INFLUENCE OF RECYCLED AGGERATES ON DURABILITY OF CEMENT CONCRETE

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CIVIL Engineering

(SPECIALIZATION IN TRANSPORTATION ENGINEERING)

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DECLARATION

I hereby declare that the dissertation entitled, **Influence of recycled aggregates on durability of cement concrete** submitted for Masters Degree is entirely my original work and all the ideas and reference have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date: 29/4/15 **UMAR MAJID**

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CERTIFICATE

This is to certify that the project work entitled "Influence of Recycled Aggregates on Durability of Cement Concrete" being submitted by Mr. UMAR MAJID (REG NO: 11011412), has been carried out under my supervision and has not been submitted to any other institute or university for award of any degree.

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ABSTRACT

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 reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. These materials are generally from Buildings, roads, bridges, and sometimes even from catastrophes, such as wars and earthquakes. There are many advantages through using the recycled aggregate

Aggregate is one of the main ingredients in producing concrete. It covers 75% of the total for any concrete mix. The strength of the concrete produced is dependent on the properties of aggregates used.

However, the construction industry is increasingly making higher demands of this material and is feared to accommodate the many requests at one time. Hence need for an alternative coarse aggregate arises. The aim for this project was to determine the strength and durability characteristics of structural concrete by using recycled coarse aggregates, which will give a better understanding on the properties of concrete with recycled aggregates.

The scope of this project was to investigate the possibility of using low cost recycled coarse aggregates as an alternative material to coarse aggregate structural concrete. The experimental investigation were carried out using detailed strength and durability related tests such as compressive strength test of cubes, split tensile strength test of cylinders, aggregate impact load test, aggregate crushing value, specific gravity & water absorption .

The tests were conducted by replacing the coarse aggregates in concrete mixes by 0, 10, 20, 30, 40 and 50% of recycled coarse aggregates. A 50% replaced mix with reduced w/c ratio was also tested. From the experimental investigation it was found that recycled coarse aggregates can be used for making concretes by adjusting the w/c ratio and admixture contents of the mix.

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LIST OF ABBREVIATION

1. C&D:-CONSTRUCTION AND DEMOLITION.
2. RAC:-RECYCLED AGGREGATE CONCRETE.
3. NAC: - NATURAL AGGREGATES CONCRETE.
4. OPC: - ORDINARY PORTLAND CEMENT.
5. GM :- GRAMS
6. AGG: - AGGREGATE.
7. AIV: - AGGREGATE IMPACT VALUE.
8. ACV: - AGGREGATE CRUSHING VALUE.
9. W/C: - WATER-CEMENT.
10. MORTH:-MINISTRY OF ROAD TRANSPORT & HIGHWAY.
11. DES.GRADATION:- DESIRED GRADATION.
12. RA:-RECYCLED AGGREGATE.
13. NA:-NATURAL AGGREGATE.
14. KN:-KILO NEWTON.
15. N/MM:-NEWTON PER MILLIMETER

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Recycling is the way, of dispensation of the used material for use in producing a new product. The practice of natural aggregate is getting more and more intense with the advanced development in the infrastructure area. To minimise the use of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are generally formed by wastes that comprises of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. These materials that are used are usually from roads, bridges, buildings and sometimes even from disasters, such as war fights and earthquakes that led to demolition & wastes generated there can be retained.

In fact, large proportion of these material that are generated from demolition other disasters can be recycled, and become recycled tangible aggregates and granular materials that are attained could be re-used in construction industry. The another main prospective is that to protect the environment and for sustainable development, it is the Government's that has the determination to promote recycling and the use of recycled products as far as possible in order to save resources and reduce the amount of wastes that are going to retrieval and landfill sites. These materials that are attained from demolition are also called as C&D materials & are a mixture of inert & non-inert materials arising from construction and demolition activities, such as clearance of site that was used for the same purpose, renovation of any structure, demolition and civil engineering and building works.

Around an aggregated estimate has revealed that about 1.5 million to l tons of C&D waste is generated every year of which an estimated description is that about 1.1 mill tons is concrete and sand stone rubble. This roughly estimate also corresponds to 2 % of the total annual aggregate production which is rather a good amount. Recycled concrete aggregate (RCA)are the aggregates that are produced by crushing C&D waste& removing the strengthening by attractive belts and then the process finally ends with crushing and sieving to a given particle size distribution. The results pertained to a granular material consisting mainly of concrete, and sometimes may comprise of masonry and asphalt particles. While it appearance wise and is mostly used as an auxiliary for natural aggregate, even the composition of recycled

concrete aggregate has some effect as it gives the material some special features such as for example lowering the density of particle and increasing the water absorption of aggregate mix

The Positive environmental policies have developed a general change of attitude towards the use of primary raw materials and have proven to be important motivations for the use of recycled waste. The growing environmental concerns are alarming at an high rate , the increasing scarcity of landfills are rapidly exhausting sources of quality natural aggregate in some regions attached with the increasing haulage and the growing landfill costs are the lashing forces that promote the recycling of concrete devastation waste in new concrete.
The recycling process of construction waste, including wastes such as concrete, and the landfill-bound constituents of the municipal solid waste stream, including glass which occurs largely as mixed-colour waste glass & are with the limited market value, are considered as an important step towards sustainable construction practice.
Many experimental results have showed up that when concrete products that are produced with recycled aggregates attained from the wastes less than 20% replacement of the natural aggregate in concrete, the effect due to the recycled aggregates on the properties of concrete is little. However, when the recycled aggregates are added higher level, the effect becomes noticeable. One of the noticeable effect due to the use of recycled aggregates is high water absorption which not only affect the control of the free water cement ratio but there is an effect on the workability of fresh concrete and which leads to high shrinkage and creep of the hardened concrete of recycled aggregates when compared with the concrete prepared with natural aggregate. The effect of these properties of concrete are pretentious by the use of recycled aggregate depends on the water absorption, crushing value and soundness of the recycled aggregate.
C&D materials comprises of a mixture of inert and non-inert materials which are developed from construction and demolition activities, such as clearance of site , renovation, demolition of buildings ,bridges etc. The materials such as concrete, soil, rock, brick and asphalt contribute to inert portions because of the fact as these will not decompose The material such as timber ,paper ,bamboo and garbage contribute to non- inert portions as these will decompose .Therefore recycled aggregate is arising from inert materials.

1.2 HISTORICAL BACKGROUND:

There are many applications of recycled aggregate and are widely used in the construction areas and they had been used long time ago.

Wilmot and Vorobieff (1997) in their study stated that in the road industry the recycled aggregates have been used in Australia from past 100 years.
According to them from the last five years there is a great improve in the use of recycled aggregates for the construction and rehabilitation of local roads which are maintained by the government.
C & D Recycling Industry, According to the fact file it has been stated that from the ancient time of the Romans, they used the stones of the roads which were demolished. These stones were reused when they were rebuilding their vaunted set of roads.
The fact file also stated that in Europe after the world war two, the recycling industry had been well established. In 2004 according to Seecharan , In 1980 the Detroid News stated that the old concrete was crushed into a powder and in Michigan ,USA it was used as popular binder.

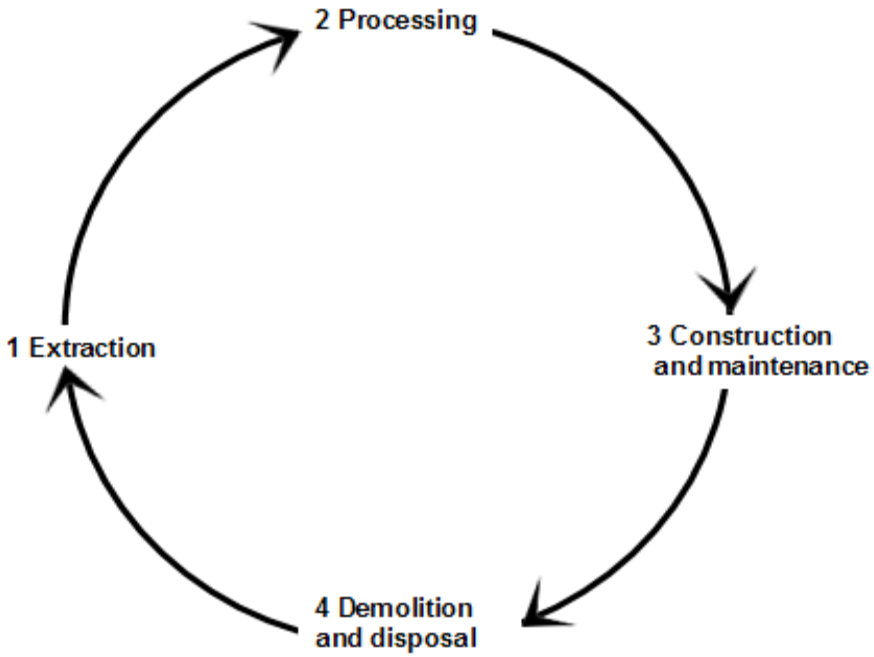


Fig1: Processes involved in recycled aggregates (source: google.com)

1.3 APPLICATION OF RECYCLED AGGREGATES:

Some of the applications are summed up conventionally; the compliance of recycled aggregate is mostly used as landfill. Nowadays, recycled aggregate in building areas are wide enough. The applications are mainly different from country to country.

