COMPARATIVE STUDY ON REPLACEMENT OF COARSE AGGREGATES WITH DIFFERENT WASTE MATERIALS IN LIGHTWEIGHT CONCRETE

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by

PEER FAHEEM HUSSAIN

(11209184)

Supervisor

Mr. S. GANESH

Transforming Education Transforming India

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DECLARATION

I, **Peer Faheem Hussain** having the university registration number **11209184**, hereby declare that this submission "**Comparative Study on Replacement of coarse aggregate with different waste material in Light Weight Concrete**" is my own work and that to the best of my insight and conviction, it contains no material beforehand distributed or composed by other individual or office. No material which has been acknowledged for reward of some other degree or certificate of the college or other organization of higher learning with the exception of where due affirmations have been made in the content. It was arranged and displayed under the direction and supervision of **Mr. S. Ganesh** (Assistant Professor).

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CERTIFICATE

This is to certify that **Peer Faheem Hussain** under Registration No. **11209184** has prepared the dessertation report titled "**Comparative study on replacement of coarse aggregates with different waste materials lightweight concrete**" under my direction. This is a bonafide work of the above competitor and has been submitted to me in fractional satisfaction of the prerequisite for the honor of Masters of Technology in Civil Engineering.

Mr. S. Ganesh

Assistant Professor

Supervisor

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Signature of Student
Peer Faheem Hussain

ABSTRACT

The growth of the industrial revolution and the advancement in machinization ecological issues had started to pose a significant threat to the environment and the solutions seemed to be too meagre. This seemed to stand in the way of the lavish life styles and the rapid transformation of the globe. Since all this began in the west, the western countries contributed a fair share to it but the countries like China, India also played an important role and they could not escape the consequences of it. This consequences of it are the enormous pollution as well as the wastes that are being generated because of it. Moreover the exploitation of the aggregates for the rapid development of the infrastructure has created acute shortage of the building materials such as the course and the fine aggregates.

Keeping in view these environmental issues and high cost of the conventional rock aggregates, a viable new source of conventional aggregates from past few years has been identified by different civil engineering researches which will, to a great extent solve both of these problems. Waste materials such as rubber, Styrofoam, plastic have successfully been installed in concrete as a replacement of fine and coarse aggregates with appreciable results. Our present work also tries to find out the effect of adding these materials into the concrete as partial replacement of coarse aggregates. We also try to enhance the strength of this concrete by using superplasticizers such as metakaolin to enhance the mechanical properties of our specimens.

In this context, our present study aims to investigate the effect of these materials when incorporated into the concrete as well as make a comparative study between all of the three. A total of 180 specimens of cubes, cylinders and beams were casted of M20 grade by replacing 5, 10, 15, 20 and 25 percent of natural coarse aggregate with the mentioned coarse aggregates and compared with regular M20 grade concrete. Different tests will be performed on the specimen and the results will be compared with each other and a then an appropriate set of recommendations will be put forward.

Keywords: compressive strength, metakaolin, superplasticizer, rubber, plastic, infrastructure

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Lightweight concrete is a type of concrete that has relatively less unit weight as compared to the normal concrete mix in other words we may say that the concrete which has density lesser than 2300 kg/m^3. This is typically obtained by replacing the coarse aggregates of the concrete and using relatively less dense materials in place of them. Light weight concrete basically reduces the dead load of the structure there improves its efficiency under working loads. Lightweight concrete has been visualized for quite an impressive value of compressive strength, endurance or generally termed as durability is quite colossal. Creep and shrinkage in light weight concrete have significantly lower values than that found in the normal concrete, this provides an edge for the use of light weight concrete over the normal concrete. Last 20 years have been glorious for the lightweight concrete. It was found that in 1990's lightweight concrete was produced equal to 20% of the total concrete works done. From an ecological point of view lightweight concrete has proved to be of quite help. Materials such as rubber, Styrofoam and plastics wastes which are generated in enormous quantities have been used to develop lightweight concrete. Estimated about 1.7 billion new tires and 1 billion waste tires get accumulated each year. 5.6 million Metric tons of plastic waste are generated in India alone and 14 million tons of waste Styrofoam is mustered annually worldwide. All these wastes can be disposed of by their utilization in concrete. This can reduce our ecological concerns and lightweight and economical concrete can be produced. This can be by far the most prudential method for disposal of these wastes without any detrimental effects on the environment. Due to thaw and freezing stresses are developed that develop cracks in concrete, lightweight concrete resists thaw and freezing and can be used in severe cases. Spalling occurs at high temperatures in concrete. It has been found that lightweight concrete resists spalling and hence comes quite handy in high temperatures. Lightweight concrete shows higher tendency for sound absorption than normal concrete and hence can be used for making sound proof structures. Lightweight concrete enables hasty and lucid constructions.

CHAPTER 2

LITERATURE REVIEW

2.1 General

All the major constructions around the globe utilize concrete as the main source of construction so it is important to understand the behavior of concrete under loading. Since concrete structures deflect under their own weight so it enhances the necessity for the use of light weight concrete therefore its necessary to study the previous works in order to identify the research gap and problems to be investigated.

2.2 Lightweight Concrete

Concrete being highly ingenuous and extensively used material of construction. With the advancements in the field of research, high-strength, high-performance and structural lightweight concrete, the adaptability or utility of lightweight concrete has increased many folds. Lightweight concrete is affiliated with many desirable properties few of them being low cost, lightweight, heat insulation, minimal value of the shrinkage when dried.

The use of lightweight aggregates in the concrete for rendering light weight concrete safeguards natural resources, provides a medium of utilizing industrial by-products or wastes and hence recovers or elevates the environment and creates scope to use concrete competently and broadly [1].

2.3 Metakaolin

When clay mineral Kaolinite is subjected to dihydroxylation in presence of thermal activation at $500\text{-}8000^0$ c it renders metakaolin [2].

When the concrete mixture was subjected to partial replacement of 5% and a fixed water binder ratio of 0.4, various dosages of super plasticizer were used the results showed that metakaolin decreased the workability of concrete [3].

Addition of metakaolin into the cement concrete at ratios of 0%, 5%, 10% and 15% by weight at a water cement ratio of 0.45 and $4.95l/m^3$ dosage of superplasticizer the slump showed a reduction in the workability with the inclusion of metakaolin [4].

Thus the generalized conclusion that can be obtained from the above is that addition of metakaolin decreases the workability of the concrete.

On addition of metakaolin it was observed that the evolution of heat or the het of hydration was significantly lesser. Dosages of 10%, 20%, and 30%, heat evolved was 8^0c, 6^0c and 1^0 c respectively [5].

