A Study on Demolished Concrete by Partial Replacement of Coarse Aggregate

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Abstract— There is a large amount of demolished waste generated every year in India and other developing countries .Demolished waste includes concrete blocks which can be recycled into stone aggregates through pre-screening, crushing, screening and separating of aggregates. In order to promote the reuse of construction waste, it is necessary to achieve the three basic concepts: (1) Assurance of safety and quality, (2) Decrease of environmental impact, (3) Decrease of cost effectiveness of construction. The experimental investigations are carried out to evaluate the effect of partial replacement of coarse aggregate by demolished waste on compressive strength and workability of demolished concrete. We have taken demolished concrete (recycled aggregates) in the ratio of 25%, 50%, 75%, and 100% by the weight of the coarse aggregates. The concrete cubes were casted by that recycled aggregates then further tests were conducted such as workability, compressive strength on that demolished concrete. Therefore, the test results obtained are found to be comparable with standard or conventional concrete.

Keywords: Recycle, Demolished, Replacement

I. INTRODUCTION

A. General

Any construction activity requires several materials such as Concrete, steel, brick, stone, glass, clay, mud, wood, and so on. However, the cement Concrete remains the main construction material used in construction industries. For its suitability and adaptability with respect to the changing environment, the Concrete must be such that it can conserve resources, protect the environment, economize and lead t0 proper use of energy. To achieve this, major emphasis must be laid on the use of wastes and by products in cement and Concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 % of Concrete is made of aggregates. In some countries it is a standard alternative for both construction and maintenance, particularly where there is a shortage of construction aggregate.

Due to modernization, demolished materials are dumped on land & not used for any purpose. Such situations affect the fertility of land. As per report 0f Hindu online India generates 23.75 million t0ns demolition waste annually. As per report 0f Central Pollution Control Board (CPCB) Delhi, in India, 48million tons solid waste is produced out 0f which 14.5 million ton waste is produced from the construction waste sector, out 0f which only 3% waste is used for embankment.

Recycling of Concrete is needed from the view point of environmental Preservation and effective utilization of resources. At present, utilization of recycled aggregate is limited mainly to sub bases of roads and backfill works. A large portion of Concrete waste ends up at disposal sites. It is anticipated that there will be an increase in the amount of Concrete waste, a shortage of disposal sites, and depletion in natural resources especially.

These lead to the use of recycled aggregate in new Concrete production, which is deemed to be a more effective utilization of Concrete waste. however, information on Concrete using recycled aggregate is still insufficient, and it will be advisable to get more detailed information about the characteristics of Concrete using recycled aggregates.

Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to minimize the usage of natural aggregate, recycled aggregate can be used as the replacement materials.

II. LITERATURE REVIEW

This research highlighted that recycled materials are a viable alternative to natural aggregate in the construction. Properties of recycled aggregates that affect their performance as unbound base/sub base layers include shear strength, stiffness, toughness, durability, frost susceptibility and permeability. Shear strength and stiffness (resilient modulus) have a much more influence on the performance of an unbound aggregate layer than the other properties. Large-scale Concrete slabs and laboratory-sized specimens containing recycled Concrete aggregate and to partially-replace the coarse aggregate were tested to failure.

Ahmad Muja hid et al. (year) Most of researchers found that the performance of recycled aggregate used in Concrete has low workability and compressive strength. Only one researcher found recycled aggregate Concrete has higher compressive strength. He claimed that recycled aggregate has a more angular shape and rough surface texture compare to natural aggregate. To increase the compressive strength, recycled aggregate should be oven dried condition that will create the interfacial bond between cement paste and aggregate particles (Poon, C.S., Shui, Z.H., Lam, L., Kou, S.C., 2oo4).

The workability of recycle aggregate Concrete is lower than standard Concrete because the rate absorption of recycled aggregate is higher than standard aggregate. The size of recycled aggregate was effected the strength in compressive strength ,the results shows the 1omm and 14mm size of recycled aggregate is better than 2omm size.

G.MURALI et al. (year) For improving the quality of recycled coarse aggregate, various surface treatment methods such as washing the recycled aggregate with water and dilute acid were investigated. Strength properties of the treated and untreated coarse aggregates were compared.

