“Experimental Studied of Density and Water absorption of Recycled Coarse Aggregate Concrete Incorporating GGBFS and FA”

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Abstract. This investigates work the density and water absorption of concrete specimens cured at the age of 28 days. Natural coarse aggregate (NCA) has been replace with 60 percent, and 100 percent by RCA of construction & destruction (C&D) waste of 30-year-old building and Ordinary Portland cement (OPC) has been replaced with 10 GGBFS and FA. To understand the physical properties of concrete of normal weight test was perform and to find suitable results. To examine the water absorption properties of GGBFS and FA with recycled coarse aggregate (RCA) stand mix concrete at the age of 28 days. Based on the experiment's study, it can be brief that the 40 percent replacement of NCA with RCA carried excellent results with 20 percent GGBFS. This research presents the outcome of GGBFS and FA as a cement replacement on the physical properties of RCA.

Keywords: NCA, RCA, GGBFS, FA, Construction & Demolition, Density, Water Absorption

1. Introduction
Concrete is the most widely used civil engineering material and the foundation of most facilities. Concrete likely to be the only construction material which will be available soon. Although concrete's strength is the most essential factor, it must also be durable, workable, and have a long service life. The development and expansion of the human race have produced severe damage on the environment and may endanger its sustainability (1). The exploitation of natural resources for construction purposes that of non-renewable resources, has led to millions of tons of C&D waste being produced every year. Since most countries have no specific treatment plan for these materials they are sent to landfill instead of being reused (2). The C&D waste is usually rejected on the side of the way, creating traffic and environmental issues (3). It enhances the administrative burden on the local government. NCA on the other hand, are in short supply and quickly depleting as construction activity increases. As a result, that critical problem must be resolved as soon. The issues can be solved by using C&D waste used to like RCA in concrete, which is now being used all around. Sustainable constructions, conservational issues of natural aggregate are all major concerns in the construction industry current scenario (4). As a result, this study aims to use as much C&D waste as possible in the manufacture of high-grade concrete. The usage of RCA in concrete would be a significant phase toward environmentally friendly building and natural resource protection (5). The essential elements of modern growth are environmental protection, natural resource management, and long-term construction. Sustainable development is now widely promoted across the globe. The building industry ingests natural resources and produces C&D waste (6). The concrete rubble has remained discovered to make up a significant ratio of C&D waste, accounting for about 40 percent of the total. Globalization and the expansion of the human race have resulted in environmental degradation. The use of natural resources for building purposes has resulted in the production of millions of tons of C&D waste per year.
The record countries do not have a single sustainability plan in place for these products, which are destined for the landfill rather than existence reused and recycled in innovative construction. The worldwide construction aggregates fair was forecast to grow at a rate of 5.2 percent per year until 2015, reaching 48.3 billion tons. Aggregates make up 70 percent to 80 percent of the capacity of concrete, 92 percent to 96 percent of tar paving, and nearly all of the volume of unbound and hydraulically bound materials (7). As a result, they show a significant part in the structure industry. Now contrast near the cement manufacturing, aggregate withdrawal and processing have a low environmental effect because it primarily consists of simple extraction without significant material alteration. The mandate for sand and gravel grows speedily in conjunction with innovative infrastructure projects, withdrawal of aggregates and rock stands attractive an ecological problem in many parts around us. This has resulted in an ecological imbalance in a variety of respects.

An increase in aggregate demand and a decrease in aggregate supply for concrete production necessitate the search for new aggregate sources. Environmental features are constantly being used to test building materials. Concrete recycling is becoming more common because it conserves ordinary resources and reduces through using readily available concrete as a source of aggregate for new concrete, the need for disposal is reduced. Via research and growth, the idea of sustainable construction growth necessitates the responsible use of regular resources and C&D waste (8). One such possible outlet is the use of RA in concrete construction. Construction products are increasingly being categorized based on their environmental attributes. Concrete recycling is important since it defends usual resources and removes the essential for removal by willingly obtainable concrete as a source of aggregate for innovative concrete. Supportable construction production necessitates judicious usage of usual resources and optimum recycling of construction waste, as well as extensive research and development. One such latent channel is the usage of RA in concrete construction.

1.1 The requirement of RCA in construction
The essential for RCA manufacture and usage is important presently. It's a really important topic, especially that now the situations are favorable for the construction of infrastructures.

