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Investigations on the Strength Aspects of Recycled Aggregates under M25 Grades of Concrete

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Abstract
The partial and full replacement of natural aggregate with recycled aggregate is a major concern in the construction industry of the world wide, as it reduces the disposal of construction wastes and as it decreases the demand of natural aggregates. Also, recycling of aggregate has major solution by reducing the environmental negative impact caused by concrete wastes and it helps to reduce the negate impacts of natural aggregates during extraction of the natural aggregate resources. On this paper I try to show reviews on the use of recycled aggregates as partial replacements with natural aggregates on concrete based on experimental results. The basic properties of concrete are discussed here are; the mechanical, physical and chemical properties of recycled concrete aggregates. Although, brief attention is given to discuss the impacts of recycled concrete aggregates on the hardened and fresh properties and durability of concrete.
In this project work, the recycled aggregate which is taken from concrete makes good quality concrete when it is mixed with replacement with natural aggregates. Concrete waste from demolished cubes were collected and crushed to select the recycled aggregate material then recycled aggregate of 60% and natural aggregate of 40% are mixed for the preparation of fresh concrete of M25. In this project work, after 28 days of curing the compressive strength with PPC ; the compressive strength for 60 percent replacement of recycled aggregate mixes were 16%, 75%, and 100%, results of 3 days 7 days and 28 days respectively.
Here, in this project work, durability and strength aspects of experimental tests were done in laboratory. Strength tests which were done for concrete with 60 percent partial replacements of recycled aggregates are such as compression strength, split tensile strength test, bond strength and flexural strength were conducted on M25 grades of concrete. In this study work the gap existing in knowledge of recycled aggregates and recycled aggregate concretes were identified and it helps to take as a reference for future study.
Key words: *Recycled aggregate concrete, M-sand*

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I. Introduction

GENERAL:

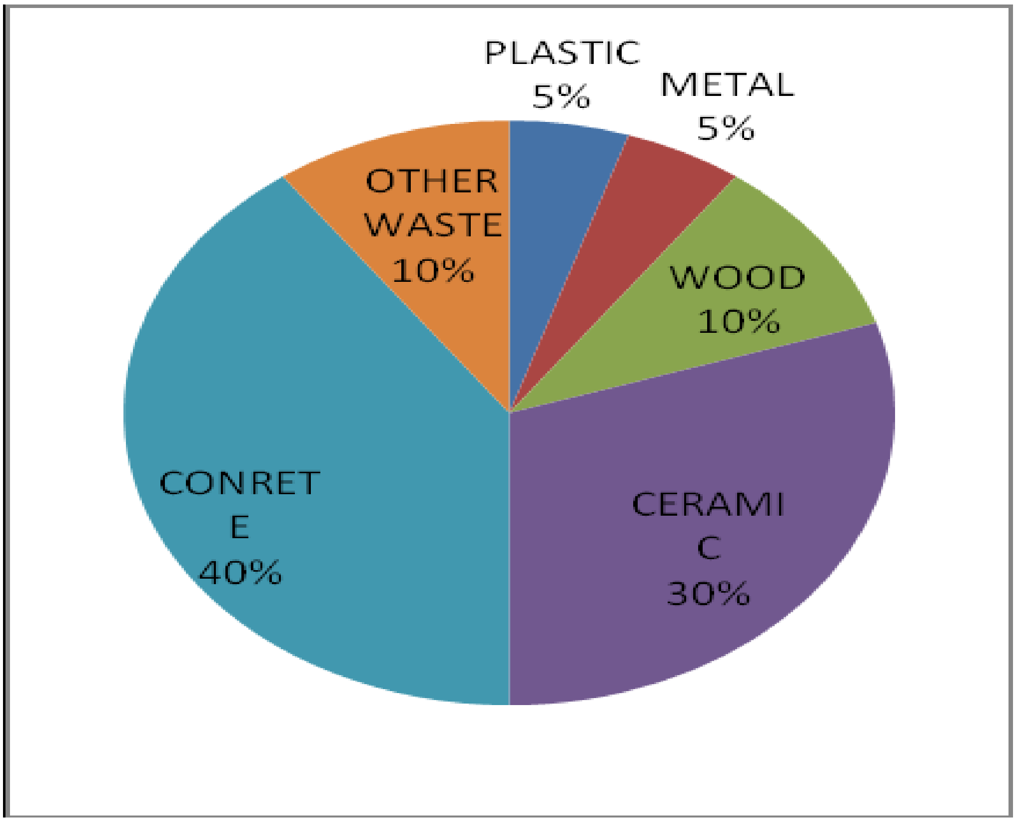
Now a day there is a remarkable development in the growth of public and private infrastructures, particularly in the area of construction industries. Also, there is a need of demand for new construction of structures, which needs a number of tons of concrete. In addition to this, it has an importance role in the development of once countries economy of GDP due to its large volume utilization. Since the coarse aggregate covers around 60–75% of the total volume of concrete, as it uses based on different researchers data approximately 20 billion tons of coarse aggregate in every year is used for the construction sector.

