Partial Replacement of Rice Husk Ash & Waste Tyre Rubber as Cement & Coarse Aggregate in Concrete

[1]Prashant Lalasaheb Jadhav, [2]Kamini Bhagwat Funde [3]Dr. Milind R. Gidde
[1]P.G.Student, [2]P.G.Student, [3]Professor
Department of Civil Engineering, Bharati Vidyapeeth (Deemed to be) University College of Engineering Pune, Maharashtra, India

ABSTRACT: Cement is the most expensive constituents of concrete. Over 5% of global CO_2 emission is attributed by cement production. The use of scrap tyre rubber in the preparation of concrete has been thought as an alternative disposal of such waste to protect the environment. consequently, it is required to find substitute materials to reduce the cost of concrete. In this work, alternate source for cement as rice husk ash (RHA) and coarse aggregate as waste tyre rubber is tried. In the current experimental analysis, the M20 grade concrete is preferred as the reference concrete specimen. A comparative study is done on properties of concrete when cement and aggregate are partially replaced by rice husk ash and waste tyre rubber. Percentage replacement of cement and coarse aggregate with RHA and tyre rubber are replaced at 0%, 5%, 10% and 15% in a mix of M20 grade of concrete. The compressive strength is found out at 7 and 14 days. The strength is compared with control concrete and the optimum % of replacement of RHA and rubber is found out. The objective of this project is to investigate the use of rubber pieces as coarse aggregate and RHA as cement in the concrete. Concrete is tested with varying percentages of rubber and RHA from 0 to 15% of normal aggregates. Compressive strength of concrete, impact value, abrasion value, slump value is measured and comparative analysis is made. Based on the analysis of results, the conclusions that can be made are: 1.The workability of concrete decreased as the percentage of rubber and RHA increased. 2. Lack of cohesiveness and proper bonding between rubber and cement causes shear slump. 3. Compressive strength of normal concrete is higher compared to rubberized and RHA concrete.4. Replacement of rubber reduces the weight of the concrete. 5 compressive strength decreases as the percentage of replacement increases.

Index Terms- RHA, Waste Tyre Rubber, Concrete Properties.

I. INTRODUCTION:

Nowadays disposing of agro waste is the major problem. One of the agro wastes is Rice Husk. Every year an average of 120 million tonnes of rice husk are produced by paddy field. Majority of rice producing countries like india, the husk produced from the rice processing is either burnt or dumped as a waste. Rice husk can be used as a fuel if its burnt at high temperature and it turn into an ash. Ash obtained is porous as fine aggregate and its grinding into a fine power. RHA is a pozzolanic material contains 85% of silica content. Using Rice Husk Ash as a substitute material in concrete reduces the environmental problem.

India is a developing country; it proposes development projects. Every budget proposal involves large construction of roads, bridges, dams, irrigation schemes, public health engineering schemes, educational buildings and residential buildings etc. all these construction schemes demand Optimum and efficient use of construction resources. Most of the modern heavy constructions require huge quantity of cement concrete incurs depletion of natural resources, resources such as river sand and rock strata. Cost of river sand and crushed rock particles is rapidly increasing because of inadequate raw materials and rise of transport cost due to hike of fuel price and of other inputs. Further mining of river sand causes severe environmental damage by lowering ground water table and disintegration of rock strata causes landslide and earthquake. This promising problem obliges contemporary material usage to balance the environmentalism.