The use of metakaolin in addition to the concrete for betterment of properties, it was observed that addition of certain percentages of metakaolin, the heat of hydration evolved was significantly lower [6].

Partial replacement of cement in concrete by metakaolin at a percentage of 0%, 5%, 10% and 15% by weight. The water binder ratio being kept fixed at 0.28 and 14 kg/m^3 dosage of superplasticizer, the results showed that there was a considerable decrease in the initial and final setting time of the concrete [7].

It was observed that replacement of 20% or more of the cement with metakaolin, the initial and final setting time showed an increase [8].

It was observed that the use of metakaolin in the concrete in suitable concrete mix designs, the cohesion between the particles increased and a significant decrease in the bleeding and cohesion was observed [9].

Sadaqat et al observed that by addition of certain amount of metakaolin into the concrete the bleeding and segregation in the concrete reduces and thereby proved fruitful in use [10].

The use of metakaolin for the replacement of cement in concrete has a fruitful effect on the compressive strength. The compressive strength was significantly increased but upto a certain replacement percentage of 20% and not above [11].

The use of metakaolin in the replacement of cement on concrete increases the split tensile strength. An increase of upto 15% in the split tensile strength was observed in the metakaolin added concrete as coMPared to the normal concrete [12].

Different specimens were casted with 10% addition of metakaolin by weight. The flexural strength showed an increase of 15%, serving to increase the toughness as well [13].

Addition of metakaolin in the concrete the creep and shrinkage were reduced significantly to a lower value. It was also observed that at higher levels of replacements there was further reduction in creep [14].

2.4 Plastic aggregates

The use of plastic aggregates in the replacement of the aggregates in concrete in the percentage of lower than 25% showed no significant decrease in the strength and thus can be used effectively [15].

The water cement ratio effect on the gaining of the compressive strength is not quite visible due to the reason that the strength of the bond between concrete and the plastic aggregates is reduced which later results in the failure. The density of the concrete mix containing the use of plastic aggregates in the replacement of the coarse .aggregates was reduced due to the low unit weight of the plastic. Compressive strength had a negative effect due to the use of the plastic aggregates in the replacements of the coarse aggregates which appears to be due to the low density of the plastic [16].

The use of plastic aggregates in the construction purposes helps to make energy efficient building in a manner that structure made with plastic concrete depicted less use of energy as compared to the same building made with normal concrete [17].

It was observed that the use of plastic aggregates reduced the overall bulk density of the concrete. A reduction of 2.5-13% which is quite significant was observed. A percentage reduction of 10-50% coarse aggregates with the plastic aggregates the compressive strength obtained was 48 and 19 MPa respectively. Compressive strength reduction was observed to be around 34% - 67% in 10-50% replacements. An inverse effect was observed in the split tensile strength a well. A 10% plastic aggregate addition showed 17% decrease in the split tensile strength. In the repair and veneer of the totaled structures plastic concrete proves quite useful. Plastic added concrete also shows renovation properties [18].

The compressive strength of the concrete containing waste plastic has a very low value compared to that of the normal concrete mix. Concrete containing 20% use of the plastic aggregates 30.5%

reduction in the flexural strength was observed after 28 days of curing. A similar decreasing effect was observed in the fresh density as well as the dry density of the concrete containing plastic aggregates replaced foe the coarse aggregates. The slump values of the plastic containing concrete shows a lower slump value than the reference concrete [19].

The shape and the size of the plastic aggregates have different effects on the concrete. Flaky and porous aggregates decreases the slump height of the slump cone whereas the opposite was seen in case of the spherical aggregates. In comparison to the normal or reference concrete a 72% decrease in the compressive strength was seen at an addition of 20% of the plastic aggregates. A gradual decrease in the flexural and split tensile strength was seen as well but that was comparatively lesser than that compared to the compressive strength. It was also observed that the permeability showed an increase which thus implies that durability property can also be prolonged due to the use of plastic aggregates. Shrinkage in the concrete containing plastic aggregates was found to be of higher value than the normal or reference concrete [20].

A quite reasonable value of compressive strength was found out for the use of 22% plastic coarse aggregates however the bonding factor had an impact in the tensile strength, which could however be increased if the bonding could be increased between the plastic and the concrete mix [21].

The work done on the incorporation of the plastic into the concrete for any use was found out to decrease the values of the strength in the concrete in reference to the normal concrete [22].

Plastic aggregates that were put to use in the concrete with the percentages of 20% and 30% showed the values of compressive strength from 35.1 to 23.5 and the values of flexural strength were observed to have dropped from 5.03 MPa to 2.89MPa, tested after 28 days. This drop in the strengths was found out to be due to the low bond strength between the plastic and the concrete paste. This low value of the strength was however applicable in the pacing of concrete in pavements where low modulus of elasticity is quite favorable [23].

Replacing of the coarse aggregates with plastic has an effect on the unit weight of the concrete thereby facilitating the production of lightweight concrete. Using of concrete tends to increase the ductility of the concrete which later increases the deformation ability of concrete before failing under the application of loads. This increase in the ductility of concrete is favorable in using the concrete in unfavorable climatic conditions such as extreme high or low temperatures. This type of ability as proves useful in the freeze and thaw cases. Energy efficiency was another favorable point of using plastic aggregates. It provides thermal insulation which helps to keep the Interiors warmer or cooler as compared to outsides [24].

2.5 Rubber

The incorporation of rubber into the concrete had a negative effect on the compressive as well as the tensile strength of the concrete. Major effect was observed on the compressive strength of the concrete however the tensile strength was effected but to a lower value as compared to the compressive strength [26].

The use of rubber for the replacement of the coarse aggregates resulted in the decrease of the properties of the concrete such as compressive strength, flexural strength, split tensile strength. However such reduction of the properties is also feasible in some construction purposes viz; road construction purposes [27].

A decrease in the height of the slump was observed while addition of rubber was done to the concrete, however, the workability had no significant effects. 75mm and 60mm were the heights for 5% replacement of crumb rubber. Due to the low bonding between rubber and concrete the compressive strength is decreased below the reference normal concrete. The rubber inside the concrete cubes acts as a shock absorber due to which no proper cracking of the specimen occurs during the testing phase. Good impact resistance is a desirable property in some structures this can be provided by adding rubber to the concrete [28].

