MANTECH Publications

Journal of Ceramics and Concrete Technology
Volume 8 Issue 3
ISSN No: 2457-0826 (Online)

Influence of Fly Ash on Slump Loss & Strength of Concrete Fully Incorporated With Recycled Aggregates

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Abstract

The infrastructure of a country or state depends on the development of innovative ventures constructed in that state/ country. Due to increase in construction the natural aggregates are depleting day by day. So the recycling technique is adopted in construction field. Recycled coarse aggregate (RCA) is one of the approaches for this need. The strength of concrete decrease with increase in the percentage of recycled coarse aggregate but there are methods to increase the strength of recycled concrete aggregate (RCA) such as surface treatments, two stage mixing and pozzolanic material. In this project the method of using pozzolanic material and two stage mixing method is studied, here fly ash is used as pozzolanic material. The paper investigates about the effect of replacement of fly ash on fresh and hardened properties of recycled aggregate concrete. Most of the research work done on replacement of coarse aggregate with recycled aggregates about 25%, 50%, 75% & 100% and fly ash is used to replace ordinary Portland cement by 10% & 20% to improve the workability and strength of recycled aggregate concrete. The compressive strength and split tensile strength of recycled aggregate concrete is compared with the conventional concrete.

Keywords: *Compressive strength, fly ash, ordinary Portland cement, Recycled coarse aggregate, Split tensile strength.*

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INTRODUCTION

Concrete is the most commonly used construction material due to its sustainability, durability, versatility etc. It is highly used in the construction of buildings, bridges, and pavements. The various constituents of concrete are cement, fine aggregate, coarse aggregate, and water in which 5% of the world's CO is produced during the manufacture of the cement. In addition, the concrete is heavy, thus in order to reduce the self-weight of the structure, some portion of the concrete needs to be removed. Hence, to achieve this, a new type of concrete is introduced called Bubble deck concrete. Bubble deck concrete is a type of concrete in which some amount of the concrete is replaced by the plastic hollow bubbles, which are made by the waste plastic material that reduces the self-weight of the structure and reduces the CO emission. The main advantage of using Bubble deck slab is that it can be highly used for large-span structures, large overhang areas, and it can be used where only fewer supporting points (like columns and walls) are available for the slab [1–7].



Fig.1.1 Concrete

In this project, Bubble deck slab is cast by using hollow balls made by recycled plastic. It is an innovator method of virtually eliminating the concrete part below the neutral axis of Conventional slab, which does not contribute to the tensile strength of the member. By introducing this recycled plastic in the concrete, there is nearly one-third reduction in the weight of Bubble deck concrete compared to Conventional concrete. This reduction in slab

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weight reduces the load acting on the beams, walls, and columns, which in turn reduces the size of the beam, column, and other structural components of the building Water has to be applied for few days over the concrete surface soon after its setting because the Hydration reactions between cement and water will continue for a longer period due to which hardening of concrete takes place. This period over which concrete is kept moist during which concrete gains strength is called curing period.

Hence, the strength of concrete increases with age. The process of solidification of concrete from plastic stage is called setting while gaining of strength after setting called hardening. Usually, setting completes with in maximum duration of 10 hours, which about 90% of hardening is completed by 28 days. The properties and quality of cement concrete are influenced by the properties of its ingredients and quality control maintained during its making and curing. Hence, it is necessary to study the properties of ingredients of concrete. Concrete structures have become very common in Civil engineering construction. Concrete has established as universal building material because of its high compressive strength, its adoptability to take any form of shape, resistant to fire and corrosion, and abundant availability of its constituent materials with negligible maintenance cost. Concrete is utilized in building structures in the form of plain concrete, reinforced concrete and pre-stressed concrete. It is estimated that the global production of concrete is at an annual rate of 1m3 (approximately 2.5 tones) per capita (Neville 2003). The global consumption of natural aggregate (NA) will be in the range of 8-12 billion tones after 2020.