The results indicated that compressive, flexural, split tensile strength of recycle aggregate is found to be less than the natural aggregate. The strength of recycled Concrete can be improved by the water and acid treatments. Further more recycled aggregate treated with nitric acid displayed the recent result compare to hydrochloric and sulphuric acid and

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from economical point of view; water and acid treated recycled aggregate can be used in the place of natural aggregate for temporary structures.

III. MATERIALS AND METHODOLOGY

A. *Cement Ordinary Portland cement (OPC) 53 Grade*

53 grade Ordinary Portland Cement (OPC) is a higher strength cement to meet the needs of the consumer for higher strength Concrete. As per BIS requirement, the 28 days minimum compressive strength of 53 grade OPC should not be less than 53 Mpa.

Fig. 1: represents Cement OPC 53 Grade

Applications

- Rcc works (preferably where grade of Concrete is M25 and above)
- Precast Concrete item such as pavement blocks, Tiles building blocks etc
- Prestressed Concrete components
- Run ways, Concrete roads bridges etc.

B. *Fine Aggregates*

Fine aggregate is natural sand which has been washed and sieved to remove particles larger than 5mm and coarse aggregate is gravel which has been crushed, washed and sieved.

Those particles passing the 9.5mm sieve, almost entirely passing the 4.75mm sieve and predominantly retained on the 75um sieve are called fine aggregate

Fig. 2: Represents River Sand

C. *Coarse Aggregates*

Those particles that are predominantly retained on the 4.75mm sieve are called coarse aggregate.

Fig. 3: Represents the Coarse Aggregates

Purpose and uses:

- Increase the volume of Concrete, thus reduces the cost.
- Provide dimensional stability.
- Influence hardness, abrasion resistance, elastic modulus and other properties of Concrete to make it more durable, strong and cheaper

D. *Recycled Aggregates*

Recycled Concrete aggregates produced from all but the poorest quality original Concrete can be expected to pass the same tests. Recycled Concrete aggregates contain not only the original aggregates, but also hydrated cement paste.

This paste reduces the specific gravity and increases the porosity compared to similar natural aggregates. Higher porosity of RCA leads to a higher absorption.

Fig. 4: represents Recycled Aggregates

E. *Properties of Recycled Concrete Aggregate*

1) *Particle Size Distribution*

The result of sieve analysis carried out as per IS 1o262 for different types of crushed recycled Concrete aggregate and natural aggregates. It is found that recycled coarse aggregate

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are reduced to various sizes during the process of crushing and sieving (by a sieve of 4.75mm), which gives best particle size distribution. The amount of fine particles (<4.75mm) after recycling of demolished were in the order of 5-2o% depending upon the original grade of demolished Concrete.

The best quality natural aggregate can obtained by primary, secondary & tertiary crushing whereas the same can be obtained after primary & secondary crushing incase of recycled aggregate. The single crushing process is also effective in the case of recycled aggregate.The particle shape analysis of recycled aggregate indicates similar particle shape of natural aggregate obtained from crushed rock. The recycled aggregate generally meets all the standard requirements of aggregate used in Concrete.

2) Specific Gravity and Water Absorption

The specific gravity (saturated surface dry condition) of recycled Concrete aggregate was found from 2.35 to 2.58 which are lower as compared to natural aggregates. Since the RCA from demolished Concrete consist of crushed stone aggregate with old mortar adhering to it, the water absorption ranges from 3.o5% to 7.4o%, which is relatively higher than that of the natural aggregates. In general, as the water absorption characteristics of recycled aggregates are higher, it is advisable to maintain saturated surface dry (SSD) conditions of aggregate before start of the mixing operations

IV. TESTS ON MATERIALS

A. Tests on Cement

1) Normal Consistency of Cement

Introduction: 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. For finding out initial setting time, final setting time, soundness of cement and compressive strength of cement, it is necessary to fix the quantity of water to be mixed in cement in each case. This experiment is intended to find out the quantity of water to be mixed for a given cement paste of normal consistency and can be done with the help of vicat apparatus.

