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Experimental Investigation on Partial Replacementof Coarse Aggregateby Recycled Aggregatein Concrete

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Abstract : *Aggregate resulting from the processing of inorganic material which are previously used in the construction is known as recycled Aggregates. Nowadays using the Waste materials is a global trend. In the fieldof construction, this trend has gained a lot of importance due to depletion of natural aggregates and land fill spaces takes place. Recycled Aggregate is the material for the Future. Many Countries like European, American, Russian and Some Asian Countries has started the use of used (recycled) aggregate in number of Construction Project. Some Countries are also giving relaxation to the Infrastructural laws so that the use of recycled aggregates can be increased in Construction. This study also develops, best economic solution by using the demolished debris as recycled aggregates in structural Concrete to reduce the Environmental Impact and also keeps the construction costs down. The main goal of research is to investigate the hardness properties of used (recycled) aggregates and Recycled Concrete Aggregate including impact value test, Abrasion Test, Water Absorption, Specific Gravity test on aggregates while slump for fresh Concrete and Compressive Strength and Split Tensile Test on Hard Concrete, which provides a good understanding on various properties of concrete with Recycled Aggregates, which is substitute material to virgin coarse aggregate in structural concrete.The Laboratory Trials were conducted with the aggregate size 10-20mm to determine the properties of the recycled aggregate by studying the influence of limited percentage of recycled aggregate in concrete. In this research total eight batches of two mixes M20 with 0.5 W/c and M30 with W/c 0.42 consist of RA 00%, 20%, 40% & 60% of recycled aggregates Replacement. In Concrete the Workability decreases as the amount of recycled aggregates increases but in the end, it is Considerable in mix as it is still under the limits. This was done by Standard Slump Test. Result of Strength Characteristic shows a decrease in Split tensile and compressive Strength at RA60 specimen but at last most of the results is satisfactory and under the limits.*

Keywords *-Natural aggregates (NA), Recycled aggregate and concrete.*

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I. INTRODUCTION

This dissertation is concerned about the recycled aggregates obtained from the C&D waste of concrete. C&D materials means any material, matter or thing which is generated as a result of construction and demolition work. It consist of material which comes from the site clearance, demolition and other works such as road, construction. Over 80% of C&D materials are idle and are known as public fill. Public fill includes the following such as debris, rubble, and earth and concrete which is suitable for land redemption and site development. When it is properly sorted, concrete can be recycled so that it can beused in construction works.

Concrete is the premier construction material across the world and the most widely used in all types of construction works along with infrastructure, defense installations, low and high-rise buildings, and environmental protection facilities while aggregate plays one of the most vitally important part in concrete production as it profoundly influences concrete properties and performance. About the usage of aggregate in concrete, a conservative estimate is that in a general way 4.5 billion tons of concrete aggregates are consumed in the world per year. This figure is assumed to represent total aggregate making, along with usage in concrete and road base. Usage of Aggregate in concrete constitutes nearly 35 percent of the total production of aggregate.

Construction activity leads to generation of solid wastes, which include gravel, sand, bricks, stone, concrete, bitumen, metal, wood etc. The management of construction and demolition waste is a dominant matter for town architect due to the growing measure of demolition's rubble, continuing shortage of dumping sites, booming in conveying and laying charge and above all growing concern about pollution and environmental deterioration.

