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A Study on Mechanical Properties and Stress Strain Behaviour Of ConcreteContaining Plastic Waste

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Abstract

Now a day's one of the major problems in construction industries is insufficientand unavailability of construction materials, on the other side the main environmentalproblem is the disposal of the waste plastics. In this experimental study, an attempt hasbeen made to use the plastics in concrete and studies have been conducted to focus on the behaviour of flexural and compression members under various proportions of plastics.Two types of plastics namely polythene sheets and plastic straws were selected andmixed with concrete in various proportions (0.5% ,1.0% & 1.5%).The specimens werecasted and tested for its flexural and compression strength respectively. Among the two types of plastic products used, polythene sheets were found to give better results incompression, flexural & tensile strength. The Indian concrete industry is today consumingabout 400 million tonnes of concrete every year and it is expected, that this may reach abillion tones in less than a decade. All the materials required to produce such huge quantities of concrete, come from the earth's crust, thus depleting its resources every yearcreating ecological strains. On the other hand human activities on earth produce wasteplastics. The use of plastics in various places as packing materials and the products such asbottle, polythene sheet, containers packing strips etc,. are increasing day by day. Thisresults in production of plastic waste from all sort of livings from industrial manufacturers to domestic users. So, we are in need to search for new construction materials as well as a method to dispose the plastic waste.

Keywords: plastics, compressive strength, flexural and compression members etc.

1. Introduction

Concrete is a composite material composed mainly of water, aggregate, andcement. Often, additives and reinforcements are included in the mixture to achieve thedesired physical properties of the finished material. When these ingredients are mixedtogether, they form a fluid mass that is easily moulded into shape. Over time, thecement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses Famous concrete structures include theHoover Dam, the Panama Canal and the Roman Pantheon. The earliest large-scaleusers of concrete technology were the ancient Romans, and concrete was widely usedin the Roman Empire. The Colosseum in Rome was built largely of concrete, and theconcrete dome of the Pantheon is the world's largest unreinforced concrete dome.After the Roman Empire collapsed, use of concrete became rare until the technology was re-pioneered in the mid-18th century. Today, concrete is the most widely usedman-made material (measured by tonnage)

MERITS AND DEMERITS OF CONCRETE

Some Merits of concrete are given below in brief.
1) Concrete is economical when ingredients are readily available.

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2) Concrete's long life and relatively low maintenance requirements increase its economic benefits.
3) It is not as likely to rot, corrode, or decay as other building materials.
4) Concrete has the ability to be moulded or cast into almost any desired Shape.
5) Building of the molds and casting can occur on the work-site whichreduces cost.
6) Concrete is a non-combustible material which makes it fire-safe and able to withstand high temperatures.
7) It is resistant to wind, water, rodents, and insects. Hence, concrete is often used for storm shelters.

Some Demerits of concrete are given below in brief.

1) Concrete has some disadvantages too along the advantages stated above.
2) Concrete has a relatively low tensile strength
3) Low ductility
4) Low strength-to-weight ratio and Concrete is susceptible to cracking.

3.DISPOSALOF PLASTIC WASTE

Disposal of plastic waste in environment is considered to be a big problem due to its very low biodegradability and presence in large quantities. In recent time significant research is underway to study the possibility of disposal of these wastes in mass concrete where strength of concrete may not be major criteria under consideration, such as heavy mass of concreting in PCC in pavements. If plastic wastes can be mixed in the concrete mass in some form, without significant effect on its other properties or slight compromise in strength, we can consume large quantities of plastic waste by mixing it in the concrete mass.

Plastic is one component of Municipal solid waste (MSW) which is becoming a major research issue for itspossible use in concrete especially in self-compacting concrete and light weight concrete. Although some of these materials can be beneficially incorporated in concrete, both as part of the cementations binder phase or as aggregates, it is important to realize that not all waste materials are suitable for such use.

Concrete has proved to be an excellent disposal means for fly ash, silica fume,ground granulated blast furnace slag (GGBS), marble powder, and so forth which notonly traps the hazardous material but also enhances the properties of concrete.Concrete, as a material, has significantly been benefited from the usage of fly ash,silica fumes, and GGBS. For a constant workability, the reduction in water demand ofconcrete due to fly ash is usually between 5 and 15% when compared with Portlandcement only mix. The reduction is large at higher w/c ratio. In recent years there hasbeen an increased use of mixing the Portland cement and GGBS components directly in the concrete mixer. An advantage of this procedure is that the proportion ofPortland cement and GGBS can be varied at will.

2.Lyiterature Review

Prabir Das (2004) has suggested that plastics can be used in construction industry at various places. Proper selection of material / grade and suitable design considerations can help to replace many more applications. Lighter weight, design flexibility, part integration, low system cost, very high productivity and improved product appearance are the main features for use of engineering plastics. The engineering thermoplastics and introduction of application specific grades has thrown challenges to conventional materials in the industries. This paper provides all the supports in selecting suitable engineering plastics, process and design for conversion of conventional material to engineering plastics for performance and system cost benefits.

