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EFFECT OF CURING METHODS ON TENSILE STRENGTH OF GREEN CONCRETE CYLINDERS MADE WITH DEMOLISHING WASTE AS COARSE AGGREGATES

Bashir Ahmed Memon[1], Mahboob Oad[*2], Abdul Hafeez Buller[3], Ali Raza[4]

[1]Professor, Department of Civil Engineering, Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan.

[2]*Assistant Professor, Department of Civil Engineering, Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan.

[3]Engineer, Department of Civil Engineering, Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan.

[4]Post Graduate Scholar, Department of Civil Engineering, Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan.

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***Corresponding Author**
Dr. Mahboob Oad
Assistant Professor, Department of Civil Engineering, Quaid-e-Awam University of Engineering, Science & Technology, Nawabshah, Sindh, Pakistan.

ABSTRACT

Proper curing is one of the properties which ensures proper strength and durability of the concrete. This research article presents laboratory investigations on the effect of different curing methods on tensile strength of green concrete cylinders cast with 50% dosage of recycled aggregates from demolishing waste. Total of 30 cylinders were cast in six batches using normal mix concrete and 0.45 water to cement ratio. One batch of cylinders was cast with all-conventional aggregates to compare the results of proposed concrete. Other five batches were cured using standard water curing with potable water, open air, gunny bags, steam and waste water. All the specimens were cured for 28 days. After curing weight and tensile strength were determined following the ASTM standards. The comparison of the results reveals that curing of recycled aggregate concrete by gunny bags gives better results in terms of weight and tensile strength. Using curing by gunny bags the samples observed about 10% reduction in weight and 0.3% increase in average tensile strength.

KEYWORDS: Demolishing waste, recycled concrete aggregates, curing types, tensile strength, green concrete.

1. INTRODUCTION

Proper strength and durability during the service life are important for all type of structures. Among several qualitative measures, strength evaluation of the concrete from running batch is one. The strength of concrete highly depends on the curing type. Generally, potable water is used to cure the concrete for required period. However, scarcity of water around the globe force the industry to adopt different other curing methods. Also, different curing methods are adopted to improve the concrete strength. Among established methods other than potable water, chemical compounds, sheets, gunny bags etc. have been studied for conventional concrete.

Modern pace of development and needs of the society in line with modern development, require new infrastructure and associated facilities. It is also true to accommodate large population particularly in city center due to continuous migration from rural areas. The requirement is generally met through vertical expansion instead of unit or short height buildings. This leads to demolishing of the old, deteriorated and sometimes short height structures. The phenomenon generates demolishing waste to the extent that it has become management issue. This waste is used as filling material under floors and around the buildings. But the residual is still huge in quantum and normally goes to landfills. The space problem in and around the cities on other hand makes it difficult to deal. Also, dumping the same poses threats to the society and environment. In case if it is dumped near or in the agriculture lands will multiply the problem with negative impacts on the agricultural lands. The same is the situation in Pakistan, whose economy is mainly dependent on agriculture. A possible solution of the problem is to transport the waste to far areas, but it will add up the problem as cost of the project will increase. Therefore, to save the environment, natural deposits of the aggregates and reduce the waste management issue to some extent, this waste may be used in new concrete. It is reported in the literature that the waste may be used as fine and coarse aggregates. But as the coarse aggregates take more volume in the concrete body therefore, using it as coarse aggregates is a good option.

Therefore, in this research study use of demolishing waste as coarse aggregates and different curing methods are combined to study their effect on the tensile strength of concrete cylinders. For the purpose of curing of proposed concrete specimens, ponding, gunny bags,

open-air, steam and wastewater are adopted. In proposed specimens the dosage of demolishing waste as coarse aggregates is kept 50% following the recommendations of Oad and Memon.[3] To compare the results of proposed specimens, control specimens with all-conventional aggregates are cast and cured standard way.

2. LITRATURE REVIEW

There are several issues associated with the recycled aggregates particularly those obtained from demolishing waste. Recycling process, age of concrete, environment to which the structures was exposed during service life, old mortar attached with the aggregates are few among many. Although good quantum of the research is devoted to study the recycling processes, properties of the aggregates and properties of the resulting concrete at fresh and hardened state but the scatter in results is evident from the literature. Therefore, more work is still required to develop certain level of confidence about the use of the material. In the following review of the available literature pertaining to the topic of research is presented.

