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Utilization of Recycled Aggregate and Brick Kiln Dust in Concrete

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Abstract: *The Recycled Concrete Aggregates (RCA) in concrete leads to possible solution to the environmental problem caused by concrete waste, and reduces the negative environmental impact of the aggregate. Extraction from natural resources also, the use of Recycled Concrete Aggregate (RCA) in concrete partial and full replacement of the Natural Coarse Aggregate (NCA) is growing interest in the construction industry, as it reduce the demand of virgin aggregate. The project presents a comprehensive review on the use of RCA in concrete based on the experimental data available in the published researches. The most important physical, mechanical and chemical properties are discussed in this project. However more imphasis has been given to discuss the effect of RCA on the fresh and harden properties and durability of concrete.*

Keywords: Concrete, Natural Coarse Aggregate, Recycled Concrete, Properties

I. INTRODUCTION

Demolition of old structure and construction of new ones are frequent phenomenon due to change of purpose, structure deterioration, rearrangement of city, expansion of traffic direction, and natural disasters. About 850 million of tons of construction and demolition waste are generated in European Union each year which represents 31% of the total waste generation. In USA the waste produce from building demolition alone is approximately 123 million tons per year. In 2005 the total solid waste generated in Malaysia was 6,971,500 tons at a rate of 19,100 tons per day.

Globally, a vast amount of concrete waste is derived from the demolition of old concrete structure. Most commonly this concrete waste is disposed to landfills, thus causing substantial environmental load and health hazard. Furthermore, shortage of land and the increasing charges for landfills worsen this environment problem. The utilization of concrete waste in sustainable development may alleviate such problem.

The concept of sustainable development was first presented at the 1992 Earth Summit in Rio de Janeiro city of Brazil. Now it has become guiding principle for the construction industry. The recycling and reuse of concrete waste can be an effectively way to achieve sustainability in the construction sector. In fact many government throughout the world have recently introduce various measures aimed at reducing the use of natural aggregate, and increasing the recycling of concrete waste for reuse as aggregate wherever it is technically, economically of environmentally acceptable.

Recycle Aggregate

Aggregate form skeleton of concrete. These usually occupy about 70% of the total volume of concrete. A major portion of this aggregate volume is occupied by coarse aggregate. Therefore, the demand for coarse aggregate from the natural resources is required to meet this high demand. The increasing demand of natural coarse aggregate creates an ecological imbalance. The use of recycle aggregate obtain from demolished concrete structure will mitigate the ecological imbal

Brick kiln dust

Brick dust is a waste material obtained from brick kiln industries. Now day's construction work is on large scale so demand of brick also increases, so due to this brick kiln industries all over the world also increased. Tons of brick kiln dust comes out from such materials are used in filling low lying area and also in construction work it also used in mixture of cement concrete to fill the void. As brick dust contains mixture of ashes (coal+ wood) and dust particles (soil + sand).

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Problem Statement

There has been great interest in recent year in using recycle concrete aggregate as a base coarse in Wisconsin and elsewhere for the economic and environmental benefits offered by such practice

Laboratory studies showed that RCA have resilient modulus value equal to or higher than typical natural aggregates and also generally higher durability, in particular freeze-thaw cycle. However, it also recognized that RCA exhibits tufa formation and potentially lowered drain ability than natural aggregate.

Objectives

- To find out the application of recycle concrete aggregate.
- To determine implementation problem of recycling concrete or aggregate.
- To replace natural aggregate by the recycled course aggregate in various percentage (0%, 20%, 40%, 60%, 80%, 100%).
- To study the compressive strength of hardened concrete specimen with the and without recycled aggregate.

Scope of the project work

This research will identify about the recycle collection method, technical and process of aggregate is being study. Besides that, is to study the application of recycle concrete aggregate in construction industry.

Lastly is the factor which may affecting the recycling potential such as, economic benefit, environment consideration and carry out the recycle service of concrete aggregate also a part of scope of study.

The data and information were collected through literature review and no assumptions have been made.

Limitations of study

- Downgrading of quality of concrete.
- Increase in water absorption capacity ranging 3% to 9%.
- Decrease in compressive strength of concrete (10-30%).
- Reduce workability of concrete.
- Lack of specification and guidelines.
- Less durability of RCA.
- It has higher drying shrinkage and creep.