On other side, our nature is affecting by the huge usage of natural aggregates in the construction sector of area. In addition to this, it has influence on the sustainable development of the society. So that, the use of replacement of recycled aggregates with the natural aggregates from the demolition and construction waste as a substituent alternative material (aggregate) during production of fresh concrete, has appositive impacts in the process of saving the natural resources and increases the free land by reducing the waste disposal which covers the land of the earth.

Scarcity in natural aggregates and the increment of the construction and demolition wastes (C&DWs) in huge amounts in every year has a strong positive impact on the increasing attention on recycled concrete that can effectively alleviate resource and environmental issues. Recycled concrete has been used for both structural and non structural members of the concrete in world wide. Now a day, the utilization of construction demolition wastes in the use of mixing preparation of recycled concrete is greatly increasing, and it has reached more than 80% in some countriesof the world.

For the reinforced concrete material, it is necessary to create suitable bond between the surrounding concrete and the steel bar. When stress is transferred across the steel-concret THE bond provides that there will be no slip or little slip of the steel bars relative to the concrete (Hadi 2008, Warner et al 1998). Bond resistance is composed of friction, chemical adhesion and mechanical interlock between the bar and surrounding concrete. Nowadays, oil is mainly used in construction area to avoid the adhesion of the hardened concrete in the construction forms. This method may have several impacts on the bond between the steel bar and the concrete due to pollution of the steel bar with the oil before a concrete is casted.

Under concrete construction, after mixing, placing, and finishing the external curing for concrete will be applied. The major purpose of curing is to regulate and control the fast process of hydration of concrete by keeping wet and moist conditions under appropriate temperature. Good and correct curing of structures of concrete is a mandatory to control the early change of volume and to get the desired strength of the concrete structures. This will be related with the increment of durability of the concrete. In addition to this, curing of concrete enables for the concrete structures to hydrate correctly; by providing less porosity, good micro structure development, and by sufficient strength of concrete to enable concrete dimensional stability without shrinkage and or creeping. However, inattention during curing time, especially during the early age of concrete, can cause irreplaceable cost because of the lower degree of hydration as the concrete will not achieved the desired properties. Early age cracking is also caused by this improper hydration during curing of concrete because of the effects that drying and shrinkage, particularly in a concrete with low w/c. Therefore the problem of using recycled concrete aggregate (RCA) is related with its residual mortar, that makes which makes RCA weak in strength , porous and high absorbent. When RCA is used in production of recycled concrete aggregate (RAC) , The higher water absorption capacity of RCA has a negative impacts in controlling on the w/c ratio, that reduces the workability of fresh concrete and also it has an adverse effects on the durability and strength of the settled and hardened concrete. Water transfer during and after hydration is induced by the effect of the excessive use of high w/c ratio of RAC and high water absorption of RAC. Generally, the final performances of concrete are largely affected by the curing conditions. Though, the effect of curing process RCA is based on the types of curing condition or regime.



Concrete is a major material which is used as a main back bone in the construction industry. It is a product made from a mixtures of aggregates of cement, sand , coarse aggregates and with addition of water with or without admixtures.

1.1 Cement

Cement has a major role among the constituents of concretes production; it helps to paste the ingredients of mixtures of concrete by joining the ingredients of the concrete. The wide use of it in structures, from buildings to factories, from bridges to airports, makes it one of the most investigated materials of the 21st century. Due to the rapid population explosion and the technology boom to cater to these needs, there is an urgent need to improve the strength and durability of concrete. Among various materials used in the mixtures of ingredients of concrete, cement plays a major role due its size and adhesive property. So, during production of concrete with improved properties, the mechanism of cement hydration has to be studied properly and better substitutes to it have to be suggested.

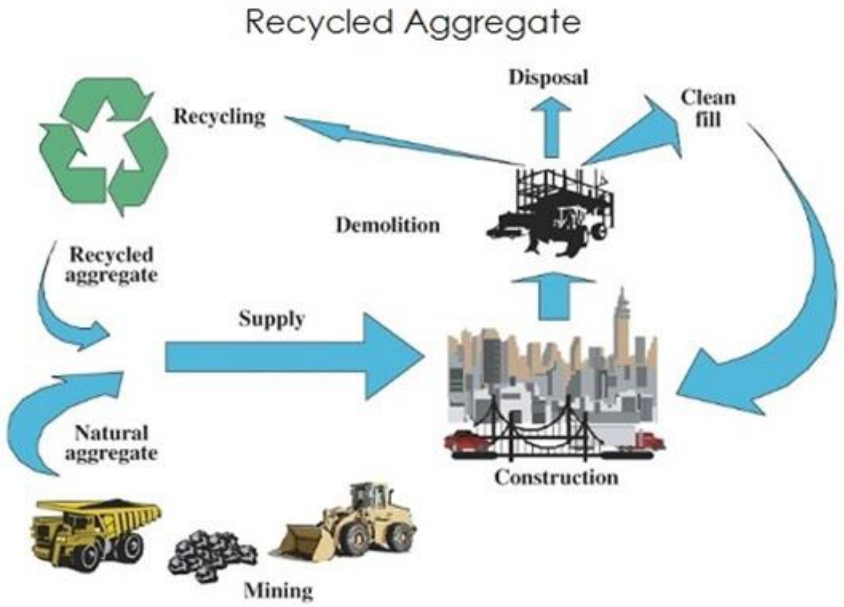
1.2 RECYCLED AGGREGATES:

Recycled aggregates are an aggregate which is extracted by crashing of a hardened concrete which was previously used in concrete structures. A coarse aggregate is derived from by crashing clean and sound hardened concrete of demolition waste.

