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# Influence of Parent Concrete on Recycled Aggregate Concrete Using Pozzolanic Materials

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*ABSTRACT*

***The availability of demolished concrete is increasing day by day and natural resources are depleting due to rapid development of construction industry. To meet the requirements of the construction industry there is a need to use recycled materials from C&D wastage as an aggregate in concrete. The current specifications in many parts of the world are not able to support and encourage the recycling of C and D waste. In recent past the usage of recycled concrete aggregate has gained its peak to use as an aggregate in concrete. As the recycled the aggregate has more water absorption, and adhered mortar can be controlled by using pozzolanic materials such as met kaolin, silica fume, fly ash, slag, VCAS.***

***In the present work, the physical and mechanical properties of natural aggregate and recycled aggregate were studied and found that the properties of recycled aggregate fall within the limits. Trail mixes were carried out to achieve M20, M25, M30, M35 and M40 grades of concrete. The casted cubes after achieving the strength were crushed at 28 days of curing for recycling aggregate.***

***These recycled aggregate obtained from different grades is replaced to natural aggregate in percentages of 50%, 75% and 100% to get M25 grade of concrete. The cement also replaced with FA of 20% and SF of 10% to improve the mechanical properties.***

***It is concluded the compressive strength of M25 concrete is achieved by replacing the natural aggregate with recycled aggregate by 50% of its weight and with 20% FA and 10% SF.***

*KEY WORDS:* ***Recycled aggregate, fly ash, silica fume, compressive strength, density, water absorption.***

## INTRODUCTION

### Construction Scenario

Construction Industry of India is an important indicator of the development as it creates investment opportunities across various related sectors. The period 1950 to mid-60's witnessed the government playing an active role in development of these services. The professional consultancy company, national Industry development corporation (NIDC) was set up in the public sector in 1954. Some important elements in this respect are the reduction of the consumption of energy and natural raw materials and consumption of waste materials. Sustainable construction is to reduce the environmental impact of a constructed facility over its lifetime. Concrete is the main material used in construction in the world. Due to increase in Construction and Demolition activities worldwide, the waste concrete after the destruction of any infrastructure is not used for any purpose which is totally loss in the economy of the country because natural resource are depleting day by day. Although construction industry world-wide is promoting the use of recycled aggregates for concrete production, mainly to respond to the problem of the depletion of natural aggregates, the current specifications in many parts of the world are not able to support and encourage the recycling of C and D waste. Recycled concrete aggregates mainly differ from natural aggregates in that they are composed of two different materials: natural aggregate and cement mortar attached. Cement mortar is the origin of the worse properties of recycled aggregates: lower density, higher absorption, and Los Angeles abrasion. Recycled aggregates are also highly heterogeneous and porous, as well as contain a high content of impurities. There will however be increased costs in other areas.

## Issues Related To Sustainability In Case Of Aggregates

Crushed stone, gravel, sand and clay, known in the industry as aggregate, are essential in most of our lives. Used in concrete for buildings, asphalt for roads and even in toothpaste, aggregate is essential, but is also low in value per tonne. To keep costs in check, it must be sourced close to its end use, and therefore extraction often happens close to cities and towns.

Consequently, as urban areas expand into the countryside, there are greater conflicts over the operation of existing facilities, which may disturb new, nearby receptors. Additionally, permitting any new operations or the approval to expand existing operations is often hard to come by due to opposition from residents.

## Use of Recycled Aggregates

Materials studied in the given project include three types of aggregates. They are:

Land recovery after extraction activities was excluded from the study due to its insignificance with regards to the aim of the study.

1. The storage of aggregates was not included in the study due to the lack of available data regarding this issue.

2. The stage of aggregates use in construction was excluded due to its insignificance with regards to the objectives of the study. This stage is mostly investigated when considering and comparing the properties of selected aggregates during their life cycle (e.g. in Olsson, 2005; Mroueh, 2000 etc.). Thus when considering the whole system of aggregate provision on the regional level it was assumed that considering this stage would be too complex and at the same time not important for the achievement of the aim of the study.

3. Secondary aggregates were excluded during the Life Cycle Assessment (due to the lack of statistical data regarding this type of aggregates in the chosen regions).