Application

- It can be used for construction of gutters.
- It can be used pavement in road construction.
- Recycled concrete rubbles can be used as coarse aggregate in concrete.
- Large pieces of crushed aggregate can be used for building revetments which in turn is very useful in controlling soil erosion.
- To reduced demand of Natural Aggregate.
- To reduced demand of cement in concreting

II. LITERATURE REVIEW

Animesh Awasthi (2018) [1] : Studied the effect of adding recycled aggregate concrete containing silica fume as partial replacement for cement and found that the higher water absorption capacity of recycled aggregates has greater influence on the water added to mix which can be affect concrete's workability. They also found that it is possible to gain the same compression and split tensile strength as conventional concrete up to 30% replacement of natural aggregate with recycled ones. But both the compression and split tensile strength value are decreasing with increase in replacement levels of recycled aggregates. The increase of recycled aggregates content beyond 30% has negative effect on compressive strength of recycled aggregate concrete. The reduction in compressive strength after 28 day is about 10% when 50% recycled aggregates are used.

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Jitendra Kumar, Tanaji Mohite (2015) [2] : Studied about the different test on the natural aggregate, recycled aggregate and blended aggregate and compare results and found that the strength of recycled aggregate concrete is slightly less for the same condition as that of the natural aggregate. The amount of reduction depends on the parameters such as amount of blending of the recycled aggregate, w/c ratio, quality of the processed recycled aggregates.

Prabhat Kumar (2016) [3] : Presented a review of existing literature work for understanding thoroughly about RCA and conclude from various studies that natural aggregate can be used with recycle aggregate with a ratio of 80:20 and 70:30. Higher the ratio of recycled aggregate can worsen the properties and strength of mix and due to use of recycled aggregate in construction industry it can slow the impact of waste on environment. Also it will be promote the sustainable growth.

Anurag Gautam (2017) [4]: Presented the effect of replacing river sand particle by quarry dust. The proportion of quarry dust replacing by 0%, 25%, 35%, 45% and 55%. The material testing workability, compressive and tensile strength of concrete were examined at 7th, 14th and 28th day of curing M20 grade of concrete. They examined that the results are comparatively good by replacing partially with natural sand. The replacement of quarry dust up to 45% gives better result. The compressive strength and tensile strength of 45% replacement gives
31.92 N/mm^2 and 3.85 N/mm^2 respectively at 28th day of curing.

Animesh Awasthi (2018) [5] : Studied the effect of adding recycled aggregate concrete containing silica fume as partial replacement for cement and found that the higher water absorption capacity of recycled aggregates has greater influence on the water added to mix which can be affect concrete's workability.

They also found that it is possible to gain the same compression and split tensile strength as conventional concrete up to 30% replacement of natural aggregate with recycled ones. But both the compression and split tensile strength value are decreasing with increase in replacement levels of recycled aggregates. The increase of recycled aggregates content beyond 30% has negative effect on compressive strength of recycled aggregate concrete. The reduction in compressive strength after 28 day is about 10% when 50% recycled aggregates are used

III. METHODOLOGY

Research Methodology

In this project, a methodology for prediction of long term properties of recycled aggregate concrete is presented, based on an extensive literature review of international experimental campaigns on this type of environment, friendly concrete. The methodology presented is based on the previous determination of the main properties of aggregates, primary and recycled and alternative the 28 day compressive strength of concrete made with those aggregates. The methodology is validated, based on a graphical analysis of the most important properties of hardened concrete. It is concluded that the methodology can predict the long term performance of recycled aggregate concrete as compare with an equivalent conventional concrete and that this prediction can be used to adept structural design this material.

Cement

Cement is a binder, a substance used for construction that sets, hardens and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel produces concrete. Concrete is most widely used material in existence and is only behind water as the planet' Concrete has been normally produced using ordinary Portland cement (OPC)

Table no 3.2.1: CEMENT PROPERTIES

Sr. No.	Characteristics	Value obtained	Standard value
1.	Normal consistency (%)	30%	26%-33%
2.	Initial setting time (min.)	32	Not less than 30
3.	Final setting time (min)	596	Not less than 600
4.	Fineness (%)	8%	<10
5.	Specific gravity	3.15	3.15

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Test on CEMENT:

Initial Setting Time (IS 4031, Part 5 1988, 2000):

Initial setting time is the time lapse between the moments when water is poured in cement to the moment when the cement paste start losing its plasticity.

