

Strength and Permeability of Recycled Aggregate Concrete Containing Silica Fumes

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ABSTRACT: Recycled aggregate are substantially different in composition and properties compared with natural aggregate. The present work addresses the Strength and Permeability of recycled aggregate concrete containing Silica Fume containing 100% & 50% recycled coarse aggregate. In this study, concrete mixes containing both natural and recycled aggregate are producing by replacing of Portland cement 5%, 10% of silica fume by weight. The test results, in general, showed that the incorporation of mineral admixtures improved the properties of the recycled aggregate, the replacement of cement by 10% of silica fume improved both mechanical and durability performance. It has been observed that Silica fumes of 5% and 10%, can be adjudged as the most appropriate combination to be employed in RAC concrete for compressive strength, split tensile strength, flexural strength and Coefficient of permeability.

KEYWORDS: Construction and Demolition Wastes, Recycled concrete aggregate, Mineral admixtures, Compressive strength, tensile strength, flexural strength and coefficient of permeability.

I. INTRODUCTION

In this rapid industrialized world, recycling of construction material plays an important role to preserve the natural resources. Rapid industrial development causes serious problems all over the world such as depletion of natural aggregate and creates enormous amount of waste material from construction and demolition activities. One of the ways to reduce this problem, the possible use of recycled aggregate (RA) derived from construction and demolition (C&D) wastes have received increasing interest, due to its potential to be used in environmentally friendly concrete structures by et al [1]. Important role in the sustainable development of the built environment, reduction of pollution, conservation of natural resources and energy savings certainly has the entire civil engineering, especially construction material industry by et al [2]. The study of compressive strength and characteristics of the Interfacial Transition Zone (ITZ) of concrete containing recycled aggregates and nano-silica by et al [3]. It is observed that RCA up to a level of 60 % replacement of the natural coarse aggregate may be utilized in infrastructural applications like concrete pavements and blocks presented in [4]. The effects of incorporating silica fume (SF) in the concrete mix design to improve the quality of recycled aggregates in concrete are presented. Portland cement was replaced with SF at 0%, 5% and 10%. Specimens were manufactured by replacing natural aggregates with recycled aggregates presented in [5]. The replacement of cement by 10% of SF or 15% of MK improved both mechanical and durability performance, while the replacement of cement by 35% FA or 55% GGBS decreased the compressive strength, but improved the durability properties of the recycled aggregate concretes. Moreover, the results show that the contributions of the mineral admixtures to performance improvement of the recycled aggregate concrete are higher than that to the natural aggregate concrete. The mortar contents attached to RAs obtained from different sources varied greatly, and this might be related to original mortar content and the degree of prior mechanical crushing received. The experimental results on compressive strength, splitting tensile strength and elastic modulus indicated that RA of good quality (namely, low attached mortar content and water absorption value, high 10% fines value) can be used to fully replace NA to produce concrete with mechanical properties comparable to the concrete that are made with NA presented in [6-10].

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The work in this paper is divided in six chapters. (1) Nature of introduction to the uses of mineral admixtures in concrete containing recycled concrete aggregate and its benefits and need in the present construction practices scenario. The main objectives and scope of the report are stated. Finally, the organization of report is presented. (2) Available literature on effects of strength and durability properties of concrete with mineral admixtures is presented.(3) The problem formulation, research significance and objectives of the research. (4) The details of the experimental programmed. The properties of the various constituent materials used are presented. The details of the test procedure and strength and durability tests on hardened concrete undertaken in this study are also presented. (5) Presentation, analysis and discussion of the test results. The results of compressive strength, flexural strength, split tensile tests and permeability test are analyzed and discussed in detail. (6) The main conclusions of the study and identifies the scope for further research.