II. LITERATURE REVIEW

1. Recycled Aggregates

The aggregates that can be outcome from the disintegration and breakdown of actual Portland cement concrete pavement and structural elements is called recycled aggregate. Recycled aggregate are comprised of crushed, graded inorganic particles prepared from the materials that have been taken from the constructions and demolition debris. These materials are collected normally from the roads, buildings, bridges and sometimes even from human and natural disasters like wars and earthquakes. There are several advantages by using the RA. The major advantage is based on the environmental gain. Confer to CSIRO (Commonwealth Scientific and Industrial Research Organization) construction and demolition waste makes up to around 40% of the entire expenditure every year (approx. 14 million tons) going to landfill. Through recycling process the material, it keeps diminishing there sources of urban aggregated. The cost of recycled aggregate is cheaper than Natural Aggregate. The conveyance cost of the recycled aggregate is less because the weight of recycled aggregate is lighter than virgin aggregate. Besides that, the recycling site may accept these aggregates materials at lower cost than landfill withoutlevying tax and recycled aggregate can be used at cheaper cost than natural aggregate in the work of construction. Recycled aggregates have great potential in concrete. According to Environmental Council of Concrete Organization, recycled or used concrete aggregate can be used for path walk, curbs, substructures of bridges and, concrete shoulders, residential driveways, general and structural fills. It also specified that RCA can be used in sub-bases and backing layers such as unsterilized base and permeable bases Thus, the use of recycled aggregates in concrete provides environmental as well as economics benefits.

2. Studies on RAC

2.1 Worldwide Studies

Applications of the recycled or used aggregate in the construction industry are wide and they had been used long time ago. It is stated that recycled aggregate have been used in the industry of roads nearly for the last 100years in Australia. The adoption of RA for the construction and improvement of local government roads has a great improve in the last five years. During the time of the Romans, the stones from the previous roads were reused when rebuilding their vaunted set of roads. It also stated that since the end of Second World War, there cycling industry had been well established in Europe.

USA – Nearly 22% of the total C&D waste is generated in the USA

Reusing and recycling of C&D debris is one element of larger holistic practices called sustainable or green building practice.

Promoting deconstruction instead of demolition,

Deconstruction includes planned demolition of a building with reuse being the main motive.

Japan – Much of the Research and Development in Japan is focused on materials which can withstand earthquake and prefabrication. Approx. 85 Million tons of C&D debris has been produced in 2000, out of which 95% of concrete is crushed and reworked as road beds and backfilling concrete, total 98% of asphalt + concrete and 35% sludge is recycled.

Singapore – Huge amount of C&D waste is freely collected and recycled. A private company has built an automated facility with capacity of 300,000 ton per annually.

Hong Kong – Due to finite skills in using RA and Hong Kong's different essence of building construction, a more careful access has been adopted. After the detailed laboratory investigations and plant trails, the govt. has also formulated the two sets of specifications governing the use of Recycled Aggregate for concrete production.

For lower grade operations, concrete with 100% RA is allowed. Recycled fines are not allowed to be used. The marked strength is cited at 20MPa, the concrete can be used in benches, stools, planter walls, concrete mass walls and other minor concrete structures. Concrete bricks and the paving blocks have successfully produced impregnation of photo catalyst for controlling NOx in ambient air.

Netherlands – Near About 40 million of C&D waste is being produced in which 80% consist of brick and concrete. Many initiatives have been taken about recycling material since 1993 such as;

Avoidance of waste,

Encouraged recycling,

Promoting building materials having longer life,

Products which can be easily dismantled,

Partition at source and

Prohibition of Construction & Demolition waste laying at landfills.

Scotland – About 63% debris has been reprocessed in 2000, remaining 37% material being disposed in landfill and exempt sites. The Government is resolving specifications of recycling and practice codes. Attempts are being made for establishing connections with the devising system, computerizing transmission note system to facilitate data analysis and ease in dialogue among companies for acceptance of recycled aggregates by consultants and contractors.

Denmark – In 2003, according to theDanish Environmental Protection Agency, 30% of the total waste generated was C&D waste.

- DEPA recorded around 70-75% waste was produced from deconstruction activities, 20-25% from renovation and the remaining are from new structure construction.
- Because of constraints of landfill site, recycling is the main focus for the nation.
- Action plan, voluntary agreements and Legal orders have been carried out, e.g., reuse of asphalt (1985), sorting of Construction & Demolition waste (1995) etc.

Others – The author has counseled that a strong commitment & investment by government bodies as well as private bodies make this compulsory for sustainability. Some materials are also reused for recycling such as plastic, glass etc. In the same manner concrete can be used steadily as long as the specification is done proper manner. Recycling solid waste materials for construction purposes becomes progressively important waste management option, as it can lead to environmental and fiscal benefits. Conservation of natural resources, saving of energy in production and transportation, and reduction of adulteration are also the advantages of recycling. In particular, for recycling concrete is a perfect construction material for structures.

