weft interlacement. However, certain special 3-D warp-knitted and spacer fabric structures have also gained wide acceptance as concrete reinforcement. Furthermore, resin-coated fabrics have demonstrated improvements in strength utilization of constituent yarns in cementitious composites, leading to improved mechanical behaviour of TRC.

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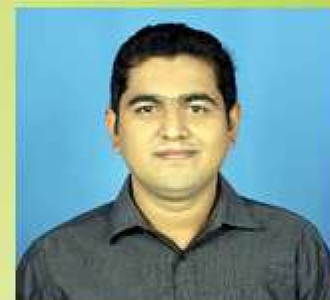

E- CERTIFICATE

This is to certify that Prof./Dr./Mr./Ms **Mr. Nabo Kumar Barman,** PhD scholar, Department of Textile Engineering, The M.S. University of Baroda *has presented a paper titled* Development of Hybrid Yarn based Woven Textile Structure for Textile Reinforced Concrete Applications *in the '5th International Conference on Industrial Textiles – Products, Applications and Prospects - InduTech 2020' on 21st - 23rd August 2020, organized by Departments of Textile Technology and Automobile Engineering, PSG College of Technology, The M.S. University of Baroda, Gujarat, Hof University of Applied Sciences Fachhochschule, Germany; Institute for Frontier Materials (IFM), Deakin University, Australia and Northwest Composites Centre, School of Materials, University of Manchester, UK in collaboration with Office of the Textile Commissioner, Ministry of Textiles, Govt. of India.*

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