II. OBJECTIVE

In the present work, the effects of partial replacement of cement with addition of silica fume as mineral admixture, on strength & permeability of recycled aggregate of concrete are investigated. The precise objectives of the study are as follows:-

1)To study the compressive strength of recycle aggregate concrete with 50% & 100% of recycles aggregate each containing 0%, 5%, 10% silica fumes by weight of cement.2) To study the flexural strength and split tensile strength of RAC with 50% & 100% of recycles aggregate each containing 0%, 5%, 10% silica fumes by weight of cement.3) To study the coefficient permeability of RAC with 50% & 100% of recycles aggregate each containing 0%, 5%, 10% silica fumes by weight of cement. 4) To compare the results of strength & permeability of RAC with Natural aggregate concrete NAC containing silica fume (SF) as mineral admixture by replacing 0%, 5%, 10% of cement by weight

III. TEST DESCRIPTION

The experimental program comprised of casting and testing the concrete samples to determine the co-efficient of permeability, compressive strength and split tensile strengths and flexural strength. A design concrete mix will be used in this investigation. On total nine concrete mixes will be used in the investigation, the detail of which is given in Table 1.1 below. The testing for strength and permeability characteristics was carried out at curing ages of 7 and 28-days. The Size 150mm X 150mm X 150mm were cast for determine the Compressive Strength of concrete, standard beam specimen 100mm X 100mm X 500mm were cast to determine the Flexural strength test & Cubes of size 100mm X 100mm X 100mm were cast and test for split tensile strength and to determine the coefficient of permeability

Table: 1 Details of the Concrete Mixes

No.	Mix Designation	% age of recycled aggregate by weight of total aggregates	% age of silica by weight of cement
1.	N A C	0%	0%
2.	N A C 5	0%	5%
3.	N A C 10	0%	10%
4.	R A C 50 - 0	50%	0%
5.	R A C 50 - 5	50%	5%
6.	R A C 50 - 10	50%	10%
7.	R A C 100 - 0	100%	0%
8.	R A C 100 - 5	100%	5%
9.	R A C 100 - 10	100%	10%

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Preparation of NAC & RAC mixes & Proportioning of NAC & RAC Mixes

In the present investigation, the control mixes were prepared according to the *IS 10262* guidelines. An initial trial mix for control mix was obtained referring the procedure suggested in the *IS 10262* thereafter, calculating the mixture proportions. SF were used as cement replacements on a weight basis. In all concrete mixtures, a constant water/Cement ratio at 0.42 was used. Several trials were made keeping in view the basic workability requirements adjustments in the mix proportions were made to obtain a suitable mixes with required workability and stability. The slump flow of mix was kept on higher side (> 100mm) as the workability. The dosage of super-plasticizer (Glenium 51) was adjusted to obtain the required workability for all the SCC and SFRSCC mixes. The dosage of super-plasticizer used varies from 1.7% to 2.5% by weight of cement. The details of the final mix proportions of NAC and RAC used in the investigation work are presented in Table- 2.

Proportions for NAC and RAC Mixtures
Table 2

Mix.	Cement Kg/m3	Fine Aggregate Kg/m3	Coarse Aggregate Kg/m3	SP* (by weight of Cement)	Mineral admixture Kg/m3
NAC 0	206	762	935	0.25 %	0
NAC 5	195.7	762	935	0.25%	10.3
NAC 10	185.4	762	935	0.25%	20.6
RAC 50-0	206	762	935	0.25%	0
RAC 50-5	195.7	762	935	0.25%	10.3
RAC50-10	185.4	762	935	0.25%	20.6
RAC100-0	206	762	935	0.25%	0
RAC100-5	195.7	762	935	0.25%	10.3
RAC100-10	185.4	762	935	0.25%	20.6

IV. RESULT AND DISCUSSION

Compressive Strength Test Results

Table 3 Values of Compressive strength for 7 & 28-days water curing

Mix Sample	Compressive strength (MPa) 7 Days	Compressive strength (MPa) 28 Days
NAC	22.55	38.3
NAC 5	27.25	45.21
NAC 10	30.74	47.86
RAC 50-0	17.5	35.43
RAC 50-5	18.73	37.53
RAC 50-10	19.30	39.43
RAC 100-0	16.4	32.05
RAC 100-5	17.04	34.87
RAC 100-10	18.61	36.6

