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# CHARACTERISTICS OF CONCRETE BY USING NON-BIODEGRADABLE MATERIALS AS ALTERNATES

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**Abstract:** Industrial activities in fast-developing countries are strongly linked to the generation of non-biodegradable solid waste. The most visible of these wastes are rubber and plastic. Instead of throwing them away, they could be recycled in a variety of ways and reused as replacement materials in the preparation of concrete. Worn-out rubber that has been mechanically triturated can also be used in the preparation of concrete. Researchers discovered the use of recycled rubber waste as a replacement for aggregate in concrete over the years. "Rubcrete-Mix" which is a result of such replacement is found to have many engineering applications and holds promise in the future. Rubcrete also possesses good mechanical properties and is considered to be one of the best and most economical ways of recycling used tires. This project aims to determine the strength characteristics such as compressive strength, Split tensile strength and workability, etc., of the concrete with replaceable materials and compare it with the concrete made of regular materials. In this process, we use $M_{40}$ grades of concrete, cast in 150*150*150 mm cubes. Fly-ash is replaced as 10 Percentage. Coarse aggregate is replaced in 20 and 30 percentages. The compressive and tensile strength is calculated for 7, 14 & 28 days. The percentage at which the maximum values of compressive strength, tensile strength, workability, etc., are observed. In this process, we target to prove that, replacing the regular materials of concrete (such as cement, coarse aggregate) with materials such as Fly Ash, Rubber, etc., results in the equivalent strength, and would therefore be Eco-Friendly and also reduce the Cost of Construction.

***Key Word: Rubcrete, Rubber, Compressivess strength***

## 1. INTRODUCTION

Infrastructure development across the world created a demand for construction materials. Concrete is the premier civil engineering construction material. Concrete manufacturing involves the consumption of ingredients like cement, aggregates, water, and admixture. Among all the ingredients, aggregates form the major part. Two billion tons of aggregate are produced each year in India. Production is expected to increase to more than 2.5 billion tons per year by the year 2020. Similarly, the consumption of the primary aggregate was 110 million tons in the UK in the year 1960 and reached nearly 275 million tons by 2006. The use of natural aggregate at such a rate leads to a question about the preservation of natural aggregates sources. In addition, operations associated with aggregate extraction and processing are the principal causes of environmental concerns. In light of this, in contemporary civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete sustainable and environmentally friendly construction material. Different alternative waste materials and industrial by-products such as fly ash, bottom ash, recycled aggregates, foundry sand, china clay sand, crumb rubber, and glass were replaced with natural aggregate and investigated properties of the concretes.

Therefore an attempt has been made in this study to utilize the waste disposal tire rubber and fly ash as a partial replacement for coarse aggregate and cement in the development of lightweight and economical concrete. About one crore 10 lakhs of all types of new vehicles are added each year to the Indian roads. The increase of about three crores of discarded tires each year poses a potential threat to the environment. Hazardous materials can be classified as chemical, toxic, or non-decaying material accumulating with time. The accumulation of rubber and plastic can be considered non-decaying materials that disturb the surrounding environment. However, a positive method for disposing of this non-decaying material, such as reuse in concrete mixes, would have a beneficial effect. One of the major environmental challenges facing municipalities around the world is the disposal of worn-out automobile tires. Most discarded tires are buried in landfills. Only fewer are used as fuel or as raw materials for the manufacture of rubber goods. Burying scrap tires in landfills is both wasteful and costly. Disposal of whole tires has been banned in most landfills because they are bulky and tend to flow to the surface with time, so tires are often shredded. If tires are reused as a construction material instead of being burnt, the unique properties of tires can once again be exploited beneficially. In this context, the use of tire chips in lightweight concrete is considered a potentially significant avenue. Thus, the use of scrap tires in concrete manufacturing is a necessity than a desire. The use of scrap tires in concrete is a concept applied extensively over the world. The use of scrap tires rubber in normal strength concrete is a new dimension in a concrete mix design and if applied on a large scale would revolutionize the construction industry, by economizing the construction cost and increasing the worn-out tire disposal. It is with this intention, that an experimental study is proposed to be conducted by using crumb rubber as a replacement for coarse aggregate in concrete

### 1.1: Rubber

As the population is growing day by day the greater use of disabled materials has increased considerably the generation of solid residue, to the landfill cannot accommodate the total demand. One of the major contributors to the solid waste problem is the growing volume of tires. The disposal of tires has become a global problem, the increased storage of discarded tires created potential fire hazards fire as well as health risks due to mosquitoes breeding in stagnant water which accumulates in the tires. Rubber from scrap tires is one of the most recent waste materials investigated for its potential use in the construction field. In general, it is reported that a reduction in mechanical properties of concrete additive is a possible disposal solution due to the elastic properties of rubber. The evaluation of tire rubber particles in cement-based materials generally focuses on using tire rubber particles as a coarse aggregate in concrete. and Malaysia. When rubber is produced it consists of Polymers of the Organic Compounds isoprene with minor impurities of other Organic compounds and water.

