Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 08, August-2019

Use of Recycled and Waste Materials in Cement Concrete with Partial Replacement of Aggregate and Cement

Pawan Sahu
Student, Department of Civil Engineering,
Medi-Caps Institute of Science and Technology,
M.P., India

Rahul Kanojia
Student, Department of Civil Engineering,
Medi-Caps Institute of Science and Technology,
M.P., India

Alok Rarotiya
Assistant Professor,
Department of Civil Engineering,
Medi-Caps Institute of Science and Technology, M.P., India

***Abstract*— The present laboratory study focused to examine the performance of recycled aggregate concrete prepared with the incorporation of different mineral admixtures like silica fines (SF), Fly ash (FA) etc. The variation in water cement ratio in cement concrete mix is also incorporated. In general, the test results, showed that incorporation of mineral admixtures improves the properties of recycled aggregate concrete. The replacement of cement by 10% SF improved compressive strength while the replacement of cement by 35% fly ash contribute in durability property of recycled aggregate concrete. The RAC prepared with the SF (10%) showed higher (55%) compressive strength than the RAC with RA. The test outcomes of water-cement variation showed that at lower water cement ratios (0.50, 0.55) the compressive strength of recycled aggregate concrete at 28 days were lower than natural aggregate while at higher water cement ratio (0.6) the compressive strength of recycled aggregate concrete at 28 days was almost same as natural aggregate concrete.**

Keywords-Recycled aggregate; silica fume; fly ash; compressive strength; water cement ratio.

I.INTRODUCTION

In today's world rapid advancements are taking place in the field of construction. In the researches, many materials have been found which can be used for the construction. But effective replacement of concrete is still not found. Concrete that is the mixture of cement, sand and aggregate is the most widely used construction material. Reasons behind it's popularity are it's strength, durability and economy. Around 10 billion tonnes of concrete is produced every year globally. The chief constituent of concrete is the coarse aggregate which contributes the durability and strength to the concrete. The huge quantity of aggregate is required for the production of concrete. But everything present in environment has some limit and it implies for concrete ingredients also. There is a need to explore it's alternatives.

RAC (Recycled Aggregate Concrete) have received increasing interest in the past decades due to its great environmental effects. RAC can be defined as the concrete made up of recycled aggregate (RA), processed from construction and demolition (C&D) waste either as a partial or full replacement of conventional natural aggregate. The sources of RA are the C&D sites. About 2-3 billion tonnes per year is estimated as the building waste production globally of which 30-40% is concrete waste [1].

Many researchers have studied the potential benefits and drawbacks of using recycled aggregate in concrete[2-6]. RILEM Committee 121-DRG [7] has published recommendations for the use of recycled aggregate. Suitable tests should be performed on the recycled aggregate before using it and the results should be compared with the natural aggregate and checked as per the IRC guidelines.

Although it is environmentally beneficial to use RA, shortcoming of using recycled aggregate can not be underestimated. The use of recycled aggregate generally increases the drying shrinkage, creep and water sorptivity and decreases the compressive strength and modulus of elasticity of concrete compound to those of natural aggregate concrete [8-11]. To compensate the loss of strength and other quality parameters mineral admixtures like fly ash (FA), silica fume (SF) etc. can be incorporated in concrete [12-14].

The American Concrete Institute (ACI) defines SF as a "very fine silica produced in electric arc furnaces as a by product of the production of elemental silicon or alloys containing silicon". It is usually a grey colored powder, somewhat similar to the Portland cement or some ashes. SF can exhibit both pozzolanic and cementitious properties. The use of SF improves the mechanical and durability properties of concrete [15].

Fly ash (FA) is a coal combustion product that is composed of the particulates (fine particles of burned fuel) that are driven boilers together with the flue gases. The incorporation of FA results in the reduction of early strength of concrete but it have long term advantages such as improves long term strength, reduced permeability and porosity and reduced alkali silica reaction expansion [16-19].

