A Study on Use of Recycled Aggregate in Standard Mix Design & its Sustainibility

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Abstract – *Waste management industry moves around the collection, storage and waste disposal. A waste management system is a process of treating waste which consists of collection, recycling and disposal or waste processing.* ***Recycling****,* ***reuse****, combustion and landfill methods helps in reducing waste. Waste disposal is a major issue especially in the field of construction industry. Landfilling method is cheaper and easiest among all but finding land for it is getting difficult.* ***NR*** *protection is the first priority.*

Thus recycling and reuse can reduce construction and demolition waste. This will help in conservation of ***NA*** *for next generation. The main objective is to save environment and resources both. For reaching above objective mentioned steps are to be followed for making* ***RCA****, first collection of demolished waste. Second addition of collected waste to* ***NA*** *in different proportions. Third,* ***RCA*** *produced will be tested for different parameters. Finally, it is analyzed for its application. The study is dealing with the usage of* ***RCA*** *in standard* ***mix design*** *and involves validation of* ***NC*** *formed based on concrete test results. These test results is helpful in determing its application in different constructions. Its use will reduce the percentage of* ***NA*** *in construction without compromising the quality of concrete. Also its contribution on environment protection and* ***sustainability.***

Thus, this project gives a brief idea about need of recycling of aggregates and benefits of ***RCA*** *in comparison with the* ***NA.*** *Contractors must turn their focus in spending in recycling which in turn helps in conservation of* ***NA.***

Key Words: Recycling, Reuse, NR-natural resource, NA-natural aggregate, RCA- recycled concrete aggregate, sustainability.

1. INTRODUCTION

Researchers have conducted some researches from 10 years ago, related to recycled aggregates to be used in concrete roads, pavements, bridges, etc. however, they have not applied recycled aggregates for structural concrete. The purpose of this research is to use recycled aggregate for structural concrete in Raipur (C.G). The reason of selecting Raipur(C.G) for this study is this city is now more concerned for its environmental conditions & waste management. This chapter focuses on previous research studies about environmental issues, waste management and Recycled Aggregate Concrete (RAC).

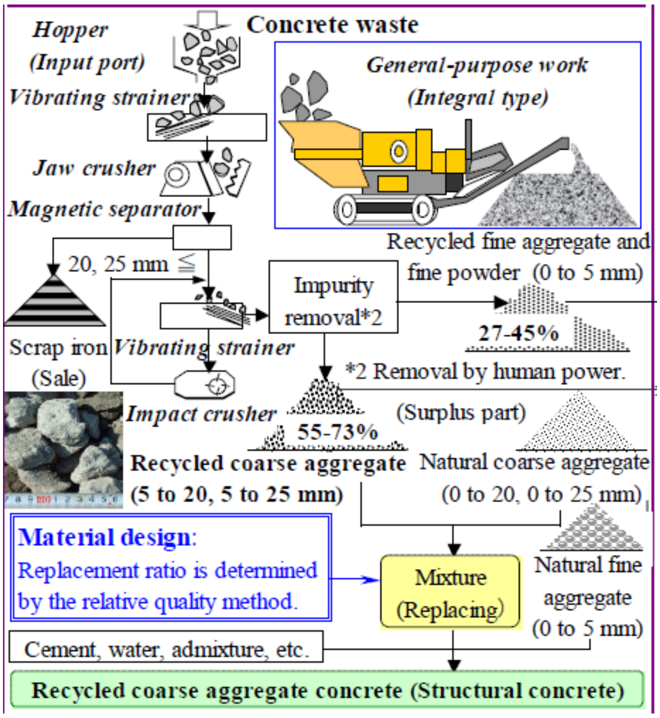


Fig:1

1.1 Natural Aggregates

Natural aggregates, which consist of crushed stone and sand and gravel, are among the most abundant natural resources and a major basic raw material used by construction, agriculture, and industries employing complex chemical and metallurgical processes. **Coarse aggregates** are particles greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter. **Fine aggregates** generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve.

