Experimental Investigations on the Behaviour of Eco-Friendly Concrete

G.HathiRam [1], B.Prakash[2,] M.Indira[3]

[1]Associate Professor, KLR College of Engineering & Technology, Bhadradri Kothagudem Dt.

[2]Assistant Professor, KLR College of Engineering & Technology, Bhadradri Kothagudem Dt.

[3]M.Tech student, KLR College of Engineering & Technology, Bhadradri Kothagudem Dt.

Abstract

Concrete is the most popular construction material. In its lifetime, natural resources such as limestone and aggregate are consumed. Meanwhile, emission of air pollutants and discharge of waste concrete in large quantities are of great concern. However, in recent years, high performance concrete and new types of concretes have been developed to decrease the environmental burden in its lifespan or in production phase, to utilize a substantial amount of recycled industrial waste, and to improve local environment. These eco-friendly concretes are classified into environmental protection type such as high performance concrete and recycled concrete and environmental creation type such as porous concrete used for planting and air-purifying concrete with TiO_2 coating. This paper introduces the concept of eco-friendly concrete and summarizes present technologies and application.

Index Terms— *Self Healing, Microbiologically Induced Calcite Precipitation (MICP), Bio Mineralization, 'Bacillus Subtilis'*

I. INTRODUCTION

Now a days , the change in life style and increasing population has resulted in significant plastic and rubber usage which resulted in humongous escalation in the post consumer waste, of which only a certain extent can be recycled. Industrial wastes are creating environmental pollution in one or the other way. These industrial wastes if not taken care, can effect human health and rein the peace of society. Many efforts have been made by construction industry to utilize these industrial wastes in construction and thus reducing the environmental pollution load. The changed lifestyle and endlessly increasing population has resulted in a significant rise in the quantity of post-consumer Plastic waste and Waste Tyre Rubber.

The world's annual consumption of plastic materials has increased from around 5 million tons and 20 million tonnes in the 1950s to nearly 100 million tons in recent times, resulting in a significant increase in the amount of Plastic waste and Waste Tyre Rubber generation. Out of this waste, a significant part is recycled but the majority of post-consumer Plastic waste and waste tyre rubbers, like shampoo sachets, carry-bags, nitro packs, milk and water pouches and rubbers in Waste tyres etc. Looking to the global issue of environmental pollution by post-consumer Plastic waste and Waste Tyre Rubber, research efforts have been focused on consuming this waste on massive scale in efficient and environmental friendly manner. Researchers planned to use Plastic waste and Waste Tyre Rubber in form of concrete ingredient as the concrete is second most sought material by human beings after water. The use of post-consumer Plastic waste and Waste Tyre Rubber in concrete will not only be its safe disposal method but may also improve the concrete properties like tensile strength, chemical resistance, drying shrinkage and creep on short and long term basis. The present review highlights the Plastic waste and waste tyre rubbers which can be used as concrete ingredient and their effect on properties of concrete. It also presents current trends and future needs of research in the area of use of post-consumer Plastic waste and Waste Tyre Rubber in concrete.

II. LITERATURE REVIEW

Few researchers have focused on utilizing the granular form of recycled or waste plastics to replace the sand and natural aggregate contents in the mix to reduce the exploitation of natural resource. Marzouk OY et al utilized the Plastic waste and Waste Tyre Rubber of polythene terephthalate (PET) bottles as an aggregate substitute in the concrete mix. Authors used these Plastic waste and waste tyre rubbers in M_{20} grade concrete in form of fine and coarse aggregates to check its feasibility and effects on mechanical properties of the concrete. M.Elzafraney et al used recycled plastic aggregate as coarse aggregate to improve the thermal properties of concrete mix. Hasan S. Dweik et.al Used waste of thermo set plastic as sand replacement to check the feasibility of the use.

