

EFFECT OF SHORT POLYPROPYLENE FIBRE CONTENT ON THE MECHANICAL PROPERTIES OF TEXTILE-REINFORCED ENGINEERED CONCRETE COMPOSITE

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Abstract

The disadvantage of textile-reinforced concrete (TRC) composite was the sensibility with the cracking of the cementitious matrix. So, the addition of short fibres or powder in different natures to improve the ductility of concrete could be a solution to overcome this weakness. This can lead to an alternative material that has remarkable tensile properties and satisfies the current material requirements. Over the last decade, the textile-reinforced engineered cementitious composite (TRECC) material has been increasingly and widely applied in the civil engineering field. This paper presents experimental results at the mesoscale on the mechanical properties of ECC and glass TRECC materials in which the polypropylene fibres were added to the concrete matrix to improve the ductility of the composite. The experimental tests were performed on ECC and glass TRECC specimens according to the ASTM and European standards. As a result, the addition of polypropylene fibre enhanced the flexural tensile strength of ECC specimens (up to 20.52%), the bonding strength of the glass textile/ECC interface (up to 26.62%) as well as ultimate strength of glass TRECC (up to 11.29%). From that, the effect of short polypropylene fibre content in glass TRECC on its mechanical properties was highlighted and analyzed. With a highest content of PP fibre (0.6% by weight of cement), the improvement was 20.52% for flexural tensile strength of concrete, 11.29% for TRECC tensile strength and 26.62% for the bonding strength of the interface.

Keywords:

Engineered concrete composite;
 Textile-reinforced concrete;
 Polypropylene fibre;
 Fibre content;
 Mechanical properties.

1 Introduction

Over the past recent decades, Engineered Cementitious Composite (ECC) material has been widely studied and applied in the civil engineering field [1, 2]. In this material, short fibres or/and powder in different natures were added to improve the mechanical properties (especially ductility) of concrete. Furthermore, in some necessary cases, this material was also reinforced by the continuous fibre in different forms such as mesh, textiles, and grid [3, 4]. With the high performance of artificial fibres of textiles, the textile-reinforced engineered cementitious composite (TRECC) material presented remarkable properties in tensile [5, 6]. Thus, this material was widely and increasingly used for the repairing or/and strengthening of different structures (RC members, masonries, ...). For identifying the mechanical properties, the tensile behaviour of TRECC specimens was characterized by tensile or bending tests [7, 8]. In the literature, there were several experimental studies on the mechanical behaviour of ECC and TRECC materials. The following paragraphs present the previous research which focuses on the experimental and numerical behaviour of the ECC and TRECC materials and the effect of the studied parameters on their behaviour.

Azadmanesh et al. [9] studied the influence of styrene-butadiene and ethylene-vinyl-acetate-based resin content on the mechanical properties of ECC materials. Cai et al. [10] developed the components for a superplasticizer ECC to produce coatings with high elasticity and remarkable fire resistance. Nano-silica materials were added to the composition of ECC to manufacture a superplastic

material with high destructive strain [11]. George et al. [12] mixed different types of short fibres (PVA – Poly Vinyl Alcohol, PP - Polypropylene and natural fibres) to evaluate the effect of these fibres on the mechanical properties of ECCs. Recently, polypropylene and glass fibres were used to improve the mechanical properties of lightweight concrete exposed to high temperature in the works of [13].

In the work of Abdulkadir et al. [14], the authors have determined an optimal Polyvinyl alcohol (PVA) fibre volume fraction and high volume fly ash (HVFA) replacement of cement in ECC materials by using the technique of multi-objective optimization. As result, the optimal PVA fibre volume fraction was from 1 to 2%, and the fly ash replacement level was about 50–70%. From the experimental data, these authors developed a model to predict the mechanical properties (compressive, flexural and tensile strengths) of ECC material depending on the contents of PVA and HVFA (function of a quadratic polynomial). This model presented a high significance level with a coefficient of determination (R^2) ranging between 87–97% for all the responses considered.

Recently, Alaloul et al. [15] have used crumb rubber, PVA fibre and superplasticizers to replace fine aggregate in ECC material. This study has investigated the compressive strength, flexural strength, direct tensile strength, and deflection abilities of ECC specimens with different contents of crumb rubber and PVA fibre. As a result, depending on the type of ECC specimen strength, the optimal contents of crumb rubber and PVA fibre were identified. For reaching the highest compressive strength of 58.21 MPa, the contents of crumb rubber and PVA fibre were respectively 0% and 1%. The highest flexural strength was 11.49 MPa with the contents of crumb rubber and PVA of 15% and 2.41% while the highest recorded direct tensile strength was 4.3 MPa with the contents of 1% and 15%, respectively. This study concluded the use of concrete containing crumb rubber in structural elements that require less strength such as road barriers, pavement, and sidewalks.

