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Review Article

An Overview of Strengthening Concrete Members with Textile Reinforced Mortar

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Abstract

Textile-reinforced mortar (TRM) or fabric-reinforced concrete has a wide range of applications, including repair work, structural strengthening, ditch lining, erosion control, pipe protection, trackways, flood defenses, roofing, and emergency helicopter landing pads. This paper focuses specifically on structural strengthening, particularly shear strengthening and jacketing. According to the findings, among the materials considered, benzobisoxazole (PBO) proves to be the most effective, enhancing the shear capacity of the members by 43.3%, followed by carbon, basalt, and glass fibers. When using fixed materials for strengthening, a U-shaped configuration is more effective than an S-shaped one, increasing shear capacity by 131% compared to 71% for the S-shape. The results also show that increasing the number of textile layers during the strengthening process boosts the shear capacity of the element. Applying the textile layers directly in a straight pattern provides higher capacity than a spiral application. Furthermore, using epoxy resin as a mortar for TRM results in a greater load capacity for column strengthening. A column strengthened with two layers of textiles had more capacity than one with just a single layer. Additionally, when the mortar contains a cementitious material modified with polymer, the flexural capacity is 5.3% higher than that of textiles using cement alone as the mortar.

Keywords: Flexural Strengthening, Jacketing, Shear Strengthening, Textile Materials, Textile Reinforced Mortar

Introduction

Textile reinforced mortar, also called fabric reinforced concrete, is a composite material consisting of fabric reinforcement which is placed in the cementitious mortar. It is known for its light weight and provides tensile strength and ductility to these surfaces which are used for [1]. In recent years, substantial study has been conducted on the durability of TRM (also known as Textile Reinforced Concrete—TRC, or Fabric Reinforced Cementitious Matrix composites—FRCM), which has been summarised by several authors [2-4]. Textile Reinforced Mortar (TRMs) is inorganic (cementitious) matrix-based systems [5]. TRM is also more fire resistant than epoxy-based composites because of the proper mechanical nature and behaviour of the inorganic matrix at high temperatures [6]. These factors which control the property of the textile reinforced mortar are the number of the layers and the thickness of the mortar layer with the type of the textile and the composition of the mortar [7]. Textile reinforced mortar can be used for repairing, strengthening, construction Ditch lining, Erosion control, Pipe protection, Track way, Flood defences, Emergency helicopter landing [8, 9]. The research about this topic started in the 1980's and it was slow in its development and usage by people in construction, but it peaked from 2002 to today [7]. It is made up of two major components: fabric or textiles and mortar, where the composition of the mortar is one of the important things in using textile reinforced mortar because mortar is the zone which transfers the force to the textile after applied on it [9, 10]. These properties which mortar must have must be of non-shrinkage material and must has workability that allow to be used by trowel, and must has high viscosity, and must be capable to stay workable (may be applied more than one layer and during applied second layer the first must stay in wet condition), and must has high shear resistance to prevent early deboning. The strength of textile reinforced mortar depend mostly on the bond between mortar and the textile for this reason the property of the mortar can be improved by using finer cement or adding fly ash or using smaller aggregate particle [7]. Textiles can be made from a variety of materials, including glass, basalt, carbon, polypropylene, benzobisoxazole (PBO), aramid, hemp, and flax. Each one of these materials is able to provide fatigue and corrosion resistance and also has a high strength to weight ratio [7, 8]. Glass is obtained from a non-metallic organic material in which there must be alkali resistance to prevent alkali silica reaction as shown in Figure 1. The process of production were such that the raw material undergoes a temperature of 1250 to 1300 °C at which the glass was yield and after that it were put in the required molds providing coat to the glass for obtaining required surface and bonding its composition [8], while carbon fibre considered as a chemical fibre and the main element used in its production is poly-acrylonitrile and it was pass through three chemical processes, polymerization (for combined monomers), carbonization (for taking any atoms out of the composition except carbon), and graphitization (for surface treatment) at a temperature of 1000 to 3000 °C [9]. It may be coated with sand or uncoated as shown in Figure 2, its tensile strength is 3.3 GPa and its modulus of elasticity is 220 GPa [9]. About Basalt, the process of producing basalt is similar to that of making glass; it is obtained from a mineral source, volcanic rock, and the initial equipment used in its production is almost prohibitively expensive, its appearance is as in Figure 3 [10]. Aramid textile shown in Figure 4 is one of the heat-resistant fibres, with a melting point greater than 500 °C and a wide range of applications. Its history dates back to 1974 [11], while Polyvinyl Alcohol (PVA) with Polyvinyl chloride (PVC) coating textile is one of the materials used in textiles, and it has a lower strength and toughness than others [12], its appearance shown in Figure 5. Based on the function of the textile, which is based on the strengthening purpose (shear, flexural and jacketing for the column), the textile is used in different places, If the textile reinforced mortar

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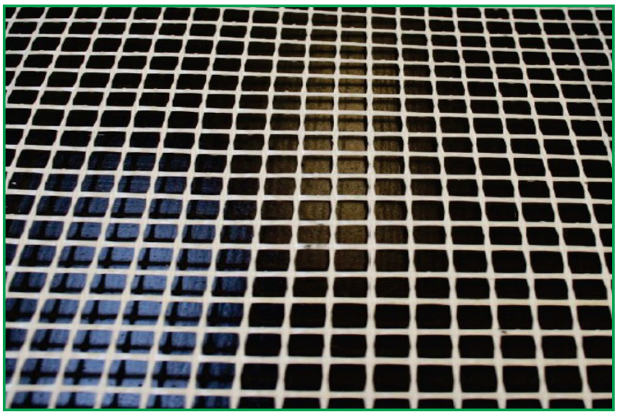

Figure 1. Sample of alkali resistance glass textile [8]

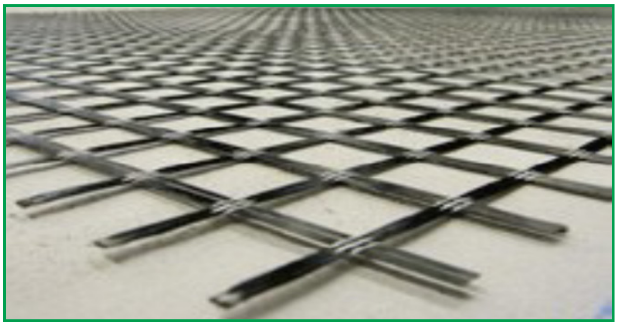

Figure 2. Sample of carbon textile [9]

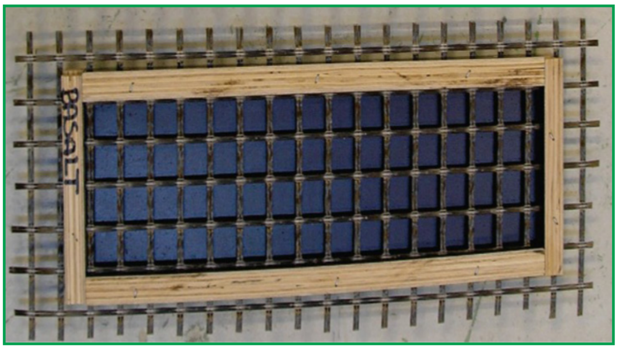

Figure 3. Sample of basalt textile [10]

