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EXPERIMENTAL STUDY ON HIGH PERFORMANCE CONCRETE USING RECYCLED AGGREGATE WITH METAKAOLIN

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ABSTRACT

With the rapid development of construction industry leading to excessive natural resource consumption and the deterioration of the environment, the contradiction between the sustainable development of construction industry and the shotage of resources will become more and more severe. At the same time, a large amount of solid waste is produced in the process of construction of new buildings every year. Today, the reuse of construction waste has become a common concern issue and deserves deep researches. It can be foreseen that the recycled aggregate concrete as a method of reuse and recycling of the construction waste will bring considerable economic and environmental benefits. In this paper experimental investigation is done to study the mechanical properties for M40 grade HPC by replacement of coarse aggregate with recycled coarse aggregate and metakaolin as an additive at varying percentage. The inclusion of metakaolin in concrete enhances the engineering properties of the basic materials, and the concrete

Keywords: Coarse aggregate, Recycled Aggregate, Metakaolin

I. INTRODUCTION

Now-a-days HPC has become an object of intense research due to its growing use in the construction practice. High-performance concrete (HPC) exceeds the properties and constructability of normal concrete. Special mixing, placing, and curing practices may be needed to produce and handle high-performance concrete. High-performance concretes are made with carefully selected high-quality ingredients and optimized mixture designs.

Here this study deals only the strength of concrete. The demolished aggregates are used in the study for partially replacing coarse aggregate. The partial or full replacement of fine aggregates and coarse aggregates by recycled aggregate is an effective way for sustainable construction.

Mineral admixtures like fly ash, silca fume etc act as pozzolonic materials as well as fine fillers, thereby the microstructure of hardened cement matrix becomes denser and stronger. Pozzolans play an important role when added to Portland cement because they usually increase the mechanical strength and durability of concrete structures. Here metakaolin used as the pozzolan.

II. EXPERIMENTAL INVESTIGATION

Concrete is a composite building material formed by the combination of cement, fine aggregate, coarse aggregate and water in a particular way that is designed to meet the job on hand with regard to desired workability, strength, durability and economy. Materials used for the study are cement, fine aggregate, coarse aggregate, recycled aggregate, metakaolin and admixture used is arromix. Materials used and their properties are tested according to IS specifications.

Compressive strength, flexural strength and split tensile strength of M40 grade concrete and concrete containing 5%, 10%, 15%, 20% of recycled coarse aggregate which replaces coarse aggregate are experimentally investigated. Compression test is the most common test conducted on hardened concrete. The compressive test is carried out on specimens cubical in shape having a size of 150x150x150mm. The compression tests were conducted after 7 days, 28 days. The test was conducted according to IS specifications.

Fig 1. Test setup for compressive strength and split tensile strength respectively.

A standard test cylinder of concrete specimen of size 300mm x 150mm is used to determine the split tensile strength. The test is done using compression testing machine. Test setup for compressive strength and split tensile strength respectively shown in fig1.

Fig 2. Test setup for flexural strength

Flexural strength is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 100 x 100 mm x 500mm concrete beams with a span length of at least three times the depth. Fig 2.Shows the test setup for flexural strength of concrete.

Compressive strength, split tensile strength and flexural strength of the concrete containing 15% of recycled aggregate which replaces natural coarse aggregate and then addition of metakaolin at various percentage of cement to optimum mix(7.5%) are experimentally investigated.

III. RESULTS AND DISCUSIONS

From the experiments, the result obtained shows that the compressive strength was increasing as the replacement of natural coarse aggregate with recycled coarse aggregate increase up to 15%. The increase in strength is shown in table I and its graphical representation in fig 3. The strength was 35.55 N/mm^2 on 7 day test and 48.345 N/mm^2 on 28 day test. Further replacement shows the decrease in the compressive strength.