Chandrakaran (2004) has explained a laboratory experimental study carried out to utilize waste plastics (in the form of strips) obtained from milk pouches in the pavement construction. Results of the study indicate that by adding plastic strips in the soil, shear strength, tensile strength and CBR values of the soil increases. In this study, plastic or polythene sheets having thickness of 0.5mm and which are made up of high density are used. Two types of plastic strips were used in this study to act as a reinforcing material. The first one was cut into 20mm x 40mm size, second one was 25mm x 50mm size and the third one was of 30mm x 60mm size. These plastic strips have innumerable advantageous properties like high tensile strength, low permeability etc., These plastic strips act as a good barrier to gases and liquids and are unaffected by cycles of wetting and drying. For all the strips used in this experimental work, an aspect ratio of 2 is maintained.

4.Experimental Program

Plastics are normally stable and not biodegradable. So, their disposal poses problems. Research works are going on in making use of plastics wastes effectively as additives in bitumen mixes for the road pavements. Reengineered plastics are used for solving the solid waste management problems to great extent. This study attempts to give a contribution to the effective use of waste plastics in concrete in order to prevent the ecological and environmental strains caused by them, also to limit the high amount of environmental degradation.

CEMENT

Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Carehas been taken to see that the procurement was made from single batching in air tight containers to prevent it from being effected by atmospheric conditions.

FINE AGGREGATES

River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963.The sand was surface dried before use.

COARSE AGGREGATES

Crushed aggregates of less than 10mm size produced from local crushing plants were used. The aggregate exclusively passing through 10mm sieve size and retained on 6.5mm sieve is selected. The aggregates were testedfor their physical requirements such as gradation, fineness modulus, specificgravity and bulk density in accordance with IS: 2386-1963.

Fig 1.coarse aggregates

PLASTIC STRAWS

These are tubular plastic products used in day today life. These were mixed along with concrete after cutting them along its cross section. Then the cast specimens were de-moulded next day and subjected to curing.

Fig 2.Plastic Straws

POLYTHENE SHEETS

In the present investigation, plastic straws and plastic sheets available after the usage are taken as plastic wastes which are available on the road sides and dump yards around the town .The plastic wastes in the form of collected plastic straws and plastic sheets are allowed for cleaning process.

WATER

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete.

5. MIX DESIGN

Mix design for m20grade concrete

Water		Cement		Fine agg.		Coarse agg.
191.6 lit		383kg		605.2kg		1190.04kg
0.50	:	1	:	1.58	:	3.10

Calculation of quantity of plastic materials

We are adding two different plastics of two different proportions by the volume of concrete in the mould.

They are:

1) Plastic Straws - 0.5%, 1.0% and 1.5%
2) Polythene sheets - 0.5%, 1.0% and 1.5%

The ratio obtained from Concrete Mix design is =1:1.58:3.10

Addition of 0.5%, 1.0&& 1.5% plastic straws and polythene sheets to concrete cubes.Prisms, cylinders.

6. Testingof specimens

a. normal consistency of cement

Trail No.	Weight of cement (gm)	Percentage of water added	Depth of penetration (mm)
1	400	28	15
2	400	30	10
3	400	32	7

Hence the Consistency of cement is **32%**.

b.INITIAL SETTING TIME OF CEMENT

Initial setting time obtained = 53 minutes.

Final setting time = 458 minutes.

c. SPECIFIC GRAVITY OF CEMENT

Specific gravity of cement = 3.14

D.SPECIFIC GRAVITY OF COARSEAGGREGATES

Specific gravity =2.63

E.SPECIFIC GRAVITY OF FINE AGGREGATES

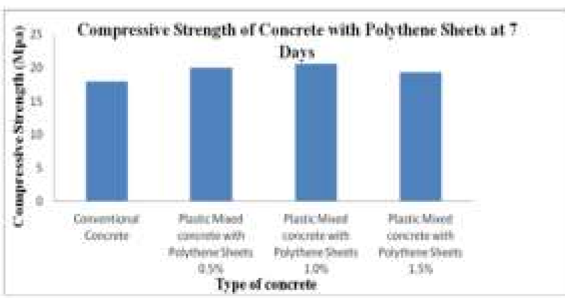
Specific gravity =2.75

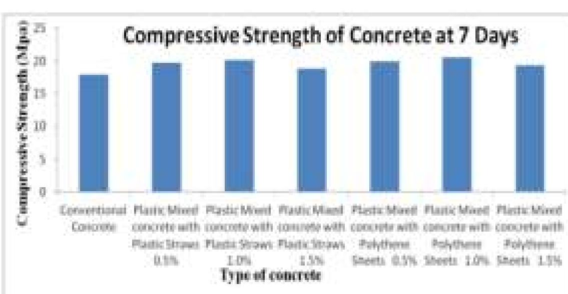
f.WATER ABSORPTION TEST

Percentage of water absorbed = 1%

g. compressive strength

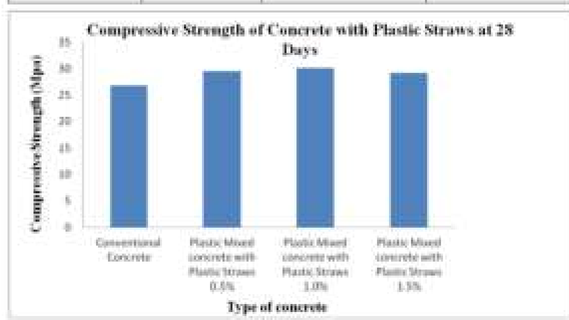
Type of Concrete	Mix Designation	Percentage of Addition	Average Compressive Strength of 3 cubes (Mpa) at 7 days
Conventional Concrete	M0	0%	17.95
Plastic Straws	M1	0.5%	19.80
	M2	1.0%	20.12
	M3	1.5%	18.90
Polythene Sheets	M4	0.5%	20.00
	M5	1.0%	20.60
	M6	1.5%	19.33