It is very difficult to exactly know the moment when cement paste starts loosing plasticity, hence a convenient but arbitrary limit is defined by the initial setting time test.

Final Setting Time (IS 4031 Part 5 1988, 2000) :

Final setting time is defined as the time lapse between the moment when water is added to cement and the moment when the paste has completely lost its plasticity

Fineness:

Fineness of cement refers to the size of grains or particle of cements. Lesser the grain size, finer the cement.

Due to small grain size, more surface area is available for contact with water and the reaction of hydration become faster, gaining of strength is more rapid and rate of evolution of heat increase

Soundness (IS 4031, Part 3, 1988, 2000) :

If the cement contains excess lime, or is insufficiently burnt during manufacture, it is called unsound cement as it shows large volume changes with change in temperature, after setting and hardening.

Such changes are undesirable as they will causes disruption of the hardened mass. Unsound may also be due to excessive proportion of magnesia or of sulphates.

Recycled Aggregate :

The concrete industry makes up approximately 30% of the total market for aggregates and it is estimated that 165 million tone are used annually in concrete. There is, therefore, considerable incentive to develop alternative aggregate sources based on waste materials. The aggregate products currently coming from most aggregate recycling plants are unbound fills, capping, sub-base and pipe bedding as the recycled concrete aggregate (RCA) is blended with other materials. Recycled aggregate concrete has crushed sound and clean waste concrete of at least 95% by weight of concrete with typical total contamination lower than 1% of the bulk mass. Class 1A RCA is well graded RCA with not more than 0.5% brick content.Recycled concrete aggregate contain not only the original aggregates, but also hydrated cement past. This paste reduces the specific gravity and increases the porosity compare to similar virgin aggregates. Higher porosity of RCA leads higher absorption

Process of Making Recycled Aggregate

Step involved in recycled aggregate concrete:

- Crushing
- Pre-sizing
- Sorting
- Contaminant elimination

Production Sequence of RCA:

Crushing and screening systems start with primary jaws, cones and/or large impactor taking rubble from 30 inches to 4 feet. A secondary cone may or may not need to run, and then primary and secondary screens may or may not be used, depending upon the project, the equipment used and the final product desired. A scalping screen will remove dirt and foreign particles. A fine harp deck screen will remove fine material from coarse aggregate. Further cleaning is necessary to ensure the recycled concrete product is free of dirt, clay wood, plastic and organic materials. This is done by water flotation, hand Picking, air separators

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Test on Recycled AGGREGATES:

Specific GRAVITY:

The specific gravity in saturated surface dry condition of recycled concrete aggregate was found from 2.35 to 2.58 which are less but satisfying the results. If specific gravity is less than 2.4, it may cause segregation, honeycombing & also yield of concrete may get reduced

Water ABSORPTION:

The RCA from demolished concrete consist of crushed stone aggregate with old mortar adhering to it, the water absorption ranges from 1.5% to 7.0%, which is relatively higher than that of the natural aggregates. Thus the water absorption results are satisfactory.

Crushing and Impact VALUES:

The recycled aggregate is relatively weaker than the natural aggregate against different mechanical actions. As per IS 2386 part (IV), the crushing and impact values for concrete wearing surfaces should not exceed 30% & for other than wearing surfaces 45% respectively. The crushing & impact values of recycled aggregate satisfy the BIS specifications limit. From crushing & impact test it is found that use of recycled aggregate is possible for application other than wearing surfaces.

Compressive test on Aggregate:

Recycled Coarse Aggregate crushing value is the percentage by weight of the crushed material obtained when test aggregate are subjected to a specified load under standardized conditions. Recycled Aggregate Crushing Value is a numerical index of the strength of the aggregate and it is used in construction of roads and pavements.

Crushing value of recycled aggregates indicates its strength. Lower crushing value is recommended for roads and pavements as it indicates a lower crushed fraction under load and would give a longer service life and a more economical performance.

Los Angeles Abrasion Test:

Los Angeles Abrasion Test on aggregates is the measure of aggregate toughness and abrasion resistance such as crushing, degradation and disintegration. This test is carried out by AASHTO T 96 or ASTM C 131: Resistance to degradation of small size coarse aggregate by abrasion and impact in the Los Angeles Machine.

