Surface Absorption Characteristics of Recycled Concrete

Roshni John, A. A. Bage

Abstract*: Recycled aggregate is known to have higher water absorption produced due to the porosity of the cement paste adhered to the old concrete in the recycled aggregate, this in turn affects the durability. This study attempts to investigate the surface water absorption properties of recycled concrete when fly ash is added to concrete mix. In the mix proportion considered for study, 25% of natural coarse aggregate is replaced by recycled aggregate and 30 % Cement is replaced by fly ash. Surface water absorption property is studied experimentally by Initial Surface Absorption Test. Results indicate that pozzolanic properties of fly ash helps in reducing the water permeability of recycled concrete to a great extent.

Keywords: water absorption, recycled concrete, fly ash, initial surface absorption.

I. INTRODUCTION

In concrete construction, aggregates contribute about three fourths of the total quantity of concrete. There is a scarcity of natural coarse aggregates (NCA) and river sand in India today with a huge supply and demand gap. The supply and demand gap is going to be wider day by day as the demand for construction is going up and the natural resources are depleting day by day. As land costs are exorbitant in cities and developed areas, old and deteriorated buildings are being replaced by new ones. Demolition of old buildings generates massive deposits of construction wastes, leading to environmental pollution. The major part of the demolition waste goes to landflls only. According to Mirjana et al., (2010), a possible solution to these problems is to recycle the demolished concrete and produce an alternative aggregate for structural concrete [1]. Therefore recycling of construction waste is imperative to safeguard the environment through resource conservation.

Ann et al., (2008) quotes that a number of studies have been performed on evaluating the strength and other parameters of recycled concrete, but they always resulted in lower level of concrete strengths [2]

Recycled aggregate (RCA) consists of 65-70% original aggregate and 30-35% cement paste by volume. Sahoo et al., (2016) reported that in recycled aggregate, a certain amount of mortar from the parent concrete remains adhered to the stone particles during crushing. This adhered mortar forms a weak porous interface, which influences the strength and performance recycled aggregates. [3]

It is essential to improve the properties of RCA to get better quality of concrete made with them.

There are quite a few techniques adopted by researchers to enhance the properties of RCA.

- Removing the attached or loose mortar by ultrasonic cleaning method, ball milling, heating first and then rubbing.[4]
- Pre-soaking RCA in an acidic environment also removed adhered mortar, using different acids in different concentrations.[4]
- Using super plasticizers[5]
- Adding pozzolanic materials (SCM) like silica fume, fly ash etc to concrete[6]
- Using Bacteria (Microbial Remediation)[3]

II. SIGNIFICANCE OF THE STUDY

Durability of recycled concrete is a major concern which hinders the effective utilization of recycled aggregates in concrete construction. A review of literature indicates that the durability studies on concrete with recycled aggregate and pozzolanic materials are limited. Therefore an attempt is made in this study, to evaluate the durability properties such as water absorption characteristics of recycled concrete under the influence of fly ash as a pozzolanic material. Initial Surface Absorption Test [7] is used to evaluate the surface absorption characteristics of recycled aggregate. It is observed that use of lower percentage of water cement ratio or addition of pozzolanic materials is a good way to reduce the corrosion potential and drying shrinkage problems in reinforced concrete [8].

III. LITERATURE REVIEW

Recycled aggregates show higher water permeability which can lead to the corrosion of reinforcement. It is essential to study the moisture penetration characteristics and chloride ion ingress into concrete

Ann et al., (2008) investigated the durability of recycled concrete containing pozzolanic materials PFA and GGBS in binder [2]. In this study, chloride ion penetrability at 180 days was measured using rapid chloride penetration test corrosion rate was measured at 28 days using polarization method.

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The test results indicated that the use of 30 % PFA and 65% GGBS in binder resulted in a decrease in the charge passed through concrete specimens which implies enhance resistance to chloride ion permeability. Corrosion rate was also significantly reduced by PFA and GGBS. [2]

Kou et al., (2007) studied the influence of fly ash as cement replacement on the mechanical and durability properties of recycled concrete. Test results showed that when cement is replaced by flyash partially, the resistance to chloride ion penetration is increased. This improved resistance to chloride ion is due the formation of C-S-H gel which absorbed more chloride ions. [8]

IV. OBJECTIVES OF THE STUDY

The main focus of the study will be on durability aspect of recycled concrete, to be carried out by experimental investigations on concrete specimens made with recycled aggregate used as partial replacement of natural coarse aggregate and addition of pozzolanic material, fly ash as partial replacement of OPC.