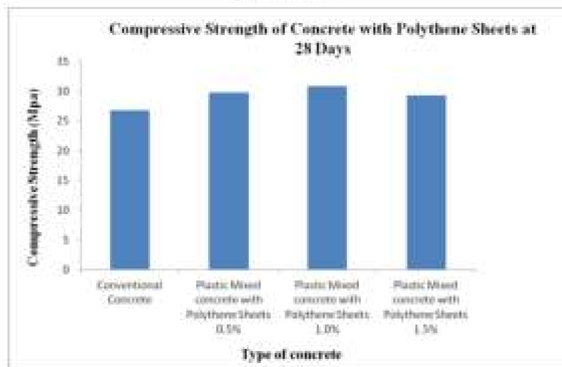


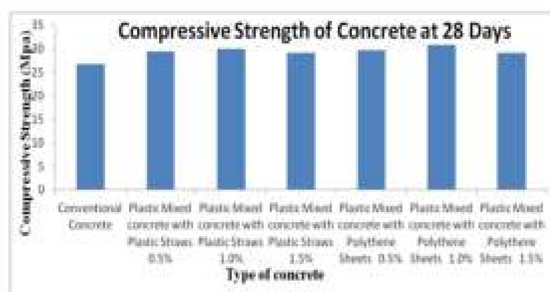


Compressive strength of concrete at 28 days

Type of Concrete	Mix Designation	Percentage of Addition	Average Compressive Strength of 3 cubes (Mpa) at 7 days
Conventional Concrete	M0	0%	26.74
Plastic Straws	M1	0.5%	29.50
	M2	1.0%	30.05
	M3	1.5%	29.21
Polythene Sheets	M4	0.5%	29.70
	M5	1.0%	30.80
	M6	1.5%	29.22

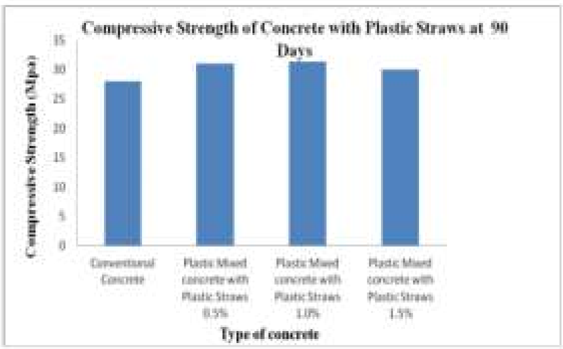


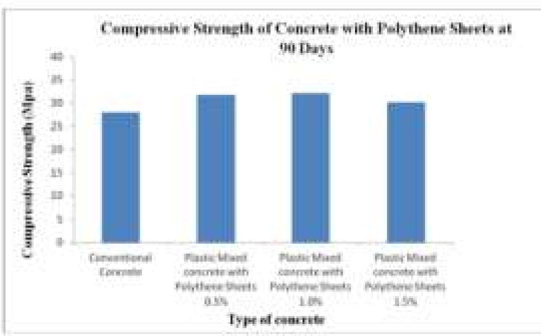


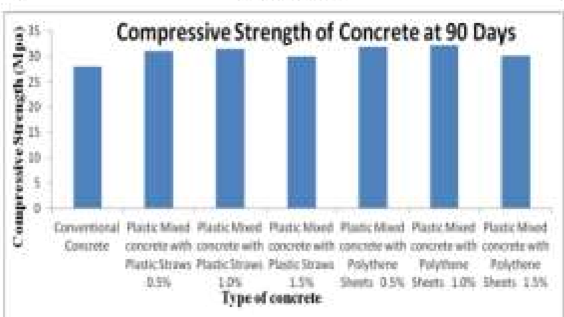


Compressive strength of concrete at 90 days

Type of Concrete	Mix Designation	Percentage of Addition	Average Compressive Strength of 3 cubes (Mpa) at 7 days
Conventional Concrete	M0	0%	28.0
Plastic Straws	M1	0.5%	31.00
	M2	1.0%	31.40
	M3	1.5%	30.00
Polythene Sheets	M4	0.5%	31.80
	M5	1.0%	32.20
	M6	1.5%	30.20







