EFFECT OF RECYCLED AGGREGATES ON THE MECHANICAL PROPERTIES OF CONCRETE

Aastha[1], Dr. R.R. Singh[2]

[1]Ph.D. Student, Civil Engineering Department, Punjab Engineering College (Deemed To Be University), Chandigarh , India
[2]Professor & Head, Department of Civil Engineering Punjab Engineering College (Deemed To Be University), Chandigarh , India

---

Abstract - Recycled aggregates are the aggregates which are retrieved from the demolished structures. Basic difference of these aggregates from natural aggregates is the adhered mortar on the surface of aggregates which is left over the old concrete. When recycled aggregates are used in concrete mix, these aggregates absorb part of the water which is initially calculated for the cement hydration and it adversely affect some other characteristics of the concrete such as strength and durability. One of the most significant issues that determine the strength characteristics are the types of coarse aggregates in recycled concrete. This study is aiming to investigate experimentally the effect of recycled aggregates in concrete which are obtained from laboratory waste. This investigation also aims to determine the influence of pre-saturation and polymer impregnation on mechanical properties of recycled aggregate concrete.

In this study, behaviour of recycled aggregate concrete (RAC) at varying percentages i.e. (0%, 40%, 60%, 80%, 100%) of recycled aggregates in terms of their mechanical properties was investigated and results are compared with two different techniques used to modify the properties of recycled aggregates. It was observed that with the use of silicon-based polymer mechanical properties of RCA were enhanced and water absorption of RCA was also reduced. Mechanical properties like compressive strength, split tensile strength and flexure strength were compared and it was observed that the strength achieved by silicon based polymer was more beneficial than the other technique. Replacement of 60% natural aggregates by RCA has shown the maximum improvement in the mechanical properties of concrete.

1. INTRODUCTION

Concrete is a composite material consisting of binding medium and aggregate particles. This binding medium is the product of reaction between hydraulic cement and water. The main constituent of concrete is cement, sand, aggregate and water. Concrete is a composite product obtained by mixing cement, water and an inert matrix of sand and gravel or crushed stone. Concrete has been the leading building material since it was first used and is bound to maintain its significant role in the upcoming future due to its durability, maintenance free service life, adaptability to any shape and size, wide range of structural properties plus cost effectiveness. The concrete is the most important construction material which is manufactured at the site. It undergoes a number of operations such as transportation, placing, compaction and curing. Calcium silicate hydrate(C-SH) is the main product of the hydration of Portland cement and is primarily responsible for the strength in cement based materials. C-S-H is the most important phase of concrete which is governing the majority of its properties. C- S-H in hydrated cement paste forms a network of Nano particles and the interaction between them is caused by the Van der Waals as well as by ionic forces, linked with ionic double layer.

The increasing number of concrete buildings being demolished, the difficulties of disposing of concrete rubble produced together with a developing scarcity of aggregate need to the major urban areas has prompted an interest in the possibility of using concrete rubble as aggregate in concrete. Infrastructural development plays an important role in the growth and enhancement of any country or society. This facility is accompanied by construction, remoulding, maintenance and demolition of buildings, roads, subways and other structural establishments. Work aims to provide an overview of recent studies that have been carried out to investigate the incorporation of recycled aggregates, hereafter referred to as RA, into the production of concrete. In particular, results of study were examined in regard to the compressive strength of concrete blocks made with RA, hereafter referred to as recycled aggregate concrete, or simply, RAC. Considerable amount of research has been carried out with different types of materials.

1.1 *Recycled Aggregates*

Recycled aggregates are the aggregates produced from the processing of previously used construction materials such as concrete or masonry. Recycled aggregates consists of hard, graduated fragments of inert mineral materials, including sand, gravel, crushed stone, slag, rock dust, or powder. Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. These materials are generally from

buildings, roads, bridges, and sometimes even from catastrophes, such as wars and earthquakes. Recycling and reuse of building wastes have been found to be an appropriate solution to the problems of dumping thousands tons of debris accompanied with shortage of natural aggregates.