The principle of Los Angeles Abrasion Test is to produce abrasive action by use of standard still balls which when mixed with aggregates and rotated in a drum for specific number of revolutions also causes impact on aggregates. The percentage wear of the aggregates due to rubbing with still ball is determined and is known as Los Angeles Abrasion Value.

Mechanical Properties:

Aggregate Abrasion Value:

The aggregate abrasion value is a measure for a wear resistance of aggregate. A higher aggregate abrasion value obtain when the loss of material due to wear become greater. The aggregate abrasion value of RCA is usually higher than that of NCA.

Aggregate Crushing Value :

The aggregate crushing value provides a measure for the resistance of crushing under gradually applied compressive load. The lower the value, the stronger is the aggregate. It has been found that the aggregate crushing value of RCA is considerably higher than that of NCA.

Aggregate Impact Value:

The aggregate impact value is strength of an aggregate subjected to impact. Aggregate impact value shows the resistance of aggregate to dynamic load. It has been found that the aggregate impact value of RCA is greater than NCA

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Chemical Properties :

Soundness :

The soundness of aggregate is an indication of aggregate's resistance to weathering and other environmental effect. RCA commonly fails sodium sulphate soundness test, but passes magnesium sulphate soundness test.

Alkali Aggregate Reactivity :

RCA may cause alkali aggregate reaction in concrete if the aggregate of original concrete were susceptible to alkali aggregate reactivity.

Sulphate Content :

RCA can have higher sulphate content due to sulphate compounds present in cement adhered mortar. A higher sulphate content of RCA reveals that a greater amount of mortar is attached to RCA.

Organic Matter :

Paper, wood, textile fabrics, joint seals, plastic, rubber and other polymeric material can be present in RCA. The acceptable limit of organic matter in concrete is 0.15% by weight of RCA.

Chloride Content :

Higher chloride level have been found in the RCA produced from the sources with long-term exposure to chloride based decing chemicals. The RCA derived from the old concrete containing chloride more than 0.04 kg/m^3 should not be used in concrete, because the accelerated steel corrosion could lead to the early failure of reinforced concrete structure.

Brick kiln DUST:

Sr. No.	Characteristics	Value NCA	Value RCA
1.	Specific gravity	2.8 kg/m^3	2.52 kg/m^3
2.	Water absorption	2.08 %	3.14%
3.	Impact test	18.6%	7.66%
4.	Abrasion test	27.99%	36.56%
5.	Crushing test	18.18.54%	31.8%

The present day world is witnessing the construction of very challenging and difficult civil engineering structure. often, concrete is most important and widely used material is called upon to process very high strength and sufficient workability properties. Effort are being made in the field of concrete technology to develop such concrete with special characteristic. Researcher all over world are attempting to develop high performance concrete by using brick kiln dust in concrete up to certain proportion on the other hand brick kiln dust is waste product obtained from different part of the country.

Brick dust is a waste product obtain from different brick kiln and tile factories. There is numerous brick kiln which has grown over the decades in an unplanned way in different part of the country. Tons of waste product like brick dust or broken pieces or flakes of brick come out from there kilns and factories. So far, such material have been used just for filling low lying areas or are dumped as waste material. The specific gravity was 2.50 the brick kiln dust conforms to grading zone III as per IS; 383-1970 respectively.

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Mixing

An integral part of concrete mix proportioning is the preparation of trial mixes and effect adjustments to such trials to strike a balance between the requirements of placement that is workability and strength, concomitantly satisfying durability requirements. As per IS 10262, the method is adopted for finding the proportion of M30 was studied and design as per requirement.

Mixing design adopted for M20 grade concrete

Generally there are many methods like Indian Standard are available designing normal strength mixtures for mix design. The process of respective proportions of Cement, Fine aggregate, Coarse aggregate, water so as to obtain concrete of desirable quality is known as proportion of concrete. The mix proportion for the M20 grade concrete is given below.

