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Use of Textile Nets to Reinforce Concrete Elements

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Abstract

Concrete elements are basic things in our life in our house building, roads, ports, bridges and other civil engineering field applications. But concrete can be exposed to many problems that need to be fixed. These problems such as thickness, heavy weight, cracking and thermal bridges. Reinforcing of Concrete elements became important according to its low resistance, different uses, or due to design or implementation errors. Also, concrete need repairing as different environment affect its' loading. Textile has a huge role in building structure offering good properties such as light weight, strength and also gives thermal and acoustic insulation and sunlight, chemical and pollution resistance to solve those problems as textile reinforced concrete (TRC) for reinforcing and repairing mortars and concrete. Textiles were used with different materials such as fiber glass. Carbon fibers, basalt, steel etc. Also, different constructions and different techniques were used such as woven, knitted, bonded and non-woven. This paper reviews some of TRC techniques, constructions and materials for used grides to solve problems which facing concrete for reinforcing or repairing.

Keywords: Textile Reinforced Concrete; Constructions; build tech; repairing; materials

1. Introduction

Technical textiles were defined: "Technical textiles are considered all fabrics that cannot be addressed within the traditional sectors of clothing, home and decoration"

Todays' defensing is: "Materials designed for specific applications requiring concert and demanding properties (mechanical resistance, tenacity, insulation, thermal resistance, acids, UV, IR….)"

Also, The Textile Institute defines it: **"**Textile materials and products manufactured primarily for their technical and performance properties rather than their aesthetic or decorative characteristics" [1].

Textile reinforced concrete is a novel type of composite material with a high level of sophistication. In contrast to steel reinforcing, it usually consists of alkali-resistant fibre glass (AR) or any other material such as carbon fibres with cementitious matrix reinforcement. Single AR glass or carbon fibres can be positioned in any direction in the textile, resulting in a perfect alignment of the applied load. It is appropriate to construct an extremely effective reinforcement for this purpose. [2]**.**

Nowadays, there is a growing awareness of the need to reduce energy resources, intensity, waste, and consumption, especially in the construction business.

TRC was exposed in order to create light-weight, slender, modular, and freeform structures that decrease or eliminate the possibility of corrosion. TRC are composite materials that perform similarly to steel reinforced concrete in terms of durability while lowering weight and maintaining high-quality surfaces.

Textile reinforced concrete (TRC) is a low-maintenance material with a wide range of design possibilities. Because the used textiles are non-corrosive, TRC thickness is determined solely by load-bearing capacity, unlike steel reinforced concrete. As a result, 1 cm thicknesses can be achieved, yielding concrete savings of up to 80%. TRC elements are often strengthened in 2D or 3D meshes made of alkali-resistant glass (ARG), basalt, carbon, polyvinyl-alcohol (PVAc) polypropylene with a polyvinyl chloride (PVC) matrix, or a mix of these materials [3, 4].

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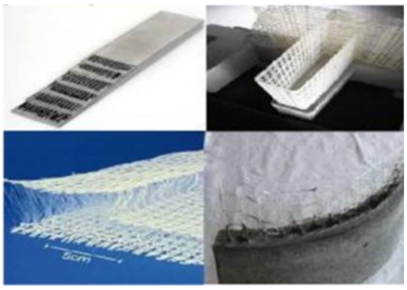

Fig. 1. Examples of 2d and 3d TRC

Composite TRC

Textile composites are rigid and textile-containing materials with characteristics such as light weight, flexibility, well-built, and toughness, as the name implies. Because of their exceptional quality, they are used for structural or load-bearing applications. Textile composites can also be characterised as a resin system containing a textile fibre, yarn, or fabric system. Tyres, heavy-duty conveyor belts, and inflatable life rafts all use textile composites. Rubber components have an elastic unreceptive matrix, resulting in failure of the desired performance. However, it is successful for flexible composite goods when this component is paired with a textile system with tensile strength and stability, such as a textile reinforced rubber system [6].