- There is a material for the current protection of the country’s natural resources, which stay neither immeasurable.
- There is a reduction in the quantity of extra waste material that is illegally deposited in uncontrolled regions.
- The goal of sustainable development is monitored, and as a condition, the framework for coexistence between humanity and beast is established.
- The presence of a national and policy of the treatment of C&D waste that should include solutions to key requests such as the regulator mechanism for C&D waste deposition with guidance, fines, and so on, is a prerequisite for the use of recycled concrete aggregate.
- Develop deposit areas for before and RCA treatment transport, especially near major cities, with the help of government and private team members to implement RCA.
- Encouragement of technical studies, and the implementation of the use of RCA in the presence of state development.

1.2 Need of alternate for Ordinary Portland cement
There is continuous technical progress and the incorporation of modern technology in the cement business. In India, only seven percent of the volume in the industry is produced from traditional wet and semi-dry course tech, and the remaining 93 percent of the volume is rooted in modern and eco-friendly dry process techniques (9). Cement production is not just one of the most emission building materials, and it is also a source of carbon-dioxide emissions, that account for
about 65 percent of global warming among greenhouse gases and is second to only fossil fuels. As an outcome, the PC industry has become unsuitable for current industry thoughts and concepts. The incorporation of a high proportion of pozzolanic materials into the manufacturing of OPC has greatly improved the condition. It is critical to discover an alternative to OPC to assist the building sector in becoming more eco-sustainable. That should also have acceptable mechanical and durability properties that are similar to if it’s not better than, typical cement-based concrete.

1.3 Necessity for the Present Work

In India, the Central Pollution Board (CPCB) takes projected solid waste group as approximately 48 million tons per annually of which 25 percent remain after the construction manufacturing. This generates noteworthy difficulties with solid waste management. The main influence toward the excess group is the C&D waste. The whole amount of excess is valued toward stand 12 to 14.7 million tons annually after the building manufacturing; obtainable of which individual three percent of the waste is cast-off for the bank. Projections of construction substantial requirements of accommodation subdivision direct a deficiency of aggregates toward the level of around 55,000 m³. Recycling C&D waste may decrease the demand hole popular parts. Concrete and masonry scrap accounts for almost half of C&D wastes, and it is reportedly rarely recycled (10). As per the report submitted by Technology, Information, Forecasting and Assessment Council regarding the possibility of recycling of C&D waste from the building manufacturing the supreme main motive aimed at not accepting the recycling of waste since the building manufacturing remains “lack of awareness of the recycling techniques”. Around 70 percent of participants stated lack of awareness among the reasons, and 30 percent of participants said they were aware of recyclable materials. The hence be industries responded that existing requirements may not provide for use of recyclable materials in construction. Around 67 percent of the workers replied that the non-availability of the recycled creation remained unique of the details aimed at not by it. Concrete is among the most important building materials. Concrete is moldable, adaptable, flame, widely available, and cost-effective. The properties of properly constructed and manufactured concrete include applying the knowledge, mechanical properties, and durability. Each year, the construction industry requires 10 billion tons of concrete. Coarse aggregate makes 70 to 80 percentage of the capacity of concrete and has a huge impact on its properties. As just a response, an alternate coarse aggregate product should be found to protect natural aggregate. In this background, the use of RA in concrete has become a popular method in recent times, with several countries encouraging this. Because of variations in RA quality between situations to a situation or the existence of adherent mortar on its periphery, many investigators used it for reduced concrete applications and insignificant activities. This project aims to M-25 grade of concrete through using of RCA found from C&D waste. In comparison, a multitude of application issues have been resolved and agreeable use was illustrated in several cement types. All things considered, the use of RA in cement is relatively rare. Overall Economic–straight expenses can likewise stand unfavorable. A constant supply of suitable aggregates is indeed a chicken-and-egg situation. Aggregate producers would not like to RA for concrete since there is no demand, and concrete producers cannot plan to make RCA without all the knowledge of high demand. The main goal of such a thesis is to create a work that acts as a single world base of knowledge mostly on results of just using RCA on the concrete property by gathering sufficient data and information and quite well techniques, then objectively analyzing, evaluating, and republishing this. To a certain effect, the first objectives of this paper were to investigate the properties of RA obtained from C&D waste and compared them to NA. This is mostly natural, considering also that the main feature of RCA is the replacement of NA with RA, and thus a significant amount of attention must be given to the evaluation of such recyclable materials. This apart from thorough RA identification; one of the aims of such a work is to analyze the effect of using such materials.
on the most common engineering and durability properties of the concrete. Such experience must significantly assist future researchers, architects, and designers in understanding the role of RA in concrete structures. The density of concrete, water absorption of concrete, compressive strength, split tensile strength, flexural strength, and modulus of elasticity, chloride ion penetration, water permeability sulphate & acid attack effect are indeed the properties of concrete examined in this study. Lastly, it’s also expected that several latest trends and similarities must develop from such an extensive numerical analysis of data gathered inside the systematic review on this subject, allowing a deeper understanding of the shortcomings of just using RCA to concrete. The data gathering on the object will then allow the development of simple and practical designs which can push the total use of RCA throughout the development of the RCC product.