1.2 *Modification of Recycled Aggregates*

Sodium Silicate is a generic name for chemical compounds with the formula $Na_{2x}SiO_{2+x}$ or $(Na_2O)_x{\cdot}SiO_2$, such as sodium metasilicate Na_2SiO_3, sodium orthosilicate Na_4SiO_4, and Sodium Pyrosilicate $Na_6Si_2O_7$. The anions are often polymeric. These compounds are generally colourless transparent solids or white powders, and soluble in water in various amounts.

Concrete treated with a sodium silicate solution helps to significantly reduce porosity in most masonry products such as concrete and plasters. A chemical reaction occurs with the excess Ca (OH) 2 present in the concrete that permanently binds the silicates with the surface, making them far more durable and water repellent(Despotovic). This treatment generally is applied only after the initial cure has taken place (7 days or so depending on conditions).

Pre-Saturation of Recycled Aggregate for short interval of time. Pre –Saturation can be done in acid or in water(Despotovic). Here, in this study we are using Pre-Saturation of Recycled aggregate using water.

2. MATERIALS AND METHODS

Total number of cubes, beams, cylindrical specimens were casted during thesis work to show strength and durability characteristics of recycled aggregate concrete. In each mix, 6 cubes, 6 cylinders and 6 beams were casted. However, 3 cubes in each mix were tested after 7 days of moist curing to obtain the 7 day cube compressive strength of recycled aggregate concrete. The remaining 3 cubes were tested after 28 days for each mix. In a similar manner cylindrical and prismatic specimens were tested for split tensile strength and flexural strength. Overview for the number of sample casted are listed in Table 1.

Table -1: Overview of Number of Specimen Casted

S. No.	Cube	Cylinder	Beam	Comment
1	3+3	3+3	3 +3	Normal Control Mix
2	3+3	3+3	3 +3	Mix with 40% Replacement of Coarse aggregate with Recycled Aggregate
3	3+3	3+3	3 +3	Mix with 60% Replacement of Coarse aggregate with Recycled Aggregate
4	3+3	3+3	3 +3	Mix with 80% Replacement of Coarse aggregate with Recycled Aggregate
5	3+3	3+3	3 +3	Mix with 100% Replacement of Coarse aggregate with Recycled Aggregate
6	3+3	3+3	3 +3	Mix with 40% Replacement of Coarse aggregate with Pre-Saturated Recycled Aggregate
7	3+3	3+3	3 +3	Mix with 60% Replacement of Coarse aggregate with Pre-Saturated Recycled Aggregate
8	3+3	3+3	3 +3	Mix with 80% Replacement of Coarse aggregate with Pre-Saturated Recycled Aggregate
9	3+3	3+3	3 +3	Mix with 100% Replacement of Coarse aggregate with Pre-Saturated Recycled Aggregate
10	3+3	3+3	3 +3	Mix with 40% Replacement of Coarse aggregate with Recycled Aggregate immersed in 5% Sodium Silicate Solution
11	3+3	3+3	3 +3	Mix with 60% Replacement of Coarse aggregate with Recycled Aggregate immersed in 5% Sodium Silicate Solution
12	3+3	3+3	3 +3	Mix with 80% Replacement of Coarse aggregate with Recycled Aggregate immersed in 5% Sodium Silicate Solution
13	3+3	3+3	3 +3	Mix with 100% Replacement of Coarse aggregate with Recycled Aggregate immersed in 5% Sodium Silicate Solution

The property of concrete which determines the amount of useful internal work, necessary to produce full compaction i.e. workability is the amount of energy to overcome Friction while compacting. Also defined as the relative ease with which concrete can be mixed, transported, moulded and compacted.

Slump test was carried out to study the workability of concrete mix with the partial replacement of recycled aggregates with different techniques. With increase in recycled aggregates workability of mix gets reduced. It was reported by Amer et al.(2016) that for pre-saturated recycled aggregates slump remain substantially unaffected. With pre-saturation of recycled aggregates workability first increases and then decreases due to more recycled aggregates used as more rough surface is available and more water absorption take place. For recycled aggregate immersed in 5% sodium silicate solution workability of mix is more than that of pre-saturation as with immersion of recycled aggregates, the mortar surrounding the recycled aggregates gets little bit of slurried out and the rough surface reduces as compared to intial rough surface of recycled aggregate. With increase in the replacement of recycled aggregates immersed in 5% sodium silicate solution workability of mix decreases.