M. Sivaraja et. Al: plastic waste as fibrous constituents of concrete mix: west virginia university institute of technology,montegomery, international journal of engineering science invention ,sept 2013.
M.Sivarajaet. al. tested various mechanical properties of concrete specimens made by mixing the plastic fibers in concrete. The volume fraction of waste was varied from 0. 5% to 1.5%. M. They studied the effects of addition of plastic fibers obtained from

rural waste in the reinforced concrete beam under cyclic loading. K.S.RebeizET.al. tested the flexural behavior of concrete produced by addition of recycled Plastic waste and Waste Tyre Rubber containing unsaturated polyester resin. Authors also predicted flexural strength of such beams. Victor C. Li et al carried out an experimental study on mortar, reinforced by synthetic fiber with volume fraction up to 3% to study the effect on workability and reduction in drying shrinkage.

Osmani et. Al: plastic waste and waste tyre rubber as powder in the concrete mix: international journal of innovative research in science, engineering and technology, march2013
They experimented with glass reinforced Plastic waste and Waste Tyre Rubber in concrete by making them powder form. The glass reinforced Plastic waste and Waste Tyre Rubber was used in volume fraction in 5% to 50% as sand replacement. Authors concluded that waste has good contribution in concrete properties. S.S.Verma proposed to use Plastic waste and Waste Tyre Rubber in roads in form of powder up to 3% to 4% volume fraction.
Mohamed osmani et. al:: international journal of innovative research in science, engineering and technology, may `13

Mohamed Osmani et al, carried out assessment of the compressive strength of glass reinforced Plastic waste and Waste Tyre Rubber filled concrete for potential application in construction with the concentration of 5%, 15%, 30%, and 50% by weight. Authors found improvement in compressive strength due to the addition of the Plastic waste and Waste Tyre Rubber.

III. TYPES OF PLASTIC WASTE AND WASTE TYRE RUBBERS

Types of Rubber:

*1) **Chipped Rubber***: The rubber has a dimension of about 25-30 mm. It was used to replace the coarse aggregates in concrete.

*2) **Crumb Rubber***: These particles are highly irregular, in the range of 3– 10 mm. The rubber was used to replace sand.

Crumb Rubber   Ash Rubber   Chipped Rubber

*3) **Ash Rubber***: The rubber consists of particles smaller than 1 mm. It was not prepared from crumb rubber by grinding, but was the powder formed unintentionally during the trituration process, fallen from the machinery of the plant handling the waste rubber.

IV. USAGE OF PLASTIC WASTE AND WASTE TYRE RUBBERS IN CONCRETE

It is observed that Plastic waste and Waste Tyre Rubber is used as concrete ingredient in various forms. They are commonly used in the form of fine and coarse granular particles, powder and discrete fibers. This form of ingredient is mainly controlled by economical, physical and chemical limitations of converting the wastes in a particular shape or form. Few selective research efforts have been summarized here to present a general scenario of usage of post-consumer Plastic waste and Waste Tyre Rubber like carry bags, wrapping and packaging materials, left over or crushed bottles and small to medium containers etc in various forms. And waste and worn out tyres from the vehicles.

V. FUTURE OF PLASTIC WASTE AND WASTE TYRE RUBBERS AS CONCRETE INGRADIENT

The idea to use post-consumer Plastic waste and Waste Tyre Rubber as concrete ingredient will result in its large volume disposal which is environmentally safe and does not pose any health hazard At present these trials are mostly limited to laboratory or research level. However, these investigations pose a big challenge to provide a bridge to gap the laboratory works and real applications. A need is also felt to accomplish the form plastic waste and waste tyre rubbers apart from powder, grain and fibers, which can be used directly in concrete without any pre-treatment. The process of making plastic waste and waste tyre rubbers suitable for concrete is energy intensive hence an energy efficient method is required to be developed. No clear-cut methodology is available for mix design using PLASTIC WASTE AND WASTE TYRE RUBBERS; a significant experimentation is required for its formulation. Durability aspects of concrete using different types of plastic waste and waste tyre rubbers require thorough investigation. An in-depth experimental analysis of mechanical behavior of concrete containing plastic waste and waste tyre rubbers needs an urgent attention.

