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Performance of Recycled Aggregate Concrete for Structural Applications

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Abstract- Now-a-days cost of construction materials are affecting the economy of all structures. It is a dominating factor affecting environmental housing system around the world. Conventional aggregates namely gravel, and fine aggregate is sand in concrete will be used to control. While natural aggregate is Recycled Aggregate as coarse aggregate will be investigated to replace the aggregate in concrete and Robo sand (Stone dust) as fine aggregate will be replace the sand in concrete. In this investigation, M25 grade of concrete with combination of natural material Recycled Aggregate content as Coarse aggregate in the proportion of 0%,5%,10%,15%,20% & 25% will be replaced and Robo sand (stone dust) as fine aggregate with full 100% replacement of natural sand, sample specimens are prepared and will be tested for workability, compressive strength, split tensile strength and flexural strength for 7,14 and 28 days respectively and also showing the comparative results with Conventional M25 grade concrete. By this project investigation, concrete may be less dense, light weight concrete by Recycled Aggregates and good quality of concrete by Robo sand.

Keywords: Recycled Aggregate, coarse aggregate, Robo sand, compressive strength, split tensile strength, flexural strength, replacement, workability & light weight concrete..

I. INTRODUCTION

General

Concrete is basically a mixture of cement, fine and coarse aggregates. High-performance concrete (HPC) conforms to a set of standards above those of the most common applications, but not limited to strength. Some of the standards are ease of placement, compaction without segregation, early age strength, permeability etc. The researchers have done considerable work on replacing the cement with baggage ash and robo sand without affecting the strength. River sand (Fine aggregate), which is one of the constituents used in the production of concrete, has become expensive and scarce. So there is large demand for alternative materials.

The three basic needs of man are food, clothing, and shelter. Civil Engineer has relevance with all basic needs of man directly or indirectly. Man has progressed a lot in developing the method of constructing shelter. Initially man used to stay in huts and time passed it developed into house that is load bearing. In this constructed environment, the rising cost of building construction materials is the factor of great concern. The cost of building materials are raising day by day. Concrete is the most abundant using composite material which is composed of aggregates, cement and water which is using by the people all over the world. Demand of construction material is increased due to infrastructural development across the world. Production is expected to increase to more than billion tons per year. Production of concrete is increasing due to high growth of infrastructure development and construction activities in the world , Production of concrete demands its constituents like aggregates, cement, water and admixtures. Sources of conventional aggregates occupy the major part of the concrete.

II. MATERIALS AND MIX DESIGN

Materials Used

- **Cement:**

The raw materials required for manufacture of Portland cement are calcareous materials such as limestone or chalk, and argillaceous material such as

shale or clay. There are two processes known as wet and dry processes depending upon whether the mixing and grinding of raw materials is done in wet or dry condition. The raw materials used for the manufacture of cement consist of mainly of lime, silica, alumina and iron oxide. These oxides interact with one another in the kiln at high temperature to form more complex compounds.

The chemical reactions that take place between cement and water is referred as hydration of cement. The hydration of cement can be visualized in two ways. The first is through solution mechanism in which cement dissolve to produce super saturated solution from which the hydrated products get precipitated. Second is that water attacks cement compounds starting from the surface to the interior of compounds with time.

In this study Ordinary Portland cement of 53 grade (ACC cement) has been procured and has been used. The various tests on this material is conducted and resulted in 4.3.

OPC 53 grade cement

- Aggregates:

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end product in their own raw materials. They are also the raw materials that are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of cement.

Aggregates are divided into two categories from the consideration of size.

i).Coarse aggregate ii). Fine aggregate

Coarse Aggregate

Coarse aggregates are particles greater that 4.75mm but generally range between 9.5mm to 37.5mm in diameter. They can either be from primary, secondary or recycled sources. Primary or virgin aggregates are either land or marine-won. Gravel is a coarse marine-won aggregate, land-won coarse aggregates include gravel and crushed rock. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

In this study coarse aggregate of nominal sizes of 20mm, 12mm are used.

20mm coarse aggregates

Fine Aggregate:

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 4.75mm sieve. The fine aggregate used in this study is river sand which is obtained from local company and shown in figure 4.4. The basic tests on these materials are conducted and resulted in 4.3.

Fine aggregate

Robo sand

Robo Sand is also called as manufactured sand obtained by crushing natural granite stone. Robo Sand is defined as a crushed granite aggregate produced by crushing natural granite stone. The perfect substitute for river sand is Robo Sand. River sand is one of the basic ingredients in manufacture of concrete. River sand has become expensive and scarce. Therefore looking alternate to the river sand. The crusher dust is known as Robo sand can be used as alternative material to the river sand.

