STUDY THE MECHANICAL PROPERTIES OF HPC CONTAINING RECYCLED AGGREGATE

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Abstract: Aggregate is one of the main ingredients in producing concrete. It covers 75% of the total for any concrete mix. However, the construction industry is increasingly making higher demands of this material and is feared to accommodate the many requests at one time. Hence need for an alternative coarse aggregate arises. The aim for this project was to determine the strength and durability characteristics of high strength structural concrete by using recycled coarse aggregates, which will give a better understanding on the properties of concrete with recycled aggregates. The experimental investigation were carried out using detailed strength and durability related tests such as compressive strength test of cubes, split tensile strength test of cylinders, acid resistance test and test for saturated water absorption. The tests were conducted by replacing the coarse aggregates in high strength concrete mixes by 0, 25, 50 and 75% of recycled coarse aggregates. From the experimental investigation it was found that recycled coarse aggregates can be used for making high strength concretes by adjusting the w/c ratio and admixture contents of the mix.

I. INTRODUCTION

High-Performance Concrete (HPC) Concrete, a composite consisting of aggregates enclosed in a matrix of cement paste including possible pozzolona, has two major components – cement paste and aggregates. However, with the recent advancement in concrete technology and the availability of various types of mineral and chemical admixtures, and special super plasticizer, concrete with a compressive strength of up to 100 MPa can now be produced commercially. These developments have led to increased applications of high-strength concrete (HPC) all around the globe. In spite of the rapid development in concrete technology in recent years, concrete with compressive strength higher than 40 MPa is still regarded as HPC.

A high-strength concrete is always a high performance concrete, but a high-performance concrete is not always a high-strength concrete. Durable concrete Specifying a high-strength concrete does not ensure that a durable concrete will be achieved. It is very difficult to get a product which simultaneously fulfills all of the properties. Concrete is considered as durable and strong material. Reinforced concrete is one of the most popular materials used for construction around the world. Reinforced concrete is exposed to deterioration in some regions especially in coastal regions. There for researchers around the world are directing their efforts towards developing a new material to overcome this problem. Invention of large construction plants and equipment's around the world added to the increased use of material. This scenario led to the use of additive materials to improve the quality of concrete. As an outcome of the experiments and researches cement based concrete which meets special performance with respect to workability, strength and durability known as "High Performance Concrete" was developed.

II. LITERATURE REVIEW

Macro Breccolotti et al., (2010), did a theoretical research on the structural use of concrete manufactured with recycled aggregates. The influence of the quality and quantity of recycled aggregates on the structural reliability of RC elements was evaluated. A methodology for the calibration of the partial safety coefficient has been applied. The different provisions and indications regarding RAC were found using structural codes. The experiments were investigated by determining the statistical properties of the compressive strength of normal and recycled concretes which showed that RACs displayed higher scattering in the compressive resistance. Theoretical analyses carried out in the framework of the structural reliability theory allowed to put in evidence that the higher scattering of RAC compressive strength produced on the structural safety. The results of both the experimental and theoretical works suggested the adoption of appropriate adjustments to the design procedure when dealing with RAC for structural use.

Wengui li et al., **(2012),** studied the mechanical property, durability and the structural performance of recycled aggregate concrete for around 10 years (1996-2011). The author compared the obtained results with the results of conventional concrete. The observations revealed that the aggregates – cement matrix interfacial zone of recycled aggregate concrete consisted of loose and porous hydrates. The mix design procedure used was same as conventional concrete's. The mechanical properties such as compressive strength, tensile strength, and shear strength are lower than conventional concrete. With reference to the durability properties the carbonation resistance, chloride penetration resistance was lower when compared with the conventional concrete. The factors such as shrinkage and creep showed an increased amount with respect to the conventional concrete. The structural behavior of recycled aggregate was considered suitable to replace finer and coarse aggregates in large proportions as long as the target strength is achieved.