Table I. Compressive strength of concrete at various % of coarse aggregate replacement (N/mm^2)

Cube designation	**Compressive strength (N/mm^2)**	
	7 day	**28 day**
M40	35.67	48.22
5%RA	30	43.55
10%RA	32	46.97
15%RA	35.55	48.345
20%RA	31.59	45.731

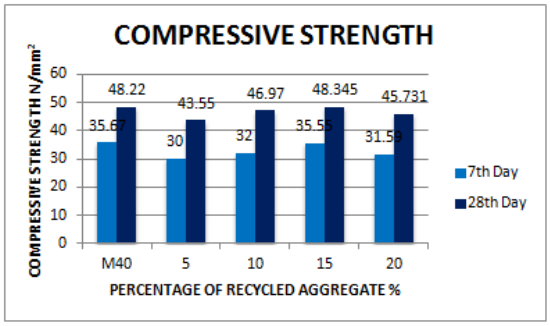

Fig 3. Graphical representation of compressive strength at 7day and 28day .

Similarly for the split tensile strength, the increase in strength is shown in table II and its graphical representation in fig 4.

Table II. Split tensile strength of concrete at various % of coarse aggregate replacement. (N/mm^2)

Cylinder designation	Split tensile strength (N/mm^2)	
	7 day	28 day
M40	2.15	2.69
5%RA	2.122	2.617
10%RA	2.22	2.67
15%AR	2.29	2.79
20%RA	2.26	2.73

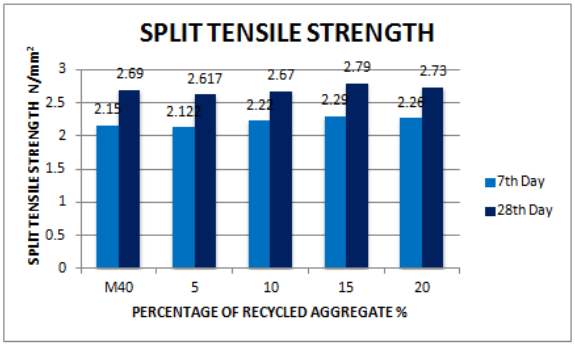

Fig 4. Graphical representation of split tensile strength at 7day and 28day.

Table III. Flexural strength of concrete at various % of coarse aggregate replacement. (N/mm^2)

Beam designation	Flexural strength (N/mm^2)	
	7 day	28 day
M40	4.2	5.8
5%RA	4.4	6.06
10%RA	4.56	6.2
15%RA	4.8	6.4
20%RA	4.6	6.04

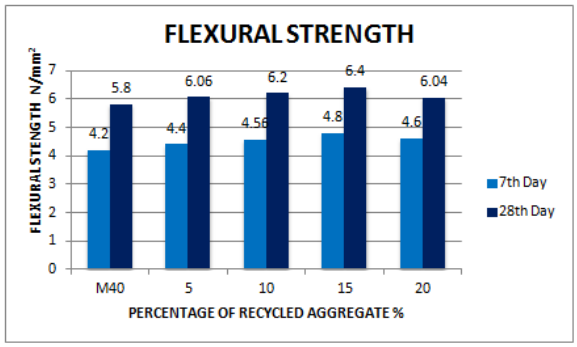

Fig 5. Graphical representation of flexural strength at 7day and 28day

By the addition of metakaolin to the optimum % replacement of natural coarse aggregate (15%), compressive strength, split tensile strength and flexural strength increases. The variation in compressive strength and split tensile strength is shown in table IV and table V respectively. The respective graphs are figure 6 and figure 7.

Table IV. Compressive strength of concrete by addition of metakaolin to optimum % replacement of natural coarse aggregate. (N/mm^2)

Cube designation	Compressive strength (N/mm^2)	
	7 day	28 day
15%RA	35.55	48.345
15%RA+2.5%MK	35.6	45.94
15%RA+5%MK	38.059	48.6
15%RA+7.5%MK	40.58	50.64
15%RA+10%MK	39.04	48.1
15%RA+12.5%MK	35.9	45.2