**Figure 1. Cutting of rubber pieces in 20mm size**

### 1.2: Fly Ash

Ash is produced in small dark fleets by the burning of powdered coal or other materials carried into the air. (or) This can be simply defined as that portion of pulverized fuel ash that is free enough to be taken before the gas from a furnace before the gas is discharged into the atmosphere is called Fly Ash. This can also be called Pulverized Fuel Ash.
Fly Ash is not a Non-Bio-Degradable Waste it will not cause any kind of environmental pollution. It can be used as a replacement material for Cement in Concrete up to an extent. It is produced in the burning process of manufacture of Bricks in Brick kilns. Our materials like GGBS, Tile powder could be used.

**Figure 2. Fly Ash**

### 1.3: Advantages of Rubcrete

- **Eco-Friendly:** As the rubber is being recycled and being reused instead of being squandered as waste it is used in concrete. Hence the environment.
- **Cost of Construction**: The rubber used for construction is just a scrap. Hence its cost will be very low. So, with this, the cost of construction could also be minimized.
- **Resource Availability:** As a material like rubber could be easily available either in the form of rubber tires or in the form of industrial waste. Hence the crisis for the resource never comes.
- **Sustainability:** The number of waste materials for landfills will be reduced by the usage of Rubber. This will reduce the scale of quarrying for aggregates; therefore, this will extend the lives of natural resources and extend the lives of sites that are used for landfills.
- **Job Opportunities:** Mixing of Rubcrete demands skilled people such as General Workers, drivers, etc. because this is an advanced technology. Hence, by using Rubcrete, job opportunities will be created and hence employment could be generated.
- **Ease in Handling and Transport:** As rubber does not possess high unit weight like aggregates and is soft, it provides us with ease in handling and transport.

### 1.4: Aims and Objectives

The major objective of the project is as follows:

- To obtain the fresh concrete properties of Regular Concrete and various properties of Rubcrete (Slump, compaction factor)
- To evaluate the mechanical properties of Rubcrete.
- To determine the strengths of Rubcrete with different proportions [0%, 20%, 30%, (20% Rubber + 10% Fly Ash) (30%Rubber+ 10% Fly Ash]
- To compare the strength characteristics of Regular concrete and Rubcrete.

## 2. LITERATURE REVIEW

**Khatib and Bayomy [et.al].** They have investigated the workability of rub create and reported that there is a decrease in a slump with the increase in rubber content by total aggregate volume. They further mentioned that at rubber contents of 40% by total aggregate volume, the slump was almost zero, and concrete was not workable manually. It was also observed that mixtures made with fine crumb rubber were more workable than those with coarse tire chips were or a combination of tire chips and crumb rubber

**Fedroff, [et.al].** He has reported higher air content in rub create mixtures than in control mixtures even without the use of air-entraining admixture (AEA). A similar observation was also made by Khatib and Bayomy. This may be due to the non-polar nature of rubber particles and their tendency to entrap air in their rough surface, and when rubber is added to a concrete mixture; it may attract air as it tends to repel water. This way air may adhere to the rubber particles. Therefore, increasing the rubber content results in higher air contents of rub to create mixtures.

**Eldin and Senouci [et.al].** They have reported that concrete mixtures with tire chips and crumb rubber aggregate exhibited lower compressive and split tensile strength than regular Portland cement concrete. There was approximately an 85% reduction in compressive strength and a 50% reduction in split tensile strength when coarse aggregate was fully replaced by coarse rubber chips. However, there reduction of about 65% in compressive strength and up to 50% in split tensile strength when fine aggregate was fully replaced by fine crumb rubber. However, the mixes demonstrated a ductile failure and could absorb a large amount of plastic energy under compressive and tensile loads.

