Flexural Performance of Alkali Resistant Glass Textile Reinforced Concrete Panel Made with Quartz Sand

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Abstract - *Textile Reinforced Concrete is a new composite material made from fine grained concrete and fiber textile. Different fiber textiles are used as a replacement to the steel reinforcement. The flexural performance of Alkali Resistance Glass fiber textile (AR Glass) is analyzed experimentally by conducting the four point bending test in the laboratory. The effect of single layer textile and double layer textile is also analyzed in this paper. The load versus deflection behavior and the failure pattern of the precast TRC panel is recorded in this paper. It is found that the AR Glass TRC panel acts as a under reinforced panel.*

Key Words: Textile Reinforced Concrete, Alkali Resistance Glass fiber textile, Single layer textile panel, Double layer textile panel, Flexural performance.

1. INTRODUCTION

Textile Reinforced Concrete (TRC) is a new composite material made from the fine grained concrete and fiber textiles. Fiber textiles are non-corrosive in the nature this is the main reason of using fiber textile as reinforcement. Various different fiber textiles can be used as reinforcement but AR glass, Basalt and Carbon fibers have all the necessary properties required for designing and casting of TRC [1]. Coarse aggregates are not used in TRC due to the small opening size of the textile reinforcement. The maximum size of aggregates used for TRC should be less than 2mm [2]. Theoretically this matrix is called as mortar, but this mortar gives higher compressive strengths hence it is termed as fine grained concrete. For this experiment quartz sand is used as aggregates. As the thickness of the roving increases the ultimate strength of the textile reinforcement decreases [2].

Textile Reinforced Concrete elements can be easily manufactured in the precast industry using different methods depending upon the size and shape of the element. TRC can be used for both load bearing and non-load bearing structural elements. Mainly TRC is used for exterior building facades, stay-in-place formwork. A previous study shows that, cracking moment and load bearing capacity and of the beam increases with stay-in-place formwork [3]. Thin TRC elements can be manufactured as the minimum reinforcement cover is limited to 4mm [4]. Due to the small thickness of TRC, the handling and transportation becomes easy and cost effective. TRC is also effectively used for strengthening the existed structures such as beams, columns. It is found that, the deflection capacity of the beam strengthen with the basalt textile is increased by 83% [5].

In this paper, the flexural performance of the AR Glass fiber textile concrete is analysed experimentally by performing the four point bending test. Fine quartz sand of different sizes is used in the concrete due to the small opening the mesh. The failure mode of these TRC panels is observed in this paper. The bonding between the textile mesh and cementitious matrix is determined from the failure pattern.

2. EXPERIMENTAL WORK

The casting of all TRC panels is done at Concrete Solutions, A1 MIDC Jejuri. It is a precast industry which manufactured all kinds of precast building elements. TRC panels are casted using the hand layup technique. The details of the work done are described in the following sections.

1.2 AR Glass fiber textile

For this experiment the coated Alkali Resistant Glass (AR Glass) fiber textile mesh is used as reinforcement. The AR Glass fiber textile is imported from the locally available supplier. The textile mesh has an opening of 5mm X 5mm centre to centre. The width of the textile mesh roll is 1200mm. Fig 1 shows the actual AR Glass fiber textile mesh used for the experiment.

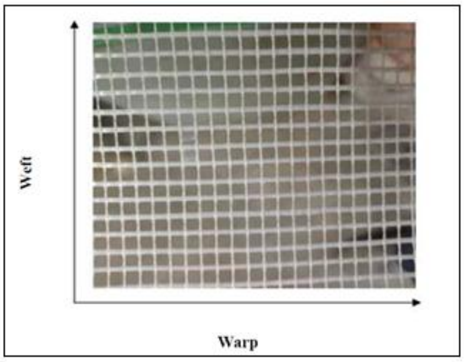


Fig -1: AR Glass fiber textile mesh

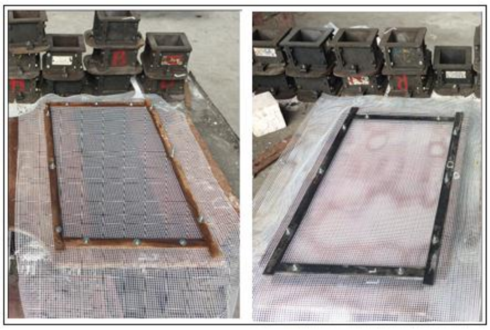
The cost performance of the AR Glass fiber textile is good due to cheaper cost. The properties of AR Glass fiber textile mesh are given in the Table 1.