## Types and Use of Pozzolanic materials

The benefits of pozzolan utilization in cement and concrete are threefold. First is the economic gain obtained by replacing a substantial part of the Portland cement by cheaper, pollution free, natural pozzolans or industrial by-products. Second is the lowering of the blended cement environmental cost associated with the greenhouse gases emitted during Portland cement production. A third advantage is the increased durability of the end product. Additionally, the increased blending of pozzolans with Portland cement is of limited interference in the conventional production process and offers the opportunity to create value by converting large amounts of industrial and societal waste into durable construction materials.The increased chemical resistance to the ingress and harmful action of aggressive solutions constitutes one of the main advantages of pozzolan blended cements. The improved durability of the pozzolan-blended binders enables to lengthen the service life of structures and reduces the costly and inconvenient need to replace damaged constructions.

- The strength of the concrete is increased
- Its density is increased
- Efflorescence is decreased
- The propensity for alkali-silica reaction (reaction with glass) is decreased, or even virtually eliminated

Depending upon the particle size, chemical composition and dosage, different pozzolans will affect the concrete strength differently and at different times during curing.

Typical pozzolans include:

- metakaolin
- silica fume
- fly ash
- slag
- VCAS (vitrified calcium alumina-silicate)
- ground recycled glass pozzolans such as Bottle-Pass, brand

Of these, silica fume is the most reactive, with meta kaolin being close to silica fume in terms of reactivity. Fly ash is less reactive, especially during the first few days of curing when less calcium hydroxide is generated.

## EXPERIMENTAL PROCEDURE

We are observed that experimental procedures the aggregate of cement properties of natural and recycled aggregates. When the properties of cement, fine and coarse aggregate of specific gravity and water absorption fineness it's all compare to natural aggregate, recycled aggregates lower at all stages. The properties and methodology included in this chapter for awareness. In methodology contain all work we were done in project area in recycled aggregates.

Determination of Fineness of cement As Per IS 4031 (Part I)-1996

- Agitate the sample of cement to remove any lumps.
- Stir the resulting powder gently using a clean brush in order to distribute the fines throughout the cement. Attach a pan under the sieve to collect the cement passing the sieve.
- Weigh approximately 10g of cement to the nearest 0.01g and place it on the sieve. Fit the lid over the sieve.
- Agitate the sieve by swirling, planetary and linear movement until no more fine material passes through it.
- Remove and weigh the residue. Express its mass as a percentage (R1) of the quantity first placed in the sieve to the nearest 0.1 percent.
- Repeat the whole procedure using a fresh 10 g sample as above to obtainR_2.
- Then calculate the residue of the cement R as the mean of R_1 and R_2 as a percentage, expressed to the nearest 0.1 percent.
- When the results differ by more than 1 percent absolute, carry out a third sieving and calculate the mean of the three values.

**TABLE3.2: Fineness of cement**

| DESCRIPTION | SAMPLE | | |
|---|---|---|---|
| | I | II | III |
| a) Weight of cement (W), g | 10 | 10 | 10 |
| b) I.S. sieve size, μ | 90 | 90 | 90 |
| c) Sieving time, min | 15 | 15 | 15 |
| d) Weight retained on sieve($W_1$), g | 0.71 | 0.99 | 0.86 |
| e) Percent weight retained on sieve =($W_1$/W)x100 | 7.1 | 9.9 | 8.6 |

Determination of Soundness of Cement As Per IS 4031 (Part 3)-1988

1. Take 300grams of cement i.e., 100g for each sample and add water of quantity 0.78*P*C, where P is standard consistency of cement paste and C is quantity of cement.
2. Apply oil for all sides of the mould to prevent loss of cement paste to the mould. Place the mould on a glass plate.
3. Now, fill the mould with cement paste, which is prepared in step 1.

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4. Cover the mould with another piece of lightly oiled glass sheet, place a small weight on this covering glass sheet and immediately submerge the whole assembly in water at a temperature of 27±2ºC and keep there for 24hours.
5. After 24hrs, measure the distance separating the indicator points to the nearest 0.5 mm.
6. After measuring, place the mould in water. Bring the water to boiling, with the mould kept submerged, in 25 to 30 minutes, and keep it boiling for three hours.
7. Remove the mould from the water, allow it to cool and measure the distance between the indicator points.
8. The difference between these two measurements indicates the expansion of the cement.