Basic and primary objective of this project work is to resolve the durability and strength characteristics of concretes under normal aggregates and recycled aggregates in structural concrete, which helps to get brief awareness based on the strength and durability aspects of properties of concrete produced by recycled aggregates, and it will be a replaceable material with the normal natural aggregates under production of concrete.

Recycling process of RCA

Recycling is the act of processing the used material for use in creating a new material. The consumption of natural aggregate is increasing due to the development of cities in infrastructures of construction sector. In order to save the natural aggregate, recycling of concrete aggregate is the very important and best option. RCA are extracted and produced from by crashing a concrete waste materials which are used before, the value of availability of demolished concrete for use as recycled concrete aggregates is increasing. Recycled aggregates will be the best replaceable materials of natural aggregates for the future generation. In many countries the applications of using of recycled aggregates has been started and increased under the construction sector of the projects.



Applications of Recycled Aggregates

In some parts of the world recycled aggregate was mostly used as a land fill, but currently recycled aggregates are mostly used in worldwide in the process of production of concrete under construction sector. It has different application among different countries of the world. Those are;

- Backfill materials
- Paving blocks
- Building blocks
- Concrete kerbs
- Embankment fill materials
- Granular base course

Advantages of Recycled Aggregates:
Fully usage and replacing recycled aggregates has different advantages. The outcomes of advantages during usage of recycled aggregates are:

- ✓ Environmental gain
- ✓ Saving of energy
- ✓ Cost

Disadvantages of Recycled Coarse Aggregates

i. Lack of guidelines and specifications:
ii. Water pollution:

1.3 **MANUFACTURED SAND (M-SAND) :**

It is among the ingredients of concrete mix which substitutes the natural river sand. The size is not less than 4.75mm and it is cubical in shape with grounded edges, well graded and clean for use as a concrete construction material.

It is the best alternative for the replacements of the river sand. Due to the rapid growth in the construction industry, the need for the use of the sand is also increasing, which causes scarcity of suitable river sand in most parts of the countries.

1.4 NECESSITY OF PRESENT STUDY

This project work helps to reduce the negative impacts of building construction and waste disposal in to the earth's environment. The impacts are reduced by using recycled aggregates from recycling of construction wastes and demolition products, and recycled aggregates are used by replacing with the natural aggregates in the production of mixing of fresh concrete for structural elements of construction.

The process of act of processing the used material and creating as a useful material is known as Recycling. Replacement of recycled aggregates with natural aggregate is the good way to save and reduce extraction of natural aggregates. The RCA material is taken from collapsed buildings, bridges , roads and other structural members of a concrete.

The habit of using of recycled aggregates has been started and increased in many countries for construction projects. Recycled aggregates will be the best replacement of natural aggregates for the future.

The demand for sand in the construction sector is increasing in a huge amount due to the great development of construction sector that causes a scarcity in the availability of suitable river sand in most parts of the earth. Due to the scarcity of river sand manufactured sand will be the best suited alternative for the river sand.

To reduce energy consumption during production and to save the natural resources the use of recycling demolution and construction waste can be the best alternative

1.5 OBJECTIVES

- ✓ To check the percentage ratio of possibility of replacement of natural aggregates with recycled aggregates in concrete mix.
- ✓ To optimize the ratio of replacement of recycled aggregate with natural aggregates which produce a good result of concrete mix.
- ✓ To study investigations on the behavior of Recycled aggregates under concrete mix.
- ✓ The bond strength can be investigated between the reinforcement bar and concrete which is made from recycled aggregates.
- ✓ To assess the compressive strengths at 3,7 and 28th days of the mix used in the investigation.
- ✓ To assess the split tensile strength at 3, 7 and 28th days of concrete mixes used in the investigation.
- ✓ To assess the flexural strength at 3,7 and 28th days of the concrete mixes which were used in the investigation.
- ✓ To assess the workability using slump cone test for the concrete mixes which were used in the investigation.
- ✓ To study water absorption of the concrete made with recycled aggregates.
- ✓ to appreciate and motivate the culture of using of recycled aggregate
- ✓ To study and compare the results of tests of concrete with natural aggregates and recycled aggregates.
- ✓ To make a recycled aggregates as a source of aggregate for the concrete production.
- ✓ To study the relationship between the strength parameters of concrete of recycled aggregates.
- ✓ To investigates properties of recycled aggregate concrete based on the aspects of strength and workability.

II. Methodology And Experimental Investigation

2.1 GENERAL

Different experimental testes were done to investigate and study about the strength and durability properties on concrete mix with M -Sand as a fine aggregate and 60% replacement of recycled aggregates. Physical properties of materials are investigated with different tests; Conclusions regarding the durability and strength properties of concrete made with recycled aggregates and manufactured sand as affine aggregates replacements were adopted based on the results of the experimental test results. M25 design mix was adopted.

M25 grades of mixes were employed to determine the impacts of recycled coarse aggregate with M-sand. The mixes were conventionally cured. Several trail mixes were done in order to achieve the required target mean strength for the M25 mixes.

