World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 5.924

TENSILE STRENGTH OF CONCRETE WITH BIOMEDICAL WASTE ASH

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Article Received on 06/07/2020 Article Revised on 27/07/2020 Article Accepted on 17/08/2020

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ABSTRACT

Use of alternative ingredients and management of waste generated from different primary processes is active area of research around the globe. This research article combines both aspects by investigating the tensile strength of concrete made with partial replacement of cement with biomedical waste ash. Ten by weight replacement of cement (0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7%, 0.8%, 0.9% and 1.0%) were used to cast 288 concrete cylinders of standard size. 1:2:4 concrete mix with 0.5 w/c ratio was used. Additionally, one batch of concrete cylinders was prepared without biomedical waste to compare the results of proposed concrete. Curing of specimens was done for 7-, 14-, 28- and 90-day. Comparison of the results shows that the tensile strength of proposed concrete was within the specified range of tensile strength of conventional concrete. In relation with 28-day cured conventional concrete minimum

reduction is obtained at 5% dosage of 28-day cured specimens. Elongated curing shows increase in the parameter for all levels of cement replacement with the waste ash. Maximum increase is recorded at 1% replacement of cement with ash.

KEYWORDS: Biomedical waste, tensile strength, green concrete, ash, cement replacement.

1. INTRODUCTION

Provision of proper medical facilities in a region is one of the basic needs. With growth in population, medical facility centers are also increasing. Also, the waste generated by these facility centers is increasing. The management of this waste has become the serious issue around the world. The waste is composite material containing the infectious material. If it is not properly handled may cause severe problems to environment and mankind. According to a study, the mishandling of this material caused millions of patients of hepatitis B, C and HIV around the globe.[1] Other than hazardous material it also contains non-infectious material also and it can be utilized as an ingredient in concrete. To this end, researchers around the globe have given it good time and effort to study the possibilities of reusing this waste in new concrete by reviewing the subject matter.[234] The use of the material in new concrete as partial replacement of one of the ingredients will save the related waste management issue to some extent. However, it needs proper study of the waste and concrete using it to understand its behavior and impact. It has been attempted as cement replacement by first converting it to the ash. Replacement of fine and coarse aggregates by the waste has also been attempted. Liu et. al.[5] reviewed the characteristics of the medical waste and the methods to convert it into the ash, with particular reference to different methods used for the purpose. Devi and Rathiga6 used biomedical waste in concrete as coarse aggregates to study the compressive strength thus the suitability of the waste in new concrete. From the results authors observed that 20% higher strength can be achieved by using 2% dosage of the waste. The waste in the form of ash is also used as cement replacement by Singh et al.[7] The authors observed decrease in workability with increase in dosage of the waste ash. They also observed that the compressive strength of resulting concrete at the dosage level of 10% is comparable with that of the conventional concrete. Proper treatment and use of Incinerated ash and slag of biomedical waste in concrete is also highlighted in literature with particular remarks that concrete produced with the waste is non-hazardous.[8]

Elinwa[9] with reference to biomedical waste and its associated problems in Nigeria, argues that incinerated ash of the waste has Cementous and pozzolanic characteristics thus can be used as cement replacement. However, both workability and strength of the concrete reduces with increase in dosage. Thus, need to take special care or use plasticizer to maintain the workability. Prasanth and Rao[10] also concluded similar finding and suggest 2% as the optimum dosage of cement replacement.Sathvik et al.[11] also used biomedical waste ash as cement replacement to study the strength properties of the concrete. Based on the results authors finding about the basic properties i.e. density and workability were same as of other scholars. But they concluded 10% replacement as the optimum dosage with remarks that at this level of biomedical waste ash compressive strength is comparable with that of conventional concrete and the split tensile strength is almost same as that of the conventional concrete. Biomedical waste incinerated ash has also been used in ferrocement panels,[12] as replacement of fine aggregates[13,18], to determine the workability by slump test,[14] to evaluate the flexural behavior of beams[15], in production of economical concrete.[16]

Memon et al.[17] in their research work used the biomedical waste collected from Rawalpindi. The test results for strength of concrete with incinerated ash of the waste as replacement of cement showed the authors that 2% is the optimum dosage. Bakkali et al. on other hand conducted research to characterize the biomedical waste ash to be used in the concrete. Test results on the biomedical waste collected from the medical facility centers of Morocco authors concluded that the bottom ash in incineration plants meets the required criterion to be used in the concrete.