Usage of post-consumer Plastic waste and Waste Tyre Rubber in concrete as ingredient can solve its disposal problems to significant extent. Improvement in the mechanical properties of concrete such as compressive strength, split tensile strength, thermal properties, energy absorption, flexural strength, crack arresting behavior etc. by adding post consumer Plastic waste and waste tyre rubbers may be found. However, a thorough investigation is required to be taken-up in this area. The plastic waste and waste tyrerubbers is mostly used in form of powder, aggregates and fibers as a concrete ingredient. All these forms have smooth surface and hence require surface roughening treatment for better bond characteristics. Use of plastic waste and waste tyre rubbers in concrete is quite a new research area hence presents a great research potential.

Mix Proportioning Concepts:

Currently, there does not exist a standard or recommendation for mixture proportioning of plastic waste and waste tyre rubbers concrete. However different people have developed their own procedures, and in one-way or more, some have similarities with each other. plastic waste and waste tyre rubbers has been proportioned based on several concepts and considerations. There are three techniques of incorporating plastic waste and waste tyre rubbers relative to fine aggregate in the concrete mix

a) Addition to fine aggregate and coarse aggregate directly.
b) Partial replacement of fine aggregate by the equal volume of plastic waste and waste tyre rubbers(1:1 replacement)
c) Partial replacement of fine aggregate by the less volume of plastic waste and waste tyre rubbers (5%,10%, 15%, 20%)

In the third technique, it is possible to use plastic waste and waste tyre rubbers to reduce the cost for comparable quality by reducing the fine aggregate content and replacing it with a lesser amount of plastic waste and waste tyre rubbers.

PLASTICS USED FOR PRESENT INVESTIGATION

The plastics used in the present investigation are domestic waste plastics which are processed in polyethene carry bag industry and are made into granules of variable sizes which in turn are graded according to the design requirements and are used as partial replacement for fine aggregate in concrete.

VI. EXPERIMENTAL INVESTIGATIONS

The experimental investigation was taken up on M_{30} grade of concrete. The investigation was aimed at studying the effect of Plastic waste and waste tyre rubbers in concrete cubes cast with M_{30} grade concrete and tested under Compression testing Machine. To reach the purpose of this research, experimental laboratory study was developed using the materials-53 grade Portland cement, graded coarse aggregate, river sand, Plastic waste and waste tyre rubbers and bore well water.

COLLECTION OF MATERIALS REQUIRED

PORTLAND CEMENT:

Portland cement is made from heating limestone and chalk, combined with silicates. Portland cement holds the aggregates together and is available in different grades and colors. The type of Portland cement generally available in hardware or lumber store is gray in colour. The cement used in this investigation is Orient Gold make, 53-grade Portland, for casting of the cubes, cylinders.

FINE AGGREGATE:

Sand is generally used as fine aggregate for production of the concrete. The sand should be sharp to grab the cement onto it. This sharp sand is also called as brick sand or mortar sand. The grains of

sand from pit run sand are usually too round. Stone dust, a waste product from quarries or stone works can also be added to produce concrete, and usually for smooth mixtures for small scale concrete production. This stone dust adds strength, and reduces shrinkage on setting, and improves visual appearance of concrete. Limestone (dolomite) or marble dust is two types of dust. For the present experimental work river sand procured from Man air is used as Fine Aggregate.

COARSE AGGREGATE:

Crushed hard granite stone or gravel of size less than 10mm is used as coarse aggregate. Stone adds strength in larger work and also controls shrinkage. Stone is cheaper than cement. The coarse aggregate is procured from Jayagiri, Hanamkonda and used for investigation.