Robo sand: is a material of high quality, in contradiction to non-refined surplus from coarse aggregate production. Water The water, which is used for making concrete and for curing, should be clean and free from harmful impurities such as oil, alkali, acid, etc., in general, the water, which is fit for drinking should be used for making concrete.

Robo sand possesses similar properties as that of river sand, hence accepted as a building material. Robo Sand or M-Sand was used as replacement of fine aggregate. Robo Sand is a result of crushed stone, here the stones are crushed into smaller granular size of river sand granules and washed to remove the fine rock dirt to improve the quality as per IS: 2386-1975.

S. No	Property	Value
1	Grading	Zone II as per IS code
2	Specific gravity	2.69
3	Fineness	2.81
4	Silt modulus	Absent
5	Surface moisture	0.9%
6	Water absorption	2.27%

Recycled Aggregates

Recycled Aggregate particles are used as reinforcing material for investigation. Shell particles of size between 20 mm – 600 µ are prepared in grinding machine. Recycled Aggregate aggregates are potential candidates for the development of new composites because of their high strength and modulus properties. An approximate value of Recycled Aggregate density is 1.60 g/cm3 .

Recycled Aggregate aggregates

WATER:

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, in the quantity and quality of water is required to be looked into very carefully. C3S

requires 24% of water by weight and C2S requires 21%. It has also been estimated that on an average 23% of water by weight of cement is required for chemical reaction with Portland cement compounds .This 23% of water chemically combines with cement and, therefore, it is called bound water. It has been further estimated that about 15% by weight of cement is required to fill up the gel-pores.

Therefore, a total 38% of water by weight of cement is required for the complete chemical reaction and to occupy the space within gel-pores.

Quality of water affects the strength, it is necessary for us to go into the purity and quality of water. A popular yard-stick to the suitability of water for mixing concrete is that, if water is fit for drinking it is fit for making concrete. Carbonates and bi-carbonates of sodium and potassium effect the setting time of cement. Salts of Manganese, Tin, Zinc, Copper and Lead cause a marked reduction in strength of concrete. A turbidity limit of 2000ppm has been suggested.

Locally available potable fresh water which is free from concentrations of aid and organic substances has been used in this experimental program for mixing and curing.

III. EXPERIMENTAL INVESTIGATION

Workability

Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. It is 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.

Concrete is said to be workable when it is easily placed and compacted homogeneously i.e. without bleeding or Segregation. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs may also be visible in finished concrete.

The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product.

Slump cone test

A Slump test is a method used to determine the consistency of concrete. The consistency or stiffness indicates how much water has been used in the mix. The stiffness of the concrete mix should be matched to the requirements for the finished product quality. The concrete slump test is used for the measurement of a property of fresh concrete. The test is an empirical test that measures the workability of fresh concrete more specifically, it measures consistency between batches. The test is popular due to the simplicity of apparatus used and simple procedure. The apparatus consists of frustum of a cone and is hollow at top and bottom.

Figure 4. 1 Slump cone test

This test is carried out with a metallic mould called slump cone whose top diameter is 10cm, bottom diameter is 20cm and height is 30cm. before conducting test the internal surface of the mould is thoroughly cleaned. Then mould is placed on a smooth, horizontal rigid non-absorbent surface. The mould is then filled in three equal layers with prepared concrete. Each layer is tamped 25 times by tamping rod. After the top layer has been leveled, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in vertical direction. This allows the concrete to subside. The subsidence is referred as slump of concrete. The difference in level between height of the mould and that of the highest point of subsided concrete is measured, this difference is measured in millimeter (mm) is taken as slump of concrete.

Compaction factor test

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The compacting factor test works on the principle of determining degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. The degree of compaction called the compacting factor is measured by the density ration. The ratio of the density actually achieved in the test to density of same concrete fully compacted.

The sample of concrete to be tested is placed in the upper hopper up to the brim. The trap door is opened so that concrete falls into lower hopper. Then the trap door of the lower hopper is opened and the concrete is allowed to fall in the cylinder. Then measure the weight of the cylinder which is known as "weight of partially compacted concrete". The cylinder is emptied and then refilled with the concrete from the same sample in three equal layers. The layers are heavily rammed to obtain full compaction. This weight is known as "weight of partially compacted concrete". Compacting factor is the ratio of "weight of partially compacted concrete" to "weight of partially compacted concrete".

$$\text{Compaction factor} = \frac{(\text{Weight of partially compacted concrete})}{(\text{Weight of fully compacted concrete})}$$

Figure 4. 2 Compaction factor test

Mixing of concrete

Concrete was mixed in a tilting type concrete mixer. The mixer was hand loaded with coarse aggregate first, then with fine aggregate and with cement. During the rotation of the mixer, water, were added to the ingredients inside. The rotation was continued up to minutes. The mixer was tilted and the concrete was unloaded one clean platform.

