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A COMPARATIVE STUDY OF CONCRETE WITH USING FIBRE AND RECYLED AGGREGATE

V.ARAVINDHA KUMAR, R.KARTHIK, C.SIVASANKARAN, P.KISHORE SELVAM

1.1 General

In the modern construction world, concrete is the most widely used man-made construction material. Concrete is a high-volume, low-cost building material produced by mixing cement, water and coarse & fine aggregates. It is an essential component of roads, foundations, high-rises, dams and other staples of developed landscape.

The urbanisation & industrialisation increases the demand for production of concrete. In the world-wide 900 million tons of concrete are generated annually and approximately 470 million tons of waste concrete are generated annually from construction and demolition (C&D) and public works project. In India the production of concrete is about 83 million tons annually and the generation of waste concrete is approximately 52 million tons annually.

The production of this much of concrete utilizes large quantity of cement, water and coarse & fine aggregates.

1.2 Aggregates

Aggregate is the essential basic construction material affecting the properties of concrete and taking approximately 70% of volume of Portland cement concrete and over 90% of Asphalt concrete (metha et.al, 2006). Therefore the strength of a concrete is mainly depends on the characteristics of aggregate itself. The strength of an aggregate is mainly depends on their size, shape, surface, compressive, and bond strength permeability and reactions to chemicals. Classification of aggregates is generally based on their geological origin, size, and shape & unit weight.

- According to the geological origin aggregates can be classified into natural aggregate & artificial aggregates.
- According to the size, aggregate can be classified into fine and coarse aggregates.
- According to shape, aggregate can be classified into rounded aggregate, irregular aggregate, angular aggregate, flaky & elongated aggregates.
- According to the unit weight aggregate can be classified into normal weight aggregate, heavy weight aggregate and light weight aggregate.

1.3 Need for Recycled Aggregates (RA)

The production of larger quantity of concrete causes serious problems all over the world such as depletion of the natural aggregates and creates enormous amount of waste materials from construction & demolition activities. One of the ways to reduce this problem is to utilise recycled aggregate (RA) in the production of concrete (khalaf, et.al, 2004). The RA has been collected from the C&D waste.

1.4 Construction & Demolition waste (C&D)

Construction & Demolition waste (C&D) is developed from the complete or partially removal of buildings, which includes bricks, concrete, masonry, soil, rocks, lumber, paving materials, plastics, glass, wooden materials, electrical & roofing materials. C&D waste will increased from time to time proportionate with the development of the town & country. Reducing, reusing & recycling appear to be profitable alternatives that will increase the lifetime of landfills and reduce exploration of natural resources.

1.5 Properties of Recycled Aggregates (RA)

Recycled aggregate is also an aggregate produced through recycling process of waste concrete from C&D. Such RCA from C&D waste are generally employed for low value added use including land reclamation, filling, sub-base material for road and concrete secondary product manufacturing. It has been known that the workability of recycled aggregate concrete is lower than the natural aggregate concrete. However with a recent advancement of technology for processing the waste concrete it is possible to produce recycle aggregate as of similar quality as the natural aggregate (song, et.al, 2009).

The compressive strength & elastic modulus of recycled aggregate concrete are also lower about 15% to 20% than the natural aggregate concrete. These can be rectified by the addition of fibre to the recycled aggregate concrete.

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1.6 Need of Fibre

Fibres are the filamentous structure which can be made from any material. There are variety of fibres are available in the market. Among them the polyethylene fibres are most commonly used one in the concrete. In random orientation, ultra-high molecular weight polyethylene molecules give very low mechanical properties. However, if dissolved and drawn from solution into a filament by a process called gel-spinning, the molecules become disentangled and aligned in the direction of the filament. The molecular alignment promotes very high tensile strength to the filament and the resulting fibre. Such fibres in different proportions are used in making of the concrete will help to increase the compressive strength of the concrete.

The Polyethylene terephthalate (PET) bottles are most commonly used throughout the world. Some of the PET bottles are recycled and most others are simply thrown out in the environment. This will leads to the serious issues related to the environment. If the concrete made with PET fibres with recycled aggregates satisfies the conditions when compared to the nature concrete, then it is easy to protect the environment by making PET fibres from the PET bottles.

1.7 Objectives

Based on the above discussion, it is important to protect the natural aggregates from over exploitation. Therefore it is necessary to find the replacement for the natural aggregate. There are two types of aggregates are used in the concrete, (i) Coarse aggregate & (ii) Fine aggregate. In this study the replacement is only focussed on the coarse aggregates. In order to increase the compressive strength the PET fibre is used. The PET fibre is chosen because of its high tensile strength of the filament. Thus the main objectives of this study are given as:

1) To find the compressive strength of the concrete using Recycled Coarse Aggregate (RCA) with fibre (PET).
2) To find the compressive strength of the concrete using Recycled Coarse Aggregate (RCA) without fibre.
3) Finally, to compare the results of the above mentioned[1] with the natural aggregate concrete.

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[1] The compressive strength of the concrete using RCA with/without fibre.

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2.LITERATURE REVIEW

2.1 Introduction

In recent year, there are various studies on of concrete in diversifying sources of the materials involved. Among the materials involved in the study the important one is aggregate. Now there is various type of aggregate which has been produced. Among the resulting aggregate consists of crushed glass, materials, industrial waste, the construction waste such as concrete, crushed brick and more.

Through the observation of several studies, see that the material used in this study consist of waste materials. The evidence can be seen with the aggregate income by disposal of construction waste such as crushed brick and concrete (aggregate applicable) that has been done in many countries like America and England. The materials are usually available from the work of collapsed buildings or structures.