It may be observed from the above discussion that although good quantum of the work is devoted to the biomedical waste management, particularly for using it in new concrete. However, the non-synchronous results show that more work is required in the field. Also, the tensile strength of the concrete with biomedical waste is addressed very less. Furthermore, the properties of biomedical waste differ from region to region. Therefore, in this experimental study aims at evaluating the tensile strength of concrete made with biomedical waste ash as partial replacement of cement.

2. MATERIAL AND TESTING

Medical facility centers were the source of the biomedical waste collection used in this research work. Mixed waste was brought into the laboratory. It was then sorted for non-hazardous and non-infectious plastic items. After washing the items were burnt. The lumps obtained from burning (Figure 1) were then ground to fine powder/ash (Figure 2). The ash is then sieved to ensure fineness equal to the fineness of the cement. This ash is then used in five concrete mixes in the dosage of 1%, 3%, 5%, 7% and 9% by weight of the cement. To prepare the concrete mixes 1:2:4 with 0.5 water-cement ratio is used. The cement opted for the work is ordinary Portland cement. Fine and coarse aggregates are used from Jamshoro quarries. Both of the aggregates are sieved. Maximum size of coarse aggregates used is 1-inch. The water used in preparation of the mixes is obtained from city water supply scheme having pH value equal to 6.9. Table 1 gives the details of the quantities of the material used for casting the specimens.

Figure 1: Biomedical waste . **Figure 2: Ash.**

For each dosage of the biomedical waste ash 48 cylinders of standard size are cast in standard fashion. Additionally, 48 cylinders of same size and mix are cast without using biomedical waste. These cylinders are treated as control specimens and are used to compare the test results of proposed specimens. After completion of the casting process, equal number of the cylinders in each group is cured for 7-, 14-, 28- and 90-days. Standard water curing is used for the purpose (Figure 3). After elapse of respective curing age, the specimens are tested for split tensile strength in universal testing machine under gradually increasing load (Figure 4).

Figure 3: Curing of Specimens. **Figure 4: Testing of specimens.**

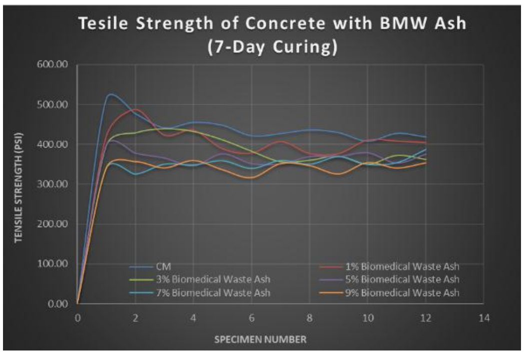
The load at failure is recorded followed by computation of the tensile strength by using $f_t = 2P/\pi HD$. In the expression P represents failure load and H and D denotes height and diameter of the specimen. The obtained results are presented, discussed and analyzed in next section.

Table 1: Quantities of the materials used.

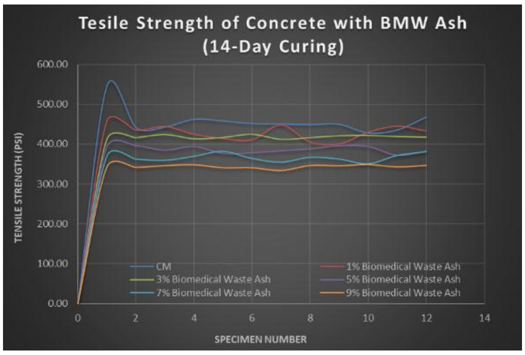
S#	BMW Ash (%)	No. of cylinders casted	Cement (Kg)	BMW Ash (Kg)	Fine Aggregates (Kg)	Coarse Aggregates (Kg)	Water (Kg)
1	0	48	92.29	0	184.59	369.18	46.15
2	1	48	91.37	0.9229	184.59	369.18	46.15
3	3	48	89.53	2.7688	184.59	369.18	46.15
4	5	48	87.68	4.6147	184.59	369.18	46.15
5	7	48	85.83	6.4606	184.59	369.18	46.15
6	9	48	83.99	8.3064	184.59	369.18	46.15
TOTAL:		**288**	**530.69**	**23.0736**	**1107.53**	**2215.07**	**276.90**