Table-1: Properties of AR Glass fiber textile

Material	Direction	Properties				
		Grammage g/m2	Axial speing (mm)	Density (g/cm3)	Yarn tensile strength N/mm2	Modulus of elasticity N/mm2
AR Glass fiber textile	Warp 0°	120	5	2.68	1700	72000
	Weft 90°		5			

2.2 TRC panel moulds

Two different panel moulds are made (single layer and double layer fiber textile) for the casting of flexural test panels. The warp direction of textile is placed along the length of the panel. The size of the moulds is 600 mm X 350 mm. The height of the mould is different depending upon the number of layers of fiber textiles. 18mm thick plywood is used as a base plate for both the moulds. All the inner sides of the both moulds are sealed with the sealant to achieve the perfect size of panels. The details of the moulds are given Fig 2. Thickness of single layer textile and double layer textile is 12mm and 18mm respectively.



a) b)

Fig -2: TRC panel moulds a) single layer b) double layer

2.3 Cementitious matrix

The mix design of matrix is done as per the requirement of the precast industry. Silica fume and metakaolin are also used to improve the bonding properties of the mixture. The cementitious content (700 kg/m3) and water/cement ration (0.25) is already fixed for the mix design. Ordinary Portland Cement (OPC) of 53 grade is used for the mix. Silica fume and metakaolin are replaced in 8% each of total cementitious content. Whole work is done using the quartz sand. The quartz sand is imported from Rajasthan. The maximum aggregate size is 1.18mm. 3% High-Range-Water-Reducing-Admixture (HRWRA) of cementitious matrix is used to reduce the water content in mix design and to make the flowable matrix. The composition of the mix design is given in following Table 2.

Table -2 Mix design composition

Materials	Cement	Silica fume	Metakaolin	Quartz (mesh size)				HRWRA	Water
				16-30	30-80	80-100	300		
Contents (Kg/m3)	588	56	56	384.638	384.638	384.638	384.638	21	175

3. TESTING

TRC panels are demoulded after 3 days to avoid the damages to the edges. The wet gunny bags were placed on the panels after 24 hrs. of casting to avoid the cracking due to heat of hydration. TRC panels were cut in the small sheets of size 600mm X 50 mm for the flexural testing.

3.1 Four-point bending test

The flexural properties of TRC are analyzed by conducting the four point bending test carried out using UTM. The two point loading is given on the TRC panels. The setup of the flexural test is given in the following Fig 3. The load is constantly increased by 30 N. dial gauge is used to measure the mid span deflection. The dial gauge is attached to the UTM pole. The dial gauge is centered at midpoint of TRC panel. Deflection is recorded after every increasing load of 30 N.

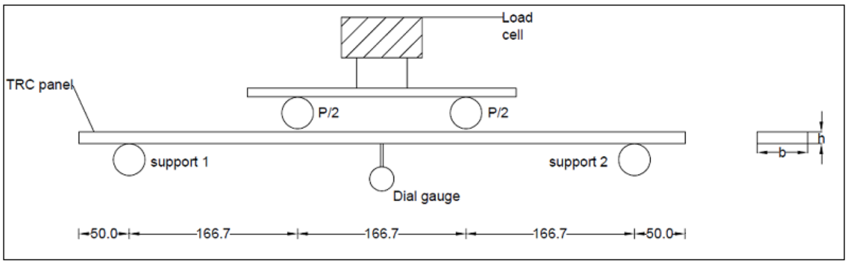


Fig -3: Schematic setup of **f**our point bending test setup

The flexural strength of the specimen shall be expressed as the modulus of rupture (fcr) and calculated by using following expression, For this experiment the average value of 'a' is 197 mm and 182 mm for SLT and DLT respectively.