DEVELOPMENT OF MIX DESIGN

The investigation was carried on M30 grade of concrete IS 10262 : 1962 was used to obtain the mix proportions for the above grade of concrete. The mix proportion adopted was 1**: 1.45: 2.95** with water

binder Ratio is 0.46.

MIX PROPORTIONS TABLE: 1

Quantity	Cement	Fine aggregate	Coarse aggregate	W/c ratio
(Kg/m^3)	404	586	1191	186
Proportions	1	1.45	2.95	0.46

NOMENCLATURE TABLE: 2

Cube	Cylinder
C_0 - Cube with 0% plastic and 0% rubber	CY_0 - Cylinder with 0% plastic and 0% rubber.
$C_{2.5}$ - Cube with 2.5% plastic and 2.5% rubber	$CY_{2.5}$ - Cylinder with 2.5% plastic and 2.5% rubber
C_5 - Cube with 5% plastic and 5% rubber	CY_5 - Cylinder with 5% plastic and 5% rubber.
$C_{7.5}$ - Cube with 7.5% plastic and 7.5% rubber	$CY_{7.5}$ - Cylinder with 7.5% plastic and 7.5% rubber
C_{10} - Cube with 10% plastic and 10% rubber	CY_{10} - Cylinder with 10% plastic and 10% rubber

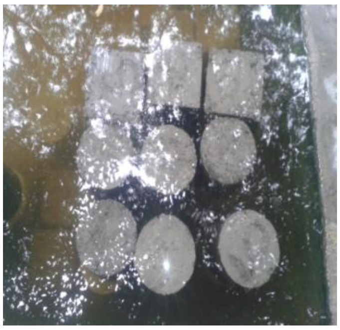
VII. EXPERIMENTAL WORK DONE: MIXING, CURING, TESTING.

After weighting accurately cement, sand, normal coarse aggregate and waste plastic and waste rubber these have been mixed to get uniform color. Waste plastic and waste rubber aggregates is added and mixed such that the waste plastic and waste rubber aggregate are distributed uniformly throughout. Water has been added to mix and proper mixing is ensured. Balling of lump formation if found anywhere has been lossened to achieve a homogenious mix.

VIII. TESTS ON SPECIMENS

Table 3: compressive strength of concrete

PERCENTAGE OF REPLACEMENT	7 DAYS COMPRESSIVE STRENGTH IN MPa				28 DAYS COMPRESSIVE STRENGTH IN MPa			
	Sample				Sample			
	S1	S2	S3	Avg	S1	S2	S3	Avg
0	32.5	32	31	31.8	44.96	44	42	43.65
5	30.8	28.8	25.72	28.77	40.54	39.67	38.5	39.57
10	26.76	25.28	24	25.34	38.6	37.6	36	37.4
15	25.72	22.67	21.8	23.39	37.4	36.6	34.4	36.2
20	24	22	21.5	22.15	32	31	31	31.4