The contribution of the discontinuous short glass fibres (AR chopped strands with the length of 6mm) on the thermomechanical properties of glass textile-reinforced engineered concrete composite at elevated temperatures was highlighted in the study of Homoro et al. [16]. As a result, the thermomechanical properties of glass TRECC at the first and second phases improved two times with the reinforcement of the AR chopped strands. Concerning the ultimate strength of TRECC composite, the improvement of about two times related to that of composite non-reinforced with short glass fibres was observed at a temperature lower than 300 °C. At the higher temperatures, both composite specimens provided a similar value of ultimate tensile strength because of the elevated temperature action on these short fibres.

Regarding the tensile and flexural mechanical behaviour of ECC or TRECC materials, almost all available experimental results showed a strain-hardening behaviour with different phases. For the ECC materials, their mechanical properties depended on several factors such as the water-cement ratio, dimension and length of short fibres, mixing techniques, temperature and use of fly ash in high volume [17], fibre properties, specimen size and geometry, and strain rate [18]. For the TRECC materials, the effect of reinforcement ratio, nature of textile and ECC, structure and treatment of textiles, environmental action, and test setup have been reported in available studies [17-20].

In all short fibres and powder used for ECC materials, polypropylene (PP) fibres were commonly used to enhance the mechanical properties of concrete [21-23]. However, to the best of the authors' knowledge, rare existing results consider the effects of this short fibre on the performance of TRECC at different scales. So, this study aims to contribute additionally to the knowledge concerning the effect of PP fibre content on ECC's properties, TRECC's performance and bond strength between textile and ECC. In this paper, PP fibre was added to the mixture of ECC with three fibre contents of 0.2%, 0.4% and 0.6% by weight of cement. After that, this cementitious matrix was reinforced by glass textile to manufacture glass TRECC material. From the experiment performed on ECC and TRECC specimens, the mechanical properties of ECC (compressive and flexural strengths, Young's modulus), performance of TRECC and bonding strength of the glass textile/ECC interface were identified. The effect of PP fibre content on the experimental results was highlighted and analyzed.

2 Experimental works

2.1 Material used

2.1.1 Reinforcement textile

The glass textile was industrially manufactured in grid form with the dimension of 12 mm x 12 mm (see Fig. 1a). The weft and the warp of glass textiles were structured from 2400 micro-filaments. The cross-section of textile yarn (weft as well as warp) was 1.76 mm². In order to identify the mechanical characteristics of glass textiles, tensile tests were performed on the textile specimens

which was a textile yarn with a length of 400 mm cutting from the glass grid. The two ends of the textile yarn are bonded with steel plates with a length of 100 mm by Sikadur 731 adhesive to ensure that the textile yarn does not pull off before failure (see Fig. 1c). Then, the specimen was placed into the clamping system of the tractor, aligning the test sample vertically and centered with the tractor's loading system (see Fig. 1b). The tensile force was applied to the specimen by moving the tractor at a speed of 1 mm per minute. The test procedure used on glass textile specimens was according to ASTM D6637, and the experimental results are presented in Table 1 below.

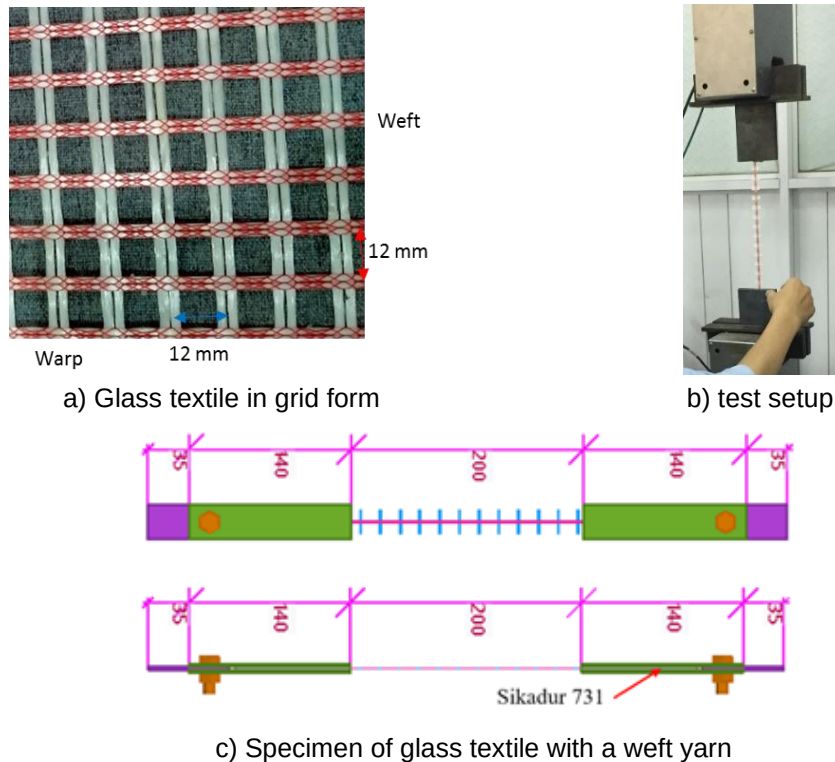


Fig. 1: Glass textile used for TRECC material.

