The Effect of Textile on Compressive Strength of Concrete

Muhammad Faizan Ali*, Noor Ahmed Memon, Bashir Ahmed Memon, Muneeb Ayoub Memon, Ammaar Noor Memon

Department of Civil Engineering, QUEST, Nawabshah, Sindh, Pakistan
*Corresponding author: faizanafridi9@ gmail.com

Abstract

In this research paper, effect of textile waste on compressive strength of concrete cubes are analyzed. Textile waste is collected from stitching shops and cut into small fibers size of $25\,mm \times 5\,mm$. Ten concrete mixes with dosage of textile waste from 0.1% to 1% with an increment of 0.1% are used. Additionally, one concrete mix without textile waste is prepared to compare the results. In all mixes, 1:2:4 concrete mix and 0.5 w/c ratio is used. To check the workability of concrete, slump test is performed for all mixes. Total 88 concrete cubes of standard sizes are casted in 11 batches each having equal number of cubes. These cubes are cured for 14- and 28-day by standard water curing. Unit weight (density) and compressive strength of all specimens are evaluated in a standard fashion. Comparison of the results reveals that the maximum increase in compressive strength of concrete is recorded at the textile waste dosage of 0.6% (28-day cured specimens) and is equal to 11.7%. Based on the laboratory investigations and the results, it is concluded that the use of textile waste in concrete has a promising effect on compressive strength. The content of textile waste may be considered to be 0.6% of total volume of concrete which may lead to a higher strength of concrete as compared to the conventional concrete.

Keywords—Textile waste, concrete, fiber reinforced concrete, alternative material.

1 Introduction

CONCRETE is the major ingredient or component used in the modern construction industry. Today it has almost become impossible to build any modern structure without the use of concrete. In its simplest form, concrete is made from the mixture of cement, aggregates (rocks) and water. The paste, which is made essentially of cement and water, coats the surface of fine and coarse aggregates. The paste then becomes hard by a series of chemical reaction called hydration. It gains strength and forms rock-like mass which is called as concrete.

Growing demand of structures and modern pace of development requires construction of high-rise structures. New ideas and trends of architects and designers result in amazing shapes of structures. On the other hand, vertical expansion of structure poses serious problems due to wind force on the buildings. These all require use of high strength concrete. Achieving high strength of concrete is possible by using admixtures such as super plasticizer or alternative materials such as various cementitious materials like textile waste as fibers. The use of admixtures and alternative materials not only ensures proper strength of the structure, but it also provides stability and durability during service life. On the other hand, it paves the way of utilization of indigenous materials and byproduct of primary processes (waste). This not only leads to the preservation of conventional concrete ingredients for future use but also helps in preservations of the environment which otherwise gets affected by these wastes.

Towards the search of alternative materials for the basic ingredients of concrete and admixtures, various scholars have attempted use of different materials in concrete such as fly ash, ground granulated blast furnace slag, silica fume, limestone dust, cement kiln dust, natural or manufactured pozzolans, fabric materials, steel fiber, rice husk, textile, Jute, sawdust, and recycled demolishing concrete, etc. The use of alternative materials also helps in achieving improvements in workability and durability.

Several attempts of scholars regarding the use of the textile waste in different forms in concrete are also reported in the literature. Among them Hegger et.al. [1] reviewed the development of textile reinforcement

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in concrete. Whereas, Brameshubur et al. [4] reviewed the reinforcement development techniques from textile waste. Papanicolaou et al. [5], on other hand, reviewed the same to be used in precast industry for preparation of concrete panels, parapet walls and sound barriers. The authors presented details of the use of textile as reinforcement and its effect on the said members. Du et al. [2] attempted textile waste as reinforcement along with chopped steel fiber in different layers to improve the flexural behavior of the concrete. Experimental results of 24 samples of the proposed material showed improved crack flexural strength. The improved crack monitoring was also recorded by Quaddflieget. al [3] while reinforcing the concrete pipes with textile reinforcement along with glass and carbon wrappings.