2. Research Methodologies

The project goal is to improve the percentage of RA that is used to produce new concrete. To attain the key goal, the existing problems connected to RCA were methodically considered to understand the basic situation of RCA. To use a mixture of processing and mixing techniques, the numerous properties of RCA in both stages of fresh and hardened were inspected. Numerous influences affect the future performance of RA conclusion of the review of the literature, a treating technique known as "straight forward mechanical grinding" and "modified two-stage mixing methods" were selected for use in combination to solve the problems faced by RA and RCA in the construction. The adherent cement mortar and waste matter were removed from RA during the first phase that used a dry rolling method in instruction to progress the overall excellence of RCA. After adhered cement mortar was being eliminated, the RA supplements of elevated concrete are being improved. The effect of the processing technique on the several properties of RCA has been examined in this phase to choose the best RCA used. The different methodologies were adopted to improve the quality of RCA by removal of the adhered mortar content. Different test techniques and experimental measures were used to revision the probable conducts that the quality of the RCA is upgraded. A method is proposed in this work to particularly that is originated to be effective in removing a determined part of adhered mortar content with economically and improved the performance of the RCA.

Table 1 Mix of one cubic meter of concrete with RCA and GGBFS

| Mix ID            | RCA (%) | RCA (Kg/m³) | Cement (Kg/m³) | NCA (Kg/m³) | GGBFS (Kg/m³) | FA (Kg/m³) | Water (Kg/m³) | Plasticizer (Kg/m³) |
|-------------------|---------|-------------|----------------|-------------|---------------|------------|---------------|---------------------|
| RCA-1-60-GGBFS-20| 60      | 747.70      | 268.8          | 498.46      | 67.2          | 659        | 148           | 3.36                |
| RCA-2-60-GGBFS-20| 60      | 747.70      | 268.8          | 498.46      | 67.2          | 659        | 148           | 5.04                |
| RCA-3-60-GGBFS-20| 60      | 747.70      | 268.8          | 498.46      | 67.2          | 659        | 148           | 5.04                |
| RCA-4-60-GGBFS-20| 60      | 747.70      | 268.8          | 498.46      | 67.2          | 659        | 148           | 5.04                |
| RCA-5-60-GGBFS-20| 60      | 747.70      | 268.8          | 498.46      | 67.2          | 659        | 148           | 5.04                |
| RCA-1-100-GGBFS-30| 100    | 1246.16     | 235.2          | -           | 100.8         | 659        | 148           | 5.04                |
| RCA-2-100-GGBFS-30| 100    | 1246.16     | 235.2          | -           | 100.8         | 659        | 148           | 6.72                |
| RCA-3-100-GGBFS-30| 100    | 1246.16     | 235.2          | -           | 100.8         | 659        | 148           | 6.72                |
Table 2 Mix of one cubic meter of concrete with RCA and FA