Table 1: Mechanical characteristics of glass textile.

Type of textile	Tensile strength [MPa]	Tensile strain [%]	Young's Modulus [GPa]
Glass textile	2120.28	16.07	129

2.1.2 Fine-aggregate concrete

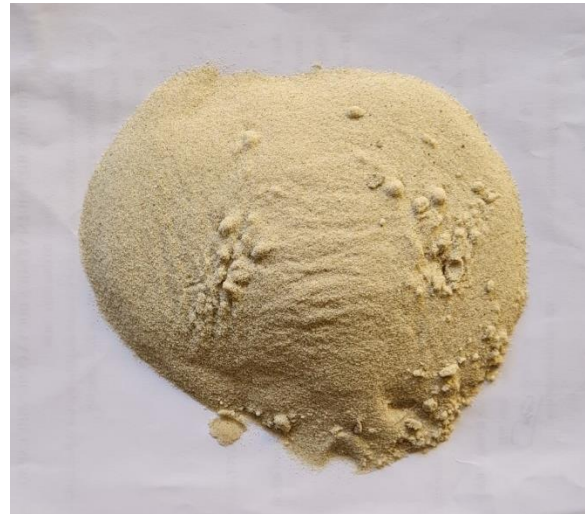
The mixture composition of fine-aggregate concrete used in this experimental study was designed following the works of Ngo et al. [23]. The main aggregates of fine-grained concrete were river sand 1 with an aggregate diameter ranging from 0.3 mm to 1 mm and river sand 2 with an aggregate diameter ranging from 0.1 mm to 0.3 mm (see Fig. 2 a, b). A sufficient amount of Pha Lai fly ash was added to the mixture composition to reduce the amount of cement used. The superplasticizer Polycarboxylate R-209 in powder (see Fig. 2c) form was used to increase the workability of fine-grained concrete, increasing the ability to penetrate the glass textile. The mixture composition of fine-grained concrete is presented in Table 2 below.

Table 2: Mixture of engineered concrete composite.

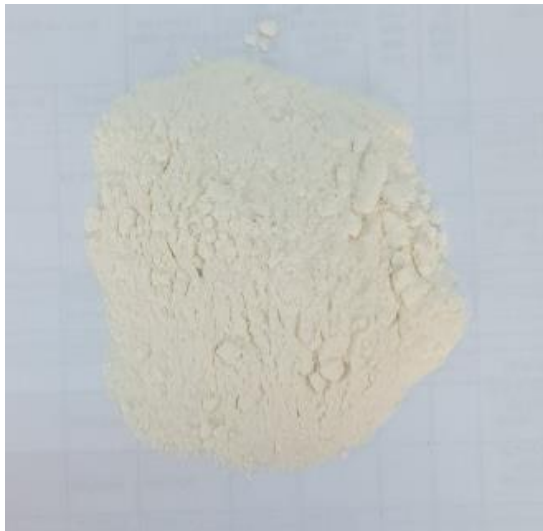
Composition	Mark - Original	Type	Content [kg/m ³]
River sand 1	Phong Dien - Quang Ninh – Viet Nam		942
River sand 2	Mong Cai - Quang Ninh – Viet Nam		626
Cement	Xuan Thanh	PCB40	600
Fly ash	Pha Lai	F	110
Water			233
Superplasticizer	Sika	Polycarboxylate R-209	2.4
Short fibre		Polypropylene fibre	(0, 0.2%; 0.4%; 0.6%) by weight related to cement



a) River sand 1



b) River sand 2



c) Polycarboxylate R-209



d) Polypropylene fibre

Fig. 2: Image of mixture composition used for fine-aggregate concrete.

2.1.3 Polypropylene fibre

Polypropylene (PP) fibres used in this study (commercial product) have a low density of 0.91 g/cm^3 , high tensile strength of around 650 MPa and length ranging from 5 to 6 mm. They have a multi-directional reinforcing effect to protect concrete against micro-cracks. So, adding PP fibre helps the ECC specimen improve tensile and flexural strength. According to previous studies [24] [25], the authors choose the range of the PP fibre contents from 0% (referent specimen), 0.2%, 0.4% to 0.6% related to the weight of cement.