**TABLE3.3: Soundness of cement**

| DESCRIPTION | SAMPLE | | |
|---|---|---|---|
| | I | II | III |
| Weight of sample (C),g | 100 | 100 | 100 |
| Water added to the sample(0.78*P*C),% | 25.74 | 25.74 | 25.74 |
| Time at which the sample is kept in water at 27°C to 32 °C | 12.15pm | 12.15pm | 12.15pm |
| Distance between the pointer ends before heating (D1), mm | 38 | 37 | 32 |
| Time when the water is brought to boiling point | 1.00pm | 1.00pm | 1.00pm |
| Time of heating | 3hr | 3hr | 3hr |
| Distance between the pointer ends after heating (D2), mm | 34 | 35 | 33 |
| Difference (D2-D1), mm | 4 | 2 | 1 |
| Average Difference, mm | 2.33 | | |

Determination of Consistency of standard cement paste As Per IS 4031( Part 4)-1988
1. The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould.
2. Prepare a paste of weighed quantity 400g of Cement with a weighed quantity of potable or distilled water, care should be taken that the time of gauging is not less than 3 minutes, nor more than 5 minutes from the time of adding water to the cement.
3. Fill the Vicat mould with this paste, the mould resting upon a non-porous plate.
4. After completely filling the mould, smooth the surface of the paste, making it level with the top of the mould. The mould may be slightly shaken to expel the air.
5. Place the test block in the mould, together with the non-porous resting plate, under the rod bearing the plunger.
6. Lower the plunger gently to touch the surface of the test block, and quickly release, allowing it to sink into the paste.
7. Prepare trial samples with varying percentages of water and test as described above until the amount of water necessary to reach the plunger point 5 to 7 mm from the bottom of the Vicat mould.

**TABLE 3.4: Consistency of standard cement**

| S.No. | Quantity of water added (ml) | Time of gauging (minutes) | Penetration from the bottom of the mould |
|---|---|---|---|
| 1. | 92 | 5 | 42 |
| 2. | 100 | 5 | 39 |
| 3. | 108 | 5 | 36 |
| 4. | 116 | 5 | 24 |
| 5. | 124 | 5 | 13 |
| 6. | 132 | 5 | 6 |
| The Normal consistency of Standard cement paste is 33%. | | | |

Determination of initial setting time As Per IS 4031(Part 5)- 1988

1. Prepare a neat cement paste of 300gramsby adding a water of 0.85*P*C, where P is standard consistency of cement paste and C is quantity of cement.
2. Start a stop-watch at the instant when water is added to the cement.
3. Fill the Vicatmould with a cement paste gauged as above completely and smooth off the surface of the paste making it level with the top of the mould.
4. Place the test mould lower the needle gently until it comes in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block.
5. In the beginning, the needle will completely pierce the test block. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0 ± 0.5 mm measured from the bottom of the mould.
6. The period elapsing between the time when water is added to the cement and the time at which the needle fails to pierce the test block to a point 5.0 ± 0.5 mm measured from the bottom of the mould shall be the initial setting time.

The test results are given below,
Quantity of water to be added = 0.85*P*C
= 0.85*33*300
= 84.15ml.
Time at which water is first added (T1) = 10.50AM

**TABLE 3.5: Initial setting time for cement**

| S.No. | Time in minutes after water added | Penetration reading |
|---|---|---|
| 1. | 5 | 16 |
| 2. | 10 | 25 |
| 3. | 15 | 15 |
| 4. | 20 | 23 |
| 5. | 25 | 24 |
| 6. | 30 | 24 |
| 7. | 35 | 24 |
| 8. | 40 | 28 |
| 9. | 45 | 30 |
| 10. | 50 | 31 |
| 11. | 55 | 36 |

Determination of Compressive Strength of cement As Per IS 4031 (Part 6) - 1988
1. Take sample of cement and sand such that the quantity of cement and sand should be 1:3.

2. Then add water of quantity [(P/4)+3.0] of combined mass of cement and sand, whether P is the percentage of water required to produce a paste of standard consistency.