Actually, the use of this material pos been instituted at about more than 50 years after the end of Second World War. Countries involved in the war have resulted in the city piled with a lot of concrete piles from the effects of fire. With the presence of a lot of concrete piles, there is a problem of disposals of these materials. Then here comes the idea of remaining debris is used us a new aggregate alternative measures for the disposal of this material. Currently, there are several factors that lead to the use of waste materials as aggregate concrete. Among these are economic factors in the areas difficult to get the aggregate suooly due the lack of these resources. In at the same time to travel far distance to obtain these materials from seeks to apply the existing aggregate. In addition, the remaining concrete is cheaper than the cost of disposal

According to a researcher, Frandistou-Yannas, 1980, there are several factors to the successful use of this material as a new aggregate. Among these are,

1. These remain a concrete waste materials and access.
2. High disposal costs for waste material are reduced.
3. Major route facilitating the concrete waste is picked up by large trucks.
4. There are suitable industrial lands.
5. The lack of other quality materials to be used as the cost of the aggregate is high.
6. Existing markets.

2.2 Production of aggregate in economics:

In general, reply to the aggregate income is one of the alternative disposals of waste concrete rubble. As we know, the war the world has left many of them is the effects and the remaining debris a lot of concrete. Alternative selection is made to address the problem of disposal concrete. Waste caused by the Second World War and subsequently received adopted to date for most countries in the Americans and Europe. This is because the costs of the aggregate used are lower than the costs of waste disposal concrete rubble. Through studies carried out, potentially applicable to the aggregate used as secondary sources of natural aggregate (aggregate normal). Then use increasingly sophisticated technology now provides an opportunity to generate aggregate applies to more quickly and quality is lower operating cost.

2.3 Recycled aggregate concrete:

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 aggregate produces from all but the poorest quality original concrete can be expected to pass the same test required of conventional aggregate.

Recycled aggregate can be batched, mixed, transported, placed and compacted in the same manners as convention concrete. Special care is necessary when using fine recycled aggregate. Only up to 10%-20% recycled fine aggregate is beneficial. The aggregate should be tested at several substitution rates to determine the optimal rate.

Recycled aggregate consists of original aggregate and original mortar. Recycled aggregate using the aggregate refining method or manufactured for the purpose of acquiring equivalent quality to natural aggregate such as gravel and / or sand, and being used as a substitute. However in order to manufacture such recycled aggregate removing original mortar, an advanced processing technique using special facilities such as the method of “heating & rubbing” (Kuroda and Hashida 2005), & Mechanical grinding (Yanagibashi et.al, 2005) are as high as about 56% and about 50% respectively.

A buildings’ lifetime distribution is required to forecast the generation of demolition concrete, this distribution can be determined by fitting the observed remaining rate of buildings to a normal, longitudinal, or weibull distribution (Yashiro 1990).

The long-term demolition rate of buildings calculated from fixed asset statistics is investigated and regressed using the proportional hazard model (PHM; cox 1972) with the economic indices of the construction year serving as covariates. The lifetime distribution of buildings and the generation of concrete are estimated from the regressed demolition rate (Shima, 2003).

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2.4 Properties of aggregate recycling

2.4.1 Size distribution

Generally, a series of successive crushers are used, with oversize particles being returned to the respective crusher to achieve desirable grading. The best particle distribution shape is usually achieved by primary crushing and the n secondary crushing, but from an economic point of view, a single crushing process is usually most effective. Primary crushing usually reduces the C&D concrete rubble to about 50mm pieces and on the way to the second crusher, electromagnets is used to remove any metal impurities in the material (corinaldesi et.al, 2002). 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.

2.4.2 Strength

Though researchers have reported a reduction in strength in recycled aggregate, it should be noted that the extend of reduction is related to the parameters such as the type of concrete used for making the recycle aggregate (high, medium or low strength), replacement le to ratio, water cement ratio and the Moisture condition of the recycled aggregate (Crentsil et.al, 2001; Ajdukiewicz and Kliszewicz, 2002). For example, Katz found that at a high w/c ratio (between 0.6 and 0.75), the strength of recycled aggregate is comparable to that of reference concrete even at a replacement level if 75% (Katz, 2003). Rao found the strength of recycled aggregate and reference concrete to be comparable even at 100% replacement, provided that the water cement ratio was higher than 0.55. However, as the water cement ratio is reduced to 0.40, the strength of RCA was only about 75% of the reference mix (Rao, 2005).

2.4.3 Water absorption:

The water absorption in recycled aggregate ranges from 3 to 12% for the coarse and fine fraction (Jose 2002, Katz 2003 and Rao 2005) with the actual value depending upon the type of concrete used for producing the aggregate. It may be noted that this value is much higher than that of the natural aggregates whose absorption is about 0.5-1%. The high porosity if the recycled aggregate can mainly be attributed to the residue of mortar adhering to the original aggregate.

2.4.4 Specification and application

Internationally, the RILEM specification is the most commonly accepted standard for recycling aggregate. But in Honk Kong, due to our limited experience in using recycling aggregates and Honk Kong's different nature of building construction, a prudent approach has been adopted. For lower grade of application, concrete with 100% recycled coarse aggregate is allowed. Recycled fines are not allowed to be used in concrete. The target strength is specified at 20MPa and the concrete can be used in benches, stools, planter walls, concrete mass walls and other minor concrete structures. (Winston F.K. Fong, Jaime S.K Yeung, and C.S. Poon, 2002).