For fulfilling the need of construction in gulf countries indigenous resources are imported from the different locations. Small sources are feasible in gulf countries &in Arabian Peninsula are limited. For construction work, demand of desalinated water & sand locally available exist. Preserving of natural sources, saving natural resources, energy transportation & decrease in pollution are advantages.

The Cement and Concrete Association of New Zealand (CCANZ) has shown the cost of applying $10/ton on dumping. The use of RCA to sustain virgin aggregate & the associated environmental amount of exploration & transportation waste deduction & decreasing the load on dumping sites is a global issue. Comprehensive research has been carried out globally adopting RA in concrete. It shows that all over theworld concrete construction industry has taken a good and responsible attitude to assure that its natural resources are not over exploited. Due to Contention relating to conservancy and finite natural resources, it's certain that the use of recycled and secondary aggregates, for example, crushed concrete, asphalt and industrial wastes like fly ash and furnace residue, will grow. However, presently it's only in the United States, Japan, regulations of western components have been comfortably put in the place that the use of RCA outpace 10% of the total aggregate used. Consequently, worldwide the use of recycled and secondary aggregates stands at approximately 750 million tones, it is less 3% out of total aggregates use in world. They insist that the sustainability is generally recognized as foundation for resource and energy – saving the technological improvements in several sectors which include construction.

Mirjana Malešev et al states that the quantity of recycled aggregate varies with river aggregate by % of 0, 50,100 respectively. The workability propertiesare done(slump test) immediately after the mixing and then after 30 minutes later, bulk density of fresh concrete, bulk density of hardened concrete, air content, water absorption (28 days age), wear resistance (28 days), compressive strength (2, 7 and 28 days), splitting tensile strength (28 days), flexural power(28 days), elastic modulus (28 days), drying shrinkage (3, 4, 7, 14, 21 and 28 days), link between the ribbed and mild reinforcement and concrete are tested. Ninety nine copies were made for testing of the listed properties of hardened concrete.

Compressive strength mainly depends on the quality of the recycled aggregate used in the mix. If good quality aggregate is used for the manufacturing of new concrete, the recycled aggregate has no influence on the compressive power, regardless of the replacement ratio of NA with RA. The same results are found for concrete tensile strengths. The modulus of elasticity of concrete also decreases with increasing recycled cumulative content as a consequence of lower modulus of elasticity of recycled aggregate correlated to natural aggregate. Shrinkage of concrete depends on the quantity of RCA.

Brett (in 2010) state that the use of RA in concrete is economically viable as well as technically feasible. RA can also be composed of excess Concrete materials returned to the plant.

Mirza and Saif have studied the effect of silica fume on RAC characteristics. The percentages of reused aggregate replacements of virgin aggregate used by wt. were 0, 50, and 100%, on the other hand the percentages of silica fume replacements of cement taken by wt. were 5, 10, and 15%. The results show that the compressive and tensile strengths values of the reused concrete aggregate increase as the recycled aggregate and the silica fume contents increase. The study is also indicating that in favor of accommodating the 50% of Recycled Aggregate in structural concrete mix, the mix also needs to merge the 5% silica fume.

III. MATERIAL USED AND METHODOLOGY

Materials other-than recycled aggregates was collected from the local construction site. Materials are natural coarse aggregate, natural fine aggregate, cement and super-plasticizer. These materials are available and escorted easily at the laboratory though there is a construction under progress in that college which is linked with the college. Following are the description of the materials;