$$fx = \frac{3P.l}{2b.d^2}$$

Where,

fcr = Flexural strength (MPa)

Pf = Central load thorough two point load system (KN)

L =Span of the beam (mm)

b =Width of beam (mm)

d =Depth of beam (mm)

a = The distance from the line of fracture to the nearer support, measured on the centreline of the tensile side of the specimen in mm (Note: if 'a' is less than 170mm then the results of the test shall be discarded.)

4. EXPERIMENTAL RESULTS AND DISCUSSION

The effect of number of textile layers on flexural behaviour of TRC is interpreted through load vs deflection curve in Fig 4 and Fig 5. Mid span deflection of SLT and DLT panels starts at 7.83 KN and 7.62 KN respectively. For SLT and DLT, the first crack is appeared at 8.13 KN and 8.13 KN respectively. The average ultimate mid span deflection for SLT is 12.345 mm. For DLT the average mid span deflection is 32.225 mm, which is more than SLT. The failure of both Single layer textile (SLT) and Double layer textile (DLT) takes place at the point the under reinforcement of the specimen. Cement matrix do not crushed during the failure. Fig 6 shows the failure of specimen. Table 4 shows the results of flexural test.

Table -4 Flexural test results

Specimen	First crack load (KN)	Ultimate load (KN)	Flexural strength (Mpa)	Ultimate deflection (mm)	Number of cracks	Failure mode
SLT	8.13	8.19	853.12	12.34	1	F
DLT	8.13	8.22	380.55	32.22	1	F