CHAPTER 3

SCOPE

Since the present day growth of industrial wastes such as rubber, Styrofoam and plastic is growing at an alarming rate thus there needs to be an alternative that will help in the safe disposal of all these materials without having adverse consequences. All these materials can be used as replacements of the coarse aggregates in the concrete which thereby renders the lightweight concrete. Moreover lightweight concrete is used in making insulation walls, tiles, roofs, floors, floating houses, sound barrier walls. Lightweight concrete decreases the dead weight of the structure which helps to reduce the overall manufacturing cost of the project. Light weight concrete also provides an edge in the regulation of the internal temperatures of the structure. Fire resistance is another important aspect of the lightweight concrete structures. Thus the purpose or outlook can be visualized as:

- Ecologically, waste can be disposed off from the environment at a price easy on the pocket without any repugnant consequences back on the entourage.
- All these materials can be used in concrete, reducing the overall weight of the concrete which has favorable properties like high compressive strength, resistance to spalling, resistance to freeze and thaw etc. over the normal concrete economically.
- Different materials will be used in the study, thus an overall comparative study can be done on the materials visualizing the best option out of all.
- Structures resistant to fire can be obtained as well as structures that can regulate the temperatures in different climates.

CHAPTER 4

OBJECTIVE OF THE RESEARCH

Since many methods have been utilized for the disposal of the industrial wastes but more of them have had some serious hazards which are thus not quite handy for the use. Moreover these materials have not been disposed by putting them to any use instead they are just discarded.

The main objective of the research is to put these materials to some use and test their effectiveness. Also these materials are wastes and this research also provides an economical and safe system of disposing of these wastes. The materials being used in this research have different properties as well as behaviors, thus this research will help us to find the most suited alternative for our use in the future. The strengths of the various combinations of the materials used along with the admixtures is to be determined. To test the usability of the materials in different combinations and to find their usability in everyday life.

CHAPTER 5

MATERIALS AND PROPERTIES

5.1 Cement

The cement used in this research project is ppc which stands for Portland Pozzolana Cement. It is also a cementatious material that is used to replace the traditional OPC. PPC basically contains siliceous materials added to the concrete which enhance the mechanical properties of concrete. The different materials added usually are volcanic ash, calcined clay, flyash or silica fumes. The strength of the ppc are 16MPa 22MPa 33MPa at 3,7,28 days respectively. PPC cement has only one grade in comparison to 3 grades of OPC. The cement used was of ACC company that was locally available.

Some properties off PPC

- Fineness 300m^2/kg
- Initial setting 30min
- Final setting 600 min

Fig 5.1 Cement bag

Fig 5.2 cement powder

5.2 Metakaolin

It is a puzzlonic material which is obtained from dihydroxylation of the clay known as Kaolin. This material is basically added to concrete in order to increase the mechanical properties of the concrete. This however decreases the workability of the concrete which later is corrected by using a suitable superplasticizer.

a) Physical properties of Metakaolin

- Sp. Gravity 2.60
- Bulk Density 0.3 to 0.4
- Physical form powder
- Color White
- **b) Chemical properties of metakaolin**

Table 5.1 Chemical properties of metakaolin

Chemicals	Cement	Silica fume	Metakaolin
Si O_2	21.0%	92.9%	51.2%
Al_2O_3	5.2%	0.69%	45.3%
Fe_2O_3	2.3%	1.25%	0.60%
Mg O	3.9%	1.73%	—
Ca O	63.9%	0.4%	0.05%
Na_2O	0.5%	0.43%	0.21%
K_2O	0.5%	1.19%	0.16%
SO_3	2.4%	—	—
LOI	—	1.18%	0.51%
Color	Gray	Dark gray	White

5.3 Rubber

A polymer of an organic material Isoprene also added some other organic compounds is rubber. Latex is the main constituent for the manufacture of rubber. Natural rubber finds its applications in many fields either being used separately or used in conjugation with other materials. Waste tyres are basically waste rubber that can be used for the manufacture if the lightweight concrete. Waste rubber is accumulated mostly in the form of waste tyres that are accumulated in very huge quantities in the environment around us. Waste rubber can be in different sizes as

- Crumb rubber
- Ground rubber
- Shredded or chipped
- Slit rubber

The rubber utilized in this project was locally available and was obtained from waste tyres. The size of the particles was less than 20mm and this was hand cut.

Fig 5.3 Waste rubber

Properties of Rubber

- Specific gravity 0.902
- Compressive Strength 10MPa to 30MPa
- Bulk Modulus 1.5Gpa to 2Gpa
- Tensile Strength 2.4MPa t0 5.5 MPa

5.4 Plastic

It is a manmade material obtained from wide sources of organic polymers which basically include polyethylene, polyvinylchloride, nylon etc as well as from the petrochemicals being the most used sources to obtain them. Being relatively cheaper, easy to yield and the versatility, plastic has found application from smallest to the largest things. They have started to be used instead of the traditional materials like wood, leather, paper, metal, glass, ceramic, stones etc. It has the ability to be moulded into any shape while soft. This versatility of use has led to enormous amounts of wastes being generated that are hard to dispose off. The molecular mass of plastic is very high. The plastic used in this project was locally available and had to be obtained by remolding the melted plastic. The plastic used was high density plastic so the heat of hydration does not melt the aggregates used.

Properties of plastic

- Compressive strength 20MPa
- Specific gravity 0.96g/cc
- Tensile Strength 31.7MPa
- Flexural modulus 12Gpa
- Melting point 120^{o}c to 180^{o}c
- Density 0.93 to 0.97g/cm^3

Fig 5.4 Waste plastic

CHAPTER 6

RESEARCH METHODOLOGY

6.1 CEMENT TESTS

Material testing is an important part of the research work. I had to conduct tests on the cement, fine aggregates as well as the coarse aggregates. Below mentioned tests were conducted on the materials used:

- Cement tests: Consistency test, determination of initial and final setting time, compressive strength test, fineness test (sieve analysis), soundness test.
- Tests For fine and coarse aggregate:-crushing test, impact test, abrasion test, water absorption test, soundness test, Shape test, Specific gravity and water absorption test, Sieve analysis.

6.1.1 CONSISTENCY TEST:

The property of the cement paste to spread of the spilling property or ability of concrete is known as or may be defined as consistency. This may basically depend on two different things associated with concrete, the basic composition and the fineness. The depth of 33-35 m from the top concrete surface of the mould on the vicat apparatus is usually taken as Standard consistency of cement. A sample of 400 grams of cement with the water cement ratio kept fixed at 0.25-0.26 this test was performed. The diameter standard of the needle of the apparatus is 10mm and 50mm long. Mixing was not done for more than 3 to 5 minutes.

Apparatus required: The Apparatus required for measuring consistency of cement are: Vicat Apparatus according to IS: 5513, Balance whose capacity should be 1000g and least count of balance is 1g, and measuring cylinder of capacity 100ml and least count is 1ml. The other apparatus required are tray and glass plate.