- Natural Coarse Aggregate of 20mm

- Natural Coarse Aggregate of 10 mm
- Natural fine aggregate(sand) of size less than 2.36 mm
- Cement OPC 53 grade
- Super plasticizer – Aster Super Plasticizer ASP 200
- Recycled Aggregates: - Recycled aggregates are collected from Ragora Sidra near TawiVihar Colony. There was a residential Building which was demolished by the Jammu Municipal Corporation because some people have illegally constructed the building on the Land which belongs to Jammu Development Authority. It was 3 years old which is good for the project point of view. Recycled aggregates which are to be tested must have the age of one year of serving in the concrete structures so it will be considered as well stressed aggregates in terms of different stresses. Concrete Debris in the form of boulders was packed in the emptied cement bags and then escorted through loading vehicle to the laboratory.
  Rubbles are hammered to the required size of "recycled aggregate" on which tests were to be performed. Debris sized of 80-150 mm boulders. It was hammered twice to prepare main content. Firstly it was hammered to separate aggregates from mortar and then again hammered to make the aggregate of required size i.e. 20mm and10mm.
  Sieve analysis- sieve analysis was done to separate the hammered aggregates in the necessary sizes 10mm & 20mm.

1. Mix Design

The selection of materials to be mix and their required quantity must have done through a process called mix design. There are lots of methods for determining concrete mix design. In this project, mix was prepared according to IS 10262-2009 & MORT&H for two mix designs of compressive strength M20 & M30.
The mix design of concrete usually depends on compressive strength which is sufficient to achieve the requirements of the hardened concrete for obtaining good quality concrete;

- Water / cement ratio should be low enough to give the required strength for structural strength and durability purposes.
- The mix should be cohesive and workable enough to ensure that it should be thoroughly compacted and homogeneous material.
- The mix design of RAC is no different from that of conventional concrete ant the same mix design procedures can be used. But in practice, some modifications may take place
- Trial mixes should be made to obtain the required workability and the most suitable w/c ratio.
- When the coarse aggregate is used with natural sand, it may be assumed at the design stage that the free water / cement ratio necessary for a certain compressive strength will be the same for Recycled Aggregate Concrete as for as conventional concrete. If trial mixes shows that the compressive strength is lower than required, adjustment of water / cement ratio should be made.

2. Mix Proportion and Batches

M30- The mix design M30 was designed for slump 40-70 mm. Admixture (Aster Super-plasticizer 200) is used. The mix proportion is taken by weight is shown below;

Cement	Sand (Fine Aggregate)	Coarse Aggregate(20mm)	Coarse Aggregate(10mm)	Water	Admixture
1	1.87	2.43	0.94	0.42	5.26(gm)

Table 2.1 Ratio of Mix by Weight

Mass of cement (OPC 53grade)	380kg /m^3
Water	160
Sand	711
Coarse Aggregate 20mm 10mm	1283 924 359
Admixture	1.9
Water/Cement	0.42

Table 2.2 Proportion of Materials used in 1 cubic meter

M20- The Mi M20 was designed for Slump 25mm, no admixture was used in it according to IS mix design for M20.
The mix Proportion is taken by Weight is shown below;

Cement	Sand (Fine Aggregate)	Coarse Aggregate (20mm)	Coarse Aggregate (10mm)	Water
1	2.4	3.54	1.37	0.5

Table 2.3 Ratio of mix by Weight

Mass of Cement (OPC 53 Grade)	290kg/m^3
Water	145
Sand	696
Coarse aggregate 20mm 10mm	1429 1029 400
Admixture	-
Water/Cement	0.5

Table 2.4 Proportion of materials used in 1 Cubic Meter

3. Percentage Replacement of RA

Two mixes M20 & M30 will be designed for same replacement of recycled aggregates with natural aggregates. RA00, RA20, RA40, RA60 are the Four batches prepared for M20 & M30 consecutively, overall eight batches were made. The initial mix batch will be 100% natural aggregate mix batch (RA00 means replacement of recycled aggregate with natural aggregate is 0%), second mix batch was 80% natural aggregate and 20% recycled aggregate (RA20), third mix batch was 60% natural aggregate and 40% recycled aggregate (RA40), and fourth mix batch was 40% natural aggregate and 60% recycled aggregate (RA60). M20 & M30 mix design has different water cement ratio, cement content, different proportion of coarse and fine aggregates. The only main difference is that admixture is used in M30 and not used in M20 mix design.