1.1.2.Properties

1.1.2.1. Absorption, Porosity & Permeability

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surfacetexture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption relates to the particle's ability to take in a liquid.Porosity is a ratio of the volume of the pores to the total volume of the particle. Permeability refers to the particle's ability to allow liquids to pass through.

1.1.2.2. Surface Texture

Surface texture is the pattern and the relative roughness or smoothness of the aggregate particle. Surface texture plays a big role in developing the bond between an aggregate particle and a cementing material. A rough surface texture gives the cementing material something to grip, producing a stronger bond, and thus creating a stronger hot mix asphalt or portland cement concrete. Surface texture also affects the workability of hot mix asphalt, the asphalt requirements of hot mix asphalt, and the water requirements of portland cement.

1.1.2.3. Strength & Elasticity

Strength is a measure of the ability of an aggregate particle to stand up to pulling or crushing forces. Elasticity measures the "stretch" in a particle. High strength and elasticity are desirable in aggregate base and surface courses. These qualities minimize the rate of disintegration and maximize the stability of the compacted material. The best results for portland cement concrete may be obtained by compromising between high and low strength, and elasticity. This permits volumetric changes to take place more uniformly throughout the concrete.

1.1.2.4. Density & Specific Gravity

Density is the weight per unit of volume of a substance. Specific gravity is the ratio of the density of the substance to the density of water.

1.1.2.5. Aggregate Voids

There are aggregate particle voids, and there are voids between aggregate particles. As solid as aggregate may be to the naked eye, most aggregate particles have voids, which are natural pores that are filled with air or water. These voids or pores influence the specific gravity and absorption of the aggregate materials.

1.1.2.6. Hardness

The hardness of the minerals that make up the aggregate particles and the firmness with which the individual grains are cemented or interlocked control the resistance of the aggregate to abrasion and degradation. Soft aggregate particles are composed of minerals with a low degree of hardness.

1.2 Recycled Aggregate

Recycled aggregate is produced by crushing concrete, and sometimes asphalt, to reclaim the aggregate. Recycled aggregate can be used for many purposes. Ex- fly ash, silica fumes etc.

2. METHODOLOGY & WORK

The main aim of this study is to perform experimental study to investigate the properties of concretes produced with recycled aggregates in Raipur (C.G) and comparison of them with normal concrete. During the experimental work, different concrete samples with various concrete mix designs were investigated.

For casting normal concrete samples, cement with grade 53 is used. Sand & boulders are used as fine and coarse aggregate respectively. Drinkable water was used as mixing water.

For casting recycled concrete samples, same cement is used. Recycled concretes with different strength levels (20-30 MPa) need to be crushed by jaw crusher and are separated according to their size distributions. Two different concrete samples will be casted. Cubic samples with the sizes of 150 mm and cylinder samples with the size of 100×200 mm are chosen for compressive strength, non-destructive tests, freeze-thaw resistance, and splitting tensile strength, respectively. The natural curing condition is performed for the samples. Compressive strength and splitting tensile test are conducted at 7 days, 14 days and 28 days. Non-destructive tests need to be done at 14 and 28 days and freeze-thaw resistance tests will be done at 28 days.

Steps to be followed:

1. Structural concrete need to be crushed and sieve analyses is done for both group of aggregates (normal aggregates and recycled aggregates).
2. Water absorption test and specific gravity of normal and recycled aggregates are performed.
3. According to two different mix designs, materials were mixed; concrete is made and poured into forms and compacted; and the hardened concrete samples are cured.
4. Compressive strength, splitting tensile strength, PUNDIT, rebound (Schmidt) hammer and freeze-thaw resistance of each sample is determined.
5. According to the test results, comparison between normal concrete and recycled aggregate concrete were performed.

2.1. Tests to be followed

2.1.1. Specific Gravity Test

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values.

Aggregate sample is washed thoroughly and immersed in distilled water and a cover of at least 5cm of water above the top of basket. The basket and aggregate should remain completely immersed in water for a period of 24 hour afterwards. The basket and the sample are weighed while suspended in water.