| Mix Id      | RCA (%) | RCA (Kg/m³) | Cement (Kg/m³) | NCA (Kg/m³) | FA (Kg/m³) | NFA (Kg/m³) | Water (Kg/m³) | Plasticizer (Kg/m³) |
|-------------|---------|-------------|----------------|-------------|------------|-------------|---------------|---------------------|
| RCA-1-60-FA-10 | 60      | 747.70      | 302.4          | 498.46      | 33.6       | 659         | 148           | 3.36                |
| RCA-2-60-FA-10 | 60      | 747.70      | 302.4          | 498.46      | 33.6       | 659         | 148           | 5.04                |
| RCA-3-60-FA-10 | 60      | 747.70      | 302.4          | 498.46      | 33.6       | 659         | 148           | 5.04                |
| RCA-4-60-FA-10 | 60      | 747.70      | 302.4          | 498.46      | 33.6       | 659         | 148           | 5.04                |
| RCA-5-60-FA-10 | 60      | 747.70      | 302.4          | 498.46      | 33.6       | 659         | 148           | 5.04                |
| RCA-1-100-FA-20 | 100     | 1246.16     | 442.4          | -           | 67.2       | 659         | 148           | 5.04                |
| RCA-2-100-FA-20 | 100     | 1246.16     | 442.4          | -           | 67.2       | 659         | 148           | 6.72                |
| RCA-3-100-FA-20 | 100     | 1246.16     | 442.4          | -           | 67.2       | 659         | 148           | 6.72                |
| RCA-4-100-FA-20 | 100     | 1246.16     | 442.4          | -           | 67.2       | 659         | 148           | 6.72                |
| RCA-5-100-FA-20 | 100     | 1246.16     | 442.4          | -           | 67.2       | 659         | 148           | 6.72                |

Nomenclature of mixes
In this study, one control concrete (natural aggregate) and 30 (recycled concrete aggregate) mixes are created. The nomenclature of the content is shown below.
NCA-1-60-0
Wherever NAC refers to NAC, first '1' refers to the source of aggregate and second '60' refers to aggregate % replacement of NA by RA, and third '0' refers to % of a mineral admixture.
NCA-2-60-0
Where NAC refers to NAC, first '2' refers to the source of aggregate and second '60' refers to aggregate % replacement of NA by RA, and third '0' refers to % of a mineral admixture.
NCA-3-60-0
Where NAC refers to NAC, first '3' refers to the source of aggregate and second '60' refers to aggregate % replacement of NA by RA, and third '0' refers to % of a mineral admixture.
NCA-4-60-0
Where NAC refers to NAC, first '4' refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘0’ refers to % of a mineral admixture.

NCA-5-60-0
Where NAC refers to NAC, first '5' refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘0’ refers to the replacement of cement % of a mineral admixture.

NCA-1-100-0
Where NAC refers to NAC, first '1' refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘0’ refers to % of a mineral admixture.

NCA-2-100-0
Where NAC refers to NAC, first '2' refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of natural aggregate by RA, and third ‘0’ refers to % of a mineral admixture.

NCA-3-100-0
Where NAC refers to NAC, first '3' refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of natural aggregate by RA, and third ‘0’ refers to % of a mineral admixture.

NCA-4-100-0
Where NAC refers to NAC, first '4' refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of natural aggregate by RA, and third ‘0’ refers to % of a mineral admixture.

NCA-5-100-0
Where NAC refers to NAC, first '5' refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘0’ refers to the replacement of cement % of a mineral admixture.

NCA-1-60-GGBFS-20
Where NAC refers to NAC, first '1' refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘20’ refers to cement % of GGBFS.

NCA-2-60-GGBFS-20
Where NAC refers to NAC, first '2' refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘20’ refers to cement % of GGBFS.

NCA-3-60-GGBFS-20
Where NAC refers to NAC, first '3' refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘20’ refers to cement % of GGBFS.

NCA-4-60-GGBFS-20
Where NAC refers to NAC, first '4' refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘20’ refers to cement % of GGBFS.

NCA-5-60-GGBFS-20
Where NAC refers to NAC, first '5' refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘20’ refers to the replacement of cement % with GGBFS.

NCA-1-100-GGBFS-30
Where NAC refers to NAC, first '1' refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘30’ refers to the replacement of cement % with GGBFS.