Fresh concrete tests such as Slump flow value, Compaction factor value are investigated. Hardened concrete tests such as compressive strength for cubes (150mm x 150mm x 150mm); Split tensile strength for cylinders (150mm x 300mm), flexural strength for prisms (500mm x 100mm x 100 mm), were done at 3,7 & 28 days. In addition to this bond strength tests of cubes were tested after 28 days of curing of 150mm x 150mm x 150mm cubes.

Table 3.1 Specimens cast for strength and durability tests

Name of the Test	RAC M25
Number of cubes cast for compressive strength	9
Number of concrete cylinders cast for split tensile strength	9
Number of concrete cylinders cast for modulus of elasticity	3
Number of prisms cast for flexural strength	9
Number of cylinder for sorptivity	3
Number of cubes cast for bond strength	3
Total number of sample cast	36

Total number of samples cast for the present work: 33

2.2 MATERIALS USED AND TEST

- ✓ Cement
- ✓ Ramco PPC was used. Physical Properties of Cement are shown in Table 3.2
- ✓ Fine Aggregate. M-sand of Zone-II was used. The properties of normal sand is shown in Table 3.3
- ✓ Coarse Aggregate; 60% of recycled coarse aggregate of demolished structures of 20mm passing and retained on 10mm sieve were used and natural crashed aggregate were subdivided into another 40% of passing 20 mm and retained on 10 mm sieve and 60 % passing 10mm and retained on 4.75 mm sieve was used. The details of both recycled and crushed aggregate and their properties are shown in Tables- 3.5 to 3.8
- ✓ Clean water which is free from acid or any organic substances, were used during mix of concrete aggregates.

2.2.1 CEMENT

It is the binding material in cement concrete .Cement is produced by intimate mixing of calcareous, siliceous and aluminous substances at high temperatures and crushing the resultant clinkers to a fine powder. Cements properties is based upon the process of manufacturing, the degree of fineness and the chemical composition. During the process of mixing water and cement, a chemical reaction will be takes place on the mixtures and finally the cement paste will be hardens like a stone. Based on different characteristic properties of cement (hardening, chemical compositions, settling and hardening properties), cement can be classified as the following types;

Cement can be categorized as follows;

i. Portland cement
ii. Special cement

2.2.2 AGGREGATES

Aggregates are among the ingredients of concrete mixes that helps to produce a strong and durable concrete. Aggregates constitute the bulk of the total volume of concrete and hence they influence the strength of concrete to a great extent. Aggregate is originated from igneous , metamorphic and igneous rocks. The properties of concrete are directly related to those of its constituents and as such

aggregate used, in a concrete mix should be hard, strong, dense, and durable. And free from injurious amounts of clay, loam, vegetable and other such foreign matter. The presence of deleterious substances such as

coal, lignite, clay lumps. Soft fragment of foreign materials and other deleterious materials prevent cement adhesion on the surface of aggregates and it has a negative impact on the properties of concrete.
Based upon their sizes of aggregates, it can be classifies as below:
i. Fine aggregate
ii. Coarse aggregate

FINE AGGREGATE

If the size of material of an aggregate is below 4.75mm size it is said to be fine aggregate. The sum of percentage of all types of deleterious materials in fine aggregate should not exceed 5% Natural sand or crushed stone dust is the fine aggregate chiefly used in concrete mix. M-Sand is the best substituent of replacement for the natural river sand for the concrete construction. M-Sand is produces by crushing the hard granite stone.

COARSE AGCREGATE

The material whose particles are of such size as are retained on I.S. sieve No 480(4.75 mm) is termed as coarse aggregate. The size of the coarse aggregate depends upon the nature of work. The maximum size may be 20mm for mass concrete, such as in dams etc. and 30mm for plain concrete work. For R.C.C construction aggregate having a nominal size of 20mm are generally considered satisfactory. and laky and elongated pieces of stone should be avoided to some extent. Broken brick is cheap aggregate for plain concrete but it renders the mix weak in strength. It is not used in R.C.C work on account of the possibility of the reinforcement getting rusted due to the high porosity of the aggregate. Clinker slag, coal ashes and coke-breeze are also used as aggregate for light weight and insulating concrete where great strength not desired. Gravel (as obtained from pit or river) or crushed stone contain high percentage of fine material and in this state it is only used for un-

Size of Aggregates:
As the bigger the size of aggregates, the lesser will be the surface area and then less matrix or paste is required for lubricating the surface to reduce internal friction and less amount of water will be required for wetting the surface. In a give quantity of paste and water, higher workability will be attained by the bigger size of aggregates.

NATURAL AGGREGATES
Aggregates may come from either manufactured of natural sources. The natural aggregates come from rock, of which are classified in to three broad geological classifications.
Igneous rock; these types of rocks primarily crystalline and are formed by in during the process of cooling of molten rock material beneath the crusts (magma) of the earth.
Sedimentary rocks; These type rocks are formed from deposited insoluble material (e.g., the remains of existing rock deposited on the bottom of an ocean or lake).
Aggregates are produced in quarry in the process of conversion of in situ or raw rock in to aggregates with the specified characteristics. The raw rock is obtained from the quarry walls and then crashed in to small sizes after reducing the rock in to small sizes we will obtain the desired aggregates with the required sizes using a series of screens and crushers.