3. RESULT AND DISCUSSION

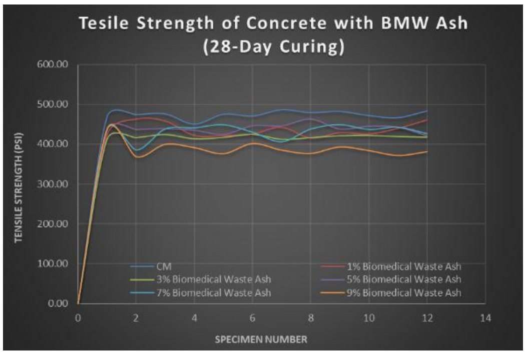
The tensile strength computed from the failure load of the specimens of proposed and conventional concrete is plotted in Figure 5. The tensile strength pattern of proposed specimens may be observed in good agreement with that of the control specimens. The average values of the tensile strength in each group for each curing age are listed in Table 2. These values of proposed concrete versus conventional concrete for each curing age are compared in Figure 6. It may be observed from both Table 2 and Figure 6 that induction of biomedical waste ash in concrete results reduction in tensile strength.



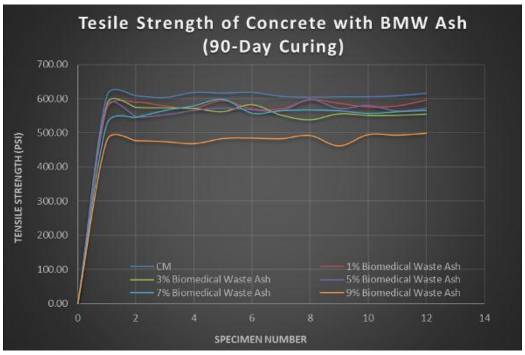
(a) 7-Day curing



(b) 14- day



(c) 28-Day curing

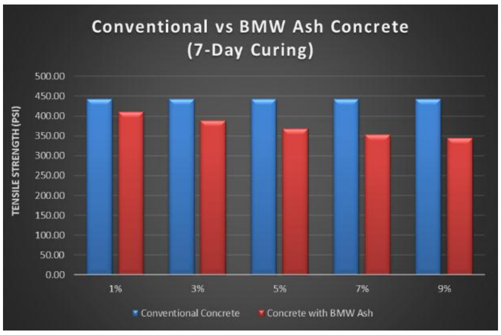


(d) 90-Day curing

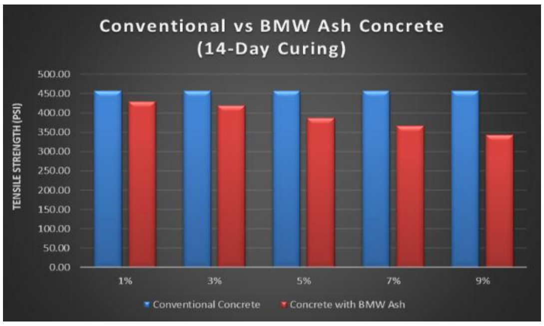
Figure 5: Tensile strength in all specimens.

Table 2: Average values of tensile strength of all groups of specimens.

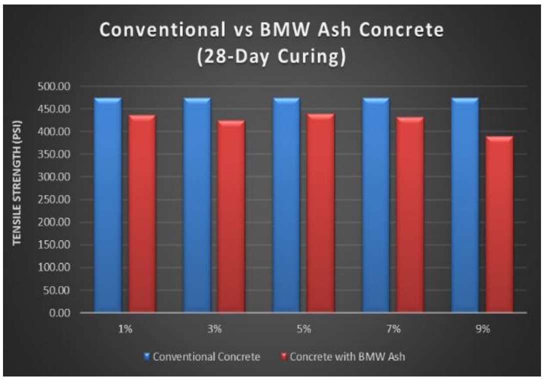
#	BMW Ash (%)	Tensile Strength (psi)			
		7-Day	14-day	28-day	90-Day
1	0	442.51	457.17	474.00	610.39
2	1	409.75	429.00	435.79	581.82
3	3	388.18	418.71	424.14	562.59
4	5	368.37	386.27	438.94	569.95
5	7	352.86	366.84	431.60	562.51
6	9	344.32	343.28	388.80	481.91