Figure 4. Sample of Aramid textile [11]

Figure 5. Sample of of PVA textile [12]

used for the shear strengthening, which is done for beam or girder or bridge due to the low or insufficient amount of shear reinforcement, or concrete has low strength or the amount of applied load has increase or due to the shear reinforcement corrosion, it was installed in the shape of the U near supports as in the Figure 6,The use of fibre-reinforced polymer in the flex zone with fibres oriented at forty-five degrees in the shear zone of the joint showed the most significant changes in behaviour [24]. If the textile reinforced mortar is used for the flexural strengthening, it were installed on the face which has tension, as in the Figure 7, if the textile reinforced mortar is used for the column strengthening, it were installed in the box shape surrounding the column, as in the Figure 8 below. Using textiles in construction has so many advantages, such as it has thin layer with high strength, reduce using cement reduce CO2 emission. The original of these materials are more effective and capable to provide more flexibility with more tensile strength and non-corrosive, also require no heavy equipment, can be used at these places which have low temperature, has good fire resistance and can be used over wet area [13]. But it is not indicator to show that this usage is without any problem, but non-applicability on wet surfaces or at low temperatures, lack of vapour permeability, incompatibility of resins and substrate materials. This paper deals with the explaining different between used textile for the different strengthening in the beams and columns with showing effect of each one Longley.

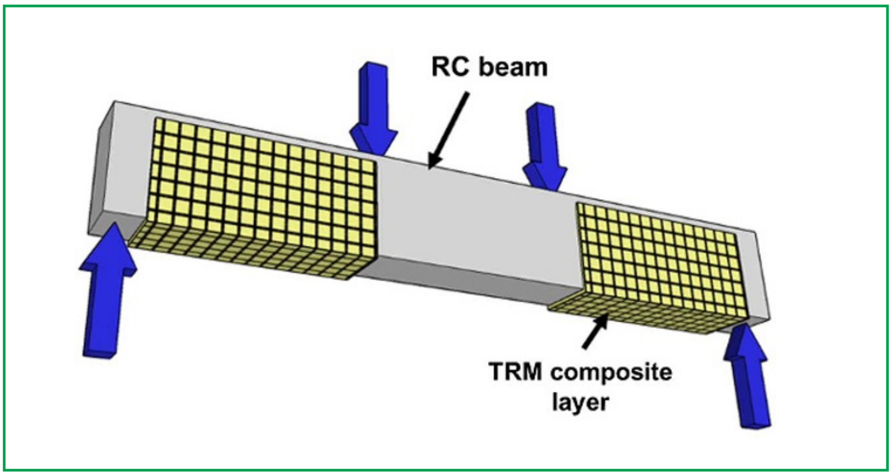

Figure 6. Shear strengthening of an RC beam with U-shaped TRM jacketing subjected to symmetric four-point monotonic loading [13]

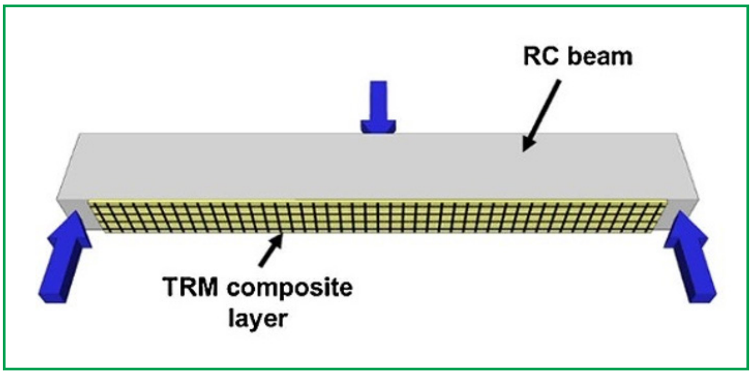

Figure 7. Flexural strengthening of an RC beam with TRM [13]

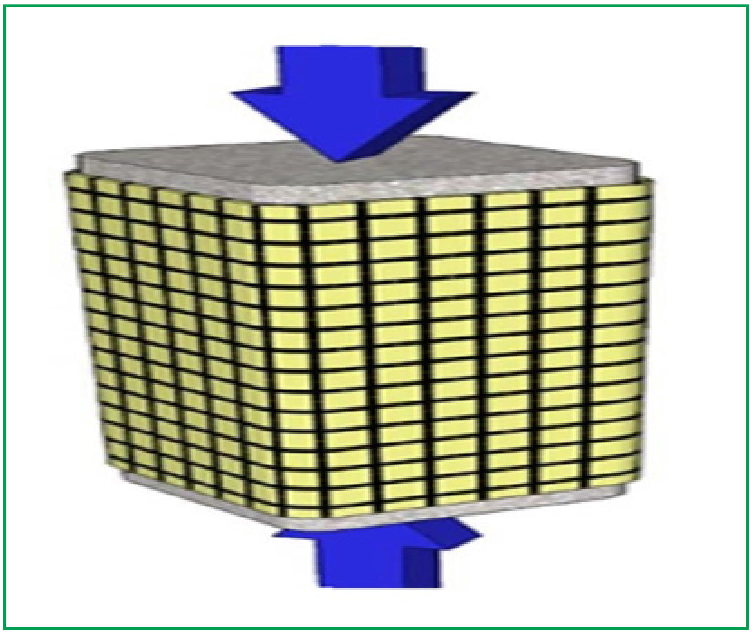

Figure 8. Strengthening for column [13]

Objectives

This paper aims to assess the impact of textile materials and the number of textile layers on the capacity of structural elements during strengthening processes, such as shear strengthening and jacketing. It also seeks to compare the effects of different types of materials and to analyze how the number of textile layers influences the strength of the reinforced members.

Methodology

In the life cycle of any building or any structure, there are many factors which may damage the strictures at any time, such as (changing in the amount of the live load used by the designer or change in the dead load, age of the building, exposure of the structure to fire or steel corrosion, change in the function or removing a load bearing part in the structure, error during construction and seismic cases), so that strengthening is required for damaged elements in the building. This paper presents a state-of-the-art review on the strengthening of concrete structures with TRM, number of previous experimental works have been

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reviewed, of using textile reinforced mortar in strengthening (shear, flexural and jacketing) to analyse and fine the most effective type of the textile for each type of strengthening, also to show the method of placing with number of textile layer on the member strength which used with as explained in the Figure 9, all the reviewed work have been shortly explained in Table 1.