The main objectives are:

a. To investigate the compressive strength of concrete when recycled aggregate is added and fly ash replaces cement partially.

b. To investigate the surface absorption characteristics of concrete when coarse aggregate is partially replaced by RCA and fly ash replaces cement partially.

V. EXPERIMENTAL INVESTIGATIONS

The experimental investigations for were carried out by casting concrete specimens of grade M 30 in the following three phases.

Table-1: Type of Concrete Mixes under study

Mix ID	NCA	RCA	Cement	Fly Ash
NCA	100%	--	100%	--
RCA	75%	25%	100%	--
RCA+FA	75%	25%	70%	30%

In this study, 25% of natural coarse aggregate is replaced by recycled aggregate obtained from old and demolished construction waste. Fly ash is added as a replacement to cement by 30%. Compressive strengths are investigated for control mix (NCA), concrete mix with 25% recycled aggregate (RCA) and concrete mix with recycled aggregate and fly ash (RCA +FA).

A. Materials used

Grade of Concrete : M 30
Water/Binder Ratio: 0.40

Table-2: Properties of ingredients for concrete Mixes

Ingredients	Type of Material	Source of materials	Average specific gravity	Water absorption %
Cement	OPC 53G	Ultra tech	3.14	
Coarse aggregate	20 MM	NCA	2.76	1.58
	10 MM	NCA	2.72	1.6
	4.75 to 20mm	RCA	2.55	3.52
Fine aggregate	Crushed sand	NA	2.63	4.88
Pozzolanic materials	Fly ash	ASH-TECH	2.17	
Chemical Admixture	Plasticizer	Fosroc Conplast-SP-430	1.22	

VI. RESULTS AND DISCUSSIONS

A. Compressive Strength

Compressive strength of different mixes was determined by conducting tests on 150 mm cubes [9] at 7 days and 28 days of casting.

Table-3: Compressive Strength Test Results

Type of Concrete mix	Avg. Compressive Strength (N/mm^2)	
	7 days	28 days
NCA	25.5	41.3
RCA	16.24	27.08
RCA+FA	9.48	27.68

RCA and Fly ash mix showed very less compressive strength at 7 days. But after 28 days of curing, pozzolanic properties of fly ash helped recycled concrete to gain more strength.

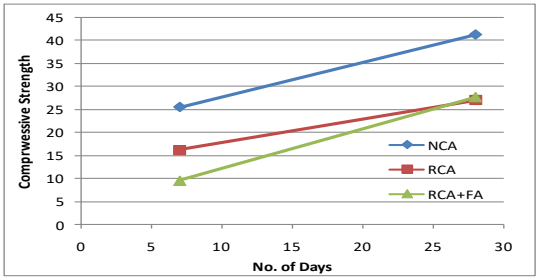

Fig.1 Variation of compressive strength after 7 and 28 days

B. Initial Surface Absorption Test (ISAT)

The ISAT is the test procedure developed by the British standards in accordance to (British Standards BS 1881-5, 1970) and (British Standards BS 1881-208, 1996). According to BS 1881, [7] the test investigates the porosity and water penetration via capillary suction through a specified unit area. This test is vital as the surface of a structure needs to be impermeable so that water would not be absorbed into the specimen and corrode reinforcement inside.

