Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 3, Issue 5; April-June, 2016, pp. 475-478

http://www.krishisanskriti.org/Publication.html

Study on Recycled Coarse Aggregate Concrete with Metakaolin

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Abstract—*Recycled Coarse Aggregate (RCA) is a term given to removed and/or milled from concrete structures and pavements containing mortar and aggregate. This material is obtained from recycling the existing concrete structures and rigid pavements which have reached the end of their design life. Now a days the use of RCA has grown extensively reducing the use of virgin aggregates which leads to conservation of resources and which will be cost effective. RCA can be used in construction of concrete structures and rigid pavements which results in huge savings. Metakaolin (MK) is a dehydroxylated aluminium silicate and having pozzolanic action. This paper deals with the partial replacement of cement with Metakaolin with varying percentages of 0%, 5%, 10%, 15% and 20% and Natural Coarse Aggregate (NCA) with RCA at constant proportion of 20% by trial and error method. The Mechanical properties of concrete i.e. compressive strength, Split tensile strength and Flexural strength are studied of concrete made with partial replacement of MK-RCA and compared with conventional concrete.*

Keywords*: Metakaolin (MK), Recycled Coarse Aggregate (RCA), Percentage Replacement.*

1. INTRODUCTION

The use of supplementary or alternative aggregate material is very essential for developing low-cost construction materials and ecological benefits for use in developing countries like India. It is estimated as per report of Central Pollution Control Board (CPCB) in India, 48 Million tons of solid waste is produced out of which 14.5 Million tons is produced from the construction sector wastes annually. Use of recycled aggregate is not very common in India and other developing countries. There is huge requirement of the aggregate because of fast development in the infrastructure area. In order to reduce the usage of fresh aggregate, recycled aggregate can be used as a replacement materials. The overall development of a country depends upon on a good infrastructure and well-connected road network. In the U.S. more than 50 Million tons of RCA mixtures from roads itself milled annually and the majority is recycled into new asphaltic mixtures (Collins and Ciesielski 1994). However, large quantities of RCA aggregate remain unutilized and further uses should be explored.

Recycling of construction materials has become a viable alternative in constructive world to decrease the need of virgin materials. Conservation of resources, preservation of the environment are some of the benefits obtained by reusing recycled materials. Reconstruction and Pavement rehabilitation generates large quantities of recycled coarse aggregates (RCA). It is the removal and reprocessed building material containing mortar and aggregate. These materials are generated when buildings and pavements are removed for reconstruction and rehabilitation. There are two methods of sorting or cleaning of RCA. First one is dry separation method, which involves removal of lighter matter from the heavier stony materials by means of blowing the air or constantly causes a lot of dust and second one is wet separation method, which separates a low density impurity are separate by water jets or float-sink tank and fabricate very clean aggregate. Recycled aggregate has inferior relative density and more water absorption capacity whereas fresh aggregate has less. The twelve five-year plans faces a dearth of aggregates in infrastructure trade and due to large boom in manufacturing trade currently and in future, there is a huge predicament of mining and this crisis might be boost exponentially. The scope of the topic is to study on the utilization of Recycled Coarse Aggregate (RCA) concrete for construction can be an effective and cost efficient method and also it reduces the disposal problem caused by industrial waste and also helps to conserve natural aggregates.

Advantages of Recycled Coarse Aggregate (RCA):

- Saving the time by using available RCA
- Conservation of Virgin aggregates
- Less emission of Carbon due to less requirement of crushing
- Reduction of the cost of construction
- Preservation of the Environment

Disadvantages of Recycled Coarse Aggregate (RCA):

- Less quality
- High absorption of water
- Durability of life cycle of project may affect
- Lack of specifications and guidelines
- Special equipments may require for cleaning

2. MATERIALS AND METHODOLOGY:

2.1. Materials

The main objective of this research study is to determine the suitability of Recycled Coarse Aggregate (RCA) in construction field. For that purpose the materials used for the construction field as well as road sub layers essentially having partially or fully replaced Recycled Coarse Aggregate (RCA) with the fresh aggregates. A quality construction should be always have well graded particles of different sizes.

It is very necessary to carry out the series of physical tests on the aggregates to check their suitability before using them in any building or road construction. Many properties of aggregates are needed in designing the concrete mixes as well as the pavement mixes.