2.2 Specimen preparation

2.2.1 ECC specimens

In this study, all ECC specimens were molded in laboratory condition. This material has an aggregate diameter of $D_{\max}$ less than 1 mm, so it can be considered a type of cement mortar. To ensure the ECC mixtures with high uniformity and workability, it is necessary to use conventional forced mixers with mixing speed regulators. Before mixing, the mixer was prepared and cleaned to avoid impurities (see Fig. 3a). The ECC manufacturing process includes two phases as follows:

Phase 1: Dry mix two types of sand aggregate in one minute. Continue adding the cement and fly ash mixture and continue mixing for one minute. Add the short PP fibres and powdered superplasticizer to the dry mixture and continue mixing for one minute.

Phase 2: Add 70% of the required amount of water to the mixture mixed in phase 1 and mix for 3 minutes until it turns into a plastic state. Add another 30% water slowly and rotate at high speed for about 5 minutes to achieve the required workability. Total mixing time is about 10 minutes.

There were two types of ECC specimens. The first (called ECC1 specimens) with dimensions of 160 x 40 x 40 mm (length x width x thickness) aims to determine their flexural and compressive strengths (see Fig. 3c). The second (called ECC2 specimens) was ECC cylindrical specimens with standard size 150 x 300 mm according to ASTM C192 [26] in order to determine the Young's modulus of ECC specimens and to compare and verify with the compressive strength results of ECC specimens according to cement mortar standards (see Fig. 3d).



a) Preparation of concrete mixer



b) ECC in fresh status



c) Specimens with dimensions of 40 x 40 x 160 mm (ECC1)

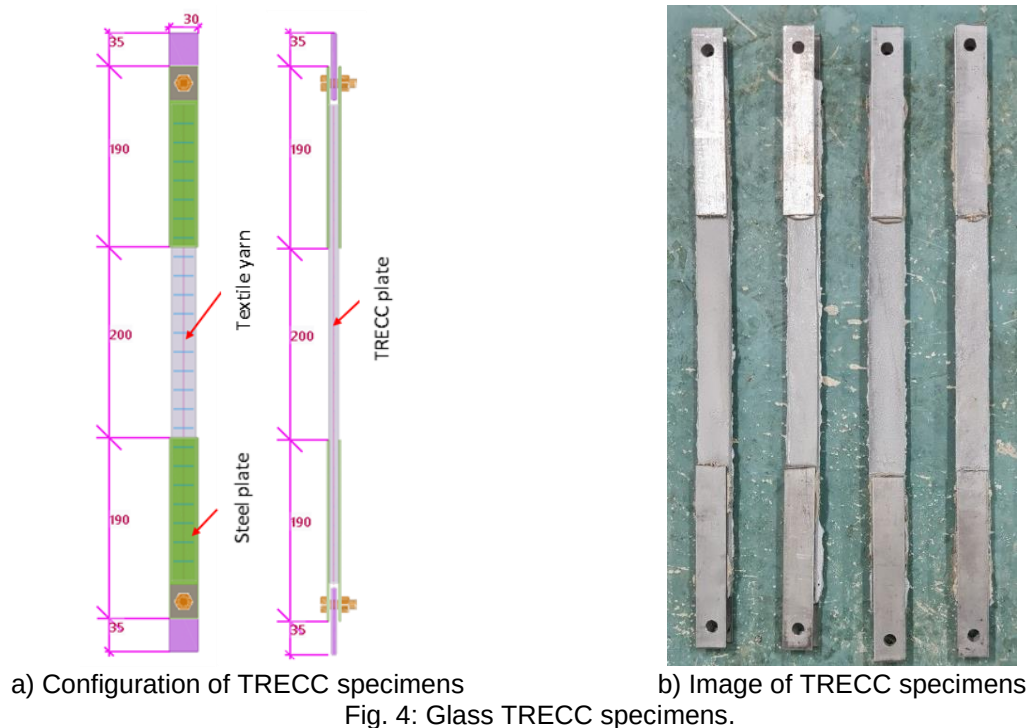


d) Standard specimens with dimensions of 150 x 300 mm (ECC2)

Fig. 3: Preparation of ECC specimens.