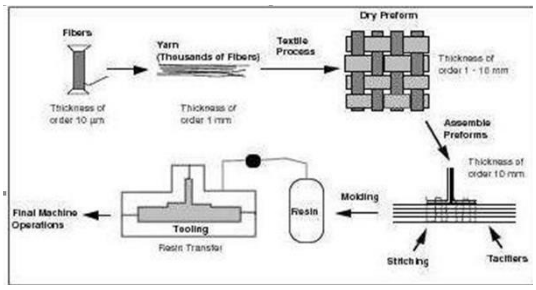

Fig. 2. Manufacturing process of textile composites [6]

TRC Constructions

Filament yarns with drawn comparable threads are preferred for reinforcing applications due to their lower elongation as compared to other yarn processes like bonded and twisted. In addition, for cementitious matrix penetration, a stable open-grid structure is preferred. Woven meshes and other less common knitted textiles were employed in additional research. The bulk characteristics and geometrical features of textile textiles were researched in order to predict the performance of cement composites reinforced with textile fabrics, according to A. Peled et al. It was observed that the geometry of an accurate fabric might promote bonding and allow strain hardening behaviour from low modulus yarn fabrics due to the specific shape of the yarn generated by the fabric. Fabric geometry, on the other hand, can have a significant impact on efficiency, resulting in a weakening effect of the fabric's threads as compared to single yarns not in a fabric shape. Because of the difficulty of perceiving the Fabrics as a means of holding together continuous yarns to be inserted readily in the matrix, cement composites are not the same as polymer matrix composites.

In A. Peled et al research, three different fabrics' structures were studied:

a. weft inserted warp knitting with fabric (Fig.3 (a))
b. short weft knitted fabrics (Fig.3 (b))
c. plain weave woven fabric with, (Fig.3 (c))

Using different yarn's combination way such as:

a. In the weft insertion knitted fabric ,the reinforcing yarns work straightly (similar to reinforced plastic by fabric composites)
b. In the short weft knitted fabric, the reinforcing yarns have a complicated geometry.
c. In the woven fabric, the reinforcing yarns are crimped.

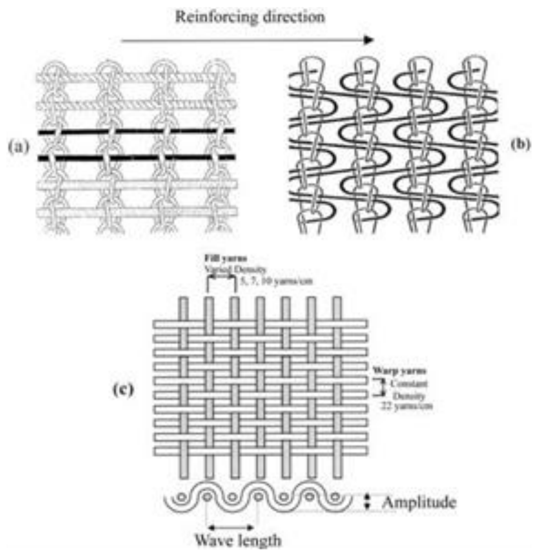

Fig. 3. Different (TRC) fabrics' structures

To prepare for pullout and flexural tests, samples were damaged in a 0.3 water, cement ratio matrix.

Low modulus yarns, such as polyethylene, polypropylene, and high modulus Polyethylene and high Density , were used.

In this investigation, the weft knitted fabric had the maximum flexural efficiency factor. [7].