Calculation

$P = (w/c) \times 100$

W= water added and c= cement used

Table 6.1 Consistency readings

S.no	Wight of cement (gms)	% by water of dry cement (%)	Penetration (mm)
1	300	25	41
2	300	27	34
3	300	29	31
4	300	30.5	23
5	300	32.5	11
6	300	34.5	7

Therefore standard consistency is 34.5%

6.1.2 INITIAL SETTING TIME

Initial setting time is the time when needle of the vicat apparatus penetrates the cement paste between 5mm to 7mm from bottom of the mould just after water is added.

Calculation

Sample weight 300gms

Water volume added is 0.85P

= 0.85×34.5=29.32%

Thus volume of water added = 29.32 × (300/100) = 87.97ml

Initial setting = T_2-T_1

Table 6.2 Initial setting time reading

Sample	T_1	T_2	Setting Time
1	10:15	10:52	37
2	11:05	11:39	34
3	12:02	12:33	31

Initial setting is the average of 3 which is equal to 34 min.

FINAL SETTING TIME:

Final setting time is defined as a time in which concrete/mortar changes its state from its initial plastic state to harden state.

Calculation:

Initial setting time=t2-t1

Final setting time=t3-t1

Here

T1 = Time at which water is added.

T2 = Time at which needle fails to penetrate 5mm to 7 mm from bottom of mould.

T3=Time when the needle makes an impression but the attachment fails to do so.

6.1.3 FINENESS TEST

Apparatus required

90 micron sieve, Balance, tray, lid may be needed, brush, glass rod

Calculation

Table 6.3 Fineness readings

Sample no	Wt. of cement	Wt. of cement retained	Fineness(X/200)×100
1	200	11.5	575
2	200	10.9	5.45
3	200	10.7	5.35

The fineness is the average value of the three and is equal to **5.5%.**

6.1.4 SOUNDNESS TEST

Ability to resist volumetric expansion is termed as soundness. Concrete expands or contracts as per the climatic conditions where expanding in the hot climate and contracting in the cold climate. This ability is determined by the soundness test.

Apparatus required

Le-Chatelier apparatus according to IS: 5514- 1969, Water bath whose range is 100ºC and least count of the bath is 1ºC, Caliper (30cm), Measuring cylinder of capacity 100ml and least count is 1ml and balance of capacity 100g and least count is 1g, Glass sheet, trowel, tray.

Environmental conditions:

Temperature 25ºC to 27ºC

Humidity 60º C to 70ºC

Table6.4 Soundness readings

S.NO	L_1	L_2	Soundness
Sample 1	1.5	1.9	0.4
Sample 2	1.5	1.85	0.35
Sample 3	1.5	1.75	0.25

Thus soundness comes out to be 0.33 by taking out the men of all the three

6.1.5 SPECIFIC GRAVITY

The ratio of the weight of the give volume of material to the equal volume of water is termed as Specific gravity. It cannot be determined by using water as the cement will harden thus kerosene or diesel is used.

Calculation

Specific gravity of cement $\frac{W}{W-\{(W2-W1)\times 0.85\}}$

Specific gravity of diesel = 0.85 Here, W=50 gm W_1= 240.35 gm W_2= 279.352 gm

Therefore, specific gravity of cement = **2.967**

6.2 COARSE AND FINE AGGREGATES

6.2.1 SIEVE ANALYSIS

Sieve analysis is commonly known as gradation test. The sieve analysis helps us in determining the gradation of particles i.e., the distribution of aggregate particles by size.

a) Determination of sieve analysis for coarse aggregates:

Objective: To determine the fineness modulus of coarse aggregates.

Apparatus required: Sieves of size 80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, Balance

Calculation:

Weight of coarse aggregates taken= 5kg.

Table 6.5 Sieve analysis for coarse aggregates

S.NO	Sieve size (mm)	Weight retained (kg)	% weight retained	Cumulative % weight retained (X)	Cumulative percent passing
1.	80	0	0	0	100
2.	40	0	0	0	100
3.	20	0.400	8	8	92
4.	10	2.850	57	65	35
5.	4.75	1.480	29.6	94.6	5.4
6.	2.36	0.270	5.4	100	0
Total		5.000 kg		267.6	

Result:

Therefore, the fineness modulus of coarse aggregates = $\frac{X}{100}= \frac{267.6}{100}= 2.676$.

b) Determination of sieve analysis for fine aggregates

Objective: to determine the fineness modulus of fine aggregates by sieve analysis.

Theory: With the help of fineness modulus, we can determine the fineness of sand, whether it is coarse sand, medium sand or fine sand.

Fine aggregates having fineness modulus more than 3.2 will be unsuitable for preparing concrete.

Apparatus required: Test Sieves conforming to IS : 460-1962 having specification of 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron, 150 micron, Balance, Gauging Trowel, Stop Watch, etc.

Calculation:

Weight of fine aggregate taken = 1kg

Table 6.6 Sieve analysis for fine aggregates

S.NO	Sieve size	Weight retained (kg)	% weight retained	Cumulative % weight retained (kg)	% weight passing (kg)
1.	4.75 mm	0.02	2	2	98
2.	2.36mm	0.045	4.5	6.5	93.5
3.	1.18mm	0.092	9.2	15.7	84.3
4.	600 μm	0.177	17.7	33.4	66.6
5.	300 μm	0.492	49.2	82.6	17.4
6.	150 μm	0.161	16.1	98.7	1.3
7.	Pan	0.013	1.3	100	0
Total		1 kg		X=238.9	

Result:

Therefore, the fineness modulus of the fine aggregates = $\frac{X}{100} = \frac{238.9}{100} = 2.389$

Also the given sample of fine aggregates belong to the Grading zone *III* taking IS:383:1970 into consideration (grading limit for fine aggregates).

6.2.2 SPECIFIC GRAVITY AND WATER ABSORPTION OF COARSE AGGREGATES

Apparatus required

Wire basket, Oven, Container for filling water and suspending the basket, Air tight container, balance, tray and absorbent clothes.

Calculations:

W_1= weight of saturated dry sample.

W_2= weight of wire basket in water.

W_3= weight of wire basket + sample in water.

W_4= weight of oven dried sample.