2.5 Fibre

The main idea of this study is to obtain post-consumed material with enhanced Mechanical properties and at the same time to give them new uses. However the development of new multiphase blend materials is dependent primarily on the controlling of interfacial chemistry and microstructure. There are several material parameters that could influence morphology; viscosity ratio, composition elasticity, shears stress, and interfacial modification. The morphology can be improved by controlling this parameter to obtain an increase the Mechanical properties. Immiscible polymer blends have large interfacial tension, poor interfacial adhesion & poor Mechanical properties. To enhance these properties, it is necessary to improve adhesion between two phases in the blends (Avila, and Dvarte, 2003).

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3. MATERIALS AND METHODS

In order to attain the objectives given in the introductory chapter, the test specimens were made with the materials satisfying and conforming their standards. The detailed nature of materials used throughout this study and also the procedure of the suitable tests made, and the experimental design is explained in this chapter.

3.1 Material preparation

3.1.1 Water

Water is used should be of potable quality if possible, but in no case should dirty or saline water be used. Water sources from rivers or groundwater are usually suitable for making cement mixtures. Acutually, water is need for two purposes that are chemical reaction with cement and contribute in the workability. The workability or consistency is affected by the water content, the amount of cement paste in the overall mix and the physical characteristics of the aggregates such as maximum size, shape and grading. Only 1/3 of the water is needed for chemical reaction while the extra water remains in pores and holes.

Water is important because water distribute every single particles of cement so every crushed rock are covered tightly and water make the mixture of concrete easy to handle. Water from standing ponds or swamps may be high in organic materials and it is not suitable to use in concrete mixture. The mass ratio of water to cement is the main factor that determines the strength of concrete. A lower water cement ratio will yield a concrete which is stronger, while higher water to cement ratio make a concrete with a lower strength. Therefore potable water conforming to IS 3025:1964 2is used for mixing.

3.1.2 Cement

The most common hydraulic cement is ordinary Portland cement, a finely pulverized material that develops its binding property using water. The term hydraulic cement is referred as any cement that turns into a solid product in the presence of water, resulting in a material that does not disintegrate in water.

The raw materials used to manufacture Portland cement are lime, silica, alumina, and iron oxide. It is manufactured by heating a mixture of limestone and clay until it almost fuses and then grinding the clinker of a fine powder.

The Ordinary Portland cement (OPC) of 53 grade Ramco conforming to IS 12269:19873 was used. The maximum size of the cement particles is 0.09mm.

Table – 3.1: Specifications for OPC 53 grade	
Initial setting time	Not less than 30 minutes
Final setting time	Not more than 10 hours
Fineness of cement	Not more than 10% of weight of cement
Specific gravity	3.15

3.1.3 Fine Aggregate (FA)

River sand fine aggregates are formed from weathering and decomposition of all types of rock, the most abundant material constitunet being quartz. It is used in variety of product such as brick.glass, concrete and explosive. Manufactured sand is produced by crushing stones, gravel or air-cooled blast-furnace slag and is characterized by sharp and angular particles. Sand is known as very fine loose fragment of crashed rock. Fine aggregates also known as sand shown consists of natural particles ranging in size from 600μm to 3/16(4.75μm).

According to IS 383:1970 the FA is being classified into four different zones, that is Zone I, Zone II, Zone III & Zone IV.

Table – 3.2: Grading of fine aggregates as per IS 383-1970

IS sieve designation	Percentage of passing for			
	Grading zone I	Grading zone II	Grading zone III	Grading zone IV
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

[2] IS 3025:1964, method of sampling and test (physical and chemical) for water used in industry.

[3] IS 12269:1987, specification for 53 grade ordinary Portland cement, Bureau of Indian Standard (BIS), New Delhi.

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Fine aggregates (FA) which is passing through an IS sieve that is less than 4.75mm were used in making of test specimens.

3.1.4 Coarse Aggregate (CA)

In conventional crushed rock was used as coarse aggregate. Coarse aggregate should be rough and clean with broken face; rounded particles will not adhere well in the mixture and should be avoided, if possible. Generally the aggregate which is beyond 4.75mm gauge are known as coarse aggregate (CA). In this study, the crushed rock with size 20 mm will be used.

3.1.5. Recycled Coarse Aggregate (RCA)

The recycled aggregate used in this work was processed from the C&D waste. The C&D waste was collected from the nearby areas, the type of the C&D waste is demolished concrete of the building. The collected C&D waste was crushed using the machine jaw crusher. After crushing it was soaked in water for 24 hours for water treatment then kept drying. The water treatment was made in order to remove the mortar which binds to the coarse aggregate. It is necessary to remove otherwise the coarse aggregate will not bind with the new mortar paste. Similar to coarse aggregate the RCA also sieved using standard IS and the conforming of the standards was made.

Fig.no:3.1 – Recycled aggregates

3.1.6 Fibre

Polyethylene terephthalate (PET) fibre can be used in this concrete. It can be act as a fibre to increase the strength of the concrete cubes. And also it is useful where low weight, High impact or abrasion resistance, and low cost are required. The fibre should be added at the percentage of 0.5 & 1.0% with Recycled aggregate of 75% and 100% of concrete.

fig.no:3.2 – Cube specimen with fibres

Fig.no:3.3- Pet fibres

3.2 Test on materials

The tests were made to the above mentioned materials for conforming the IS are given below.

3.2.1 Test for cement

The general tests employed are:

- Fineness of cement
- Consistency of cement
- Initial and final setting time of cement.