The basket and aggregates are removed from water and allowed to drain for a few minutes, after which the aggregates are transferred to the dry absorbent clothes. The empty basket is then returned to the tank of water jolted 25 times and weighed in water

The aggregates placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in single layer and allowed to dry for at least 10 minutes until the aggregates are completely surface dry.

The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110° C for 24 hrs. It is then removed from the oven, cooled in an air

Specific gravity = (dry weight of the aggregate /Weight of equal volume of water)

2.1.2. Slump Test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. The slump test is used to ensure uniformity for different loads of concrete under field conditions.

The test is carried out using a metal mould in the shape of a conical frustum known as a slump cone that is open at both ends and has attached handles.This cone is filled with fresh concrete in three stages. Each time, each layer is tamped 25 times with a metal rod. At the end of the third stage, the concrete is struck off flush with the top of the mould. The mould is carefully lifted vertically upwards, so as not to disturb the concrete cone.

The concrete then slumps (subsides). The slump of the concrete is measured by measuring the distance from the top of the slumped concrete to the level of the top of the slump cone.

2.1.3. Compressive Strength Test

Test for compressive strength is carried out either on cube or cylinder.For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete

2.1.4 SplitingTensileTest

Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The wet specimen is taken out from water after 7 days of curing & wateris wiped out from the surface of specimen. The weight is noted down and dimension of the specimen. The compression testing machine is set for the required range. Place the other plywood strip above the specimen. The upper plate is brought down to touch the plywood strip & the load is applied continuously without shock at a rate of approximately 14-21kg/cm2/minute (Which corresponds to a total load of 9900kg/minute to 14850kg/minute) the breaking load(P) is noted down.

2.1.5. Ultrasonic Pulse Velocity Test

Structural defects causes serious damages & collapses. Ultrasonic testing provides information on the strength & uniformity of concrete and can be used to detect voids, cracks and defects. A pulse of ultrasonic (> 20 kHz) longitudinal stress waves is introduced into one surface of a concrete member by a transducer coupled to the surface with a coupling gel or grease. The pulse travels through the concrete and is received by a similar transducer coupled on the opposite surface. The transit time of the pulse is determined by the instrument. The distance between the transducers is divided by the transit time to obtain the pulse velocity. The longitudinal pulse velocity, Cp, of an elastic solid is a function of the elastic constants (modulus of elasticity, E, and Poisson's ratio) and the density, ".

$$C_P = [E(1-v) / p(1+v)(1-2v)]$$

2.1.6. Rebound (Schmidt) Hammer Test

Procedure for rebound hammer test on concrete structure starts with calibration of the rebound hammer. After the rebound hammer is tested for accuracy on the test anvil, the rebound hammer is held at right angles to the surface of the concrete structure for taking the readings. Six readings of rebound number is taken at each point of testing and an average of value of the readings is taken as rebound index for the corresponding point of observation on concrete surface.

2.2. Casting Concrete

According to British Standards,the process of batching, weighting and mixing of required materials were performed. First, aggregates and cement were mixed with mixer for 30 seconds, and then water was added and mixed for almost 3 minutes. For slump test, sample was taken from fresh concrete, test was conducted and then, sample of fresh concrete was poured back to the mixer for remaining mixing and finally moulds were filled

2.3. Compacting and Curing

After casting and compacting concrete samples, the samples were placed to curing room with more than 90% moisture and 21°C temperature for 24 hours. Then,samples were put into the water tank and kept until testing ages of 7, 14 and 28 days.

3. Results & Discussion

The experiments performed were consisted of specific gravity, slump, rebound hammer test, compressive strength, splitting tensile test.

3.1. Slump Test

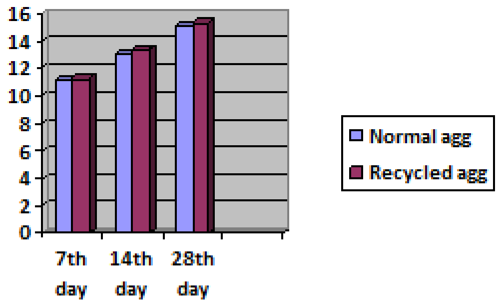
Slump test was conducted for each mix design.