Table 6.7 specific gravity and water absorption for coarse aggregates

SAMPLE	W_1 (kg)	W_2 (kg)	W_3 (kg)	W_4 (kg)
Sample 1	2	0.108	1.382	1.991
Sample 2	2.	0.637	1.910	1.995
Sample 3	2	0.177	1.432	1.994
Average	2	0.307	1.574	1.993

Average specific gravity= $\frac{W4}{W4-(W3-W2)} = \frac{1.993}{1.993-(1.574-0.307)}$ =**2.74.**

Water absorption percentage= $\frac{W1-W4}{W4} \times 100$= $\frac{2.000-1.993}{1.993} \times 100$= **0.7%**

Result:

The average specific gravity of coarse aggregate is 2.74

The water absorption percentage is 0.7%.

6.2.3 SPECIFIC GRAVITY AND WATER ABSORPTION OF FINE AGGREGATES:

.**Apparatus required:**

Pycnometer, 1000-ml measuring cylinder, oven, Taping rod, Filter papers and funnel, balance, etc.

Calculations:

Table 6.8 specific gravity and water absorption foe fine aggregates

Sample	Weight (g)
Weight of saturates and dry aggregates (W)	500
Weight of pycnometer, sample and water (W_1)	1896
Weight of pycnometer and water (W_2)	1584
Weight of oven dry sample (W_3)	494

Result:

Specific gravity = $\frac{W3}{W-(W1-W2)}$= $\frac{494}{500-(1896-1584)}$ = **2.62**

Water absorption =$\frac{W-W4}{W4} \times 100$= $\frac{500-494}{494} \times 100 = \mathbf{1.1\ \%}$

6.2.4 SURFACE MOISTURE CONTENT AND WATER ABSORPTION:

Apparatus required:

Apparatus which are required to find out surface moisture content and water absorption are; metal tray or frying pan, gas stove or an electric hair dryer, metal rod and scale for measurement.

Absorption = $\frac{[(Wsd - Wbd)]}{Wbd} \times 100\%.$

Calculation:

W = 500g

W_{sd} =494g

Wbd =490g

RESULT: Value of surface moisture content and water absorption comes out 1.21% and 0.81%.

CHAPTER 7

RESULT AND DISCUSSIONS

This study was conducted to check the effect of different ecological wastes such as rubber and plastic on the concrete. This process involved replacement of the coarse aggregates by feasible sized particles of these wastes. This study helped to provide a medium for the incorporation of the waste materials into the concrete which renders lightweight concrete. This study involves use of plastic and rubber in certain percentages. First normal mix was created and then the replacements of 5% 10% 15% 20% 25% of individual materials was done. The samples created were tested for compressive, flexural and split tensile strengths. The tests were done after 7 and 28 days. The test reading were taken as an average of three readings to be more accurate. During the testing process it was found that the strengths decreased, however, there was an optimum percentage in both cases of materials after which the strengths decreased significantly. Metakaolin, an admixture was added during the casting process so that the results are not totally negative. The testing was done at different rate of loadings as 5N/mm^2 for the cubes and cylinders i.e. for compression and split tensile test and 0.1N/mm^2 for beams i.e. for flexural test.

7.1 MIX DESIGN

M20 grade of concrete was employed to perform the research work. The cement used was Pozzolana Portland cement (PPC). Normal mix was created without the addition of any of the replacement materials with M20 design mix. Water cement ration was kept fixed at 0.45. It is a common observation that greater the amount of water in concrete, it tends to have lesser values of the strength, thus the water cement ration was maintained throughout the experiment. In the replacement of first material 5% 10% 15% 20% 25% replacement was done by using rubber and in the second mix, same percentage of replacements were done by using plastic. However, metakaolin was used as an addition in order to maintain the strength of the samples at a percentage that was kept fixed at 15%. Various design mixture are tabularized below:

Table 7.1 Mix design

S.NO.	Addition Material	Percentage
1	No addition (Normal concrete)	M20
2	Rubber + Metakaolin	(5% 10% 15% 20% 25%) Rubber + 15% Metakaolin
3	Plastic + Metakaolin	(5% 10% 15% 20% 25%) Plastic + 15% Metakaolin

7.2 EXPERIMENTAL SETUP

The mix design was done as per the Indian Standard Code IS 10262-1982. Since n this experiment we evaluated three parameters, the compressive behavior, split tensile strength and the flexural variations of the concrete. Thus we needed to have samples in cubes, cylinders and beams for the evaluation and casting was done for the same. The cubes used in this experiment were (150×150×150) mm, the cylinders were (200×100) mm and the beams were of dimension (500×100×100) mm. The specimens were tested for 7 and 28 days after the casting process was done using a fixed water cement ratio of 0.45. Before the filling up of the moulds with concrete, it had to be properly oiled up so that later during the removal of moulds, the specimen wouldn’t stick to it. During the filling of the concrete, care was taken that the concrete was properly compacted. The filling was done in three layers and each layer was compacted with 25-30 blows from a tapering rod. After the filling was complete the specimens were subjected to vibrations in a vibrator table to eliminate any air or water voids present in between the aggregates which could later decrease the strength. The specimens were left undisturbed for 24 hours before the moulding was removed and the specimens were subjected to curing.

Fig 7.1 Empty moulds **Fig 7.2 Cube casting** **Fig 7.3 Cylinders and beams**

7.3 CURING PROCESS

After the moulds were casted they were left undisturbed for 24 hours before the moulds were removed. After the removal of moulds, the curing process was started. The specimens were placed in a curing tank in which the level of water was in a manner that the specimens were completely submerged in it leaving no surface of the specimen above water. Curing is an important aspect in concrete masonry because it helps to achieve the required strength. Today steam curing is also done which gives efficient results. The specimens were removed from the curing tank before 4-6 hours of the testing process.

Fig 7.4Curing of beams **Fig 7.5 Curing of cubes and cylinders**

7.4 RESULTS OF THE TESTS DONE WHILE REPLACING COARSE AGGREGATES WITH RUBBER

The specimens containing rubber as a replacement of the coarse aggregates was subjected to three tests, compressive, split tensile and flexural. The testing was done for 7 and 28 days in all the three cases and the percentage of replacements also being the same i.e. 5% 10% 15% 20%+ 25%. The results were as follows

i) Compressive strength:

Table 7.2 compressive strength readings

Percentage	7 days	28 days
0%	28.45	35.4
10%	25.26	32.3
15%	21.8	30.5
20%	16.5	26.6
25%	13.4	16.3

Fig 7.6 Compression Test Setup

The values of the compressive strength showed a decrease after using the rubber as a replacement material. This is attributed to the less bonding of the concrete and the rubber aggregates. From the reading obtained it can be seen that the decrease is not more than 13% upto the replacement of

15% however, it falls to 53.9% at 25% replacement. Upto 15% replacement the decrease is not significant. Graphically it is visualized below

