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RESEARCH ARTICLE

STRENGTH OF CONCRETE USING RECYCLED CONCRETE AGGREGATE WITH MANUFACTURED SAND

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ABSTRACT

Growing concern of the planet due to heavy consumption of sand and coarse aggregate in concrete made it a necessity to find way through sustainable construction practices. Gigantic numbers of building and destruction trashes are produced in emerging countries like India. The clearance of these trashes is serious problem because it requires huge space. Recycled concrete can produce an alternative aggregate for structural concrete as partial or total replacement. The present work is to study the properties of concrete with replacement of 100% of natural sand by manufactured sand and coarse aggregates by different proportions with recycled concrete aggregates (RCA). A mix proportion for M25 grade concrete is derived with standards confirming to IS codes. RCA was partially replaced for coarse aggregate in the proportions of 20%, 40% and 60% fine aggregate by M-sand for 100%. The fresh and hardened properties of thus prepared concrete are studied and compared with concrete made using conventional materials. A comparison with control mix mainly their compressive strength, split tensile strength will allow assessing the suitability of using Recycled aggregate in concrete with replacement to sand with conventional or artificial sand.

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INTRODUCTION

Concrete industry, which uses 12.6 billion tons of raw materials each year, is the largest user of natural resources in the world. On the other side when a building is demolished after its use, for repairs or for deterioration it generates large amount of C&D, which conventionally and till today is used for land filling. In recent years, the recyclable potential of construction and demolition waste has made it a target of interest and the main focus of waste management policies on encouraging minimization, reuse, recycling, and valorisation of the waste as opposed to its final disposal in landfills. Recycled aggregate is generally produced by two stages crushing of demolished concrete, screening and removal of contaminants such as reinforcement, wood, plastic etc. Manufactured sand is a substitute of river for construction purposes sand produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. Efforts to improve the properties of concrete are continuously being made by researchers.

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In the last decade, construction industry has been conducted research on the utilization of waste products in concrete. Unwanted concrete and brickwork can be reprocessed by arranging, crushing and separating into recycled aggregate. Aggregates normally make up around 55% to 70% of the capacity of a concrete mixture. The management of C&D waste is a alarm due to growing considerable amount of demolition's rubble, lack of dumping spots, rise in shipping and clearance cost. But most of the industries and construction companies are still not aware of this environmental dangerous wastages and its recycling.

As a standby to river sand, Manufactured sand (M-sand) has been produced by crushing stone. Several experimental results shows that the quality of M-sand is better than the river sand in several phases. Investigational outcomes recommend that the sharp ends of the particles in non-natural sand offer healthier connection with the cement. The main objective of the present work is to systematically study the properties of concrete with constant replacement of 100% of natural sand by manufactured sand and coarse aggregates with recycled aggregates at the rate of 20%, 40% and 60%.

Manufactured Sand

Manufactured sand is an alternate fine aggregate that may be used in the making of the concrete. Here that term "manufactured" denotes purposely taking coarse aggregate, primarily granite, and crushing it to create a new product sand. These particles have sharp edges and rough surface textures. When they are used in concrete, it involves the usage of admixtures to rise the flexibility of the wet concrete. In order to avoid these deficiencies the surface textures of the sand particles should be smooth and edges should be rounded. There are machines to manufacture sand having good surface texture and edges of the granules of the sand are rounded. Manufactured Sand is a sand produced from crushing of granite stones in required grading to be used for construction purposes as a replacement for river sand.

Recycled Concrete Aggregate

After demolition of old roads and buildings, the removed concrete is often considered worthless and disposed of as demolition waste. By collecting the used concrete and breaking it up, recycled concrete aggregate (RCA) is created. This study focuses on coarse RCA which is the coarse aggregate from the original concrete that is created after the mortar is separated from the rock which is reused.

The use of RCA in new construction applications is still a relatively new technique. Buck cites the beginning of RCA use to the end of World War II, when there was excessive demolition of buildings and roads and a high need to both get rid of the waste material and rebuild Europe. After the immediate need to recycle concrete, the use of RCA tapered off. In the 1970s, the United States began to reintroduce the use of RCA in non-structural uses, such as fill material, foundations, and base course material. Since this time, some research has been conducted regarding how viable RCA is as an option to replace unused natural aggregate (NA) in structural concrete.