**Topcu and Khatib and Bayomy[et. al].** The addition of coarse rubber chips in concrete lowered the compressive strength more than the addition of fine crumb rubber. However, results reported by Ali and Fathi, and Clark indicate the opposite trend. Segre and Jockes have worked on the use of tire rubber particles as an addition to cement paste. In their work, the surface of powdered tire rubber was modified to increase its adhesion to cement paste. Low-cost procedures and reagents were used in the surface treatment to minimize the final cost of the material. Among the surface treatments tested to enhance the hydrophilicity of the rubber surface, a sodium hydroxide (NaOH) solution gave the best result. The particles were surface-treated with Noah saturated aqueous solutions for 20 minutes, and then, scanning electron microscopy (SEM), water absorption, density, flexural strength, compressive strength, abrasion resistance, modulus of elasticity and fracture energy measurements were performed using test specimens (w/c= 0.36) containing 10% of as-received or 10% of NaOH-treated rubber. The test results showed that the NaOH treatment enhances the adhesion of tire rubber particles to cement paste, and mechanical properties such as flexural strength and fracture energy were improved with the use of tire rubber particles as an addition instead of aggregate. The decrease in the compressive strength was significantly lower than what has been reported in the earlier literature.

## 3. PROPERTIES OF MATERIALS

### 3.1 Materials

### 3.1.1 : Cement:

Cement is binding material invented by Joseph Aspdin in 1824. It is manufactured from calcareous materials, such as limestone or chalk, and argillaceous materials such as shale and clay.

**Figure 3. Cement**

### 3.1.2: Coarse Aggregate:

If the size of the aggregate is bigger than 4.75 mm, then the aggregate is considered coarse aggregate.

**Figure 4. Coarse Aggregate**

### 3.1.3: Fine Aggregate

The aggregate which will pass through a 4.75 mm IS sieve and entirely retained on a 75 µ sieve is considered a fine aggregate.

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**Figure 5. Fine Aggregate**

### 3.1.4: Water

Water is the main ingredient used to mix all the contents. Potable water is used as using any other water may contain salts and cause a decrease in the strength of concrete.

Slump Value (mm)

**Figure 6. Potable Water**

In the present study, $M_{40}$ grade concrete is used for the water-cement ratio of 0.40

| Cement | Fine aggregate | Coarse aggregate | w/c ratio |
|---|---|---|---|
| 360 kg | 772.56kg | 1172.16 | 0.40 |

**Table 1. MIX DETAILS FOR $M_{40}$ CONCRETE (1:2.1:3.20)**

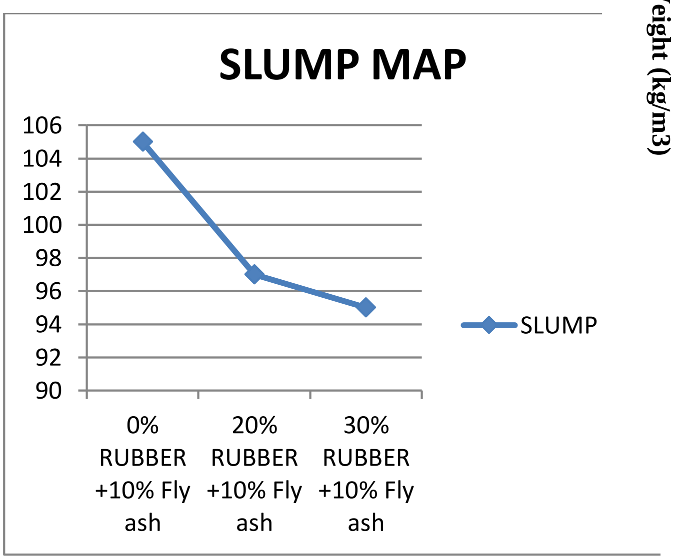
## 5.Test Results of Concrete

A detailed discussion has been carried out on the test results obtained. The results have been tabulated and the necessary graphs have been plotted. Discussions about the results have been carried out in the respective tables and graphs.

### 5.1 Workability of concrete for the given specimen

| S.No | Specimen | Density of concrete(kg /m$^3$) |
|---|---|---|
| 1 | 0% RUBBER +10% Fly ash | 2450 |
| 2 | 20% RUBBER +10% Fly ash | 1994 |
| 3 | 30% RUBBER +10% Fly ash | 1782 |