Procedure:

1) Prepare a paste of weighed quantity of cement (5oo grams) with a weighed quantity of potable or distilled water, starting with 28% water of 5oog of cement.
2) Take care that the time of gauging is not less than 3 minutes, not more than 5 minutes and the gauging shall be completed before setting occurs.
3) The gauging time shall be counted from the time of adding the water to the dry cement until commencing to fill the mould.
4) Fill the vicatmould with this paste, the mould resting upon a nonporous plate.
5) After completely filling the mould, trim off the surface of the paste, making it in level with the top of the mould. The mould may slightly be shaken to expel the air.
6) Place the test block with the mould, together with the non-porous resting plate, under the rod bearing the plunger (1omm diameter), lower the plunger gently to touch the surface of the test block and quickly release, allowing it to penetrate into the paste.
7) This operation shall be carried out immediately after filling the mould.
8) Prepare trial pastes with varying percentages of water and test as described above until the amount of water necessary for making the standard consistency as defined above is obtained.
9) Express the amount of water as a percentage by weight of the dry cement.

2) Specific Gravity:

The specific gravity of solid particles is the ratio of the mass density of solids to that of standard fluid. It is determined in the laboratory using the relation.

Weigh a clean, dry, lechatlier flask or specific gravity bottle with stopper (W_1). Place sample of cement up to half of flask about 5oogms and weigh with its stopper (W_2). Add kerosene (polar liquid) to cement in flask till it's about half full mix thoroughly with glass rod to remove entrapped air continue strings & add more kerosene, till its flush with graduated mark. Now weigh the bottle (W_3). Now remove the cement and kerosene and clean it thoroughly. Fill the bottle with kerosene and weight it (W_4).

3) Fineness of Cement:

Accurately weigh 1oo gm of cement sample and place it over the test sieve. Gently breakdown the air set lumps if any with fingers. Hold the sieve with pan in both hands and sieve with gentle wrist motion, in circular and vertical motion for a period of 3 to 4 minutes without any spilling of cement. Place the cover on the sieve and remove the pan. Now tap the other side of the sieve with the handle of bristle brush and clean the outer side of the sieve. Empty the pan and fix it below the sieve and continue sieving as mentioned in the steps 2 and 3. Totally sieve for 15 minutes and weigh the residue (Left over the sieve).

- Weight of cement taken =1oo gm.
- Weight of cement retained after sieving = 8 gm.
- Fineness of the given sample is 92 %

4) Initial and Final Setting Time:

Prepare a neat cement paste with o.85 times of water required to given standard consistency. Start the stopwatch at the instant of addition of water. Fill the vicat mould with above paste completely and smooth off the surface. Place the test block under rod bearing needle lower the needle gently in contact with the surface of test block & quickly release allowing it to penetrate into the test block. Repeat this experiment until the needle brought in contact with test block fails to pierce, the block for 5 $\pm$ o.5mm measured from the bottom of mould, stop the stopwatch. The period elapsed since adding water in initial setting time.

To determine the final the test block. The cement is considered finally set, in the above process when the needle makes impression, while the attachment fails to do so. The total time taken from the instant water is added to the dry cement to final set stage is known as final setting time.

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V. MIX DESIGN

(AS PER IS: 1o262:2oo9)

A. *Design of a Standard Concrete Mix of M_{3o} Grade:*

Indian Standard Recommended Method of Concrete Mix Design (IS 1o262-1982)

The Bureau of Indian Standards recommended a set of procedure for design of Concrete mix mainly based on the work done in national laboratories. The mix design procedures are covered in IS 1o262-82. The method given can be applied for both medium strength and high strength Concrete.

Type of cement : OPC 53 grade
Slump : 5omm
Degree of quality control : good
Type of exposure : mild
Size of aggregate : 2omm

1) Test data of materials:

- Sc – Specific Gravity of cement = 3.15
- Sca – Specific Gravity of coarse aggregate = 2.87
- Sfa – Specific Gravity of fine aggregate = 2.6o

VI. PREPARATION AND CASTING OF CUBES AND TESTS ON CONCRETE

A. *Mixing and Casting:*

Initially the constituent materials were weighed and dry mixing was carried out for cement, sand and coarse aggregate and admixtures. This was thoroughly mixed manually to get uniform colour of mix. The mixing duration was 2-5 minutes and then the water was added as per the mix proportion. The mixing was carried out for 3-5 minutes duration. Then the mix poured in to the cube moulds of size 15o x 15ox 15o mm and then compacted manually using tamping rods.

Fig. 5: Represents the mixing and casting of cubes

B. *Curing:*

The cubes are demoulded after 1 day of casting and then kept in respective water for curing at room temperature with a relative humidity of 85% the cubes are taken out from curing after 7, 14, 21, 28,56 and 9o days for testing.