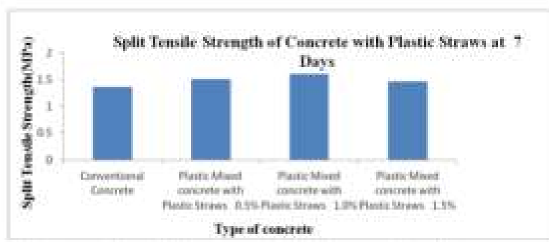
Compressive strength of concrete

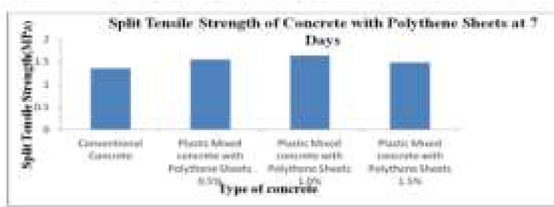
Type of Concrete	Mix Designation	Percentage of Addition	Average Compressive Strength of 3 Cubes (Mpa)		
			7 Days	28Days	90Days
Conventional Concrete	M0	0%	17.95	26.74	28.0
Plastic Straws	M1	0.5%	19.80	29.50	31.00
	M2	1.0%	20.12	30.05	31.40
	M3	1.5%	18.90	29.21	30.0
Polythene Sheets	M4	0.5%	20.00	29.70	31.80
	M5	1.0%	20.60	30.80	32.20
	M6	1.5%	19.33	29.22	30.20

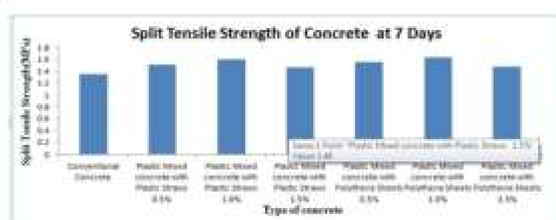
h. split tensile strength

Split Tensile strength of concrete at 7 days

Type of Concrete	Mix Designation	Percentage of Addition	Average Split Tensile Strength of 3 Cylinders (Mpa) at 7 days
Conventional Concrete	M0	0%	1.35
Plastic Straws	M1	0.5%	1.51
	M2	1.0%	1.6
	M3	1.5%	1.46
Polythene Sheets	M4	0.5%	1.55
	M5	1.0%	1.63
	M6	1.5%	1.48

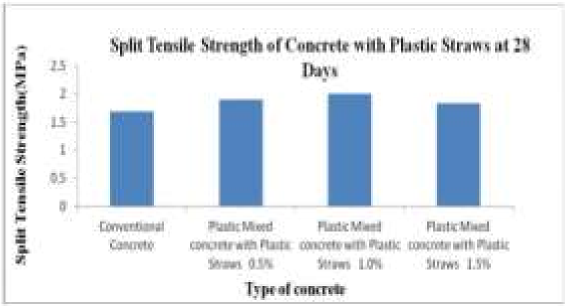


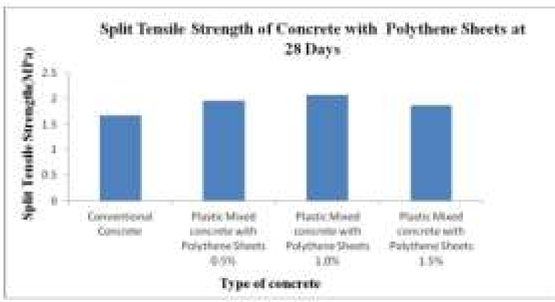


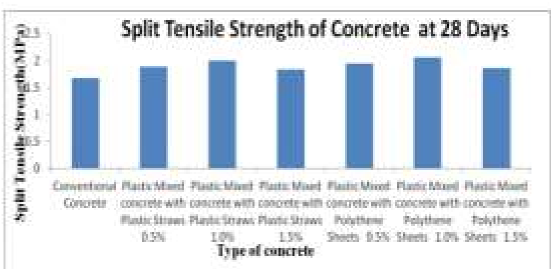


Split Tensile strength of concrete at 28 day

Type of Concrete	Mix Designation	Percentage of Addition	Average Split Tensile Strength of 3 Cylinders (Mpa) at 28 days
Conventional Concrete	M0	0%	1.68
Plastic Straws	M1	0.5%	1.89
	M2	1.0%	2.0
	M3	1.5%	1.83
Polythene Sheets	M4	0.5%	1.95
	M5	1.0%	2.06
	M6	1.5%	1.86