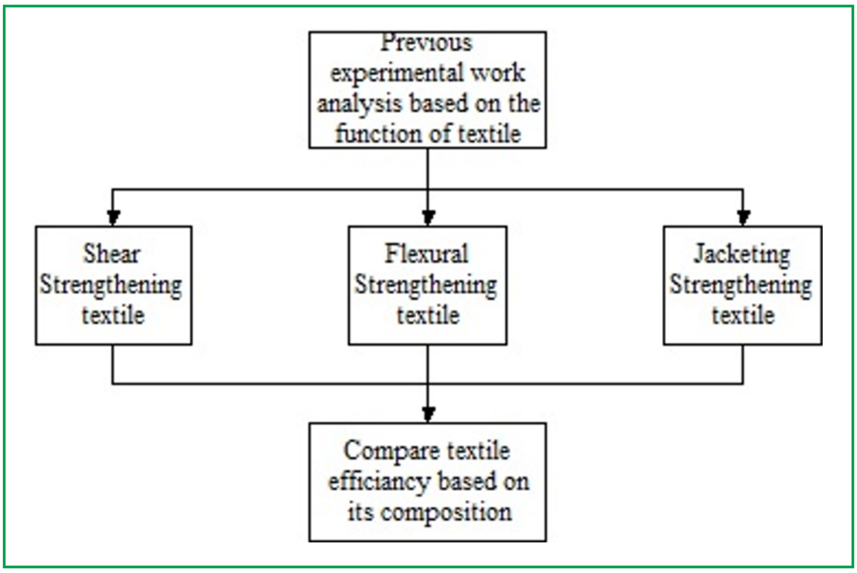

Figure 9. Methodology

Shear Strengthening

Escrig et al. [14] prepared eight different samples with control samples (9 samples) for shear strengthening, By using three different concrete mixes, the first concrete mix compressive strength (fc') was 34.07 MPa, the second mix was 33.78 MPa and the third one was 40.85 MPa., The difference of the compressive strength was done to show performance that the different TRM combinations used were able to increase the load bearing capacity and change their failure mode, and the used steel (Fy) was 517.2 MPa, and the used mortar in the textile reinforced mortar was of four different types, with different properties (PHDM, XM750, XM25 and R3). The used textiles in these samples consist of four different types (basalt, carbon, PBO and glass). The loads are not put in the centre to prevent short shear span effect loading of all the following results obtained, as shown in Figure 10.

Based on the obtained result, carbon textile with the first mortar increases the shear capacity of the member by 36.4% compared to the control sample, while carbon textile with the second mortar increases the shear capacity of the member by 22.4%. Based on the obtained result, benzobisoxazole (PBO) textile with the first mortar increases the shear capacity of the member by 33.6% compared to the control sample, while carbon textile with the second mortar increases the shear capacity of the member by 43.3%. Based on the obtained result, basalt textile with the first mortar increases the shear capacity of the member by 31.9% compared to the control sample, while carbon textile with the second mortar increases the shear capacity of the member by -19.5%. Based on

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the obtained result, glass textile with the first mortar increases the shear capacity of the member by -35.5% compared to the control sample, while carbon textile with the second mortar increases the shear capacity of the member by 35%. These results are indication to that benzobisoxazole (PBO) can be considered as the first material which increase shear capacity of the element and followed by Carbon textile and basalt as a third one.

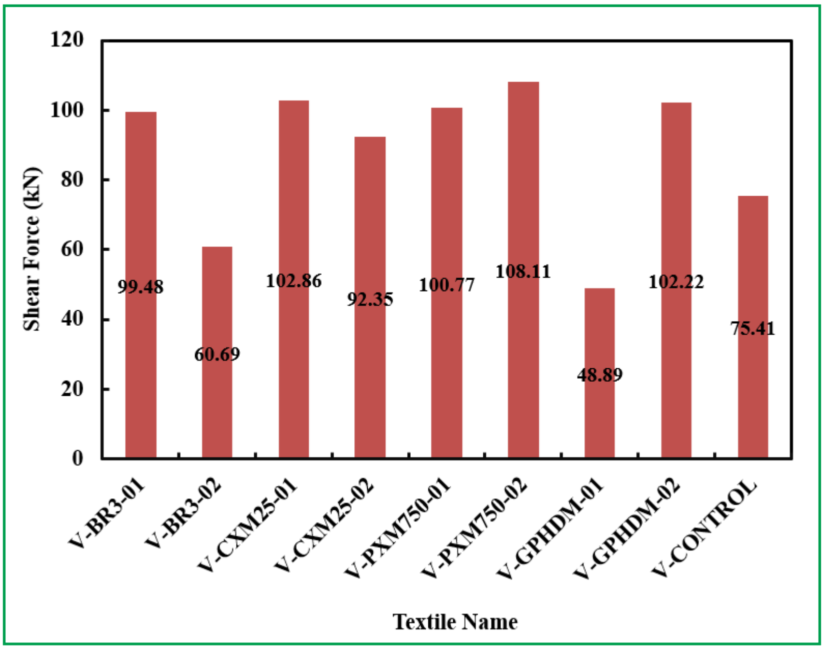

Figure 10. Shear force capacity for samples based on the number of layers and the type of textile

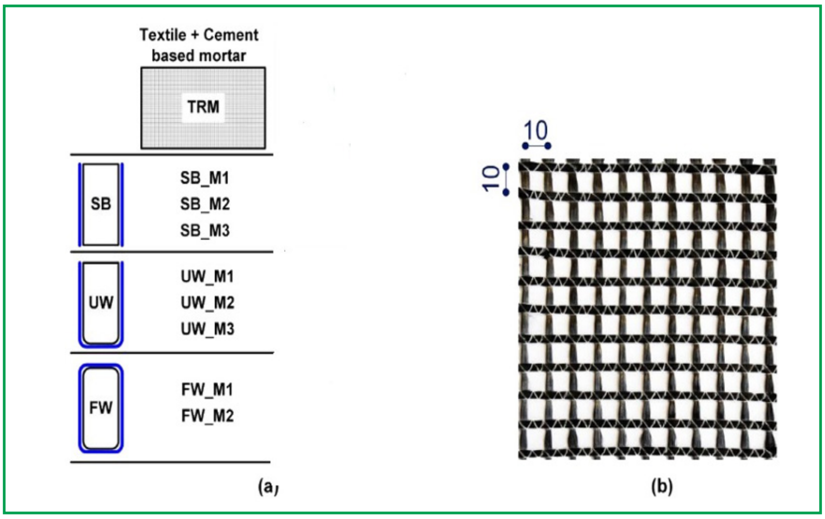

Figure 11. (a) Specimen groups; (b) carbon textile geometry used (mm dimensions) [15]

Tetta et al. [15] prepared nine reinforced concrete beams for shear strengthening, in which eight of them had shear strengthening and one of them served as a control sample and five samples were prepared and strengthened by a fibre reinforced polymer. Prepared textile to be used in the strengthening are installed as described in the Figure 11.

Part a, indicate how to install textile reinforcement mortar on the beams, which in the first part are just installed on the sides of the beams, and in the second part are installed in a U shape and the last one is installed in the surroundings of the beams. Part b depicts the space between the textile's lines. After preparing all samples one by one put under loading as in Figure 12. After testing all samples the following result obtained as shown in the Figure.13.