NCA-2-100-GGBFS-30
Where NAC refers to NAC, first '2' refers to the source of aggregate, and second ‘100’ refers to aggregate % replacement of NA by recycling RA

NCA-3-100-GGBFS-30
Where NAC refers to NAC, first '3' refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘30’ refers to cement % of GGBFS.
NCA-4-100-GGBFS-30
Where NAC refers to NAC, first ‘4’ refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘30’ refers to cement % of GGBFS.
NCA-5-100-GGBFS-30
Where NAC refers to NAC, first ‘5’ refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘30’ refers to cement % of GGBFS.
NCA-1-60-FA-10
Where NAC refers to NAC, first ‘1’ refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘10’ refers to cement % of FA.
NCA-2-60-FA-10
Where NAC refers to NAC, first ‘2’ refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘10’ refers to cement % of FA.
NCA-3-60-FA-10
Where NAC refers to NAC, first ‘3’ refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘10’ refers to cement % of FA.
NCA-4-60-FA-10
Where NAC refers to NAC, first ‘4’ refers to the source of aggregate and second ‘60’ refers to aggregate % replacement of NA by RA, and third ‘10’ refers to cement % of FA.
NCA-5-60-FA-10
Where NAC refers to NAC, first ‘5’ refers to the source of aggregate and second ‘60’ refers to aggregate percent replacement of NA by RA, and third ‘10’ refers to cement % of FA.
NCA-1-100-FA-20
Where NAC refers to NAC, first ‘1’ refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘20’ refers to cement % of FA.
NCA-2-100-FA-20
Where NAC refers to NAC, first ‘2’ refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘20’ refers to cement % of FA.
NCA-3-100-FA-20
Where NAC refers to NAC, first ‘3’ refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘20’ refers to cement % of FA.
NCA-4-100-FA-20
Where NAC refers to NAC, first ‘4’ refers to the source of aggregate and second ‘100’ refers to aggregate % replacement of NA by RA, and third ‘20’ refers to cement % of FA.
NCA-5-100-FA-20
Where NAC refers to NAC, first ‘5’ refers to the source of aggregate and second ‘100’ refers to aggregate percent replacement of NA by RA, and third ‘20’ refers to cement % of FA.

3. Experimental
3.1 Density
Fig. shows that variation of density of concrete mixes containing percentages of RCA. The density of CC is 2496 kg/m³, and it falls to R-1 to R-5 for RAC-60 percent (2456kg/m³, 2443 kg/m³, 2423 kg/m³, 2415kg/m³ and 2435kg/m³), R-1 to R-5 for RAC-100 percent (2352kg/m³, 2342 kg/m³, 2358 kg/m³, 2347 kg/m³, 2336 kg/m³) NCA is exchanged with RCA. The lighter weight and porous nature of the old mortar attached to RCA accounts for the reduction in density in both phase. The reduction in RAC density is 1.60 percent, 2.12 percent, 2.92 percent, 3.25 percent and 2.44 percent for 60 percent, and 5.77 percent, 6.17 percent, 5.52 percent, 5.97 percent, 6.41 percent for 100 percent of RCA.
Table 3 Percentage decrease in density with RCA

| Sr. No. | Mix ID       | Density in kg/m³ | % loss in density |
|---------|--------------|------------------|-------------------|
| 1.      | Control Concrete | 2496            | -                 |
| 2.      | RCA-1-60     | 2456            | 1.60              |
| 3.      | RCA-2-60     | 2443            | 2.12              |
| 4.      | RCA-3-60     | 2423            | 2.92              |
| 5.      | RCA-4-60     | 2415            | 3.25              |
| 6.      | RCA-5-60     | 2435            | 2.44              |
| 7.      | RCA-1-100    | 2352            | 5.77              |
| 8.      | RCA-2-100    | 2342            | 6.17              |
| 9.      | RCA-3-100    | 2358            | 5.52              |
| 10.     | RCA-4-100    | 2347            | 5.97              |
| 11.     | RCA-5-100    | 2336            | 6.41              |

Fig.1 Variation in density of concrete mixtures with RCA-60% to 100%

The NCA replace with 60 percent RCA are substituted in (R-1 to R-5); the density of RAC with 20 percent of GGBFS decreases by 1.24 percent, 1.60 percent, 2.20 percent, 2.80 percent and 1.60 percent. The NCA replace with 100 percent RCA are substituted in (R-1 to R-5); the density of RAC with 30 percent of GGBFS decreases by 5.52 percent, 4.80 percent, 4.61 percent, 5.60 percent and 4.49 percent. This decrease in density is mainly due to the RCA lower specific gravity and higher water absorption ration compare to NCA and lower specific gravity of GGBFS comparison to that of OPC.