- CONCRETE CURB AND GUTTER MIX:

Recycled aggregate that have been generated by the demolition of old buildings are used as concrete edge on the road and sewer mix. According to Building Innovation & Construction Technology (1999), has showed a greater use of stone says of 10mm recycled aggregate and merged recycled sand are used for the purpose of concrete kerb and gutter mix

Fig2:Concrete curb

(Source: Building Innovation & Construction Technology, 1999)

- GRANULAR BASE COURSE MATERIAL:

According to Arcade Development Study for Recycled Aggregate Products (2001), the recycled aggregate are mostly utilised for the purpose granulated base course in the road construction. The arcade development study has foreseen that the recycled aggregate had demonstrated & showed better qualities than natural aggregate when the recycled aggregates are used as granular base course in roads construction. They also found the another benefit that when the road is built on the wet sub grade areas, recycled aggregate will soothe the base and provide an improved working surface for pavement structure construction.

Fig3: Granular base course material (Source: Mehus and Lillestol (n.d))

- EMBANKMENT FILL MATERIAL:

Arcade Development Study for Recycled Aggregate Products (2001) also stated that recycled aggregates have another important property that they can be used in ridge fill. The reason for being used in the embankment fill was the same as stated for the granular base. As the embankment location is also on the wet sub grade areas. Recycled aggregate can alleviate the base and can provide an improved working surface than natural aggregates for the lingering works.

- PAVING BLOCKS:

In Hong Kong Recycled aggregate have been used for the purpose of pavement blocks pavement blocks.

According to Hong Kong Housing Department, they used the recycled aggregate as typical for the paving blocks. In 2002 a long term trial project had been started in order to test the recital of paving blocks which were made by the recycled aggregate

- BACKFILL MATERIALS:

Recycled aggregate can also be used for the purpose of backfill materials. Mehus and Lillestol initiate that the Norwegian Building Research Institute had made analysis in the laboratory that the recycled aggregates can be used as the material for backfill in the pipe zone region along ditches.

Fig4: Backfill material (Source: Mehus and Lillestol (n.d))

- BUILDING BLOCKS:

Recycled aggregate have another important advantage that they were used as building blocks. Mehus and Lillestol which earlier had stated about the Norwegian institute now again stated that OptirocAS has used reprocessed aggregate in the purpose to produce the masonry sound

and the lagging blocks. During the laboratory testing revealed that the masonry sound insulation blocks that were made of recycled aggregates had met all the requirements

Fig5: Building blocks (Source: Mehus and Lillestol (n.d))

- ADVANTAGES:

There are many advantages concluded using the recycled aggregate. The some of the main advantages of the recycled aggregates are summed up & are enlisted below.

- ENVIORNMENTAL GAINS:

One of the main concerns nowadays is our environment that is degraded by a number of factors but the recycled aggregates have shown betterment in the pertaining field. The main lead is based on the environmental gain. According to CSIRO ,the destruction and the demolition wastes are summed up to around 40%of the total wastes generated each year and an estimate of about 14 million tons is deployed in landfills However if these aggregates are the recycled , it can help us in shrinking the resources of urban aggregated. So in a way natural aggregate can be used in higher grade solicitations.

- SAVES ENERGY:

The main aspect by which energy can be saved is that the reprocessing process can be done on site. According to Kajima Technical Research Institute (2002), an important method known as Kajima is emerging the way of recycling the crumpled concrete that can be used in the construction, it is also known as the Within-Site Recycling System. However the Totality can be obtained through this system by the of recycling of aggregates and manufacturing on site and use them .this would help us in saving the energy in a way of transporting the recycled aggregates to the plant and then again back to the site

- COST:

One of the important aspects of recycled aggregates that have laid a deep impact over the natural aggregates is their cost, as the cost of recycled aggregates is very low when compared with the natural aggregates.

According to PATH Technology Catalogue, has calculated the costs of recycled Concrete aggregates are sold around $3.50 to $7.00 per cubic yard which makes it to be contingent on the local obtainability& aggregate size restraint.

The another prospective which laid influence is the weight of recycled aggregates which lighter than natural aggregates, this helped in the reduction of transportation cost Concrete Network stated that if we reutilized the concrete from the devastation projects it can save transportation cost as we have to transport the concrete to the land fill & an roughly estimate (around $0.25 per ton/ mile), and the cost of disposal is about ($100 per ton). Besides that, Aggregate Advisory Service also have stated that the recycling site will accept the aggregates materials at lower cost than landfill as these aggregates would be summed up without tax levy and recycled aggregate can be used at a low prices

- SUSTAINABILITY:

One of the advantages is that the amount of waste materials that are used for landfill will be reduced by the usage of recycled aggregate. This will help in reducing the total of quarrying. Therefore this will help us in increasing or encompassing the life span of natural resources and also will outspread the lives of sites that using for landfill

- WIDE MARKET:

As we know the markets for the recycled concrete aggregate are diverse. According to Environmental Council of Concrete Organization, the recycled concrete aggregate can be used for the various purposes such as in the sidewalk, curbs, bridge infrastructures and superstructures, structural fills in the concrete shoulders. It also enhanced that the recycled Aggregates can be used in the sub bases and sustenance layers such as un-stabilized base and permeable bases.

- DISADVANTAGES:

Though there are many advantages by using recycled aggregate. But still as we know every good thing has some bad effects so does the recycled aggregates.
Some of the disadvantages of recycled aggregate are stated below.

- HARD TO HAVE PERMIT:

Jacobsen in the year (1999) stated that it is very firm to get the authorization for the recycling process as machinery that needed air permit in order to conclude the work. These issues are generally depended upon the local or state regulations whether this technology should be executed or it should not be allowed

- LACK OF SPECIFICATION GUIDELINES:

According to Kawano, the recycled aggregates have no description or any standard, when the recycled concrete aggregate are used in any construction work sometimes the strength characteristic will not meet the requirement as per the design.
Therefore, while using the recycled concrete aggregate aggregates more testing should be adopted.

- WATER POLLUTION :

One of main drawback of the recycled aggregates is that while the process of recycling it will give rise to water pollution. Morris of the National Ready Mix Concrete Association had cited that the water used for the process of recycling will be the high pH is a serious environmental matter. According to Building Green (1993), the water that retained or obtained after the recycling process has the PH 12 means the water is highly alkaline. The water obtained after recycling process is deadly to the fishes and other aquatic life.

1.4 CLASSIFICATION OF AGGREGATES:

- RECYCLED AGGREGATES:

Recycled aggregates must conform to the optimum standards laid for the engineering use The aggregates obtained after the process of recycling should have properties like clean, hard enough to resist the loads, strong& durable to resist wear and tear the aggregates should be free from chemical that are toxic, coating of clay on aggregates, and other fine materials in quantities that can lay the distress on the bonds & hydration of the cement paste.
Recycled aggregate are made of crushed, graded inorganic particles that have been earlier used in the construction works & demolitions. These materials attained that are used in the process of new construction generally from buildings, roads, bridges, and sometimes even from disasters such as battles and tremors.
Recycled aggregate concrete is concrete artefact that is prepared as a whole in order to overcome the natural aggregates

- NATURAL AGGREGATES:

The natural aggregates are generally are attained from the construction masses that are produced from natural sources such as gravel and sand, and Extractive products such as Rocks that are crushed, gravel & sand, River gravel and these possess better quality than the RA.

1.5 SCENARIO OF RECYCLED AGGREGATES:

- IN INDIA**:**

As we our country today is in the top three largest countries in the world with the highest population and as such it is growing at alarming rate and mostly with in the years we will be the top most. And as such our country is growing at a fast rate so is the need of aggregates therefore the supply of aggregates has also emerged as one of the important issues of the conurbation in India. . The requirements of natural aggregates are not only mandatory in order to justify the importance of the demand of the imminent projects proceeded, but our other needs for replacement & the repairs for the existing infrastructure& buildings that were built few decades back.

As with the shortage of aggregates seen today and the rise in price the forthcoming seems to be in dark or completely down for the construction sector in the years to come.

The problem that has aroused now in India is demolition of the dumping. In the present time the demolition & construction has turned to tonnes as an roughly estimate of 23.75 million tons annually as per the Hindu online of March 2007, which is akin to some of the developed nations and the probability is generally that these figures are likely to get double fold in the coming years. The management of construction and demolition waste is a major concern of the demolition sites and the cost of transportation, however still these could be overcome but the main problem is the degradation of the environment as due to increased quantity of demolition rubble, increase in cost of disposal

Since a survey in Delhi has revealed that concrete composes 35% of the waste as per the survey that was conducted by Municipal Corporation of Delhi, India may also have to extremely think of reusing demolished rubble and concrete for creation of recycled construction material. The non-inert portions clinch decomposable materials such as bamboo, timber, paper and garbage. Reprocessed aggregate is arising from inert materials.