**Table 2. workability of the given specimen**



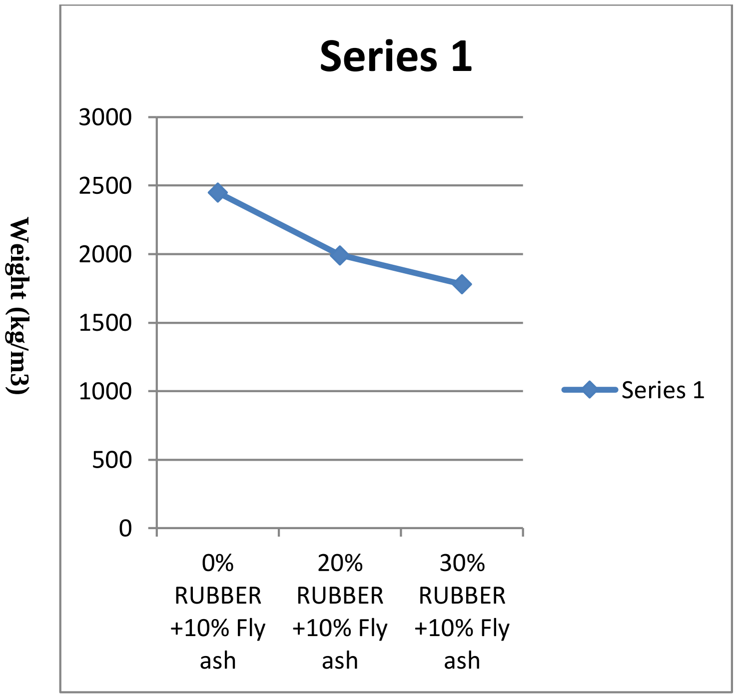

**Graph 1. Slump values of conventional and Rubber Create Concrete.**

### 5.3: Density

Cubical concrete samples of size 150x150x100mm were cast for the density test. The results reported in the Graph below show that the incorporation of higher rubber quantity lowers the density of the mixtures. This decrease in the density is obviously because of lower specific gravity and unit weight of rubber. Density was within the limit of lightweight concrete when rubber replacement increased up to 30%.

**Table 3. Density of concrete**

| S.No | Specimen | Slump values In mm |
|---|---|---|
| 1 | 0% RUBBER +10% Fly ash | 105 |
| 2 | 20% RUBBER +10% Fly ash | 97 |
| 3 | 30% RUBBER +10% Fly ash | 95 |



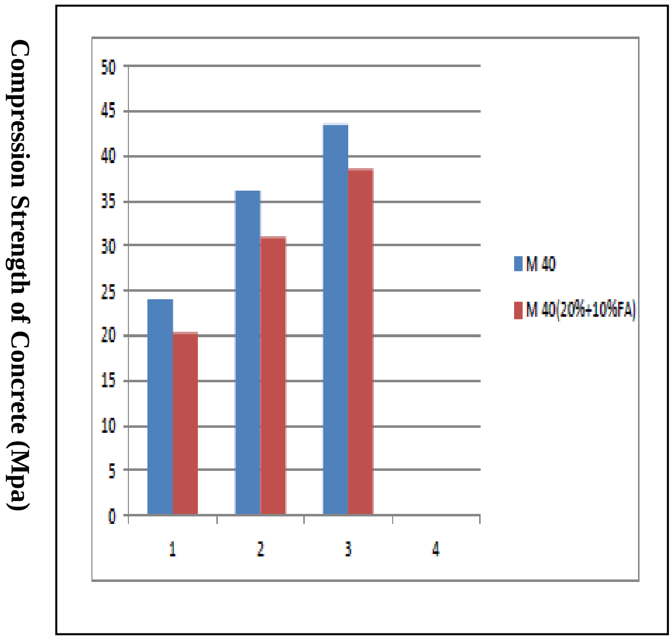

**Percentage of Rubber and Flyash Replacement**

**Graph 2. The density of concrete for various percentage replacement**

### 5.4: Compression Test Result and Analysis:

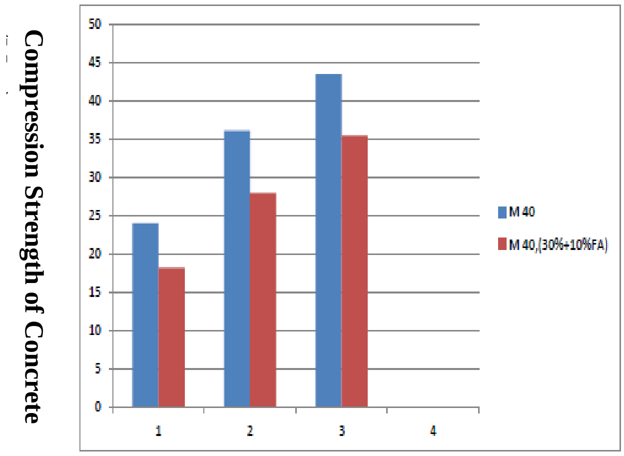
The compression test indicates an increasing trend of the compressive strength in the early age of the concrete specimen. However, it shows that the strength of the Rubcrete specimen is lower than the Regular Concrete specimen. The table below shows the compressive strength with age recorded during the test and a graphical representation of the variation of compressive strength of each batch was discussed