Axial fatigue behavior of concrete with multi-layer textile reinforcement is evaluated by Mesticouet et al. [10]. The authors used textile waste with glass and carbon grid. Under 60% and 80% of fatigue load at 100 cycles results showed improvement in rigidity and dissipative capacity of composite material. Addition of glass and carbon in matrix also showed improvement in the results. Effect of flexural strength on flexural performance of RC slabs is studied by Bruknaret et al. [17] . Based on the results, the authors presented a simple model for dimensioning of the flexural strengthening of RC slabs. Based on the observations, the authors also argue that using the same material in beams will lead to an improved shear capacity of the reinforced concrete beams. On the other hand, Shareiet et al.[18] used textile reinforcement to study the load bearing behavior of thin walled light weight vault structure. Finite element simulation of the behavior and its comparison test data showed improvement in the behavior. Shear resistance of reinforced concrete members Thanasiset et al.[19] used textile reinforcement in mortar. Based on the results, the authors observed that the shear capacity of the members may be improved by using jacketing of the proposed material. In another research work, Bournasset et al.[20] used textile waste as reinforcement in concrete columns to check the effect on buckling capacity. The authors also used fiber reinforced polymer of the same stiffness and strength to prepare the samples for checking the results of the proposed material. The obtained results showed a substantial gain in compressive strength and deformation capacity by delaying buckling of the longitudinal bars. This gain increases with the volumetric ratio of the jacket. The comparison of both configurations revealed that the proposed jackets are slightly less effective than FRP jackets in terms of increasing strength and deformation capacity by approximately 10%. However, the comparison of nearly full-scale columns under cyclic uniaxial flexure shows that TRM jacketing is a very effective way of increasing the cyclic deformation capacity and the energy dissipation of old type reinforced concrete columns.

Other scholars have also addressed the textile waste in concrete from the point of view of design modeling [6], durability [7], structural behavior [8] and bond proper-ties [12]. Not only the textile waste, but other materials as additives have also been utilized by different scholars in concrete such as jute, coir and banana mixture [13], fiber rein-forced concrete [14], carpet fibers[15], date-palm-mesh fi-bers [16], glass textile reinforced concrete [9], and demolished concrete [21].Observations from the above-mentioned literature review motivates the work presented in this experimental research to evaluate the effect of textile waste as fiber reinforcement on compressive strength of the concrete.

2 Methodology

Textile waste used in this research work was collected from stitching shops of local market of Nawabshah city (Figure 1). It was a mix of different types of fabrics from which one type (cotton) was separated (Figure 2) to be used in this research work. Mixed size of the waste was then cut manually into pieces of $25\,mm \times 5\,mm$ (Figure 3). This waste is used in concrete into dosage of 0.1% to 1% with increment of 0.1% by weight of the specimen.

For the proposed work, 1:2:4 mix with 0.5 water-cement ratio is used. The selected mix was the same as the commonly used mix in the industry. A slightly higher water-cement ratio is selected considering the water absorption of the textile fibers.

3 Slump

For all dosage of the textiles waste and control mix slump test is conducted using slump cone. The test is conducted as per standard procedure of the test (Figure 4).

4 Casting & Curing

Total 88 standard sized cubes (4” × 4” × 4”) are casted in eleven batches. In ten batches, textile waste is used as mentioned above. Whereas, one batch of the cubes is casted without textile waste to compare the results of the proposed concrete. Table 1 gives the details of the specimens along with mix quantities. In each batch, 8 cubes are casted. Mixing of concrete ingredients is done by weight. Preparation of the mix and filling of the moulds is done in accordance with

Fig. 1: Textile waste

Fig. 2: Sorted textile waste

Fig. 3: Sorted textile waste

Fig. 4: Slump test

Fig. 5: Compressive strength test

the relevant ASTM provisions. In each batch, equal number of specimens is cured for 14- and 28-days by fully immersing in potable water.

5 Unit Weight (Density) & Compressive Strength

After the elapse of respective curing time, each specimen is weighed using digital weight balance. Compressive strength of the specimens is then evaluated using universal load testing machine under a gradually increasing load (0.5 kN/sec) till failure (figure 5).

6 Results & Discussion

This section provides an in-depth discussion on the experimental results.