- Grade designation: M20
- Type of cement: OPC 53 grade
- Maximum nominal size of Aggregate: 20 mm
- Minimum cement content: 300 kg/m^3
- Maximum water cement ratio: 0.55
- Workability: 50 mm slump
- Exposure condition: Mild (for RCC)
- Degree of supervision: Good
- Type of aggregate: Crushed angular aggregate
- Maximum cement content: 450 kg/m^3

Test Data for Materials

Cement used = OPC 53 grade
Specific gravity of cement = 3.15
Specific gravity of:
Coarse Aggregate= 2.65
Fine Aggregate = 2.60
Water absorption:
Coarse aggregate = 0.4%
Fine aggregate = 0.3%
Free surface moisture
Coarse aggregate = Nil
Fine aggregate = Nil
Mix Design Procedure

Step 1 :

f'ck = fck + 1.65 s where,
f'ck =target average compressive strength at 28 days
fck =Characteristic compressive strength at 28 days and s = standard deviation
From table 1, standard deviation, s = 4 N/mm2.
Therefore, target strength = 20 + 1.65=26.N/mm2.

Step 2 : Selection of W/C Ratio
From Table-5 of IS: 456-2000, maximum W/C ratio = 0.6, Based on experience adopted w/c ratio as 0.55
0.55< 0.6, hence ok

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Step 3 : Selection of water content From table-2 maximum water content for size of Aggregate 20 mm = 186 litre

Step 4 : Calculation of cement content
Water-cement ratio= 0.55 Water used= 186 liter Cement content= 186/0.55 = 338.18 kg/m3
As per IS: 456-2000. Table-5. Minimum cement content for mild exposure condition = 300 kg/m3.
338.18 kg/m3 > 300 kg/m3, hence O.K.

Step 5 : coarse aggregate and fine aggregate content
From Table-6, volume of coarse aggregate corresponding to 20 mm maximum size Aggregate and fine aggregate grading (Zone- II) for water cement ratio 0.50 = 0.6.
In the present case w/c = 0.55. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As water-cement ratio lower by 0.05, the proportion of volume of coarse aggregate is increased by 0.01 (at the rate of -/+ 0.01 for every +/- 0.05 change in water-cement ratio).
Therefore, corrected proportion of volume of coarse aggregate for water- cement ratio of 0.55 = 0.6. Therefore, volume of coarse aggregate = 0.60-0.01 = 0.59 Volume of fine aggregate content = 1- 0.59 = 0.41
Step 6 : Calculation of Mix Proportion

Volume of concrete	= 1 m3
Volume of cement	= (mass of cement/specific gravity of cement)x(1/1000) = (338.18/3.15) x (1/1000) = 0.1073 m3
Volume of water	= (mass of water / specific gravity of water) x (1/1000) = (186/1) x (1/1000) = 0.186 m3
Volume of all in aggregates	= [a-(b + c)] = [1-(0.1073+0.186)] = 0.707 m3
Mass of coarse aggregate	= d x volume of coarse aggregate x specific gravity of coarse aggregate x 1000 = 0.707 x 0.59 x 2.65 x 1000 = 1105.394 kg
Mass of fine aggregate	= d x volume of fine aggregate x specific gravity of fine aggregate x 1000 = 0.707 x 0.41 x 2.6 x 1000 = 753.662 kg

Step 7 : Mix Proportion for trial No 1

Cement = 338.18 kg/m3 Water =186 lit
Fine aggregate =753.662 kg/m3 Coarse aggregate =1105.394kg/m3 w/c ratio = 186/338.18
= 0.55

Step 9 Mix Proportion (by mass)

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Water	: Cement	: F.A.	: C.A.
186 lit.	: 338.18 kg	: 753.662 kg	: 1105.394 kg
0.55	: 1	: 2.23	: 3.26

Mix Proportion (control concrete)

MATERIAL	DRY WT.	
Cement	338.18	kg/m3
Water	186	kg/m3
Fine aggregate	753.662	kg/m3
Coarse aggregate	1105.394	kg/m3
Water-cement ratio	0.55	

IV. EXPERIMENTAL ANALYSIS

Preparation of Moulds and Testing

Cement was well checked and the entire field tests on cement for its satisfactory use were done. The aggregate of 20 mm size were used for concreting the material used was clean from all types of impurities and standard concrete procedure was followed while concreting.

