STUDIES ON CONCRETE RECYCLED BUILDING MATERIALS

Mr. Chetan Kumar[1], Mr.Nitin kumar[2], Mr. Ramesh Kumar Dhaka[3], Er. T.N. Panday[4] ,Er.Bharat Phulwari[5], Er.Amit Choudhary[6]

[1]*PG Scholar, Department of Civil Engineering,Bhagwant University , Ajmer Rajasthan., India*
[2]*PG Scholar, Department of Civil Engineering,Bhagwant University , Ajmer Rajasthan., India*
[3]*PG Scholar, Department of Civil Engineering,Bhagwant University , Ajmer Rajasthan., India*
[4]*Assistant Professor, Department of Civil Engineering,Bhagwant University , Ajmer Rajasthan., India*
[5]*Assistant Professor, Department of Civil Engineering,Bhagwant University , Ajmer Rajasthan., India*
[6]*Assistant Professor, Department of Civil Engineering,Bhagwant University , Ajmer Rajasthan., India*

ABSTRACT

Construction industry uses cement which is known to be a heavy contributor to the CO2 emissions and environmental damage. Incorporation of industrial wastes like demolished old concrete, silica fume (SF) and fly ash (FA) as supplementary cementing materials (SCMs) could result in a substantial reduction of the overall CO2 footprint of the final concrete product. However, use of these supplementary materials in construction industry especially in the making of concrete is highly challenging. Significant research efforts are required to study the engineering properties of concrete incorporating such industrial wastes. Present research is an effort to study the properties of concrete incorporating industrial wastes such as demolished concrete, SF and FA.

Recycled coarse aggregate (RCA) concrete construction technique can be called as 'green concrete', as it minimizes the environmental hazard of the concrete waste disposal. Indian standard recommends target mean compressive strength of the conventional concrete in terms of water cement ratio (w/c). The behaviour of RCA concrete, prepared from two samples of parent concrete having different age groups, is investigated, to propose the relationship of compressive strength with water cement ratios, in the present study. Number of recycling may influence the mechanical properties of RCA concrete. The influence of age and number of recycling on the properties such as capillary water absorption, drying shrinkage strain, air content, flexural strength and tensile splitting strength of the RCA concrete are examined. While the compressive strength reduces with number of recycling gradually, the capillary water absorption increases abruptly, which leads to the conclusion that further recycling may not be advisable.

Keyword: - *Concrete, Recycled coarse aggregate, Ureolytic bacteria, Silica fume, Fly ash, Variability, Fragility.*

---

1. INTRODUCTION

Most engineering constructions are not eco-friendly. Construction industry uses Portland cement which is known to be a heavy contributor to the CO2 emissions and environmental damage. In India, amount of construction has rapidly increased since last two decades. Using various types of supplementary cementing materials (SCMs), especially SF and FA, as a cement replacement could result in a substantial reduction of the overall CO2 footprint of the final concrete product. Lesser the quantity of Portland cement used in concrete production, lesser will be the impact of the concrete industry on the environment.
The deposition of construction garbage which is increasingly accumulated due to various causes such as demolition of old construction is also an environmental concern [Topcu and Guncan 1995]. In India, the Central Pollution Control Board has assessed that the solid waste generation is about 48 million tonnes per annum of which 25% are

from the construction industry. This scenario is not so different in the rest of the world. In order to decrease the construction waste, recycling of waste concrete as aggregate is beneficial and effective for preservation of natural resources [Khalaf and Venny 2004].

Usage of demolished concrete, SF and FA in construction industry is more holistic as it contributes to the ecological balance. However, use of these waste materials in construction industry especially in the making of concrete is highly challenging. Significant research efforts are required to study the engineering properties of concrete made of such industrial wastes. Present research is an effort to study the properties of concrete incorporating industrial wastes such as demolished concrete, SF and FA.