3.2.1.1 Fineness of cement

Procedure:

- Weigh accurately 100 gm of cement and place it on a standard IS Sieve 90 microns.
- Breakdown any air set lumps in the sample with fingers, but do not rub on the sieve.
- Continuously sieve the sample by holding the sieve in both hands and giving a gentle wrist motion or mechanical sieve shaker may be used

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for this purpose. The sieving should be continuous for 15 minutes.

- Weigh the residue left after 15 minutes sieving. This residue shall not exceed the specified limits
-

Calculation:

a) Weight of cement (W) = 100 gm
b) IS sieve size = 90 micron
c) Sieving time = 15 minutes
d) Weight retained on sieve (W1)= gm
e) Percentage of weight retained on sieve = (W1/W) x 100

3.2.1.2 Consistency of cement

Procedure:

- Weigh 400 gm of cement accurately and place it in the enamel trough.
- To start with, add about 25% of clean water and mix it by means of a spatula. Care should be taken that the time of gauging is not less than 3 minutes and not more than 5 minutes. The gauging time shall be counted from the time of adding water to the dry cement until commencing to fill the mould.
- Fill the vicat mould with this paste, the mould resting on non-porous glass plate.
- Make the surface of the cement paste in level with the top of the mould with a trowel weighing 210 gm. The mould should be slightly to expel the air.
- Place this mould together with the non-porous glass plate under the rod bearing plunger. Adjust the indicator to show 0-0 reading when it touches the surface of test block.
- Release the plunger quickly, allowing it to sink into the paste.
- Prepare trial paste with varying percentages of water and test as described above until the needle penetrates 5mm to 7mm above the mould.
- Express this amount water as a percentage by weight of the dry cement.

Calculation:

a) Quantity of cement used (C) = gm
b) Quantity of water added (W) = ml

Percentage of water for standard consistency (P) = (W/C) x 100

3.2.1.3 Initial and final setting time of cement

Procedure:

Initial setting time

- Weigh about 400 gm of neat cement.
- Prepare a neat cement paste by adding 0.85 times the percentage of water required for standard consistency.
- Start the stop watch at the instant when water is added to the cement.
- Fill the vicat's mould with the cement paste prepared with the mould resting on the non-porous plate. Gauging time should not be less than 3 minutes and not more than 5 minutes.
- Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould to give a test block.
- Place the test block confined in the mould and resting on the non-porous plate under the rod, bearing the needle (A).
- Lower the needle gently till it comes in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block and note penetration, after every 5 minutes.
- Repeat this procedure until the needle fails to piece the block for about 5mm, measured from the bottom of the mould. Stop the stopwatch and note the time, which is the initial setting time.

Final setting time

- Replace the needle (A) of the vicat apparatus by the annular attachment.
- Go on releasing the needle as described earlier till the needle makes an impression thereon, while the attachment fails to do so.
- The time that elapses between the moments the water is added to the cement and when the needle only makes an impression is considered as final setting time for the cement under test.

3.2.2 Test for fine aggregate

- Sieve analysis test
- Specific gravity test

3.2.2.1 Sieve analysis test

Procedure:

- Weigh 1000 gm of dry fine aggregate.
- The weighed sample is placed on the sieve and sieved successively on the appropriate sieves with the largest as 4.75mm, 2.36mm, 1.18mm, 600 micron, 300 micron, 150 micron ends with receiver (Figure 2)

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- The sieves are connected and sample is allowed to sieve on sieves for a period of 2 minutes.
- At the end of sieving 150 micron sieve is cleaned from the bottom by light brushing with fine camel hair brush.
- On completion of sieving, the material retained on each sieve together with any material cleaned from the mesh, is weighed.

Calculation:

Fineness modulus = (cumulative percentage of weight retained/100)

3.2.2.2 Specific gravity

Procedure:

- Take a clean pycnometer with its cap weigh it (W1).
- Take about one third of fine aggregate in the pycnometer and find the weight of the pycnometer with fine aggregate (W2).
- Fill the pycnometer with water up to hole in the conical cap and shake it to remove the air then take the weight of pycnometer with water and fine aggregate (W3).
- Empty the pycnometer and clean it thoroughly than fill it with water up to the hole of the conical cap and weigh it (W4).
- From the above weights calculated the specific gravity of fine aggregate.

Calculation:

$$Specific\ gravity\ of\ fine\ aggregate \frac{\text{Dry weight of fine aggregate}}{\text{Weight of equal volume of water= (W2−W1) / ((W4−W1)−(W3−W2))}}$$

3.2.3 Test for Coarse aggregate

- Sieve analysis test
- Impact value test
- Specific gravity test

3.2.3.1 Sieve analysis of coarse aggregate

Procedure

- Weigh 2000 gm of dry coarse aggregate.
- The weighed sample is placed on the sieve and sieved successively on the appropriate sieves with the largest as 80mm, 40mm, 20mm, 10 mm, 4.75 mm, 2.36 mm ends with receiver.
- The sieves are connected and sample is allowed to sieve on sieves for a period of 2 minutes.
- On completion of sieving, the material retained on each sieve together with any material cleaned from the mesh, is weighed.