The casting was done of standard size moulds of Cube and Beam. Moulds of standard size were easily available at the Late G.N.Sapkal Collage of Engineering, Nashik. The mould with good conditioned were used for the concreting purpose. The beam moulds were brought from Late G.N.Sapkal Collage of Engineering, Nashik. The various sizes were made ready one day prior to concreting. All the nuts and bolts of the moulds Were checked and tightened. Oiling was done with brush

Casting of Specimen

After the preparation of moulds the concrete batching is done and concrete of various proportions are prepared with a water cement ratio of 0.35 % of the total weight of the proportion of the grade and is poured in mould for casting of specimen. The concrete poured in moulds is well compacted will hand or with mechanical means and is left undisturbed for 24 hour so the it dries and forms hardened solid mass structure and then is made ready for further curing process

Casting of Cube

The mould of the cube of standard size 15x15x15 cm was made ready. All these moulds were of cast Iron and were well cleaned and all the nuts and bolts were well tightened All the holes or the gaps were filled properly so as to reduce bleeding. There were total 36 cubes casted in all. The table 4.1 shows the casting and testing of cubes accordingly. These cubes were casted according to grades and curved according to specific time.

Table no 4.2

GRADE	CUBES	DAYS
M20	36	28

Casting of Cylinder

The mold of Cylinder was cast in standard mould size of 150x300 mm of cast iron. The mould was well cleaned from dust and impurities and all nuts and bolts are tightened, the gaps are filled to avoid bleeding of concrete. There were total 18 Cylinder casted of various percentage of RCA used. The table 4.2.2 shows the detail information of casting of beam accordingly. These beams were cast various % of replacement of RCA and cured with specified time.

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GRADE	CYLINDER	DAYS
M20	18	28

Placing of Concrete

The concrete is poured in the moulds fore-cast of specimen. The concrete should not be dropped from a height of more than 1.5m as segregation of concrete takes place. The placing should be done uniformly to attain a clear surface on the face of concrete. The mould should have no faults and preventive measures should be provided if any. The placing must be done in three layers and compacted as discussed further.

Compaction

The compaction of concrete should be done before adding each concrete layer. Each layer should be compacted using a 16mm diameter bar or a standard tamping rod. Each layer is compacted uniformly with 25 blows to remove the entrapped layer and to remove the air voids .Compaction is necessary to increase the volume, to reduce air voids to form a dense and compact concrete. The compacted concrete is then well finished on the surface using a trove. The slurry is poured in corner while compacting so as to get a uniform surface after hardening. The sample is kept undisturbed for 24 hrs. or one day then kept for curing.

Workability Test Concrete

- Slump cone test Compaction factor test
- Slump Cone Test

The slump test is the most simple workability test for concrete, involves low cost and provides immediate results. Due to this fact, it has been widely used for workability tests since 1922. The slump is carried out as per procedures mentioned in **ASTM C143 in the United States, IS: 1199 – 1959 in India and EN 12350-2 in Europe**.

Generally **concrete slump value** is used to find the workability, which indicates water-cement ratio, but there are various factors including properties of materials, mixing methods, dosage, admixtures etc. also affect the concrete slump value.

Table 4.5.1 Slump Value

SR NO	GRADE	SLUMP VALUE
1	M20	95
2	M20	93
3	M20	90
4	M20	90
5	M20	90
6	M20	90

Compaction Factor Test

Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. It was developed by Road Research Laboratory in United Kingdom and is used to determine the workability of concrete. The compaction factor test is used for concrete which have low workability for which slump test is not suitable.

The Compaction factor values ranges from 0.7 to 0.95

Testing of Cube Specimen for Compressive Strength

For the compression test the cubes were placed in machine in such a manner that the load was applied on faces perpendicular to the direction of cast. In CTM, the top surface of machine is fixed and load is applied on bottom surface of specimen. The rate of loading was gradual and failure load was noted. Also the failure pattern was observed precisely.

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Compressive strength

The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Concrete compressive strength for general construction varies from 15 MPa (2200 psi) to 30 MPa (4400 psi) and higher in commercial and industrial structures.

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material and quality control during the production of concrete, etc.

Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates.

The % of recycled aggregate concrete increase the compressive strength goes on decreases.

Compressive Strength Formula

Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross-sectional Area

Procedure

The concrete is poured in the mould and appropriately tempered so as not to have any voids. After 24 hours, 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 placing cement paste and spreading smoothly on the whole area of the specimen replaced by recycle aggregate as % of 0,20,40,60,80,&100%

These specimens are tested by compression testing machine after 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.

Tensile Strength

Tensile strength is one of the basic and important properties of concrete. A knowledge of its value is required for the design of concrete structural elements.

Its value is also used in the design of prestressed concrete structures, liquid retaining structures, roadway and runway slabs.