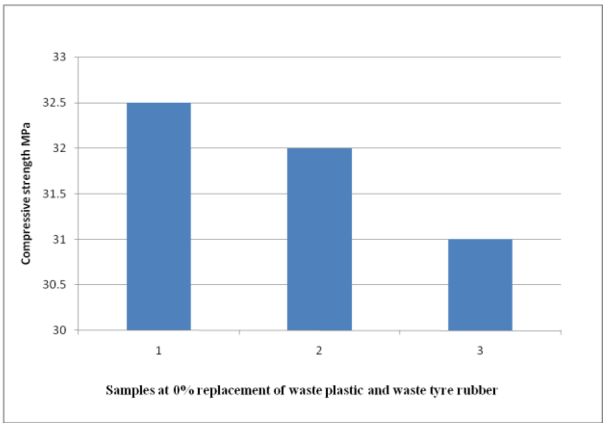


IX. ANALYSIS OF TEST RESULTS:

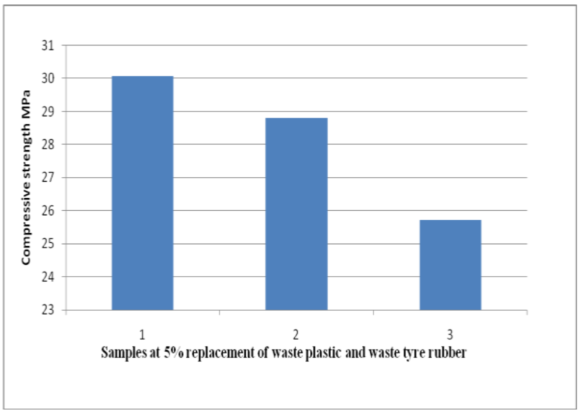
1. These graphs are the comparison graphs of normal concrete and eco friendly concrete.
2. The compressive test was conducted on tests at the ages of 7 and 28 days.
3. The cubes and cylinders were tested for compressive strength at 0%,5%,10%,15% and 20% replacement of waste plastic and waste tyre rubber as fine and coarse aggregate.

Comparison of compressive strength Vs percentage replacement of waste plastic and waste tyre rubber

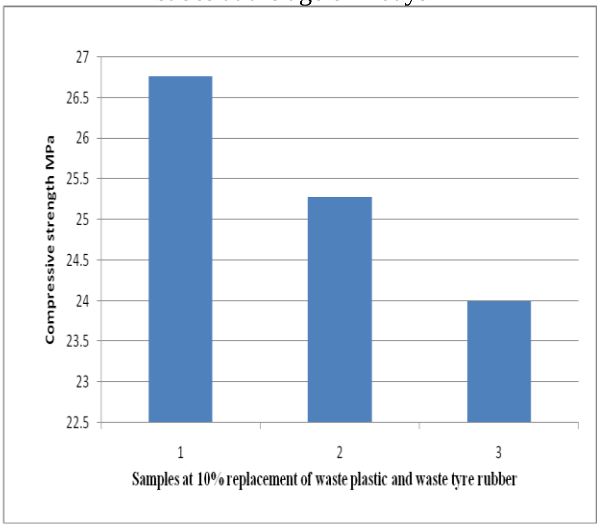
Graph No.1: Graph showing Compressive strength of cubes at the age of 7 days.



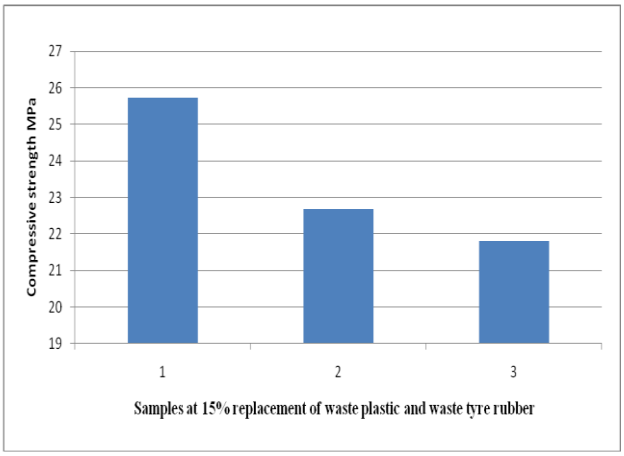
Graph No.2: Graph showing Compressive strength of cubes at the age of 7 days.