Neela Deshpande *et al*., (2014), emerged out as a promising technique for predicting compressive strength of concrete. In the study back propagation were used to predict the 28 day compressive strength of recycled aggregate concrete (RAC) along with two other data driven techniques namely Model Tree (MT) and Non-linear Regression (NLR). Recycled aggregate was the current need of the hour owing to its environmental friendly aspect of re-use of the construction waste. The study observed that, prediction of 28 day compressive strength of RAC was done better by ANN than NLR and MT. The paper presented the findings of a study carried out to predict the 28 day compressive strength of concrete using the techniques Artificial Neural Network (ANN), Model Tree (MT) and Non-linear Regression (NLR). Ten models were developed in the present study as explained using ANN, MT and NLR technique for each model with dimensional and non-dimensional parameters as inputs and 28 day compressive strength as output.

III. EXPERIMENTAL PROGRAM

The experimental work includes the preparation and testing of the normal aggregate concrete and RAC specimens for the compressive strength, Flexural tensile strength, split tensile strength, slump values and density of concrete of the concrete containing 0%, 25%, 50% and 75% replacement of the natural aggregate by recycled aggregate.

Recycled Aggregate- Conservation of natural resources and preservation of environment is the essence of any modern development. Recycled Aggregates are made from material which is usually recovered from demolition projects then crushed, screened and washed to produce the required grading. The recycled coarse aggregates obtained by crushed concrete were used for concrete production. Generally recycled aggregates are cheaper than quarried aggregates although this does not make them any less suitable. Recycled aggregates are the materials for the future. These are eco-friendly materials and it also reduces the cost of making concrete. Aggregates themselves can be recycled as aggregates. Unlike deposits of sand and gravel or stone suitable for crushing into aggregate, which can be anywhere and may require overburden removal and/or blasting, "deposits" of recyclable aggregate tend to be concentrated near urban areas, and production from them cannot be raised or lowered to meet demand for aggregates. Supply of recycled aggregate depends on physical decay of structures and their demolition. The material being recycled is usually highly variable in quality and properties.

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.

Properties of Recycled Concrete Aggregate (RCA) - The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled concrete aggregates contain not only the original aggregates, but also hydrated cement paste. This reduces the specific gravity and increases the porosity compared to similar virgin aggregates.

The concrete produced with recycled aggregate loses its workability more rapidly than the conventional concrete, because recycled aggregate is more porous than natural aggregate. Thus concrete with recycled aggregate may require more mixing water to achieve the same workability as original aggregate. Recycled aggregates produced from good quality concrete can be expected to fulfill the requirements for the Los Angeles abrasion loss percentage, crushing and impact values.

Concrete Mix Design- The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

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Test on fresh Concrete- Slump test

Test on Hardened Concrete- Compression strength Test
Split-Tensile strength Test
Flexural strength Test

SAFETY & PRECAUTIONS:

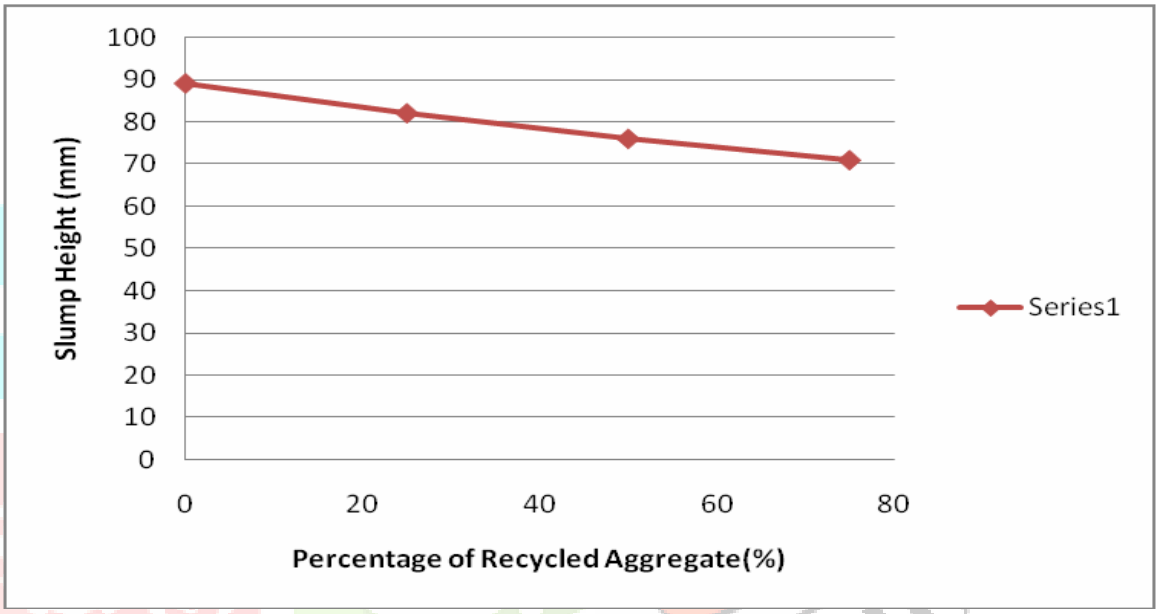
- Use hand gloves while, safety shoes at the time of test.
- After test switch off the machine.
- Keep all the exposed metal parts greased.
- Keep the guide rods firmly fixed to the base & top plate.
- Equipment should be cleaned thoroughly before testing & after testing.

IV. ANALYSIS OF RESULT

SLUMP TEST:

Variation in slump

Percentage of recycled aggregate (%)	0	25	50	75
Slump (mm)	89	82	76	71

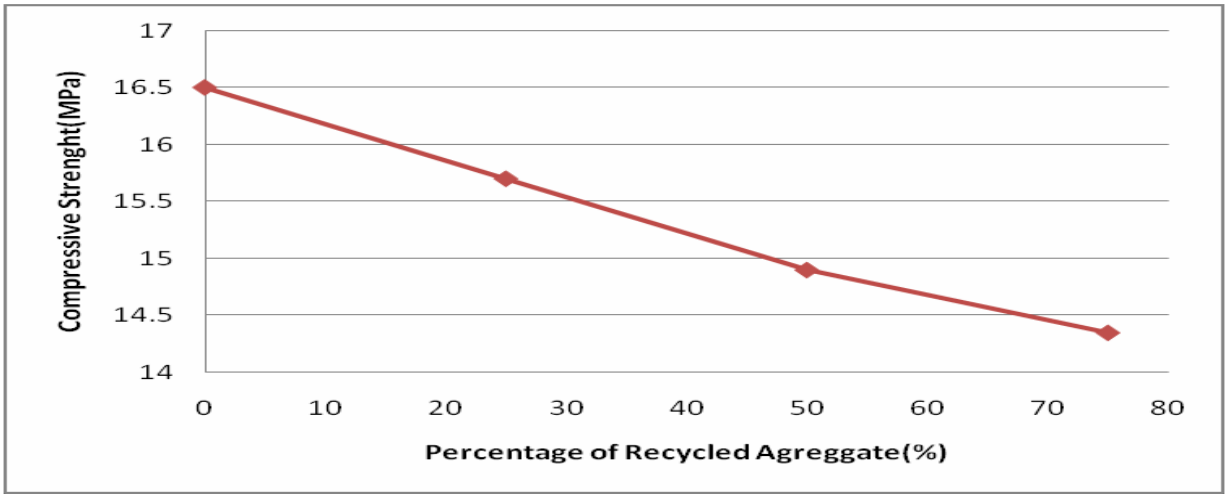


Variation in slump values

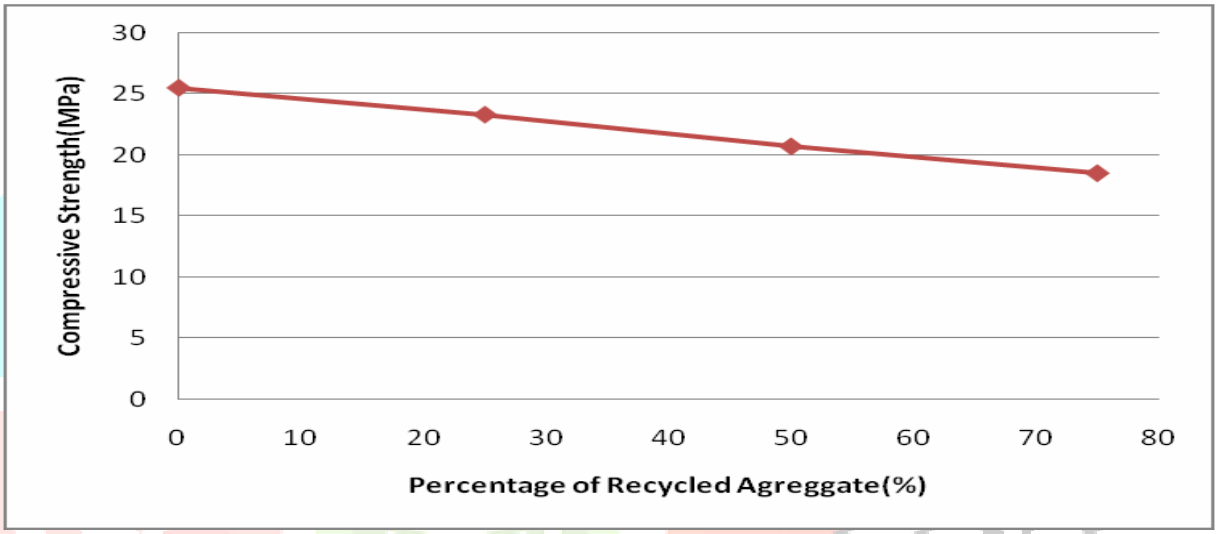
COMPRESSION TEST:

Compressive Strength Values

Percentage of recycled Aggregate (%)	7 days compressive strength (N/mm^2)	28 days compressive strength (N/mm^2)
M0	16.5	25.1
M25	15.7	23.0
M50	14.8	20.3
M75	14.3	18.9