No.	Sample ID/ Batch	Water (Kg)	Cement (Kg)	Fine Aggregates (Kg)	Coarse Aggregates (Kg)	Textile Fiber (%)	Textile Fiber (gm)	Water for Textile Fiber (gm)	Total Water (gm)
1	CM 0	1.5	3	6	12	0.00	0	0	1500
2	WTRC1	1.5	3	6	12	0.10	21	21	1542
3	WTRC2	1.5	3	6	12	0.20	42	42	1584
4	WTRC3	1.5	3	6	12	0.30	63	63	1626
5	WTRC4	1.5	3	6	12	0.40	84	84	1668
6	WTRC5	1.5	3	6	12	0.50	105	105	1710
7	WTRC6	1.5	3	6	12	0.60	126	126	1752
8	WTRC7	1.5	3	6	12	0.70	147	147	1794
9	WTRC8	1.5	3	6	12	0.80	168	168	1836
10	WTRC9	1.5	3	6	12	0.90	189	189	1878
11	WTRC10	1.5	3	6	12	1.00%	210	210	1920

TABLE 1: Sample and mix details

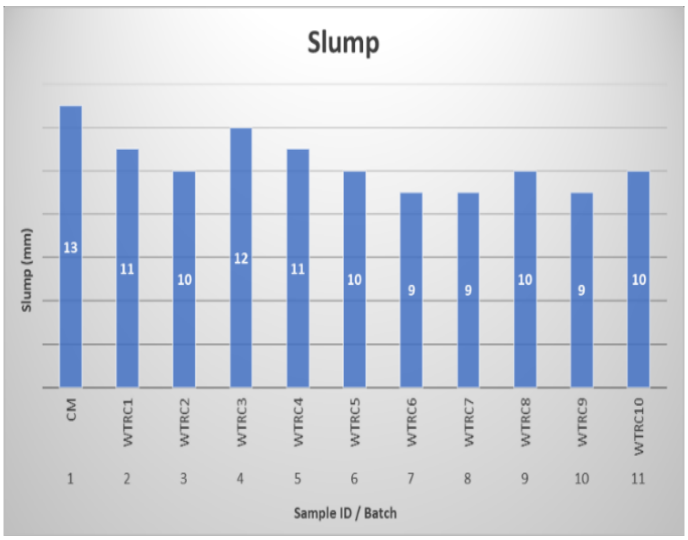

Fig. 6: Compressive strength test

6.1 Slump

The results of the slump test conducted for all mixes are shown in Figure 6. It may be noted that the maximum slump of 13 mm is observed in control mix. Whereas, all other mixes show reduction in slump value. A fluctuating trend in slump is observed. Reduced slump indicates that the concrete with textile waste demands more water to maintain the workability. Otherwise, more effort for compaction will be required.

6.2 Unit Weight (Density)

The average unit weight (density) of the specimens of all batches of proposed concrete and control mix are averaged along with percentile reduction in the unit weight of the proposed concrete mixes in Table 2. The table shows the average unit weight of both curing ages considered in this research work. The average unit weight of the proposed concrete is also compared with the conventional concrete in the same table. It may be observed that an increase in the dosage of textile waste results in a decrease in the weight of the specimens. The maximum reduction in the weight for both 14- and 28-day cured samples was observed at the textile fiber dosage of 1% and was equal to 1.6% and 1% respectively. This shows that induction of textile waste in concrete can produce lighter concrete than the conventional concrete.

7 Compressive Strength

The average values of the samples within each batch are listed in Table 3. The table also shows the percentage change in compressive strength of the proposed concrete mixes with respect to the conventional concrete for both curing ages. It may be observed that except peak values, almost same trend is observer for all mixes.

It may be observed that the compressive strength increased with the increase in dosage of textile waste up to 7% for 14-day curing and up to 6% for 28-day cured specimens. Beyond these dosages, compressive strength observed reduction. For 14-day cured specimens, maximum increase in compressive strength was found to be 33%. The same among 28-day cured specimens is recorded to be 11.7%. The compressive strength at the curing age of 14-days showed a remarkable increase, but as the 28-day curing is considered as standard curing therefore, the optimum dosage of the waste is concluded to be 0.6%.

At the optimum dosage decrease in weight of the specimens is 0.8% and 0.% for 14- and 28-day curing respectively. The change in weight is marginal. However, increase in compressive strength shows that the use of the waste in new concrete has positive effect on the parameter and help in developing concrete with more strength than conventional concrete.

