IJERST

International Journal of Engineering Research and Science & Technology

www.ijerst.org

ISSN : 2319-5991

Vol. 21 No. 4 (2025)

ijerst.editor@gmail.com

editor@ijerst.com

ISSN 2319-5991 www.ijerst.com
Vol. 21, No. 4, 2025

Research Paper

COMPARISON OF STRENGTH CHARACTERISTICS OF NATURAL AND RECYCLED AGGREGATE CONCRETE USING ADMIXTURES

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ABSTRACT

It can be beneficial for the environment and economically to use a recycled coarse aggregate the concrete. The materials in future are recycled aggregates. Similar to fly ash, silica fume and stone dust are byproducts of a variety of industries. The composition of the components that make up fly ash can vary greatly. It is residue from burning coal that is gathered in a hag house or on an electrostatic precipitator. When electric power is generated using powdered coal, it combines with the flue gases that are produced. Utilizing fly ash has significantly more benefits than drawbacks. Reduced permeability to strong chemicals and water is the main advantage. The pore diameters are smaller, fly ash-cured concrete produces a denser final product. This lowers permeability and boosts strength. Large amounts of natural resources are used by the concrete industry worldwide, and these resources are running out to fulfill the growing demand. Concrete is being demolished as a result of the vast number of ancient buildings and other structures that are being demolished since they have reached of end their useful lives. A large portion of this concrete waste is dumped in landfills, while some is utilized as backfill. By recycling concrete and substituting it for new aggregate, concrete waste can be decreased and natural aggregate supplies can be preserved. Numerous recycling techniques for debris from building and demolition have been investigated and are at a well-developed level over the past twenty years. Fly ash has been utilized a improve of ultimate compressive strength and workability into fresh concrete because it is a well-known pozzolanic substance.

Received: 08-10-2025 Accepted: 17-11-2025 Published: 24-11-2025

I. INTRODUCTION

Recycling the process of turning wasted materials into new products. With the advanced infrastructure development, the use of natural aggregate is becoming increasingly intense. Recycled aggregate can be utilized as a substitute for natural aggregate in order to minimize its use. Crushed, graded inorganic particles that have been processed from materials used in building and demolition rubbish make up recycled aggregate. Usually, these materials are derived from buildings, bridges, roadways, and sometimes even natural disasters like earthquakes and wars. In order to better understand the applications, the recycled coarse aggregates as the substitute a natural coarse aggregate into structural concrete, the goal of this ongoing project is to ascertain how to recycled coarse the aggregates can be used high strength structural concrete.

India's industrialization was led to an extremely high pace of urbanization growth. India's GDP are growing at the rate of 9%. Rapid structure growth necessitates a lot of building supplies, land, and a location. To Concrete is a material the choice for large-scale building due to its superior performance, low maintenance costs, and longer lifespan. New buildings are built and smaller structures are dismantled in order to reach the GDP rate. One fundamental element that is closely related to human survival is environmental protection. Modern building projects must adhere to certain parameters, such as sustainable development, environmental sensitivity, and the preservation of natural resources.

Demolished materials are discarded on land and never used again as a result of modernization. Land fertility is impacted by such circumstances. According to a March 2007 Hindu Online estimate, India produces 23.75 million tons of demolition garbage yearly. Only 3% of India's 48 million tons of solid waste are utilized for embankments, with 14.5 million tons coming from the building industry, according into research by a Central Pollution Control Board (CPCB) in Delhi. Concrete accounts for 40% of the total trash from construction and demolition, followed by ceramics (30%), plastics 5%, wood (10%), metal 5%, and other mixes (10%). According to Global Insight, the expansion of the global construction industry is expected to raise construction expenditures by $4800 billion in 2013. These numbers show that the construction industry has grown astronomically, about 1.5 times in just 5years. Between 70 and 75 percent aggregates are needed to make concrete. Of this, 33–40% is fine aggregate and 60–67% is coarse aggregate. The demand for building aggregates worldwide is expected to surpass 26 billion tons by 2012, according to new research conducted by the Fredonia group. China is the largest user at 25%, followed by Europe at 12% and the USA at 10%. The India is among the top 10 users. From an environmental perspective, the production of one ton of natural aggregate results in emissions into 0.0046 million tons the carbon, whereas a production of one ton the recycled aggregate results in emissions of only 0.0024 million tons of carbon.