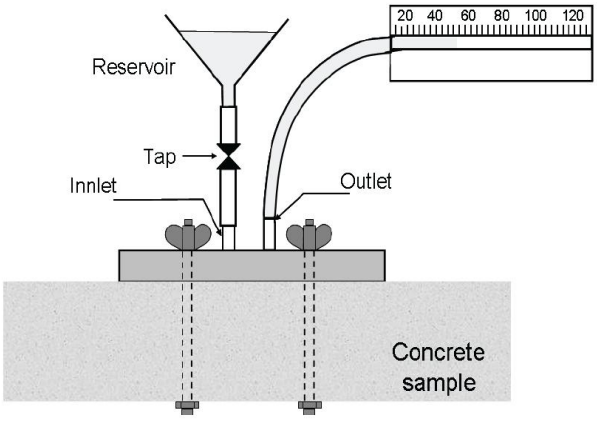

Fig.2. Initial Surface Absorption Test Set Up[2]

*1) **Procedure** [2]*

The test procedure of ISAT according to BS1881 [7] states that a pressure head of 200 mm (~0.02 bar) is to be set up by means of a water reservoir. The minimum water-concrete contact area is 5000 mm^2. When the inlet tap is opened, water flows to fill the cap and then through the outlet it climbs into the calibrated horizontal capillary tube. After 10 min, the tap is closed and the rate of water suction by the concrete is monitored by following the retraction of the meniscus in the capillary tube. This provides the initial surface absorption at 10 minutes. Record the number of scale divisions moved during the period.

2) Hardened Concrete Initial Surface Absorption Test Results

Table-13: ISAT Values for Control Mix

Sr. No	ID Mark	Concrete Surface Temp (ºC)	Duration to Note Movement (s)	Movement on Scale Unit, mm	No of Graduations	Initial Surface Absorption (10 Min) (ml/m^2.s)	Corrected Initial Surface Absorption at 20ºC (ml/m^2.s)
1	NCA1	24.9	120.0	69	22	0.108	0.097
2	NCA2	25.2	120.0	78	24	0.122	0.109
3	NCA3	26.1	120.0	85	27	0.133	0.117
					Average =		0.108

Table-14: ISAT Values for recycled concrete mix

Sr. No	ID Mark	Concrete Surface Temp (ºC)	Duration to Note Movement (s)	Movement on Scale Unit, mm	No of Graduations	Initial Surface Absorption (10 Min) (ml/m^2.s)	Corrected Initial Surface Absorption at 20ºC (ml/m^2.s)
1	RCA1	25.2	120.0	205	64	0.320	0.287
2	RCA2	24.6	120.0	215	67	0.336	0.305
3	RCA3	25.4	120.0	209	65	0.327	0.291
					Average =		0.294

Table-15: ISAT Values for recycled concrete +fly ash mix

Sr. No	ID Mark	Concrete Surface Temp (ºC)	Duration to Note Movement(s)	Movement on Scale Unit, mm	No of Graduations	Initial Surface Absorption (10 Min) (ml/m^2.s)	Corrected Initial Surface Absorption at 20ºC (ml/m^2.s)
1	RCA+ FA1	25.4	120	145	47	0.235	0.211
2	RCA+ FA2	25.2	120	132	41	0.205	0.184
3	RCA+ FA3	25.6	120	158	50	0.25	0.225
					Average =		0.206

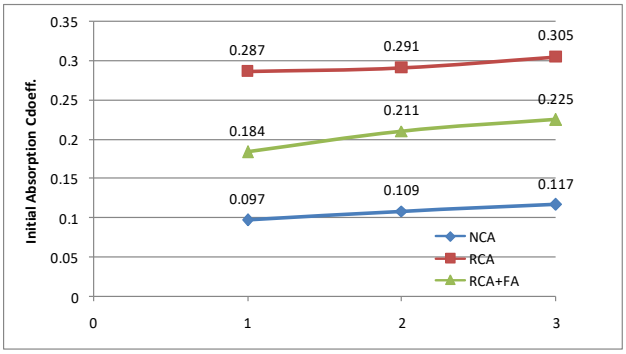

Fig.3. Initial Surface Absorption Coefficients for the three mixes

3) Interpretation of Results [2]

The initial surface absorption is simply the number of scale units moved in 1 minute [7]

Table-7: Test Result Interpretation [7]

ISAT values	**Comment**
Movement over the 5 s period exceeds 30 scale divisions	Concrete is too permeable
If the 10min reading is above 3.60 ml/(m^2.s)	Concrete is too permeable
Reading taken 10 minutes after the start of the test is below0.05 ml/(m^2.s),	concrete too permeable to be within the sensitivity of the test method

Role of Pozzolanic materials: the use of fly ash improved the distribution of pore size and pore shape of concrete [10] Ann et al., emphasizes the influence of pozzolanic properties of fly ash for enhancement of durability properties of concrete.