Materials used as TRC

Figure 4 depicts the various textile materials and structures employed in the TRC system. Commercially available nonmetallic textiles for reinforcement (carbon, basalt, glass or polyphenylene bezobisoxazole fibre fabrics) have mesh sizes ranging from 8 to 30 mm and weights ranging from 150 to 600 g/m2, depending on the fibre type. Steel fabrics are made up of unidirectional steel cords (Fig. 4(e)), each of which contains a number of twisted steel filaments, and have a density of 1 to 10 cords per centimetre. The composition of mortar used as a matrix in TRM systems has a significant impact on its reactivity as a composite material since the impregnation of fibres with mortar is crucial for forming a good bond between the fibres and the matrix. Fine grains must be present in mortar, as well as good workability, plastic consistency, low viscosity (to simplify applications on vertical or steep surfaces), and adequate shear strength (for preventing the composite material debonding from the substrate) [8,9].

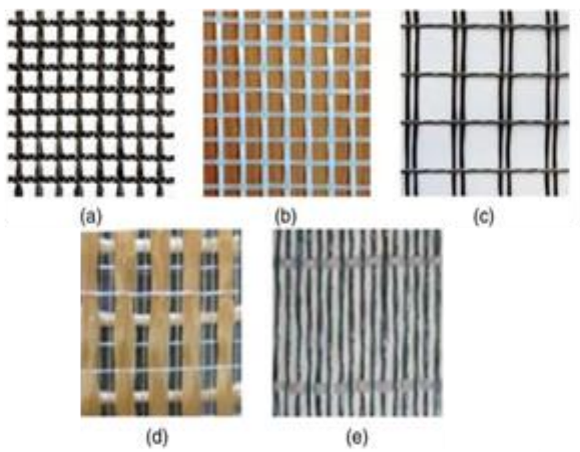

Fig. 4. Textile fiber reinforcements: (a) carbon fiber textile; (b) glass fiber textile; (c) basalt fiber textile; (d) polyphenylene bezobisoxazole (PBO) fiber textile; and (e) steel fiber textile. [8]

TRC Applications

Reinforcing of concrete beams

The use of textile reinforced mortar to strengthen concrete beams in flexure and shear is being researched in a PhD project by Mr. Christian et al. Three distinct types of commercial mortars were used, depending on the type of textile reinforcing. The mortar was mixed until the desired consistency was achieved. To blend the ingredients, an electric power hand mixer was utilised. The placement of the textile reinforcement was marked on each beam. Water was sprayed on the surface of the beam, and the excess water was swept away with a brush. This is done to clean the beam's surface of any dust or loose particles. To embed it, it was lightly troweled into the mortar. The textile reinforcing grid was centred over the concrete beam and put over the initial layer of mortar. To ensure that it was properly entrenched, it was lightly troweled into the mortar. A second coat of mortar was quickly applied. This covering was approximately 5 mm thick. After that, the surface was smoothed with the trowel. It was a little more difficult to apply the mortar to the vertical faces of the beam, and extra caution was required to avoid the mortar falling to the ground. Before applying the final layer of cement, the grid was lightly pressed into position using a trowel. The entire surface was smoothed with a trowel. The extra mortar was removed and the mortar surface was wetted again because it was a very sunny day and the mortar was drying very quickly. Three people completed the procedure of reinforcing each beam, which took around 90 minutes. The length of time it takes to reinforce the beams underscores the importance of finding a quicker solution [10].

