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TENSILE STRENGTH OF CONCRETE CYLINDERS MADE BY PARTIAL REPLACEMENT OF NATURAL COARSE AGGREGATES WITH COARSE AGGREGATES FROM OLD CONCRETE

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ABSTRACT

Growing need of residential buildings and related infrastructures in city centers due to heavy migration from rural areas have posed serious problem of space around the globe. This forces the builders to construct new strucutres with more capacity inplace of old structures which not only generates huge quantum of the demolished concrete but also consumes natural aggregates in large quantities. Dealing with this construction waste economically and saving natural aggregates requires the use of this demolished waste in new concrete. However to make use of this new material with certain confidence level study of its properties is very necessary. Therefore, this research article makes the use of demolished concrete from Nawabshah city in new concrete to study its tensile strength. For the purpose concrete cylinders are made with 50% replacement of natural coarse aggregates with coarse aggregates from demolished concrete. The loss of tensile strength in comparision to reference concrete cylinders is observed as 5% only. Thus the obtained results shows promising use of demolished concrete as coarse aggregates in new concrete particularly in areas where load is not of much prime importance.

Keywords: Demolished Concrete, Coarse Aggregates, Tensile Strength.

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1. INTRODUCTION

Concrete is the premier construction material across the world and the most widely used in all types of civil engineering works. The demand of new construction has been ever-increasing with the rise in population, which increases the requirement of concrete. To meet the needs, especially in urban areas old structures are demolished and new high rise structures are being constructed. This results in the generation of construction waste at large scale. Commonly in most of the areas this waste is thrown and dumped in landfills, especially in residential areas, rivers and roads, which not only create problems of unpleasant views around the residential areas but also cause land and ground water pollution. Instead of using it as landfill, if it is possible to recycle it in the construction industry, it would be of fabulous support to the depleting natural stock of resources. Aggregates cover 75% of the total mass of concrete mix; therefore consumption of this waste as aggregates in concrete has an encouraging effect on the economy and saving of fresh aggregates. However to use this new material with certain confidence level it is very necessary to study its properties and behavior. This issue is active area of research around the globe. Various scholars have studied different properties of this material scatter in the results shows there is still room for research on the topic.

Therefore considering the possibility of reusing this waste material, this work presents an experimental study on the effective use of recycled coarse aggregates from demolished concrete. The major purpose of this study is to evaluate the tensile strength of concrete cylinders prepared with prepared by replacing 50% natural coarse aggregates with coarse aggregates from demolished concrete from Nawabshah, Pakistan.

To achieve this objective demolished concrete was collected from the Nawabshah Medical College and total of 120 cylinders were made using 0% (Batch 1: 60 cylinders) and 50% (Batch 2: 60 cylinders) of coarse aggregatres from demolished concrete. In both batches 1:2:4 mix with water/cement ratio of 0.5 was used. 50% replacement of natural coarse aggregates was selected based on the results of Oad[1], Bhatti[2] and Memon[3]. Out of prepared specimen 30 cylinders each were then cured for 7 and 28 days. Water absorption and moisture content of both batches of concrete cylinders is evaluated. It is observed that at both curing ages (7 and 28 days) water absorption and moisture content of batch 2 remained on higher sides in comparision to batch 1.

Both bathces of concrete cylinders were then tested for tensile strength using universal load testing machine. The obtained results are presented and compared. It is observed that the tensile strength of the concrete cylinders of btach 2 at curing age of 28 days is approximately 95% of the virgin concrete. The loss of tensile strength is about 5% which shows promising use of this

material particularly in areas where load is not of prime importance.

2. LITERATURE REVIEW

The use of recycled aggregates remained the active research area of the scholars to find not only the alternate of natural aggregates but also to deal with the demolished concrete waste. Research on both front, management and recycling of demolished waste and checking of properties of new concrete made with partical replacement of natural aggregates with aggregates from demolished concrete in underway since long. However scatter present in the results of different studies shows that there is still need to work more on this material to reach a certain level of confidence. In the following literature review of the topic is summarized.

Praveen Mathew[4] in his research work stated that the increasing number of population demand new construction by demolishing old ones. This result in concrete waste, which is a serious threat to the environment. To make a better use of this waste the authors proposed and used it as coarse aggregate for fresh concrete. They used it as partial replacement of fresh aggregates in proportion of 0% (NAC), 20% (RAC 20), 30% (RAC 30) and 40% (RAC 40). Cylinders were cast and split test was carried out. For NAC the tensile strength was 2.83 N/mm^2, RAC 20 it was 2.12 N/mm^2, RAC 30 gave 2.46 N/mm^2 and RAC 40 it was 2.96 N/mm^2. The authors based on their results concluded that that the tensile strength of RAC 40 is more than the tensile strength of concrete with natural aggregates.