Advantages of Concrete

- Concrete is Economical
- Concrete Hardens at Ambient Temperature
- Ability to be cast into Shape
- Energy Efficiency in Production
- Excellent Water Resistance Characteristics, High-temperature resistance.
- Ability to Consume and Recycle wastage.
- Application in Reinforced concrete.
- Multimode Application.
- Low or Zero maintenance required.

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Disadvantages of Concrete

- Concrete is Quasi brittle material.
- Low tensile Strength.
- Concrete has low Tensile Strength.
- Concrete has low Toughness.

Aggregates:

Aggregates are the most important elements for the concrete. They add shape, body and strength to the concrete. They occupy about 70% of the Volume of concrete. They also enhance the Bulk Density of Concrete.

Fine Aggregate:

The Aggregate passing through IS: 4.75 mm sieve could be called as Fine Aggregate as shown. Generally, Fine Aggregate is a filling material for the Concrete. The Fine Aggregate used for this project is River Sand. The Specific Gravity of Fine Aggregate is 2.4 to 2.6.

Physical & Chemical Properties of POFFA

Various forms of agricultural waste have different physical & chemical qualities that, with careful selection, could be used in concrete. Table 1 shows the chemical composition & physical features of various POFFA utilized in various research studies. POFFA is mostly composed of SiO2, which accounts for more than half of its chemical composition. The total amount of SiO2, Al2O3, and Fe2O3 in most of the ashes was less than 70%, although ASTM C618 (ASTM, 2001). This should be at least 70% for class N pozzolan, according to the specification. The chemical composition of all of these ashes is nearly identical. POFFA is significantly finer than OPC, as shown in this table. Based on the chemical analysis, all of the POFFA met the pozzolana requirement in general and may be classified as class C pozzolans according to ASTM C618 (ASTM, 2001). Other studies have also recommended this class (Chindaprasirt, 2007; Tay, 1990).

Figure 2 depicts the particle size distribution of OPC, Fly ash (OFA), Palm oil fuel ash (GPOA), & Ground rice bark ash (GRBA). This image illustrates that after grinding, the POFFA has a grading curve that is comparable to that of the OPC. As demonstrated in Table-1, the grinding procedure enhanced the fineness & specific gravity of POFFA. This occurred

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as a result of the crushing of porous particles with low specific gravity into smaller particles with decreasing porosity (Cheerarot, 2004). Other investigators who ground fly ash & bottom ash came to the same conclusion (Kiattikomol, 2001; Isaia, 2003).

Coarse Aggregate:

The Aggregate passing through IS: 20 mm sieve and retained on IS: 4.75mm sieve could be called as Coarse Aggregate. Generally, Coarse Aggregate is a material that enhances the strength and stability for the Concrete. The Coarse Aggregate used for this project is from Miyapur Quarry as shown The Specific Gravity of Fine Aggregate is 2.4 to 2.6.



Fig.1.2 Fine aggregate



Fig.1.3 Coarse aggregate

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On the other hand, aggregate in fact, is known to play a substantial role in determining workability, strength, dimensional stability, and durability of the concrete. Due to their bonded mortar, recycled concrete aggregates have a lower specific gravity and a higher water absorption capacity compared to natural aggregates. The compressive strength varies with the compressive strength of the old concrete and the water-cementing materials ratio (w/c) of the new concrete.

While recycling old concrete into aggregate, a relatively simple process which involves breaking, removing, and crushing existing concrete into a material with a specified size and quality. The properties of concrete made with recycled concrete aggregate (RCA) are strongly dependent on the quality of the recycled materials used as well as the primary concrete crushed. Indeed, extracting virgin aggregates is causing huge damage to the environment and considerable energy is required for both extraction as well as crushing processes.