Curing is a procedure that is adopted to promote the hardening of Concrete under conditions of humidity and temperature which are conducive to the progressive and proper setting of the constituent cement. Curing has a major influence on the properties of hardened Concrete such as durability, strength, water-tightness, wear resistance, volume stability, and resistance to freezing and thawing.

Concrete that has been specified, batched, mixed, placed, and finished can still be a failure if improperly or inadequately cured. Curing is usually the last step in a Concrete project and, unfortunately, is often neglected even by professionals.

Fig. 6: Represents the curing of cubes

C. *TESTS ON CONCRETE*

1) Compressive strength of Concrete:

By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 1ocm X 1o cm x 1o cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used.

This Concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of this specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 7 days curing or 28 days or 56 days or 9o days curing. Load should be applied gradually at the rate of 14o kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of Concrete.

Minimum three specimens should be tested at each selected age. If strength of any specimen varies by more than 15 per cent of average strength, results of such specimen should be rejected. Average of three specimens gives the crushing strength of Concrete.

These specimens are tested by compression testing machine after 7 days curing or 28 days or 56 days or 9o days curing. Load should be applied gradually at the rate of 14o kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of Concrete.

Fig: Represents the Compressive Testing Machine

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2) Slump Cone Test:

Slump test is the most commonly used method of measuring consistency of Concrete which can be employed either in laboratory or at site work. For the present work, slump tests were conducted as per it is not suitable method for very wet or very dry Concrete. This method is suitable for medium slump. It does not measure all factors contributing to workability, nor is it always representative of place ability of the Concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of the Concrete from batch to batch.

Repeated batches of the same mix, brought to the same slump, will have the same water content and water cement ratio; provided the weights of aggregate, cement and admixtures are uniform and aggregate grading is within the acceptable limits. Quality of Concrete can also be further assessed by giving a few tapings or blows by tamping rod to the base plate.

VII. RESULTS& DISCUSSIONS

A. Results of Slump Cone Test:

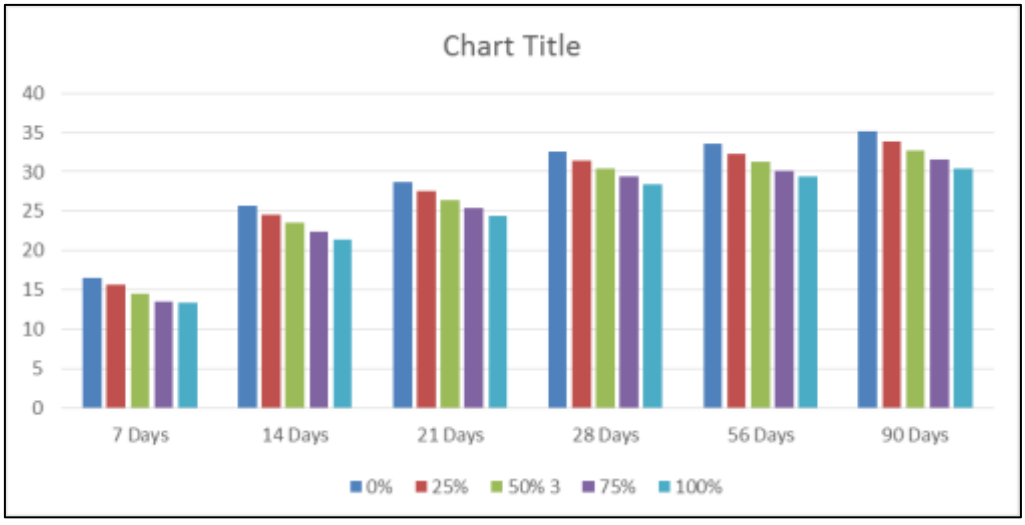
S.no	% usage of recycled aggregates	Workability(mm)
1	o% recycled aggregate Concrete	5omm
2	25% recycled aggregate Concrete	45mm
3	5o% recycled aggregate Concrete	42mm
4	75% recycled aggregate Concrete	35mm
5	1oo% recycled aggregate Concrete	25mm