Demolished concrete can be used as recycled coarse aggregate (RCA) to make new concrete (RCA concrete) by partially or fully replacing the natural coarse aggregate (NCA). Various researchers have examined the physical and mechanical properties of RCA concrete and found that the mechanical strength of the RCA concrete is lower than that of conventional concrete with NCA. This is due to the highly porous nature of the RCA compared to NCA and the amount of replacement of NCA [Rahal 2007]. The physical properties of the RCA depend on the amount of adhered mortar and its quality. Amount of adhered mortar depends on the process of crushing of parent concrete. Due to these reasons, RCA shows more porosity, more water absorption, low density and low strength as compared to the natural aggregate. Previous researchers reported that up to 25% reduction in compressive strength has been occurred due to above reasons [Amnon 2003; Elhakam et al. 2012; Tabsh and Abdelfatah 2009, McNeil and Kang 2013].

The inherent variability of cement and SF may not be similar in nature, as SF is a by-product in the carbothermic reduction of high-purity quartz with carbonaceous materials like coal, coke, wood-chips in the production of silicon and ferrosilicon alloys. Therefore, existing literatures on the variability of cement concrete may not be useful to describe the variability of concrete with SF. One of the focus of the present study is to describe the variability of concrete using SF by finding out a best fitted probability distribution matching the experimental data. An attempt has been made to study the seismic behaviour of typical RC structures through fragility analysis considering the variability of the SF concrete obtained from experiments.

FA, which is another material used to supplement cement popularly to produce concrete. A part of the present study is devoted to investigate the above described properties for FA concrete also.

EXPERIMENTAL METHODS AS PER INDIAN STANDARDS

All the experimental work conducted in this research confirming to Indian standard only. This section briefly describe the methods used for conducting experimental program.

Compressive Strength

The compressive strength of specimens is determined after 7 and 28 days of curing respectively with surface dried condition as per Indian Standard IS: 516-1959. Both moulds size and are used for evaluation of compressive strength. Three specimens are tested for typical category, and the mean compressive strength of three specimens is considered as the compressive strength of the specified category. mm150*150*150mm100*100*100mm.

Tensile Splitting Strength

Tensile splitting strength of concrete was found out as per IS: 516-1959. Cylinders of size 150*300 mm and 100*200mm are used for getting tensile splitting strength of concrete throughout experiment.

Flexural Strength

Flexural strength of concrete was found out as per IS: 516-1959. Prisms of size (500*100*100) mm was taken for the experiment.

Behaviour of RCA Concrete

Behaviour of the RCA concrete is studied experimentally with a special emphasis on the age and number of recycling of RCA. This following sections present the details of materials used and the results of experimental study in this regard.

Materials and Mixture Proportion

RCA were collected from two sources: (a) demolished concrete wall (unused) constructed for drainage purpose (three years old) and (b) crushed concrete cubes and beams from structural engineering laboratory (aged about zero to one year old). While the Source (a) can be considered as non-load-bearing type with a design characteristic strength of 20 MPa the Source (b) was a mixture of concrete with different design characteristic strength (ranging from 25 MPa to 30 MPa) and all of them were undergone a loading (direct compression or combined shear-bending) up to failure. The exposure condition for both of the sources may be considered as normal. The RCA samples are collected and grouped in two categories according to the source/age of the parent concrete. A total of 24 mixtures are considered for the investigation. The materials used, mixture proportions are explained in the following sections. Portland slag cement conforming to IS: 455-1989 code is used as the binder. It is to be noted here that the majority of the previous literature have used OPC in the preparation of RCA concrete. However, there are few papers (Myung-Kue, 2005; Sagoe et al. 2001; Hansen, 1990) that reports the results of RCA concrete made of PSC. 95% of the total cement used worldwide is PSC (Indian Cement Review, 2015; Saunders, 2015). Therefore, the motivation of this study was to check the behaviour of RCA made of PSC which may be more useful for the present construction. The fine aggregate (sand) are collected from the local river, conforming to IS: 383-1970. Two different types of demolished parent concrete are identified which are reported to have a characteristic compressive strength of 20MPa.The parent concrete is crushed using mini jaw crusher. The opening of the jaw crusher was maintained at 20mm for producing maximum size of 20mm coarse aggregate as per requirement of IS: 456-2000. As the two parent concrete samples are having different ages, they are divided into two groups named as RC-1 and RC-2. The concrete produced from RC-1 aggregate again demolished and crushed to examine the effect of number of recycling. Aggregate obtained from RC-1. concrete named as N2-RC-1 which indicates that the aggregate is recycled for two times. The age difference between the two recycles (RC-1 and N2-RC-1) was less than three months. Use of the first structure is explained earlier. After the first recycling, these aggregates (RC-1) were used in the laboratory specimens which has undergone failure load before the 2nd recycling (N2-RC-1). These properties are found to be conforming to IS: 2386 (Part III)-1963. The values of specific gravity, water absorption, impact and crushing strength of RC-1 and RC-2 show that RC-1 is better than RC-2. This is perhaps due to more amount of mortar present on the surface of the RC-2 which can be seen in Fig. 1. Also another reason for this can be attributed to the lower specific gravity of the parent coarse aggregate. Same behaviour is obtained in case of N2-RC-1 which shows inferior physical properties in comparison to RC-1. Fig 2 shows the particle size distribution of all RCA used in the present study.