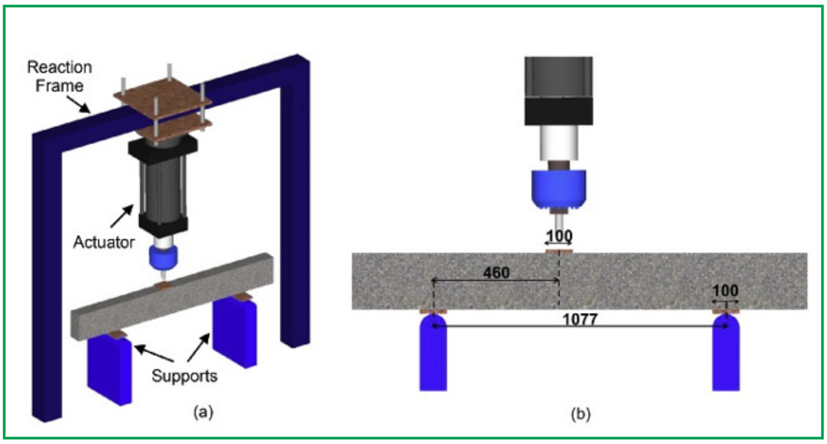

Figure 12. Sample under loading [15]

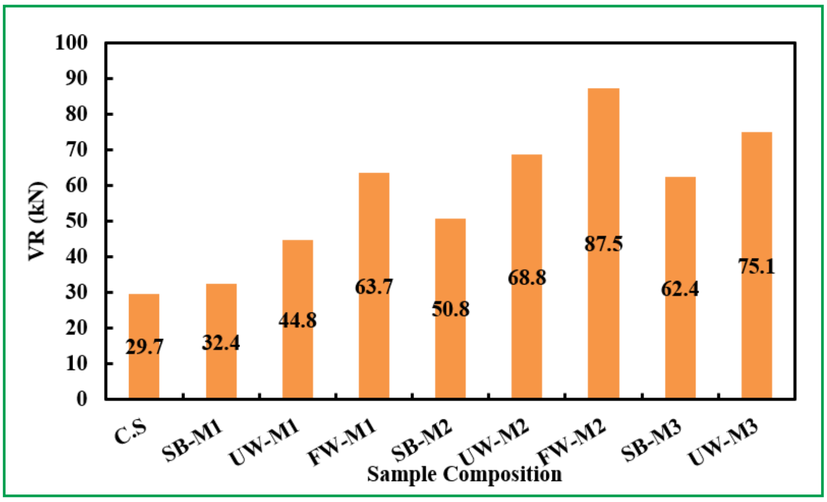

Figure 13. Shear force capacity for samples based on the installed shape of the textile

Based on the obtained results, the strengthening of the beam increase the shear capacity, when textile reinforced mortar used in S- shape of the strengthening increase the shear capacity based on the first mix, by 9.1 % and the amount of increase is 71% for second mix and it was increase by 110% for third mix. When the U-shape is used, the shear capacity increases by 50.8% with the first mix. The amount of increase is 131% with second mix, and it became 152% with third mix. When the full section-shape is used, the shear capacity increases by 114% with the first mix. The amount of increase is 194% with second mix. Tease are indication to that in the strengthening process using textile in full of the element were more effective but it is not aloud all time because internal beam are connected to slab, after that using U shape were more effective than S shape for using textile in the strengthening process.

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Triantafillou and Papanicolaou [16] prepared six samples for shear strengthening with dimensions (150 * 300 * 2600) mm, the water: cement: sand: gravel proportions in the concrete mix were roughly 0.6:1:2.5:3.5 by weight. Used material for the textile purpose is carbon in the width of the element in its mesh is 4 mm and the clear space between them is 6 mm, and its weight is 168 g/m^2, its detail explained in the Figure 14.

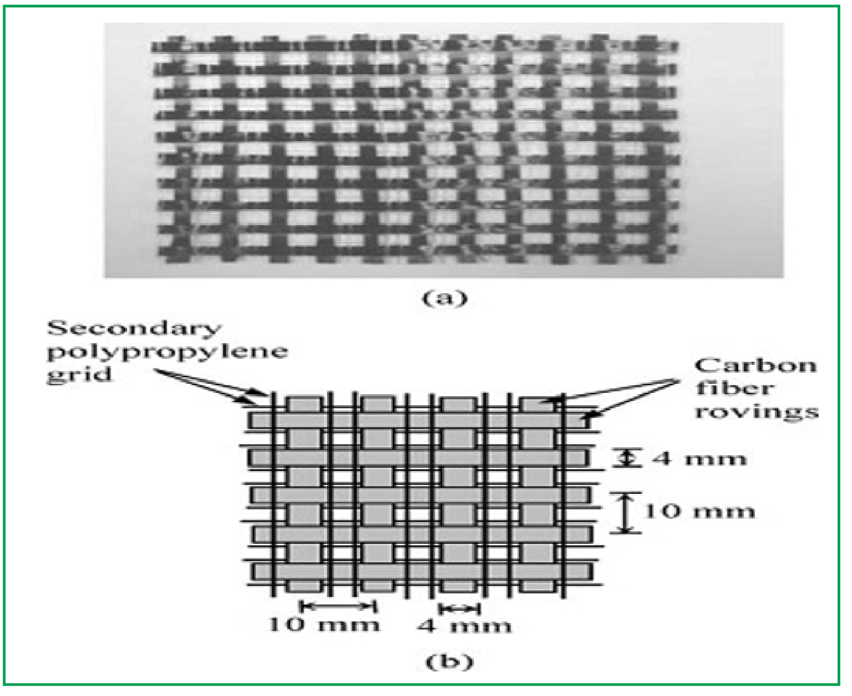

Figure 14. Using carbon textile details

These beams are tested in which four of them loaded by conventional way and two of them tested under cycle load. The first beam was prepared as control sample and has no strengthening (C), the second beam is prepared in which strengthen with two layer of textile with mortar based (M2), and the third one is prepared with two layer of textile but with resin based (R2), the fourth one prepared with two layer of spiral textile mortar based (M2-s) these beams are loaded conventionally. The last two beams are loaded by cycle load and prepared with one layer of textile one of them with mortar based (M1) another one with resin based (R1). Resin properties are as follow, the mixing ratio is 4:1 and the E-value is 3.8 GPa, while its tensile strength is 30 MPa at 7 days of curing. Mortar properties consist of binder (10:1 cement with polymer) with a ratio of 3:1 with water applied by a layer of 2 mm thickness by a trawl. After loading, the following results are obtained as shown in the Figure.15.

Based on obtained result this sample which is prepared from first mortar by using just one layer of the textile the shear capacity of the sample was increase by 71.7%, while for the same sample prepared from same mortar but with two layer of textile the incensement in the sample capacity were 109 %, and if these two layer of textile applied to the sample spirally instead of straight the capacity of the sample was increase by 104 % , these results are indication to that the shear capacity of element was increase by increase number of used textile during the strengthening process and Appling textile layer by straight way give higher capacity to the member than applied it spirally. This sample which prepared with epoxy based resin and one layer of textile, increases the capacity of the element by 124.8% compared to the controlled sample, while for same sample from same base prepared but with two layers of the textile the capacity of the member was increase by 100.3% which is indication that with epoxy resin based in the shear strengthening the number of the textile effect negatively on the member capacity.