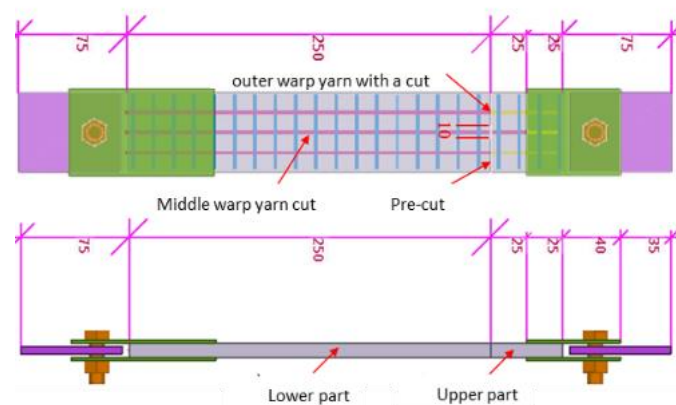
2.2.2 TRECC specimens

TRECC specimens were manufactured with the dimensions of 600 x 25 x 10 mm (length x width x thickness) at the LAS-XD 72 laboratory of the University of Transport Technology. In the cross-section of TRECC specimens, there was a textile yarn which was in the middle along the length of the TRECC specimen. In order to reinforce two ends of the specimen, they were bonded to the steel plates with Sikadur 731 glue to avoid the stress concentration which could lead the failure of specimens. The experimental specimens are named TRECC-ref, TRECC-1, TRECC-2, and TRECC-3 respectively, corresponding with the PP fibre content of 0%, 0.2%, 0.4% and 0.6% related to cement weight. Fig. 4 below shows the image of TRECC specimens before testing.



2.2.3 Pull-out test specimens

The experimental specimens were TRECC plates with dimensions of 300 x 55 x 10 mm to match the mesh size of the glass textile. The pull-out specimen was divided into two parts (upper and lower part) by a pre-cut to pre-locate the crack position. The upper part was 50 mm and the lower part was 250 mm in length. This configuration ensures that the glass textile would be pulled out of the upper part of the TRECC plate. A glass textile with three warp yarns was placed in the middle of the TRECC plate. However, there was only one warp (in the middle) along the length of the specimen from the bottom to the top and embedded to the top for a length of 25 mm. The two outer warp yarns were cut at the position of the pre-cut. The remaining width of the TRECC plate at the pre-cut position was 10 mm. The experimental specimens were labelled T_{ref} , T_1 , T_2 , and T_3 respectively, corresponding with the PP fibre content of 0%, 0.2%, 0.4% and 0.6% cement content. Fig. 5 presents all the configurations of specimens, specimen preparation, and pull-out test setup in this study.





(b) Specimen preparation



(c) Specimens



(d) Pull-out test setup

Fig. 5: Experimental works for pull-out tests.

2.3 Experimental methodology

2.3.1 Flexural tensile strength

The ECC's flexural tensile strength was identified from the three points bending tests performed on ECC1 specimens according to European standard BS EN 196-1 [27]. Fig. 6a shows the configuration of the flexural tests. The flexural tensile strength is calculated by the following equation:

$$\sigma_{ft} = \frac{3 P \times 106.7}{b^3} \quad (\text{MPa}) \quad (1)$$

where:

σ_{ft} [MPa] is the flexural tensile strength,
 P [N] is the maximum bending force of each specimen,
 b [mm] is dimension of cross-section (40 mm),
 106.7 [mm] is the distance between two supports at two ends.



a) Flexural tests



b) Compressive tests

Fig. 6: Flexural and compressive tests performed on ECC1 specimens.

2.3.2 Compressive strength

The compressive strength of ECC material was identified from the compressive tests performed on the ECC1 specimens after splitting into two parts in the flexural tests. The compressive strength is calculated according to European standard BS EN 196-1 [27] as the following equation:

$$\sigma_c = \frac{P}{A} \quad [\text{MPa}] \quad (2)$$

where:

σ_c [MPa] is the compressive strength of ECC;

P [N] is the compressive force, recorded from the test machine;

A [mm²] is area of the compressive zone (16 mm²) (see Fig. 6b);

In order to verify the compressive strength results of ECC according to European standard BS EN 196-1 [27], the compressive tests also were performed on ECC2 specimens (cylindrical specimens with size 150 x 300 mm) according to ASTM C192 [26]. Young's modulus of ECC was calculated from the experimental data of axial strain obtained from LVDT (Linear Variable Differential Transformer) equipment (see Fig. 7a).



a) Compressive test setup



b) Failure mode of ECC specimens

Fig. 7: Compressive tests performed on ECC2 specimens.

2.4 Summary of tests

Table 3 shows the list of specimens and tests (according to the standard and the corresponding reference in the literature) carried out in this study. They are the tests carried out on specimens of ECC, TRECC, and glass textile/ECC interface with different PP fibre contents.

Table 3: Summary of tests in this experimental work.