B. Results of Compressive Strength

Average compressive strengths for 7, 14, 21& 28,56 and 9o days

S.no	Usage of aggregates	Average compressive strength for 7-days(N/mm²)	Average compressive strength for 14-days (N/mm²)	Average compressive strength for 21-days (N/mm²)	Average compressive strength for 28-days (N/mm²)	Average compressive strength for 56-days (N/mm²)	Average compressive strength for 9o-days (N/mm²)
1	o% of recycled aggregates	16.53	25.76	28.72	32.58	33.54	35.2o
2	25% of recycled aggregates	15.68	24.52	27.53	31.47	32.27	33.81
3	5o% of recycled aggregates	14.56	23.47	26.4o	3o.43	31.23	32.77
4	75% of recycled aggregates	13.54	22.33	25.35	29.43	3o.18	31.51
5	1oo% of recycled aggregates	13.29	21.33	24.4o	28.44	29.43	3o.43

C. Graph:



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1) Graph Represents The Average Compressive Strength of 7, 14, 21, 28,56 and 9o Days

Test Results For o% Replacement of Recycled Aggregates

S.no	% Usage of recycled aggregate	Compressive strength of 7days (N/mm²)	Compressive strength of 14days (N/mm²)	Compressive strength of 21 days (N/mm²)	Compressive strength of 28days (N/mm²)	Compressive strength of 56days (N/mm²)	Compressive strength of 9odays (N/mm²)
1	o% of recycled aggregates	15.53	25.62	27.89	32.65	34.21	35.26
2	o% of recycled aggregates	16.85	24.75	28.72	33.25	33.96	36.13
3	o% of recycled aggregates	17.22	26.92	29.55	31.86	32.45	35.26

Test Results For 25% Replacement of Recycled Aggregates

S.no	% usage of recycled aggregates	Compressive strength of 7 days (N/mm²)	Compressive strength of 14days (N/mm²)	Compressive strength of 21days (N/mm²)	Compressive strength of 28days (N/mm²)	Compressive strength of 56days (N/mm²)	Compressive strength of 9o days (N/mm²)
1	25% of recycled aggregates	14.95	24.45	26.89	31.56	32.1o	34.26
2	25% of recycled aggregates	15.66	23.98	27.56	3o.89	31.9o	33.23
3	25% of recycled aggregates	16.45	25.15	28.14	31.98	31.82	33.96

Test results for 5o% replacement of recycled aggregates

S.no	% usage of recycled aggregates	Compressive strength of 7 days (N/mm²)	Compressive strength of 14days (N/mm²)	Compressive strength of 21days (N/mm²)	Compressive strength of 28days (N/mm²)	Compressive strength of 56 days (N/mm²)	Compressive strength of 9o days (N/mm²)
1	5o% of recycled aggregates	14.78	23.89	26.86	3o.54	31.41	32.92
2	5o% of recycled aggregates	13.77	22.76	25.76	3o.98	31.33	32.52
3	5o% of recycled aggregates	15.15	23.76	26.58	29.78	3o.96	32.85

Test results for 75% replacement of recycled aggregates

S.no	% usage of recycled aggregates	Compressive strength of 7 days (N/mm²)	Compressive strength of 14days (N/mm²)	Compressive strength of 21days (N/mm²)	Compressive strength of 28days (N/mm²)	Compressive strength of 56days (N/mm²)	Compressive strength of 9odays (N/mm²)
1	75% of recycled aggregates	13.68	22.18	25.27	29.56	3o.4o	31.86
2	75% of recycled aggregates	13.87	22.96	25.96	29.89	3o.25	31.23
3	75% of recycled aggregates	12.98	21.85	24.83	28.86	29.89	31.45