Table 4 Percentage Decrease in Density with RCA and GGBFS

| Sr. No. | Mix ID          | Density in kg/m³ | % loss in density |
|---------|-----------------|------------------|-------------------|
| 1.      | Control Concrete | 2496            | -                 |
| 2.      | RCA-1-60-GGBFS-20 | 2465          | 1.24              |
| 3.      | RCA-2-60-GGBFS-20 | 2456          | 1.60              |
Fig. 2 Variation in density of concrete mixtures RCA-60% with GGBFS-20% and RCA-100% with GGBFS-30%

If 10 percent (with RCA-60%), and 20 percent (with RCA-100%) of OPC becomes substituted by FA the density of RCA concrete decreases by 0.72 percent, 1.60 percent, 2.16 percent, 1.00 percent, 1.24 percent and 4.40 percent, 4.73 percent, 5.29 percent, 4.81 percent, 6.05 percent. Finer FA, which acts as a filler material, can penetrate into the aggregates to make the concrete denser, the fineness of the FA has an effect on density. The FA in the first one is finer than that was used in the second, which is why the existing concrete is heavier.

Table 5 Percentage decrease in density with RCA and FA

| Sr. No. | Mix ID     | Density in kg/m³ | % loss in density |
|---------|------------|------------------|-------------------|
| 1       | Control Concrete | 2496              | -                 |
| 2       | RCA-1-60-FA-10 | 2478              | 0.72              |
| 3       | RCA-2-60-FA-10 | 2456              | 1.60              |
| 4       | RCA-3-60-FA-10 | 2442              | 2.16              |
| 5       | RCA-4-60-FA-10 | 2471              | 1.00              |
| 6       | RCA-5-60-FA-10 | 2465              | 1.24              |
| 7       | RCA-1-100-FA-20| 2386              | 4.40              |
| 8       | RCA-2-100-FA-20| 2378              | 4.73              |
| 9       | RCA-3-100-FA-20| 2364              | 5.29              |
| 10      | RCA-4-100-FA-20| 2376              | 4.81              |
| 11      | RCA-5-100-FA-20| 2345              | 6.05              |
Fig.3 Variation in Density of Concrete mixtures RCA-60% with FA-10% and RCA-100% with FA-20%

3.2 Water Absorption

The effect of RAC with 60 percent and 100 percent on the water absorption quality for concrete mixes formulated for different RCA compositions during 28 days. Control concrete consumes 2.12 percent of water, rising (R-1 to R-5) to 9.43 percent, 8.96 percent, 11.32 percent, 9.90 percent and 10.38 percent for 60 percent RCA. As the increase level of RCA than same scenario increase percentage of water absorption as RCA-100 water absorption of RCA like as (R-1 to R-5) 18.86 percent, 17.45 percent, 18.39 percent, 19.81 percent and 16.03 percent. This increase in water absorption in RAC is due to the fact that RCA will have a higher water absorption capacity that NCA.

Table 6 Percentage Increase in Water Absorption with RCA

| Sr. No. | Mix ID     | Absorption of water | % absorption of water |
|---------|------------|---------------------|-----------------------|
| 1.      | Control Concrete | 2.12                | -                     |
| 2.      | RCA-1-60   | 2.32                | 9.43                  |
| 3.      | RCA-2-60   | 2.31                | 8.96                  |
| 4.      | RCA-3-60   | 2.36                | 11.32                 |
| 5.      | RCA-4-60   | 2.33                | 9.90                  |
| 6.      | RCA-5-60   | 2.34                | 10.38                 |
| 7.      | RCA-1-100  | 2.52                | 18.86                 |
| 8.      | RCA-2-100  | 2.49                | 17.45                 |
| 9.      | RCA-3-100  | 2.51                | 18.39                 |
| 10.     | RCA-4-100  | 2.54                | 19.81                 |
| 11.     | RCA-5-100  | 2.46                | 16.03                 |
So 20 percent GGBFS with 60 percent RCA is being used, the water absorption as towards 4.25 percent, 5.19 percent, 3.30 percent, 5.66 percent, 2.36 percent and as 30 percent GGBFS with 100 percent RCA is being used, the water absorption of increases towards 5.66 percent, 7.08 percent, 4.72 percent, 8.96 percent and 6.13 percent. It can be observed that the GGBFS seems to be effective in reducing the water absorption of RAC. It's obvious that the GGBFS is more effective at reducing RAC moisture content than at decreasing NAC water absorption. Because the finer GGBFS molecules that fill the pores and make the RCA denser, the pores in the RAC are distributed. The above analysis of results suggests which applying 20 to 30 percent GGBFS to NAC reduces water absorption, which would be primarily due to a start processing of fine GGBFS grains. Moreover, because the RCA is porous in nature, the blocking of pores in RCA due to the filling effect of GGBFS particles is more evident than in NCA. The stimulation of GGBFS in the absence with cement resulted in the formation of secondary compressive strength gel that covers any gaps throughout the concrete but enhances moisture content. Moreover, the finer particles of GGBFS are also having certain positive effect on blocking the pores and making the concrete microstructure denser due to which the water absorption is reduced. However, some amounts of GGBFS remain unused with increasing up-to 60 percent, after being expended through the silicate stage of GGBFS. These unused GGBFS leaches out with time leaving the empty pores. Hence, these additional pores increase the water absorption in the RAC for 30 percent GGBFS.