India has taken major initiative on developing the infrastructure such as construction of roads, but the construction of roads involves extensive use of sand and aggregates which contributes to the problems mentioned above, hence it is becoming necessary to use the alternative material to the sand and aggregates. In this research study the assessment will be done on replacement of cement and coarse aggregate i.e. sand by waste materials such as rice husk and tyre rubber respectively. Modified concrete such as fibre Reinforce Concrete, High Strength Concrete, and Ferroconcrete had been introduced to achieve their specific targeted properties. Like High Strength Concrete, additional cement and high range of water reducers are needed in order to achieve targeted performance. Fiber Reinforce Steel needs to consider the addition of fiber that may come from glass, plastic or organic material in the concrete mix design. The concrete modification also can be done by adding admixture to increase the durability of the concrete. The water reducing agent in High Strength Concrete is to increase the flow ability and workability of concrete and reduce water-cement ratio. Concrete technology now a day had implemented the sustainability factors in the mix design to help in reducing the overly dependent on the natural resources. As mentions by in their green concrete for sustainable construction research, more than 5 billion volume of concrete had been produced globally and it means that more natural resources are needed for the cement and aggregates productions. Concrete in constructions is one of the CO2 emissions contributors. With high production of cement will eventually cause the greenhouse effect to the environments. Reuse and recycle waste material is one of the tools for green concrete technology. With the use of waste rubber in concrete, it can help to reduce the pollution that caused by it and thus save our environment. It also produces new mechanical and physical properties of concrete with the rubber presence in the design. The recycle and reuse of rubber waste can also reduce the production cost of construction as the rubber waste can be easily collected at the recycle centre. So as to discover the properties of rubberized concrete, a research was conducted with the substitution of shoes rubber as a coarse aggregate in concrete. The aim of this research is to study the

effectiveness of rubber as replacement of coarse aggregate in concrete. In order to test the effectiveness, there are several objectives that need to be focus on this research are 1. To study the effect of partial replacement of coarse aggregate by tyre rubber 2. To study the effect of partial replacement of coarse aggregate by tyre rubber on hardened concrete property.

II. TYRE WASTAGE AND PROBLEMS:

Now-a-days disposal of different wastes produced from different industries is a great problem. With the development of modern society's aftermath of industrial revolution, the mobility within automobile sector got momentum. The offshoot of this pragmatic revolution gave rise to new dimensions of problems in the form of rubber garbage. Millions of waste tyres are generated and stock piled every year, often in an uncontrolled manner, causing a major environmental problem. These tyres are often deposited in an uncontrolled manner, because of the noticeable rapid depletion in sites available for waste disposal, causing major environmental problems. The ideal temperature and moisture situation for the spread of mosquitoes, mice, rats and vermin by Water accumulation simultaneously, the quantity of oxygen that exists in the interior of the tyres is suitable for fire due to conditions, resulting in harmful effects on the environment and human health

Traditionally soil, stone, bitumen, cement etc. are used for road construction. Natural resources being exhaustible in nature, its magnitude is declining slowly Also, cost of extracting Concerned about this, the scientists are looking for alternative materials for highway construction, by which the pollution and removal problems are moderately reduced. In India more than 3 million waste tyres are produced every year because of increasing population and increasing demand for vehicles. Hence, it is becoming necessary to dispose the waste tyres in a proper way. It will also help to preserve the natural reserves of aggregates, thus protecting the environment.

III. LITERATURE REVIEW:

Literature review related to this topic is as follows-

Nithyambigai Gin studied on Effect of rice husk ash in concrete as cement and fine aggregate, in this work alternate source for cement and fine aggregate as rice hush ash is used. Abubaker M. Almaleeh studied on Use of waste rubber tyres as aggregate in concrete**.** This paper discusses test results of use of recycled tyres in concrete for possible application in the construction industry [1]. Ghassan Abood Habeeb studied on properties of rice husk ash and its use as cement replacement material [2]**.** I.B. Ologunagba studied on feasibility of using rice husk ash as partial replacement for concrete. This study examined the feasibility of using rice husk ash as partial replacement for concrete. The results showed that rice husk ash replacement has enhanced performance on the compressive strength of the concrete when the added percentage is not more than 10%, while when compared with the Control observation showed that the application of rice husk ash has a reduced density [3]. Ishtiaq Alam studied on use of rubber as aggregate in concrete. [4]. Jaylina Rana studied on partial replacement of fine aggregates by rubber in concrete. The broad aim of this work was to investigate the effects of partially substituted fine aggregate by rubber on the properties of fresh and hardened concrete. The founded results established that rubber improves workability and causes a decrease in plastic density. The compressive and tensile splitting strengths, flexure and modulus of elastic significantly decrease with increasing rubber content [5].