4. Mixing and Casting of Concrete Specimens

The objective of mixing is to obtain a uniform and consistent of cement, water, aggregate, sand and any admixtures used in the concrete and also to meet the requirement of the standard. There are 24 cubes and 24 cylinders in 8 batches of 2 mix design mixed and was molded accordance with MORT&H & IS 10262-2009.

Specimen casting-

M20:

RA00% 3 cubes and 3 cylinders (full NA)

RA20% 3 cubes and 3 cylinders (NA 80%)

RA40% 3 cubes and 3 cylinders (NA 60%)

RA60% 3 cubes and 3 cylinders (NA 40%)

M30:

RA00% 3 cubes and 3 cylinders (full NA)

RA20% 3 cubes and 3 cylinders (NA 80%)

RA40% 3 cubes and 3 cylinders (NA 60%)

RA60% 3 cubes and 3 cylinders (NA 40%)

Specimen size:

Cube mould size: - 150×150×150

Cylinder mould size: - 100×200

Cubes will be tested for compression test and Cylinder will be for split tensile strength.

IV. TEST AND RESULT DISCUSSION

1. Introduction

Series of test was accomplished on the natural and recycled aggregates, concrete cubes & cylinders to get the strength characteristics of the recycled concrete aggregate for probable application in normal strength concrete. The compressive, tensile and bond strengths of concrete are relatively important mechanical properties of any hardened concrete including recycled aggregate concrete. The recycled concrete must embrace the same conventional concreting practices to guarantee the hardened concrete properties. This chapter will discuss on the results that obtained from the testing and compare them to the standards accordingly. The results are such as abrasion test, impact value test, water absorption & specific gravity of aggregates, slump test, compression test and split tensile test.

2. LA Abrasion Test result Analysis

The LA abrasion value of the recycled aggregate is 30.2% of 12-20mm sized fraction. This value is higher than that of virgin aggregates which has abrasion value 24.4%. Recycled aggregates are well washed and prepared for the testing and it shows good strength but not more than virgin aggregates. Aggregates with lower abrasion value percentage are comparatively stronger. It is possible to allow for the abrasion loss in the mixture proportion because the aggregate itself does not break down. Instead, the maximum LA abrasion value for

aggregates is 30% for cement concrete pavement course. Therefore, the result is acceptable in this experiment. Table form comparison will be given below;

Aggregate Type	Abrasion Value (%)
RA	30.32
NA	24.40

Table 2.1 Abrasion Value Comparison

3. Impact Value Test Result Analysis

The impact value of the recycled aggregate is 8.84% of 12-20mm sized fraction. Two tests were conducted and the mean value is 8.84% which is good but not better than natural aggregate whose mean value of two tests are 6.19 %. Besides, both the aggregate types are exceptionally strong as their value lies below 10% according to the transportation engineering lab manual 2013. Aggregate strength percentage lower than 10% is exceptionally strong and those vary between 10-20% will be categorized as strong while those of vary between 20-30% will be taken as satisfactory for cement concrete surface course and those which varies from 30-45% will be taken in the category of cement concrete base course while not as surface course. And here we have the aggregate better than 10% which can be easily used in the structural cement concrete. Therefore, the results are easily acceptable in this experiment. Table form comparison will be given below;

Aggregate Type	Impact Value (%)
RA	8.84%
NA	6.19%

Table 3.1 Impact Value Comparison

4. Water Absorption and Specific Gravity Test Results And Analysis

The results have shown the higher water absorption of 1.95% of recycled aggregates. Because it has little mortar attached to the surrounding of the recycled aggregate. It indicates that the cleanliness & washing of the recycled aggregate is still need to be done properly to get the results near to as of natural aggregates. The percentage of water absorption for the natural aggregates is 0.98% which is better than that of recycled aggregates. The average permissible water absorption of aggregate should not be greater than 2%. Though, normal weight aggregates of higher absorption value is acceptable depends on local performance. As far as concern about this experiment, the water absorption of recycled aggregate does not exceed permissible value so it is acceptable.