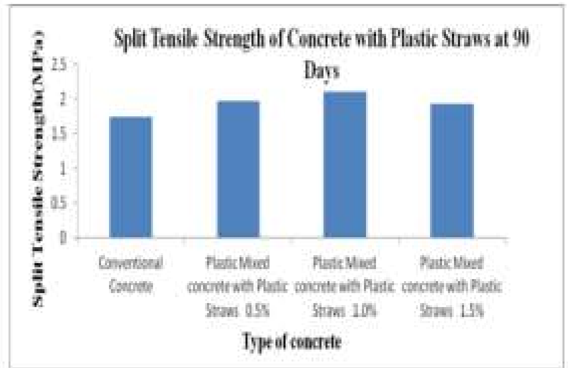


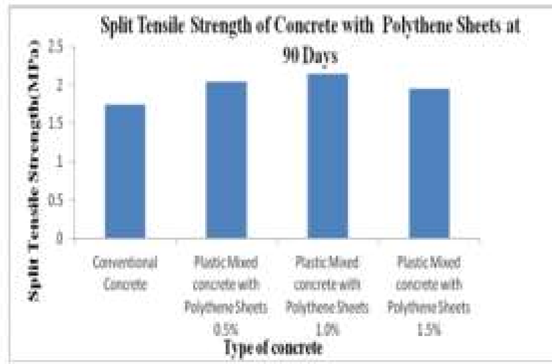


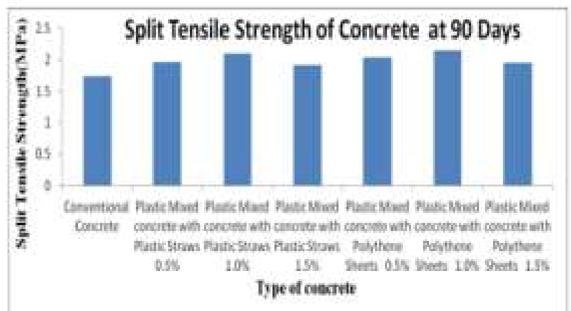


Split Tensile strength of concrete at 90 days

Type of Concrete	Mix Designation	Percentage of Addition	Average Split Tensile Strength of 3 Cylinders (Mpa) at 90 days
Conventional Concrete	M0	0%	1.74
Plastic Straws	M1	0.5%	1.96
	M2	1.0%	2.10
	M3	1.5%	1.92
Polythene Sheets	M4	0.5%	2.04
	M5	1.0%	2.15
	M6	1.5%	1.95







Average split tensile strength

Type of Concrete	Mix Designation	Percentage of Addition	Average Split Tensile Strength of 3 Cylinders (Mpa)		
			7 Days	28Days	90Days
Conventional Concrete	M0	0%	1.35	1.68	1.74
Plastic Straws	M1	0.5%	1.51	1.89	1.96
	M2	1.0%	1.6	2.0	2.10
	M3	1.5%	1.46	1.83	1.92
Polythene Sheets	M4	0.5%	1.55	1.95	2.04
	M5	1.0%	1.63	2.06	2.15
	M6	1.5%	1.48	1.86	1.95

i. Flexural strength

Flexural strength of concrete at 7 days

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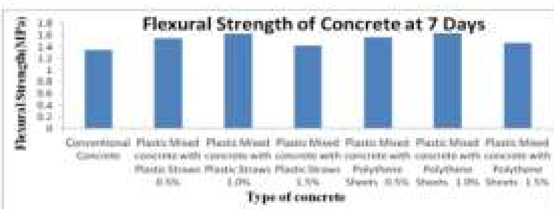
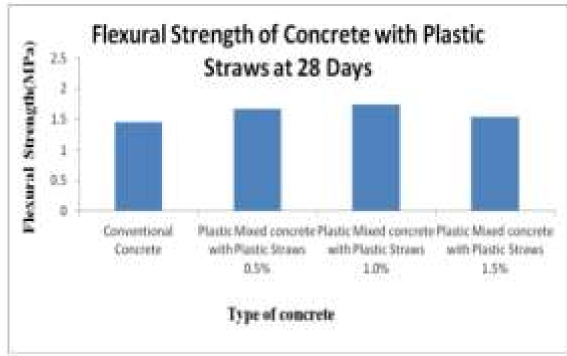
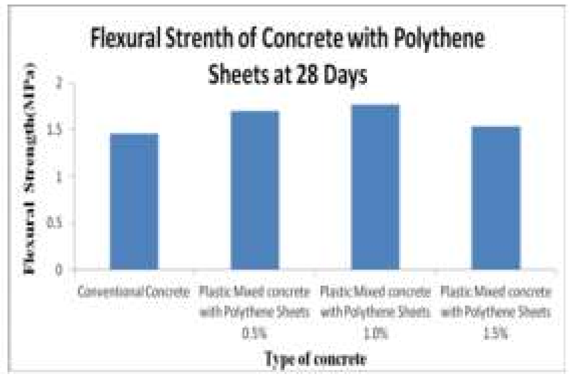
Type of Concrete	Mix Designation	Percentage of Addition	Average Flexural Strength of 3 Prisms (Mpa) at 7 days
Conventional Concrete	M0	0%	1.35
Plastic Straws	M1	0.5%	1.55
	M2	1.0%	1.63
	M3	1.5%	1.42
Polythene Sheets	M4	0.5%	1.57
	M5	1.0%	1.64
	M6	1.5%	1.47

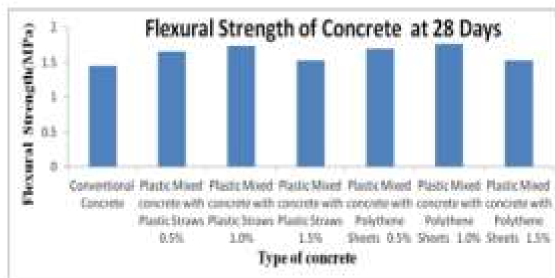


Flexural strength of concrete at 28 days

Type of Concrete	Mix Designation	Percentage of Addition	Average Flexural Strength of 3 Prisms (Mpa) at 7 days
Conventional Concrete	M0	0%	1.45
Plastic Straws	M1	0.5%	1.66
	M2	1.0%	1.74
	M3	1.5%	1.53
Polythene Sheets	M4	0.5%	1.70
	M5	1.0%	1.77
	M6	1.5%	1.53







Flexural strength of concrete at 90 days

Type of Concrete	Mix Designation	Percentage of Addition	Average Flexural Strength of 3 Prisms (Mpa) at 90 days
Conventional Concrete	M0	0%	1.50
Plastic Straws	M1	0.5%	1.75
	M2	1.0%	1.80
	M3	1.5%	1.63
Polythene Sheets	M4	0.5%	1.80
	M5	1.0%	1.84
	M6	1.5%	1.61