3. Mix the cement and sand with a trowel for one minute and then with water until the mixture is of uniform color.

4. The time of mixing shall be not less than 3min.

5. Apply petroleum jelly on all sides of mould and its base plate.

6. Place the assembled mould on the table of the vibration machine and hold it firmly in position by means of a suitable clamp.

7. Attach a hopper of suitable size and shape securely at the top of the mould to facilitate filling and this hopper shall not be removed until the completion of the vibration period.

8. Immediately after mixing the mortar, fill the entire quantity of mortar in the hopper of the cube mould and compact by vibrating. The period of vibration shall be 2 minutes at the specified speed of 12000±400 vibration per minute.

9. Keep the filled moulds in moist closet or moist room for 24 hours after completion of vibration. At the end of that period, remove them from the moulds and immediately submerge in clean fresh water and keep there until taken out just prior to breaking.

10. The cubes shall be tested on their sides without any packing between the cube and the steel plates of the testing machine.

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11. One of the plates shall be carried on a base and shall be self-adjusting, and the load shall be steadily and uniformly applied, starting from zero at a rate of 35N/mm2/min.

### TABLE 3.8: Compressive Strength of cement

| DESCRIPTION | SPECIMEN | | | | | |
|---|---|---|---|---|---|---|
| | 3 days | | | 7 days | | |
| | I | II | III | I | II | III |
| Weight of cement, g | 200 | 200 | 200 | 200 | 200 | 200 |
| Weight of standard sand, g | 600 | 600 | 600 | 600 | 600 | 600 |
| Weight of water, g | 23.4 | 23.4 | 23.4 | 23.4 | 23.4 | 23.4 |
| Area, $cm^2$ | 7.06 | 7.06 | 7.06 | 7.06 | 7.06 | 7.06 |
| Load at fracture P, KN | 80 | 70 | 85 | 115 | 95 | 120 |
| Compressive stress, $N/mm^2$ | 16.05 | 14.04 | 17.05 | 23.07 | 19.05 | 24.07 |
| Average compressive strength, $N/mm^2$ | 15.7 | | | 22.0 | | |

Determination of fineness modulus of 20mm Recycled Coarse Aggregates as per IS 2386 (Part I) -1963
1. Take 1000g of air dried aggregate sample.
2. Arrange the test sieves in the order of 80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600μ, 300μ, 150μ.
3. Place the aggregate sample in top sieve i.e., 10mm and carry out the sieving process for 10 minutes.
4. After sieving, find the weight of materials retained on each sieve separately.

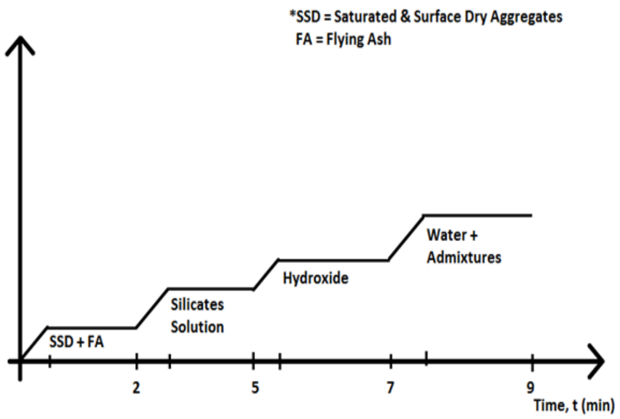


Fig 1: Three stage mixing

### TABLE 3.12: Fineness Modulus of 20mm Recycled Coarse Aggregates

| IS sieve no | Weight of aggregate retained | Percentage of total weight retained | Cumulative % of total weight retained | Percentage passing | Permissible values as per IS 383-1970 |
|---|---|---|---|---|---|
| 40mm | 0 | 0 | 0 | 100 | 100 |
| 20mm | 494.5 | 49.45 | 49.45 | 50.55 | 85-100 |
| 10mm | 493.5 | 49.35 | 98.8 | 1.2 | 0-20 |
| 4.75mm | 12 | 1.2 | 100 | 0 | 0-5 |
| 2.36mm | 0 | 0 | 100 | 0 | --- |
| 1.18mm | 0 | 0 | 100 | 0 | --- |
| 600μ | 0 | 0 | 100 | 0 | --- |
| 300μ | 0 | 0 | 100 | 0 | --- |
| 150μ | 0 | 0 | 100 | 0 | --- |
| **Total** | | | **748.25** | | |
| Fineness Modulus = 748.25/100 = 7.48 | | | | | |
| As Per IS 383-1970, Sample confirms to Single-Sized aggregate | | | | | |