Given that 10 billion tons of aggregate are used annually worldwide to produce concrete, the carbon footprint of the both natural and to recycled aggregate may be calculated. When compared into natural aggregate a concrete, the usage of recycled aggregate typically results in higher drying shrinkage creep, porosity, and lower compression strength. When aggregate is replaced, compressive strength decreases by roughly 10–30%.

A crushing machine is used to process concrete aggregate that has been gathered from demolition sites. Only clean concrete that is devoid of rubbish, wood, paper, and other items is accepted by crushing facilities. From they can benn extracted using magnets and other then sorting tools and melted to down for a recycling , metals like rebar are acceptable. Size-wise, the remaining aggregate chunks are arranged. Bigger pieces might pass through the crusher once more. Following crushing, further particles are removed by a number of techniques, including as water flotation and hand-picking.

Fly ash is widely used as ingredient in blended cement, and as a separately batched material in concrete. It is employed to save money and enhance the qualities of concrete that is used in specific applications. The goal of this experiment is to determine how fly ash affects concrete strength by varying the percentage fly ash added in conjunction with recycled materials.

The use of fly ash in, concrete has several benefits, such as improved workability, a decrease in temperature rise in fresh concrete and an increase order in strength, and durability, in hardened, concrete. Fly ash effectively utilizes the byproducts of Portland cement hydration: 1) Calcium and alkali hydroxide solution found in the cement paste's pore structure 2) the heat produced when Portland cement hydrates, which is a crucial step in starting the fly ash reaction. To cement paste, fraction of fly ash concrete reduces the permeability, to water and hostile materials by filling in the gaps between hydrated cement particles with fly ash reaction products after the concrete is adequately cured. Many fly ashes have a slower reaction time, which really helps to decrease the quantity, of early heat generation and the harmful early, temperature rise the large structures. Because fly ash reduces the amount of Portland cement, the energy-intensive, product, needed to produce the specified concrete characteristics, it saves energy when used in concrete.

The smelting process in silicon, and ferrosilicon-industries produces silica-fume (SF). SiO_2 vapours are produced when the high--purity quartz is reduced to silicon- at temperatures a high as 2,000C. In the low-temperature zone, these vapours oxidize and condense to form tiny particles, of non-crystalline silica. Non—crystalline, silica makes up 85–95% of ferrosilicon alloys with silicon concentrations of 75% or higher and by-products of silicon metal manufacturing. The resultant ferrosilicon, alloy with 50% silicon was a significantly, reduced silica concentration, and to less pozzolanic. Consequently, the kind alloy, being formed is correlated, with the SiO_2 level the silica fume. The terms micro silica condensed silica-fume, volatilized silica, and silica dust are other names for the silica-fume. "Very fine non-crystalline silica produced in electric arc furnaces as a by-product of production of elemental silicon or alloys containing silicon" is how the American - Concrete Institute (ACI) describes silica-fume. It is typically a grey powder the resembles some fly ashes a Portland cement in some ways. It can have cementitious and pozzolanic qualities. It has been established that silica fume is a pozzolanic additive that significantly improves mechanical characteristics. In a laboratory setting, it is comparatively simpler to achieve compressive strengths of 100–150 MPa by combining silica fume with superplasticizers. By lowering permeability, improving pore structure, which inhibits the diffusion of dangerous ions, and lowering calcium hydroxide concentration, which increases resistance to sulfate attack, silica fume adds durability to concrete. Increased durability will also increase silica fume concrete's capacity to prevent corrosion in the embedded steel.

Crusher plants produce stone dust as a waste product. It might be utilized in concrete in place of some of the natural river sand. In addition to improving concrete quality, using stone dust in concrete helps preserve the natural river sand for future generations. The workability, and compressive, strength a concrete built using stone dust as 10%–100% partial-replacement of fine-aggregate were investigated in the current study through an experimental program. For reference concrete, Portland pozzolana-cement (PPC) has used to build M25-grade concrete. The best replacement level was established based on compressive strength, and to workability, and compressive strength weas assessed at various fine aggregate-replacement levels, such as in reference a concrete. To findings indicated that in comparison into all other replacement-levels, concrete with a highest of the compressive strength, could be produced by substituting, 60% of the fine aggregate with a stone dust.