K. Paul Sibiyone studied on experimental study on replacing waste rubber as coarse aggregate. The aim of this study is achieved to use of rubber waste as partial replacement of coarse aggregate to produce rubberize concrete in M20 mix. The outcome showed that there is a decrease in all type of strengths for flap rubber mixture; however slump values increase as the flap rubber content increase since 0% to 20% [6]. Mohammed Mudabheer Ahmed Siddiqui studied on study of rubber aggregates in concrete an experimental investigation. In this research study an attempt has been done to discover the different properties essential for the design of concrete mix through the coarse tyre rubber chips as aggregate in an organized manner. The objective of this paper is to investigate the use of rubber pieces as coarse aggregate in the concrete [7]. N Kaarthik Krishna studied on concrete with partial replacement of cement by rice husk ash**.** In this investigation, Rice Husk Ash has been used as an admixture to cement in concrete and its properties has been studied [8]. Obilade, I.O. studied on use of rice husk ash as partial replacement for cement in concrete. This paper summarizes the research work on the properties of Rice Husk Ash (RHA) when used as partial replacement for Ordinary Portland Cement (OPC) in concrete. OPC was replaced by means of RHA by weight at 0%, 5%, 10%, 15%, 20% and 25%. 0% replacement served like the control. The results revealed that the Compacting factor decreased as the percentage replacement of OPC with RHA increased. The compressive strength of the hardened concrete also decreased with increasing OPC replacement with RHA [9]. Rahul Mahla studied on partial replacement of coarse aggregate by waste tyres in cement concrete. In this research study an attempt has been done to discover the different properties essential for the design of concrete mix through the coarse tyre rubber chips as aggregate in an organized manner [10]. Syed Mehdi Abbas studied on use of rice husk ash in concrete. This research study showed that the investigative work on the properties of Rice Husk Ash (RHA) when used like fractional substitute for Ordinary Portland Cement (OPC) in concrete [11].

IV. AIM AND OBJECTIVE:

Aim: - The aim of this research is to study the effectiveness of rubber and rice husk as replacement of coarse aggregate and cement in concrete.

Objectives of Project

1) To study the effect of partial replacement of coarse aggregate by tyre rubber on fresh concrete property.
2) To study the effect of partial replacement of coarse aggregate by tyre rubber on hardened concrete property.
3) To find the optimum percentage of RHA in concrete by partial replacement of Natural Sand.
4) To use pozzolanic material such as rice husk in concrete by partial replacement of cement.

V. METHODOLOGY:

1) Four different mixes, consisting of 0%, 5%, 10%, 15% replacement of coarse aggregate with tyre rubber and RHA with cement, are tested for workability, compressive strength, abrasion value and impact value. Two cubes of 150 x 150 x150 mm in size are prepared for each mix design. All the specimens are then cured in water for 7 days and 14 days before testing. A total of 8 cubes were tested.

VI. EXPERIMENTAL MATERIALS USED & MIX DESIGN:

A Rice Husk Ash

Rice Husk was burnt for approximately 60 hours in air under uncontrolled burning process. The temperature was at the range of 400- 600ºC.

B. Cement

Ordinary Portland cement of 53 grades was used. The specific gravity of cement is 3.17 and was determined using Le Chatelier flask.

C. Fine Aggregate

Normal river sand is used as fine aggregate of zone III. Sand passing through sieve no 4.75 mm is used. The specific gravity is 2.63.

D. Coarse Aggregate

The coarse aggregate of maximum size 20 mm is used. Its specific gravity is 2.65.

E. Water

Normal portable drinking water is used for casting and curing.

F. Super plasticizer

DR. FIXIT 101LW+ is used. It is a Sulphonated naphthalene based polymers. It is free from chloride and brown in colour. It is used to increases the workability of the concrete. Dosage limit is 0.6 to 1.5litres per 100 kg of cement.