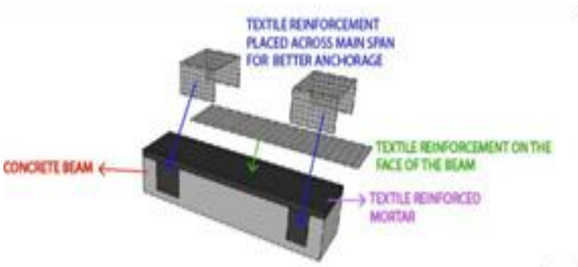

Fig. 5. Beam strengthening design

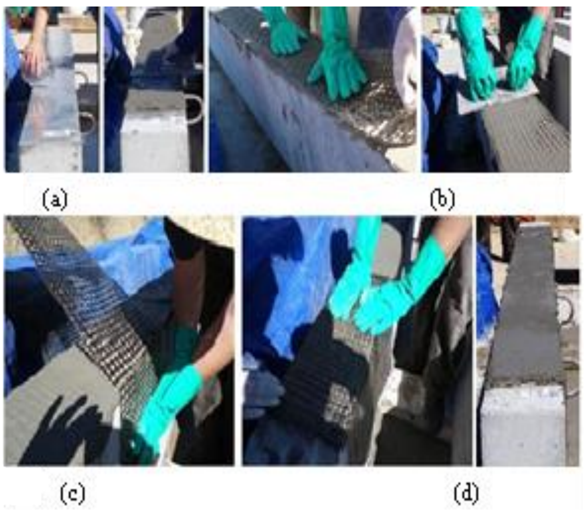

Fig. 6. Beam strengthening steps: (a) application of water and the first layer of mortar respectively, (b) Placing the textile grid and troweling it in the mortar, (c) Installing the grids across the beam for better bonding of TRM on main span, (d) strengthened beam appearance

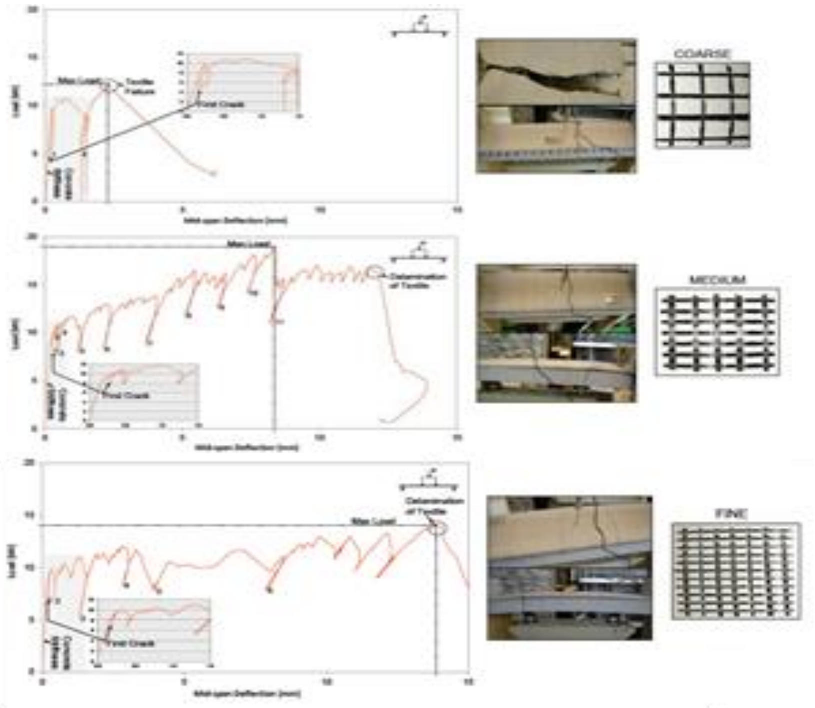

Fig. 7. Load versus mid-span deflection for coarse, medium and fine specimen [11].

Reinforcing Concrete Slabs

The four-point bending test was used to create and assess textile reinforced concrete utilising three distinct carbon fabric constructions. The results of the four-point bending test for each of the three carbon textile mesh options, coarse, medium, and fine, are displayed in the table below (Figure 7.) Initial cracking was around 10 kN in all alternatives, followed by recurrent through-going cracks till failure. Textile failure was evident in the coarse specimen, however delamination was seen in both the Medium and Fine specimens. Fine had the highest ductility of 14 mm, while Medium could withstand a force of 18 KN. The observed outcome was expected because Medium has the largest cross-sectional mesh area [11].