### Three stage mixing approach

a) Add fly ash with hydroxide into the mixture and mix it for 3 minutes.
b) After that, add silicates and continue mixing for another 2 minutes.
c) Add aggregates into the mixture and continue mixing for 3 minutes.
d) Last, add water and plasticizer and mix all the mixture for 2 minutes.

Fig 2: compressive strength for RAC

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Fig 3: cubes are curing in water

### Fly ash

Fly Ash is a by-product of coal-fired furnaces at power generation and it is a reactive spherical particle, typically finer than cement, which provides workability to concrete because of its shape, and typically allows for strength and durability enhancing lower water contents. Strength and durability results may vary based on the fly ash chemistry. Low oxide/high calcium Class C fly ash may provide higher early concrete strengths than a high oxide/low calcium Class F fly ash. Class F fly ash is typically superior to a Class C fly ash in mitigating damage from both sulfate and alkali–silica damage to concrete.

1. Reduces bleeding
2. Increase time setting
3. Improve workability
4. Reduces segregation

Fly ash used in experimental work was obtained from Simhadri Thermal Power plant, NTPC and Visakhapatnam. The specific gravity of fly ash is found to be 2.1. The particles are in the form of solid spheres with sizes ranging from less than 1 µ to 100 µ and an average diameter of 20 µ.

### Silica fume

Silica Fume is a highly reactive pozzolanic material and is by-product from the manufacture of silicon or Ferro-silicon metal. It is collected from the flue gases from electric arc furnaces. Silica fume is an extremely fine powder, with particles about 100 times smaller than an average cement grain. Silica fume is available as a densified powder or in a water-slurry form.

1. Reduced permeability
2. Improves bonding with in the concrete
3. Improve resistance to corrosion
4. Increased durability
5. Increased compressive and flexural strength

Silica Fume used in experimental work was obtained from local industries near Auto Nagar, and Visakhapatnam. The specific gravity of fly ash is found to be 2.2. SF particles are very fine with particle sizes about hundred times smaller than those of average size of OPC particles.

Table 3.21: properties of fly ash and silica fume

| | Fly ash | Silica Fume |
|---|---|---|
| Specific gravity | 1.92 | 2.2 |
| Particle size | <45µm | 150 nµ |
| Surface Area | 300-500 $m^2$/kg | 15000-30000 $m^2$/kg |

### RESULTS

In that project area recycled aggregate concrete materials using with below properties. In this properties using that the conducted the all tests and the calculated that specific gravity, water absorption and impact values. Here we conducted that the physical, mechanical properties we found that the compare to the natural aggregate, recycled aggregate less strength in all tests so we have given strength with pozzolanic materials.

### Physical properties of Aggregates

Table 4.1.1: Specific Gravity of NA & GA

| GA – grade of concrete | Aggregate sizes | |
|---|---|---|
| | 20mm | 10mm |
| NA | 2.86 | 2.76 |
| GA-20 | 2.78 | 2.67 |
| GA-25 | 2.78 | 2.65 |
| GA-30 | 2.77 | 2.63 |
| GA-35 | 2.74 | 2.62 |
| GA-40 | 2.71 | 2.61 |

**Table 4.1.2: Water Absorption (%) NA & GA**

| GA- grade of concrete | Aggregate sizes | |
|---|---|---|
| | 20mm | 10mm |
| NA | 0.5 | 0.4 |
| GA-20 | 3.03 | 5.08 |
| GA-25 | 3.07 | 5.10 |
| GA-30 | 3.17 | 5.14 |
| GA-35 | 3.2 | 5.18 |
| GA-40 | 3.24 | 5.29 |

The process by which water is absorbed. The amount of water absorbed under specific conditions, usually expressed as percentage of the dry weight of the material. The amount of weight gain (%) experienced in a polymer after immersion in water for a specific length of time under controlled environment.