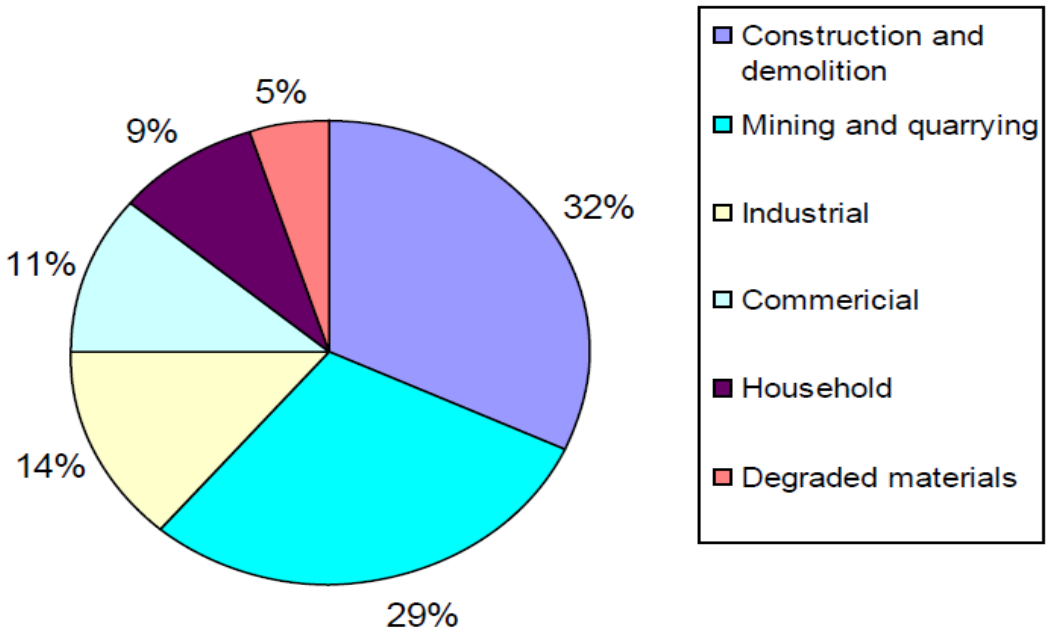


Fig6: Total Indian demolition wastes (Source: CIRIA (1993))

- WORLD WIDE**:**

In the whole world it is also a matter of concern as theatrical deterioration in the good quality aggregates that are available for construction use. World-wide an roughly estimate of around eight to eleven billion tonnes of aggregate are used for the purpose of fabrication of concrete every year.

Ontario is currently using aggregate faster than it is being made available resulting in an aggregate shortage. From 1992 to 2003 Ontario's has consumed a yearly consumption of aggregates about 170 million tons. In Canada, about fourteen tonnes of aggregate are expended per person each year. However, for every 6tonnes of aggregate is produced only 2 tonne are attained back through recycling.

More than sixteen tonnes of aggregate are used by a person in Ontario each year. From the 2 billion tons of aggregate that is consumed each year, in the US only 5% comes from recycled sources such as demolished concrete.

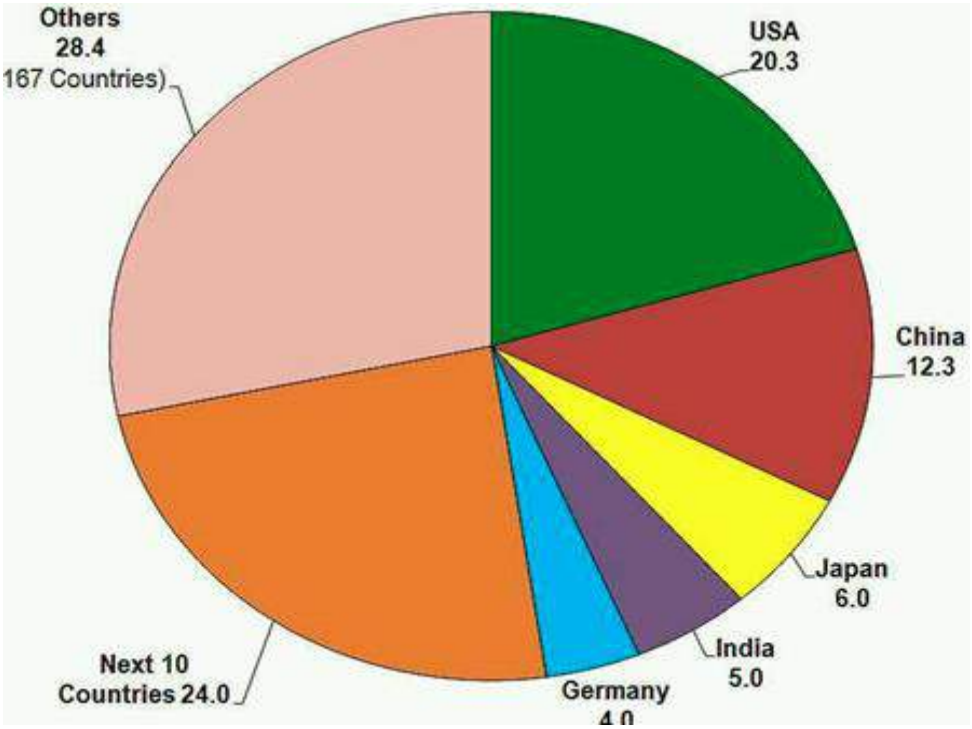


Fig7: Total worlds demolition wastes including India

(Source: UK. Demolition and reuse of concrete)

1.6NEED OF THE STUDY:

- Find out the key interaction between RCA with cement under different loading conditions.
- Construct the concrete specimens by recycled aggregates and partial replacement of RA with NA and with the addition of fly ash.
- Furthermore the effect & the results and recommendation of the recycled aggregates on the strength and the durability

1.7 OBJECTIVES OF STUDY:

- This study is to examine the properties of recycled aggregate concrete in respect to durability in terms of strength.

- To explore effect on the durability of concrete in respect to structural serviceability with recycled aggregate.

- The characteristic difference between the properties of the natural aggregates and RCA and in terms of durability

- This study is to examine the effect of addition of fly ash with the recycled aggregates and check the variations in strength.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND:

As we all know that the applications of recycled aggregate are very wide in the construction area. Since a large number of testing in the recycled aggregates is carried out in the world.

Hanson and Torben in the year (1986) stated that since 1945, the use of recycled aggregates came into the work and from since the research had been carried out in many countries. The main purpose of testing is to check out the result of the recycled aggregates for strength characteristic and to emphasize and expose analysis in order whether the recycled aggregate are suitable to be applied in the construction area.

Rammamurthy and Gumaster in the year (1998), recycled aggregate concrete have relatively lower compressive strength and these variations were dependent on the strength of parent concrete. The study stated the properties of RAC. The work have showed physical differences between recycled aggregate and natural aggregate as the recycled aggregates absorb greater amount of water & there specific gravity is high which problem in the workability and strength of concrete mix

The variations in mechanical properties of recycled concrete aggregates have attributed to the spots of cement mortar present after crushing of recycled aggregates which increases the water absorption, prolongs the mixing time and affect the strength of the mix

Marta Sanchez de Juan in their studies have concluded that the recycled aggregates having mortar vary from 40 to 60% generally depending upon the nominal size of the aggregates and the water absorption of the recycled aggregates generally lies in between 3–10 per cent while for natural aggregates the water absorption is much less and is about 5 per cent. The work done by the recycled aggregates have proved that a loss in strength is attained due high water absorption as due the presence of mortar , and other effects that will be generated are resistance to freezing and thawing, elasticity, creep, shrinkage and workability. Aggregate in the size of 4 to 8mm are found to have the highest amount of adhered mortar are these

aggregates from the better interlocking in cement paste, thus implying that the size of aggregates will have fabulous outcome on the water absorption and strength of concrete mix.

Frondistou and Yannas produced Concrete of recycled aggregates that had shown a decrease in the compressive strength & modulus of elasticity with the amount for former about 4-14 % &also 40 % for the latter.

Hansen and Narud, in their empirical studies revealed that the test results pertaining to the recycled aggregates showed similar test results as that of natural aggregates
As earlier enlisted about recycled aggregate on the mortar stuck to the aggregates has profound effect on properties of mix. The researchers concluded that the percentage of waste mortar stuck on aggregates changed between 30 and 60 %, and the mortar that is stuck to the aggregates affected the properties of concrete such as strength, elasticity, shrinkage and water absorption. When recycled aggregates are used in the mixes it is found that they require about 10 % more water in comparison to natural aggregates. They also have shown the effect by decreasing workability and loss of slump in short time

Olorunsogo and Padayachee studied about the recycled aggregates and determined that, while enhancing the properties like curing period and the mixture there is an increase in quantities of recycled aggregates but however it reduced the durability of concrete.
From various research works and as also stated earlier the mortar stuck on the aggregates hinders the use for large scale economic materials that are friendly with the environment in the construction works.

Limbachiya and Leelawatin the year (2000) concluded that there is a decrease in the relative density of about 7 to 9% lower and they also stated that the recycled aggregates have 2 times higher water absorption than natural aggregate
According to their test results, it also mentioned that recycled concrete aggregate could be used in high strength concrete mixes with the recycled concrete aggregate content in the concrete.