Carinaldesi, Moriconi [20] and Shi-Cong Koi, Chi-sun Poon, Francisco Agrela [21] conducted experiments in cement specimen that were manufactured by completely replacing fine

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 08, August-2019

and coarse aggregate with the recycled aggregate by using SF and FA as partial cement replacements. And based on their results they found that with the proper selection and proportioning of the mineral materials in the concrete satisfactory properties can be developed.
Quantity of water added in any cement concrete mix depends upon the water-cement ratio (W/C) used. As water absorption of recycled aggregate is more than the natural aggregate so in order to fulfill that requirement of recycled aggregate extra water can be add. Thus higher water-cement ratios can be used. This will satisfy the requirement of extra water and hence it contributes to the strength of concrete [22]. In this work, partial or full replacement of natural aggregate with recycled aggregate was evaluated. This paper also reports the results of study on the effect of different mineral admixtures (SF & FA) in the strength. In the concrete mixtures the replacement levels of cement chosen were 10% SF and 35% FA as per the IS 456 [23]. Also the different W/C are used and their effects on the strength is reported. The W/C variations used are 0.50, 0.55 and 0.60.

II. MATERIALS AND EQUIPMENS

A. *Materials*

The cementitious material used in this experimental study were portland cement, silica fume and fly ash. Natural aggregate used in study were crushed Basalt and Recycled aggregate sounded from demolition site. The nominal size of the recycled and natural aggregate used was 20 mm.

B. *Specimen preparation and curing*

The series of concrete mixtures were prepared in the laboratory by hand mixing. The absolute weight method was used in calculating the mix proportion. A nominal mix of 1:1.5:3 where one part binding material, one and half parts fine aggregate and 3 parts of coarse aggregate were used to prepare concrete mix. In mix proportion silica fume and fly ash were used as cement replacements on a weight basis. In all concrete mix a constant water to binder ratio 0.5 was used except the concrete mix prepared with recycled aggregate subjected to variations in water-cement ratio. The concrete mixes were designated with the following codes: C (conventional mix), R-50 (RCA-50%), R-100 (RCA100%), R-50-SF-10 (RCA-50%, SF-10%), R-100-SF-10 (RCA-100%, SF-10%), R-50-FA-35 (RCA-50%, FA-35%), R-100-FA-35 (RCA-100%, FA-35%), R-50-W-0.5 (RCA-50%, W/C-0.5), R-100-W-0.5 (RCA-100%, W/C-0.5), R-50-W-0.55 (RCA-50%, W/C-0.55), R-100-W-hi0.55 (RCA-100%, W/C-0.55), R-50-W-0.6 (RCA-50%, W/C-0.6), R-100-W-0.6 (RCA-100%, W/C-0.6). The test specimens prepared were cubes of size 150*150*150 mm and the age of curing used were 7days and 28 days.

C. *Compressive strength test*

The test confirming to IS-516-1959 [24]. The cube of size 150*150*150 mm was used for the determination of compressive strength respectively at 7 days and 28 days. The load was applied using a compression testing machine with capacity 2000 kN.

D. *Crushing value test*

The test confirming to IS-2386-1963 Part-4 [25]. The crushing value of natural and recycled aggregate were tested in crushing value testing machine as specified by above IS code. Test sample passing through 12.5 mm IS sieve and retained on 10 mm sieve were used for testing. The crushing value of aggregate was tested in crushing value machine/compression strength testing machine of capacity 2000 kN. The rate of loading was 4 t/min for 10 minutes.

E. *Impact value test*

The test confirming to IS-2386-1963 Part-4 to determine the impact resistance of natural and recycled aggregate. The test was carried out into Impact value testing machine. Impact value of coarse aggregate is expressed in percentage. Test specimen used in impact value test was same as used in crushing value test. Specimen was subjected to impact load by hammer *wei*ghted 13.5 kg and 15 such blows were applied on specimen.