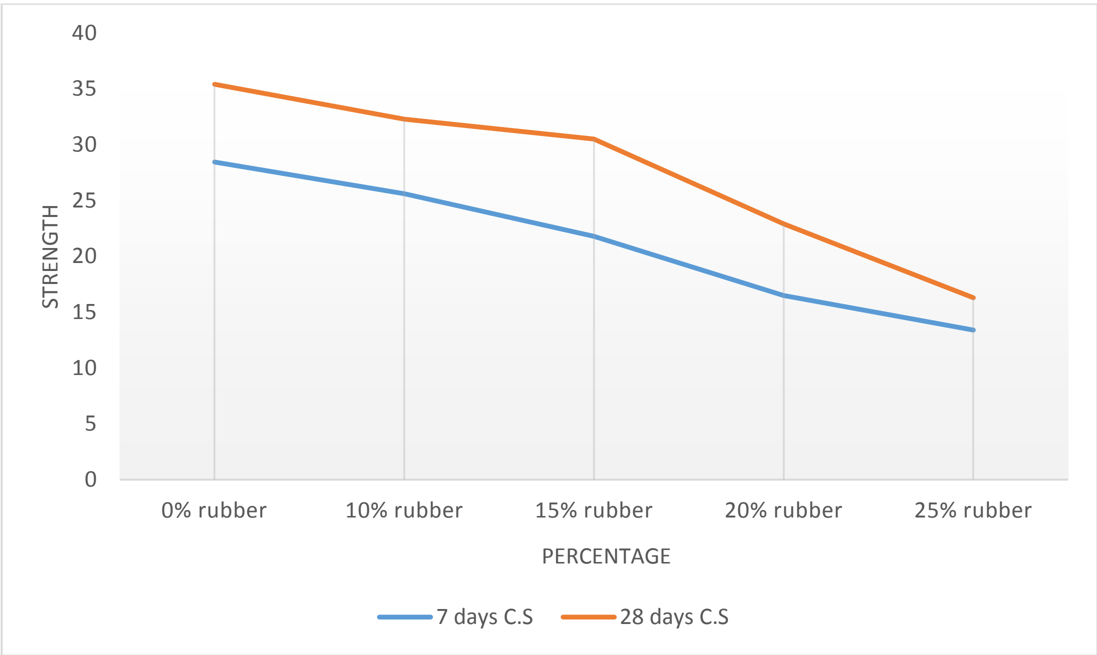

Fig 7.7 7&28 day compressive strength vs % replacement of rubber

ii) Split tensile strength:

Table 7.3 Split tensile readings

Percentage	7 days	28 days
0%	2.47	3.3
10%	2.14	3.1
15%	1.8	2.9
20%	1.47	2.45
25%	1.2	2.13

Fig 7.8 Split tensile Strength Setup

Split tensile strength test were conducted in a cylindrical specimen. The use of rubber on the replacement of the coarse aggregates at first showed no significant decrease upto a certain percentage. It was noted that strength decrease was only 12.12% after 28 days at upto 15% replacement. The decrease later increased as the percentage if the replacement was increased. From the readings it was noted that the decrease in the values of the split tensile strength is less than the values obtained in case of the compressive strength. This variation of the values upon the replacements with rubber aggregates is graphically visualized below

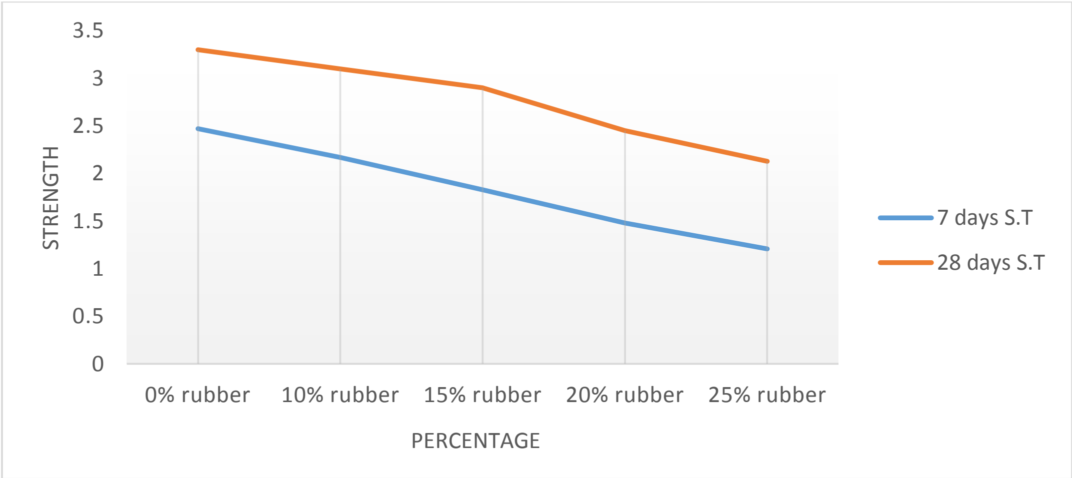

Fig 7.9 7&28 days split tensile strength vs % replacement of rubber

iii) Flexural Strength

Table 7.4 flexural strength readings

Percentage	7 days	28 days
0%	7.9	9.9
10%	7.3	9.3
15%	6.7	8.7
20%	5.9	7.7
25%	4.8	6.8

Fig 7.10 Flexural Strength Setup

Flexural strength tests were carried on a beams of size (500×100×100) mm. The tests were carried on 7 and 28 days after casting and the results showed that rubber replacement upto few percentages can be utilized without any major decrease in the strength. The decrease was not found out to be more than 15% and 12% after 7 and 28 days respectively. However the further increase in replacement percentage the decrease in the strength increased which was not favorable. The results are graphically shown below