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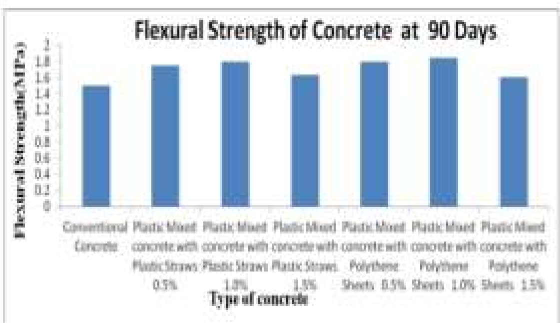
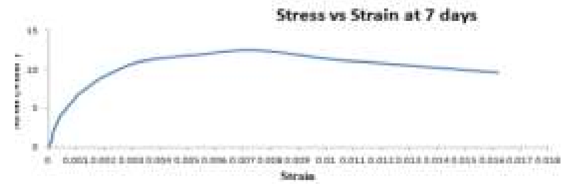


Flexural strength of concrete

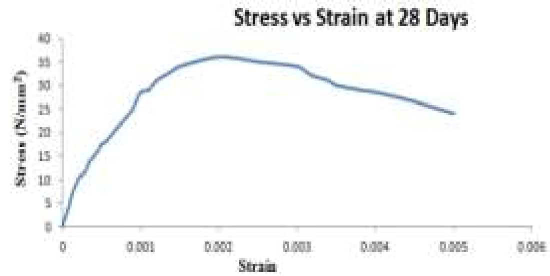
Type of Concrete	Mix Designation	Percentage of Addition	Average Flexural Strength of 3 Prisms (Mpa)		
			7 Days	28Days	90Days
Conventional Concrete	M0	0%	1.35	1.45	1.50
Plastic Straws	M1	0.5%	1.55	1.66	1.75
	M2	1.0%	1.63	1.74	1.80
	M3	1.5%	1.42	1.53	1.63
Polythene Sheets	M4	0.5%	1.57	1.70	1.80
	M5	1.0%	1.64	1.77	1.84
	M6	1.5%	1.47	1.53	1.61

STRESS STRAIN BEHAVIOUR

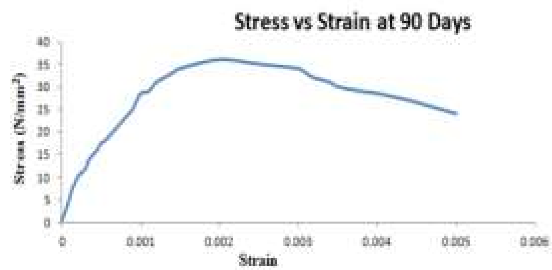
Stress Strain values of Plain concrete at 7 Days



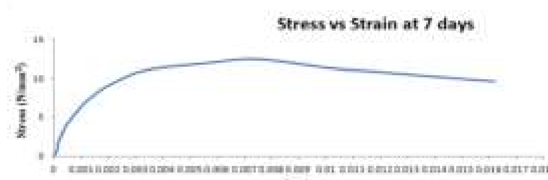
Stress Strain values of Plain concrete at 28 Days



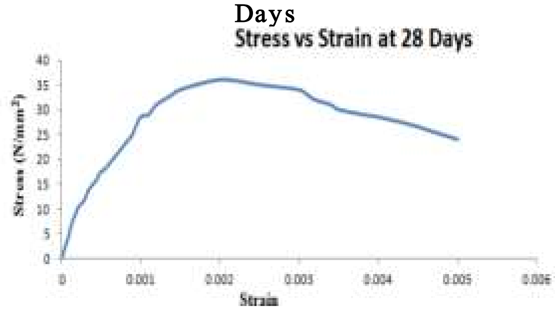
Stress Strain Behaviour of Plain concrete at 90 Days



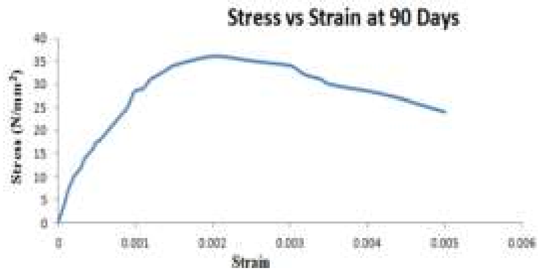
STRESS STRAIN BEHAVIOUR OF SIALFIBER REINFORCED CONCRETE



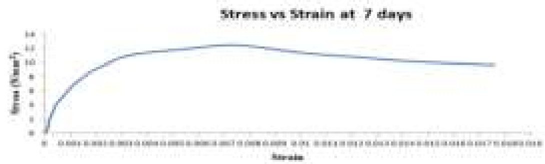
Stress Strain Behaviour with Plastic straws 0.5% at 7 Days