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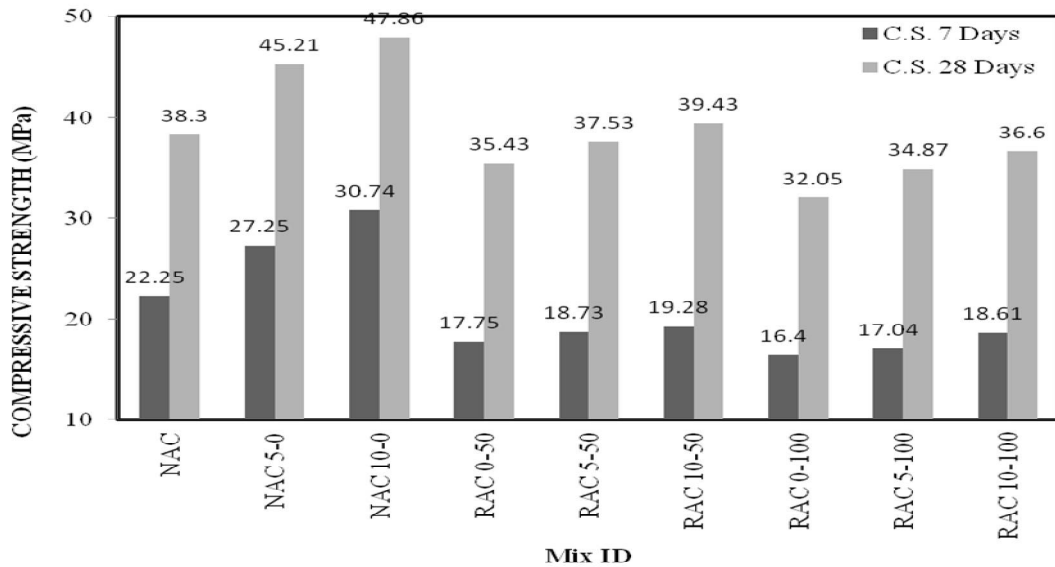


Fig- 1: Graphical representation of results of compressive strength test

It can be seen from the results of compressive strength of the natural and recycled aggregate concretes made with mineral admixtures (Fig-1) that at all test ages, the compressive strength of the natural and recycled aggregate concrete made with 5% SF and 10% SF were higher than the other corresponding concrete mixtures at 7 days and 28 days.

Tensile Strength Test Results

Table 4 Values of tensile strength for 7 & 28-days water curing

Mix Sample	Tensile strength (MPa) 7 Days	Tensile strength (MPa) 28 Days
NAC	2.64	4.6
NAC 5	3.33	4.81
NAC 10	3.59	5.62
RAC 50-0	2.2	4.23
RAC 50-5	2.29	4.62
RAC 50-10	3.12	4.81
RAC 100-0	2.05	4.01
RAC 100-5	2.12	4.6
RAC 100-10	2.31	4.81

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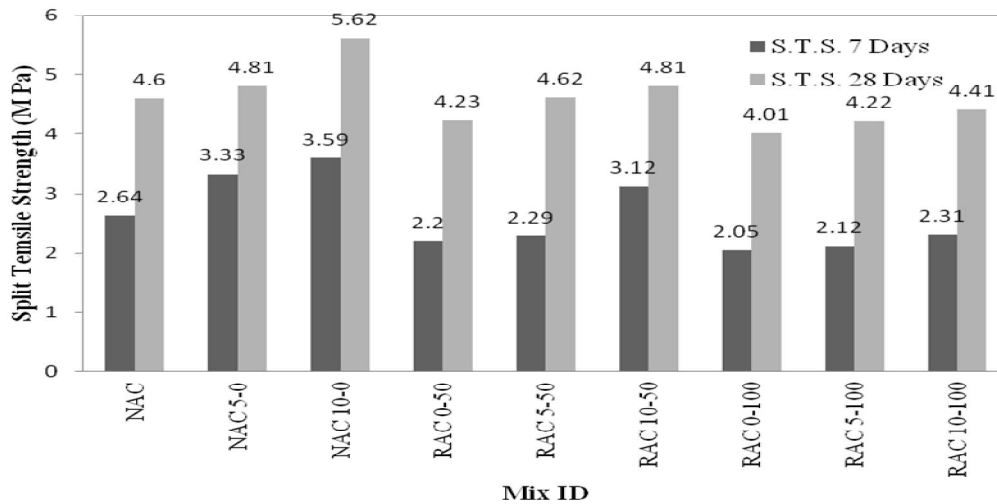