F= Failure due to under reinforced section

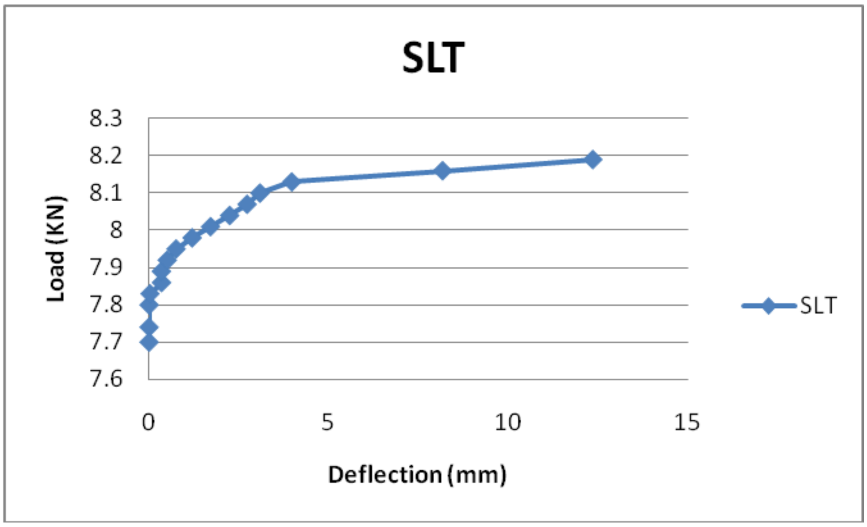


Fig -4 Load vs. Deflection graph of SLT

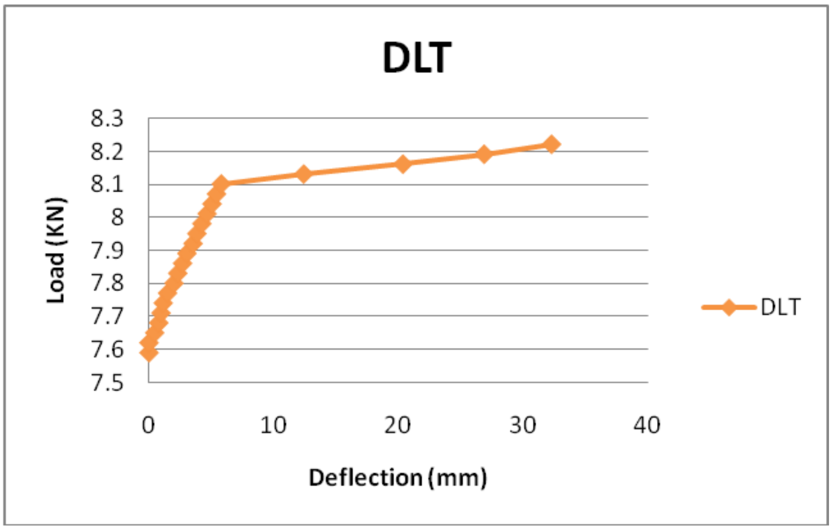


Fig -5 Load vs. Deflection graph of DLT

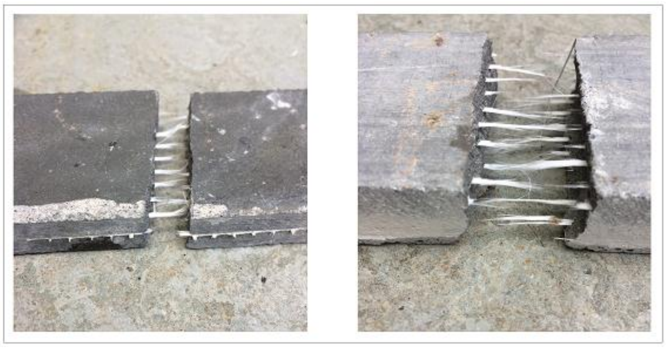


Fig -6 Failure of specimen

5. CONCLUSIONS

An experimental study of flexural performance of TRC and the effect of number of textile layers has been carried out in the laboratory. The density of TRC ranges between 2300-2400 Kg/m^3. The flexural test shows that the failure takes place due to under reinforced TRC panels. The failure of both TRC specimens is brittle failure with a single crack. The bond between textile and cementitious mix is good because the failure is brittle. De-bonding of the reinforcement and cement matrix is not observed after failure. The flexural strength of single layer textile panel (SLT) is 2.24 times more than the double layer textile panel (DLT). The DLT panel shows better results for the deflection than the SLT. When double layer textile is used in the concrete, the deflection increases 2.61 times compares to the single layer textile panels. The deflection of SLT panel is 60% less than the DLT panel. The ultimate load carrying capacity of DLT is slightly higher (0.3%) than SLT. The average compressive strength of the cementitious matrix on first day is 16.78 MPa. The early strength of matrix is good from precast industries point of view. The average fourteenth day compression strength of matrix is 79.09 MPa.

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REFERENCES

[1] D. N. B. C. Akshay Khandagale, “ICACSE2020_183,” in TEXTILE REINFORCED CONCRETE- FROM FUNDAMENTALS TO APPLICATIONS AND ENVIRONMENTAL IMPACT, 2020.

[2] J. Hegger et al., “Mechanical behaviour of textile reinforced concrete,” Text. Reinf. Concr. - State-of-the-art Rep., vol. 36, pp. 133–186, 2006.

[3] S. Verbruggen, O. Remy, J. Wastiels, and T. Tysmans, “Stay-in-place formwork of TRC designed as shear reinforcement for concrete beams,” Adv. Mater. Sci. Eng., vol. 2013, 2013, doi: 10.1155/2013/648943.

[4] W. Brameshuber, Manufacturing Methods for Textile-Reinforced Concrete. Elsevier Ltd., 2016.

[5] S. Gopinath, A. R. Murthy, N. R. Iyer, and M. Prabha, “Behaviour of reinforced concrete beams strengthened with basalt textile reinforced concrete,” J. Ind. Text., vol. 44, no. 6, pp. 924–933, 2015, doi: 10.1177/1528083714521068.