II. OBJECTIVE OF PROJECT

Finding and comparing the physical characteristics of fine, coarse, and recycled concrete aggregates such as specific gravity and water absorption is our goal. Determine the precise mix proportion of concrete by calculating the cement's specific gravity, fineness, normal consistency, and beginning setting time. Compaction factor testing is a used to determine to workability the concrete mix. Concrete cubes are then cast using recycled concrete coarse aggregates and admixtures in place of natural coarse aggregates. The compressive-strength of the cubes is measured at, 7, 14, 21 and 28 days, and the results are compared to those of regular concrete cubes cast without any replacement.

III. LITERATURE SURVEY

V.M. Malhotra, M.H. Zhang, and N. Bouzoubaa, The durability and mechanical characteristics of concrete produced with large amounts of fly-ash cement: This study examines the characteristics and longevity of fly ash-based concrete. The- slump, air content, slump loss, stability of air content, bleeding, and setting time of normal concrete were compared with those of hardened concrete. The hardened concrete's compressive and flexural strengths, Young's modulus of elasticity, drying shrinkage, resistance to abrasion, chloride-ion penetration, freezing, and thawing cycle, and deicing salt scaling were also examined. The findings demonstrate that the mechanical qualities and durability of fl-ash-produced concrete were better than those of regular concrete made separately in the mixer, with the exception of-the concrete's resistance to deicing salt-scaling.

S. Kumar, A. V. S. R. Murty, and U. K. Guru Vittal, Due-to the energy-intensive nature, of Portland-cement, which is needed to create stiff pavements, attempts are underway to develop alternatives to partially replace cement in concrete while also saving energy. However, the amount of coal being used to generate electricity is growing quickly. Because of this, power plants that burn coal have produced a lot of fly ash. Fly-ash into thermal power stations can be added to concrete as an additive to save cement and solve concrete disposal issues. Fly-ash is a waste material, that can be used in an environmentally acceptable way by being used in concrete. Fly ash is currently used in road pavement construction, mostly for embankments and sub-base/base courses. Concrete that has been blended with fly ash can be an excellent material for pavement construction. It is typically made to partially replace aggregate, cement, or both. The various ways to use fly ash as a paving material in concrete, the benefits of doing so, and the process by which fly ash-admixed concrete increases durability are all covered in this study. Additionally featured are CRRI's experiences with fly ash-admixed concrete.

B. Krishna rao (2012), R. Kamala investigated the replacement of natural aggregates by reusing solid waste from construction demolition. Three cubes, three cylinders, and three beams are cast for each partial replacement of conventional aggregate in their study, which uses different mix proportions. Compressive strength, split strength and flexural-strength tests were performed after 7, 28, and 56 days. For 28 days, the ceramic concrete's compressive strength was adjusted between 32.88 and 46.88 Mpa, its split tensile strength was adjusted between 2.47 and 3.72 Mpa, and its flexural strength was adjusted between 5.33 and 7.82 Mpa. It has been noted that when coarse aggregate is replaced by 50%, strength declines. Therefore, we can replace coarse material with ceramic tiles gathered from building destruction up to 40%.

Majid Matouqassas (2013) and asif husain, investigated the use of leftover concrete for new construction. They conducted numerous tests on them and substituted recycled aggregate for coarse aggregate in their study at different percentages. Five, sets of cubes-were cast, substituting coarse aggregate, from demolished waste at 0%, 25%, 50%, 75%, and 100% by weight for fresh aggregate. A minimum of 30-specimens were cast fora each w/c ratio, i.e. 0.60, 0.625, and 0.65 for the two-mixes (M15 & M20), totaling more than 180 specimens. When 75% dismantled aggregate is substituted for fresh aggregate, the mix's compressive strength increases by 26.75% with a different w/c ratio as advised by IS456-2000. But the slump drops to the second-third value. When 75% dismantled aggregate is used in place of fresh aggregate, the mix's compressive strength increases by 12.68%, increasing the slump from 21 to 60 mm and increasing the w/c ratio from 0.60 to 0.625, or 4.16%. The compressive strength of M15 & M20mix increases by up to 40% when 75% dismantled material is substituted for fresh aggregate at a 0.65 w/c ratio, (IS 456-2000), although slump is reduced by half.

IV. MATERIALS

Cement: Cement is one material that, when water is present, has cohesive properties. Natural a cement is made by the burning and crushing rocks that include clay, lime carbonate, and a little quantity of magnesia carbonate. Lime and natural cement are very similar. If water is added, it sets quickly. It is not as durable as artificial cement. Englishman Mason Joseph Aspidin invented artificial cement. This cement bears a striking resemblance to a popular variety of sandstone found It is occasionally called Portland cement in Portland, England. as a result.