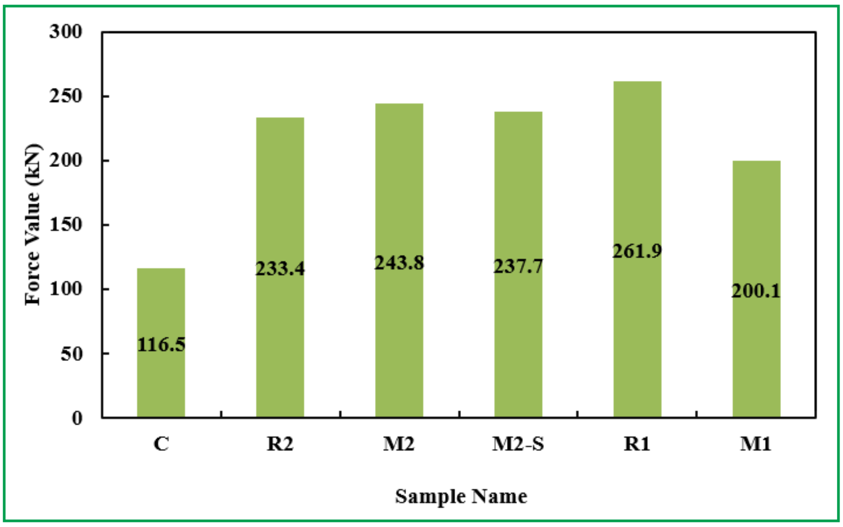

Figure 15. Shear force capacity for samples based on mortar type and number of layers

Column Jacketing

Dinh and Choi [18] prepared eight column samples for column jacketing with two different detailing the first group consist of four beam at which the first one is controlled sample and second with third one has an completely impregnated with epoxy resin while the last one is coated by aluminium oxide over epoxy resin. The second group is same as first while the reinforcement detailing changed. The concrete used in preparing samples had 21 MPa at 28 days and the properties of the used mortar in textiles were the percentage of fine aggregate to granular sand was 3:1 and the compressive strength was 39.56 at 28 days. And the installation was as in the Figure 16. After preparing all of the samples and loading them, the following results were obtained, as shown in the Figure 17.

Based on the results and graph, strengthened samples (S-2, S-3, F-2, F-3) have load capacity more than control sample by 20.3, 41.4, 20.3, 41.4 % respectively, while the fourth sample in both group (S-4,F-4) which different from second and third sample in both group by coating them with AL_2O_3 increase the capacity of the sample by 42%. These points are indications that these samples, which have textile, coated with AL_2O_3 increase the capacity of the samples more than these which just have epoxy resin.

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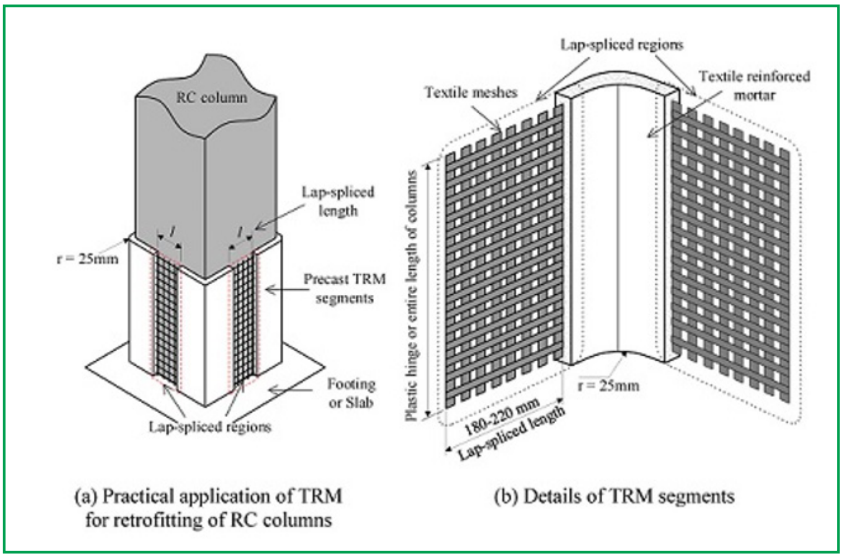

Figure 16. Textile installation in a column

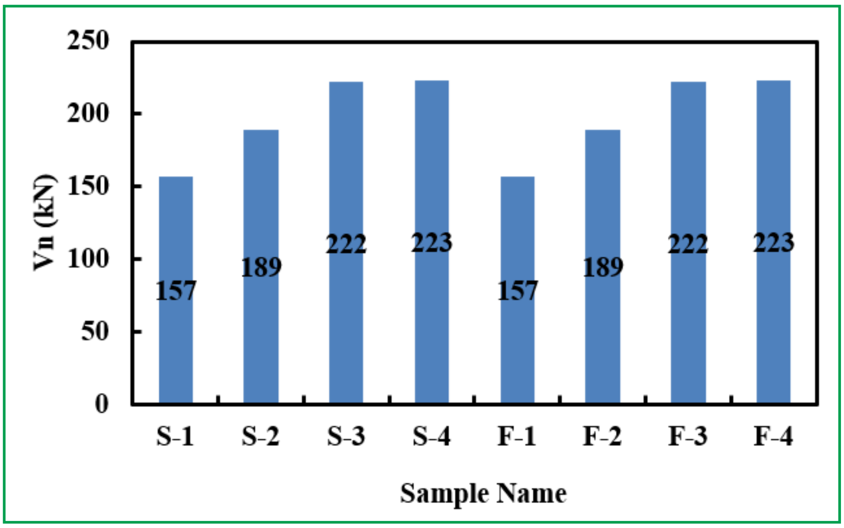

Figure 17. Load capacity for samples based on the number of layers and the type of textile

Triantafillou et al. [16] prepared ten samples for column jacketing, two of them are control samples and another eight samples have a different composition. The concrete used in the samples preparation has mix ratio 1:2:3 and w/c was equal to 0.62. These ten samples are two group(5 samples) first group consist of control sample, sample prepared from mortar I with two layer of textile, sample prepared from mortar II with two layer of textile, sample prepared from mortar I with three layer of textile, last sample prepared with three layer of textile from mortar II). Second group consist of control sample, sample prepared epoxy resin with two layer of textile, sample prepared from mortar II with two layer of textile, sample prepared epoxy resin with three layer of textile, last sample prepared with three layer of textile from mortar II). The used material for textile is carbon. The installation of the textiles on the samples was as shown in the Figure 18.