Sagoe, Brown and Taylorin the year (2002) stated that the difference of natural &recycled aggregates in reference to the characteristic of fresh and hardened concrete is relatively narrower than reported for laboratory crush recycled aggregate concrete mixes.
There was no difference between recycled & natural aggregates mixes made at the 5% significance level in concrete compressive and tensile strength

Sawamoto and Takehino (2000) initiated about the recycled aggregates that the matter of the recycled aggregate concrete can be augmented by using Pozzolanic material that can absorb the water.

Mandal in the year (2002) stated that if we attenuate the water/cement ratio while using the recycled concrete aggregate in the process of concrete mixing can enhance the better-quality of the strength of the recycled aggregate concrete specimens prepared in the mix .The results obtained by using the recycled aggregate concrete samples had the same engineering and durability enactment when we compared it to the concrete specimens made by natural aggregate within 28days design strength. Another refining method that is used is to treat the mix of recycled aggregates with the sly ash or the use of fly ash in the recycled concrete aggregate has shown an improved effect in the durability of the recycled aggregate concrete.

Chen and Kuan in the year (2003) found that the strength of the concrete samples was pretentious when they used unwashed recycled aggregate in the concrete. The effect was strange at the low water cement ratio. However these effects can be improved by using the washed recycled aggregate.

Poon in the year (2002) also stated that the use of fly ash as similar that was stated by Mandal as well but it could improve the strength specific of recycled aggregate. He stated that the compressive strength of concrete paving blocks was reached 49MPa at 28days by using fly ash

Berry and Malhotra in the year (1980) itemised that for high strength concrete, used the fly ash as the functions by providing augmented strength at late ages of curing (56 to 91 days) that cannot be achieved through the use of supplementary Portland cement.

2.2 PROPERTIES OF RECYCLED AGGREGATES:

As the recycled aggregates have shown the potential of replacing the natural aggregates and in the process address the issue of sustainability and environmental degradation in many countries outside India has also been using the product satisfactorily. However now this needs upgrading in way that waste materials are bought to normal standards and after upgrading, we need to reduce it to proper size in order to get the desired properties from the mixes.

Works of the researcher have shown that aggregates from different sources, exhibit different engineering properties. As we know aggregates is the key ingredient making up 70-80 % of volume in concrete and verbalizing the properties or attainment strength and density relationship. Hence while using the recycled aggregates in concrete mix we require to check the quality of aggregates as they are collected from different sources.

As the value of recycled aggregates is less than natural aggregates this means that natural aggregate is better than recycled aggregate as expected but the difference is not very significant.

The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled concrete aggregates contain the aggregates but the concrete or the hydrated cement paste that is stuck to the materials .This reduces some of the properties such as specific gravity and increases the porosity when compared to virgin aggregates. The concrete mix that is formed with recycled aggregate loses its workability more rapidly than the conventional concrete, as the recycled aggregates are more porous.

In order to produce a good concrete some of the basic properties of recycled concrete, such as shape, texture, specific gravity, absorption, moisture content, permeability, strength characteristics, need to be thoroughly evaluated .

Aggregates properties greatly affect the properties of a concrete. It would also be necessary to assess the effect of recycled material on final concrete in order to attain all the desirable properties of the concrete mixes. Thus concrete with recycled aggregate may require more mixing water to achieve the same workability as original aggregate.

Recycled coarse aggregate (RCA) is produced by crushing sound concrete, clean demolition waste.

RCA should not have greater than 0.5% brick content.

2.3 COMPARISION OF NATURAL AND RECYCLED AGGREGATES:

- TEXTURE:

Recycled aggregate comprises of the rough – textured, angular and elongated particles as they used earlier where Natural aggregate are smooth and angular compact aggregate.

The Portland Cement Association, stated that the properties of the freshly mixed concrete will be affected the surface texture of the aggregate and as well as by dimensions and the angularity. As already stated the recycled aggregates have rough texture and elongated size of the particle much water when compared with natural aggregates as the properties of mix such as workability and strength are highly affected.

The void gratified will increase with the angular aggregate where the larger sizes of well and enhanced grading aggregate will decrease the void content.

Fig8: Natural aggregates & Recycled aggregates (Source: Primary)

- QUALITY:

As we know that there is a difference in quality between recycled aggregate and natural aggregates. According to Sagoe and Brown in the year (1998) stated that the qualities of natural aggregate is based on the chemical & physical properties of sources sites from where they are collected , on the other hand recycled aggregate is depended on contamination of debris sources.

It also stated recycled aggregate have partial product mixes and are generally lower product mixes which restrain the market while the natural resources are suitable for multiple product and higher product have larger marketing area.

- DENSITY:

Researchers earlier enlisted their main emphasis on the density of the recycled concrete aggregate is lower when compared with the natural aggregate.

Sagoe and Brown in the year (1998) stated that the recycled aggregates have lower density when compared with the natural aggregate because of the porous and less compacted residual lumps of mortar that is stuck to the surface of aggregates. When the particle size is increased, the volume proportion of residual mortar will increase too.

- STRENGTH:

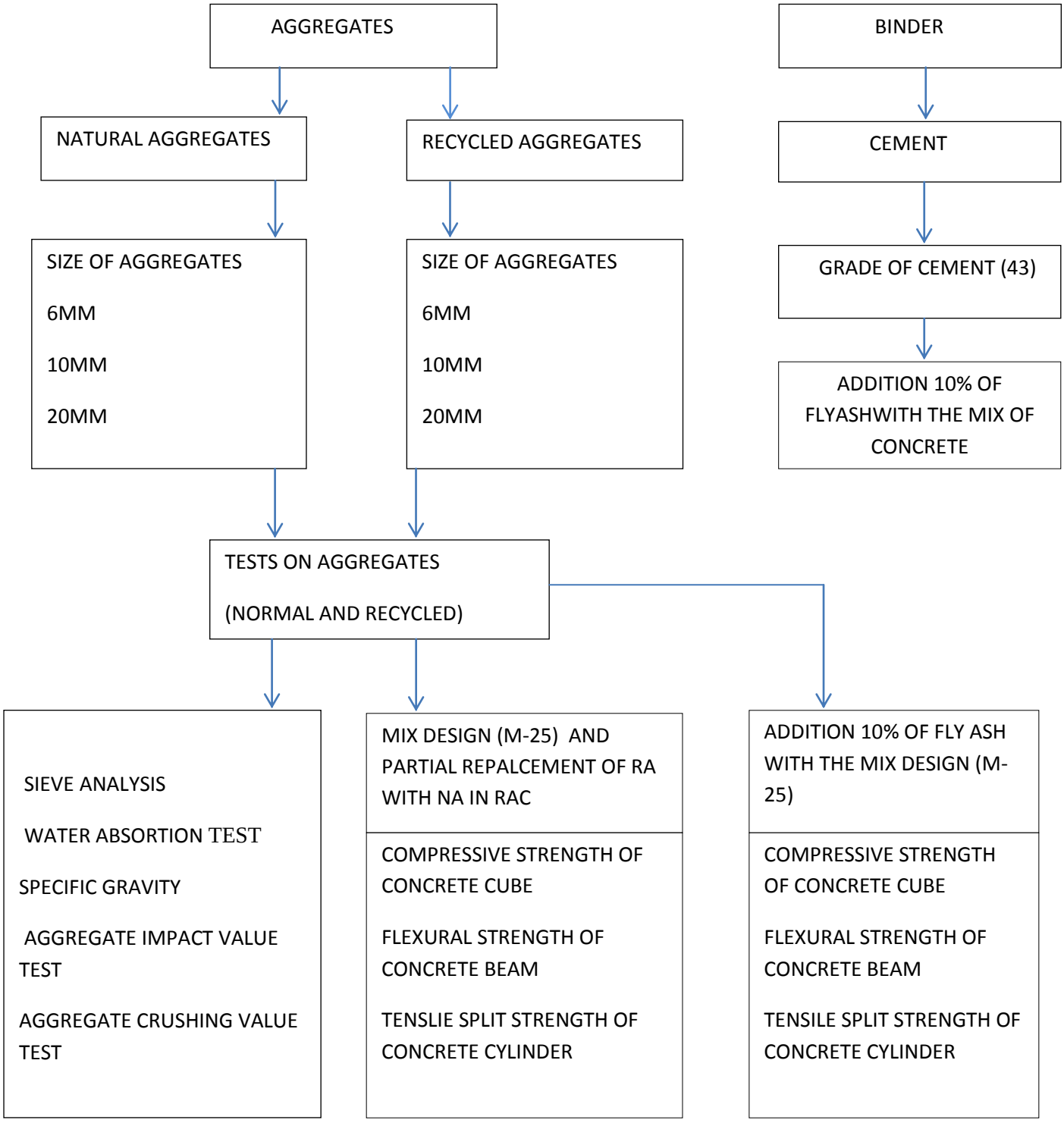
The strength of recycled aggregate is lower than natural aggregate.