| Sr. No. | Mix ID          | Absorption of water | % absorption of water |
|--------|-----------------|---------------------|-----------------------|
| 1.     | Control Concrete| 2.12                | -                     |
| 2.     | RCA-1-60-GGBFS-20| 2.21               | 4.25                  |
| 3.     | RCA-2-60-GGBFS-20| 2.23               | 5.19                  |
| 4.     | RCA-3-60-GGBFS-20| 2.19               | 3.30                  |
| 5.     | RCA-4-60-GGBFS-20| 2.24               | 5.66                  |
| 6.     | RCA-5-60-GGBFS-20| 2.17               | 2.36                  |
| 7.     | RCA-1-100-GGBFS-30| 2.24              | 5.66                  |
FA remains presented up to 10 percent in adding to 60 percent RCA, it remains create that the water absorption engagement 5.19 percent, 6.60 percent, 4.72 percent, 5.19 percent and 3.77 percent content. The water absorption of concrete comprising 100 percent RCA with 20 percent FA develops 7.55 percent, 9.43 percent, 8.02 percent, 10.38 percent and 8.02 percent.

The above analysis of results proposes that applying 10 to 20 percent FA to NAC reduces water absorption, which would be mainly due to a start processing of FA grains. Furthermore, because the RCA is porous in nature, the blocking of pores in RCA due to the filling effect of FA particles is additional evident than in NCA. The presenting an appropriate of FA, like up to 20 percent in this case, the water absorption of RCA with 30 percent of FA can be reduced. The encouragement of FA in the absence with cement resulted in the creation of secondary compressive strength gel that covers several gaps through the concrete but improves moisture content. The amounts of FA continue unused with growing up-to 30 percent, and then being consumed finished the silicate stage of FA. Later, these extra pores increase the water absorption in the RAC for 20 percent with FA.

Table 8 Percentage Water Absorption with RCA and FA

| Sr. No. | Mix ID          | Water Absorption | Percentage Water Absorption |
|---------|-----------------|------------------|----------------------------|
| 1.      | Control Concrete| 2.12             | -                          |
| 2.      | RCA-1-60-FA-10  | 2.23             | 5.19                       |
| 3.      | RCA-2-60-FA-10  | 2.26             | 6.60                       |
| 4.      | RCA-3-60-FA-10  | 2.22             | 4.72                       |
| 5.      | RCA-4-60-FA-10  | 2.23             | 5.19                       |
| 6.      | RCA-5-60-FA-10  | 2.20             | 3.77                       |
| 7.      | RCA-1-100-FA-20 | 2.28             | 7.55                       |
| 8.      | RCA-2-100-FA-20 | 2.32             | 9.43                       |
| 9.      | RCA-3-100-FA-20 | 2.29             | 8.02                       |
| 10.     | RCA-4-100-FA-20 | 2.34             | 10.38                      |
4. Conclusion