Table1: Slump

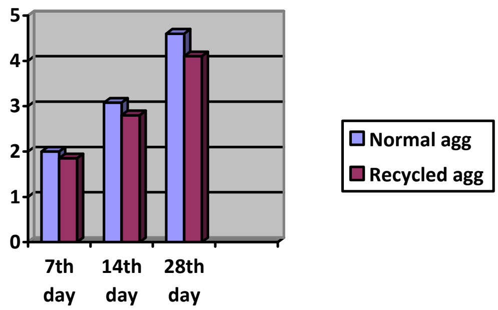
Mix Design	Slump(cm)
A	15
B	14
C	14
D	13

3.2. Compressive Strength

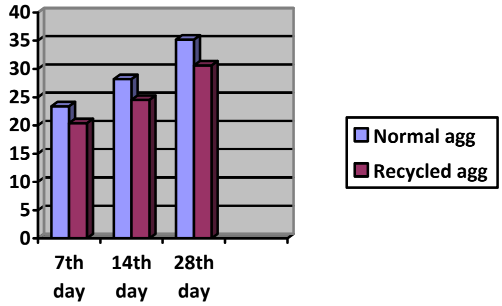
This test was performed on the cubic samples at the ages of 7, 14 and 28 days. A comparison of recycled concrete compressive strength results with normal concrete compressive strength results.



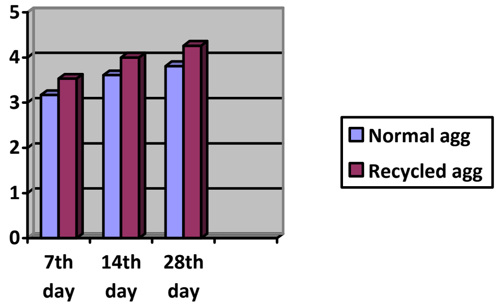
3.3.Split Tensile Test



3.4. Rebound Hammer test



3.4. Ultrasonic Pulse Velocity test



Following observations were made based on above test results

Table2: observation

Tests Applied	Comparision
Slump	High water demand in RCA
Compressive Strength	RCA>NAC slightly
Split Tensile Strength	RCA<NAC(10%)
Rebound Hammer test	RCA<NAC(15%)
Ultrasonic pulse velocity	RCA>NAC(12%)

3. CONCLUSIONS

Recycled aggregate concrete was the focus of this study. Concrete samples from Materials of Construction Laboratory of Civil Engineering Department NIT Raipur were crushed. After sieving the crushed concretes,different mixes with natural aggregates and crushed aggregates were designed.

Normal concrete and recycled aggregate concrete samples were cast, cured, and tested. Different tests were done on the samples including compressive strength, splitting tensile strength, PUNDIT, and rebound hammer. Based on the obtained results and the influence of normal and recycled aggregates on strength, porosity, and density, the following conclusions and suggestions were mentioned.

1- The numerical value of RCA slump was less than NAC slump due to high water absorption percentage.

2- Compressive strength of recycled aggregate concrete was slightly greater than normal aggregate in which the volume of cement was held constant.

3- Splitting tensile strength of recycled aggregate concrete was 10% less than normal aggregate with the same cement volume.

4- The rebound hammer test results of recycled aggregate concrete was 15% less than normal aggregate concrete because the maximum size of recycled aggregate and normal aggregate was 23(mm) and 20(mm), respectively.

3.1 Advantages

Based on their physical and chemical properties and the influence of normal and recycled aggregates on strength, porosity, and density, the following sustainibility suggestions are mentioned:

1.Can be used for constructing gutters, pavements etc.

2.Large pieces of crushed aggregate can be used for building revetments which in turn is very useful in controlling soil erosion.

3.Recycled concrete rubbles can be used as coarse aggregate in concrete.

4.Production of RAC also results in generation of many by-products having many uses such as a ground improvement material, a concrete addition, an asphalt filler etc.

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