Sagoe and Brown in the year (1998) stated this as analysed that the weight of recycled aggregate when compared with the natural aggregates is much lighter in weight. This is the main prospective that there strength is comparatively lower as that of natural aggregates

CHAPTER 3

3.1 WORK PROGRAM:

3.1.1 FLOW CHART:



3.2 MATERIAL USED:

- Cement**:** The Ordinary Portland Cement (OPC) was compatible and used for the preparation of test specimens and is of grade 43.
- Fine Aggregate**:** The fine aggregate used in this test specimen are locally available.
- Natural Coarse Aggregate**:** These comprised of crushed aggregates particles passing through 20mm ,10mm and 6mm was used as natural aggregates
- Recycled Coarse Aggregate: These comprised of the Crushed concrete aggregate waste passing through 20mm ,10mm and 6mm
- Fly ash: An addition of fly ash was utilised in the mix. It is the most abundant mineral additive; it is inexpensive in many places worldwide.
- Water**:** Portable water available that was for mixing and curing the concrete specimens.

Fig9: Demolition wastes (source: Primary)

CHAPTER 4

EXPERIMENTAL METHODOLOGY:

4.1 SEIVE ANALYSIS:

Sieve analysis is used for the purpose to find the amount of different size of aggregate used in a concrete mix. The experimental setup is in such a way that the aggregate pass through a series of sieve sizes in descending order.

The sieve analysis can be performed either by hand or sieve machine, the natural aggregates as well as recycled aggregates were sieved through the progress.

The main point is that aggregate should be air dried before the sieve analysis is carried out.

The different types of sieve sizes for course aggregate were from 45mm, 37.5mm, 26.5mm, 19mm, 13.5mm, 9.5mm, 4.75mm

Fig10: Sieve analysis (Source: Concrete lab LPU)

4.2 WATER ABSORBTION & SPECIFIC GRAVITY

- SPECIFIC GRAVITY:

The specific gravity of an aggregate may be defined as the fraction of the mass of solid in a given volume of sample to the mass an equal volume of water at the same temperature. The Specific gravity is generally calculated under three different conditions bulk, apparent and saturated. In the saturated specific gravity is determined when the aggregate is under the saturated condition, the bulk, the specific gravity of the aggregate is resolute under the natural condition. The apparent specific gravity is determined after the aggregate are oven dried for 24 hours. The specific gravity of aggregates gives us information on quality and properties and its seen higher specific gravity, the harder and stronger the mix will be.

- Specific gravity = Dry weight of aggregates/weight of equal volume of water
- Weight of saturated aggregates suspended in water with basket =W1gm
- Weight of basket suspended in water =W2gm
- Weight of saturated aggregates=(W1-W2)gm =Ws gm
- Weight of saturated surface dry aggregates in air =W4gm
- Weight of water equal to volume of the aggregates=(W3-Ws)gm
- Therefore specific gravity = Dry weight of aggregates/weight of equal volume of water= W4/W3-Ws

Fig11:Specific gravity (Source: Concrete lab LPU)

- WATER ABSORPTION**:**

Water absorption is defined as the amount water absorbed by aggregate. It is determined by the increase in mass of an oven dried sample when the sample is immersed in water for 24 hours. The total increase in ratio of the sample is expressed as a percentage and is termed as absorption. The absorption of water by aggregates affects bond between cement & aggregates and it also affects the workability.

When the water absorbed by the aggregates is higher it decreases the workability.

Water absorption = Wt. of water absorbed aggregates/ Wt. of oven dried aggregates100= (W3-W4)/W4x100

Fig12: Recycled aggregates clothed for Oven drying

(Source: Concrete lab LPU)

4.3 AGGREGATE IMPACT VALUE TEST:

For aggregate impact value, the aggregates used are first passed between 12mm sieve and retained on 10mm are used .The aggregates are laid in three layers in cylindrical cup and are tamped 25 times by the rod and cylindrical cup is placed under a hammer falling 15 times under its own weight with a free fall of 380mm. The impact value is determined by the percentage passing on 2.36mm size of sieve

The high value denotes the low performance or the loss of strength

Aggregate impact value = 100 W2/W1

W1= total weight of dry sample.

W2=weight of portion of impacted material passing 2.36mmsize of sieve

Fig13: Aggregate Impact test (Source: Concrete lab LPU)

4.4 AGGREGATE CRUSHING VALUE TEST:

In the aggregate crushing value test , the aggregates are allowed to pass from the sieve size 12.5mm and the aggregates retained on 10mm are used test .The aggregates so collected are subjected to 400 KN compression load in a cylindrical mould.

The crushing value of aggregates is defined as the percentage loss in mass on 2.36 mm sieve Bigger percentage of aggregate crushing value means the aggregate is inferior in quality.

Fig14: Aggregate Crushing test

(Source: Concrete lab LPU)

Aggregate crushing value = 100 W2/W1

W1=total weight of dry sample.

W2=weight of portion of crushed material passing 2.36mm sieve

4.5 COMPRESSIVE STRENGTH OF CONCRETE CUBE:

Compressive strength test**:**

The compression strength test is carried on concrete cube in order to determine the compressive characteristics strength .The mix design was M-25 and water /cement ratio as 0.5. In the compression test enlisted above a concrete cube is standard size is made as per standard cube mould of 150mm for concrete mix.

The cubes were made of recycled aggregates as well as natural aggregates and the percentage replacement of NA an RA i.e (70%RA +30%NA) (50% RA+50% NA) and RA and then 10% of fly ash was added to the mix.

The precautions that should be taken in order that the test results should not deviate so the apparatus should be clean and free from hardened concrete and superfluous water before testing and even a coat of kerosene or diesel is applied on apparatus in order the concrete aggregates does not stick to it. The compressive strength of each cube is calculated after curing period of 3days, 7days and 28

Fig15: filling of RAC in cube (Source: Concrete lab LPU)

Fig16: Cube after curing of 14days (Source: Concrete lab LPU)

Fig17: Failure of concrete cube (Source: Concrete lab LPU)

4.6 TENSILE SPLIT STRENGTH OF CONCRETE CYLINDER:

The cylinder of size 150mmdai X 300mm height The split tensile test shows the possible concrete that it can reach in perfect conditions ,in this test the strength is attained of the cylinder in its hardened state. The mix design is same M-25 and water /cement ratio as 0.5. The cylinders were made of recycled aggregates as well as natural aggregates and the percentage replacement of NA an RA i.e (70%RA +30%NA) (50% RA+50% NA) and RA and then 10% of fly ash was added to the mix

The precautions are same that apparatus should be clean and free from hardened concrete before testing and even a coat of kerosene or diesel is applied on apparatus in order the concrete aggregates does not stick to it. The compressive strength of each cylinder is calculated and noted down after the curing period of 3days, 7days, 28days.

Fig18:Cylinder specimen getting filled by RAC (Source: Concrete lab LPU)

Fig19: Cyliderical conrete specimen after curing of 28days

(Source: Concrete lab LPU)

Fig 20: Failure of concrete cylinder (Source: www.ijera.com)

4.7 FLEXURAL STRENGHT OF CONCRETE BEAM:

This test is carried on the concrete beam in order to determine the compressive strength. The beam is of size 100x100x500mm, the test shows the possible concrete it can reach in perfect conditions .In this test the strength of concrete beam is attained in its hardened state .the mix design is M-25and the water /cement ratio as point 0.5. The beams were made of recycled aggregates as well as natural aggregates and the percentage replacement of NA an RA i.e (70%RA +30%NA) (50% RA+50% NA)and RA with the addition of 10% of fly ash to the mix .In order to determine the variation in strength after different proportions.

The precaution are similar that apparatus should be clean and free from any hardened concrete and other materials that could deviate the results .The coat of kerosene or diesel is applied to the apparatus in order the concrete aggregates does not stick to it. The strengths at different .The compressive strength of each cube is attained after the curing period of 3days,7days, 28days.