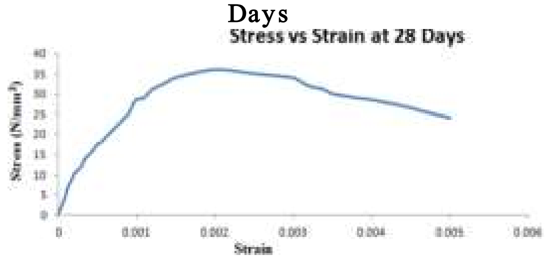
Stress Strain Behaviour with Plastic straws 0.5% at 28 Days



Stress Strain Behaviour with Plastic straws 0.5 % at 90 Days



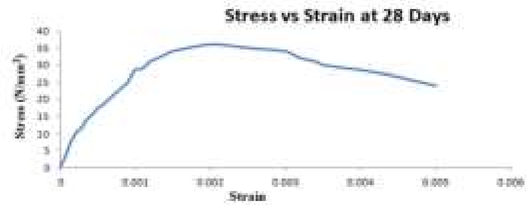
Stress Strain Behaviour with Plastic straws 1.0% at 7 Days



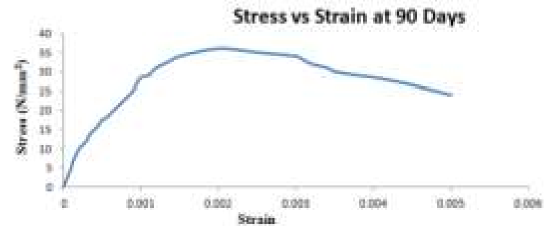
Stress Strain Behaviour with Plastic straws 1.0% at 28 Days

Stress Strain Behaviour with Plastic straws 1.0% at 90 Days

Stress Strain Behaviour with Plastic straws 1.5% at 7 Days

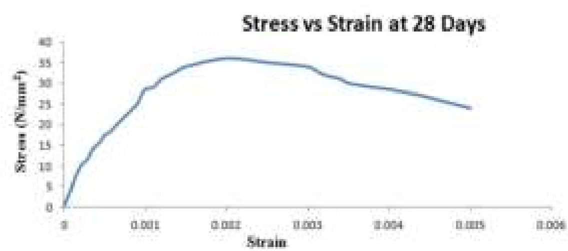


Stress Strain Behaviour with Plastic straws 1.5% at 28 Days



Stress Strain Behaviour with Plastic straws 1.5% at 90 Days

Stress Strain Behaviour with Polythene Sheets 0.5% at 7 Days



Stress Strain Behaviour with Polythene Sheets 0.5% at 28 Days

Stress Strain Behaviour with Polythene Sheets 0.5% at 90 Days

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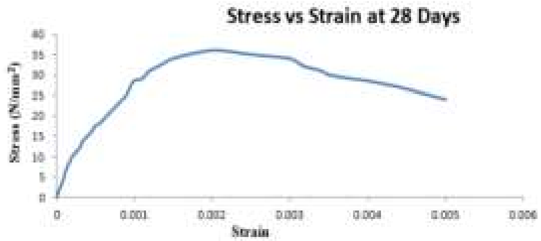
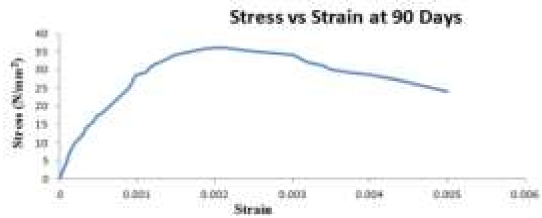
Stress Strain Behaviour with Polythene Sheets 1.0% at 7 Days



Stress Strain Behaviour with Polythene Sheets 1.0% at 28 Days



Stress Strain Behaviour with Polythene Sheets 1.0% at 90 Days

Stress Strain Behaviour with Polythene Sheets 1.5% at 7 Days

Stress Strain Behaviour with Polythene Sheets 1.5% at 28 Days

Stress Strain Behaviour with Polythene Sheets 1.5% at 90 Days

Discussion Of Test Results

Compressive Strength

1) In Conventional as well as Plastic concrete the compressive strength of concrete at 7 days, 28 days, & 90 days are found & results are tabulated.
2) It is observed that with the addition of 1.0% Plastic Straws & Polythene sheets compressive strength of concrete showed an increase by 12% & at 15% respectively at 90Days
3) The percentage of compressive strength increases with an addition of 0.5% to 1.0% plastic waste and the strength decreases with increase in the percentage of fibers to 1.5%
4) This reduction in strength may be due to reduction in homogeneity of mix
5) With the addition of 0.5% ,1.0% & 1.5% Plastic Straws the average Compressive strength increased by 10% ,12% & 5% at 7 Days
6) With the addition of 0.5% ,1.0% & 1.5% Polythene sheets the average Compressive strength increased by 11% ,15% & 8% at 7 Days
7) With the addition of 0.5% ,1.0% & 1.5% Plastic Straws the average Compressive strength increased by 10% ,12% & 9% at 28 Days
8) With the addition of 0.5% ,1.0% & 1.5% Polythene sheets the average Compressive strength increased by 11% ,15% & 9% at 28 Days
9) With the addition of 0.5% ,1.0% & 1.5% Plastic Straws the average Compressive strength increased by 10% ,12% & 7% at 90 Days
10) With the addition of 0.5% ,1.0% & 1.5% Polythene sheets the average Compressive strength increased by 22% ,25% & 7% at 28 Days