Recycled Aggregate
Recycled aggregates are obtained by the process of crushing and screening of the materials that have been used previously in the construction. The aim of the project is to determine the strength and durability characteristics of recycled aggregate for application in structural concrete, which will give a better understanding in the quality properties of concrete with recycled aggregates, as an alternative material to the natural coarse aggregate in structural concrete.
In this investigation normal coarse aggregate was replaced by recycled aggregates by 60% by total weight of normal coarse aggregates.

Here is a table showing minimum water content, maximum water cement ratio and minimum grade of concrete for different exposures conditions.

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 and 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	-	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTE:

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

Mix proportions:

Water cement ratio(w/c) has important positive impact in influencing workability. The higher the water cement ratio is, the leaner is the fresh concrete mix. During production of leam concrete, less quantity of paste is available for providing lubrication, per unit surface area of aggregate and hence the mobility of aggregate is restrained, On the other hand, in case when if a concrete with lower aggregate/cement ratio, more fluidity is available to make the mix cohesive and fatty to give better workability.

III. Tests Conducted On Aggregates

I. Sieve analysis (IS: 383-1970)

A sieve analysis is a method of practice to determine the particle size distribution (also called gradation) of a granular material. The size distribution has critical advantages to the way the material performs in use. And it can be performed on any type of organic or inorganic granular materials including sands, clays, crushed rock, granite, soils, feldspars and coal, a wide range of manufactured powders, seeds, grain, and down to a minimum size depending on the exact method. It is the most common method of particle sizing technique.

II. Fineness modulus

Fineness modulus (FM) helps to find the degree of uniformity uniqueness of aggregate particles. Fineness modulus is generally used to determine an idea of how fine or coarse the aggregate is. It is an empirical number relating to the degree of fineness of the aggregate. small value of fineness modulus indicates that the aggregate is finer and More fineness modulus value indicates that the aggregate is coarser.

FINE AGREGATE	FINENESS MODULUS
Fine sand	2.2 to 2.6
Medium sand	2.6 to 2.9
Coarse sand	2.9 to 3.2

Generally, for sand if the fineness modulus more than 3.2 is not used for making good concrete. The coarser the aggregate the higher is the fineness modulus.

III. Bulk Density (IS: 2386 Part III – 1963)

When we are conducting with aggregates it will be mandatory to know the voids that present between the aggregate particles, therefore, we will decide whether to fill them with finer aggregates or with cement pastes. As we know that the density we often conduct with equal the mass divided by volume, during using of this law to measure the density of aggregates the volume we use is the volume of aggregate and the volume of the void spaces, and, in this case we get new quantity which is known as the bulk density.

IV. Specific Gravity (IS: 2386 Part- III – 1963)

Specific gravity of an aggregate is conducted to measure the quality and strength of the material. The specific gravity test helps for the identification and classification of a stone.

Bulking of Sand (IS 2386 Part-III – 1963)

Thin film is formed around the particles when dry sand comes in contact with moisture, As a result, the particle get apart from each other. The volume of sand will be increased, This situation is called as bulking of sand.

Table -3.2 Physical properties of cement (PPC) (IS 1489 Part-1 - 1991)

S.NO	PROPERTY	VALUE
1.	Specific gravity	2.94
2.	Fineness of cement by seiving	2%
3.	Normal consistency	30
4.	Setting time Initial setting time Final setting time	 168min 284min

Table 3.3 Physical properties of fine aggregate: M-sand

S.NO	PROPERTY	Value
1	Grading of sand	Zone II as per IS 383
2	Specific gravity	2.57
3	Bulk density Loose state Compacted state	 1.77g/cc 2.00g/cc
4	Fineness modulus	2.80

Table 3.4 Sieve analysis of Fine aggregate; M-sand
Weight of sample taken= 1000gms.

Sl. No	IS Sieve	Weight Retained (g)	% Weight retained	Cumulative % Weight retained	% Passing
1	10mm	0	0	0	100
2	4.75mm	4.6	0.46	0.46	99.54
3	2.36mm	153.1	15.31	15.77	84.23
4	1.18mm	169.2	16.92	32.69	67.31
5	600 µm	228.7	22.87	55.56	44.44
6	300 µm	204.4	20.44	76	24
7	150 µm	240	24	100	100
Fineness modulus = 2.8					

With reference to IS383-1970 this M-sand is categorized under Zone-II

Table 3.5 Sieve Analysis of Recycled Coarse Aggregate

Sl. No	IS Sieve	Weight Retained (Kg)	% Weight Retained	Cumulative % Weight Retained	% Passing
1	80 mm	0.00	0.00	0.00	100.00
2	40 mm	0.00	0.00	0.00	100.00
3	20 mm	292	14.6	14.6	85.4
4	10 mm	1704	85.2	99.8	0.2
5	4.75 mm	2	0.1	99.9	0.1
6	2.36 mm	0.23	0.1	100.00	0.00
7	1.18 mm	0.00	0.00	100.00	0.00
8	600 µm	0.00	0.00	100.00	0.00
9	300 µm	0.00	0.00	100.00	0.00
10	150 µm	0.00	0.00	100.00	0.00
Fineness Modulus = 7.14					

Table 3.6 Physical properties of Recycled coarse aggregates.