Fig21: filling of RAC with percentage replacement of NA and with addition of Fly-Ash in beam specimen. (Source: Concrete lab LPU)

Fig22: Concrete beam after curing of 28days. (Source: Concrete lab LPU)

Fig23: Failure of concrete beam (Source: www.ijera.com)

CHAPTER 5

RESULT AND DISCUSSION

5.1 SEIVE ANALYSIS:

NATURAL AGGREGATES:

Table 1: Sieve Analysis of NA

Sieve size(mm)	Agg.size(20mm)gm	Agg.size(10mm)gm	Agg.size(6mm)gm
37.5			
19.5	92		
13.2	55		
9.5	30	88	
4.75	20	25	81
2.36	10	10	30
.300	0.5	1.2	3.2
.075	0.02	0.65	1.06

RECYCLED AGGREGATES:

Table 2: Sieve Analysis of RA

Sieve size(mm)	Agg.size(20mm)gm	Agg.size(10mm)gm	Agg.size(6mm)gm
37.5			
19.5	86		
13.2	64		
9.5	25	84	
4.75	16	32	78
2.36	11	14	34
.300	0.8	1.9	4.1
.075	0.06	0.8	1.2

5.2 AGGREGATES IMPACT VALUE:-

For Conventional Aggregates:

Aggregate impact value = 10.93 = 11%

For Recycled Aggregates:

Aggregate impact value = 22.46 = 22.5%

5.3 AGGREGATE CRUSHING VALUE:-

For Conventional Aggregates:

Aggregate crushing value = 21.33 = 21 %

For Recycled Aggregates:

Aggregate crushing value = 28.33 = 28.33 %

5.4 WATER ABSORPTION AND SPECIFIC GRAVITY:

For Conventional Aggregates:

Water Absorption = 1.85 %

For Recycled Aggregates:

Water Absorption = 6.2 %

SPECIFIC GRAVITY:

For Conventional Aggregates:

Specific gravity = 2.64

For Recycled Aggregates

Specific gravity = 2.2

Table No 3- Difference between NA and RA

TESTS	NATURAL AGGRGATES	RECYCLED AGGREGATES
Aggregate crushing value (%)	21	28.54
Aggregate impact value (%)	11	22.5
Specific gravity	2.64	2.26
Water absorption (%)	0.87	6.2

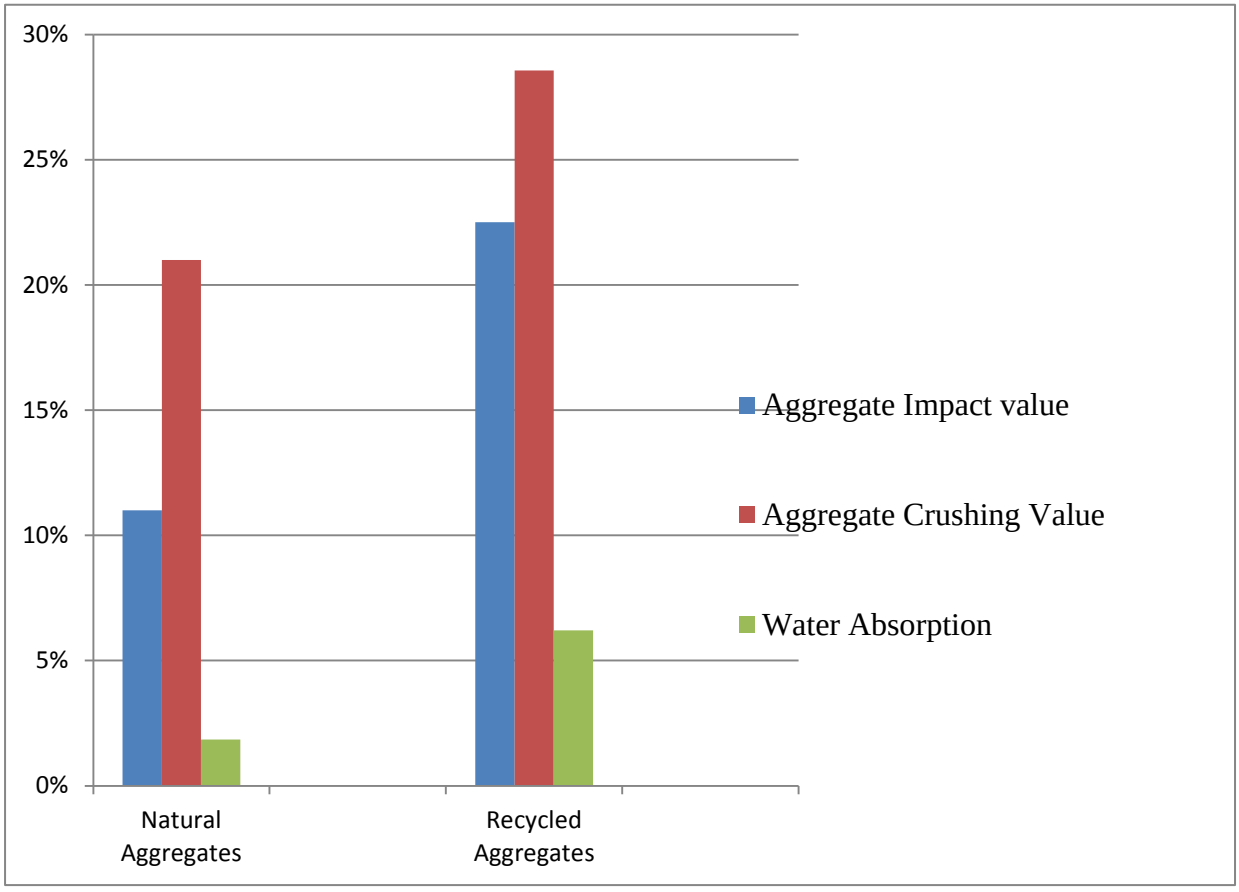


Fig24: AIV, ACV and Water Absorption of Natural and Recycled Aggregates.

5.5 MORTH (Ministry of Road Transport & Highway) LIMIT:

Natural Aggregates: Percentage passing of aggregates

Table no 4: Individual gradation of NA

SIZE OF AGGREGATE(Individual Gradation)				
Sieve size(mm)	20mm	10mm	6mm	Fine aggregates
37.5	100	100	100	100
19.5	40	100	100	100
13.2	11	92	100	100
9.5	4	35	100	100
4.75	1	9	42	100
2.36	0.2	4	26	85
.300	0.06	0.5	10	40
.075	-	-	0.4	10

BLENDING HIT AND TRIAL METHOD:

Table no 5: Hit and Trial method.

BLENDING HIT AND TRIAL METHOD						
Sieve size(mm)	20(mm)	10(mm)	6(mm)	Fine Agg	Des.gradation	Morth Limit
	25%	20%	25%	30%	100%	
37.5	25	20	25	30	100	100%
19.5	10	20	25	30	85	(71-95)%
13.2	3	18.4	25	30	76.4	(56-80)%
9.5	1	7	25	30	63	(40-65)%
4.75	0.25	1.8	10.5	30	42.55	(38-54)%
2.36	0.05	0.8	6.5	25.5	32.85	(28-42)%
.300	0.015	0.5	2.5	12	15.05	(7-21)%
.075	-	-	0.1	3	3.1	(2-8)%

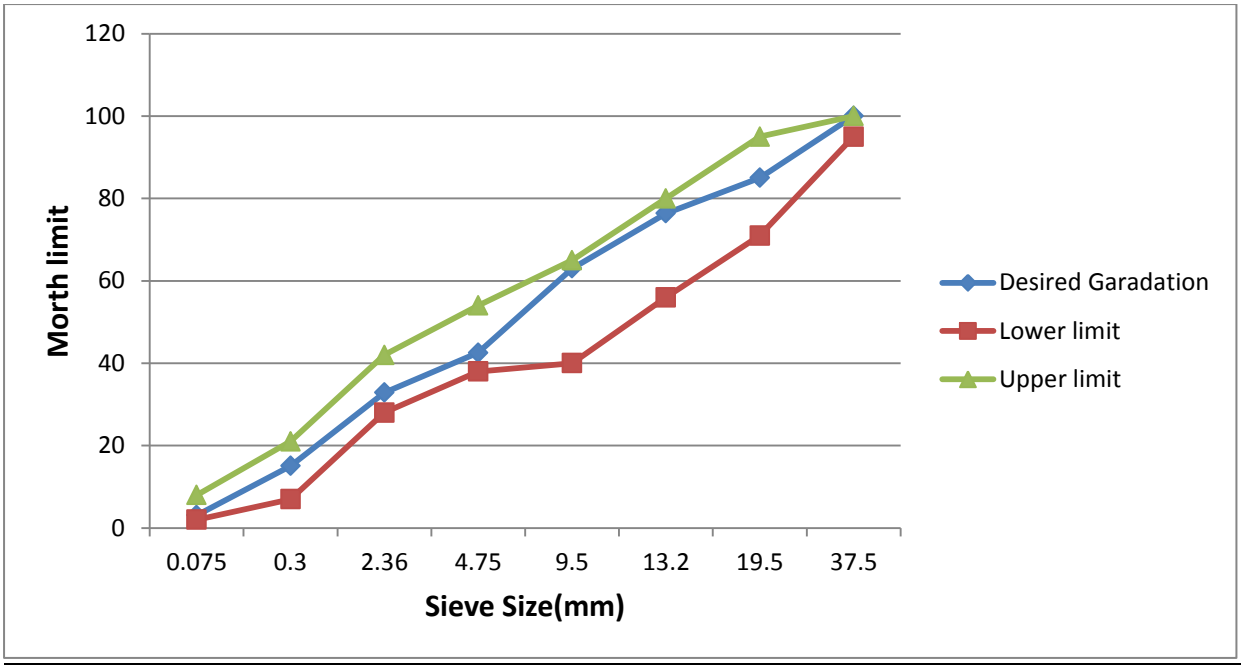


Fig25: Blending of Natural aggregates

MORTH (Ministry of Road Transport & Highway) LIMIT:

Recycled aggregates: Percentage Passing of Aggregates:

Table no 6: Individual gradation of RA

SIZE OF AGGREGATE(Individual Gradation)				
Sieve size(mm)	20mm	10mm	6mm	Fine aggregates
37.5	100	100	100	100
19.5	40	100	100	100
13.2	10	90	100	100
9.5	8	30	100	100
4.75	1.2	9	46	100
2.36	0.3	2	21	80
.300	0.05	0.5	12	38
.075	-	-	0.7	12

BLENDING HIT AND TRIAL METHOD:

Table no 7: Hit and Trial method.