Fig- 2: Graphical representation of results of Split tensile strength test

The result of split tensile strength test carried out on NAC and RAC made from different proportion with silica fumes was determined at days 7 and 28 the results are presented in Fig 2. It can be seen that at all test ages, the tensile splitting strength of the natural and recycled aggregate concrete made with SF were higher than that of the corresponding control concrete mixtures.

Flexural Strength Test Results

Table 5 Values of flexural strength for 28-days water curing

Mix Sample	Tensile strength (MPa) 28 Days
NAC	4.21
NAC 5	4.87
NAC 10	5.14
RAC 50-0	4.02
RAC 50-5	4.57
RAC 50-10	4.83
RAC 100-0	3.92
RAC 100-5	4.17
RAC 100-10	4.36

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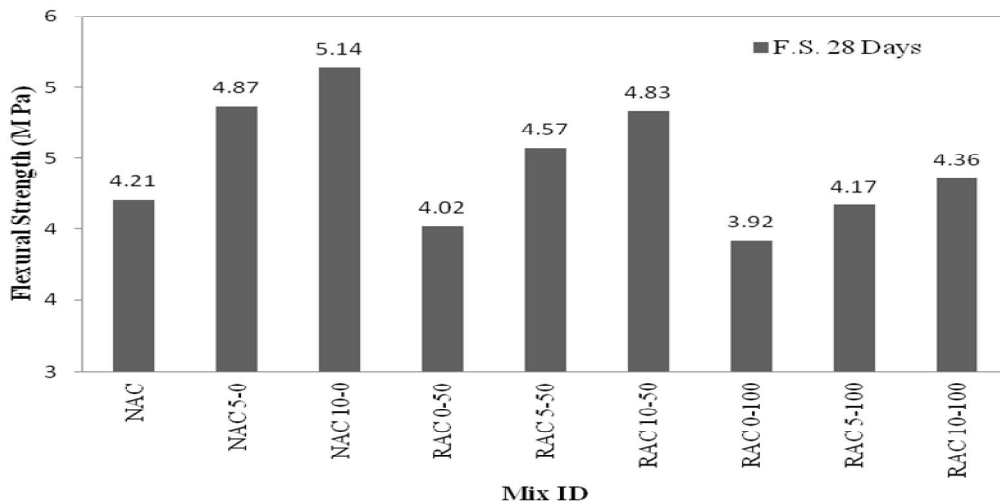


Fig- 3: Graphical representation of results of flexural strength test

As compare to flexural strength for 100% RAC replacement is the lowest while the reference concrete which had 0% RAC replacement has the highest flexural strength. The first replacement proportion 50% RAC has strength differing from the control concrete by 5.1%, while the maximum reduction for the test series is 31.5%. It can be seen that generally even the mass of the reduce with RAC increase, showing that greater than RAC content the less dense the specimen become. In the variation in flexural strength with the % RAC replacement levels, in general the flexural strength decreases as the % RAC replacement levels increases. The decreases is more significant for the 100% RAC concrete.