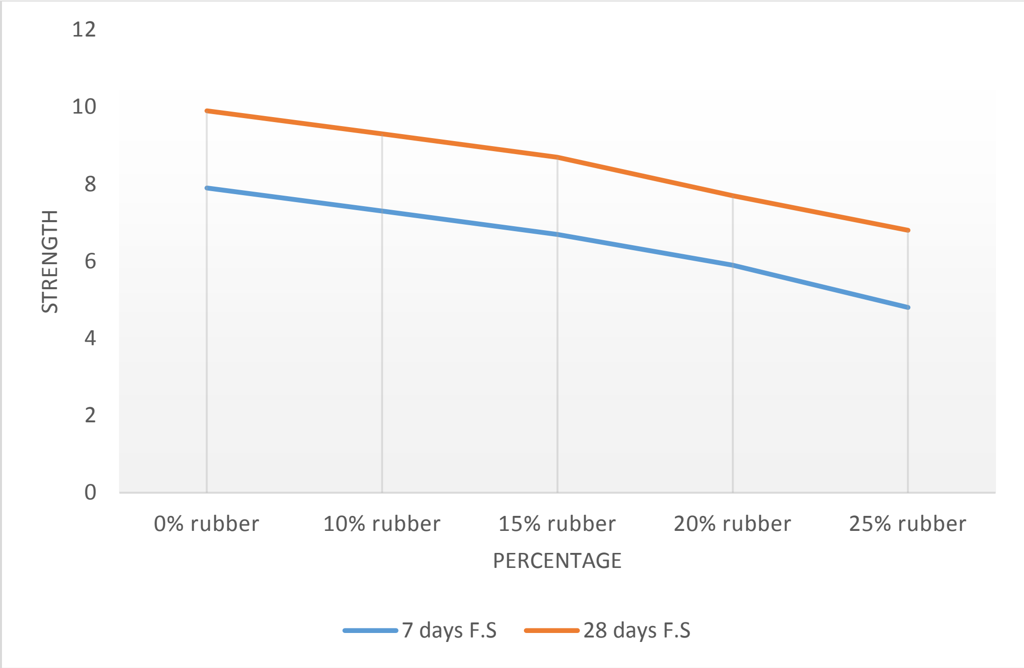

Fig 7.11 7&28 days flexural strength vs % replacement of rubber

7.5 RESULTS OF THE TESTS DONE WHILE REPLACING COARSE AGGREGATES WITH PLASTIC

The specimens containing plastic aggregates as a replacement of the coarse aggregates was subjected to three tests just like in case of the rubber aggregates earlier, compressive, split tensile and flexural. The testing was done for 7 and 28 days in all the three cases and the percentage of replacements also being the same i.e. 5% 10% 15% 20%+ 25%. Three test specimens each were tested to obtain the readings to be more precise. The results were as follows

i) Compressive strength

Table 7.5 Compressive Strength readings

Percentage	7 days	28 days
0%	28.45	35.4
10%	21.92	31.32
15%	15.38	22.63
20%	9.12	14.71
25%	4.88	8.89

Fig 7.12 compressive strength of plastic test setup

The values of the compressive strength showed a decrease after using the plastic as a replacement material. This is attributed to the less bonding of the concrete and the plastic aggregates. From the reading obtained it can be seen that the decrease is not more than 11.5% upto the replacement of 10% however, it falls to beyond 50% at 25% replacement. Upto 10% replacement the decrease is not significant. Graphically it is visualized below

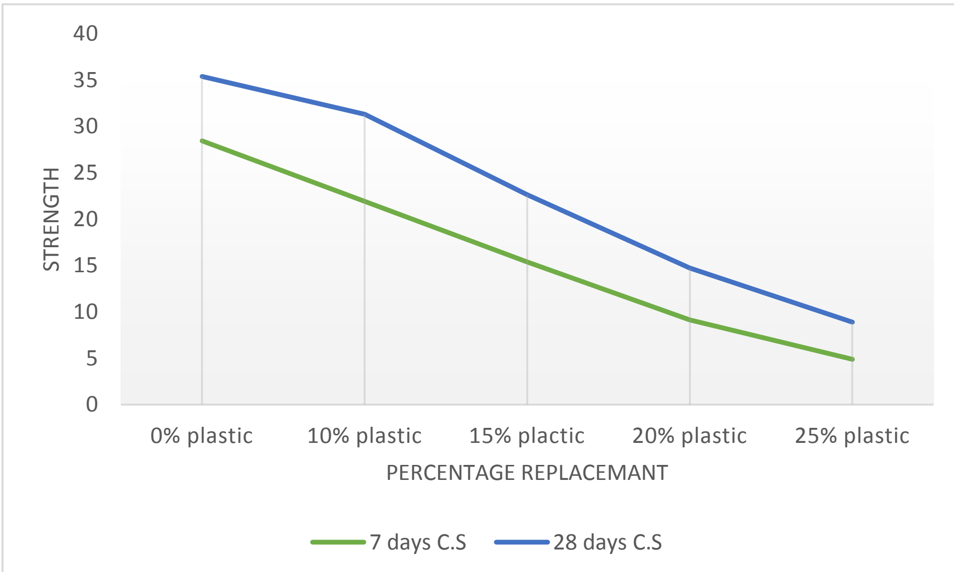

Fig 7.13 7&28 days compressive strength vs % replacement of plastic

ii) Split tensile Strength

Table 7.6 Split tensile Strength readings

Percentage	7 days	28 days
0%	2.64	3.3
10%	2.28	2.97
15%	1.72	2.62
20%	1.45	2.43
25%	1.23	2.05

Fig 7.14 Split tensile strength of plastic setup

Split tensile strength test were conducted in a cylindrical specimen. The use of plastic aggregates on the replacement of the coarse aggregates at first showed no significant decrease upto a certain percentage. It was noted that strength decrease was only 10.2% after 28 days at upto 10% replacement. The decrease later increased as the percentage if the replacement was increased. From the readings it was noted that the decrease in the values of the split tensile strength is less than the values obtained in case of the compressive strength. This variation of the values upon the replacements with rubber aggregates is graphically visualized below

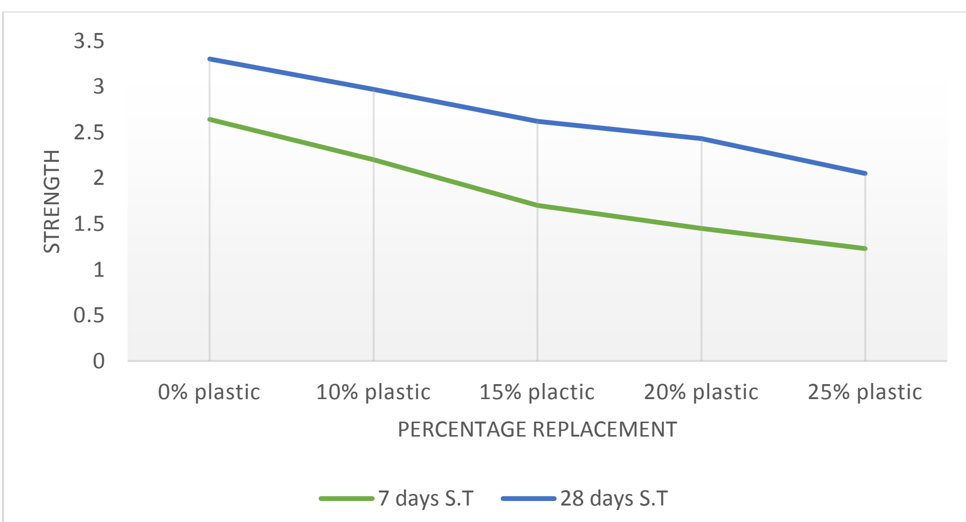

Fig 7.15 7&28 days split tensile strength vs % replacement of plastic

iii) Flexural Strength

Table 7.7 Flexural strength readings

Percentage	7 days	28 days
0%	7.9	9.9
10%	7.21	9.62
15%	5.26	7.52
20%	4.43	6.34
25%	3.47	4.96