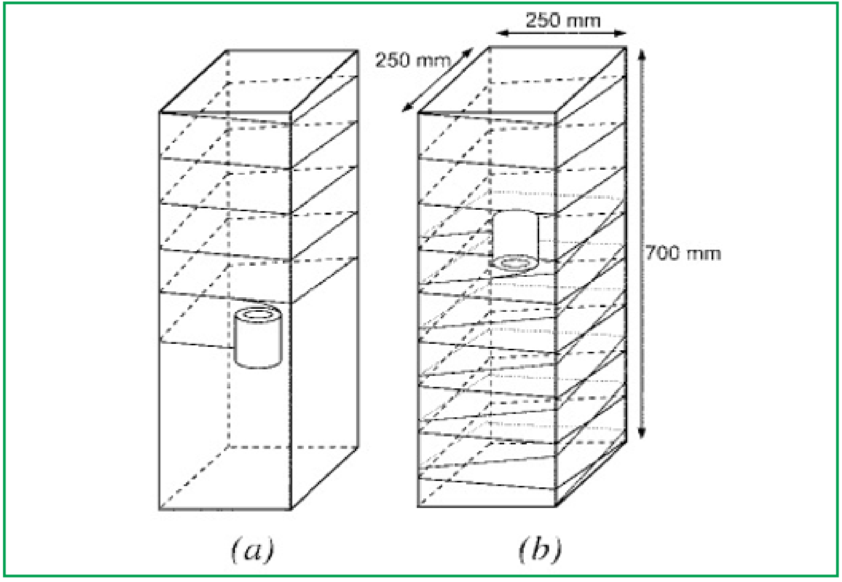

Figure 18. Method of installing textiles on the column

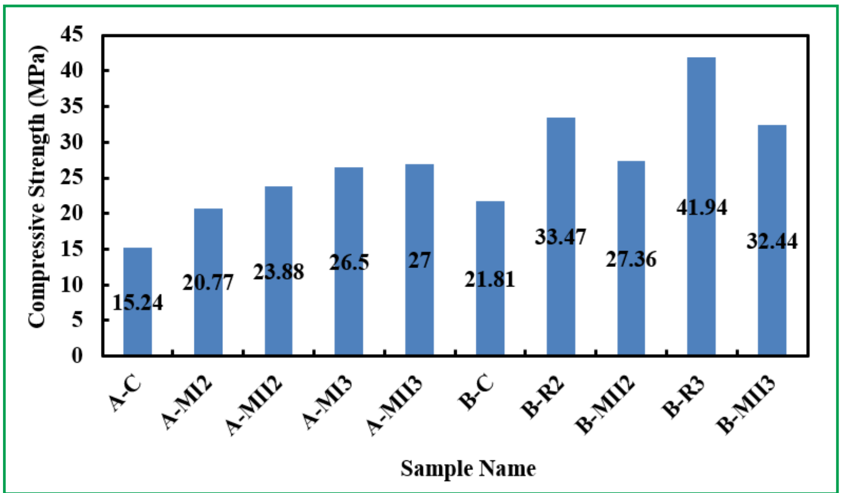

Figure 19. Load capacity for samples based on the number of layers and the type of textile

A denotes the first group of samples, while B denotes the second group. After preparing samples and loading, the following results are obtained as in the Figure 19. Based on the obtained results, sample which prepared from mortar I with two layer of textile increase the capacity of the sample by 36.2% compare to the control sample while sample from same mix but with three layer of the textile increase the capacity of the sample by 73.8% which indicate that the capacity was increase number of textile layer. For this sample which prepared from mortar II with two layer of the textile the capacity was increase by 56.6 % while for the same sample but with three layer of the textile the capacity increase by 77.1% which is another indication for that the capacity was increase by increase number of the layer of textile and also with the increase the quality of the used mortar. For the second group of samples, for this sample which is prepared from mortar II with two layers of the textile, the capacity was increase by 25.4% compared to the control sample, while for the same sample from the same mix but with three layers of textile the capacity was increase by 48.7% which is indicate that the capacity of the strengthen element was increase with the increase of number of textile layer. Another sample which is prepared with epoxy resin mortar and two layer of carbon textile increase capacity of the element by 53.4% compare to the control sample while for same sample but with three layer of carbon textile the capacity of the sample was increase by 92.3 % compare to the control sample which indicate that if the mortar was epoxy resin the capacity was increase more than used cement mortar and also by increase number of textile layer the capacity of the element was increase.

Bournas et al. [20] used strengthening for columns, in which prepared three different mixes, from each mix, prepared five samples at which, the first set of samples did not contain any amount of reinforcement. The first sample was control sample, second sample was textile was installed by using epoxy resin with two layers, third sample was installed by using mortar with four layer of textile, fourth sample was installed with epoxy resin with three layer of textile and last sample in first group was placed by using mortar with six layer of textile.

Second set of samples when prepared from second mix, contained reinforcement by amount was double compare to third mix. Installation of textile in all mix was same methods. After preparing samples from each mix and texting them, the following results as in the Figure 20 were obtained.

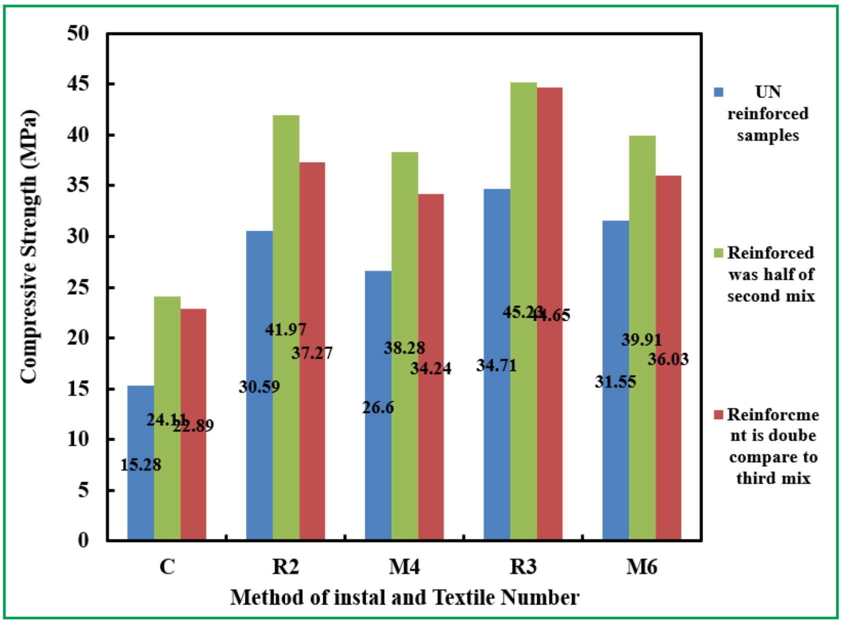

Figure 20. Columns capacity at testing, with different composition

According to the results for unreinforced samples, the column capacity is highest at the sample which has textile with three layers and installed by epoxy resin, after that is this sample which has two layer of textile and installed by epoxy resin and its capacity is lower by 13.45% than first one. For the second mix, these samples, which have a high amount of reinforcement as the first set, installed textile by epoxy resin with three layer has highest capacity but compare to third mix which has normal amount of reinforced the highest capacity in second mix is lower than highest capacity in third mix by 1.3%.

Flexural Strengthening

Park et al. [21] prepared seven samples for flexural strengthening, and the first sample was the control sample and six of them had strengthening for flexural. Three samples are strengthening with alkali resistance glass, and three of them, by carbon textile. One of these samples contained a normal range of reinforcement, the second one was pre-stressed and the third one was in the high range of steel content. After sample preparation, these results were obtained as in the Figure 21.

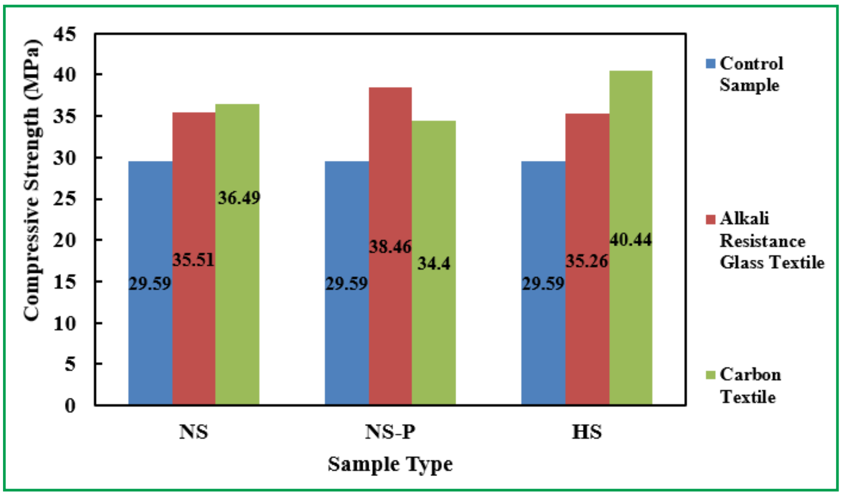

Figure 21. Flexural test results

Park et al. [21] prepared seven samples for flexural strengthening, and the first sample was the control sample and six of them had strengthening for flexural. Three samples are strengthening with alkali resistance glass, and three of them, by carbon textile. One of these samples contained a normal range of reinforcement, the second one was pre-stressed and the third one was in the high range of steel content. After sample preparation, these results were obtained as in the Figure 21.