Memon1 in his study program reviewed the developments regarding the recycling, use and problems associated with the demolishing waste. The author discussed the different methods of recycling and summarized the literature regarding the properties and characteristics of the material. Vairagade et al.[2] reviewed the combined use of demolishing waste and fly ash in making of the green concrete. The authors based on their review study concludes that use of fly ash in concrete making will help in reducing carbon dioxide emission thus leads to sustainable and green environment. Franklin and Gumede[5] also reviewed the use of demolished concrete aggregates with reference to global perspective. The authors reviewed strength (compressive, tensile and flexural) and modulus of elasticity. Based on their study they concluded that the material may be used in the new concrete. They also observed that very less efforts are devoted to the research aspect particularly in Botswana. In another review article Pandey and Pandey[6] discussed green concrete made with replacement of aggregates or cement. Under both replacement conditions the concrete manufactured reduces the burden on conventional concrete resulting in reduction on the harmful effects on the environment. The authors also discussed the merits of green concrete over the conventional concrete. Suhendro[12] also reviewed the use of waste materials and different process to prepare green concrete with particular reference to problems and potential barriers in Indonesia.

Tanwani and Memon[4] used demolished concrete as coarse aggregates to study the tensile strength of the concrete. The authors used 50% dosage of the material to replace the conventional coarse aggregates. Based on the test results of the concrete cylinders, the authors observed that with the proposed dosage the loss in tensile strength of concrete is about 5% which is small enough to be ignored. Jain et. al.[7] studied mechanical and durability properties of concrete with recycled aggregates from demolishing waste. The authors prepared M30 grade concrete using 50% and 100% dosages of the recycled aggregates. The comparison of the strength result showed that there was only 7% reduction in strength when conventional aggregates were totally replaced with recycled aggregates. Towards durability properties the authors observed that green concrete was somewhat permeable for chloride ions but did not found any trace of carbonation in all concrete mixes. Wagih et al.[8] used demolishing waste to prepare 50 concrete mixes in eight groups to study the compressive, tensile and elastic modulus. The authors also used silica fume as cement replacement and superplasticizer to maintain workability. Based on the properties, the authors found the suitability of demolishing waste as coarse aggregates for most of concrete applications in Egypt. They also argue that compressive strength of the concrete was not affected with induction of 25% recycled concrete aggregates. Moreno et al.[9] on other hand used recycled aggregates to produce hydraulic concrete and concluded almost similar conclusion but found that 30% replacement of natural aggregates with recycled aggregates is suitable dosage.

Mechanical and durability properties of green concrete were also studied by Shaikh.[10] The author developed three sets of green star concrete in accordance with Green Building Council Australis with blast furnace slag as aggregates and concrete wash water. Based on the comparison of test results with control specimens the author observed that all the durability and strength properties of the proposed concrete were less than control specimens. Use of recycled coarse aggregates has also been attempted in hot asphalt mixes to check the suitability by Alvarez et. al.[11] The authors used 20% - 80% replacement of natural aggregates with increment of 20%. The size of aggregates used was 5 mm – 13 mm. From the test results the authors concluded 40% as optimum dosage for better performance of the mix. Kalpavali and Naik also attempted demolishing waste as recycled coarse aggregates in high performance studies. Different dosages of the aggregates were used to prepare and cure the specimens for 7-, 14- and 28 days. From the test results of compressive, tensile, flexural

strength the authors concluded that although all modes of strength observed reduction but still, they fall in useable range.

Although good quantum of work has been done for studying the properties of green concrete but the effect of the curing on the tensile strength of the concrete is either less or absent. Therefore, this study aims at evaluating the effect of the curing methods on tensile strength of green concrete developed with demolishing concrete as coarse aggregates.

3. MATERIALS AND TESTING

The demolishing waste in the shape of large blocks was collected from the debris of a two-story residential building of Nawabshah region. These large blocks were down sized by hammering to get the recycled aggregates. After washing the aggregates with potable water, sieving were done as per ASTM standards to have maximum size of 1 inch. The sieving of natural aggregates was also done for same sized aggregates. Both of the aggregates meet the relevant ASTM standards of well graded aggregates. The aggregates are shown in Figure 1. The gradation of both of the aggregates is shown in Figure 2.