Fig 7.16 Flexural strength test of plastic aggregates setup

Flexural strength tests were carried on a beams of size (500×100×100) mm. The tests were carried on 7 and 28 days after casting and the results showed that rubber replacement upto few percentages can be utilized without any major decrease in the strength. The decrease was not found out to be more than 8.8% and 3% after 7 and 28 days respectively. However the further increase in replacement percentage the decrease in the strength increased which was not favorable. The results are graphically shown below

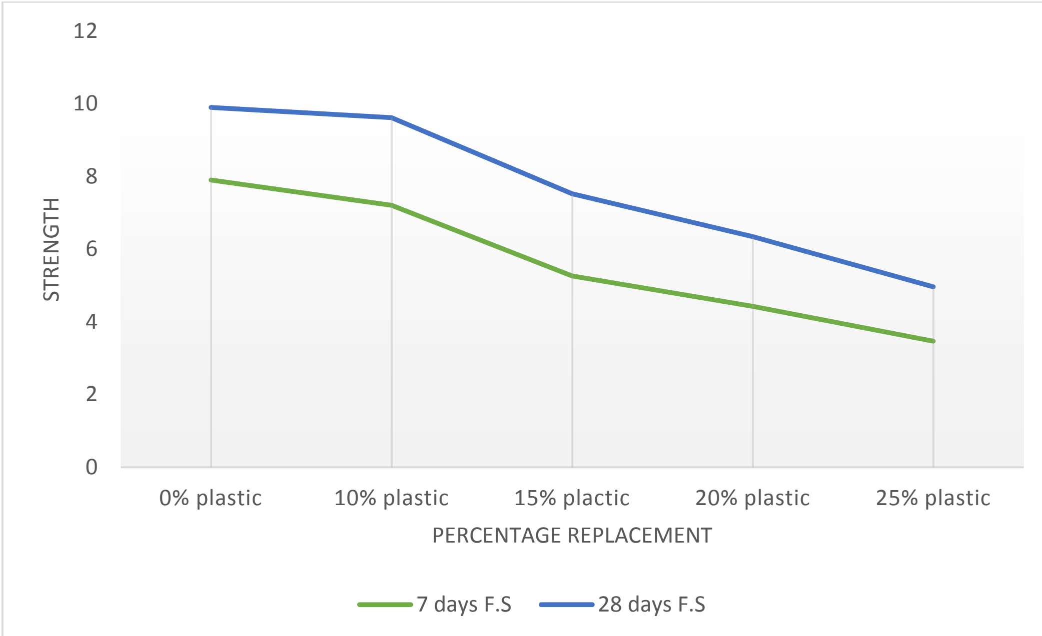

Fig 7.17 7&28 days flexural strength vs % replacement of plastic

CHAPTER 8

CONCLUSION AND FUTURE SCOPE

8.1 CONCLUSIONS:

Lightweight concrete is obtained after the utilization of the ecological wastes like rubber and plastic in the partial replacement of coarse aggregates. This incorporation is useful both ecologically as well as from engineering point of view. This method helps to reduce the waste accumulated in the environment to certain extent besides rendering lightweight concrete. The research project gave the following outcomes

- Rubber and plastic being less dense materials, decreased the density of the concrete specimens around 10-30%.
- The weight of the specimens with rubber and plastic aggregates was reduced after casting as compared to the nominal mix.
- The weight of the specimens containing plastic aggregates was even lesser as compared to the ones containing rubber aggregates.
- After 28 days the weight had reduced further down a little as compared to the weight after 7 days.
- The compressive strength in case of rubber aggregate showed a negative value but there was no significant decrease upto a percentage of 15%. However, after this value there was drastic decrease in the compressive strength.
- Compressive strength in case of rubber aggregates was reduced to not more than 13% upto 15% replacement ,however, increase in the percentage reduced it 53% at 25% replacement.
- The tests indicated a decrease of the split tensile strength upto 12.12% after 28 days at a percentage of upto 15%. Further incorporation reduced it to non-allowable limit.
- Similar test results were seen in case of flexural strength as well where the strengths showed non-significant decrease upto 15% incorporation but drastic decrease after 15%. The strength decreased not more than 12% after 28 days testing.

- 15% replacement was observed as the optimum or the allowable percentage for the use of rubber aggregates during compressive, split tensile as well as the flexural strength testing.
- The effect of the utilization of the plastic aggregates was found to be similar as rubber aggregates but the allowable percentage further reduced to 10%.
- The decrease in compressive strength upto 10% replacement with plastic aggregates was 11.5% but beyond that it eventually falls beyond 50% at 25% replacement.
- The split tensile strength values upto the replacement percentage of 10% showed a decrease of just 10.2% after 28 days testing.
- 8.8% and 3% were the decrease of the flexural strength of the specimens after 7 and 28 days testing at 10% replacement with the plastic aggregates.
- This it was concluded that the optimum or allowable percentage for rubber to be 15% and that for plastic to be at 10%.
- Metakaolin was found out to be important to prevent the further decrease of the strength values.
- From an ecological point of view, this research helped to eliminate 2 elements of environmental pollution. Though not completely but this method provided a safe custom for the disposal of wastes without any inopportune aftermath.
- Besides being safe this is an economical way of waste disposal.
- Lightweight concrete is procured at frugal means. No high tech machinery is required besides wastes are locally available.

8.2 FUTURE SCOPE:

In future this research can be efficiently employed to the waste disposal as well as rendering or generation of lightweight concrete on an economical basis. The advancement of technology in future can help to increase the strengths further that will open the ways for higher incorporation percentages of such wastes with lesser decrease of the strengths. Super plasticizers and admixtures can be use at different percentages that will help to overcome the negative effects in the strengths. Lightweight concrete has numerous advantages thus it sees added use in future. Fire insulation property, thermal regulation inside the structures by incorporation of light weight concrete makes it an important element of future constructions. Being economical, other kinds of wastes can also be tried to be incorporated which can further help to save the entourage.

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