Photo No.1 Experimental Materials

Grading, or particle size distribution, is an important feature of aggregate and is determined by a sieve analysis. Natural sand with a maximum size of 4.75 mm was used as fine aggregates. Crushed stone with a maximum size of 20mm was used as coarse aggregate.

Waste tyre rubbers are collected from the industrial area in Pune. The waste tyre rubber was initially 240 mm long. Chipped rubbers are produced by cutting the rubber into small pieces at maximum size of 20mm x 20mm. Chipped rubbers is used to replace coarse aggregate. Before the rubbers were cut, it was cleaned with soap water and rinse with clean water. Then, the rubbers were let to dry under the hot sun. The rubber aggregates for this research are made by manually cutting the rubber into required size. Water cement ratio for the concrete mix design is 0.50 by weight of the cement. Too high water cement ratio will affect the strength of the concrete while too low of water cement ratio will affect the workability of the concrete.

VII. Mix Proportion:

Concrete mix design was prepared following the DOE method to achieve target mean strength 20 MPa. The water cement ratio was 0.50. There were five types of mix considered and one mixture without rubber act as control mixture. The other four concrete mixes were made by replacing the coarse aggregates with 5%, 10%, and 15% of Tyre rubber by weight. For each chipped rubber percentage, three batches of concrete were prepared and tested to get the average reading. The details of mixture proportions are given in the following Table No. 1.

Table No.1 summary of mix design

Mix Sample	Mix Proportions
A (control mix)	Concrete with 100% coarse aggregate
B	Concrete with 95% coarse aggregate + 5% rubber
C	Concrete with 90% coarse aggregate + 10% rubber
D	Concrete with 85% coarse aggregate + 15% rubber

Initially, cement, fine and course aggregate are mixed in a mixer for 1 minute. After that, water is added and the cement, fine and coarse aggregate and water mixed just about for another 1 minute. The partial replacement of aggregate by means of rubber

follows the percentage by weight for each mix batch. The mixes are inserted into the mould by three layers and being compacted using the vibrator. The excess in volume of the mixes after compacted are trimmed on the surface to get good form of concrete. The cubes are left to harden for 24 hours before curing. The cubes are put in water for 7 days and 14 days before testing.

VIII. REPLACEMENTS:

Partial Replacement of coarse aggregate by rubber:

The source from which the waste tyre rubber obtained was cut into the required sizes of aggregates. Cut rubber was then replaced in the total weight of aggregate with unreliable percentages. The standard aggregate tests were performed on these aggregates:

A. Aggregate impact test. B. Los-Angeles abrasion test.

The above tests were performed with 5%. 10%, 15% replacements and results obtained from these tests were analyzed.

Mix design -Replacement of RHA:

The mix was designed for M20 grade as per IS: 10262-2009 at ratio of 1:1.5:3 The Table No. 1 shows various percentage replacement and Table No. 2 shows mix design proportion

Table: Table No.2 Mix design -Replacement of RHA (RISE HUSK ASH)

Bach No.	% Replacement of Cement (RHA)
1	0%
2	5%
3	10%
4	15%

Photo No.2 Replacement of RHA

Summary of Mix Design:

Table No: 3 Summary of Mix Design

Quantities	Cement Per 2 block	Water Per 2 block	Fine aggregate Per 2 block	Coarse aggregate Per 2 block	Rubber Per 2 block	Rise Husk ash Per 2 block	Percentage of rubber by weight of coarse aggregate
Per m3	2.684kg	1.5Lit	3.13kg	9.394kg	-	-	-
Per m3	2.549kg	1.5L	3.13kg	8.924kg	469.71gm	134.2gm	5%
Per m3	2.415kg	1.5L	3.13kg	8.454kg	939.49gm	268.4gm	10%
Per m3	2.281kg	1.5L	3.13kg	7.984kg	1.409kg	402.6gm	15%

A] For Impact Value test:

Impact value gives an idea about the toughness of aggregates. The impact value decreases with the increase in replacement of coarse aggregates by tyre rubber according to the weight basis.