Fig.1.4.Recycled concrete aggregates

After the removal of contaminants through selective demolition, screening, and/or air separation and size reduction in a crusher to aggregate sizes, crushed concrete can be used as new concrete for pavements, shoulders, median barriers, sidewalks, curbs and gutters, and

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bridge foundations; structural grade concrete; soil-cement pavement bases; moulded concrete bricks and blocks; bituminous concrete etc. However, there is an example of recycled concrete being used for part of the structural slabs in a high-rise building in Japan but there was no too much detail available on this project. According to research that has been conducted in Australia, current use of recycled aggregates is still only around 7% of road construction material in South Australia. national highway authority of India (NHAI) also use recycled aggregate for their The use of Recycled Concrete Aggregates has been encouraged in various countries in their own ways. In United States, Recycled Aggregates is produced by aggregate producers, contractors, and debris recycling centres for which they are given inducement. In Hong Kong and Taiwan, an experimental C & D material recycling station has been established by the government with a daily handling capacity of 2400 tonnes, this produced recycled aggregates were used in government projects, relevant research and development work.

Equipments Used In Recycled Concrete



Asphalt recycle grinding machine

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Grinding machine for concrete

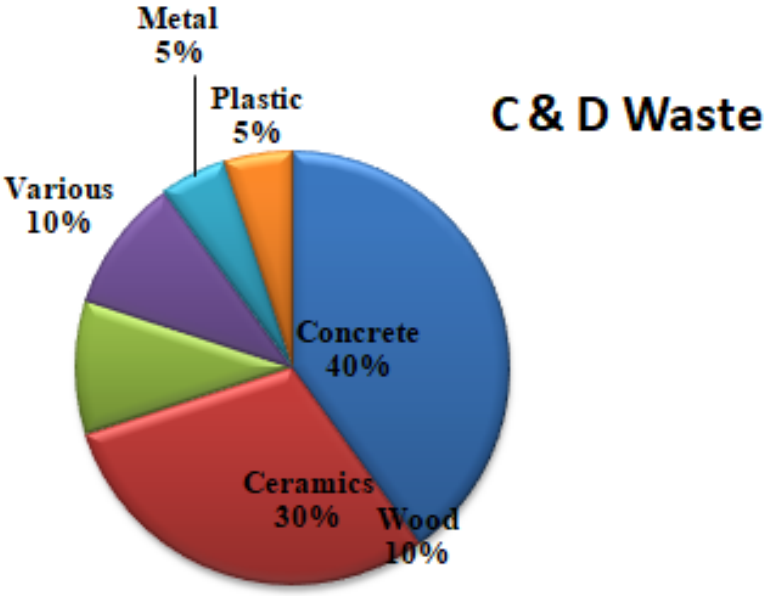
Strength of Reinforced Concrete with Recycled Coarse Aggregate

Strength of reinforced concrete is defined as the maximum load or stress it can carry. Concrete is strong in compression but weak in tension. Because of this, concrete structures with exception of pavement are designed on the assumption that concrete carries little or no tension but carries compression, while reinforcements (steel) are designed to withstand tension.

With the rapid advancement of concrete technology, high strength concrete is being increasingly widely used in the construction of high-rise buildings and other reinforced concrete structures. However, the tensile and shear strength of high strength concrete do not increase in proportion with the compressive strength. And of the two strength properties, the shear strength is of particular importance because the tensile strength is not normally relied on for carrying load but shear is unavoidable in beam column framework. Although there has been a rapid growth of interest in high strength concrete, current specifications for the shear strength of reinforced concrete beams in the American concrete institute [ACI] Building code

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and British standard are based on results of beam tests done using concrete with relatively low compressive strength.



Compressive Strength of Concrete with RCA

The compressive strength of concrete is evaluated by the concrete's 28 days cube strength. BS requires that the specimen load per unit area sustained by a concrete specimen before it fails in compression. BS stipulates that the usual test is the crushing of a 150mm cube in a compression machine loaded at the rate of 15Nmm-2 without reinforcement. However, when the maximum size of aggregate does not exceed 19mm. 100mm cubes can be used for laboratory work. Most structural concrete are proportioned to have strength of 20-30Nmm-2at 28 days.

Tensile Strength of Concrete with RCA

This is of great importance in the design of concrete roads, railways etc. Concrete members are also required to withstand tensile stresses resulting from restraint to contraction due to drying or temperature variation.