Calculation:

Fineness modulus = (cumulative percentage of weight retained/100)

3.2.3.2 Impact value test

- Sieve the material through 12.5mm to 10mm IS sieve. The aggregate passing through 12.5 mm sieve and retained on 10mm sieve comprise the test material.
- Pour the aggregate to fill about just 1/3rd depth of measuring cylinder.
- Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.
- Add two more layer in similar manner, so that cylinder is full. Strike off the surplus aggregate.
- Determine the net weight of the aggregate to the nearest gram.
- Bring the impact machine to rest without wedging or packing upon the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.
- Fix the cup firmly in position on the base of machine and placed whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.
- Raise the hammer until its lower face is 380mm about the surface of the aggregate sample in the cup and allow it to fall freely on the aggregate sample.
- Give 15 blows at an interval of not less than one second between successsive falls.
- Remove the crushed aggregate from the cup and sieve it through 2.36mm IS sieve until no further sinificant amount passes in one mintute.
- Weigh the fraction passing the sieve to an accurracy of 1 gm. Also weigh the fraction retained on the sieve.
- Note down the observation in the proforma and compute the aggregate impact value.
- The mean of two observations, rounded to nearst whole number is reported as the 'aggregate impact value'.

3.2.3.3 Specific gravity test

Procedure:

- Take a clean pycnometer with its cap weigh it (W1).
- Take about one third of coarse aggregate in the pycnometer and find the weight of the pycnometer with coarse aggregate (W2).
- Fill the pycnometer with water up to hole in the conical cap and shake it to remove the air then take the weight of pycnometer with water and coarse aggregate (W3).
- Empty the pycnometer and clean it thoroughly than fill it with water up to the hole of the conical cap and weigh it (W4).
- From the above weights calculated the specific gravity of coarse aggregate.

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Calculation:

$$Specific\ gravity\ of\ coarse\ aggregate = \frac{\text{Dry weight of coarse aggregate}}{\text{Weight of equal volume of water} = (W2-W1)/((W4-w1)-(w3-w2))}$$

3.3 Slump cone test for fresh concrete

- The internal surface of mould is through ly cleaned and freed from superflous moisture and set concrete, if any, before commencing the test.
- The mould is held firmly in placed before the concrete is filled in. concrete under test is filled in the mould in four layers and each layer is approximately one quarter of the height of the mould.
- Each layer is tamped with 25 strokes of the round end of the tamping bar. The stroke should be distributed over the entire area of the mould.
- After the top layer has been rodded, the concrete should be struck off, levelled with a trowel or the tamping rod so that the mould is exactly filled.
- All mortar which has leaked out between the mould and the base plate is cleaned away.
- The mould is immediately raised from the concrete slowly and carefully in a vertical direction.

This allow the concrete to subside and the slump is measured immeditely by determining the difference between the height of the mould and that of the highest point of the specimen being test in mm. measure slump in each case and observe workability.

Fig no: 3.4 Slump cone test

3.4 Mix design

Procedure:

- Target mean strength (f□ck) = fck + t x s
- Selection of water cement ratio.

Selection of water and sand content from the following tables

Table – 3.3: Approximate sand and water content per cubic metre of concrete for grades up to M35

Nominal maximum size of aggregate in mm	Water content per cubic metre of concrete in kg	Sand as percentage of total aggregate by absolute volume
10	208	40
20	186	35
40	165	30

Table – 3.4: Adjustment of values in water content and sand percentage for other conditions

Change in condition stipulated for the above table	Adjustment required in	
	Water content	Percentage, sand in total aggregate
For sand conforming to grading zone I, zone III, zone IV of IS 383-1979	0	+1.5% for zone I -1.5% for zone III -3.0% for zone IV
Increase or decrease in the value of compacting factor by 0.1	± 3%	0
Each 0.05 increase or decrease in free w/c	0	± 1%

Table 3.5 – Approximate air content	
Nominal maximum size of aggregate in mm	Entrapped air, as percentage of volume of concrete
10	3.0
20	2.0
40	1.0

- ✓ cement content = water content/ (water/cement)
- ✓ Calculation of aggregate content

V = (W + (C/Sc) + ((1/p) x (fa/sfa))) x (1/1000)

V = (W + (C/Sc) + ((1/1-p) x (ca/sca))) x (1/1000)

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3.5 Preparation of cube specimens

Procedure:

- Take the quantity of sand and cement in a tray, mix it thoroughly, and then mix this mixture with 20 mm coarse aggregate.
- After the mixing of ingredients, measure the required quantity of water cement ratio and again mix the mixture with the measured quantity of water.
- Keep the mould on a G.I sheet horizontally and apply oil to the inside of the mould. Check bolts and nuts of the mould in proper position.
- Fill concrete in to the mould in layers approximately 30 mm deep.
- If compaction is done by hand, tamp the concrete with the standard rod strokes being uniformly distributed over the cross- section of the mould. For 100 mm, number of strokes should not be less than 25 per layer.
- If compaction is done by vibration, then each by means of suitable vibrating hammer or vibrator or vibrating table.
- Level the top surface of the mould and furnish the identification marks on cubes such as date, batch no etc.

Repeat the same procedure for casting the other two cubes.

Fig.no : 3.5- cube specimen

3.6 Curing

- Storing the specimen in a place at temperature of 27oC for 24 hours from the time of addition of water to dry ingredients.
- Remove the specimen from the mould and keep it immediately submerged in clean, fresh water.
- Keep them till taken out just prior to test.
- Water in which specimen is submerged shall be renewed every seven days.