Table No.4 Impact Value test

Tire Rubber Replacement	Impact Value
0%	4.11
5%	3.76
10%	2
15%	1.45

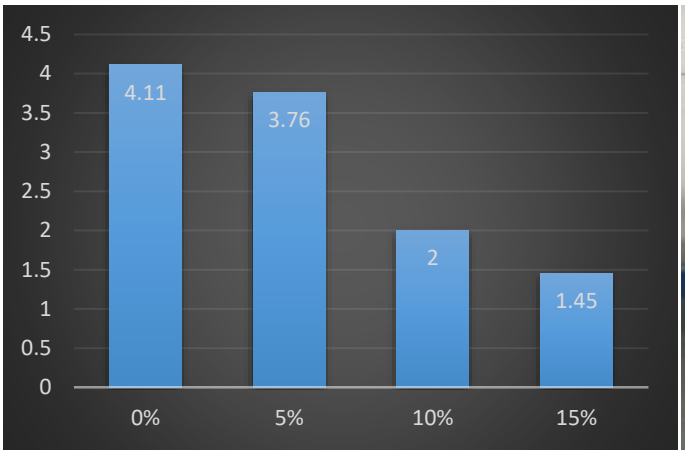

Chart No.1 Impact Value test

Photo No.3 Impact Value test set up

Aggregate impact value test gives an indication of aggregate's toughness property (i.e. property of a material to resist impact). As the value of impact decreases it's resistant to impact increases.

B] For Abrasion test:

Abrasion test gives the percentage wear resistance i.e. the hardness of the aggregates. The experimental investigation is carried out by considering the 'Grading B' of the aggregates i.e. by considering20-12.5mm and 12.5-10mmm aggregate size and 11 metallic spheres. Due to the presence of abrasive charge, this experiment gives an idea about resistance to abrasion as well as impact.

Table No.5 Los Angeles Abrasion test

Tire Rubber Replacement	Abrasion Value / % Wear
0%	12.06
5%	10.67
10%	10.66
15%	10.00

Photo No.4 Los Angeles Abrasion test

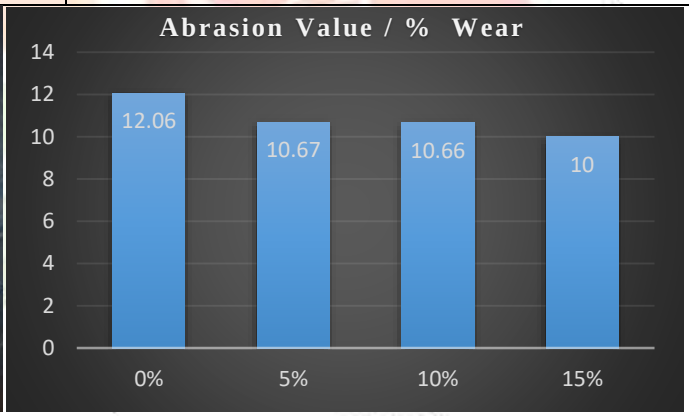

Chart No.2 Abrasion Value / % Wear

C) Slump Test:

Slump test was carried out on fresh concrete to identify the workability of the concrete and most commonly used method of measuring the consistency of concrete. The test conducted directly after the concrete mixes were pouring out from the mixer. For each type of sample, one slump test needs to be performed.

Slump Test: Slump test was conducted for all batch and the slump values are as shown in Table No. 6 and figure No. 6

Table No.6 Slump height.