Using OPC, crush, hill sand, recycled coarse aggregates and potable water in 1:2:4 mix and 0.45 water-cement ratio cylinders were prepared. Size of cylinders used is 6"/12". The cylinders were cast in six batches with five samples in each batch. Among these batches one batch of cylinders was cast with all-conventional aggregates. This batch of cylinders is treated as control specimen and is used to compare the results.

Figure 1: Aggregates

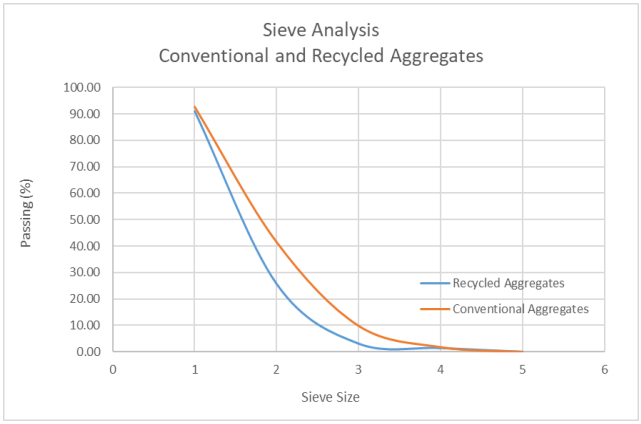

Figure 2: Gradation of RCA and NCA

In rest of the five batches of the cylinders both conventional and recycled aggregates were used in equal proportion. Casting and compaction of the specimens was done in standard

fashion as per ASTM standards. After de-moulding the specimens were air dried for 24-hour in laboratory. Then the control specimens and one batch of proposed cylinders were immersed in potable water for curing. Rest of the four batches of recycled aggregate specimens, were allowed to be cured in open air, with the help of gunny bags, steam and waste water (Figure 3). The curing of the specimens was done for 28 days.

Figure 3: Curing of specimens

Figure 4: Testing of specimen

At the end of curing time, specimens were removed from water, gunny bags, steam curing machine and waste water and were left to air dry for 24-hour. The weight of the cylinders was then determined using digital weight balance (Table 1). Followed by it, all the specimens were tested in universal testing machine for indirect tensile strength (Figure 4). At failure, load was recorded and used to compute the tensile strength by standard formula given below.

$$\sigma_t = 2P/\pi HD$$

Where, P is the failure load, H is the height of cylinder and D is the diameter of the cylinder. The computed tensile strength is given in Table 2.

Table 1: Weight of cylinders.

#	Weight for Curing Method					
	Potable water	**Potable water**	**Open air**	**Gunny bags**	**Steam**	**Wastewater**
RCA (%)	0	50	50	50	50	50
1	8.87	8.67	8.21	8.51	8.66	8.81
2	8.81	8.62	8.04	8.55	8.41	8.84
3	8.85	8.64	8.11	5.61	8.35	8.81
4	8.79	8.66	8.21	8.63	8.38	8.58

5	8.82	8.62	8.14	8.67	8.32	8.72
Avg:	**8.83**	**8.64**	**8.14**	**7.99**	**8.42**	**8.75**

Table 2: Tensile strength of cylinders.

#	Tensile Strength for Curing Method					
	Potable water	**Potable water**	**Open air**	**Gunny bags**	**Steam**	**Wastewater**
RCA (%)	0	50	50	50	50	50
1	5.89	5.74	4.89	5.379	4.74	5.92
2	5.81	5.63	4.43	6.776	5.15	6.25
3	5.86	5.60	4.53	5.841	4.36	5.02
4	5.93	5.59	4.75	5.786	4.63	5.45
5	6.17	5.85	6.14	5.962	4.22	5.41
Avg:	**5.93**	**5.68**	**4.95**	**5.95**	**4.62**	**5.61**

4. RESULT AND DISCUSSION

The weight of the specimens recorded is presented in Table 1. It may be observed from the table that maximum weight loss in proposed concrete specimens is observed with curing by gunny bags in comparison to the control specimens. The loss in weight is recorded equal to 10%. The comparison of the average weight of specimens due to different curing methods versus average weight of control specimens is shown in Figure 5.