Variation of compressive strength value after 7 days

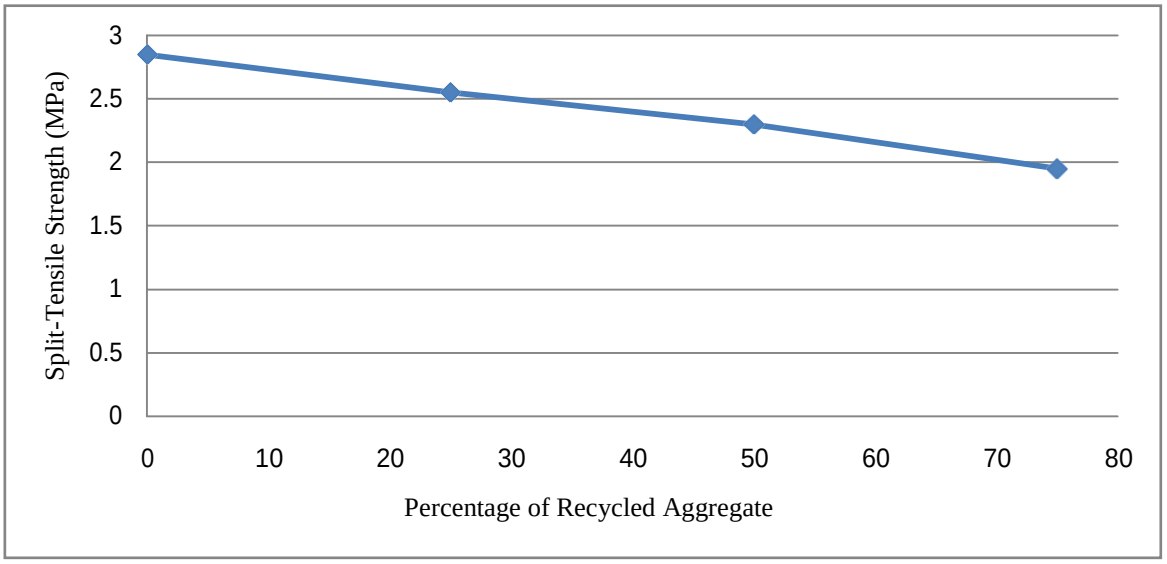


Variation of compressive strength value after 28 days

SPLIT-TENSILE STRENGTH TEST:

Split-Tensile Strength Values

Percentage of recycled Aggregate (%)	Split-tensile strength after 28days (N/mm^2)
M0	2.85
M25	2.55
M50	2.30
M75	1.95

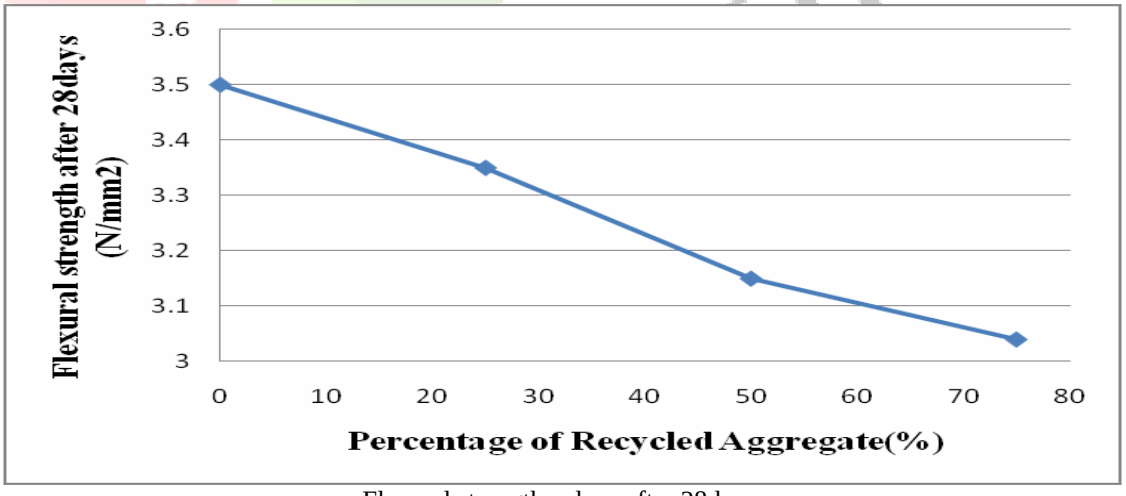


Split-tensile Strength value of Concrete after 28days

FLEXURAL STRENGTH TEST:

Flexural strength values

Percentage of recycled Aggregate(%)	flexural strength after 28days (N/mm^2)
M0	3.50
M25	3.35
M50	3.15
M75	3.04



Flexural strength values after 28days

V. CONCLUSION

Research on the usage of waste construction materials is very important because, construction waste materials is gradually increasing with the increase in population and increasing urban developments. The reason that many investigations and analysi s had been made on recycled aggregate is because, recycled aggregate is easy to obtain and the cost is cheaper than natural aggregate. Natural aggregates need to mine but recycled aggregate can ignore this process. Aim of this research project is to determine the strength and durability characteristics of recycled aggregate for potential application in the high concrete structural concrete. The study shows that:-

1) When the percentage of RCA replacement was increased, compressive strength gets reduced. However when water/cement ratio of mix was decreased, the compressive strength increases.
2) The target compressive strength (40MPa) can be achieved for 30 to 40 % of RCA replacement by decreasing the water cement ratio and adjusting the admixture content of mix. This is classified as high strength concrete and can be applied in infrastructures, which need compressive strength up to 40MPa.

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