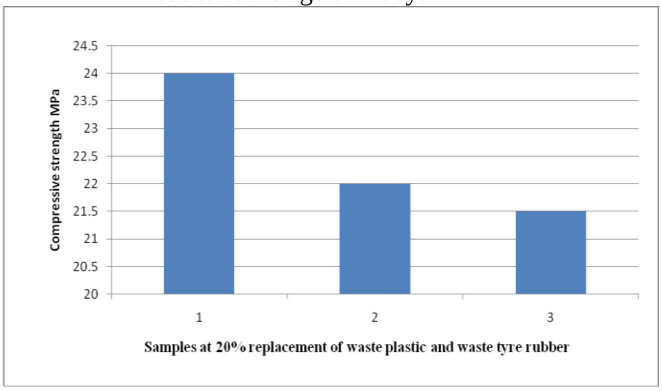
Graph No.3:Graph showing Compressive strength of cubes at the age of 7 days



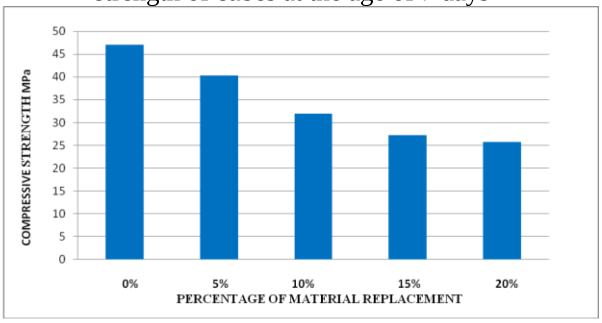
Graph No.4: Graph showing Compressive strength of cubes at the age of 7 days



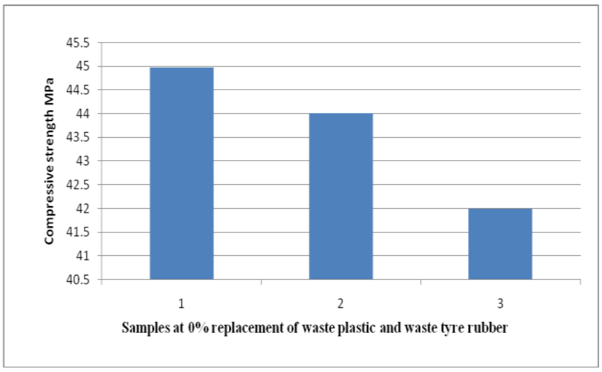
Graph No.5:Graph showing Compressive strength of cubes at the age of 7 days



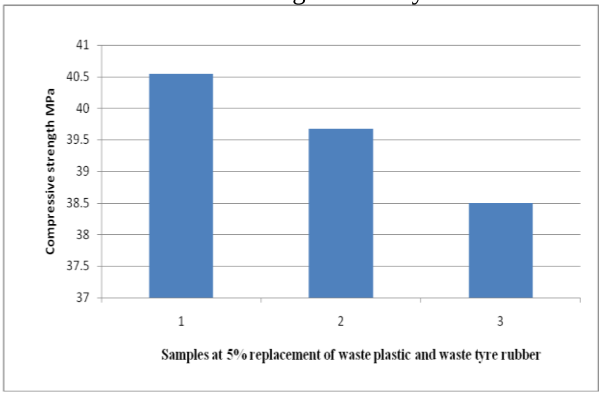
Graph No.6: Graph showing Average compressive strength of cubes at the age of 7 days