SI.No.	PROPERTY	VALUE
1	Specific gravity	2.74
2	Bulk density Loose state Compacted state	 1.45g/cc 11.6g/cc
3	Fineness modulus	7.14
4	Water absorption 20mm	 1.02%

Table 3.7 Sieve Analysis of original Coarse Aggregate

S.No.	IS Sieve	Weight Retained (gm)	%Weight retained	Cumulative %weight Retained	% passing
1	80mm	0	0	0	100
2	40mm	0	0	0	100
3	20mm	118.5	5.925	5.925	94.075
4	10mm	1881.5	94.075	100	0
5	4.75mm	0	0	100	0
6	2.36mm	0	0	100	0
7	1.18mm	0	0	100	0
8	0.6mm	0	0	100	0
9	0.3mm	0	0	100	0
10	0.15mm	0	0	100	0

Fineness modulus= 7.05925

Table 3.8 Physical properties of Original Coarse Aggregate.

S.No	PROPERTY	VALUE
1	Specific gravity	2.82
2	Bulk density Loose state Compacted state	 1.45g/cc 1.60g/cc
3	Fineness modulus	7.06
4	Water absorption 20mm 10mm	 0.81% 0.78 %

IV. Tests On Concrete

4.1 TESTS ON FRESH CONCRETE

4.4.4 WORKABILITY

Workability among the properties of concrete, it can measure the degree of how a concrete placed, mixed, transported and compacted. In other words, it measures the degree of plasticity of fresh concrete. The word workability considers the full importance of the type of work, cross section of the section, mode of compaction and the extent of reinforcement. For a concrete expert, she/he should have an overall knowledge on workability to design a concrete mix. Workability is a fresh concrete properties parameter, That a mix designer is required to specify in the mix design process of fresh concrete, with a full understand of method of placing , loss of slump, distance of transportation, type of work, and many other parameters involved in the concrete workability. Assumptions of good workability with proper understanding based on experience and skill will make the concreting process durable and economical.

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4.1.2 SLUMP CONE TEST AND COMPACTION TEST RESULTS

Figure 4.1 Slump cone test

Table 4.1 Slump cone and Compaction factor values

Grade of concrete	Slump cone value (mm)	Compaction factor
RAC M25	30	0.80

4.1.4 MIXING OF CONCRETE

Concrete ingredients were mixed with concrete mixer machine. The mixer machine was hand loaded with coarse aggregate first, then with fine aggregate and with cement. During the rotation of the mixer, water and admixture 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. And the degree of how the material mixes should be based on the concrete mix types. The mixer machine is controlled and operated by the skilled and experienced labour of operator which were supervised by the engineers and construction formans of the construction sites.