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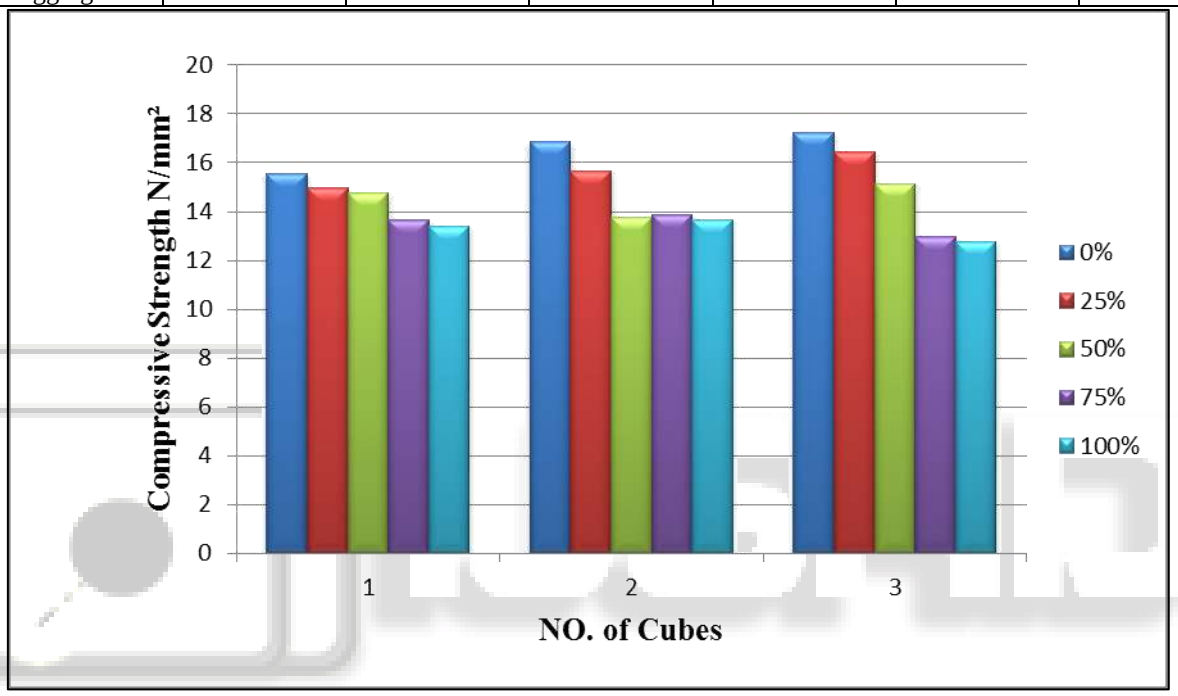
Test results of 1oo% replacement of recycled aggregates

S.no	% usage of recycled aggregates	Compressive strength of 7 days (N/mm²)	Compressive strength of 14days (N/mm²)	Compressive strength of 21days (N/mm²)	Compressive strength of 28days (N/mm²)	Compressive strength of 56days (N/mm²)	Compressive strength of 9odays (N/mm²)
1	1oo% of recycled aggregates	13.42	21.15	24.56	28.65	29.45	3o.56
2	1oo% of recycled aggregates	13.68	21.87	23.89	28.79	29.75	3o.25
3	1oo% of recycled aggregates	12.79	2o.98	24.76	27.89	29.1o	3o.49



VIII. CONCLUSION

- The test values of compressive strength of cubes of demolished Concrete aggregate for 7days, 14days, 21days,28days 56days and 9o days are obtained and the values are compared with standard Concrete.
- The test values of compressive strength 25% and 5o% of demolished Concrete aggregates are near the value of standard Concrete or conventional Concrete.
- As we observed that the difference in compressive strength of standard and demolished Concrete aggregate for a 28 days is about 12%
- As we observed that the difference in compressive strength of standard and demolished Concrete aggregate for a 56 days is about 12.55%
- As we observed that the difference in compressive strength of standard and demolished Concrete aggregate for a 9odays is about 13.52%
- The compressive strength of demolished aggregate Concrete is less than up to 2o% compared to standard Concrete.
- The Average Split Tensile strength of Concrete at 7days, 14days, 21days,28days 56days and 9o days with various amounts of RAC replacement. In this study, Concrete tensile strength is observed to gradually decrease as the percentage of RAC in Concrete increases.
- The flexural strength shows considerable increment in the strength for 7days, 14days, 21days,28days but 56days and 9o days a decrease in strength is observed for 25% replacement Concrete mix.
- More than 75% replacement of recycled aggregates is not recommended for high strength structures.
- The recycled aggregates are used for pavements and for making Concrete bricks etc,.
- Concrete with up to 25% replaced aggregate can be used in coastal region.
- From the present experimental investigation, it is observed that there is possibility to replace Recycled aggregates in Concrete to percentage up to 5o% to 1oo% for lower grade Concrete.
- This can be a good option for Sustainable and eco-friendly recycling technique for the utilizing demolition waste into construction project again, while further studies should be conducted to improve performance of recycled aggregate.

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