Now concerning about specific gravity of the recycled aggregates, it shows the result varies between 2.26 – 2.48 which is nearly 2.37 by taking average of two readings, while the specific gravity of natural aggregates varies around 2.57 – 2.65 which is nearly 2.61 by taking average of two readings. The normal specific gravity varies from 2.5 to 3. Specific gravity helps in identification of stone, to measure the strength and quality of the aggregates, in such case, quality does not matter much where strength of the aggregates have passed their test (as stated in the earlier test analysis) so this can also be accepted.

Aggregate Type	Water Absorption	Specific Gravity
RA	1.95%	2.37
NA	0.98%	2.61

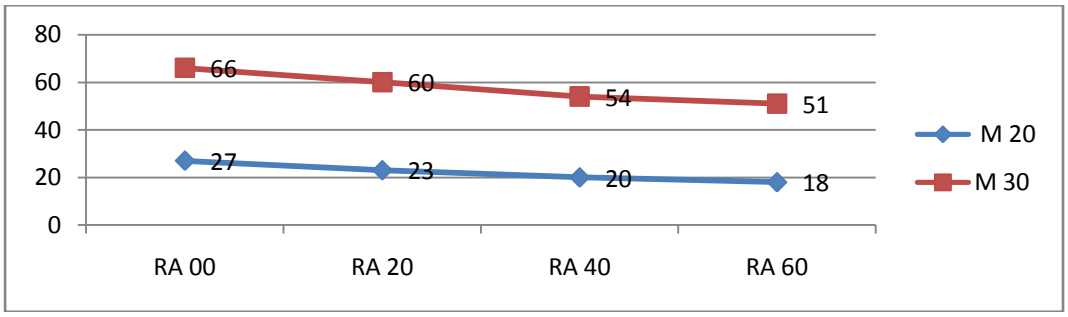
Table 4.1 Water Absorption & Specific Gravity value Comparison

5. Slump Test Result and Analysis

There are two mixes of M20 & M30 designed for 25±5mm with w/c ratio 0.5 & 50-75±10mm with w/c ratio 0.42 respectively. The slump value gives us indication of mix workability. The slump of M20 RA00 is about 27mm, M20 RA20 is about 23mm, M20 RA40 is about 20mm M20 RA60 is about 18mm with no admixture added. Whereas M30 RA00 is 66mm, M30 RA20 is 60mm, M30 RA40 is 54mm & M30 RA60 is 51mm as shown below in the table. The measured slump for natural aggregate is within the limitations while slump of mixture in which recycled aggregate was added is slightly low 2-3mm which can be considered, this difference is not so big and can be covered with little alterations in the testing. So there must be no difficulty in casting, placing & finishing.