Unlike metals it is difficult to measure concrete strength in direct tension and indirect methods have been developed for assessing this property. The concrete strength in direct tension is evaluated by "split cylinder test". This method entails diametrically loading a concrete cylinder in compression along its entire length. The load induces tensile stress over

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the loaded diametrical plane and the cylinder splits along the loaded diameter. The magnitude of the induced tensile stress at failure.

Flexural Strength of Concrete with RCA

The flexural strength of concrete is known as the modulus of rupture that is used to evaluate tensile strength as determined from tests on beams. The standard size of beams for flexural tests according to (BS 1881) is 150mm x 150mm x 700mm. However, the American society for testing materials (A.S.T.M) stipulates that the length of the beam should be at least 50mm longer than three times its depth and its width should be not more than one and half times its depth. The minimum depth of width should be at least three times the maximum size of aggregate and not less than 50mm. This is determined from simply supported beam loaded at the three points. The resulting bending moment induces compressive and tensile stresses in the top and bottom of the beam respectively.

5 Process of Making Recycled Aggregate Concrete

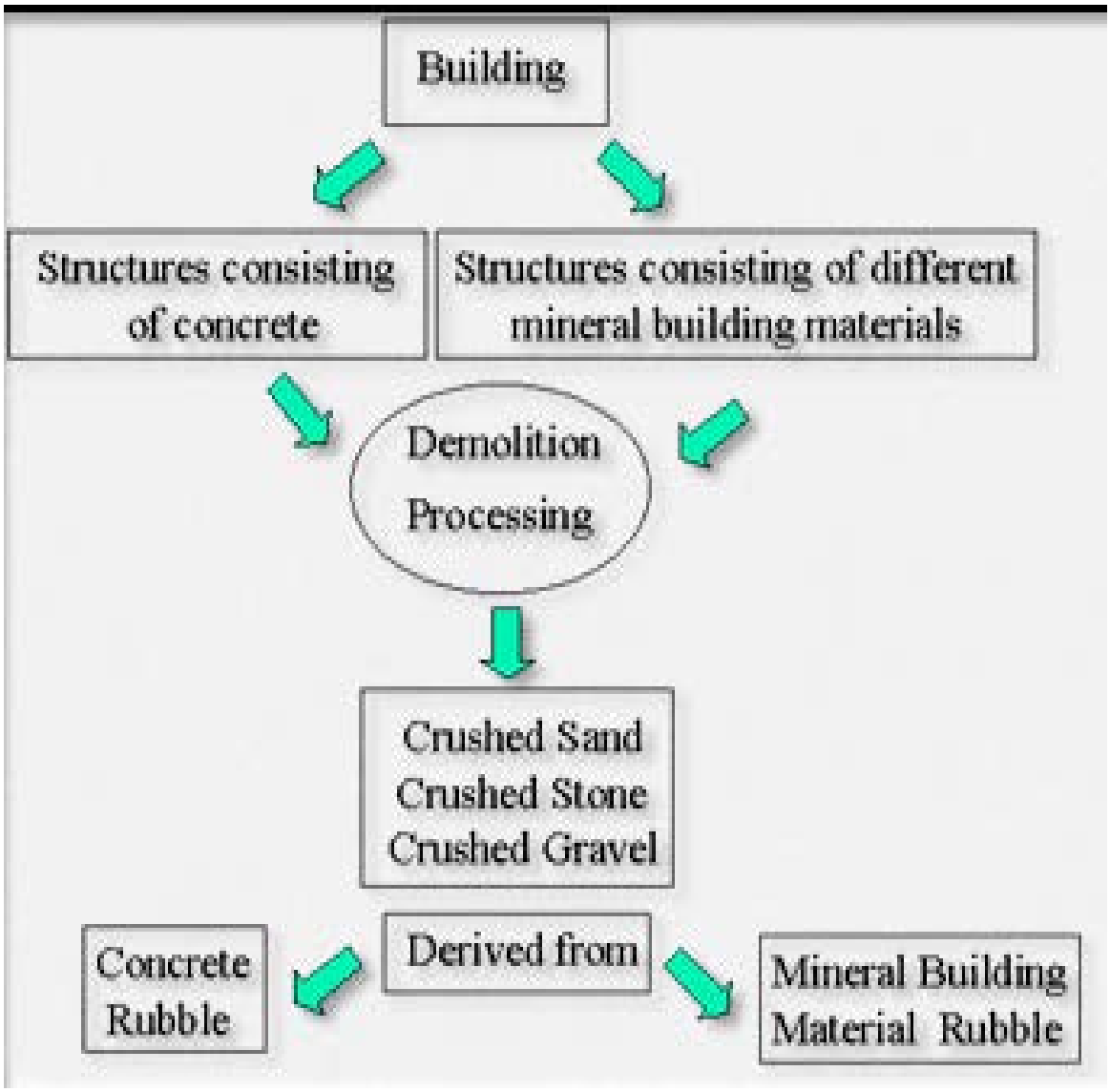
Steps involved in recycled aggregate concrete:-