Coarse aggregate: Inert materials include aggregates such as stone, brick, and sand. Since they make up around 80% of the concrete's volume, their characteristics have a significant impact on how the concrete behaves. It makes sense for the USC to use the maximum amount of aggregates because they are more affordable than cement and naturally occurring. The aggregates meet the specifications of IS 383-1970 and are categorized as fine and coarse aggregates. The aggregate should be packed and cemented as compactly as possible to get the highest strength and longevity. The gradation of aggregate and particle size to create packing is therefore very important. Good strength, durability, and weather resistance are essential, as is the absence of impurities like silt, loam, and organic matter on the aggregate's surface that could erode the bond with cement paste. Additionally, there must be no adverse chemical reactions between the aggregate and cement.

Fine aggregate: The workability and strength development of concrete, which acts like a composite material, are determined by the material's age, individual qualities, and combined action. Before considering the potential of completely replacing fine aggregate, it is necessary to understand how fine aggregate affects strength and workability.

Fly ash: The material collected from coal-fired power plants' flue gases using electrostatic-precipitators, is known as fly-ash or pulverized-flue ash, (PFA). Fly ash is available in a range of size fractions and collection zones, from moderately coarse to ultra-fine. Similar in size to cement fly ash particles, the percentage most frequently used in the manufacturing of concrete has a diameter ranging from 1 to 50 micrometres and is generally spherical.

Stone dust: The fine aggregate most frequently used in concrete is natural sand. An alternative is considered because of the severe shortage in many locations, as well as financial and environmental considerations. This study sought to determine whether stone dust might be used to partially replace fine aggregate. In this study, a reference M25 concrete mix was utilized. According to the test results, stone dust can be utilized to partially substitute fine aggregate in concrete with success. It has been discovered that adding stone dust to concrete increases its flexural and compressive strengths. It was examined to what extent stone dust replaced the fine aggregate (30, 40, 50, 60, and 70%). Up to 40% replacement is found to have little effect on compressive strength; however, flexural-strength at the all ages increased noticeably at all the replacement-levels.

Silica fume: A byproduct of making-ferrosilicon alloys or a silicon metal is silica fume.a Concrete is one of the most advantageous applications for silica fume. Its physical and chemical characteristics make it a highly reactive pozzolan. Silica fume-infused concrete can be incredibly strong and long-lasting. When required, silica fume is easily added during the concrete-making process and can be purchased from providers of concrete admixtures. The main component of silica-fume is amorphous, or a non-crystalline, silicon-dioxide, (SiO2). Approximately 1/100th the, size of an ordinary cement particle, the individual particles are minuscule. When used in concrete, silica fume is a highly reactive-pozzolan due to a its tiny particles, huge surface area, and high SiO2 content. ASTM C-1240 and AASHTO M-307 specify the quality of silica-fume.

V. EXPERIMENTAL INVESTIGATION

The purpose of an experimental program has to compare the mechanical-properties, such as a compressive to strength, of M20 grades of concrete with varying percentages into recycled aggregate concrete (0%, 25%, 50%, and 100% by weight of the coarse-Aggregate), stone dust (0%, 20%, 25% by the weight of fine aggregate), fly- ash (0%, 25%, 30% by weight of cement), and silica fume (0%, 5%, 10% by the weight of cement).

The experiment involves casting and evaluating examples of the standard cubes (150 x 150 x 150 mm) made, and without recycled aggregate concrete and additives. All of the specimens where tested using an universal testing machine. The IS coding approach was used to design the concrete grades that were chosen. The differences in strengths were then examined for various additive percentages.

A. Properties of materials

Table. 1 Fine Aggregate Properties

S. No.	Properties	Value
1.	Specific Gravity	2.59
2.	Fineness modulus	2.58
3.	Bulk Density	1.675 Kg/Liter

Table. 2 Coarse Aggregate Properties

S. No.	Properties	Value
1.	Specific Gravity	2.58
2.	Fineness modulus	6.97
3.	Bulk Density	1.575 Kg/Liter

Table. 3 Properties of Cement

S. No.	Properties	Value
1.	Specific Gravity	3.05
2.	Consistency of cement	31%
3.	Fineness of cement	1.62%
4.	Initial setting time	1 hour 10 minutes
5.	Final setting time	3 hours 15 minutes

A hammer is used to crush the RCA used in this research experiment. In Khairthabad, Hyderabad, a portion of the building was removed. It was broken with a hammer, and sieved through 12.5 mm, and 20 mm, sieves. This project uses the aggregates that were kept on a 12.5 mm, filter and then the passed through a 20 mm, sieve. Surface drying is applied to the aggregates.