According to obtained results when samples contain normal amount of steel and strengthened for flexural, Carbon textile provide load capacity 2.76% more than Alkali resistance glass textile and 23.3% more than control sample. When samples are pre-stressed, Alkali resistance glass textile is more effective than the carbon textile by 11.8%, and also more effective than the control sample by 30%. In samples which contain high amounts of steel, carbon textile is more effective than alkali resistance glass textile by 14.7%, and by 36.6% compared to the control sample. Elsanadedy et al. [22] prepared five different samples in which each one is reinforced as in Figure 22.

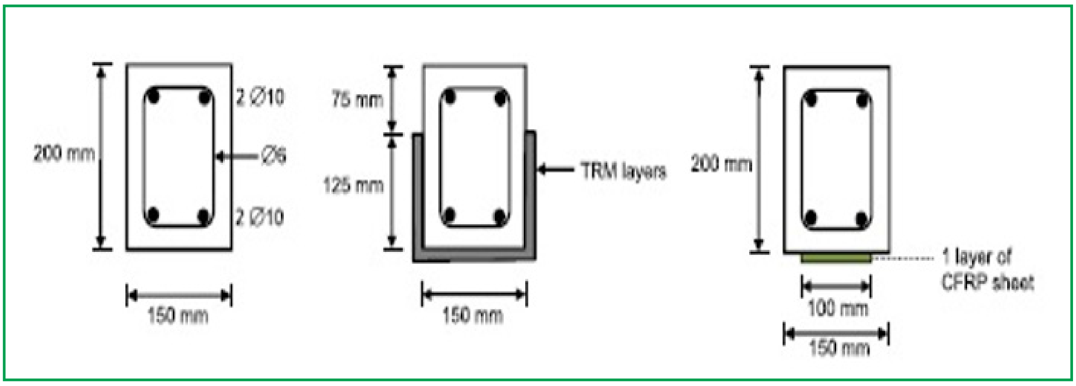

Figure 22. Beam details

The first sample was control sample, second, third and fourth sample strengthened as in second section while the last one strengthened as in the third section. Second sample mortar was conventional mortar with ten layer of textile, while third sample its mortar was polymer modified cementitious mortar with five layer of textile, fourth sample mortar also was polymer modified cementitious mortar with ten layer of textile, last one has one layer of carbon textile with epoxy resin base and after samples preparation complete, tested and following results obtained as in the Figure 23.

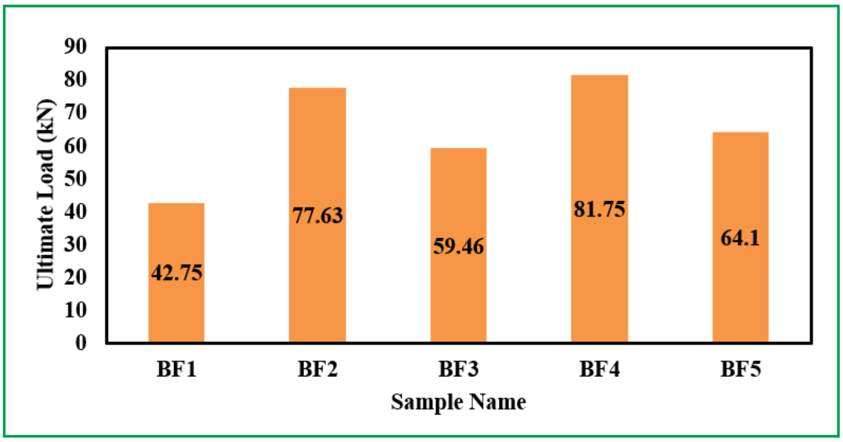

Figure 23. Ultimate load for beams under flexural test

According to the obtained results, carbon textile is so strong since one layer provides an ultimate load capacity smaller by 10% than a ten layer textile reinforced mortar with polymer modified cementitious mortar. Sample BF4 which is strengthened by ten layer of textile reinforced mortar with polymer modified cementitious mortar has higher efficiency than BF2 which is strengthened by ten layer of textile reinforced mortar by 5.3% , which is an indication that if the mortar was modified by other cementitious material were more efficiencies than cement lonely. Raoof et al. [23] prepared four samples in which the first one was a control sample and the second was strengthened for flexural by one layer of carbon textile and the third one was strengthened for textile by seven layers of basalt, and the last one was also strengthened for flexural by using seven layers of alkali resistance glass textile. After samples were prepared and tested, the following results were obtained as in the Figure 24.

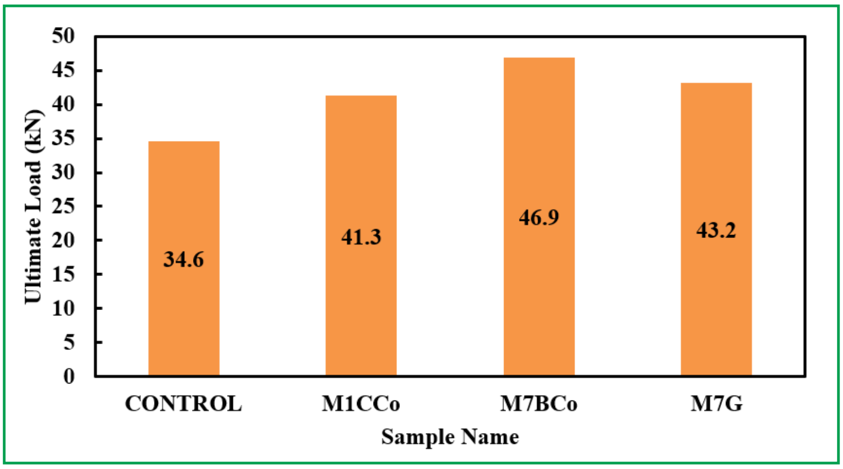

Figure 24. Ultimate load for tested samples

According to obtained result basalt textile is more effective than alkali resistance glass textile by 8.55%. Since the used carbon textile is one layer and provides a load capacity which is lower than the basalt textile (seven layers) by 12%, it is an indication that the carbon textile is stronger than basalt and glass textiles also. Sample which strengthened by Basalt textile provide higher load capacity than control sample by 35.5%. Also sample which strengthened by glass textile provide higher load capacity than control sample by 24.8%. Sample which strengthened by carbon textile provide higher load capacity than control sample by 19.3%.