Literature Review

Parekh, Modhera discuss the issues relating to sustainability and limited natural resources. They also suggest use of recycled and secondary aggregates (RSA), for example crushed concrete and asphalt and industrial by products such as fly ash and blast furnace slag. Then products now reused in different material production. According to Knights, J. 1998. the quality of recycled aggregates affects the compressive strength. Low quality of aggregates possess less compressive strength. Research project in UK indicated that concrete of a characteristic strength of 45 MPa with a slump in the range of 150-175 mm could be produced in the laboratory by replacing 60% of the natural coarse aggregate by mixed recycled aggregate collected from a demolition contract. According to Hendricks, C.F. and Pietersen, H.S. the tensile splitting strength is only marginally less compared to concrete with natural aggregates.

However, when recycled masonry aggregates are used, the bending tensile strength of the concrete can be reduced to 50-60% of that in ordinary concrete. J. M. Khatib from Centre for Infrastructure Management, MERI, Sheffield Hallam University, Howard Street, Sheffield, UK, investigated the properties of concrete containing fine recycled aggregate. Recycled aggregate consisted of crushed concrete (CC) or crushed brick (CB) with particles less than 5 mm in diameter. The free water/cement ratio was kept constant for all mixes.
The fine aggregate in concrete was replaced with 0%, 25%, 50% and 100% CC or CB. Generally, there is strength reduction of 15–30% for concrete containing CC. However, concrete incorporating up to 50% CB exhibits similar long-term strength to that of the control. Even at 100% replacement of fine aggregate with CB, the reduction in strength is only 10%. Beyond 28 days of curing, the rate of strength development in concrete containing either CC or CB is higher than that of the control indicating further cementing action in the presence of fine recycled aggregate. More shrinkage and expansion occur in concrete containing CC.

Objective

- To study the various properties of Recycled concrete aggregates.
- To replace Natural Sand 100% with Manufactured Sand.
- To replace Coarse Aggregate in 20%,40%,60%, with Recycled Aggregate.
- To study the workability, compressive strength, tensile strength of concrete made with RCA and M-sand for M25grade of concrete in comparison with normal concrete.

The property of fresh concrete is dependent on the properties of the ingredients used in its making. Therefore tests are conducted on the materials to determine their characteristics.

Table 1. Properties of Coarse Aggregates

Properties	Natural aggregate	Recycled aggregtae	Reference
Specific gravity	2.70	2.375	IS2386:1963(Part III)
Water absorption	0.8%	3.9%	IS2386:1963(Part III)
Abrasion test	34.68 %	37.72 %	IS383:1970(Part IV)
Crushing test	28.44 %	35.26 %	IS2386:1963(Part IV)
Impact value	22.40 %	31.27%	IS2386:1963(Part IV)
Combined Flakiness and Elongation index	22.58%	27.25%	IS2386:1963(Part I)
Angularity number	9	11.27	IS2386:1963(Part I)

Casting and Testing Procedure

Mixing materials of concrete i.e. cement, sand and aggregate were taken in a mix proportion 1 : 1.56 : 2.81 for preparing M 25 grade of concrete. Concrete mix design and Specimens of standard size as per Indian Standards have been used for determining the compressive strength and flexural strength. One control specimen (M1) was cast with natural sand and coarse aggregate. The collected recycled aggregates are crushed down by hammer to separate the aggregates & reduce their sizes in smaller parts. Three specimens have been prepared by replacing natural aggregates by 0%(M2), 20%(M3) , 40%(M4) and 60%(M5) of recycled aggregates by volume. For preparation of specimen, weigh batching is adopted. All the ingredients were dry mixed homogeneously in a concrete mixer, the required quantity of recycled aggregate were added and were remixed properly. Then the required quantity of water is added (w/c ratio 0.45) to get a homogenous

mix. The fresh concrete was compacted in the mould by means of table vibrator. Cubes and beams of sizes 150mm x 150 mm x 150 mm and cylinders of size 100 x 200mm were prepared. After the compaction of the specimens, a smooth finish was given and all the specimens were cured for about 24 hours in the laboratory environment. After 24 hours, the specimens were demoulded and transferred to curing tank and were allowed to cure for 3, 7 and 28 days in water bath.