B. Mix Design

The M20 Grade of concrete was used for this project, the mix proportions was mentioned in below tables

Ratio by Weight:

Water (Liters)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)
191.58	368.4	523.8	1205.74

Ratio-based proportion:

Water (Liters)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)
0.52	1	1.42	3.27

C. Casting, and curing of the test specimens

As part of a experimental program, 64 concrete cubical specimens measuring of 150 x 150 x 150 mm were tested. Fly ash (0%, 25%, 30%) by cement weight, silica fume (0%, 5%, 10%) by cement weight, stone dust (0%, 20%, 25%) by fine aggregate weight, and RCA (0%, 25%, 50%, 100%) by coarse aggregate weight are the subgroups into which this is further separated. Additionally, compressive tests were performed on the cast cubes.

In measured amounts a fine and coarse material are dispersed in layers that alternate. A shovel is used to mix the contents dry after cement has been put on top of it, rotating the mixture repeatedly until the color is uniform. After adding the necessary percentages of admixtures to the specific combination, water is taken in the appropriate amount, sprinkling the mixture, then flipping it over simultaneously. This process is repeated until the good, homogenous, and uniform concrete is a achieved.

The cube and cylinder moulds have been thoroughly cleaned, and every precaution has been made to prevent any unusual proportions. In a order to guarantee that no a water escaped during of a filling process, mould oil was applied to the joints between the mould sections and to the contact surfaces of the moulds' bottoms and the base plate. To make it easier to remove the moulds after coasting and to stop the concrete from sticking, the inside surfaces of the built moulds were lightly treated with mould oil. To create dense concrete, the mixture was layered in three layers and crushed using a table vibrator.

After adding water to the dry components, the test of specimens—cubes and cylinders in were kept in a damp atmosphere with 90% of relative humidity, and at a temperature of 27 degrees Celsius +/- 2 degrees for 24 hours without being moved. The specimens were demolded after 24 hours and submerged right away in a new, clean water tank for 7, 14, 21, and 28 days with varying proportions of RCA and Admixtures.

D. Testing

Workability (Compaction Factor test): The purpose into test is to more precisely ascertain if concrete with the low water-to-the cement ratio is workable. The standard compaction factor testing machine, which measures the internal energy needed to compaction concrete, was used to perform the test in accordance with IS 1199-1959. This test yielded the following compaction factor values.

Compressive of strength into concrete: Cube specimens for each proportion of fly ash and fiber are evaluated for 28 days of strength using a universal testing equipment. To remove the surface water and grit, as well as any projecting particles on the specimens' surface, the cube specimens were removed from the water reservoir, and set on a level surface for ten minutes on the day of testing. A bearing surface on the testing machine were cleaned and the 2000kN capacity was checked before the specimen was put inside. The resistance of the specimen to the growing load was demonstrated in the plate after the rate at which the load was applied was about 140 kgsq.cm/min. By dividing the greatest load placed on the specimen The specimen's compressive strength was ascertained during the test by measuring its cross-sectional area.

VI. RESULTS AND DISCUSSIONS

A. Compaction factor test

Table 4: Values of the compaction factor

% of fly ash	W1=weight of partially compacted concrete (kg)	W2=weight of fully compacted concrete(kg)	Compaction factor
0	4.2	4.9	0.86
5	4.2	4.7	0.89
10	4.3	4.77	0.90
15	4.2	4.6	0.91

B. Compressive strength

Table 5: The Compressive strength as natural aggregate concrete, at 7, 14, and 28 days

No. of days	Cube	Compressive strength (Mpa)
7	Cube1	20.0
	Cube2	19.6
	Cube3	21.2
14	Cube1	24.9
	Cube2	24.6
	Cube3	25.2
28	Cube1	30.0
	Cube2	29.7
	Cube3	31.4