Table 1. Detail of reviewed papers

Ref No.	Author	Paper Title	Year	Conclusion
[14]	Escrig, C., Gil, L., Bernat-Maso, E., & Puig-vert, F	Experimental and analytical study of reinforced concrete beams shear strengthened with different types of textile-reinforced mortar	2015	Used basalt, carbon, PBO and glass as textile material in different sample for shear strengthening, PBO was stronger one followed by carbon and basalt.
[15]	Tetta, Z. C., Koutas, L. N., & Bournas, D. A.	Textile-reinforced mortar (TRM) versus fiber-reinforced polymers in shear strength-ening of concrete beams	2015	Used three different shape for apply textile for shear strengthening including (S-shape, U-shape and F- shape full section). Based on result, F-shape is stronger than U and U stronger than S-shape in shear strengthen-ing.

Table 1. Continued

Ref No.	Author	Paper Title	Year	Conclusion
[16]	Triantafillou, T. C., & Papanicolaou, C. G.	Shear strengthening of reinforced concrete members with textile reinforced mortar (TRM) jackets	2006	Used six samples for shear strengthening, textile reinforced mortar with one layer, two layers, and two layers spirally, epoxy resin base with one layer and epoxy resin base with two layer with control sample. Results showed TRM with two layer more capable than TRM with one layer, and apply TR straight is more capable than spirally. used epoxy resin based is more capable than used mortar
[17]	Dinh, N. H., Park, S. H., & Choi, K. K.	Seismic performance of reinforced concrete columns retrofitted by textile-reinforced mortar jackets. Structure and Infrastructure Engineering	2020	Used eight column samples for column jacketing, consisting of two groups. Two control sample, four epoxy resin base with two different reinforced details, and two samples which coated with AL2O3. The results showed that using AL2O3 for coating increase the TRM capacity, also using epoxy resin base for textile increase the strengthen element capacity than using mortar with TRM for strengthening.
[18]	Triantafillou, T. C., Papanicolaou, C. G., Zissimopoulos, P., & Laourdekis, T.	Concrete confinement with textile-reinforced mortar jackets.	2006	Used ten samples for column jacketing, by using different textile layer, and conventional mortar and epoxy resin as a base mortar. The results shown that epoxy resin base increase the capacity more than conventional mortar and increase textile layer was increase capacity of the element.
[19]	Bournas, D. A., Lontou, P. V., Papanicolaou, C. G., & Triantafillou, T. C.	Textile-reinforced mortar versus fiber-reinforced polymer confinement in reinforced concrete columns	2007	Used three different mix, five sample from each one for column strengthening, samples were consist of control sample, epoxy resin with two layer , epoxy resin with three layer, conventional mortar with four layer and conventional mortar with six layer. The results showed that, using epoxy resin as a base mortar has more efficiencies than other samples.

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Table 1. Continued

Ref No.	Author	Paper Title	Year	Conclusion
[21]	Park, J., Park, S. K., & Hong, S.	Experimental study of flexural behaviour of reinforced concrete beam strengthened with pre-stressed textile-reinforced mortar	2020	Used seven samples for flexural strengthening. Three of them strengthen with glass textile (normal range steel, pre-stressed and high range of steel), and three of them strengthen with carbon textile (normal range steel, pre-stressed and high range of steel, the last one was control sample. Results showed that in pre-stressed alkali resistance glass stronger than carbon textile while in high range steel content carbon textile was stronger.
[22]	Elsanadedy, H. M., Al-musallam, T. H., Alsayed, S. H., & Al-Salloum, Y. A	Flexural strengthening of RC beams using textile reinforced mortar–Experimental and numerical study	2013	Used five samples for flexural strengthening, by using conventional mortar, cement modified with polymer and epoxy resin base. The result shows that strength of one layer of carbon textile reinforced with epoxy resin base is ten percent lower than ten layer textile with cement modified with polymer mortar. Mortar with cement modified with polymer more efficiencies than conventional mortar with cement only
[23]	Raoof, S. M., Koutas, L. N., & Bournas, D. A	Textile-reinforced mortar (TRM) versus fibre-reinforced polymers (FRP) in flexural strengthening of RC beams	2017	Used four samples for flexural strengthening. The first was control sample; in second strengthened with one layer of carbon while third strengthen with seven layer of basalt, and last one strengthen with seven layer of glass. Results shown that basalt is stronger than glass and carbon (one layer) was provide lower capacity than basalt (seven layer) by 12%.
[25]	Lampros N. Koutas, and Christos G. Papakonstantinou	Flexural strengthening of RC beams with textile-reinforced mortar composites focusing on the influence of the mortar type	2021	Nine medium-sized RC beams with two different mortar, and simple supports under 4-point bending were produced and put through testing. Overall, it was determined that the kind of mortar had a significant impact on the failure modes, the flexural stiffness response upon yielding, and the flexural capacity increase.

https://doi.org/10.70028/sgm.v1i2.8

Table 1. Continued

Ref No.	Author	Paper Title	Year	Conclusion
[26]	A. Al-Saidy, S. El-Gamal, Kazi Abu Sohail	Strengthening of Reinforced Concrete (RC) Beams using Textile Reinforced Mortars (TRMs)	2023	Used fifteen reinforced concrete beams (150 × 100 × 2700 mm), strengthened with one layer of textile bonded with epoxy to the tension side of the beam; and the remaining beams were strengthened with one layer, two layers, and three layers of textile bonded with different types of mortar, The test results showed that epoxy-bonded textile performed better in terms of strength enhancement, with a 33% increase in ultimate load compared to the control beam, because the bond was perfect, as compared to mortar-bonded textile, which resulted in increases ranging from 15 to 27% depending on the mortar type.

Conclusions

The primary aim of this study was to assess the role and effectiveness of textile-reinforced mortar in enhancing the capacity and performance of structural elements. Specifically, the study focused on the use of textile-reinforced mortar for shear strengthening and jacketing. The following points were obtained as a result:

a. Textile-reinforced mortar, a new composite material, can be used for strengthening and repairing with an effective role in both functions. Among these materials taken into consideration, benzobisoxazole (PBO) is more effective in increasing the shear capacity of the member in shear strengthening by 43.3%, followed by carbon, basalt, and glass, as showed.

b. With fixing the used material in the strengthening, U-shape strengthening is more effective than S-shape in shear strengthening, in which U-shape increases shear capacity for the member by 131% while S-shape increases it by 71%.also the shear capacity of element was increase by increase number of used textile during g the strengthening process, and applying textile layer by straight way give higher capacity to the member than applied it spirally.

c. Epoxy resin as a mortar for installing textile reinforced mortar gives a higher range in the load capacity for column strengthening. If mortar of used textile contain cementitious material which consist of cement modified with polymer provide flexural capacity higher than textile has cement lonely as cementitious material by 5.3%

d. Column capacity with fixing textile material was has more capacity with two layer of textile compare to one layer of textile.

e. For same layer and same type of mortar basalt textile provide flexural capacity higher than glass textile by 8.55%.

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Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

Soran Abdrahman Ahmad: conceptualization, methodology, data curation, writing- original draft preparation. **Hersh F Mahmood:** methodology, writing- original draft preparation, writing- Reviewing and editing.

Data Availability Statement

The data used to support the findings of this study are included within the article.

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