No	Designation of specimens	Specimen dimensions (mm)	Type of tests	Reference standards	PP fibre content (% by weight related to cement)	Number of tests
1	ECC1 (ref,1,2,3)	40 x 40 x 160	Flexural and compressive tests	European standard BS EN 196-1 [27]	0, 0.2, 0.4, 0.6 respectively	4x15
2	ECC2 (ref,1,2,3)	150 x 300	Compressive tests	ASTM C192 [26]	0, 0.2, 0.4, 0.6 respectively	4x2
3	TRECC (ref,1,2,3)	600 x 25 x 10	Direct tensile tests	RILEM Technical Committee 232-TDT [28]	0, 0.2, 0.4, 0.6 respectively	4x6
4	T (ref,1,2,3)	300 x 55 x 10	Pull-out tests	Lorenz et al. [29]	0, 0.2, 0.4, 0.6 respectively	4x6

3 Experimental results

3.1 Mechanical properties of ECC

3.1.1 Flexural tensile strength

Table 4 presents the experimental results of flexural tests performed on ECC1 specimens with different PP fibre contents. As a result, ECC material exhibited a progressive increase in flexural

tensile strength with the rise of PP fibre content. The flexural strength of ECC improved from 9.15 MPa without PP fibre to 11.03 MPa (an increase of 20.52%) with 0.6% of PP fibre content.

The enhancement in flexural strength may be attributed to better bonding between the aggregate and cement, with fibres that offer higher bond strength being suitable for use in structural concrete applications [30]. After the curing of concrete, the fibre bridging effect occurred in fibre-reinforced concrete and positively impacted the flexural strength of the material. This effect also contributes to the development of a crack-resistant mechanism, transforming the material from brittle to ductile.

Figure 8 a presents the evolution of flexural tensile strength of ECC specimens depending on the PP fibre content. A non-linear increase can be noted in this development. This phenomenon can be explained as follows: the higher the fiber content, the greater the fiber bridging effect, which enhances the flexural tensile strength of the concrete. However, this also results in increased porosity within the concrete structure, negatively impacting its flexural strength.

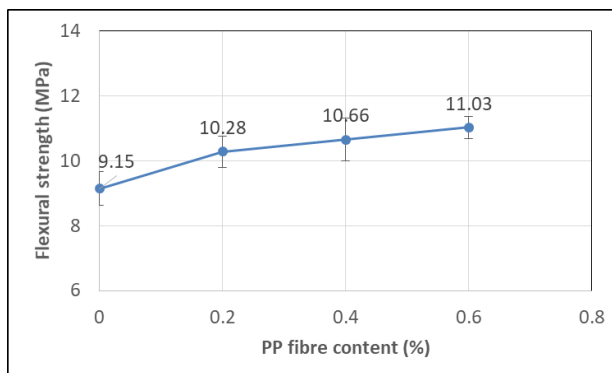
Table 4: Mechanical properties of ECC obtained from flexural and compressive tests on ECC1 and ECC2 specimens.

PP fibre contents [%] by weight of cement)	Flexural tensile strength [MPa]	Compressive strength from ECC1 specimens [MPa]	Compressive strength from ECC2 specimens [MPa]	Young's modulus [GPa]
0	9.15	40.9	39.1	31.6
0.2	10.28	40.7	38.6	30.9
0.4	10.66	39.6	38.0	30.5
0.6	11.03	39.4	36.7	30.2

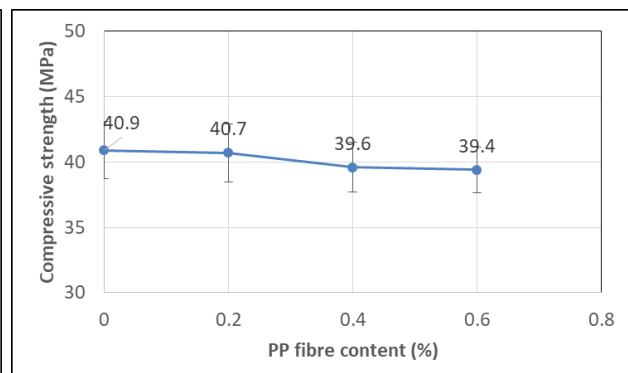
3.1.2 Compressive strength

Table 4 presents the compressive strength of concrete in comparison to the results obtained from ECC1 and ECC2 specimens. There was a little difference (maximum 7.4%) between both results. The increase of short PP fibre content from 0% to 0.6% tends to reduce compressive strength but increases flexural tensile strength. Figure 8b below presents the evolution of mechanical properties of ECC specimens as a function of the PP fibre content. A progressive decrease could be observed for this evolution. This result could be explained due to the increase in fibre volume fraction, the concrete structure has more pore-forming in the curing procedure. As a result, the mechanical bond within the cement matrix weakens, which reduces the overall strength of the concrete. However, the level of this decrease is not large (maximum 3.3%) from 40.9 MPa without PP fibre down to 39.4 MPa with 0.6% of PP fibre content.