No.	Sample ID/ Batch	Textile Fiber (%)	4-Day Curing		28-Day Curing	
			Unit Weight/ Density (kg/m3)	Change (%)	Unit Weight/ Density (kg/m3)	Change (%)
1	CM	0	2510	–	2500	–
2	WTRC1	0.1	2500	-0.5	2500	-0.2
3	WTRC2	0.2	2500	-0.4	2500	-0.2
4	WTRC3	0.3	2490	-0.6	2490	-0.5
5	WTRC4	0.4	2490	-0.6	2490	-0.5
6	WTRC5	0.5	2490	-0.7	2490	-0.3
7	WTRC6	0.6	2490	-0.8	2490	-0.5
8	WTRC7	0.7	2490	-0.9	2490	-0.6
9	WTRC8	0.8	2480	-1.1	2480	-0.9
10	WTRC9	0.9	2480	-1.3	2480	-0.8
11	WTRC10	1	2470	-1.6	2480	-0.9

TABLE 2: Average weight (Density)

No.	Sample ID/ Batch	Textile Fiber (%)	4-Day Curing		28-Day Curing	
			Compressive Strength (MPa)	Change (%)	Compressive Strength (MPa)	Change (%)
1	CM	0	21.1	–	31.36	–
2	WTRC1	0.1	28.22	33.79	32.19	2.65
3	WTRC2	0.2	26.18	24.1	32.6	3.93
4	WTRC3	0.3	27.67	31.15	32.64	4.06
5	WTRC4	0.4	30.56	44.87	32.9	4.9
6	WTRC5	0.5	31.15	47.65	34.31	9.38
7	WTRC6	0.6	31.27	48.21	35.03	11.71
8	WTRC7	0.7	32.94	56.16	33.42	6.56
9	WTRC8	0.8	28.22	33.78	30.38	-3.15
10	WTRC9	0.9	27.32	29.5	28.66	-8.62
11	WTRC10	1	21.23	0.65	22.18	-29.27

TABLE 3: Average compressive strength

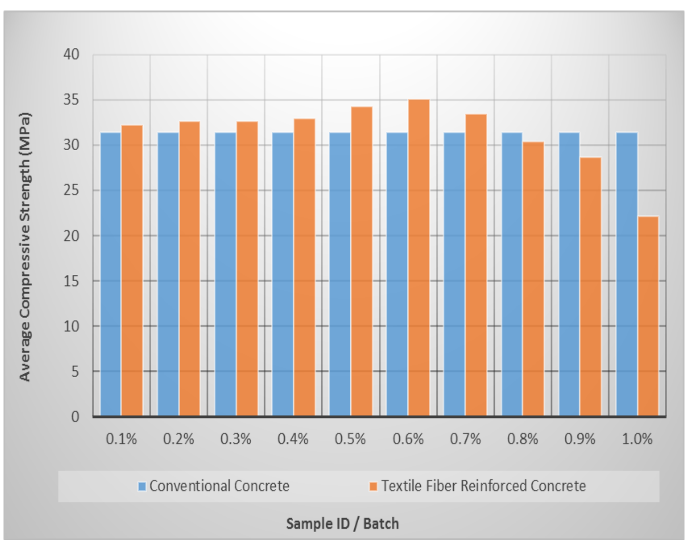

Fig. 7: Compressive strength of concrete at 28 days with various percentage of textile waste compared to normal concrete

8 Conclusion

From the laboratory investigations of compressive strength of concrete cubes cast with different dosages of textile waste following points are concluded.

(a) Maximum slump in proposed concrete is observed equal to 12 mm. It shows that the water demand of the concrete with textile waste is more, without which workability is affected and more effort will be required for proper compaction.
(b) Increasing dose of textile waste result in reduced Unit weight (density) of the resulting concrete.
(c) Compressive strength of proposed concrete increases with increase in dosage of textile waste up to 0.7% for 14-day cured concrete and 0.6% for 28-day cured specimens.
(d) As, 28-day curing is treated as standard time of curing therefore, optimum dosage of the textile waste is 0.6%.
(e) At optimum dosage 11.7% increase in the compressive strength of concrete with textile waste is recorded in comparison to conventional concrete.
(f) Based on the experimental study carried and the results achieved, it is recommended that the textile waste may be used as fibers in concrete. However, the dosage of the used textile waste may be optimized at 0.6% by the total volume of concrete.

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