JOURNAL OF MECHANICS OF MATERIALS AND STRUCTURES
Vol. 18 (2023), No. 4, pp. 593–618
DOI: 10.2140/jomms.2023.18.593

A STATE-OF-ART REVIEW ON THE MECHANICAL PERFORMANCE OF BASALT TEXTILE REINFORCED CONCRETE (BTRC)

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Textile-reinforced concrete (TRC) is a creative emerging composite material with enormous possibilities for structural applications. It makes it possible to fabricate robust, light, and thinner elements with a minimum concrete cover. With the ease of availability of basaltic rocks in India, basalt fibres and basalt biaxial textile meshes have found broad applicability in India and other countries around the globe. They have proved efficient compared to synthetic textiles in strengthening and toughening structural components. Basalt textile reinforced concrete (BTRC) has minimal research and application as a load-bearing structural component. The mechanical characteristics that govern the design of BTRC composites are reviewed in this article briefly. This review article is categorised into four main research areas, namely properties of basalt textiles, composite behaviour of BTRC in tension and flexure, dynamic response to impact loading, strengthening of existing structures. In addition, the advantages and disadvantages of BTRC in comparison to other TRCs has been discussed. Furthermore, this article proposed the futuristic direction to reinforce the research on the wide applicability of BTRC as a structural component specially for low-cost housing.

1. Introduction

After being discovered in 1923 by the scientists in America, basalt became a highly restricted material used for the research in the military domain. In the early twentieth century, the United States, Russia, and countries in Europe all started using basalt extensively in defence and aeronautical applications during World War II [11; 65]. Early in the 20th century, there was a lack of comprehension and specific regulations, which resulted in the development of concrete structures that did not conform to modern standards. Additionally, using locally available and often inappropriate materials may result in low concrete quality and mechanical characteristics [26]. For structural engineers, preserving the structural integrity of reinforced concrete structural components throughout their service life is of utmost significance; yet, degradation caused by corrosion of embedded reinforcement is a significant concern. Its implications are often made worse by the insufficient concrete cover and are evident in the RCC (reinforced cement concrete) structures with a substantial loss in strength and stiffness [33].

The efficiency of basalt textile-reinforced mortars (BTRM) was initially demonstrated by improving the shear capacity of reinforced concrete beams using two types of distinct repair mortars. One is composed of cementitious mortar, and the other of cementitious mortar with polymeric modifiers. Also, with the help of experiments, the shear resistance of the beam significantly increases as the number of wrapping layers increases. Additionally, these textiles provided the highest shear strength when embedded at a 45-degree angle. A nonlinear finite element analysis (FEA) was performed on reinforced concrete (RC) beams using LS-DYNA, and the results were well correlated with the specimens tested experimentally

Keywords: BTRC, basalt textiles, TRC, tensile strength, flexure, impact.

[4]. In 2013, many researchers observed that the existing RC beams were deteriorating in flexure. The feasibility of providing textile wrapping to these beams with a fine-grained textile reinforced mortar incorporating basalt textiles was practically effective [22; 27; 63].

In recent years, it has become more crucial to construct structures using materials with enhanced physical performance and durability; the new objective is to fabricate more sustainable, cost-effective, lightweight, durable, and maintenance-free structures. Discrete fibres have been incorporated into the concrete as a secondary reinforcing to minimise cracking. Primary steel reinforcing cannot be fully substituted by this technology [79]. For several years, RC structural parts have used carbon, polypropylene, glass, and basalt fibres as secondary reinforcing elements. It is vital to remember that these materials won't often undergo corrosion, giving structural designers the option of using thinner structural elements and lower cover requirements [71]. Replacing the steel reinforcement entirely with noncorrosive textiles was used in the production of façdes at a large scale in India, especially in metropolitan cities, including Mumbai, Pune, and Chennai. It lowered the chances of TRC façdes breaking or being damaged during handling or shipment. Textile-reinforced fine-grained concrete composite, which has excellent tensile strength, corrosion resistance, and lightweight characteristics, is a developing environmentally acceptable material in the 21st century. As less cement is used in TRC, the carbon output is significantly lowered by 70% compared to conventional RCC construction [74]. Globally, considering the sustainability aspect of construction technology, adopting an emerging technology is a need in the era that is not only sustainable but also aims to be highly durable in any climatic conditions.

This article seeks to review the mechanical performance of textile-reinforced composites with basalt textiles in the static condition of uniaxial tensile loading [2; 19], and flexural loading [16; 20; 21; 23; 43; 45; 48; 61; 76; 84] and dynamic loading states such as high-velocity impact loading [29; 35; 47]. Very few studies have been carried out on impact loading in BTRC. Additionally, due to its higher strength-to-weight potential, flexibility, high strain capacity, and ductility, TRC may be used to design buildings in earthquake-prone areas. A paradigm shift in using BTRC as a structural component for housing in developing countries is the gap identified after reviewing the literature.

2. Properties of basalt fibre and textile mesh

Since the 20th century, basalt fibres, also known as volcanic rock fibres, have been employed in construction. When volcanic lava cools, it hardens into basalt rock, which is then crushed to produce basalt fibres [75]. Basalt fibre is thin, strong, and has a high melting point. For the construction of bridges, roads, and residential structures, basalt fibres are embedded as a hybrid of steel reinforcements to resist cracking. In India, basalt rock is more abundantly available, especially in Maharashtra. Basalt fibres can resist temperature ranges from $-269\,°C$ to $+650\,°C$, and have better shear strength, higher compression strength, better radiation resistance, and higher oxidation resistance which makes them more suitable for a wide range of applications [25; 75].

The numerous natural fibres found in India are depicted in Figure 1. Natural fibres must always be extensively treated before use since they degrade more quickly in an alkaline environment. Regarding this, basalt fibres, inorganic, hold up well in both acidic and alkaline media. Basalt fibres are a better substitute to carbon and glass fibres because of their high load resistance, chemical resistance, and economic aspects [66; 71; 79]. The mechanical characteristics of natural fibres embedded as reinforcement in concrete are summarised in Table 1.