2.1.1.Cement:

In the physical properties of the cement used in present investigation i.e. Ordinary Portland Cement (OPC) of 43 grade (JP cement) was shown in below table.

Table 1: Physical properties of the cement

S. No	Property	Test Results	Standard values as per IS: 8112-1989
1	Fineness	3%	< 10 %
2	Normal Consistency	29%	26%-33%
3	Specific Gravity	3.14	3.14-3.15
4	Initial setting time	92 min.	>30 min.
5	Final setting time	186 min.	< 600 min.
6	Soundness of cement	2 mm	<10 mm
7	Compressive strength At 3- days 7- days 28- days	 24.62 Mpa 33.75 Mpa 44.21 Mpa	 >23 Mpa >33 Mpa >43 Mpa

2.1.2.Fine aggregate:

Locally available natural river sand of size less than 4.75 mm was used. The specific gravity of fine aggregate is 2.62, Fineness modulus is 3.2, Percentage of bulking of sand = 5.88% and Grading Confirming to Zone-II.

2.1.3. Coarse Aggregate:

The materials whose particles are of size are retained on IS. Sieve 4.75 mm is termed as coarse aggregates. The size of coarse aggregate depends upon the nature of work. The Coarse aggregate used in this experimental investigation is 20 mm and 10 mm size, crushed and angular in shape. Specific gravity of coarse aggregate 20 mm size is 2.71 with water absorption 0.45% and for 10 mm size the specific gravity is 2.67 with water absorption 0.407%.

2.1.4. Water:

Ordinary potable tap water is available in laboratory was used for physical propertiese of materials and mechanical propertiese of concrete.

2.1.5. Metakaolin:

Metakaolin, generally called “calcined clay” is a reactive alumina-silicate pozzolana produced by heating kaolinite at a specific temperature conditions.MK is a chemical compound that forms by treatment kaolinite type of clay mineral. Kaolinite is a hydrous aluminium silicate of the composition $Al_2o_32sio_22H_2o$. Kaolinite is the clay mineral which provides the plasticity to the raw material and changes during the heating to produce permanent material. Kaolinite is clay mineral commonly available throughout the world. As a result of thermal treatment in the range of 450^0C-750^0C, the water is vapour and forms an amorphous alumina silicate called MK ($Al_2O_32SiO_2$).

2.1.6. Recycled Coarse Aggregate (RCA):

In this study recycled coarse aggregate is obtained by crushed concrete specimens from laboratory were used for concrete production. It was initially dry in condition when collected and was sieved by IS sieves. The impact value of RCA is 14%, Fineness modulus is 5. 971, Specific gravity for 10 mm is 2.48 with water absorption 3.5% for 20 mm 2.74with water absorption 3% .

3. MIX DESIGN PROCEDURE:

In present study M_{25} grade concrete was designed as per IS: 10262-2009. The weight ratio of mix proportion is **1:1.79:3.05** keeping water cement ratio as 0.48. It was Proposed to investigate the properties of concrete, cast with partial replacement of cement with 0%, 5%, 10%, 15% and 20% of Metakaolin and 20% Natural Coarse Aggregate is replaced by RCA and cured in water. The 20% of RCA replacement is fixed trial and error method by taking care of workability and strength propertiese.

4. CASTING AND TESTING DETAILS:

In this present study average of 3- cubes, 3- cylinders and 3- beams were casted for each mix for 7- days and 28- days. For every mix after 24 hours the moulds were demoulded and

subjected to water curing. The compressive strength, Split Tensile strength and Flexural Strength (2-point load method) Test Conducted on Specimens and the results are tabulated below.