A similar result was observed for the Young's modulus of ECC specimens. The formed pores function as initiators of microcracking leading to their low modulus of elasticity compared with ordinary cement [30]. The Young's modulus of ECC specimens reduced from 31.6 GPa without PP fibre down to 30.2 MPa with 0.6% of PP fibre content.



(a) Evolution of flexural tensile strength as a function of PP fibre content



(b) Evolution of compressive strength as a function of PP fibre content

Fig. 8: Flexural tensile and compressive strength of ECC1 specimens.

3.2 Mechanical properties of TRECC

3.2.1 Ultimate tensile strength

The TRECC specimens were applied tensile force by imposed displacement axially with the rate of 3 mm/min until the TRECC specimens were in the failure phase. The maximum force obtained from tensile tests was used to calculate the ultimate tensile strength of TRECC. Table 5 below presents the ultimate tensile strength of TRECC with different PP fibre contents. As a result, the contribution of short PP fibre improved the tensile strength of TRECC from 12.71 Mpa without PP fibre up to 13.94 Mpa with 0.6% of PP fibre content. This result could be explained that with the presence of PP fibre in the matrix, and the anchor system created between the glass textile and ECC before curing, leading to the improvement of bonding strength between the glass textile and ECC.

Based on the ultimate tensile force of TRECC specimens with varying PP fibre content, the tensile stress of the glass textile was calculated and compared to its performance without a cementitious matrix (see Table 1). The tensile strength of the glass textile yarn experienced a 14.8% reduction in capacity in the TRECC specimen without PP fibres. This reduction resulted from the breakage of monofilaments in the glass textile yarn during the preparation of the TRECC specimen. When 0.6% PP fibre content (by weight of cement) was added, the strength still showed a 6.6% reduction compared to the initial value.

Table 5: Tensile strength of TRECC with different PP fibre contents.

PP fibre contents	0%	0.2%	0.4%	0.6%
Tensile stress of glass textile [MPa]	1806	1830,8	1897,6	1980,2
Tensile strength of TRECC [MPa]	12.71	12,88	13.35	13.94

3.2.2. Failure mode

The observation of TRECC specimens shows that when the imposed load increased beyond the tensile capacity of ECC, a horizontal crack appeared in the middle of the TRECC specimen. Then, tensile force continued to increase until a crack suddenly appeared next to the location of the glued steel plate. This crack widened more quickly than the 1st one. Finally, TRECC specimens were in failure by pull-out failure mode of glass textile from ECC plate.

3.3 Pull-out test results

The experimental results were treated and analyzed to calculate the adhesive strength between glass textiles and ECC. The bonding strength is calculated according to Lorenz and Ortlepp [29] as the following equation:

$$f_{avr} = \frac{N}{2bh} \quad (3)$$

where:

f_{avr} - is the average bonding strength between glass textile and ECC,

N - is the maximum pull-out force from the test,

B - is the width of glass textile yarn,

h - is the embedded length of glass textile yarn in the ECC plate.

The experimental results for the bonding strength between glass textiles and ECC are shown in Table 6. The glass textile/ECC interface achieved a bonding strength of 2.93 MPa without PP fibres, which was further enhanced with the addition of PP fibres. When the PP fibre content was 0.2% by weight of cement, the bonding strength increased to 3.42 MPa, representing an improvement of 16.72%. At a PP fibre content of 0.6%, the bonding strength improved by 26.62% compared to the reference specimen. This enhancement was attributed to the fibre bridging effect, which occurs between the gel C-S-H, PP fibres, and the monofilaments of textile yarn. This interaction forms an anchor system between the textile and matrix, thereby improving bond resistance. As a result of this improved bonding, the ultimate tensile strength of TRECC was elevated, as discussed in Section 3.2.1.

The failure mode of the pull-out specimens is shown in Fig. 9. It involved the widening of the crack at the pre-cut position as the pull-out force gradually decreased. Due to the pure friction

between the textile yarn and the cementitious matrix along the embedded length, the textile yarn remained anchored and was not pulled out of the cementitious matrix plate.

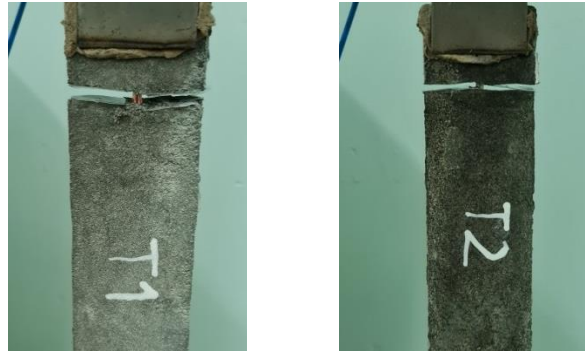


Fig. 9: Failure mode of pull-out specimens.