3. CONCLUSIONS

On the basis of results and discussions, the following conclusions are drawn:

1) Water absorption of recycled aggregates was found to be greater than natural aggregates. This is due to the fact that the mortar adhered with recycled aggregate was porous which lead to the increase in water absorption, which can be improved by polymer immersion. However, no significant change in slump was observed with pre-saturation and polymer immersion but overall cohesiveness of concrete was found to be better which was experienced visually.

2) The replacement of natural aggregates by recycled aggregates upto 60% resulted in increase in all strength parameter i.e. compressive strength, split tensile strength and flexural strength of concrete. At 60% replacement of natural aggregates by recycled aggregates resulted in 14% increase in compressive strength which may be attributed to the fact that effective water cement ratio was reduced due to high water absorption by aggregates and the quantity of adhered mortar.

3) The replacement of natural aggregates by pre-satrated recycled aggregates resulted in decrease in all strength parameters i.e. compressive strength, split tensile strength and flexural strength of concrete except for 60% partial replacement of natural aggregates with pre-saturated recycled aggregates. However, no significant decrease was observed.

4) The replacement of natural aggregates by recycled aggregates treated with sodium silicate solution resulted in increase in all strength parameter i.e. compressive strength, split tensile strength and flexural strength of concrete. There was 16% increase in compressive strength, 29.3% increase in split tensile strength and 30.9% increase in flexure strength.

5) The optimum replacement of recycled aggregates is found to be 60% replacement. For 60% replacement its compressive strength, split tensile strength and flexure strength is found to be more than all other partial replacement. Aggregates immersed in 5% sodium silicate solution shows the highest strength characteristic properties among pre-saturated aggregates and recycled aggregates.

REFERENCES

1. Al-Harthy(2007) “Properties of Recycled Aggregate Concrete”. Proceedings of the ACI- Kuwait Sustainability of Structural Concrete in the Middle East with Emphasis on High- Rise Buildings.
2. Construction and Building Materials, 123 Amnon K.(2003) “Properties of concrete made with recycled aggregate from partially hydrated old concrete” Cement and Concrete Research: Volume 33(5): 703-711.Cement and Concrete
3. Composites, 32Despotović(2016), “improvement of recycled aggregate” A review paper. Proceedings of Amer, A.A.M., Ezziane, K. and Bougara, A., 2016. Rheological and mechanical behavior of concrete made with pre-saturated and dried recycled concrete aggregates. , pp.300-308.
4. Debieb, F., Courard, L., Kenai, S. and Degeimbre, R., 2010. Mechanical and durability properties of concrete using contaminated recycled aggregates. International Conference. in Civil Engineering, 25 Journal of Materials (6), pp.421-426.
5. Ho, N.Y., Lee, Y.P.K., Lim, W.F., Zayed, T., Chew, K.C., Low, G.L. and Ting, S.K., 2013. Efficient utilization of recycled concrete aggregate in structural concrete.(3), pp.318-327.
6. Hobbs D.W.(1983) “Influence of Fly Ash on the Workability and Early Strength of Concrete, Proceedings, 1st International Conference on the Use of Fly Ash, Silica Fume, Slag and other Mineral By-Products in Concrete” ACI SP – 79, pp. 289-306.
7. IS 456:2000 “Code of practice Plain and Reinforced Concrete, Bureau of Indian Standards” New Delhi.
8. IS 516:1959 (Reaffirmed 1999) “Methods of tests for strength of concrete, Bureau of Indian Standards” New Delhi.
9. IS 2386:1963 (Part I) “Methods of tests for specific gravity of aggregates, Bureau of Indian Standards” New Delhi.
10. IS 2386:1963 (Part III) “Methods of tests for sieve analysis of coarse and fine aggregates, Bureau of Indian Standards” New Delhi.
11. IS 4031:1988 (Part IV) “Methods of tests for standard consistency of cement, Bureau of Indian Standards” New Delhi.
12. IS 4031:1988 (Part V) “Methods of tests for determination of initial and final setting time of cement, Bureau of Indian Standards” New Delhi.