(a) RC-1 (b) RC-2 (c) N2-RC-1

Fig 1 RCA used in the present study

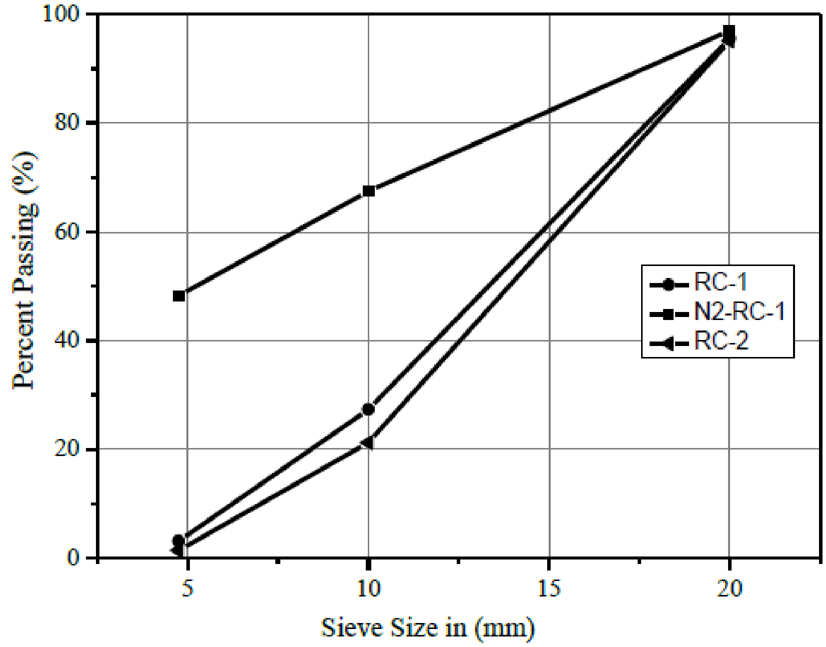
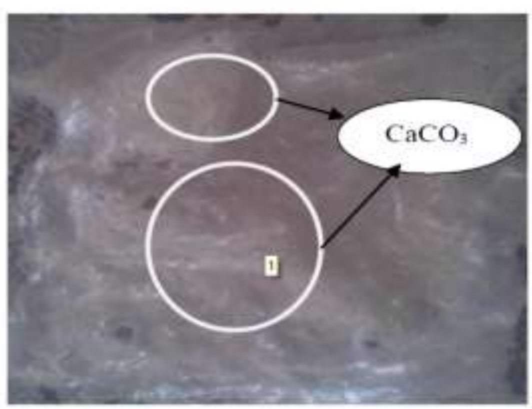


Fig 2 : Particle size distribution of RCA

Results and Discussion

Compressive strength, drying shrinkage and capillary water absorption test of hardened concrete and air content test of fresh concrete were carried out for all the concrete samples listed in previous section. Three samples were tested for each category and the average of the three was considered as the final result. Following sections discuss the results obtained from these test.