4.2 TESTS ON HARDENED CONCRETE

4.2.1 COMPRESSIVE STRENGTH: (IS:516-1959)

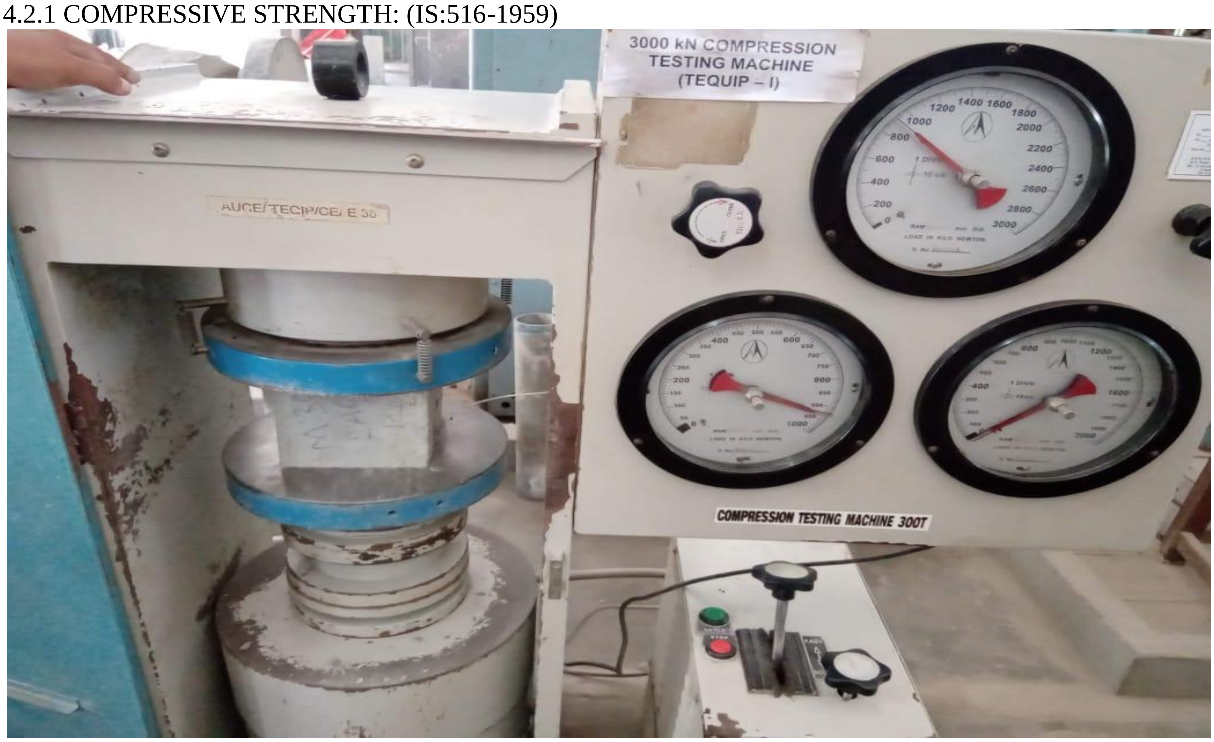

Figure 4.6 Compressive strength on cube

The test that helps to measure cube compressive strength tests of concrete is shows in fig 4.6. Compressive test on the cubes is conducted on the 300T compressive testing machine. The cube was placed in the compression testing machine and the load on the cube is applied at a rate of $140kg/cm^2/min$ up to the failure of the specimen and the ultimate load is noted. $\text{Compressive strength} = \frac{P}{A}$

Where, P = Compressive load at failure in kn.

A = cross sectional area of the cube (150mm x 150mm).

4.2.2 SPLIT TENSILE STRENGTH: (IS:5816-1999)

Split tensile strength test conducted on 300T compression testing machine as shown in fig4.7. The cylinder used for testing is 150mm in diameter and 300mm height. Straight lines are drawn once at the center of the diameter of the cylinder on two ends, Then the cylinder is placed on the bottom compressive plate of the testing machine and is aligned such that the lines marked on the ends of the specimens are should be vertical. Then the top member of compression plate will come and make in contact with the top of the concrete cylinder. The load will be applied at uniform rate, until the load is recorded cylinder breaks. using the recorded load, the split tensile strength is calculated for each specimen. A sample calculation for the computation of split tensile strength is showen in appendix. Ithis work the test has been made on the cylinder specimens after 3, 7, 28 days of curing.

$$f_{cr} = \frac{2P}{\Pi DL}$$

Where P = Split tensile load of force

D=Diameter of the specimen (150mm)

L= length or depth of the specimen (300mm)