3.7 Compressive strength test

- The testing is done after 7, 21, &28 days, the days being measured from the time the water is added to the dry ingredients.
- Test at least three specimens at a time. Test specimen, after about half an hour on removal from the water, till it is in surface saturated dry condition.
- If the specimens are recevied dry, keep them in water for 24 hours before testing.
- Note down the dimension of the specimen nearest to 0.2 mm and also note down their weight. Place the specimen in such a manner that the load shall be applied to opposite sides of cubes as cast, not to the top and bottom.
- Align carefully the centre of thrust of the spherically seated platen.
- Apply load slowly and at the rate of 140 kg/cm²/min till the cube breaks.
- The maximum load and appearance of the concrete failure aggregate has broken or cement paste has separated from the aggregate.

Fig.no:3.6 universel testing machine

3.8 Experimental set up

All the specimens used in this project were made on M20 grade of concrete. The dimensions of the specimens are 100mm×100mm×100mm.

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Table – 3.6: specimens with various combinations of aggregates			
Specimen	Percentage of Coarse Aggregate		Percentage of Fibre
	Natural aggregate	Recycled coarse aggregate	
NA	100	×	×
RCA1	×	100	×
RCA2	25	75	×
RCA1.1	×	100	0.5
RCA1.2	×	100	1.0
RCA2.1	25	75	0.5
RCA2.2	25	75	1.0

The cube specimens were made by using various combinations of coarse aggregates are given in the table – 3.6. After making the specimens they were placed for curing of 7, 21 & 28 days. Finally the compressive strength of the each specimen was tested by using the UTM (universal testing machine).

The results of the each test procedure above mentioned are given in the next chapter and the also quantities of the materials used in the concrete are given. The strength of the each concrete specimen was found and the suitable interpretation is given in the following chapters.

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4.RESULTS & DISCUSSION

The results of each test carried out in this project are tabulated and also the mix design for the M20 grade of concrete is given in this chapter. The compressive strength of the specimens was calculated and the results for each specimen are given in detailed manner.

4.1 Properties of cement

The cement used in this work is 53 grade of Ordinary Portland cement. The physical properties of that cement are given in the following table.

Table – 4.1: Physical properties of cement

Type of cement	Fineness	Normal consistency	Setting time in minutes	
			Initial	Final
Ultratech OPC 53 grade	3.2	33%	30	600

4.2 Properties of fine aggregate

The result for sieve analysis of fine aggregates are given in the table – 4.2 and the result for specific gravity of fine aggregate is given below.

Table – 4.2: Result for sieve analysis of fine aggregates

S. No	Is sieve	Weight retained (grams)	% of wt retained	Cum % of wt retained	Cum % passing through
1	4.75mm	0	0	0	100
2	2.36mm	28	2.8	2.8	97.2
3	1.18mm	110	11	13.8	86.2
4	600µ	145	14.5	28.3	71.7
5	425 µ	308	30.8	59.1	40.9
6	300µ	120	12	71.1	28.9
7	150 µ	260	26.0	97.1	2.9
8	75 µ	25	2.5	99.6	0.4
9	PAN	1	0.1	99.7	0.3

Specific gravity of fine aggregate

Specific gravity of fine aggregate = 2.62

4.3 Properties of coarse aggregate

Wt of coarse aggregate = 1000gms.

Table – 4.3: Result for sieve analysis of natural coarse aggregates

S. No	Is sieve	Weight retained (grams)	% of wt retained	Cum % of wt retained	Cum % passing through
1	80	0	0	0	100
2	40	0	0	0	100
3	20	286	28.6	28.6	71.4
4	16	279	27.9	56.4	43.5
5	12.5	232	23.2	79.7	20.3
6	10	180	18	97.7	2.3
7	6	0	0	97.7	2.3
8	4.75	0	0	97.7	2.3
9	PAN	0	0	97.7	2.3

Table 4.4: Sieve analysis: (recycled aggregate)

S. No	Is sieve	Weight retained (grams)	% of wt retained	Cum % of wt retained	Cum % passing through
1	80	0	0	0	100
2	40	0	0	0	100
3	20	286	28.6	28.6	71.4
4	16	279	27.9	56.4	43.5
5	12.5	232	23.2	79.7	20.3
6	10	180	18	97.7	2.3
7	6	0	0	97.7	2.3
8	4.75	0	0	97.7	2.3
9	PAN	0	0	97.7	2.3

Table 4.4: Comparison of properties on natural & recycled aggregate:

S.NO	AGGREGATE TEST	NATURAL AGGREGATE	RECYCLED AGGREGATE
1	Specific gravity test	2.74	2.4
2	Sieve analysis test	3.4%	3.4%
3	Impact test	32.8%	38.75%

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4.5 Result of slump cone tests

Table 4.5: Sieve analysis: (recycled agg)					
Sl. No	Water Cement ratio	Weight of cement in gm	Volume of water added in ml	Slump value in mm	Remarks
1	0.40	2545	1018	11	True
2	0.45	2545	1145	22	True
3	0.50	2545	1273	67	True
4	0.55	2545	1400	94	Shear
5	0.60	2545	1527	145	Collapse

The slump value of concrete is 67mm corresponding water cement ratio is 0.50. The slump value is in to the acceptable limit for reinforced concrete.

Table 4.6: Slump value of N.A 100%					
Sl. No	Water Cement ratio	Weight of cement in gm	Volume of water added in ml	Slump value in mm	Remarks
1	0.40	2545	1018	9	True
2	0.45	2545	1145	17	True
3	0.50	2545	1273	54	True
4	0.55	2545	1400	86	Shear
5	0.60	2545	1527	142	Collapse

The slump value of concrete is 54mm corresponding water cement ratio is 0.50. The slump value is in to the acceptable limit for reinforced concrete.