(a) RCA concrete with *B. subtilis* (B-3a)

(b) RCA concrete with *B. sphaericus* (B-3b)

(c) RCA concrete without bacteria (Control)

(d) NCA concrete without bacteria

Conclusions:

The objectives of the present work was to investigate the relationship of w/c ratio with compressive strength of RCA concrete considering age and number of recycling and to study the behaviour of RCA concrete with regard to the capillary water absorption, drying shrinkage, air content, flexural strength and tensile splitting strength. Experiments are conducted to study the above mentioned aspects and following are the major conclusions from the present study.

It is well known that the properties of concrete made with RCA are inferior to the normal concrete. The first part of this chapter discussed the aspects such as number of recycling and the age of the RCA, and its effects on the mechanical properties of RCA concrete. Second part of this chapter presented the experimental results of enhancement of mechanical properties of RCA concrete using two types of ureolytic bacteria. The last part of this chapter investigated properties of cement and cement mortar incorporating bacteria. The salient conclusions from each part of the study are summarised below.

Behaviour of RCA concrete

 The compressive strength of concrete prepared from older (2 years, RC-2) aggregate is found to be lower in comparison to RC1 (1-year-old). The reduction of compressive strength was about 6%. The reduction in compressive strength was probably higher amount of adhered porous mortar which reduces the strength of aggregate significantly.

 The compressive strength of concrete after successive (two times) recycling, N2-RC-1 is less than that of RC-1 (one time) and the decrease in strength of N2-RC-1 is about 2% compared to that of RC-1. N2-RC-1 shows higher compressive strength than NCA for w/c ratios higher than 0.42. The successive recycling reduces the quality of the adhered mortar and this may be reason for the decrease in strength after further recycling.

 Capillary water absorptions of RC-1 and RC-2 concrete are about 11% and 76% more compared to that of NCA. It is found that the capillary water absorption of N2-RC-1 is about 9 times larger than both RC-1 and NCA concrete. This abrupt increase of water absorption behaviour of N2-RC-1 leads to conclude that successive recycling may yield poor quality of aggregates that may not suit for concrete.

 The drying shrinkage strain of RC-1 and RC-2 are about 1.9 and 2.6 times more than that of NCA concrete respectively whereas that of successive recycled concrete, N2-RC-1 is about 1.2 times more than RC-1, which shows that successive recycling increases the drying shrinkage strain of concrete.

REFERENCES

1. Mehta, P.K. (1985). “Chemical attack of low water cement ratio concretes containing latex or silica fume as admixtures.” *ACI/RILEM, symposium on technology of concrete when pozzolans, slags and chemicals are used*, Monterrey, 325–40.
2. Mehta, P.K., and Aitcin, P.C. (1990). “Microstructural basis of selection of materials and mix proportions for high strength concrete.” *ACI Special Publication*, 121, 265-279.
3. Mosalam, K.M., Ayala, G., White, R.N., and Roth, C. (1997), “Seismic fragility of LRC frames with and without masonry infill walls.” *Journal of Earthquake Engineering*, 1(4):693-720.
4. Müller, I.L. (2004). “Influence of silica fume addition on concretes physical properties and on corrosion behaviour of reinforcement bars.” *Cement Concrete Composites*, 26, 31–39.
5. Myung-Kue, L., Kwang-Seo, K., Keun-Ho, L., and Sang-Hwa, J. (2005). “Strength of recycled concrete with furnace slag cement under steam curing condition.” *Journal of the Korea Concrete Institute*, 17(4), 613-620.
6. Neville, A.M. (1996) “Properties of concrete,”4th ed., *ELBS with Addison Wesley*, Longman, England.
7. Nielson, B.G. (2005). “Analytical fragility curves for highway bridges in moderate seismic zones.” Ph.D. Thesis, Georgia Institute of Technology.
8. Nowak, A.S., and Collins, K.R. (2000). “Reliability of structures.” *McGraw-Hill*, New York.
9. Ollivier, J.P., Maso, J.C., and Bourdette, B. (1995). “Interfacial transition zone in concrete.” *Advanced Cement Based Materials*, 2(1), 30-38.
10. Pacheco-Torgal, F., and Labrincha, J.A. (2013). “Biotech cementitious materials: Some aspects of an innovative approach for concrete with enhanced durability.” *Construction and Building Materials*, 40, 1136-1141.