Table 2: Materials required per m^3 of concrete

Mix Designation	MK (Kg/m^3)	Cement (Kg/m^3)	Natural sand (Kg/m^3)	RCA (Kg/m^3)	COARSE AGGREGATE (Kg/m^3)	
					20mm	10mm
Control Mix (M_0)	0	377.66	678.74	-	582.56	569.79
0% MK (M_1)	0	377.66	678.74	230.47	466.05	455.83
5% MK (M_2)	18.88	358.78	678.74	230.47	466.05	455.83
10% MK (M_3)	37.76	339.9	678.74	230.47	466.05	455.83
15% MK (M_4)	56.64	321.02	678.74	230.47	466.05	455.83
20% MK (M_5)	75.53	302.14	678.74	230.47	466.05	455.83

Table 3: Mechanical properties at 7-days and 28-days

Mix	Compressive Strength (Mpa)		Split Tensile Strength (Mpa)		Flexural Strength (Mpa)	
	7 days	28 days	7 days	28 days	7 days	28 days
M_0	19.65	33.42	2.66	3.45	1.03	1.46
M_1	20.11	33	2.75	3.5	1.05	1.28
M_2	23.98	34.73	3.02	3.74	1.12	1.55
M_3	25.17	36.08	3.13	4.01	1.17	1.65
M_4	24.89	34.24	3.03	3.95	1.02	1.37
M_5	21.15	32	2.84	3.62	0.88	1.19

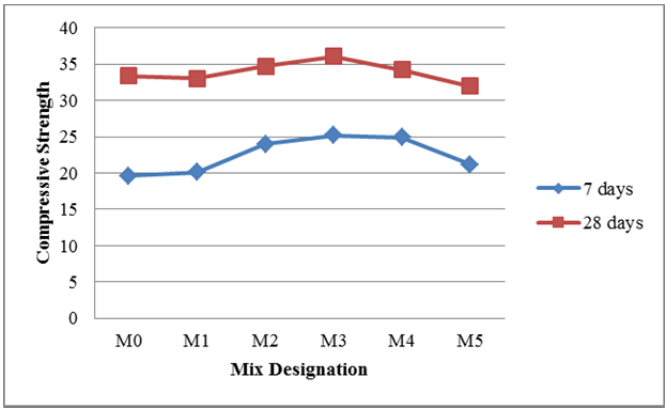

Fig. 1: Compressive Strength at 7- Days and 28- Days

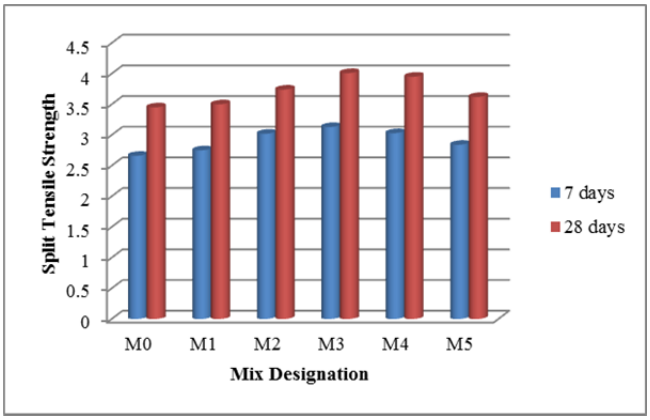

Fig. 2: Split Tensile Strength at 7-days and 28- Days

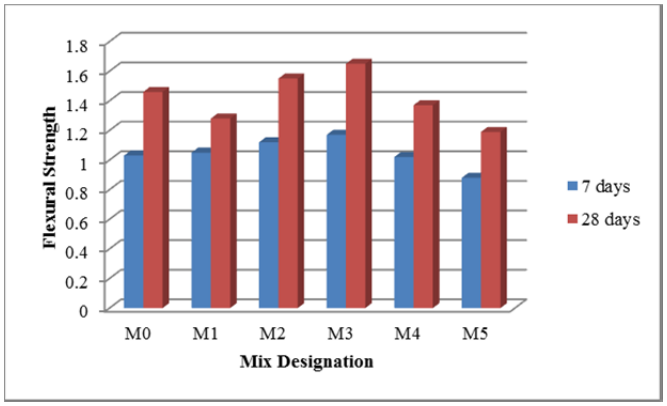

Fig. 3: Flexural Strength at 7-days and 28- Days

5. CONCLUSION

- Tests on materials indicate within the permissible limits as per Indian Standard requirements.
- There is a significant improvement in strength parameters like comperessive strength, split tensile strength and flexural strength with increasing MK at constant replacement of RCA up to 10% MK replacement and later on gradually decreasing.
- All mixes are attaining target strength. And finally use of MK and RCA gives better results than the conventional concrete.

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