Direct tensile strength of concrete is difficult to determine; resources is often taken to the determination of flexural strength or the splitting tensile strength and computing the direct tensile.

Another problem is that stresses induced due to grips. Due to grips there is a tendency for specimen to breaks as its ends.

The bearing strips are placed between the specimen and both upper and lower bearing blocks of the testing machine

The load shall be applied without shock and increased continuously at a nominal rate within the range 1.2 N/(mm^2/min) to 2.4 N/(mm^2/min).

Record the maximum applied load indicated by the testing machine at failure. Note the type of failure and appearance of fracture.

Computation

Calculate the splitting tensile strength of the specimen as follows

$$T=2P/\pi Ld$$

Where T : splitting tensile strength, kPa

P : maximum applied load indicated by testing machine, KN. L length, M.

d : length, M.

Bond Strength

The Bond stress of the recycled aggregate concrete made with Brick kiln ash (5%) was determined on 28 day. Bond stress confirming to IS 2770 (Part I) 1967 is carried out. For this test the specimen was kept vertical as concrete is at

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upper side and reinforcement pointing downward in universal testing machine with 60 ton capacity, at this rate of 200KN/min. The bond stress is calculating using following equation.

Bond Stress = P/pidL Where

P = Max Pull Out Load

d = Diameter of Bar = 12mm

L = Embedded Bar length (15*d)

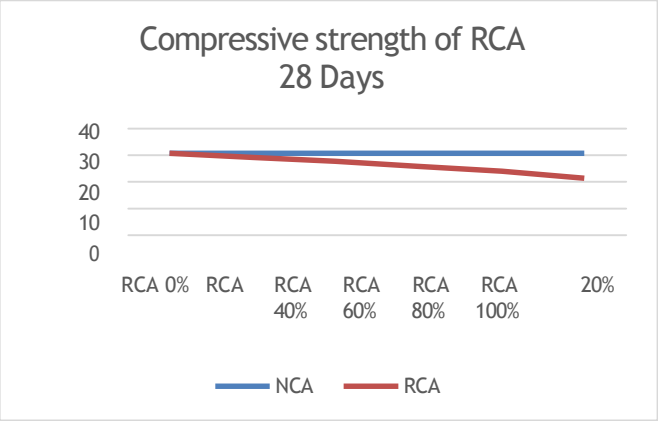
V. RESULT AND DISCUSSION

The various test conducted on hardened concrete such as Compressive strength, Tensile strength & Pull out test are tested according to standard procedure of testing of cube moulds and cylinder. The various test are conducted on concrete are discussed in Chapter 4. The various result are stated below

Result of compressive test on cube

Sr NO	Grade of concrete	Percentage of RCA	Load in KN(P)	28 Days Strength (Mpa)(P/A)	Average Strength (Mpa)
1	M20	0%	723.40	34.37	30.7
			701.00	31.16	
			598.20	26.59	
2	M20	20%	688.70	30.61	29.13
			633.50	28.16	
			644.00	28.62	
3	M20	40%	638.70	28.38	27.74
			640.20	28.45	
			593.50	26.38	
4	M20	60%	589.40	26.20	25.87
			627.90	27.91	
			528.70	23.50	
5	M20	80%	554.40	24.64	23.94
			596.50	26.51	
			465.50	20.69	
6	M20	100%	587.40	26.11	21.36
			422.20	18.76	
			432.30	19.21	

Graph showing variation of Compressive Strength



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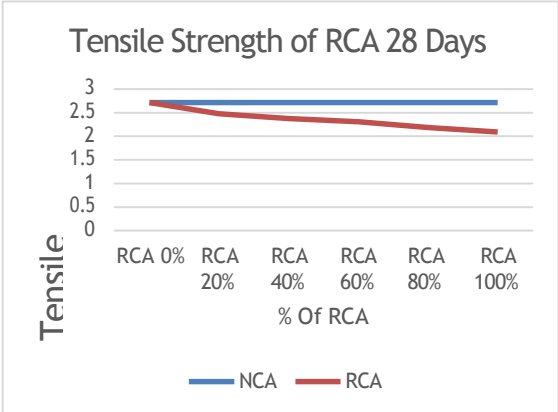
Result of Tensile test on Cylinder