### Physical properties of Aggregates

### Specific Gravity of Granite Aggregate

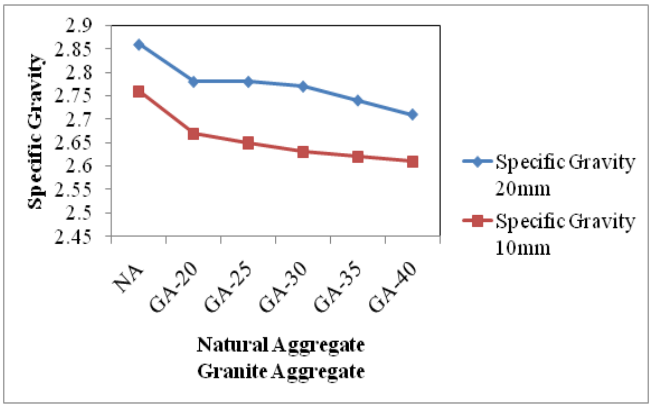


**Fig 5: Specific Gravity of Granite Aggregate**

When observed the above specific gravity of granite aggregate graph compared to the natural aggregate recycled aggregate was decreases with increases the grade of concrete. In which the replacement of recycled aggregate with increases the grade also strength was decreases. So that replacement of natural aggregate specific gravity of GA also decreases.

### Water Absorption (%) of Granite Aggregate

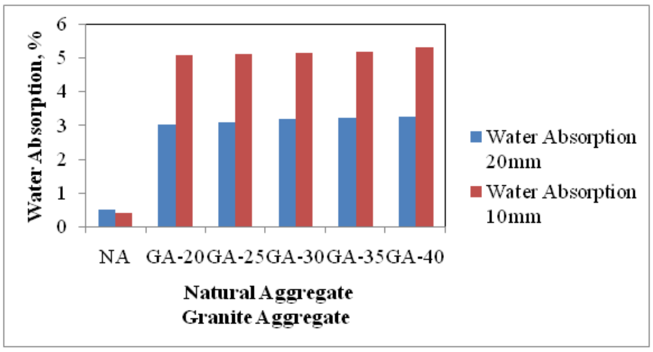


**Fig 6: Water Absorption (%) of GA**

Water absorption of GA was increases with increases the grade of concrete. When compared to the natural aggregate, recycled aggregates were highly increases. At grades (GA20, GA25, GA30, GA35 and GA40) was equal water absorption. For water absorption reducing.

We adding mineral admixes(fly ash, silica fume). There are comparing to the RAC without pozzolanic project water absorption was high. The aggregate sizes decreases the water absorption also decreases.

## CONCLUSIONS

Based on the results and discussion, the following conclusions can be drawn

1. From physical and mechanical properties of natural aggregate and recycled aggregate it is concluded that, the specific gravity of recycled aggregate is less and water absorption, impact values, crushing values and flakiness index are more than that of natural aggregate. This may be attributed to the adhered mortar and porous structure of recycled aggregate.
2. As percentage of replacement increases, compression strength decreases. Also it is concluded that as the parent concrete grade increases the strength gets reduced. The adhered mortar increases with the increases in grade of concrete which leads to loss the strength.
3. To enhance the compressive strength FA and SF were added by 20% and 10% respectively.

4. At GA20 replacement from 50 to 100% the strength reduces in the range of 0.35% to 3.04%, for GA25 replacement of 50 to 100% the strength reduces in the range of 7.3% to 21.58%, for GA30 replacement of 50 to 100% the strength reduces in the range of 18.97% to 25.5%, for GA35 replacement of 50 to 100% the strength reduces in the range of 21.58% to 29.44%, for GA40 replacement of 50 to 100% the strength reduces in the range of 25.5% to 35.97%.
5. The water absorption of concrete increased with increases in replacement and decreased with increasing grade.
6. The density of concrete decreased with increased in replacement and decrease in grade of concrete.
7. It is concluded that M25 grade of recycled concrete can be achieved by replacing 50% of GA20 with an addition of 20% FA &10% SF.

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