Batch	M20	M30
RA 00	27	54
RA 20	23	60
RA 40	20	54
RA 60	18	51

Table 5.1 Slump Test Comparison



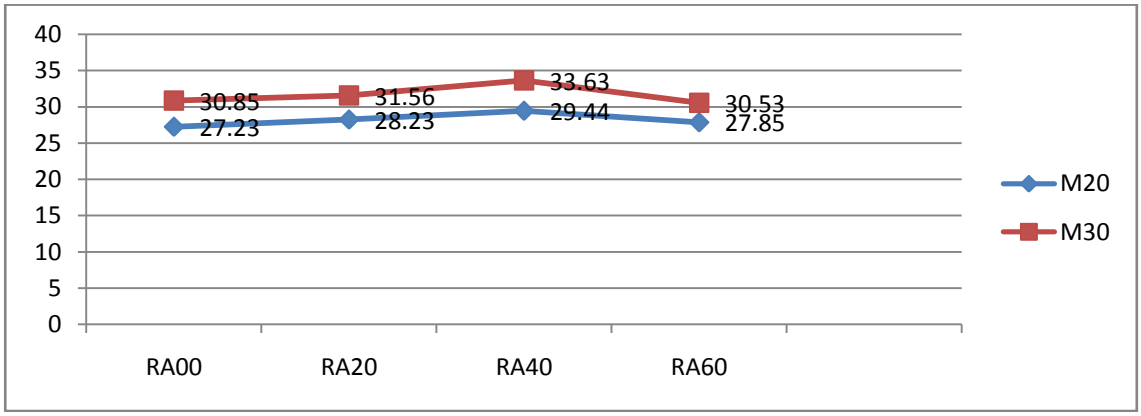
Graph 5.1 Slump Test Comparison

6. Compression Test Result and Analysis

The target strength for this project is 20MPa & 30MPa. From the obtained result, it shows that the batches that have met the target strength with 0% to 60% (RA00, RA20, RA40 & RA60) replacement of natural aggregate of both the mixes by gaining 30.85MPa, 31.56, 33.63 & 30.53MPa for M30 and 27.23MPa, 28.26MPa, 29.46MPa & 27.85MPa for M20 batch mix. It means that we can replace 40% of Virgin aggregate with Recycled aggregate in the structural construction where compressibility mainly tends to affect the structure. Strength of the concrete can also be controlled by decreasing water cement ratio. RA60 batch shows 3 to 4MPa lower strength than the strength achieved in RA 40 which can be controlled by decreasing water cement ratio, but according to the results of this experiment RA40 can be easily applied at the place of virgin aggregates. Results can be seen in the table below clearly.

Batch	M20	M30
RA 00	27.23	30.85
RA 20	28.26	31.56
RA 40	29.46	33.63
RA 60	27.85	30.53

Table 6.1 Compressive Strength Value Comparison



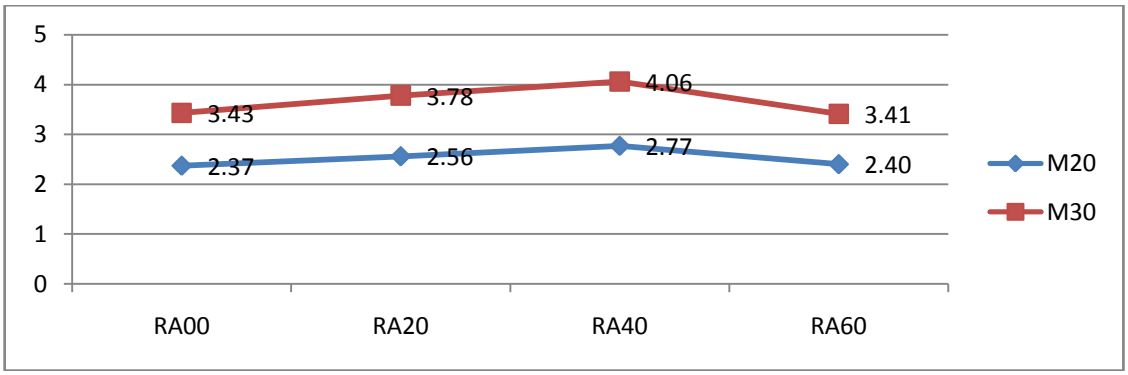
Graph6.1 Compressive Strength Comparison

7. Split Tensile Strength Test result and Analysis

The 28-day standard cured cylinder split tensile strength of all mix batches lies between the target strength. RA60 batch of M30 mix shows the split tensile 3.41MPa which is slightly lower but with in the standard value for M30 mix. Besides this, all batches of both M20 & M30 mixes also lies within the limits of standard values of mixes. Well the difference is that the tensile strength decreases at replacing RA 60% by Virgin Aggregates in both the mixes which can be controlled and considered because concrete cannot be used as the splitting resistance member. Comparison can be seen in the table below;

Batch	M20	M30
RA 00	2.37	3.43
RA 20	2.56	3.78
RA 40	2.77	4.06
RA 60	2.40	3.41

Table 7.1 Split Tensile Value Comparison



Graph 7.1 Split Tensile Value Comparison

8. Summary

The workability of recycled aggregate concrete is slightly less because the mortar adhered from the original concrete makes the recycled aggregates little porous and absorptive than its natural equivalent but around the limits, the absorption capacity of recycled aggregate is just twice of natural aggregates absorption capacity but under the limits.