Table 4.8: Slump value of R.C.A 75%					
Sl. No	Water Cement ratio	Weight of cement in gm	Volume of water added in ml	Slump value in mm	Remarks
1	0.40	2545	1018	10	True
2	0.45	2545	1145	21	True
3	0.50	2545	1273	59	True
4	0.55	2545	1400	99	Shear
5	0.60	2545	1527	147	Collapse

The slump value of concrete is 59mm corresponding water cement ratio is 0.50. The slump value is in to the acceptable limit for reinforced concrete.

Table 4.9: Slump value of R.C.A 100% + P.E.T 0.5%					
Sl. No	Water Cement ratio	Weight of cement in gm	Volume of water added in ml	Slump value in mm	Remarks
1	0.40	2545	1018	14	True
2	0.45	2545	1145	26	True
3	0.50	2545	1273	62	True
4	0.55	2545	1400	87	Shear
5	0.60	2545	1527	139	Collapse

The slump value of concrete is 62mm corresponding water cement ratio is 0.50. The slump value is in to the acceptable limit for reinforced concrete.

Table 4.10: Slump value of R.C.A 75% + P.E.T 0.5%					
Sl. No	Water Cement ratio	Weight of cement in gm	Volume of water added in ml	Slump value in mm	Remarks
1	0.40	2545	1018	13	True
2	0.45	2545	1145	24	True
3	0.50	2545	1273	69	True
4	0.55	2545	1400	94	Shear
5	0.60	2545	1527	141	Collapse

The slump value of concrete is 69mm corresponding water cement ratio is 0.50. The slump value is in to the acceptable limit for reinforced concrete.

Table 4.11: Slump value of R.C.A 100% + P.E.T 1%					
Sl. No	Water Cement ratio	Weight of cement in gm	Volume of water added in ml	Slump value in mm	Remarks
1	0.40	2545	1018	13	True
2	0.45	2545	1145	29	True
3	0.50	2545	1273	73	True
4	0.55	2545	1400	91	Shear
5	0.60	2545	1527	139	Collapse

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The slump value of concrete is 73mm corresponding water cement ratio is 0.50. The slump value is in to the acceptable limit for reinforced concrete.

Table 4.12: Slump value of R.C.A 75% + P.E.T 1%

Sl. No	Water Cement ratio	Weight of cement in gm	Volume of water added in ml	Slump value in mm	Remarks
1	0.40	2545	1018	14	True
2	0.45	2545	1145	27	True
3	0.50	2545	1273	78	True
4	0.55	2545	1400	93	Shear
5	0.60	2545	1527	149	Collapse

The slump value of concrete is 78mm corresponding water cement ratio is 0.50. The slump value is in to the acceptable limit for reinforced concrete.

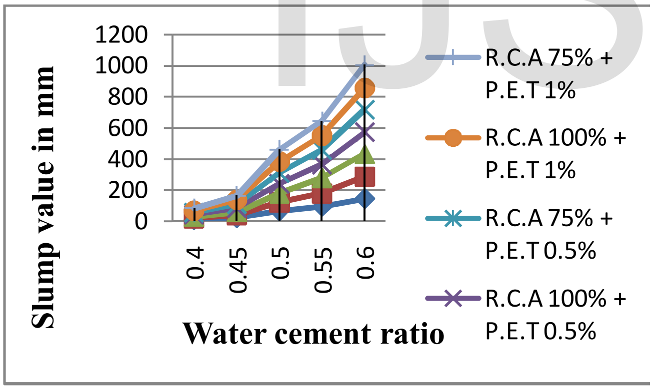
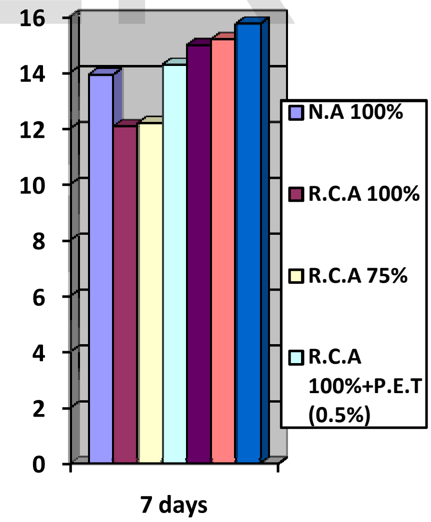


Fig 4.1comparsion of slump value

Table 4.13: Compressive strength of concrete cubes after 7 days curing

S. NO	TYPE OF CONCRETE	SIZE OF SPECIMEN	COMPRESSIVE STRENGTH
1	N.A 100%	100mm x100mm x 100mm	13.92 N/mm2
2	R.C.A 100%	100mm x100mm x 100mm	12.07 N/mm2
3	R.C.A 75%	100mm x100mm x 100mm	12.19 N/mm2
4	R.C.A 100% + P.E.T (0.5%)	100mm x100mm x 100mm	14.27 N/mm2
5	R.C.A 75% + P.E.T (0.5%)	100mm x100mm x 100mm	14.98 N/mm2
6	R.C.A 100% + P.E.T (1%)	100mm x100mm x 100mm	15.19 N/mm2
7	R.C.A 75% + P.E.T (1%)	100mm x100mm x 100mm	15.75 N/mm2



4.5 MIX DESIGN FOR M20 GRADE CONCRETE

MIX PROPORTION

Weight of water = 191.58 kg/ m3

Weight of cement = 383.16 kg/ m3

Weight of fine aggregate = 576.50 kg/ m3

Weight of coarse aggregate = 1224.08 kg/ m3

Mix proportion is 1: 1.51: 3.19

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Fig. 4.2 comparison of compressive strength at 7 days