F. *Absorption test*

The test confirming to IS-2386-1963 Part-4. The test sample of natural and recycled aggregate were immersed into clean water for 24 hours. The sample of 2 kg was used.

III. RESULTS AND DISCUSSION

A. *Crushing value*

The crushing value of natural aggregate was 8.2% while cruising value of recycled concrete aggregate was 18.25% which is 55.06% higher than the natural aggregate but it is in permissible limit as per IRC specifications.

B. *Impact value*

The impact value of natural aggregate comes out to be 10.24% while impact value of recycled concrete aggregate was founded 14.18%which is quite higher than the natural aggregate i.e., 27.78%. But the impact value of recycled aggregate was within permissible limit.

C. *Water absorption*

The water absorption of recycled aggregate was higher than the natural aggregate due to the adhered mortar on it. The water absorption of natural aggregate and recycled aggregate was 1.2% and 3.92% respectively.

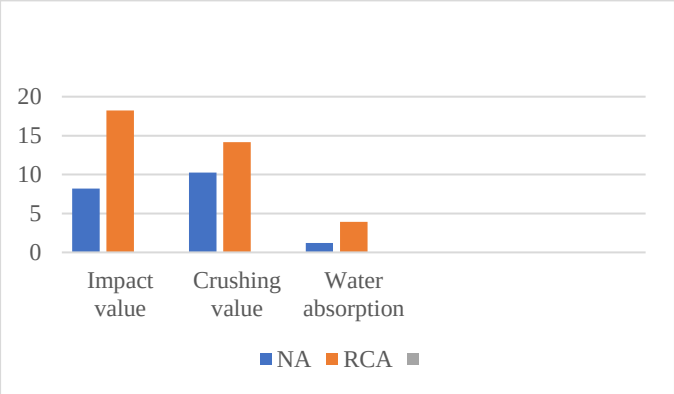

Fig.1. Comparison between mechanical properties of RCA and Natural aggregate

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 08, August-2019

D. Compressive strength

The compressive strength of recycled and natural aggregate concrete prepared with mineral admixtures and water/binder ratio variation were determined on day 7 and 28 . The compressive strength of natural aggregate concrete and recycled aggregate concrete made with 10% SF were higher than the other corresponding concrete mixtures. At 28 days the compressive strength of concrete mixtures R-50-SF-10, R-100-SF-10 were higher by 18.42% and 17.48% than that of R-50, R-100 and also slightly higher than conventional concrete. Compressive strength of concrete prepared with FA at 28 days, R-50-FA-35 and R-100-FA-35 is slightly higher by 3.98% and 10.18% respectively than that of R-50 and R-100. The test results of W/C variations are also satisfactory. The compressive strength at 28 days of specimen R-50-W-0.55, R-100-W-0.55, R-50-W-0.6, R-100-W-0.6 were higher than the R-50, R-100 by 13.45%, 13.60%, 15.24% and 15% respectively. The compressive strength of recycled aggregate concrete prepared with minimal admixtures had the highest compressive strength and this might be attributed to RA. Generally recycled aggregate are more porous than natural aggregate. When concrete prepared with the use of mineral admixtures, two mechanism may enhance the properties of the concrete produce. 1.Part of the mineral admixtures would penetrate into the pores of RA which would subsequently improve the interfacial transition zone bonding between the paste and aggregate. 2.Cracks originally present in the aggregate would be filled by hydration product.