The recycled aggregate test results showed that the recycled aggregate concrete can give strength almost similar to an equivalent concrete with natural aggregates. The use of recycled aggregate does not gravely affect the compressive strength of the concrete. Using 40% of recycled coarse aggregate in concrete mixes shows comparatively better compressive strength than conventional aggregate concrete in M30 mix while little less compressive strength of M20 mix with same percentage replacement but still crosses the target strength.

The behavior of recycled aggregate concrete is the same as natural aggregate concrete under split tensile loading in both Mixes but a bit low in RA60 batch of both mix.

9. Advantages

There are many preferences through using the RA. The major preference is based on the environmental profit. According to Commonwealth Scientific and Industrial Research Organization (CSIRO) construction and demolition waste makes up to around 40% of the total waste each year (estimate around 14 million tons) going to landfill worldwide. Through recyclingprocess of the material, it can keep lessening there sources of metropolitan aggregated. Therefore, RA can be used in higher grade applications.

- The cost of RA is reasonable than NA.
- The conveyance cost for the RA is less due to the bulk density of RA is lower than that of NA.
- The recycling siteaccept these aggregates at a low cost than landfill without levying any tax and recycled aggregate can be used at lower prices than primary aggregate in the construction works.
- Recycled aggregates have great potential in concrete. According to ECCO (Environmental Council of Concrete Organization), RCA can be used for side walk, bridge substructures, curbs, concrete shoulders, residential driveways, and superstructures, general and structural fills.
- It also mentioned that recycled concrete aggregate can be used in support layers, sub-bases and such as permeable base and unsterilized bases.
- The most considerable advantage is the reduced environmental impact by reducing the amount of debris that must be disposed.
- Less demand for natural aggregates.
- Produce job opportunities in the local area & around and also a financial benefit for business like, Local council engineers; Concrete subcontractors; Specialist of civil works; Demolition contractors; recycled material plants etc.

Thus, the use of recycled aggregates in concrete provides environmental as well as economics benefits.

10. Disadvantages

The major concern is the variation in concrete strength with recycled aggregate. In such projects, the bulk mass of the concrete obtained is from demolition work. Although, the laboratory tests of three different batches took more than two months besides, RA60 batch shows less strength instead of RA40 in which recycled aggregate percentage is less than that of RA40 batch so basically if increment of recycled aggregate by 60% in concrete reduces strengths of concrete than it is good to use recycled aggregates up to 40%. It means it is unpredictable & it is recommended to perform lab testing before applying RAC into the projects.

V. CONCLUSION &FUTURE SCOPE

According to the test which has been carried out in the laboratory, results shown by testing the multiple samples that good quality concrete could be produced with recycled aggregates. The use of aggregates produced from recycled construction and demolition waste should be further promoted. Based on the experimental investigation reported in the work, the following conclusions are drawn:

Test results of recycled aggregates has shown good strength according to standards, i.e; mean abrasion value of RA is 30.32%, impact value is 8.84% & water absorption is 1.95% and all are under the limits. So it is clear that there is no issue of using the recycled aggregates instead of natural aggregates in the implementations where compression is concerned.

Workability of the concrete varies from 51-66mm for M30 and 18-27mm for M20 which are around the limits 50 & 25mm respectively. It is considerable and hence can be achieved by adding super plasticizers in the mix especially when the mix contains RA not more than 40% according to the test results of this project. Adding of admixtures in mix can improve the workability and setting time of concrete can be controlled according to the needs of the implementation of concrete with recycled aggregates.

Compression, & split test mean values of RA40 batch for M20 & M30 mixes have well passed the standards as shown in the results.

So there is a noteworthy conclusion that after confirmation of the laboratory test results; compressive strength & split tensile strength & of recycled aggregate concrete can meet the requirements of normal strength of standards of conventional concrete. So RAC can be used according to the mixes used in this work.

Hence Recycled aggregate concrete has been proved to perform adequately and in a manner as good as to the concrete containing natural aggregates. It is likely that this study may lead to a greater use of Recycled Concrete Aggregate materials and its diversion from landfills.

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