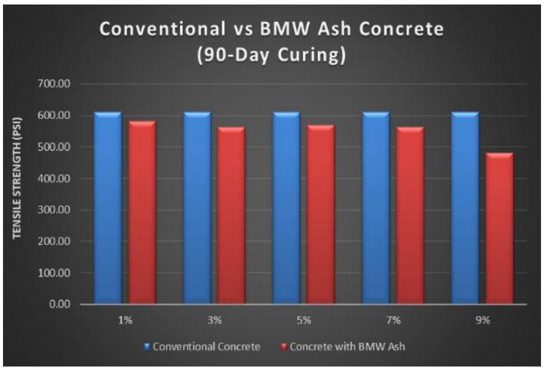
(a) 7-Day curing



(b) 14- day



(c) 28-Day curing



(d) 90-Day curing

Figure 6: Average tensile strength of proposed vs conventional concrete.

It may also be observed that increase in dosage of the biomedical waste ash remained proportional to the reduction in tensile strength except at the dosage of 1%. It may be due to the least quantity of the ash which might have not well been spread in the body of specimen. Table 3 gives the details of the comparison of average tensile strength with respect to the tensile strength of conventional concrete at respective curing age. Whereas, Table 4 gives the comparison of tensile strength of all specimens with respect to conventional concrete cured for 28-days. The comparison tensile strength of proposed concrete versus conventional concrete at respective curing age shows that maximum reduction is at the dosage of 9%. Whereas the minimum reduction is noted at the dosage of 1% for 7-, 14- and 90-day curing. The same for 28-day curing is observed at the dosage of 5%. As 28-day curing is considered as standard curing therefore, the optimum dosage of the waste ash is 5%. The comparison with conventional concrete cured for 28-days also shows that optimum dosage of the biomedical waste ash is 5% where the reduction in tensile strength of proposed concrete is minimum of (7.4%). This comparison shows that elongated curing shows improvement in tensile strength for all curing ages. Tensile strength at all dosages of the waste ash shows increase with maximum at the dosage of 1% (about 23%). Therefore, if the elongated curing can be afforded then the good increase in tensile strength of proposed concrete with 1% biomedical waste ash may be utilized.

The comparison of the results further shows that the tensile strength of proposed concrete at all levels of replacement remained within the specified range of tensile strength of conventional concrete. Hence, it may be seen that the biomedical waste ash in new concrete has positive response for tensile strength.

Table 3: Reduction in tensile strength versus conventional concrete at respective curing age.

#	BMW Ash (%)	Reduction in Tensile Strength (%)			
		7-Day	14-day	28-day	90-Day
1	0	--	--	--	--
2	1	-7.40	-6.16	-8.06	-4.68
3	3	-12.28	-8.41	-10.52	-7.83
4	5	-16.76	-15.51	-7.40	-6.63
5	7	-20.26	-19.76	-8.94	-7.84
6	9	-22.19	-24.91	-17.97	-21.05

Table 4: Reduction in tensile strength versus conventional concrete curing for 28-days.

#	BMW Ash (%)	Reduction in Tensile Strength (%)			
		7-Day	14-day	28-day	90-Day
1	0	-6.64	-3.55	0.00	28.77
2	1	-13.56	-9.49	-8.06	22.75
3	3	-18.11	-11.66	-10.52	18.69
4	5	-22.29	-18.51	-7.40	20.24
5	7	-25.56	-22.61	-8.94	18.67
6	9	-27.36	-27.58	-17.97	1.67

4. CONCLUSSION

The laboratory investigations for tensile strength of concrete cast with biomedical waste ash as cement replacement show the following.

1. Increase in quantity of biomedical waste ash is directly proportional with decrease in the tensile strength except for 1% replacement.
2. For all levels of replacement, the tensile strength of proposed concrete observed with in the specified range of tensile strength for conventional concrete.
3. Within the curing age all levels of cement replacement observed reduction in tensile strength.
4. Taking 28-day curing as standard, minimum reduction in tensile strength is for 5% replacement of cement with biomedical waste ash.
5. Elongated curing shows increase in tensile strength for all replacements with maximum at 1% replacement of cement.

Therefore, the use of biomedical waste ash has good effect on the tensile strength of concrete particularly with elongated curing. As 28-day curing is considered standard and is commonly used therefore, 5% is the optimum dosage of the biomedical waste ash.

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