- Crushing
- Pre-sizing
- Sorting
- Screening
- Contaminant elimination

Production Sequence of RAC:-

1. Crushing and screening systems start with primary jaws, cones and/or large impactor taking rubble from 30 inches to 4 feet.
2. A secondary cone or impactor may or may not need to be 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.
3. A scalping screen will remove dirt and foreign particles. A fine harp deck screen will remove fine material from coarse aggregate.
4. Further cleaning is necessary to ensure the recycled concrete product is free of dirt, clay, wood, plastic and organic materials.
5. This is done by water

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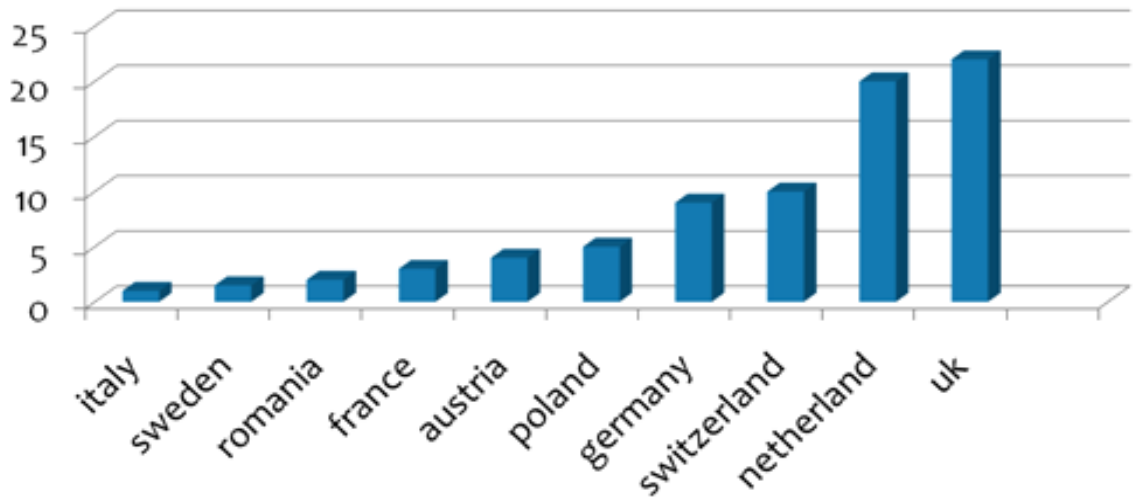


FLOW CHART OF RECYCLING PROCESS

Applications of Recycled Aggregate Concrete (RAC)

1. Smaller pieces of concrete are used as gravel for new construction projects.
2. Sub-base gravel is laid down as the lowest layer in a road, with fresh concrete or asphalt poured over it. The US Federal Highway Administration may use techniques such as these to build new highways from the materials of old highways.
3. Crushed recycled concrete can also be used as the dry aggregate for brand new concrete if it is free of contaminants. Also, concrete pavements can be broken in place and used as a base layer for an asphalt pavement through a process called rubblization.
4. Larger pieces of crushed concrete can be used as riprap revetments, which are "a very effective and popular method of controlling stream bank erosion.