RESULTS

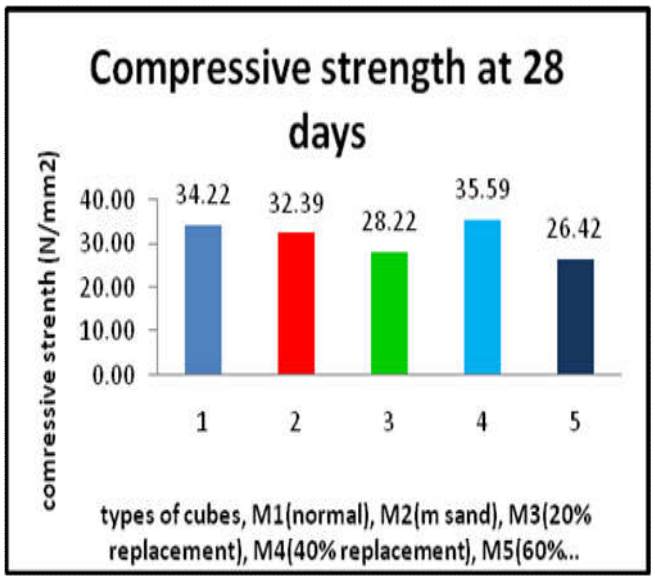
Workability: Increasing percentage replacement of both RCA and manufactured sand (100%) decreased the workability. This can be easily avoided by using super plasticizer. The results show that slump of reference specimen is higher while the concrete Mix specimen (50% replacement of RCA) has lesser slump. The slump of RAC is low and that can be Improved by using Saturated Surface Dry of RCA (SSD RCA) to improve the workability of fresh concrete. From the results obtained, concrete made with 50% SSD RCA has competitive slump compared to the concrete made with CA Fresh Concrete.

Table 2. Results for workability in terms of slump value

Type of mix	Slump value(mm)
Normal mix	65
Mix with M Sand	60
20% Replacement of NA with RCA	50
40% Replacement of NA with RCA	45
60% Replacement of NA with RCA	35

Compression Strength

The cubes are then tested in compression testing machine at the end of 3 days and 7 days. The average value of results of 3 cubes is then worked out. During the test, the load is to be applied uniformly at the rate of 350 kg/cm^2 or 35 N/mm^2. Testing was performed in general accordance with Indian Standard Test Method. For the compressive strength, tests were conducted at the ages of 7, 14 and 28 days It has been observed that the compressive strength goes on increasing with replacement of 100% of natural sand by manufactured sand and coarse aggregate with RCA up to 20%, 40% and 60% replacement.



Split Tensile Strength

Cylindrical specimen of diameter 150mm and length 300mm have been cast. After required days of curing are taken for test. Diametrical lines are drawn on the two ends of the specimen to ensure that they are on the same axial place.

Table 3. Experimental results for cube strength

Type of cubes	Strength (N/mm^2) 7 days	Strength (N/mm^2) 14 days	Strength (N/mm^2) 28 days
M1	16.71	26.01	34.22
M2	14.673	25.340	32.39
M3	19.83	21.147	28.22
M4	21.89	28.58	35.59
M5	20.557	25.58	26.42

Plywood strips are placed on the lower plate to place the specimen. Align the specimen so that the lines marked on the ends are vertical and centred over the bottom plate. Load is applied continuously without shock at a rate of approximately 14-21kg/cm2/minute. The specimen was loaded until it fails. The test is done at the age of 7, 14 and 28 days.

Table 4. Split tensile strength of concrete

Cylinders	Strength (N/mm^2) 7 days	Strength (N/mm^2) 14 days	Strength (N/mm^2) 28 days
M1	12.16	16.57	16.08
M2	12.487	14.713	15.42
M3	11.25	11.03	12.33
M4	12.03	13.837	14.15
M5	10.920	11.3	11.86

Conclusion

- The availability of river sand is very scarce nowadays. M-sand full-fill the requirement of sand in concrete.
- Recycled concrete aggregate can be used as an alternative to the natural coarse aggregate.
- Water required producing the same workability increases with the increase in the percentage of both M-sand and RCA.
- We see that with 40% replacement mix has higher strength compared to 20% and 60%, hence optimum is 40%.
- We see that the strength of concrete with M sand and recycled coarse aggregate is more than regular concrete.
- The idea of reusing waste material is very encouraging in concrete technology especially it will be helpful in minimizing destruction to earth's crust and green forestation.

Scope for Further Study

- Further testing and studies on the recycled coarse aggregate concrete is highly recommended to indicate

the strength characteristics of recycled coarse aggregate for application in high strength concrete.

- Due to more water absorption of recycled coarse aggregate it may give less workability. Therefore, it is recommended to add admixtures such as super plasticizer, fly ash, silica fume. etc into the mix so that the workability can be improved.

- More investigations and laboratory tests should be done on the strength characteristics of recycled coarse aggregate. It is recommended that, the testing can be done on concrete slabs, beams and walls.
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- More trials with different particle sizes of recycled coarse aggregate and various percentages of replacement of recycled coarse aggregate with fly ash as cementitious material with % replacement of cement are recommended to get different outcomes and higher strength characteristics in the recycled coarse aggregate concrete with fly ash.
- Investigation can be done to study variation in strength of hardened concrete with different age of Recycled coarse aggregate.

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