- All the control mix and mix with partial replacement of coarse aggregate by 60-100 percent with RCA creates practicable through an essential w/c ratio such as IS: 456: 2000 for grade of concrete.
- The workability in terms of compaction factor shows satisfactory results in the range of 0.85 to 0.90 on an average for concrete grade M-20 to M-40. This is as per the specified limit 0.8 to 0.92 in IS: 456: 2000.
- The workability in terms of slump shows satisfactory results in the range of 75mm to 89mm on an average for concrete grade M-20 to M-40. This is as per the specified limit 75 to 95mm in IS: 456: 2000.
- For all the design mix of NA replace by NCA gives the optimum value of a compaction factor in the range of 0.86 to 0.92 on an average as indicated in the graphical comparative presentation.
- Further replacement beyond 60 percent reduces the workability leading to bleeding, segregation and honeycombing.
- From the physical observation, w/c ratio and compaction factor results of RCA, the concrete can be utilized for ready mix applications.
- The density of dry concrete falls in the range of 60 percent of RCA lies 2415 to 2456 kN/m³ and 100 percent of RCA lays 2336 and 2358 kN/m³. It is as per the standard value 24.00 kN/m³.
- The density of dry concrete falls in the range of 60 percent of RCA with 20 percent of GGBFS lies 2426 kN/m³, 2465 kN/m³ and 100 percent of RCA with 30 percent of GGBFS lies 2356 kN/m³, 2384 kN/m³. It is as per the standard value 24.00 kN/m³.
- The density of dry concrete falls in the range of 60 percent of RCA with 20 percent of FA lies 2426 kN/m³, 2465 kN/m³ and 100 percent of RCA with 20 percent of FA 2442 to 2478 kN/m³ and 2345 to 2386 kN/m³. It is as per the standard value 24.00 kN/m³.
- The water absorption of dry concrete falls in the range of 60 percent of RCA lies 8.96 to
11.32 percent and 100 percent of RCA lays 16.03 to 18.86 percent of control concrete.

- The water absorption of dry concrete falls in the range of 60 percent of RCA with 20 percent of GGBFS lies 2.36 to 15.661.32 percent and 100 percent of RCA with 30 percent of GGBFS lays 4.72 to 8.96 percent of control concrete.

- The water absorption of dry concrete falls in the range of 60 percent of RCA with 20 percent of FA lies 3.77 to 6.60 percent and 100 percent of RCA with 20 percent of FA lays 7.55 to 10.38 percent of control concrete.

Reference
[1] Lauritzen, E. K. (2004). International RILEM Conference on the Use of Recycled Materials in Buildings and Structures (Volume 1) (Vol. 1, p. 297). RILEM Publications.
[2] Kumar, V., & Jain, P. K. (2002). Commercializing new technologies in India: a perspective on policy initiatives. Technology in Society, 24(3), 285-298.
[3] Sridhar, K. S., & Kumar, S. (2013). India’s urban environmental challenges: Land use, solid waste and sanitation. Yojana, 31.
[4] Faruqi, M. H. Z., & Siddiqui, F. Z. (2020). A mini review of construction and demolition waste management in India. Waste Management & Research, 38(7), 708-716.
[5] Tam, V. W., & Tam, C. M. (2007). Assessment of durability of recycled aggregate concrete produced by two-stage mixing approach. Journal of Materials Science, 42(10), 3592-3602.
[6] Shang, H. S., Zhao, T. J., & Cao, W. Q. (2015). Bond behavior between steel bar and recycled aggregate concrete after freeze–thaw cycles. Cold Regions Science and Technology, 118, 38-44.
[7] Yehia, S., Helal, K., Abusharkh, A., Zaher, A., & Istaitiyeh, H. (2015). Strength and durability evaluation of recycled aggregate concrete. International journal of concrete structures and materials, 9(2), 219-239.
[8] Tam, V. W., Gao, X. F., Tam, C. M., & Chan, C. H. (2008). New approach in measuring water absorption of recycled aggregates. Construction and building materials, 22(3), 364-369.
[9] Ismail, S., & Ramli, M. (2013). Engineering properties of treated recycled concrete aggregate (RCA) for structural applications. Construction and Building Materials, 44, 464-476.
[10] Al-Yaqout, A., El-Hawary, M., Nouh, K., & Khan, P. B. (2020). Corrosion Resistance of Recycled Aggregate Concrete Incorporating Slag. ACI Materials Journal, 117 (3).
[11] Ju, M., Jeong, J. G., Palou, M., & Park, K. (2020). Mechanical behavior of fine recycled concrete aggregate concrete with the mineral admixtures. Materials, 13 (10), 2264.