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Uses of RAC in different parts of world

NECESSITY FOR THE USE OF RCA

The need for the production and use of RCA [3–8] is nowadays very urgent. This subject is considered very important especially for Greece, because there are now suitable conditions for construction of big infrastructure tures. By the production and use of RCA:

- There is an establishment of presuppositions for sub- stantial protection of natural sources of country, which are neither endless nor inexpensive.
- There is a decrease of high volumes of fresh concrete wastes, which illegally ends up in uncontrolled areas of deposition.
- The aim of sustainable development is followed and, consequently, the basis for a friendly co-existence of man and nature is set.
- A basic presupposition for the use of RCA in Greece is also the existence of a national and local policy for the treatment of building and demolition waste (BDW), which should contain answers to main questions as:
- control system of deposit of BDW with guidance's, penalties, etc.;
- definition of deposition areas, for pre-selection, treat- ment, transport of RCA, especially close to big urban centers The need for the production and use of RCA is nowadays very urgent. This subject is considered very important especially for Greece, because there are now suitable conditions for construction of big infrastructures. By the production and use of recycled concrete aggregate :
- There is an establishment of presuppositions for substantial protection of natural sources of country, which are neither endless nor inexpensive.

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- There is a decrease of high volumes of fresh concrete wastes, which illegally ends up in uncontrolled areas of deposition.

Objectives

- The objective of this study is to use demolished building wastes in construction sector successfully.
- The present study is to identify the mechanical properties of recycled coarse aggregate concrete by adding fly ash (5%, 10%, 15%, 20%.) as partial replacement cement.
- Identify the workability property of recycled coarse aggregate concrete and suggest best combination for good workability.
- Comparison of properties of concrete with different proportions of fly ash and recycled coarse aggregates and suggests the best combination.

Drawbacks

POFFA's use in cement or concrete has a number of engineering, financial, & environmental advantages that have already been discussed in this study. Despite these positive effects of POFFA in concrete, it also has certain negative impacts, which are listed below:

- When compared to OPC concrete, the use of POFFA in concrete has a comparatively significant carbonation impact.
- As Portland cement was replaced with POFFA, the water requirement in concrete mixtures increased when compared to OPC concrete.
- Concrete's strength is greatly reduced when more than 30% of it is replaced; at a young age, strength is slowly gained.
- The original coarse POFFA (lower fineness) does not help to improve concrete strength.

Future scope

- **Optimization of fly ash content**: Further research can focus on determining the optimal percentage of fly ash in concrete mixtures that fully incorporate recycled aggregates. This investigation can involve studying the influence of varying fly ash proportions on both slump loss and strength characteristics to identify the most beneficial combination.

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- **Performance evaluation over time:** The long-term performance of concrete incorporating fly ash and recycled aggregates can be studied to assess the evolution of slump loss and strength properties. This analysis would provide valuable insights into the durability and sustainability aspects of such concrete, as well as the potential impact of environmental factors.
- **Effect of curing conditions:** Investigating the effect of different curing conditions on the slump loss and strength of concrete with fly ash and recycled aggregates can be explored. This research can help determine the optimal curing techniques or treatments that mitigate slump loss and enhance strength development.

CONCLUSION

From the study following conclusions are made The strength of concrete decrease with increase in the percentage of recycle aggregate, this may be because of the loose mortar around the recycle aggregate which do not allow the proper bonding between the cement paste and aggregate. Workability of RAC concrete can be improved by replacing cement with fly ash about 10% and 20% by weight of cement. The strength (30Mpa) is generally used for a wide range of structural uses. From the present study it is concluded that by decreasing the water to cement ratio to 0.42, the above strength can be achieved through recycled aggregates and fly ash. Generally, fly ash based concrete has the ability to develop strength over prolonged periods of time. So at a long period of run the compressive strength of RAC with fly ash achieves similar strength of natural aggregate concrete by adding fly ash. In conclusion, if mixed designed RAC, especially that containing fly ash, can be an effective alternative to natural concrete for structural purposes.

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