BLENDING HIT AND TRIAL METHOD						
Sieve size(mm)	20(mm)	10(mm)	6(mm)	Fine Agg	Des.gradation	Morth Limit
	25%	20%	25%	30%	100%	
37.5	25	20	25	30	100	100%
19.5	10	20	25	30	85	(71-95)%
13.2	2.5	18	25	30	75.5	(56-80)%
9.5	2	6	25	30	63	(40-65)%
4.75	0.3	1.8	11.5	30	43.6	(38-54)%
2.36	0.075	0.4	5.25	24	29.725	(28-42)%
.300	0.0125	0.1	3	11.4	14.5125	(7-21)%
.075	-	-	0.175	3.6	3.775	(2-8)%

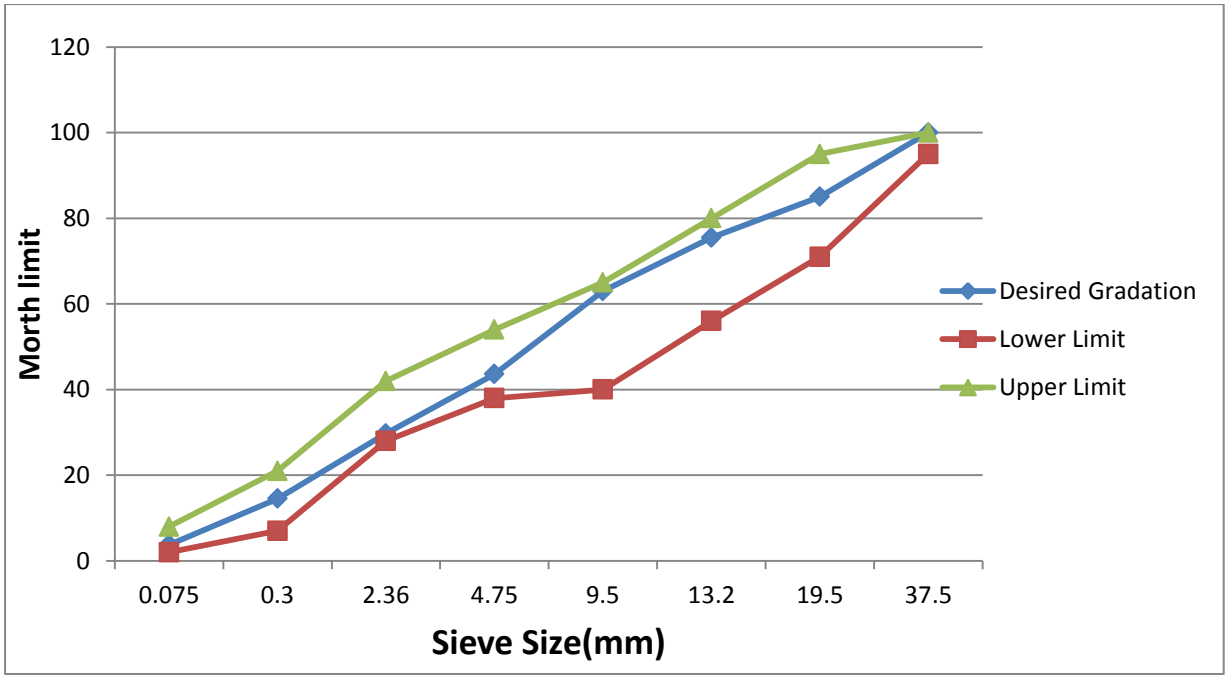


Fig26: Blending of Recycled Aggregates

THE AIV, ACV, WATER ABSORPTION AND SPECIFIC GRAVITY OF RA AND NA:

The effect of AIV, ACV, and water absorption of Recycled aggregates is higher when compared to the natural aggregates is much higher and it is due to the fact that RA has already used once and now the RA are reused that why there is a difference in strength of RA and NA. The rough surface is the factor responsible for the low value of strength.

Water absorption of RA is higher than NA because the adhered mortar that attached to the aggregates which absorb a good amount of water in order there is an increase in water absorption

BLENDING OF NATURAL AGGREGATES AND RECYCLED AGGREGATES:

The main purpose of blending of RA and NA is to find out whether the RA and NA are within the allowed limits stated by Morth (Ministry of Road Transport & Highway). The blending has been done for different size of aggregates (6mm10mm, 20mm) and are found within the allowed limits. The main perspective for blending was satisfied and hence on the basic of values we plotted the graphs

5.5 COMPRESSIVE STRENGTH CONCRETE CUBE

Table no 8: Compressive strength of Cube at different curing period:

COMPRESSIVE STRENGTH OF CONCRETE CUBE						
M-25	Load(KN)	Strength (N/mm)	Load(KN)	Strength (N/mm)	Load(KN)	Strength (N/mm)
NAC	438.3	19.48	595.57	26.47	706.95	31.42
RAC	349.65	15.54	420.025	18.69	513.45	22.82
30%NA+70% RA	402.75	17.9	555.75	24.7	657	29.2
50%(NA+RA)	432	19.2	632.25	28.1	754.65	33.54
RAC with addition of 10% of Fly Ash	396	17.6	459.25	20.41	550.75	24.47

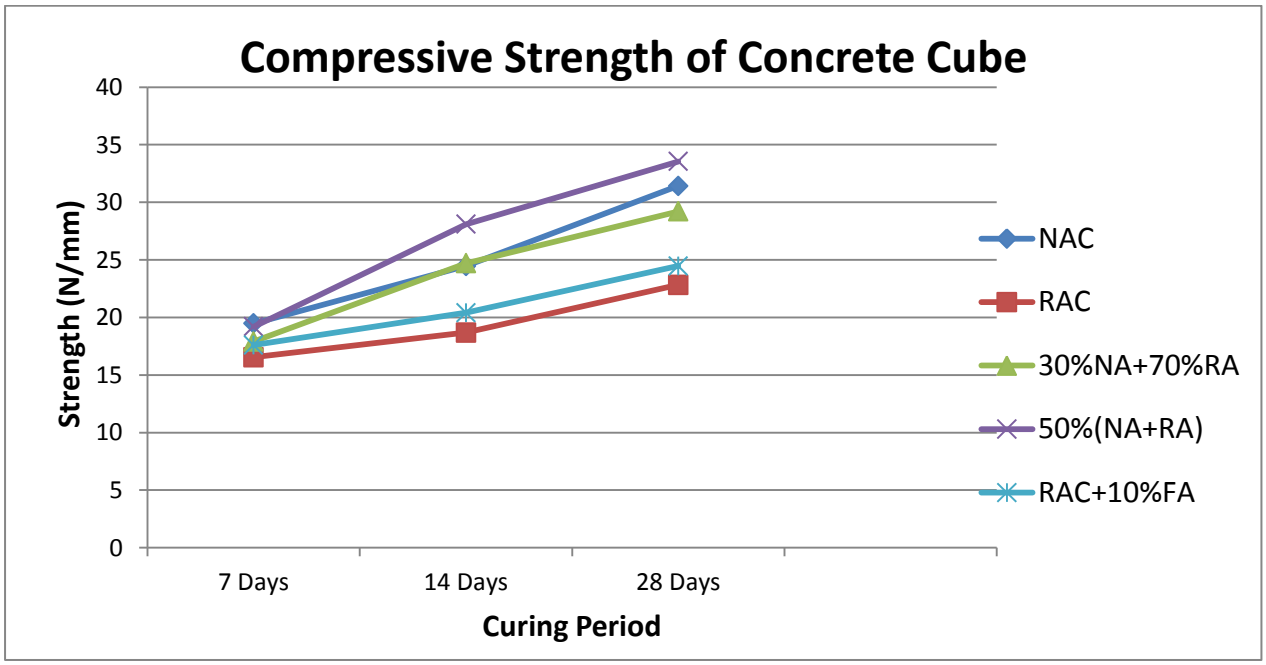


Fig 27: compressive strength at different curing period

5.6 SPLIT TENSILE STRENGHT OF CYLINDER:

Table no 9: Split Tensile Strength of Cylinder at different curing period.