Table 6: Bonding strength of glass textile/ECC interface.

Specimens	PP fibre contents	Width of textile yarn b [mm]	Embedded length h [mm]	Pull-out force [N]	Bonding strength (in average) [MPa]
Ref	0	4	25	585	2.93
T1	0.2	4	25	684	3.42
T2	0.4	4	25	697	3.49
T3	0.6	4	25	742	3.71

4. Discussion

4.1. Effect of PP short fibre content on mechanical properties of ECC and TRECC

Figure 10 below illustrates the effect of PP short fibre content on the mechanical properties of ECC and TRECC in comparison to reference samples without PP fibre. The results indicate that incorporating 0.6% PP fibre content positively influences the flexural tensile strength of ECC, resulting in a 21% increase. This reinforcement effect is highly favourable compared to previous studies [24] [25]. However, in terms of the compressive strength of ECC, the addition of PP fibre reduces the concrete's density, leading to a gradual decline in compressive strength as the fibre content increases. Regarding to TRECC's strength, the PP short fibres enhances the bonding efficiency between the textile and ECC matrix, contributing to a 10% improvement in tensile strength with a fibre content of 0.6% relative to the cement weight.

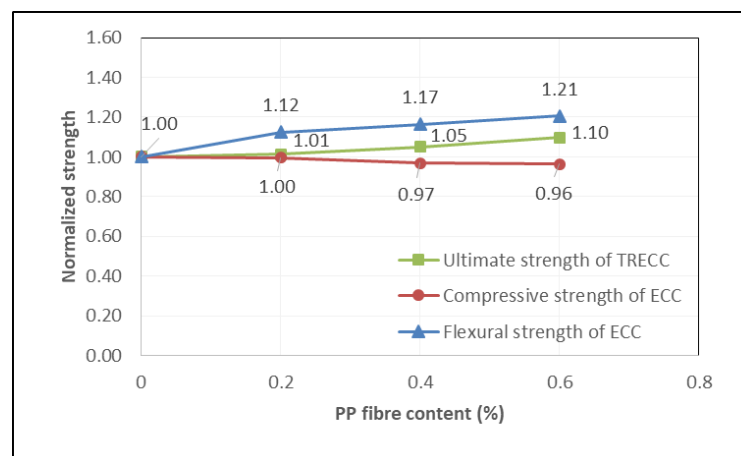


Fig. 10: Effect of PP fibre content on the mechanical properties of ECC and TRECC materials.

4.2. Effect of PP short fibre content on bond strength of glass textile/ECC interface

The experimental results obtained from the pull-out test showed the effect of PP short fibre on the bonding strength of the glass textile/ECC interface. The value of bonding strength in average increased with the rise of fibre content. The positive effect of PP short fibre on the textile/ECC interface could be understood by the interface structure and its strength formation. Generally, the bonding strength of the textile/matrix interface depends on the mechanical capacity of the interfacial transition zone (ITZ) between the textile and cementitious matrix. With the cement-based matrix, the ITZ includes the gel C-H-S that was hydrate products being created from cement paste's curing. So, it could be damaged by the shear stress from the pull-out force along the textile length. When the PP short fibre was added to the ECC composition, its random presentation at the ITZ created the anchor system between the PP short fibre and ECC. It strengthened the ITZ capacity against the shear stress, leading to the improvement of the bonding strength of the glass textile/ ECC interface. With a high content of PP fibre, this improvement was elevated as presented in the experiment.

5. Conclusion

This paper presents the experimental results on the mechanical properties of ECC and TRECC specimens with different contents of polypropylene fibre ranging from 0 to 0.6% by weight of cement. As experimental results, the following conclusions can be drawn for this work:

The fine-grained concrete mixture, consisting primarily of river sand aggregates (with diameters ranging from 0.1 mm to 1 mm), supplemented with Pha Lai fly ash and powdered Polycarboxylate R-209 superplasticizer, demonstrates an acceptable mechanical performance. It achieves a compressive strength of 40.9 MPa, a flexural strength of 9.3 MPa, and a Young's modulus of 31.6 GPa.

The fibre content has a positive effect on the tensile properties and a negative effect on the compressive capacity of ECC material. The flexural tensile strength increased 20.52% corresponding with the fibre content of 0.6% related to cement weight while the compressive strength and Young's modulus decreased with the rise of fibre content.

The anchor system between PP fibre, glass textile, and ECC improved the mechanical properties of the glass TRECC and the bonding strength of glass textile/ECC interface. With a high content of PP fibre (0.6% by weight of cement), the improvement was 11.29% for TRECC tensile strength and 26.62% for the bonding strength of the interface.

Future work: it would be interesting to investigate the evolution of mechanical properties of ECC and TRECC materials with the durability or with different environments.

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