Table 6: The Compressive strength for 5% replacement at 7, 14, and 28 days

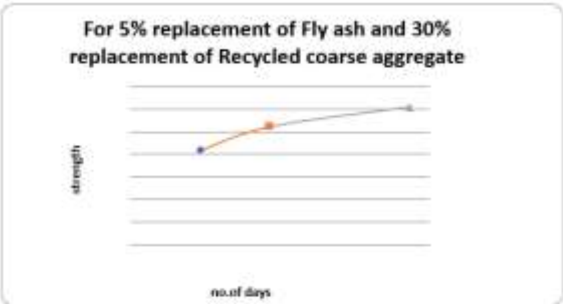
No. of days	Cube	Compressive strength (Map)
7	Cube1	21.2
	Cube2	20.4
	Cube3	20.9
14	Cube1	26.7
	Cube2	25.8
	Cube3	25.9
28	Cube1	30.1
	Cube2	29.7
	Cube3	31.6

Table 7: The Compressive strength for 10% replacement at 7, 14, and 28 days

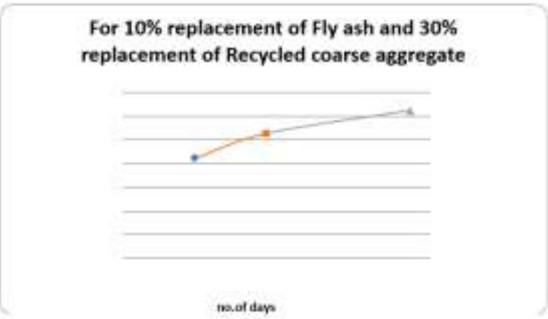
No. of days	Cube	Compressive strength (Mpa)
7	Cube1	20.2
	Cube2	21.4
	Cube3	21.9
14	Cube1	25.7
	Cube2	26.8
	Cube3	26.9
28	Cube1	31.1
	Cube2	30.7
	Cube3	31.6

Table 8: For 15% replacement, compressive strength at 7, 14, and 28 days

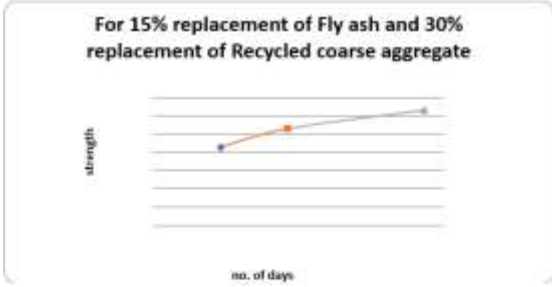
No. of days	Cube	Compressive strength (M pa)
7	Cube1	22.23
	Cube2	21.4
	Cube3	20.8
14	Cube1	25.6
	Cube2	26.9
	Cube3	26.7
28	Cube1	31.4
	Cube2	31.6
	Cube3	31.8



Graph.1: The Compressive strength with time graph for a 5% fly ash replacement



Graph 2: Compressive strength versus days for a 10% fly- ash into replacement graph



Graph 3: The Compressive strength versus days for a 15% fly ash replacement graph

VII. CONCLUSIONS

1. Recycled coarse aggregate has in wide range of uses of the building industry. Around the world, numerous tests based on recycled coarse aggregate have been conducted.

2. The main objective of using recycled coarse aggregate is to use less natural resources. The literature analysis indicates that the results of several attributes all primarily decline as the amount of recycled coarse aggregate used in the concrete increases.

3. The further method of improving the aggregate mixture is to incorporate fly ash, which is recycled coarse. Fly ash can be added to recycled coarse aggregate concrete to boost its durability. Fly ash can be used to improve the strength characteristics of recycled coarse aggregate concrete.

4. The effect of RCA use on concrete material properties. The residual adhering mortar on RCA has the biggest impact on the aggregate characteristics. As a result, RCA is more porous, less dense, and capable of absorbing more water than NA. Although the gradation of RCA and NA is comparable, the RCA particles are rounder and include more fineness. The compressive strength of concrete is reduced by 13% when RCA is used in place of NA.

5. Construction aggregate, energy, and excavation and natural resource transportation costs are greatly reduced. directly lessens the environmental impact of waste materials.

VIII. FUTURE SCOPE

- To determine Recycled coarse

aggregate's strength properties for use in high-strength concrete, more research and testing on the recycled coarse aggregate concrete is strongly advised.

- Recycled coarse aggregate may be less workable as the result of increased water absorption.
- To the strength properties in recycled coarse aggregate should be the subject of more research and laboratory testing. It is suggested that concrete walls, beams, and slabs be tested.

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