Graph No.7: Graph showing Compressive strength of cubes at the age of 28 days



Graph No.8: Graph showing Compressive strength of cubes at the age of 28 days



Graph No.9: Graph showing Compressive strength of cubes at the age of 28days

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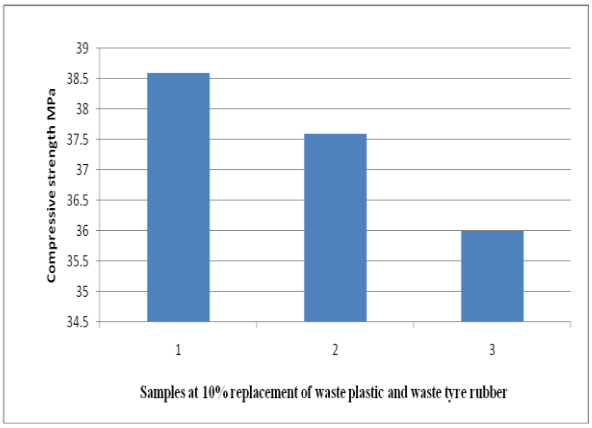
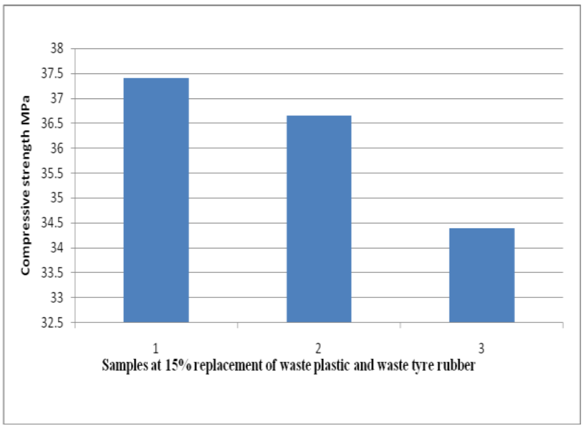
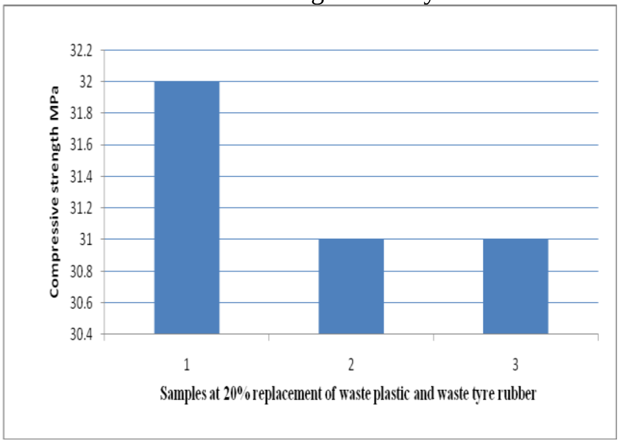


Graph No.10: Graph showing Compressive strength of cubes at the age of 28days



Graph No.11: Graph showing Compressive strength of cubes at the age of 28days



Graph No.12: Graph showing Average compressive strength of cubes at the age of 28 days

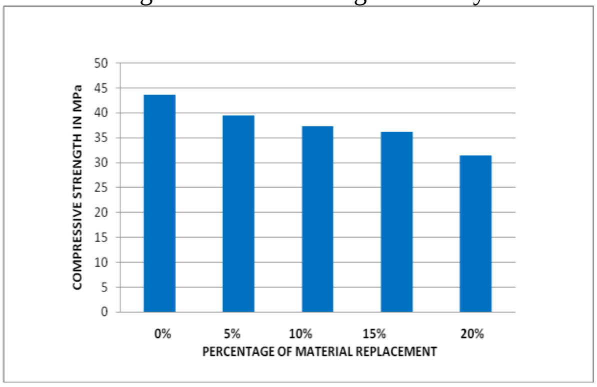


Table No 12: Split Tensile Test Values

PERCENTAGE OF REPLACEMENT	7 DAYS SPLIT TENSILE TEST STRENGTH IN MPa				28 DAYS SPLIT TENSILE TEST STRENGTH IN MPa			
	Sample1	**Sample2**	**Sample3**	**Average**	**Sample1**	**Sample2**	**Sample3**	**Avg**
0	2.95	3.65	3.00	3.2	2.91	3.75	3.05	3.23
5	3.65	2.75	2.95	3.11	3.75	2.77	3.05	3.19
10	2.77	3.55	2.89	3.07	2.77	3.75	2.91	3.14
15	3.05	2.69	2.76	2.83	3.05	2.77	2.63	2.81
20	2.63	3.05	2.17	2.61	2.63	3.19	2.27	2.7