Batch No.	Slump Height (mm)	Slump type
1(A)	80	Shear slump
2(B)	30	True slump
3(C)	40	True slump
4(D)	70	Shear slump

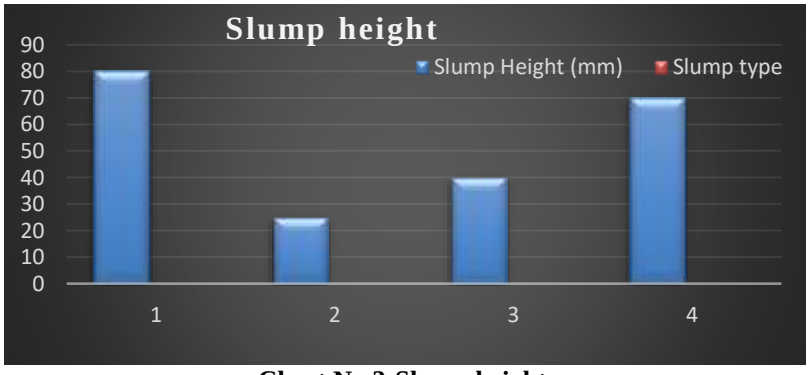

Chart No.3 Slump height

From the slump result obtained, control mix sample have the highest slump which is 80 mm. The concrete slump obtained can be said not too dry and not too wet. The slump reduces to 30 mm when 5% of rubber and rice husk replaces the coarse aggregate and cement in the concrete. Replacement of 10% of rubber and rice husk replaces the coarse aggregate and cement has the slump 40 mm. The slump for mix sample A, B, and C are categorized as true slump. The decreasing in slump value reflects the workability of the concrete is also decreasing. Although the slump declining, mix samples A, B, and C has a workable concrete. Unlike for mix sample D has shear slump. The type of slump having by mix sample D indicates that the concrete is lack of cohesion. The increasing of rubber percentage in concrete contributes to the weaker bond between the rubber and cement. The shear slump also reflects that the mix design should be avoided because it will affect the durability of the concrete as the concrete may undergoes segregation and bleeding.

As conclusion, from the analysis of slump test results, it can be clearly stated that the replacement of coarse aggregate by rubber in the concrete can affect the workability of the concrete. The concrete is not workable when the percentage exceed 10% of rubber. Finally conclude that, 1) the workability of rubberized concrete decreases as the percentage of rubber increases.
2) Lack of cohesiveness and proper bonding between rubber and cement causes shear slump.

Photo No.5 Slump height test

D) Compressive Strength:

Compressive strength test: Compression Testing Machine of 2000kN is used for Compressive strength test. Cube size of 150 x150x 150 mm was used. Two cubes of each batch were casted and tested for 7 and 14 days. Compressive strength tests were conducted at the ages of 7, 14 days. A comparative study was made on control concrete with replacement of cement by RHA and coarse aggregate by tyre rubber in 0%, 5%, 10% and 15%. The tests results are reported in Table: 7.

Table No.7 Compressive Strength at 7 & 14 days blocks

Batch No.	RHA Content (%)	Rubber Content (%)	Compressive Strength After 7 Days (N/mm^2)	Compressive Strength After 14 Days (N/mm^2)
1	0%	0%	24	35
2	5%	5%	18	28
3	10%	10%	16.5	22
4	15%	15%	14	20.5

Photo No.6 Compressive Machine

Photo No.7 Compressive Strength at 7 & 14 days

RESULT:

The result obtained from the laboratory testing reflects the properties of the concrete. These tests were conducted on the mix sample A, B, C, D which consists of 0%, 5%, 10%, 15% of rubber chips substitute to coarse aggregate and cement by rice husk ash respectively. Unlike the combination of coarse aggregate with cement that produce good bond, rubber and cement results to the weak bond in concrete. This was the reason to the high reduction of strength for mix sample for both 7 days and 14 days. The reduction in compressive strength also may be due to the non- uniform distribution of rubber in the concrete. Rubbers which also have elastically deformable properties when load is applied, also contribute to the reduction of the concrete strength. The small rigidity of the rubber compared to the high rigidity of the coarse aggregate also contributes to the decrease in strength. High proportion of rubber in concrete will eventually reduces the stiffness of the concrete and also the concrete strength. The gradual decrease in the compressive strength as the percentage of replacement increases at 7 and 28 days & the maximum compressive strength is obtained at 5% replacement of fine aggregate by RH.