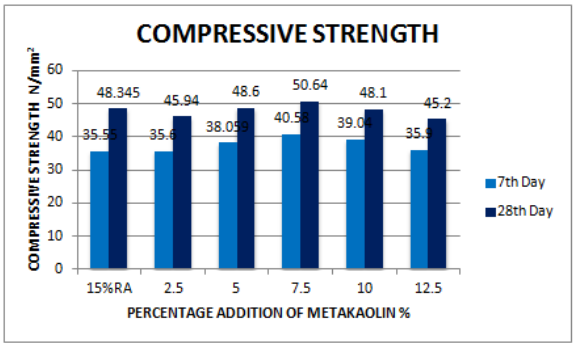

Fig 6. Graphical representation of compressive strength at 7day and 28day by addition of metakaolin

Table V. Split tensile strength of concrete at various % of coarse aggregate replacement. (N/mm^2)

Cylinder designation	Split tensile strength (N/mm^2)	
	7 day	28 day
15%RA	2.29	2.79
15%RA+2.5%MK	2.193	2.69
15%RA+5%MK	2.25	2.76
15%RA+7.5%MK	2.32	2.84
15%RA+10%MK	2.28	2.77
15%RA+12.5%MK	2.22	2.72

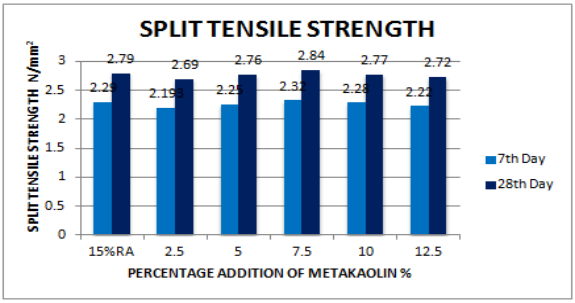

Fig 7. Graphical representation of split tensile strength at 7day and 28day by addition of metakaolin

The flexural strength variation in concrete is tabulated in Table VI and fig 8 shows the strength variation.

Table VI. Flexural strength of concrete by addition of metakaolin to optimum % replacement of natural coarse aggregate. (N/mm^2)

Beam designation	Flexural strength (N/mm^2)	
	7 day	28 day
15%RA	4.8	6.4
15%RA+2.5%MK	4.4	6
15%RA+5%MK	4.6	6.4
15%RA+7.5%MK	5	6.6
15%RA+10%MK	4.8	6.4
15%RA+12.5%MK	4.4	6.2

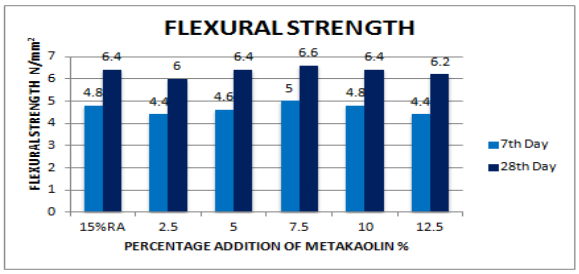

Fig 8. Graphical representation of flexural strength at 7day and 28day by addition of metakaolin.

IV. CONCLUSION

High-performance concrete (HPC) exceeds the properties and constructability of normal concrete. High-performance concrete almost always has a higher strength than normal concrete. Experimental investigation on compressive strength, split tensile strength and flexural strength is conducted to find out the optimum strength of concrete by partially replacing coarse aggregate by recycled coarse aggregate, additive meatakolin is added to concrete improves the strength.

From the results obtained from the study it is clear that the mechanical properties will be improved by the partial replacement of coarse aggregate with recycled coarse aggregate upto 15%. The result also showed that addition of metakaolin into recycled aggregate concrete had influence in the mechanical properties of concrete.

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REFERENCES

[1] Miguel Bravo, Jorge de Brito, Jorge Pontes, Luís Evangelista, '*Durability Performance of Concrete with Recycled Aggregates from Construction and Demolition Waste Plants*', Conctruction and Building Materials, January 2015, 77, 357-369.