Table 4.14 Compressive strength of concrete cubes after 21 days curing			
S. NO.	TYPE OF CONCRETE	SIZE OF SPECIMEN	COMPRESSIVE STRENGTH
1	N.A 100%	100mm x100mm x 100mm	18.23 N/mm2
2	R.C.A 100%	100mm x100mm x 100mm	16.92 N/mm2
3	R.C.A 75%	100mm x100mm x 100mm	17.73 N/mm2
4	R.C.A 100% + P.E.T (0.5%)	100mm x100mm x 100mm	18.69 N/mm2
5	R.C.A 75% + P.E.T (0.5%)	100mm x100mm x 100mm	19.11 N/mm2
6	R.C.A 100% + P.E.T (1%)	100mm x100mm x 100mm	19.94 N/mm2
7	R.C.A 75% + P.E.T (1%)	100mm x100mm x 100mm	20.17 N/mm2

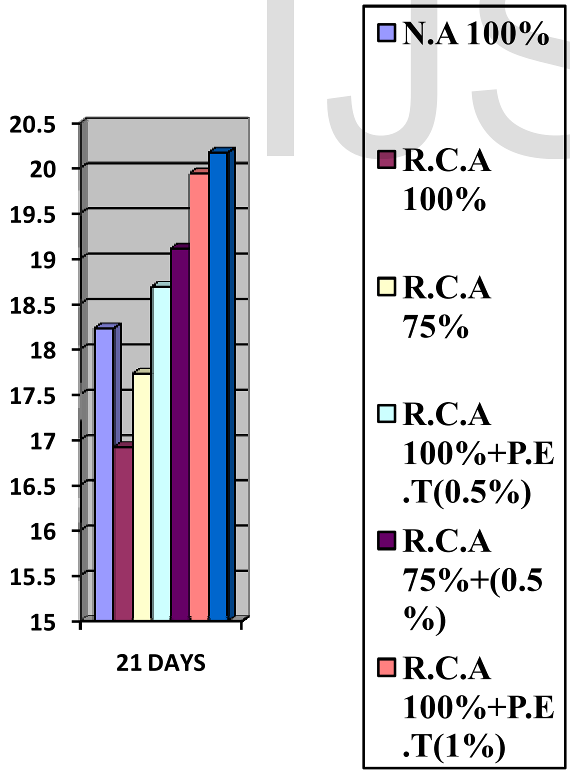

Fig. 4.3 comparison of compressive strength at 21 days

Table 4.15 Compressive strength of concrete cubes after 28 days curing			
S. NO.	TYPE OF CONCRETE	SIZE OF SPECIMEN	COMPRESSIVE STRENGTH
1	N.A 100%	100mm x100mm x 100mm	23.12 N/mm2
2	R.C.A 100%	100mm x100mm x 100mm	20.63 N/mm2
3	R.C.A 75%	100mm x100mm x 100mm	21.47 N/mm2
4	R.C.A 100% + P.E.T (0.5%)	100mm x100mm x 100mm	24.17 N/mm2
5	R.C.A 75% + P.E.T (0.5%)	100mm x100mm x 100mm	24.63 N/mm2
6	R.C.A 100% + P.E.T (1%)	100mm x100mm x 100mm	25.22 N/mm2
7	R.C.A 75% + P.E.T (1%)	100mm x100mm x 100mm	26.73 N/mm2

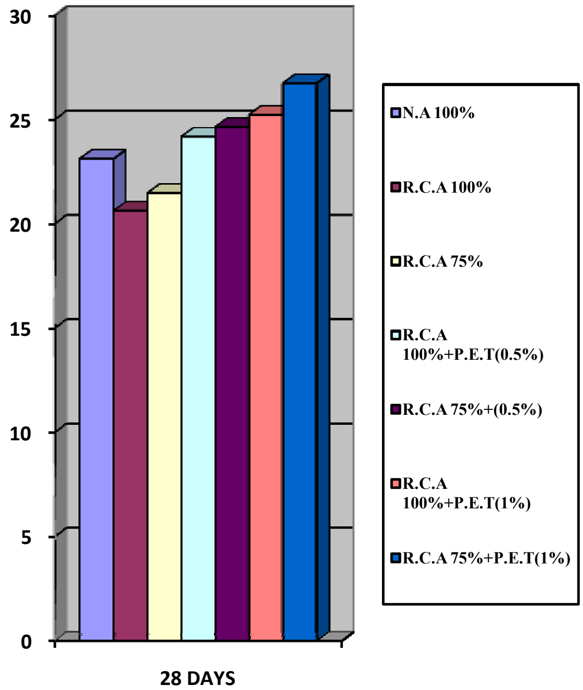

Fig. 4.4 comparison of compressive strength at 28 days

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5. CONCLUSION

The conclusion of the above project is,

- The compressive strength of RCA with 0.5% of fibre gives the strength more than natural aggregate concrete on 7 days,21 days & 28 days.
- Workability of recycled aggregate concrete tested by slump cone gives the sufficient results. So the workability of concrete not affected by recycled aggregate concrete.
- The prize of PET fibre also too low, but it gives the more strength against natural aggregate concrete.
- Mechanical and physical characteristics of recycled aggregate concrete in various ratios and combined with fibres in different ratios are tested and compare with the natural aggregate concrete; it gives the results in a significant ways.

The success of recycling in the future is based on global visions for the implementation of RCA concrete world-wide in order to save natural resources and protect the environment.

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