Casting of specimens

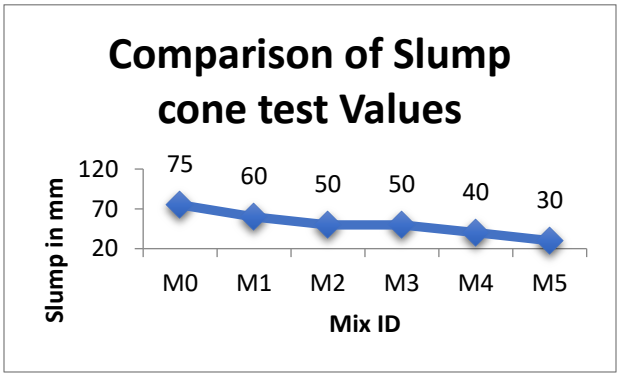
Casting is a manufacturing process by which concrete material is usually poured into a mould, which contains a hollow cavity of the desired shape, and the allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mould to complete the process. Each mould is provided with a metal base plate having a plane surface. The base plate is of such dimension as to support the mould during the filling without leakage and it is preferably attached to the mould by springs or screws. In assembling the mould for use, the joints between the sections of the mould are thinly coated with mould oil and a similar coating of mould oil is applied between the contact surface of the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. The interior surface of the assembled mould is also required to be thinly coated with mould oil to prevent adhering of concrete.

IV. RESULTS AND ANALYSIS

Workability of concrete

Slump cone test results

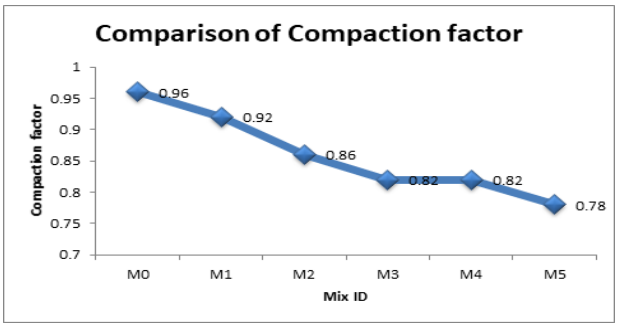
S. No	Percentage of Recycled Aggregates and Robo Sand	Mix ID	Slump in mm
1	0%+100%	M0	75
2	5%+100%	M1	60
3	10%+100%	M2	50
4	15%+100%	M3	50
5	20%+100%	M4	40
6	25%+100%	M5	30



From the above table and graph it was observed that the by using Recycled Aggregates and robo sand in M25 grade concrete the value of slump decreases from 75mm to 30mm for mix M0 to M5 by using Recycled Aggregates and robo sand the water concrete decreases in the concrete mix because of this reason the slump value decreases.

Compaction factor test results

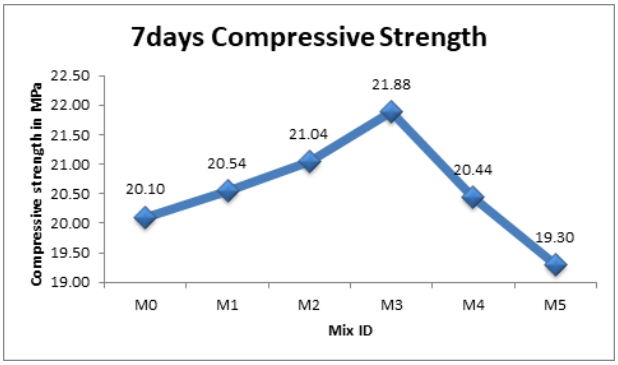
S. No	Percentage of Recycled Aggregates and Robo Sand	Mix ID	Compaction factor
1	0%+100%	M0	0.96
2	5%+100%	M1	0.92
3	10%+100%	M2	0.86
4	15%+100%	M3	0.82
5	20%+100%	M4	0.82
6	25%+100%	M5	0.78