Split Tensile Strength

11) For Plastic concrete as well as for Conventional Concrete the split tensile strength of concrete at 7 days, 28 days, & 90 days are found & results are tabulated.
12) It is observed that with the addition of 1.0% Plastic Straws & Polythene sheets split tensile strength of concrete showed an increase by 18% & at 19% respectively at 90Days
13) The percentage of split tensile strength increases with an addition of 0.5% to 1.0% plastic waste and the strength decreases with increase in the percentage of plastic waste to 1.5%
14) This reduction in strength may be due to reduction in homogeneity of mix
15) With the addition of 0.5% ,1.0% & 1.5% Plastic Straws the split tensile strength increased by 11% ,18% & 8% at 7 Days

16) With the addition of 0.5% ,1.0% & 1.5% Polythene sheets the split tensile strength increased by 14% ,20% & 9% at 7 Days
17) With the addition of 0.5% ,1.0% & 1.5% Plastic Straws the split tensile strength increased by 12% ,19% & 9% at 28 Days
18) With the addition of 0.5% ,1.0% & 1.5% Polythene sheets the split tensile strength increased by 16% ,22% & 10% at 28 Days
19) With the addition of 0.5% ,1.0% & 1.5% Plastic Straws the split tensile strength increased by 13% ,20% & 10% at 90 Days
20) With the addition of 0.5% ,1.0% & 1.5% Polythene sheets the split tensile strength increased by 17% ,23% & 12% at 90 Days

Flexural Strength

21) For Plastic concrete as well as for Conventional Concrete the Flexural strength of concrete at 7 days, 28 days, & 90 days are found & results are tabulated.
22) It is observed that with the addition of 1.0% Plastic Straws & Polythene sheets Flexural strength of concrete showed an increase by 20% & 22 % respectively at 90Days
23) The percentage of Flexural strength increases with an addition of 0.5% to 1.0%plastic waste and the strength decreases with increase in the percentage of plastic waste to 1.5%
24) The plastic concrete increases the cracking resistance of concrete which improves the flexural strength
25) In conventional concrete beams the visible flexural cracks developed at 65% to 75% of the ultimate load of each beam and in plastic concrete beams they developed at 70% to 80% of the ultimate load of each beam.
26) This crack pattern is observed to be same for all the conventional and plastic concrete beams.
27) With the addition of 0.5% ,1.0% & 1.5% Plastic Straws the Flexural strength increased by 14% ,20% & 6% at 7 Days
28) With the addition of 0.5% ,1.0% & 1.5% Polythene sheets the Flexural strength increased by 16% ,21% & 4% at 7 Days
29) With the addition of 0.5% ,1.0% & 1.5% Plastic Straws the Flexural strength increased by 15% ,20% & 7% at 28 Days
30) With the addition of 0.5% ,1.0% & 1.5% Polythene sheets the Flexural strength increased by 17% ,22% & 5% at 28 Days
31) With the addition of 0.5% ,1.0% & 1.5% Plastic Straws the Flexural strength increased by 16% ,20% & 8% at 90 Days
32) With the addition of 0.5% ,1.0% & 1.5% Polythene sheets the Flexural strength increased by 20% ,22% & 8% at 90 Days

Stress-Strain Behaviour OfConventional and Plastic Concrete

1) The relationship between stress and strain is important in understanding the basic elastic behaviour of concrete in hardened state which is useful in design of concrete Structures
2) From the values of stresses and strains, average stress-strain curve for each mix is plotted, taking the average values of the results of the three cylinders. The stress strain curves for conventional and plastic concrete mixes at 7 days, 28 days, 90 days for Conventional concrete and plastic concrete are shown in Figures. and the corresponding stress-strain values are given in Tables
3) Strain values at Peak Stress for conventional concrete is 0.0023 at90Days, whereas for plastic straws of 0.5%,1.0% & 1.5% the strain values at peak stress are 0.0024,0.0028 & 0.0026 respectively
4) Strain values at Peak Stress for conventional concrete is 0.0023 at 90Days,whereas for polythene sheets of 0.5%,1.0% & 1.5% the strain values at peak stress are 0.0025,0.0029& 0.0025 respectively
5) From the observations made from stress-strain curves of all the conventional and plastic concrete mixes, the stress-strain behaviour is observed to be almost similar.
6) The only difference is that plastic concrete mixes have shown improved stress values for the same strain levels compared to that of conventional concrete mixes

Conclusions

1) The plastic concrete is having more compressive strength and tensile strength values than the conventional concrete and therefore it is more preferable for the construction of compression members.
2) As the plastic concrete shows higher tensile strength & flexural strength than conventional concrete values it can be used in the plain concrete structures as well as reinforced concrete structures
3) When the Plastic Straws are mixed with concrete it can be used for concrete work of less importance. For example foot path kerbs, pavement blocks etc.,
4) As the plastic concrete shows higher tensile strength & flexural strength we can also utilize Road side plastic waste and raw plastics in plastic concrete
5) The concrete industry, which uses vast amounts of energy and natural resources and contributes to generation of CO_2, can improve its record with an

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increased reliance on recycled materials and in particular by replacing large percentages of Portland cement by waste plastic materials. Substitution of waste materials will conserve resources, and will avoid environmental and ecological damages. But let us now all work together to keep our planet livable. .

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