B. Ahmed[5] investigated the tensile strength and other parameters of concrete made with recycled and natural aggregates by testing concrete cylinders cured for 7 and 28 days. The authors observed 13.8% and 9.3% reduction in tensile strength for 7 and 28 day cured cylinders respectively. Based on the results the authors concluded that recycled aggregates can be used in concrete for CC works, sub base and other temporary structures.

Suvash Chandra Paul[6] used coarse aggregates from demolished concrete in three different proportions, 0%, 30% and 100% (0% refers to 100% natural aggregates) to study strength, stiffness and durability. The author based on the tensile strength results observed that 30% replacement of natural aggregates produces better results than other proportions.

Ganesh S.Ingle[7] aimed to evaluate physical properties of concrete using recycled coarse aggregate. In his experimental work he used 0%, 25%, 50%, 75% and 100% replacement of natual aggregates with aggregates from demolished concrete. For each percentage 15 cylinders were prepared. Tensile test was done with the specimens that were cured for 28 days. Tensile

strength of reference concrete was observed equal to 3.82 MPa where as 3.86MPa, 3.92MPa and 3.68MPa and 3.50MPa were obtained for 25%, 50%, 75% and 100% replacement of natural aggregates. From the results it is clear that 50% of RAC with 50% of natural aggregate gave the maximum strength even more than reference concrete. With the increasing proportion of RAC the gradual decrease in strength is observed. Therefore based on the test results the author concluded that right proportion of aggregates is 50-50 of both types of aggregates.

Hossain[8] in his research article presented a comparative analysis of fresh aggregates with the recycled ones. The author tested 120 cylinders made with five types of proportion, 0%, 25%, 50%, 75% and 100%. Cylinders were cured for a different period, i.e. 7, 14, 90 days. With the comparison to all the ratios, 50% of RAC with the natural aggregate provides much more tensile strength. He also concluded that by increasing the period of curing, tensile strength increases in all the proportions used.

Kumutha[9] (2010) investigated the properties of concrete containing recycled aggregates. Crushed concrete was used in 0%, 20%, 40%, 60%, 80% and 100% in place of natural aggregates. The specimens were cured for 7 days and 28 days and the results were compared with the specimen made with 100% natural aggregates. For 7 days curing, the splitting tensile strength of specimen made with 100% natural aggregates was 1.93N/mm^2, where as specimen with 20%, 40%, 60%, 80% and 100% replacement of natural aggregates gave tensile strength equal to 1.91N/mm^2, 1.68N/mm^2, 1.26N/mm^2, 1.24N/mm^2 and 1.21N/mm^2 respectively. For 28 days cured specimen, the results obtained were 3.25N/mm^2, 3.08N/mm^2, 2.81N/mm^2, 2.73N/mm^2, 2.23N/mm^2 and 2.09N/mm^2. Based on the experimental observations the author concluded that 50% is the omptimum one and with increasing percentage of aggregates from demolished concrete tensile strength decreases.

Yong[10] in his research article pointed out the in this rapid industrialized world, recycling construction materials plays an important role to preserve natural resources. The author in his work used three percentages of coarse aggregates from demolished concrete i.e. 0%, 50%, 100%. In addition he also used specimen with 100% aggregates from demolished concrete but made the specimen saturated surface dry. The spilt tensile strength test results for 50% replacement were almost same to that of reference concrete, whereas the tensile strength of specimen with 100% replacement of natural aggregates and in SSD condition showed higher results than reference control specimen.

Bamorth et al[11] studied different properties of concrete with aggregates from demolished concrete for the purpose of including results in Euro Code 2 and Kandekar[12] evaluated

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possibilities of using demolished waste as fine aggregate.

3. EXPERIMENTAL WORK

To achieve the object of this research work old concrete was collected from the Nawabshah Medical College. The material was of roof slab and beams. Large pieces (fig 1) were broken into small size pieces by hammering. Then 1.25", 3/4", and 1/2" sieves were used to get required size of coarse aggregate (fig 2 and fig 3). Concret mix proportioning was done using ACI method for mean strength of 3000 psi using ordinary Portland cement and standard fine aggregates. Total of 120 cylinders of stardard size (6"x12") were then cast in two batches namely B1 (with 100% natural coarse aggregates) and B2 (with 50% coarse aggregates from demolished concrete). Table 1 gives the details of the specimen. Batch B1 is refered as reference concrete and will be used to compare the results of batch B2. In both of the batches maximum size of coarse aggregates is kept same that was 1.25" and the water cement ratio used was 0.5. Mixing of concrete ingredients was then done in standard fashion in roller mixer followed by casting of cylinders. 30 cylinders of each batch were then cured for 7 and 28 days in water pond respectively. After required time all the cylinders were taken out of water. Basic properties of the cylinders i.e. water absorption and moisture contenet were then evaluated using standard test procedure. Finally the cylinders of both batches were tested for tensile strength using universal load testing machine following all the precautions and procedures for the operation of the machine.