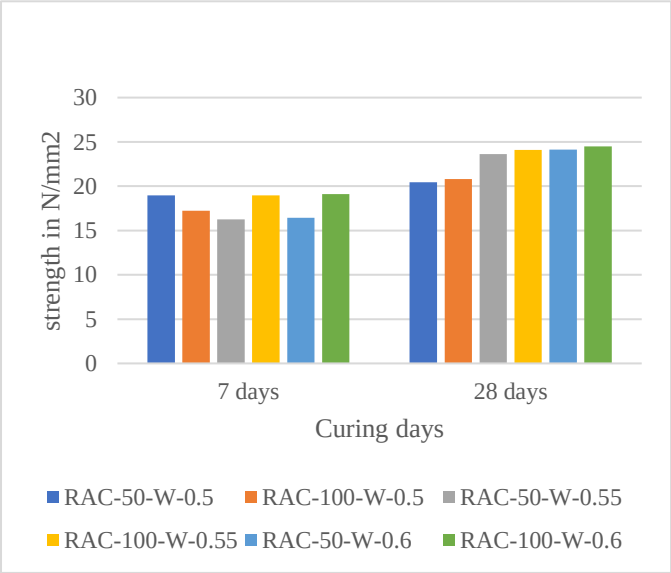

Fig.2. Comparison between compressive strength of RAC and RAC+W/C ratio variations.

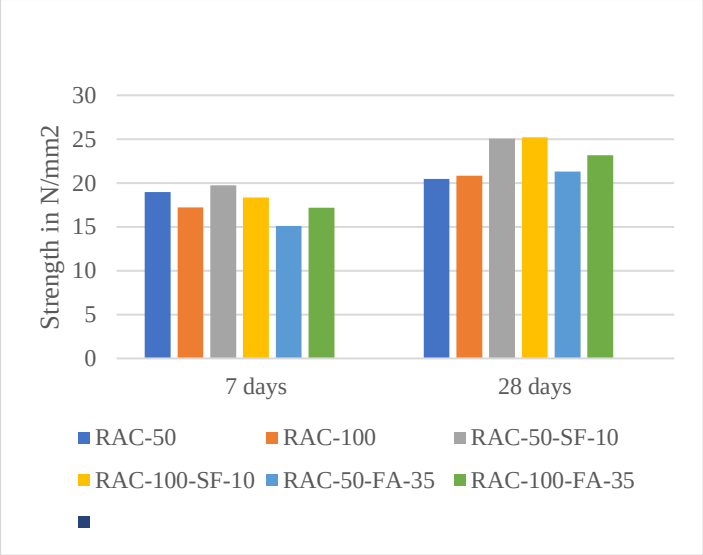

Fig.3. Comparison between compressive strength of RAC and RAC+Mineral Admixtures

CONCLUSIONS

Following conclusions drawn from this research investigation are :

- The water absorption of recycled concrete aggregate is higher than natural aggregate which results in an increase in water cement ratio to get required workability of concrete.
- The resistance of recycled aggregate to mechanical actions i.e., impact and crushing is lower than natural aggregate, but the values are in acceptable limits.
- The compressive strength of concrete prepared with recycled aggregate at 7 and 28 days is lower than that of the conventional mix but can be compensate by the use of mineral admixtures.
- With increase in water cement ratio from 0.5 to 0.55, there is an increase in compressive strength of recycled aggregate concrete as well as natural aggregate concrete.
- With increase in water cement ratio from 0.55 to 0.6 there is reduction in compressive strength of natural aggregate concrete where as recycled aggregate concrete shows increase in compressive strength.
- At higher water cement ratio (0.6) the compressive strength of recycled aggregate concrete is close to strength of natural aggregate concrete.
- The results shows that the contribution of the mineral admixtures to performance improvement of recycled aggregate concrete are higher than that of the natural aggregate concrete.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 08, August-2019

ACKNOWLEDGMENT

The author would like to thank the Civil Engineering Department of Medi-Caps University for their support and encouragement.