The tensile strength (TS) of proposed specimens due to different curing methods is compared with the tensile strength of control specimens in Figure 6 to Figure 10. It may be observed from these figures that trend of tensile strength in the samples is almost same except for the samples cured by gunny bags. In this batch of the specimens one sample observed tensile strength even more than the strength any of the samples of the control specimens. It might be due to stronger aggregates present in the sample. However, the average strength of the five samples remained lower than that of the control specimens. It may further be observed that this batch of cylinders observed 0.3% increase in tensile strength in comparison to the tensile strength of control specimens. Therefore, for recycled aggregate concrete cured by gunny bags proved the best method of curing. The maximum strength loss (22%) is observed in sample cured by steam curing whereas, the waste water cured samples observed tensile strength loss equal to 5.45%. The samples cured in open air observed loss in tensile strength equal to 16.56%. The standard method of curing; immersing the samples in potable water; remained second best after curing by gunny bags. With this method of curing the loss in tensile strength of proposed concrete cylinders was recorded equal to 4.19%. It is further observed despite of different curing methods the concrete observed tensile strength within

specified range of ASTM standards. Figure 11 shows the comparison of the average tensile strength of proposed concrete specimens versus the control specimens curing by ponding.

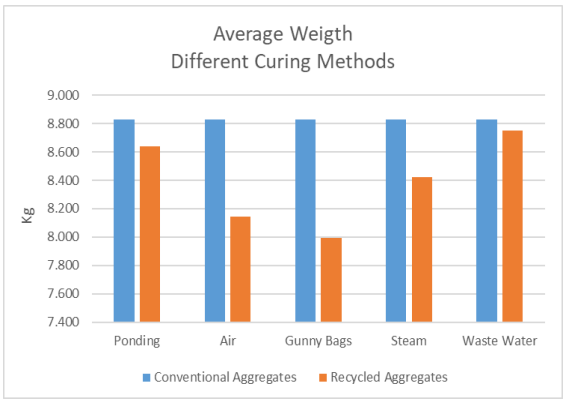

Figure 5: Weight of RCA vs NCA cylinders

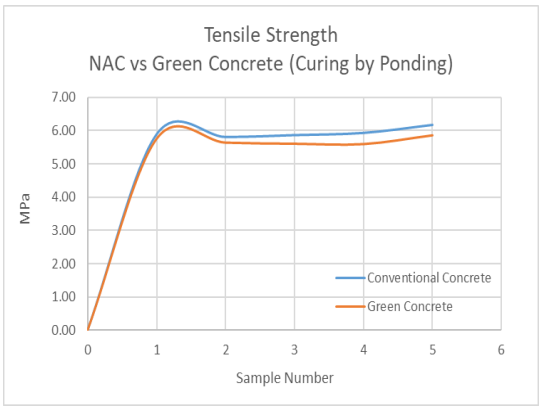

Figure 6: TS of NAC vs RAC (Ponding)

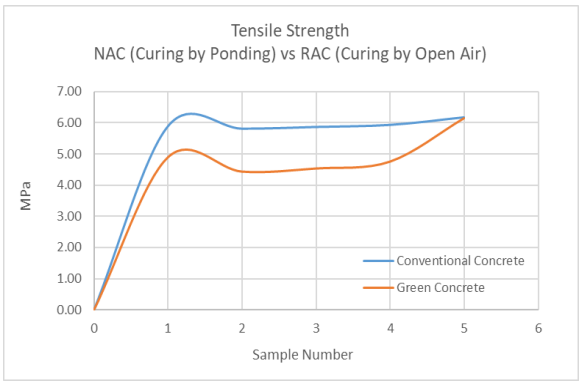

Figure 7: TS of NAC vs RAC (Open air)

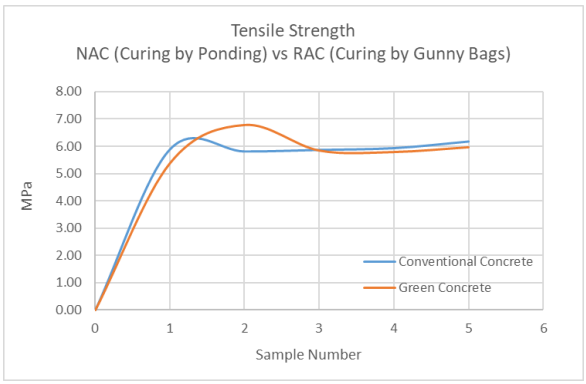

Figure 8: TS of NAC vs RAC (Gunny bags)