For each cylinder the load at which concrete cylinders split in two halves was noted, and the tensile strength is calculated by using following relation;

$$f_t = \frac{2P}{\pi LD}$$

Where,

P= Load at failure

L = Length of the cylinder

D = Diameter of the cylinder

Fig 1: Large pieces of demolished concrete

Fige 2: Sieving of aggregate

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Fig 3: Seived coarse aggregate

Table 1: Specimen Details

Batch	Replacement of natural aggregates	No of cylinders	Curing (days)
B1	0%	30	7
		30	28
B2	50%	30	7
		30	28

5 RESULTS & DISCUSSIONS

Basic properties of the cylinders i.e. moisture content and water absorption are evaluated using standard test procedures and are listed in table 2. It is observed that cylinders cured with 7 days shows 37.97% increase in moisture content in comparision to reference concrte where as 14.45% increase in moisture content for 28 day cured cylinders of batch B2 is recorded in comparision to the results of reference concrete.

Table 2: Moisture Content and water absorption

Batch	Curing	Average Moisgure Content (%)	Average Watrer Absorption (%)
B1	7 days	2.225	2.225
	28 days	2.23	3.01
B2	7 days	3.07	3.07
	28 days	3.88	3.36

Results of water absorption of concrete cylinders showed almost similar trend. For 7 day cured cylinders water absorption is recorded as 37.97% higher than that of

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reference concrete cylinders. The results of water absorption of batch B2 for 28 day curing remained 11.62% higher than the results of batch B1. In deed it is mainly because of old mortar attached with coarse aggregates from demolished concrete which absorbs more water than conventional concrete thus giving rise to the water absorption and moisture content. Results of both the parameter were found in good aggrement with results obtained by Oad[1], Bhatti[2] and Memon[3]. This is the main reason due to which concrete mix with coarse aggregates from demolished concrete require more water cement ratio than regular concrete mix. Tensile strength of the cylinders is evaluated using standard procedure and the average value of all the cylinders of the batch and the curing age are listed in table 3. Based on the results it is found that cylinders cured for 7 days of batch B2 observed 14.83% decrease in the tensile strength w.r.t reference concrete cylinders. On the other hand tensile strength of concrete cylinders of batch B2 cured for 28 days remained 4.79% in comparision to tensile strength of concrete cylinders of batch B1.

Table 3:Tensile strength

Batch	Curing (Days)	Average Tensile Strength	
		Psi	MPa
B1	7	401.8	2.78
	28	443.7	3.06
B2	7	342.2	2.36
	28	423.4	2.92

As 28 day curing is the standard curing in concrete industry there fore loss of tensile strength of concrete made with 50% replacement of natural coarse aggregates with coarse aggregates from demolished concrete is about 5% which shows its promising effect to be used as the alternative of natural coarse aggregates in

new concrete particularly in areas where load is not of prime importance. Hence it will not only reduce the problem of finding landfill areas for demolishing waste but also save the natural coarse aggregates.

6 CONCLUSION

This experimental study is carried out to check the tensile strength of concrete cylinders using coarse aggregates from demolished concrete in 50% replacement. A total of 120 cylinders are prepared in two batches with 60 cylinders in each batch. One batch of cylinders is prepared using 50% replacement of natural aggregates whereas in second batch 100% natural coarse aggregates are used to check the results. In each batch 50% cylinders are cured for 7 days and 50% for 28 days. Basic properties i.e. water absorption and moisture contents are evaluated and compared with reference concrete. It is found that both of the parameters remained on higher side. It is mainly due to the old mortar attached with the coarse aggregates with increases the water demand thus giving rise to water absorption and moisture content.

Tensile strength of concrete cylinders is evaluated and compared with reference concrete cylinders. It is observed that 7 days cured cylinders observed 14.83% reduction, whereas 4.79% reduction is recorded for 28 days cured cylinders. As 28 days curing is the standard curing age, therefore it can be concluded based on this limited experimental study that with 50% replacement of natural coarse aggregates with coarse aggregates from demolished concrete 95% of tensile strength is obtained.

Based on the results of this experimental work, it can be concluded that by 50% replacement of natural coarse aggregates can effectively be used in new concrete for locations where load is not of much importance i.e. footpaths, walkways, partition walls etc.

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