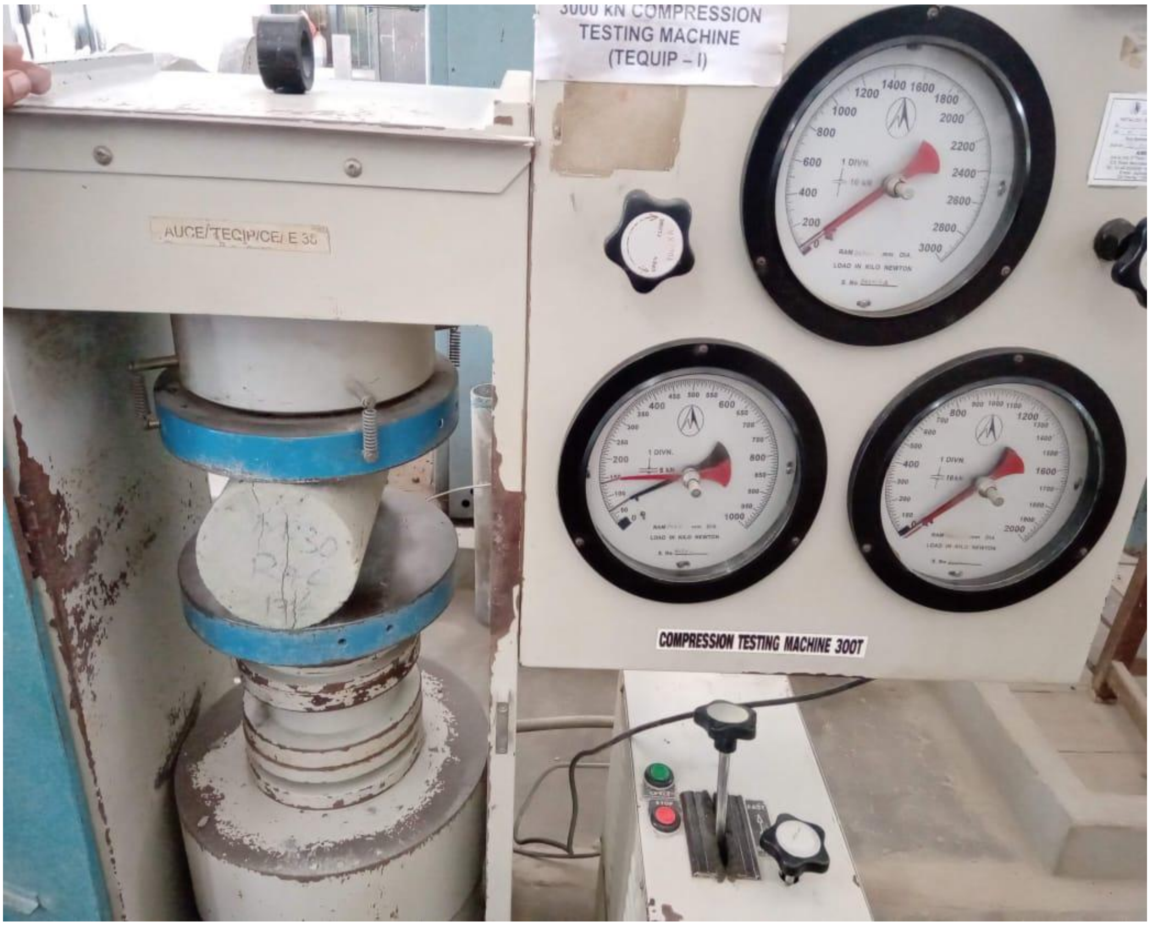

Figure 4.7 Split Tensile Strength on cylindrical specimen

4.2.3 FLEXURAL STRENGTH TES: (IS516-1959)

Flexural strength test is conducted on 10T universal testing machine (UTM). The arrangement of loading during testing of concrete beam specimens of the flexural strength is shown in Figure 4.8. The beam element is a simply supported on two steel rollers of 38mm in diameter, the rollers should be so mounted that the distance from the center to center is 400mm for 10mm diameter of specimens.

$f_b = \frac{PL}{bd^2}$ (when crack length is greater than 13.33cm)

$f_b = \frac{3Pa}{bd^2}$ (when crack length is between 13.33 and 11.0cm)

Where P = Flexural load
L = Support length of the specimen
b = Measured width of the specimen
d = Measured depth of the specimen
a = distance from support to tensile crack

Figure 4.8 Flexural strength on prism

V. Experimental Results

In this chapter results based on the experimental work are presented in the form of tables and graphs and are discussed. The results include split tensile strength, flecural strength, compressive strength , modulus of elasticity and bond strength tests.

5.1 COMPRESSIVE STRENGTH OF CONCRETE OF RAC M25

After mix of M35 grade of concrete the specimens are socked in a curing tank. Compressive strength of specimen of 3,7,28 days after the specimen are kept in the curing tank were tested using compression machine.

Table 5.1 Compressive Strength of Concrete

Average compressive strength(N/mm^2) of RAC M25			
Sample No	3days	7days	28days
1	13.1	16.8	31.6
2	13.2	17.4	31.4
3	13.6	17.2	31.5
Average	13.3	17.1	31.5

5.5 SPLIT TENSILE STRENGTH OF CONCRETE OF RAC M25

After mix of M25 grade of concrete the specimens are socked in a curing tank. The specimens split tensile strength of 3,7,28 days of specimen after the specimen are kept in the curing tank were tested using compression machine.

Table5.5 Split tensile Strength of Concrete

Average split tensile strength (N/mm^2)of RAC M25			
Sample No	3 days	7 days	28 days
1	1.13	1.58	2.6
2	1.2	1.62	2.8
3	0.98	1.6	3.6
Average	1.1	1.6	3

5.6 FLEXURAL STRENGTH OF CONCRETE OF RAC M25

After mix of M25 grade of concrete the specimens are socked in a curing tank. The specimens Flexural strength of 3,7,28 days of specimens after the specimen are kept in the curing tank were tested using compression machine.

Table 5.6 Flexural strength of concrete

Average Flexural strength (N/mm^2) of RAC M25			
Sample No	3 days	7 days	28 days
1	2.8	3.43	6.13
2	2.65	4.1	5.46
3	2.96	2.58	5.8
Average	2.77	3.53	5.7

5.7 BOND STRENGTH OF CONCRETE OF RAC M25

After mix of M25 grade of concrete the specimens are socked in a curing tank. The specimens Bond strength of 28 days of specimens after the specimen are kept in the curing tank were tested using tensile strength testing machine.

Table 5.9 PULL-OUT (Bond Strength) of & M25 RAC

GRADE	Dia (mm)	Length of bar (mm)	LOAD (Kn)	AVG	% YIELD	% ULT
M20(RAC)	15.95	1000	50	54.67	77.27	68.40
	15.95	1000	52			
	15.95	1000	62			

VI. Conclusions

6.1 CONCLUSIONS

A study was done on 60% replacement of recycled concrete by weight of cement, Compressive strength, Split tensile strength, Flexural strength.

Based on the experimental work results of strength of Recycled aggregates concrete, The given conclusions were made:

- Recycling of concrete construction building is the best solution for the problem of damping of the construction wastes in the earth and it helps to save the fertile land from the disposing of construction wastes. The habits of using replacement of recycled aggregates has a significant positive impact on the environment and also in the economic respects. The habit of using of RCA reduces the fertile land covered by the disposal of construction materials.
- From testing results of materials recycled aggregates has coparataively less specific gravity than the natural aggregates. And the water absorption of recycled aggregates has more water absorption than the natural aggregates due to the adhered mortar around the aggregates. But recycled aggregate has comparatively the same bulk density with the natural aggregates.
- Based on the strength test results using of 60% replacement of recycled aggregates in M-25grade of concrete, The result shows that using of RCA has good strength ant it has similar to the natural aggregates mix, Therefore it is recommended to use as a best alternative.
- The cost indicates that, the cost per meter cube for the RCA is lesser than the natural aggregates mix. Therefore, this investigation generalized that 60%RCA is can be used as a best replacement of natural aggregates in M25 grade of concrete.

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