Coefficient of Permeability

Table 6 Values of Coefficient of permeability for 7 & 28-days water curing

Mix Sample	Co-efficient of permeability, K_s (m/sec) X 10^{-12}	Co-efficient of permeability, K_s (m/sec) X 10^{-12}
NAC	65.32	35.23
NAC 5	44.25	29.31
NAC 10	34.37	22.32
RAC 50-0	70.25	44.21
RAC 50-5	52.6	31.89
RAC 50-10	46.2	26.17
RAC 100-0	89.25	50.95
RAC 100-5	60.32	36.21
RAC 100-10	52.32	29.23

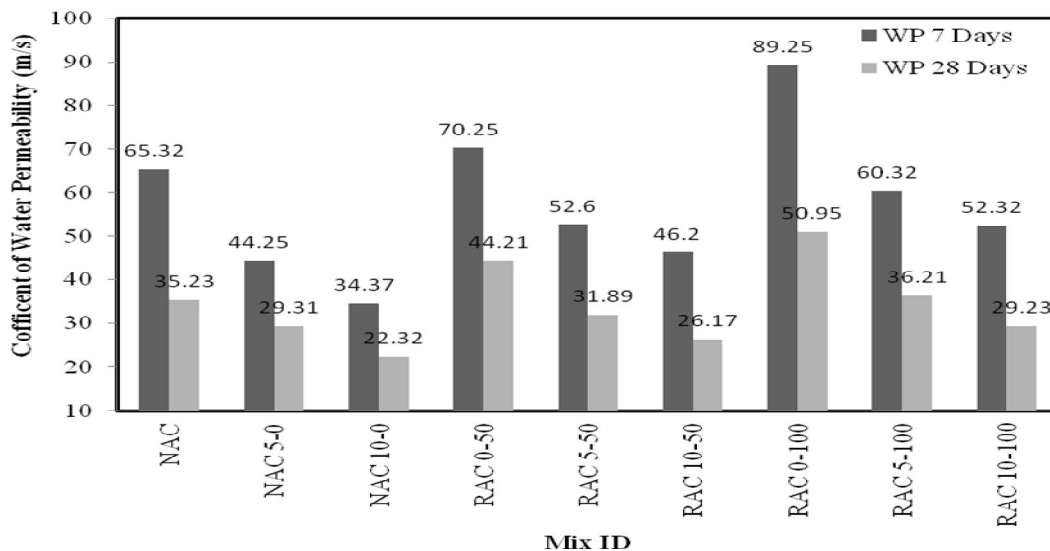


Fig- 4: Graphical representation of results of Permeability test

The results of permeability test carried out on NAC and RAC incorporating different amount of silica fumes 0%, 5% and 10% replacement by the weight of cement. it is observed that coefficient of permeability decreases significantly at all ages with the addition of Silica fumes 5% and 10% to the plain concrete.

V. CONCLUSION

1. The replacement of natural aggregates (NA) with recycled concrete aggregates (RA) reduces the compressive strength of concrete NAC as well as RAC. However the rate of reduction was higher for RAC. This reduction is more prominent during the early stages i.e. at 7 days and gradually reduced with the age. Moreover the greater the percentage of recycled aggregates more is the reduction in strength
2. On addition of silica fumes to the RAC mixes the decrease in the compressive strength, due to replacement of NA with RA, is reduced. Overall there is increase in the compressive strength of all the NAC and RAC mixes.
3. On addition of silica fumes to the RAC mixes the reduction in compressive strength was higher at 7 days compared to 28 days. The strength at 28 days for RAC100-10 was marginally i.e. 6% less than the NAC and for RAC50-10 the compressive strength was even greater than the control NA.
4. The present investigation has shown that the use of recycled concrete aggregates in concrete mixes does reduce the split tensile strength but this reduction was lower compared to the reduction in compressive strength even at a replacement level of 100% i.e. 12% without any use of silica fumes.
5. For both dosages of silica fumes i.e. 5% and 10% the mix with 50% replacement with recycled aggregates yields almost similar or better results for split tensile strength if compared with control NAC at 28 days.
6. On addition of 10% silica fume as mineral admixture the flexural strength of the RAC increased and the flexural strength for RAC50 as well as RAC 100 were found to be higher than the control NAC mix by 12.8 and 3.4 % at 28 days. Even on 5% addition of silica fumes the flexural strength of RAC mixes were comparable to NAC.
7. The permeability the NAC as well as RAC mixes increased with the increase in the replacement of natural aggregates with the recycled aggregates. This reduction in permeability was more significant for NAC mixes compared to RAC mixes. Also the permeability reduced with the curing age of the concrete.

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