REFERENCES

[1] Vilas and Guiberto (2007), "Construction and Demolition Waste Management: Current Practices in Asia", International Conference on sustainable Solid Waste Management, Chennai, India.
[2] M. Tavakoli, P. Soroushian, “Strength of recycled aggregate concrete made using field- demolished concrete as aggregate”, ACI Mater. J. 93 (2) (1996) 182-190.
[3] I.B. Topcu, N. F. Gumcan, “Using waste concrete as aggregate”, Cem. Concr. Res. 25 (7) (1995) 1385-1390.
[4] Dhir R. K. and Jappy T.G. (edit), “Proceedings of International Conference on Exploiting Waste in Concrete”, Thomas Telford, UK, 1999.
[5] Sagoe-Crentsil, K.K., Brown, T. AND Taylor, A.H., “Performance of concrete made with commercially produced coarse recycled concrete aggregate”, Cem. Conr. Res. 31. 707-712, 2001.
[6] R.J. Collins, “Recycled aggregate in ready-mixed concrete”, in: K.W. Llewellyn, H. Davis (Eds.), “Proceedings of Sustainable Use of Materials”, Building Research Establishment, UK, 1996.
[7] RILEM 121-DRG, “Specification for concrete with recycled aggregate”, Material and Structures 27 (173) (1994) 557-559.
[8] Hasaba, S.Kawamura, M. Kazuyuks, T. AND Kunio, T., “Drying shrinkage and durability of concrete made from recycled concrete aggregate”, Transaction of Japan Concrete Institute, Tokyo, Vol.3, 1981, pp.55.60.
[9] Hansen, T.C. AND Boegh, E., “Elasticity and drying shrinkage of recycled aggregate concrete”, Journal of American Concrete Institute, 82(6), pp.648-652, 1985.
[10] Coloring, F.T. AND Padayachee, N., “Performance of recycled aggregate concrete monitored by durability indexes”, cement and concrete research, 32(2002), 179-185.
[11] Dhir, R.K. Limbachya, M. Leelawat, C.T., “Suitability of recycled concrete aggregate for use BS 5328 designated mixes”, Proc. Inst. Civ. Engrs and Bldged, 1999,134, Aug , 1207.274.
[12] Buford, K., “Carbonation of concrete with silica fume and fly ash”, Oslo: Nordic Concrete Research, Publication no. 4; 1985.p. 26-35.
[13] Ogha H, Nagataki S., “Prediction of carbonation depth of concrete with fly ash”, In: Proceedings of the third international conference. Trondheim,Norway: SP-114; 1989. p. 275-94.
[14] Atis CD, “Accelerated carbonation and testing of concretade with fly ash”, Constr Build Mater 2002;17:147-52.
[15] Larbi JA, Bijen JM, “Influence of pozzolana on the Portland cement paste aggregate interface in relation of diffusion of ions and water absorption in concrete”, Cem Concr. Recs.1992-22:557-62.
[16] Koi SC, Poon CS, Chan D., “Influence of fly ash as cement replacement on the properties of recycled aggregate concrete”, J Mater Civil Eng. 2007;19(9):709-17.
[17] Kou SC, Poon CS, Chan D., “Influence of fly ash as a cement addition on the harden properties of recycled aggregate concrete”, Mater Strut 2008:41(7):1191-201.
[18] Feng TK, Cheng PX., “Strengthening effect of finely ground fly ash, granulated blast furnace slag and their combination”, Cem Concr, Res 1998:28(12):1819-25.
[19] Bijen J, “Benefits of slag and fly ash”, Constr. Build Mater 1996:10(5):309-14.
[20] Valeria Corinaldesi, Giacomo Moriconi, “Influence of mineral addition on the performance of 100% recycled aggregate concrete”, Constr. Build Mater 2009:23:2869-76.
[21] Shi-cong Koi, Chi-sun Poon, Francisco Agrela, “Comparisons of natural and recycled aggregate concretes prepared with the addition of different mineral admixtures”, 2011.
[22] Aiyewalehinmi E.O., Adeoye T.E., “Recycling of concrete waste materials from construction demolition”, 2016.
[23] IS-456-2000, Plain and ReinforcIS-2386-1963, Methods of Test for Aggregate for Concrete, Part 4, Mechanical properties.
[24] IS-516-1959, Methods of Test for Strength of Concrete.
[25] sssssssssssssssIS-2386-1963, Methods of Test for Aggregate for Concrete, Part 3, Specific gravity Density Absorption and Bulking.