Sr NO	Grade of concrete	Percentage of RCA	Load in KN(P)	28 Days Strength (Mpa)(2P/πdL)	Average Strength (Mpa)
1	M20	0%	201.60	2.85	2.72
			195.20	2.76	
			180.80	2.55	
2	M20	20%	170.80	2.41	2.48
			176.60	2.50	
			180.40	2.55	
3	M20	40%	174.20	2.46	2.38
			162.80	2.30	
			168.60	2.38	
4	M20	60%	163.06	2.30	2.31
			168.80	2.39	
			158.20	2.24	
5	M20	80%	173.80	2.45	2.19
			150.20	2.12	
			140.60	1.99	
6	M20	100%	138.60	1.96	2.09
			150.80	2.13	
			155.40	2.20	

Graph showing variation of Tensile Strength:



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Result of Bond strength on cube Equation

Bond Stress = P/πdL Where

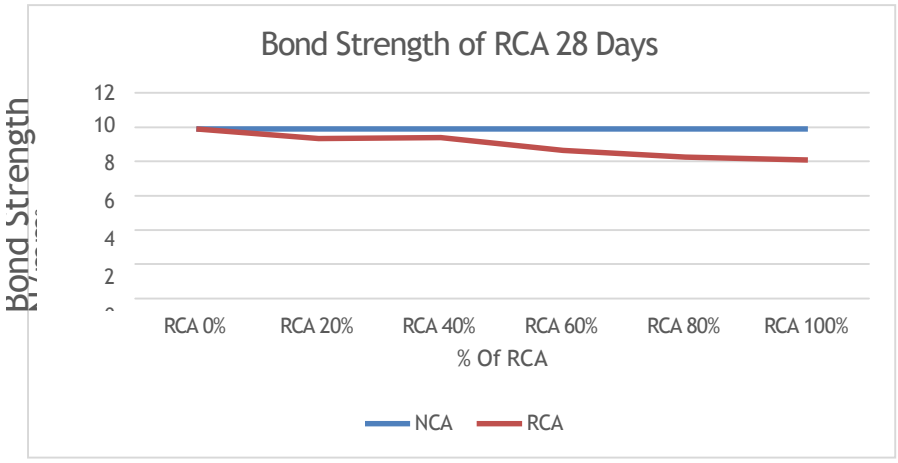
P = Max Pull Out Load

d = Diameter of Bar = 12mm

L = Embedded Bar length (15*d)

Sr No	Grade	Percentage of RCA	28 Day Bond Strength
1	M20	0%	9.90
2	M20	20%	9.33
3	M20	40%	9.40
4	M20	60%	8.63
5	M20	80%	8.26
6	M20	100%	8.09

Graph of Bond Strength :



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VI. CONCLUSION

In the present experimental investigations the Bond stress, Compressive strength and Split tensile strength of recycled aggregate concrete with partial replacement of cement with Brick Kiln Ash is studied. The basic test variables are replaced with replacement ratios for natural aggregates (0%, 20%, 40%, 60%, 80%, and 100%) with recycled aggregates and use of 5% Brick Kiln Ash as a substitution to cement. The combined effect of recycled aggregates and Brick kiln ash on the properties of concrete is explored in the present study.

With increasing recycled aggregate content and in presence of brick kiln ash the workability of mixes is observed to be reduced.

As mortar is attached to the surface of RCA it exhibits low specific gravity and high water absorption than conventional aggregate.

After crushing the net quantity of the coarse aggregate from the recycling process is collecting to be 60% of the total quantity.

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The results show that with increasing recycled aggregate content bond stress go on reducing. However, it is observed that replacement of natural aggregates up to 40% cause small reduction in strengths. All the specimens with up to 40% recycled aggregates with and without fly ash satisfy the design strength

Using Brick Kiln Ash 5% in concrete is economical to replace the recycled aggregate to the natural aggregate. For 12mm bar, the concrete failed before the bar fails.

Such a combination of higher recycled aggregate content and high volumes of brick kiln ash may make concrete green and sustainable.

If the result of compression test taken on the concrete cubes is studied it is observed that as the percentage replacement of the natural aggregates (0% ,20% ,40% ,60% ,80% ,100%) with recycled aggregates increases then the compressive strength goes on reducing.

Also the same thing is observed when the results of split tensile test are studied i.e. “as the percentage of recycled aggregates in concrete increases the tensile strength decreases."

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