X. DISCUSSION ON TEST RESULTS

1. The concrete cubes cast 0% replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a compressive strength of 0% (43.65MPa) at an age of 28 days curing.
2. The concrete cubes cast 5%(2.5%+2.5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a compressive strength of 5% (39.57MPa) at an age of 28 days curing.
3. The concrete cubes cast 10%(5%+5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a compressive strength of 10% (37.4MPa) at an age of 28 days curing
4. The concrete cubes cast 15%(7.5%+7.5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a compressive strength of 15% (36.2MPa) at an age of 28 days curing.
5. The concrete cubes cast 20%(10%+10%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a compressive strength of 20%(31.4MPa) at an age of 28 days curing.
6. The concrete Cylinders cast 0% replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a Split tensile strength of 0% (3.23MPa) at an age of 28 days curing.
7. The concrete Cylinders cast 5%(2.5%+2.5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a Split tensile strength of 5% (3.19MPa) at an age of 28 days curing.
8. The concrete Cylinders cast 10%(5%+5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a Split tensile strength of 10% (3.14MPa) at an age of 28 days curing.
9. The concrete Cylinders cast 15%(7.5%+7.5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a Split tensile strength of 15% (2.81MPa) at an age of 28 days curing.
10. The concrete Cylinders cast 20%(10%+10%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a Split tensile strength of 20%(2.7MPa) at an age of 28 days curing.

XI. CONCLUSIONS

1. The concrete cubes cast 0% replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a compressive strength of 0% (43.65MPa) at an age of 28 days curing.
2. The concrete cubes cast 5%(2.5%+2.5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a compressive strength of 5% (39.57MPa) at an age of 28 days curing.
3. The concrete cubes cast 10%(5%+5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a compressive strength of 10% (37.4MPa) at an age of 28 days curing
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6. The concrete Cylinders cast 0% replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a Split tensile strength of 0% (3.23MPa) at an age of 28 days curing.
7. The concrete Cylinders cast 5%(2.5%+2.5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a Split tensile strength of 5% (3.19MPa) at an age of 28 days curing.
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9. The concrete Cylinders cast 15%(7.5%+7.5%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a Split tensile strength of 15% (2.81MPa) at an age of 28 days curing.
10. The concrete Cylinders cast 20%(10%+10%) replacement of waste plastic and waste tyre rubber in M_{30} grade concrete gave a Split tensile strength of 20%(2.7MPa) at an age of 28 days curing.
11. The Compressive Strength of the concrete cubes cast with 5%(2.5%+2.5%), 10%(5%+5%), 15%(7.5%+7.5%) replacement of waste plastic and waste tyre rubber in fine and coarse aggregates approximately showed same results as that of concrete cubes cast with 0%.
12. The concrete cubes cast with 20%(10%+10%) replacement of fine and coarse aggregate by (waste plastic and waste tyre rubber) showed a result of (31.4MPa) which is very less, when compared to the concrete cubes cast with 0% replacement.
13. Hence I conclude that utilization of waste plastic and waste tyre rubber has partial replacement of fine and coarse aggregate in M_{30} grade of concrete may be up to 15%(7.5%+7.5%).

SCOPE OF FURTHER WORK

1.The Durability Studies on partial replacement of waste plastic and waste tyre rubber in fine and coarse aggregate need to be studied.

2.Thermal effects on replacements of waste plastic and waste tyre rubber in fine and coarse aggregate is to be studied.

3.The strength properties of different grades of concrete above M_{30} grade of concrete need to special attension.

4.This is the first experimental investigation done by partial replacement of fine and coarse aggregate by waste plastic and waste tyre rubber limited research was done on the same topic and it is either by partial replacement of waste plastic and waste tyre rubber but not on replacement of both waste plastic and waste tyre rubber.

5.As this is the latest investigations done by replacing both waste plastic and waste tyre rubber in M30 grade of concrete, it may show a path to the futher generation in protecting the environment from the degradation and effective utilization utilization usable waste in concrete.

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