**Table 4. Compressive Strength Values**




**Percentage of Rubber and Flyash**

**Graph 3. Compressive Strength Analysis ( M40, 20% R+10%FA)**




**Percentage of Rubber and Flyash Replacement**

**Graph 4. Compressive Strength Analysis (M40, 30% R + 10% FA)**

**5.5: Split Tensile Test Result and Analysis:**

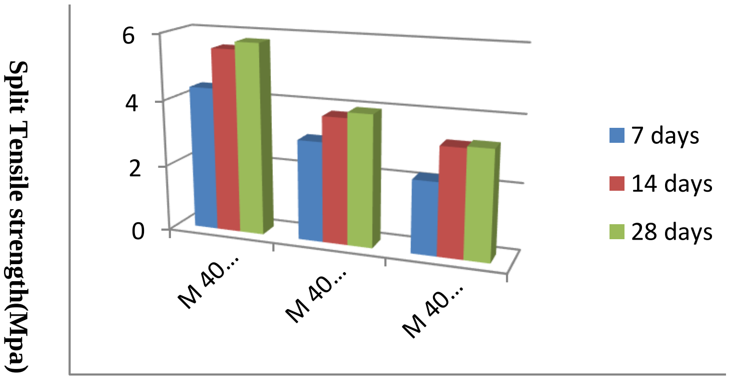
A split tensile strength test was conducted following ASTM C496. Cylinders of 100 x 200 mm size were used for this test, the test specimens were placed between two platens with two pieces of 3 mm thick and approximately 25 mm wide plywood strips on the top and bottom of the specimens. The split tensile strength was conducted on the same machine on which the

| **Type of concrete** | **Compression Strength of Concrete (Mpa)** | | |
|---|---|---|---|
| | 7 days | 14 days | 28 days |
| M 40 (0%R+(10FA) | 24.0 | 36.1 | 43.5 |
| M 40 (20%R+10 FA) | 20.3 | 31.0 | 38.6 |
| M 40 (30%R+10 %FA) | 18.2 | 28.0 | 35.52 |

compressive strength test was performed. The specimens were tested for 3, 7, and 28 days.

**Table 5. Split Tensile Strength Values**

| Type of concrete | Split Tensile Strength of Concrete (Mpa) | | |
|---|---|---|---|
| | 7 days | 14 days | 28 days |
| M 40 (0%R+(10FA) | 4.35 | 5.55 | 5.78 |
| M 40 (20%R+10FA) | 3.02 | 3.79 | 3.96 |
| M 40 (30%R+10%FA) | 2.19 | 3.23 | 3.28 |




**Percentage of Rubber and Flyash Replacement**

**Graph 5. Split Tensile Strength test of concretes**

From the above results, it shows that the only batch that met the required strength is the batch with 0% rubber. The compressive strength and Split Tensile strength for other batches is lower. This may be because the usage of rubber in the concrete specimen may reduce the compressive and tensile strength.

## 6. CONCLUSION

Research on the usage of waste construction materials is very important due to the materials waste is gradually increasing with the increase of population and increasing urban development. The reason that many investigations and analyses had been made on rub-Crete is that rubber is easy to obtain and the cost is cheaper than the fresh aggregate.

From the observations of the results we can conclude that the replacement of coarse aggregate with rubber for about 20%, 30% is recommended as it attains satisfactory strength. Replacement of Fly ash by about 10% can also be recommended. To obtain higher strength addition of some admixtures is also recommended. With the effective replacement of non-biodegradable waste in our construction, it would be Eco-friendly. The cost of construction is also minimized as replaced materials are scrap waste which is of negligible cost. In this process, we can find alternates for basic materials in Concrete.

### 6.1 Scope For Further Studies

Further testing and studies on the rub-create concrete are highly recommended to indicate the strength characteristics of rub-create concrete for application in high strength concrete.

Below are some of the recommendations for further studies:

- Although by decreasing the water/cement ratio Rubcrete can achieve high strength concrete. Therefore, it is also recommended that add admixtures such as superplasticizer and silica fume into the mixture so that the workability will be improved.

- More investigations and laboratory tests should be done on the strength characteristics of rub create. It is recommended that testing can be done on concrete slabs, beams, and walls. Some mechanical properties such as creep, durability, and abrasion were also recommended.
- More trails with different sizes of rubber and percentage of rubber are recommended to get different outcomes and higher strength characteristics in rub-create concrete.

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