[2] Nikola Tosic, Snezana Marinkovic, Tina Dasic, Milos Stanic, '*Multicriteria Optimization of Natural and Recycled Aggregate Concrete for Structural Use*,' Journal of Cleaner Production', October 2014,1-11.

[3] Manuel G. Beltran, Francisco Agrela, Auxi Barbudo, Jesus Ayuso, Antonio Ramirez, '*Mechanical and Durability Properties of Conctretes Manufactured with Biomass Ash and Recycled Course Aggregates*', Construction and Building Materials, September 2014, 72, 231-238.

[4] Mahdi Vlipour, Farhad Pargar, Mohammad Shekarchi, Sara Khani, '*Comparing a Natural Pozzolan, Zeolite, to Metakaolin and Silica Fume in Terms of Their Effect on the Durability Characteristics of Concrete: A*

Laboratory Study', Construction and Building Materials, 2013, 41, 879-888.

[5] Aiswarya S, Prince Arulraj G, Dilip C, '*A Review on Use of Metakaolin in Concrete*', International Journal of Research in Engineering and Technology, June 2013, Vol.03, Issue: 03.

[6] Kou Shi-Cong, Poon Chi-Sun, '*A Novel Polymer Concrete Made with Recycled Glass Aggregates, Fly Ash and Metakaolin*', Construction and Building Materials, January 2013, 41, 146-151.

[7] Mahdi Valipour, Farhad Pargar, Mohammad Shekarchi, Masoud Moradian, '*In Situ Study of Chloride Ingress in Concretes Containing Natural Zeolite, Metakaolin and Silica Fume Exposed to Various Exposure Conditions in a Harsh Marine Environment*', Constuction and Building Materials, May 2013, 46, 63-70.

[8] R.V. Silva, J. de Brito, R.K. Dhir, '*Prediction of the Shrinkage Behavior of Recycled Aggregate Concrete: A Review*', Construction and Building Materials, December 2014, 77, 327-339.

[9] H. Bahrami Jovein, '*Influence of Metakaolin as Supplementary Cementing Material on Strength and Durability of Concretes*', Journal of international academic research for multidisciplinary, 2011, Volume 2, Issue 3.

[10] Alaa M. Rashad, '*A Preliminary Study on the Effect of Fine Aggregate Replacement eith Metakaolin on Strength and Abrasion Resistance of Concrete'*, International Journal, 2012, 25, 3187–3192.

[11] D.M. Roy, '*Effect of Silica Fume, Metakaolin and Low Calcium Fly Ash on Chemical Resistance of Concrete*', International Journal of Research in Engineering and Technology, 2001, Vol.04.

[12] R.San Nicolas, '*Performance-Based Approach to Durability of Concrete Containing Flash-Calcined Metakaolin as Cement Replacement*', Journal of Cleaner Production, 2012.

[13] Prof. Chetna M Vyas, Prof. (Dr.) Darshana R Bhatt, '*Use of recycled coarse aggregate in concrete'* International Journal of Scientific Research, January 2013, Volume 2, Issue 1,70-74.

[14] Vaishali.G. Ghorpade, '*Effect of Recycled Coarse Aggregate on Workability and Shear Strength of Fibre Reinforced High Strength Concrete'*, International Journal of Innovative Research in Science, Engineering and Technology, August 2013, Volume 2, Issue 8, 3377-3383.

[15] Anilkumar P M, M Raghavendra, J Sudhakumar, '*Effects of Silica fume and Fly ash on Durability Characteristics of High Performance Concrete'* International Journal of Emerging Technology and Advanced Engineering, Octobe r 2014, Volume 4, Issue 10, 298-303.

[16] Sudarsana Rao.Hunchate, Sashidhar. Chandupalle, Vaishali. G.Ghorpode, Venkata Reddy.T.C, '*Mix Design of High Performance Concrete Using Silica Fume and Superplasticizer*', International Journal of Innovative Research in Science, Engineering and Technology, March 2014.Volume 3, Issue 3, 10735-10742.

[17] Design and Control of Concrete Mixtures-EB001, '*High-Performance Concrete'*, Chapter 17, 299-314.