Reinforcing concrete Columns

The efficiency of textile-reinforced mortar is investigated by Dionysios et al. TRM jackets are a method of confining reinforced concrete columns that have limited capacity due to longitudinal bar buckling. By comparing TRM to fiber-reinforced polymer (FRP) jackets of comparable stiffness and strength, the efficiency of TRM against FRP can be determined. The tests were conducted using short prisms under concentric compression and nearly full scale nonseismically detailed RC columns subjected to cyclic uniaxial flexure with constant applied loads. According to compression tests on 15 RC prisms, TRM jackets improve compressive strength and deformation capacity by delaying buckling of the longitudinal bars; this gain increases with the volumetric ratio of the jacket. TRM jackets are slightly less effective than FRP in terms of increasing strength and deformation capacity in this investigation, by about 10%. According to studies on nearly full-size columns under cyclic uniaxial flexure, TRM jacketing is notably useful (and similarly effective as its FRP counterpart) in boosting the cyclic deformation capacity and energy dissipation of old-type RC columns with low detailing by delaying bar buckling. According to the test results presented in this work, TRM jacketing is an extremely promising method for confining reinforced concrete columns, particularly those with poor detailing in seismic zones. [12].

Another study on reinforcing concrete columns by Regine Ortlepp et al. looked at all possible cross-sections of columns, from square to circle, with various radius changes. As a result, the influence of the transition radius on the local-bearing capacity of the reinforcing textile was measured. In addition, the effects of different fibre types and TRC strengthening layer reinforcement degrees have been studied. The first results show a considerable disproportionate increase in the confinement impact as the transition radius increases, as well as an increase in the confinement effect when the TRC strengthening layer level of reinforcement increases.

Short columns with a 30 cm height were built. As indicated in Figure 8, the cross-section has been considered as a square with a size of 15cm 15cm [sample no. 1] to a circle with a diameter of 15cm [sample no. 6]. As a textile grid, Ar-glass (1200 tex) and Carbon (800 tex) were employed Figure 8.

Textile-Reinforced Concrete can boost load-carrying capacity, according to the experiments. When compared to the reference series, textile reinforcing layers (series 3–5) increase load-carrying capabilities for all column geometries (Figure 11).

Finally, for practical usage of TRC for strengthening columns, it is critical to round the edges as much as possible to maximise the confinement effectiveness. [13].

Reinforcing concrete Arches

Florentia A. Kariou et al. explore the effectiveness of the (TRM) strengthening technology on clay brick masonry arches. Eight half-scaled samples were subjected to static monotonic loading for a quarter length of the span till failure. As experimental parameters, the quantity of TRM layers, the textile material, and the strengthening design, i.e., application in the extrados or intrados, were all utilised. When compared to the control sample, all reinforced samples demonstrated increased deformation capacity and maximum load. [14].

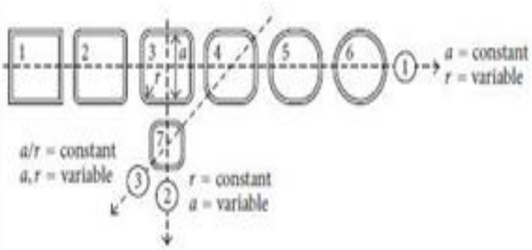

Fig. 8. Schematic depiction of the connection between the examination parameters

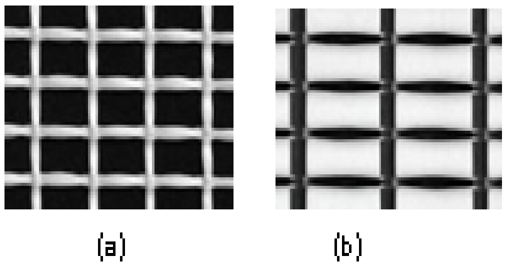

Fig. 9 Used TRC for reinforcing coloumn: (a) textile out of alkali resistant glass fibers (AR-glass), (b) textile out of carbon fibers