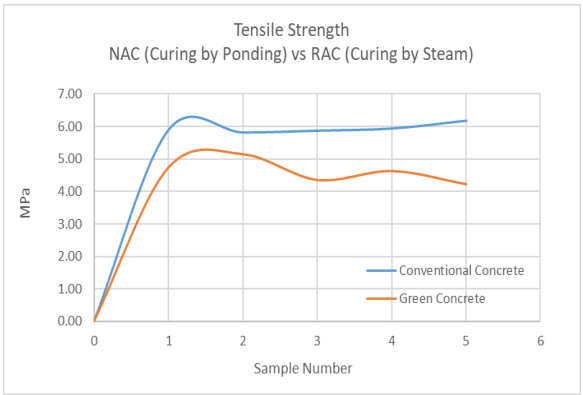

Figure 9: TS of NAC vs RAC (Steam)

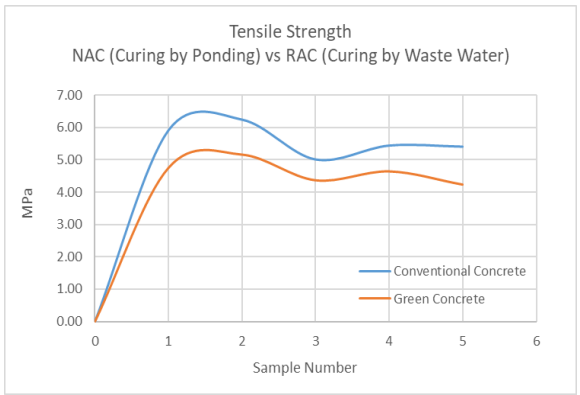

Figure 10: TS of NAC vs RAC (Wastewater)

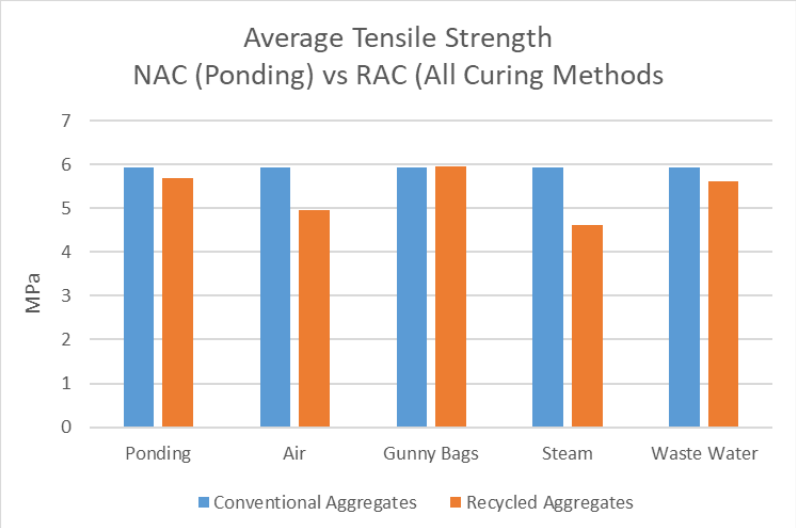

Figure 11: Comparison of average tensile strength.

5. CONCLUSION

In this research article effect of five curing methods; ponding, open air, gunny bags, steam and wastewater on tensile strength of concrete made by using demolished concrete as coarse aggregates is presented. The comparison of test results of weight and tensile strength with concrete specimens cast with all-conventional aggregates and cured in traditional way shows that curing of recycled aggregate concrete by gunny bags has positive impact on weight and tensile strength of concrete. With this method, proposed concrete was observed about 10% light in weight. Also, it observed 0.3% increase in tensile strength in comparison to control specimens. Although the increase is very less but equal tensile strength is also a positive sign and proves that the demolishing waste can be used in new concrete without compromising on tensile strength of the product.

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