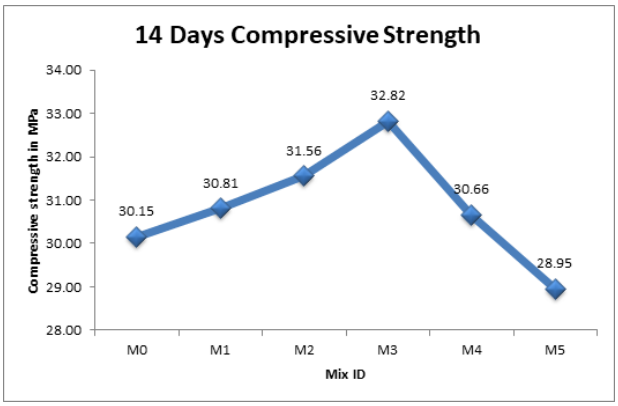
From the above table and graph it was observed that the by using Recycled Aggregates and robo sand in M25 grade concrete the value of compaction factor decreases from 0.96 to 0.78 for mix M0 to M5 by using Recycled Aggregates and robo sand the water concrete decreases in the concrete mix because of this reason the slump value decreases.

Compressive strength of concrete

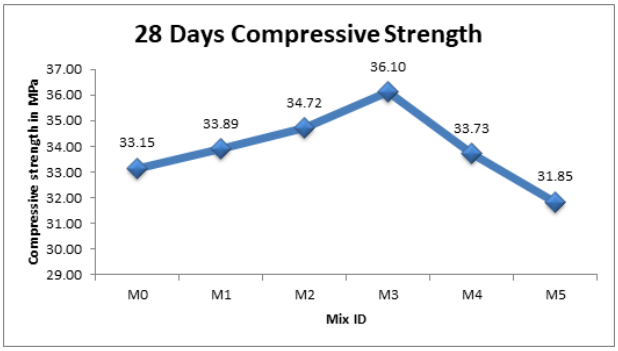
S. No	Percentage of Recycled Aggregates and Robo Sand	Mix ID	Compressive strength of M25 Grade concrete		
			7 Days	14 Days	28 Days
1	0%+100%	M0	20.10	30.15	30.15
2	5%+100%	M1	20.54	30.81	33.89
3	10%+100%	M2	21.04	31.56	34.72
4	15%+100%	M3	21.88	32.82	36.10
5	20%+100%	M4	20.44	30.66	33.73
6	25%+100%	M5	19.30	28.95	31.85



The above plot shows the variation of 7days compressive strength in M25 grade concrete using Recycled Aggregates and robo sand the optimal value of compressive strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decreases to M5 mix in M25 grade concrete mix.



The above plot shows the variation of 14days compressive strength in M25 grade concrete using Recycled Aggregates and robo sand the optimal value of compressive strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decrease to M5 mix in M25 grade concrete mix.



V. CONCLUSIONS

On the basis of results obtained by this experimental investigation, following conclusions are shown below: -

1. In this project we had done detailed study and investigation on Recycled Aggregate as Coarse aggregate in replacement of Crushed stone and Robo sand as replacement of fine aggregate. we studied various properties of Recycled Aggregate and Robo sand like physical properties &composition etc. We did various tests on cement, fine aggregate and coarse aggregate.
2. In some areas crushed stones and natural sand are become costly and also have scarcity. At that time crushed stones are replaced by Recycled Aggregate and natural river sand by robo sand which is easily available and cheap cost. Recycled Aggregate and Robo sand are very useful materials as aggregates in concrete preparation and we compared all the properties of Recycled Aggregate and Robo sand with conventional aggregates.
3. Recycled Aggregate have great resistant against crushing, impact and abrasion and also have less specific gravity except water absorption. If we can use Recycled Aggregate as coarse aggregate replacement we can get good bonding, good workability and good strength. On the other hand, Robo sand (stone dust) have good strength giving property and improves more quality of concrete.
4. By replacing the Recycled Aggregates and Robo sand, the strength of M25 grade mix concrete increases from 0%CA+100%RS to 15%CA+100%RS is comparatively increasing with normal concrete.
5. The compaction factor values decreases with increase in the percentage of coconut aggregates and robo sand quantity from 0%CA+100%RS to 25%BA+100%RS
6. The optimal values of compressive strength found at 15%CA+100%RS at 7days, 14days and 28days curing and the strength values are decreasing after M3 mix.
7. The optimal values of split tensile strength found at 15%CA+100%RS at 7days, 14days, and 28days curing.
8. The optimal value of flexural strength is also obtained at M3 mix which is similarly to the compressive strength and split tensile strength.
9. By using the Robo sand and Recycled Aggregates in concrete, it improves the quality of concrete and gives good strength and conserve the natural river sand for future generation.

10. Hence, we concluded that Robo sand and Recycled Aggregates would be used as replacement of fine aggregate and coarse aggregate.

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