Fig. 10 Test setup of strengthen column

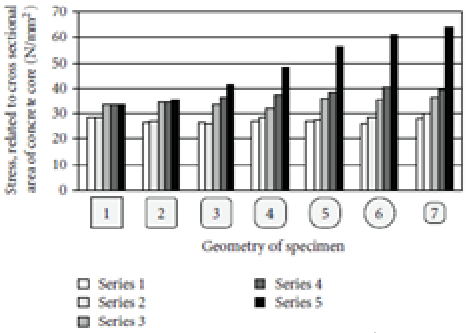

Fig. 11 Load-carrying capacity of the reinforced columns in dependence of the geometry

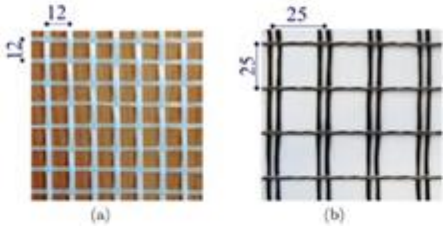

Fig. 12 TRM used for reinforcing arches (a) coated glass, (b) coated basalt and corresponding mesh sizes considered in this study [14].

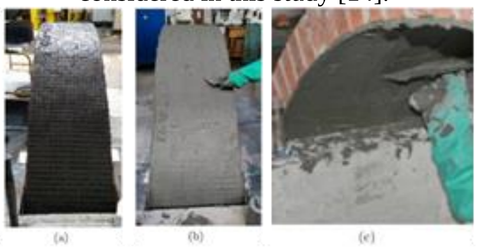

Fig. 13 Arch reinforcing steps: (a) Application of basalt textile into the mortar, (b) extrados, (c) intrados final strengthening configuration [14].

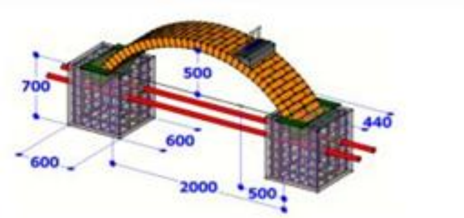

Fig. 14 Geometry and load configuration of arch reinforced with TRM [14]

Reinforcing BARREL-SHELL structures

Reinforced with textiles Due to its material properties, concrete is ideal for the creation of complex geometries, such as roof structures. Forming (bending or folding) two-dimensional building components, for example, can increase bearing capacity. The barrel shell pieces in Fig.16 can be realised due to the ease of shaping fabrics into curved shapes. Even for reinforced concrete structures, simple channel-section folded beams are one of the most cost-effective methods of construction. The shell effect of thin concrete can be relatively successful in barrel-shell roofing. The structure is exceptionally light-weight, with a material thickness of 2.5cm in textile-reinforced concrete, and the shell is robust in both the longitudinal and lateral directions. With a structural depth of roughly 50cm and a span of up to 8m, this type of TRC structure can be used in a variety of ways. [15,16].

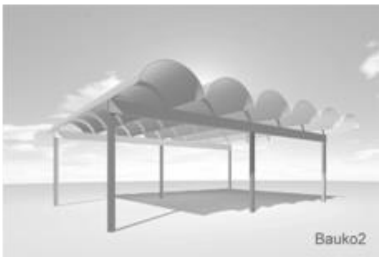

Fig. 15 Design of TRC barrel shells [15,16].

Conclusion

There are several issues with concrete that must be addressed. Thickness, high weight, cracking, and thermal bridges are examples of these issues. Textile reinforced concrete (TRC) was utilized to overcome this problem for reinforcing and repairing mortars, walls, and concrete. Textiles have been using a variety of materials such as carbon fiber, glass fiber, basalt fiber, polypropylene and steel fiber. Also, varieties of constructions were used such as weft knitted, warp knitted and woven structures, and methods. This article classified different materials and constructions for the purpose of reinforcing concrete. Also, TRC were applied in different concrete elements such as columns, beams, slabs, arches and barrel shells. TRC gave good results in reinforcing concrete elements and solved corrosion, high thickness, weight problems by different textiles techniques.

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