Pozzolanic materials produce a dense insoluble calcium silicate hydrate gel in the cement matrix due to the reaction between siliceous oxide and the free calcium oxide in concrete pore water.[2] This pozzolanic reaction is a slow process which is responsible for the delayed strength gain of concrete mixes (Neville, 1995)[11]

VII. CONCLUSION

This study investigated the influence of fly ash in the surface absorption characteristics of recycled concrete when it is added as a cement replacement partially. The test results show that fly ash addition can enhance the resistance to water penetration of recycled concrete. The results of the experimental investigations can be summarized as

a. The compressive strength of recycled concrete mix(RCA) is 36% less after 7days and 34% less after 28 days of curing compared to the control mix containing natural coarse aggregate.
b. Recycled concrete with fly ash (RCA+FA) attained less compressive strength after 7 days compared to the control mix (NCA) RCA mixes.
c. Recycled concrete with fly ash showed marginal increase in compressive strength after 28 days. RCA and FA mix attained 30.1% increase in compressive strength compared to the recycled concrete mix (RCA). This result justifies the slow strength gaining property of fly ash as mentioned by previous research works. The compressive strength was 14.6% less than the 28 days compressive strength of Control Mix.
d. Initial surface absorption coefficient of recycled concrete without fly ash is high.
e. Addition of fly ash improves the resistance to water penetration. Fly ash added concrete shows less initial surface absorption due to the reduction in the pore structure in the outer surface.

REFERENCES

1. Mirjana Malešev, Vlastimir Radonjanin and Snežana Marinković. "Recycled Concrete as Aggregate for Structural Concrete Production", Sustainability 2010,2,1204-1225:doi:3390/su2051204
2. Ann, K.Y., Moonb, H.Y., Kimb, Y.B. and Ryoub, J. (2008). "Durability of recycled aggregate concrete using pozzolanic materials." Elsevier Waste Management Volume 28, Issue 6, 2008, pp:993–999
3. Kirti Kanta Sahoo, Manoranjan Arakhab, Pradip Sarkar, Robin Davis P and Suman Jhab. "Enhancement of properties of recycled coarse aggregate concrete using bacteria", International Journal of Smart and Nano Materials, 2016 VOL. 7, NO. 1, 22–38
4 Revathi Purushothaman, Ramesh Ruthirapathy Amirthavalli and Lavanya Karan, "Influence of Treatment Methods on the Strength and Performance Characteristics of Recycled Aggregate Concrete" - Journal of Materials in Civil Engineering(ASCE) 2015, 27(5)
5. Silva, R.V., de Brito, J. and Dhir, R. K. (2015). "Tensile strength behavior of recycled aggregate concrete." Construction and Building Materials;83 (2015)108-118 Elsevier
6. Weerachart Tangchirapat, Rak Buranasing, and Chai Jaturapitakkul, "Use of High Fineness of Fly Ash to Improve Properties of Recycled Aggregate Concrete" Journal of Materials in Civil Engineering(ASCE) Jun 2010, Vol. 22, No. 6, Pp. 565-571
7. BS 1881-part 208-1996 – Testing concrete. Recommendations for the determination of the initial surface absorption of concrete
8. Shi Cong Kou, Chi Sun Poon, and Dixon Chan,"Influence of Fly Ash as Cement Replacement on the Properties of Recycled Aggregate Concrete" - Journal of Materials in Civil Engineering Sep 2007, Vol. 19, No. 9, Pp. 709-717
9. IS 516-1959 – Indian standard Methods of test for strength of concrete
10. Ali Mardani-Aghabaglou, Murat Tuyan and Kambiz Ramyar, "Mechanical and Durability Performance of Concrete Incorporating Fine Recycled Concrete and Glass Aggregates" - Springer Materials and Structures, August 2015, Volume 48, Issue 8, pp: 2629–2640
11. Neville, A.M., 1995. Properties of Concrete, fourth edition. Longman group Ltd.

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