SPLIT TENSILE STRENGTH OF CONCRETE CYLINDER						
M-25	Load(KN)	Strength (N/mm)	Load(KN)	Strength (N/mm)	Load(KN)	Strength (N/mm)
Natural Aggregates	130	1.83	164	2.32	240.331	3.4
Recycled Aggregates	31.8	0.45	50.18	0.71	77.04	1.09
30%NA+70% RA	101.08	1.43	136.42	1.93	219.12	3.1
50%(RA+NA)	124.40	1.76	175.30	2.48	268.60	3.8
RA with addition of 10% of F A	33.92	0.48	62.91	0.89	102.49	1.45

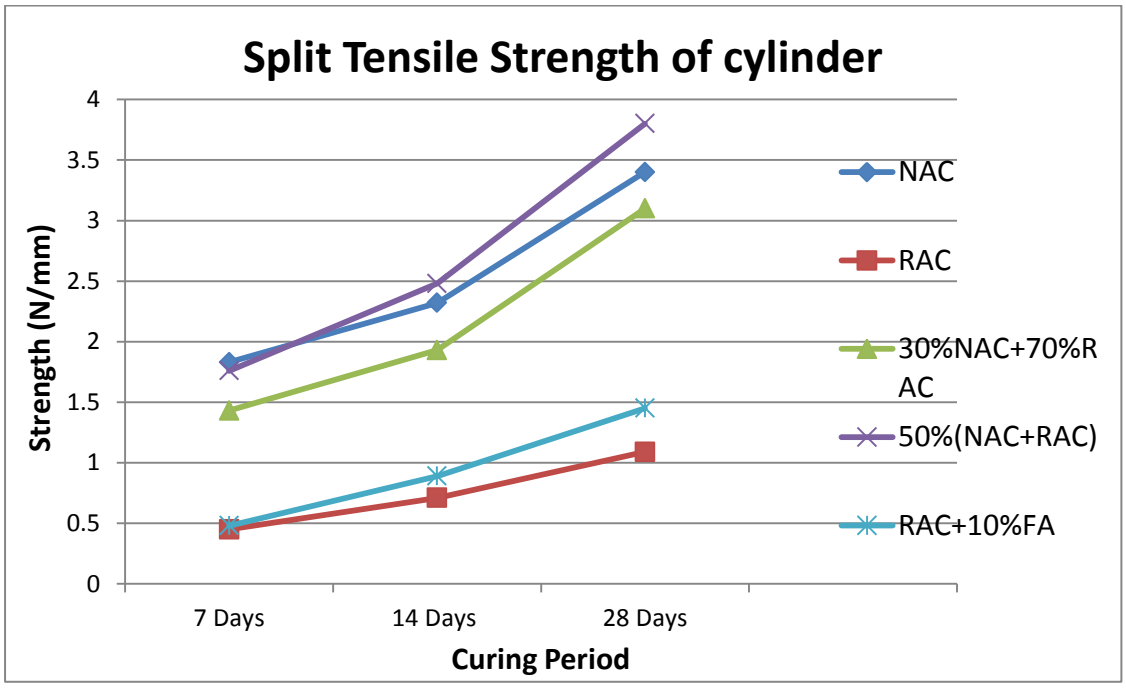


Fig 28: Split tensile strength at different curing periods

5.7 FLEXURAL STRENGTH OF BEAM:

Table no 10: flexural Strength of Beam at different curing period.

FLEXURAL STRENGTH OF CONCRETE BEAM						
M-25	Load(KN)	Strength (N/mm)	Load(KN)	Strength (N/mm)	Load(KN)	Strength (N/mm)
Natural Aggregates	8.2	4.1	13.86	6.93	16.48	8.24
Recycled Aggregates	3.8	1.9	6.48	3.24	8.8	4.4
30%NA+70% RA	6.5	3.25	12.86	6.43	15.6	7.8
50% (NA+RA)	7.9	3.95	15.28	7.64	18.76	9.38
RA with addition of 10% of Fly Ash	4.6	2.3	8.7	4.35	11.81	5.905

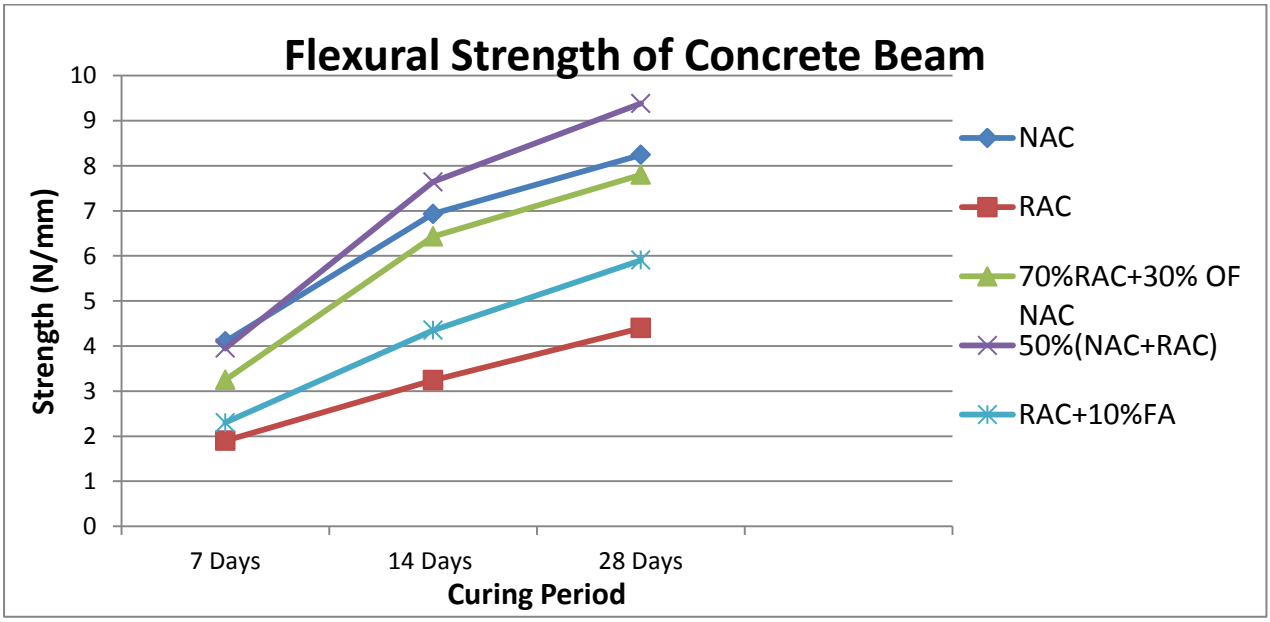


Fig 29: Flexural strength at different curing periods.

DISCUSSION:

- The results show a good increase in the early curing periods of RAC but at the later ages the strength increases at slow rate due to the rough texture of RCA and poor mechanical properties of RAC

- The general properties of RA including various tests such as AIV, ACV and specific gravity show less difference between RA and NA but it is proven that size of RA effects workability and strength is effected by water absorption

- The compressive strength of Concrete gets increased with 50% of(NAC +RAC)and the strength attained is higher than 100%NAC and this may be due be due the cement mortar that is attached to the RAC participates in hydration process and gives additional strength

- On addition of fly ash in RAC it has been seen there is an increase of strength because it has less permeability and lubricating effect which reduces water demand (3%-8%).

- The compressive strength, split tensile and flexural strength of RAC with replacement of 30%NA and 70%RA shows a good increase in strength almost equal to NAC. And on replacing RAC with 50% RA 50% NA there is an increase in strength greater than NAC because of the good bonding in aggregates due adhered mortar and with the curing period.

- The strength of RAC can be attained on higher scale if proper specification standards would have been available.

CHAPTER 6

CONCLUSION

This on-going research project is to determine the durability of Recycled Aggregate in terms of strength characteristics and the replacement NA with RA and interaction of specimen with different loading conditions:

- The compressive strength of Concrete gets increased with 50% of (NAC +RAC) and the strength attained is higher than 100%NAC and this may be due be due the cement mortar that is attached to the RAC participates in hydration process and gives additional strength.in a similar case a good increase is seen on 30%replacement with NA almost equal to NAC.

- The tensile split and the flexural strengths shows an increase in strength on replacement with 50% of RA with NA in RAC when compared with NAC and followed a similar trend workability was increased and gain in strength due to adhered mortar on aggregates and hence makes it satisfactory and economical for structural applications

- It has also been seen that the water absorption of RAC is much higher than NAC because water is absorbed by the cementitous material on RA and other materials

- In this research on using 100% RA were used, which show comparatively decrease in strength in all the mixes of RAC than NAC, as for the fact that strength of concrete is influenced by the type or more precisely by the aggregate strength similarly as RA limits the strength RAC mix and it is generally controlled by weakest link in the concrete mix, i.e the matrix, bond between RA and the interfacial zone.

- Due to the lack specification standards of RA the adequate strength of RAC is not achieved and hence are marginally deformable

6.2 FURTHER SCOPE:

Most of all further testing and studies on the recycled aggregate should done in terms of strength characteristic for their use in structural and road application.
Some of the recommendations for further studies are below:

- Improvements of the durability of concrete with recycled aggregates in chloride exposed environment.
- Balancing durability and environmental impact in concrete combining of low grade recycled aggregates and minerals.
- Durability performance of concrete made with fine recycled concrete aggregate
- Recycled aggregate from C&D wastes and its use in concrete-A break through towards sustainability in construction.
- Utilisation of fine recycled aggregates in concrete with fly ash and steel slag
- Comparison of NAC and RAC prepared with the addition of different mineral admixture.
- Recycled concrete and mixed rubble as aggregates in influence of variation in composition on the concrete properties and their use as structural material.
- Effect of ground bagasse ash on mechanical and durability properties of RAC
- Study on the influence of attached mortar content on the properties of RA

CHAPTER 7

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