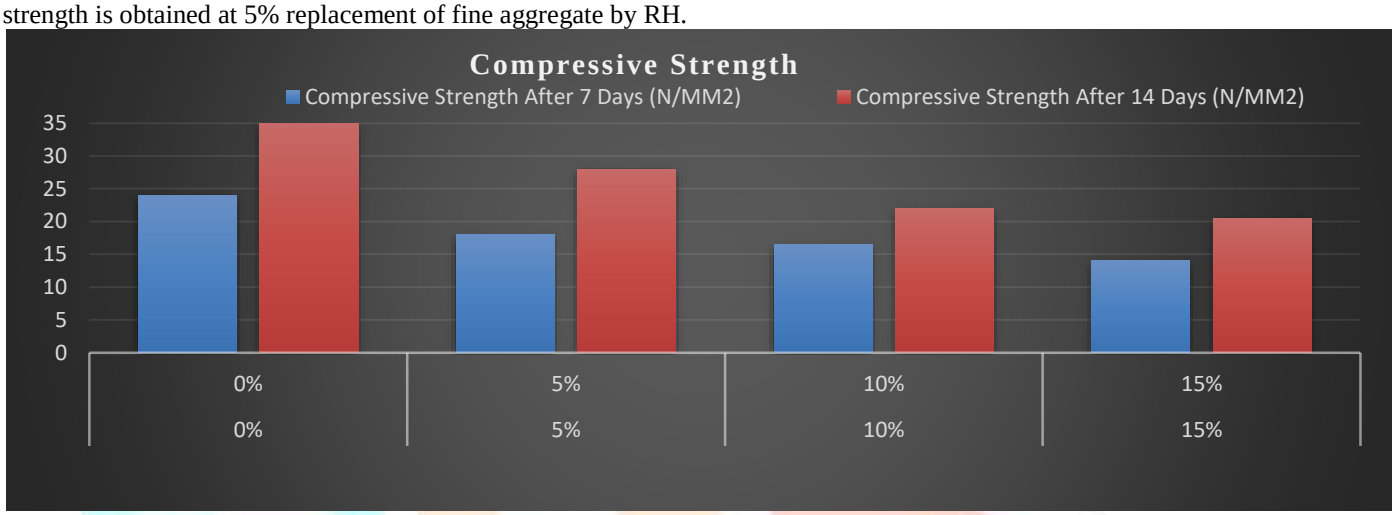

Chart No.4 Illustration of Compressive Strength

CONCLUSIONS:

Large volumes of waste products like rubber and rice husk ash are generated. Because of stricter environmental regulations, landfill disposal has become difficult and therefore disposal cost is escalating. Recycling is the best option over disposal. It helps in reducing disposal costs, conserves natural resources. Substitution of conventional materials by recycled waste materials helps in efficient use of waste material and sustainable use of natural resources. Reduce the aggregate impact value by substitution of coarse aggregates by tyre rubber. The present tests are not completely adequate for higher percentages of replacement of rubber. The substitution of coarse aggregate by rubber has revealed significant improvement in the physical properties. Therefore tyre rubber can be used in the actual road construction and the problem of rubber disposal can be solved up to certain extent. Thus rubber can be a partial substitute for coarse aggregate.

Based on the analysis of results, the conclusions that can be made are:

1. When the percentage of rubber increases, the workability of rubber contained concrete decreases.
2. Causes shear slump because of lack of cohesiveness and proper bonding between rubber and cement.
3. Compressive strength of normal concrete is higher as compared to rubberized concrete.
4. Replacement of rubber reduces the weight of the concrete.
5. The gradual decrease in the compressive strength as the percentage of replacement increases at 7 and 28 days.
6. The maximum compressive strength is obtained at 5% replacement of fine aggregate by RHA.
7. The workability of RHA concretes have decreased if the percentage of replacement increases.

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