Experimental Investigation on Concrete Using Polyvinyl Chloride Pipes

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Abstract – This Project evolves on experimentally investigating the concrete using polyvinyl chloride. Polyvinyl chloride, commonly known as "PVC" or "vinyl," is one of the most common synthetic materials. PVC is a versatile resin and appears in thousands of different formulations and configurations. With the growing needs for resource materials and the environmental protection requirements associated with sustainable development, it has become necessary to study all the possibilities of reusing and recycling industrial wastes and by-products. In the research presented by us, non-biodegradable polyvinyl chloride (PVC) waste, obtained from scrapped PVC pipes, is used in partial replacement of conventional aggregates in concrete. The project proceeds with testing and comparing analyzing the strength of the concrete with normal concrete. We will enhance our project through several tests and methods. The partial replacement to coarse aggregate at levels 15, 20, 25 percent and the basic material properties, strength parameters are studied. The strength will be tested during the period of 7, 14 and 28 days respectively.

Index Terms – Concrete, Polyvinyl chloride (PVC), Non-Biodegradable.

1. INTRODUCTION

1.1 GENERAL:

Construction technology has seen a rapid change over time. Many typical structures can be constructed within a month of duration using advanced construction techniques. Through it is proven that no construction can be done economically without using concrete. Concrete is a construction material that consists of cement, aggregate, and water. Concrete solidifies and hardens after mixture and placement due to a chemical process known as hydration. The water reacts with cement, which bonds the other components together and eventually creating a stone material. It is used to make pavement, architectural structure, foundation, overpasses, parking structure etc.., those concrete are rigid material with high compressive strength and weak in tensile strength. Reinforcing bars are used to improve the tensile strength. Fresh concrete is a freshly mixed material; which can be moulded into any shape, the relative quantities of cement, aggregate and water mixed together control the properties of concrete in the wet state as well as in the hardened state. The strength of concrete mainly depends on water cement ratio. If the water cement ratio increases then too much the bleeding of concrete takes place and the strength of concrete also reduced. Generally the high performance concrete usually contains ordinary Portland cement. The use of different types of sub-products into the cement based materials has become a common practice in concrete industry. However the partial introduction of PVC waste is helpful to increase their strength. The waste can be used economically into the concrete is advantageous. This project is to study the concrete made with PVC in normal concrete. It has been observed that the composites reinforced with PVC are more advantageous in terms of post- cracking behavior and load carrying capacity. Since the PVC are available locally, they can be used in concrete. Due to their nature they may offer they may offer more resistance to loads.

2. LITERATURE REVIEW

2.1 GENERAL

A detail review of literature has been carried out and the works done by various researches in the field of plastic materials in various concrete are presented in this chapter.

2.2 LITERATURE SURVEY

Chandana Sukesh et al, They have studied about the partial replacement of cement in concrete by use of waste material, plastic. They have found that the addition of up to 15percentage plastic as a cement replacement has a negligible effect on the strength of the block (W/B = 0.5). Results show that concrete with partial cement replacement by PVC powder although it has minor strength loss possess increase durability performance. Experiments have been conducted by replacing 10percentage, 20percentage, 30percentage, 40percentage and 50percentage of PVC by weight of Ordinary Portland Cement. The strength and found to be two times greater than the plain cement concrete. With these results it is very clear that we can effectively use these eco-friendly materials in partial replacement of cement.

Khilesh Sarwe. [2014] this study presents the results of addition of waste PVC along with steel fibers with an objective to seek maximum use of waste PVC in concrete. Two different categories of mix were casted in cubes (150mm x 150mm x 150mm), one with varying percentages of PVC wastes (0.2percentage, 0.4percentage, 0.6percentage, 0.8percentage and 1percentage weight of cement) and another mix of PVC waste/steel fibers (0.2/0.1, 0.4/0.2, 0.6/0.3, 0.8/0.4 and 1/0.5 percentage by weight of cement) to study the compressive strength at 7 and 28 days strength. The combine mix of PVC waste and steel fibers has shown more strength as compare to concrete mix prep only with PVC waste. He has reached to conclusion that a PVC waste of 0.6percentage weight of cement when used with steel fiber of 0.3 percentage (weight of cement) has shown the maximum compressive strength. This study has really focused on addressing the issue of reduced compressive strength with addition of PVC waste. Steel fibers when used along with PVC wastes will affect all the properties of concrete but the researcher only focused on compressive strength property which is insufficient to give clear picture of concrete behavior.

Praveen Mathew et al. [2013] they have investigated the suitability of recycled plastic as partial replacement to coarse aggregate in concrete mix to study effect on compressive strength, modulus of elasticity, split tensile strength and flexural strength properties of concrete. Coarse aggregate from plastic was obtained by heating the plastic pieces at required temperature and crushed to required size of aggregate after cooling. Their experimental results shown that plastic aggregate have low crushing (2.0 as compare to 28 for Natural aggregate), low specific gravity(0.9 as compare to 2.74 for Natural aggregate), and density value(0.81 as compare to 3.14 for Natural aggregate), as compare to Natural coarse aggregate. Their test results were based on 20percentage substitution of natural coarse aggregate with plastic aggregate. Increase in workability was reported when slump test for sample was carried out. Volumetric substitution of natural aggregate with plastic aggregate was selected best in comparison with grade substitution. At 400 centigrade temperature Plastic coarse aggregate shown considerable decrease in strength as compare to normal concrete. An increase of 28percentage was observed in compressive strength but decrease in split tensile strength and modulus of elasticity was observed. They recommended that with use of suitable admixture @0.4percentage by weight of cement will improve the bonding between matrix and plastic aggregate; however they demand more research to address the tensile behavior of concrete prepared with 20percentage plastic aggregate.

Raghatate Atul M. The paper is based on experimental results of concrete sample casted with use of plastic bags pieces to study the compressive and split tensile strength. He used concrete mix by using Ordinary Portland Cement, Natural River sand as fine aggregate and crushed granite stones as coarse aggregate, portable water free from impurities and containing varying percentage of waste plastic bags (0percentage, 0.2percentage, 0.4percentage, 0.6percentage 0.8percentage and 1.0percentage). Compressive strength of concrete specimen is affected by the addition of plastic bags and with increasing percentage of plastic bag pieces compressive strength goes on decreasing (20percentage decrease in compressive strength with 1percentage of addition of plastic bag pieces). On other hand increase in tensile strength of concrete was observed by adding up to 0.8percentage of plastic bag pieces in the concrete mix afterward it start decreasing when adding more than 0.8percentage of plastic bags pieces. He concluded that utility of plastic bags pieces can be used for possible increase in split tensile strength. This is just a basic study on use of plastic bags in concrete. More emphasis was required by varying the shape and sizes of plastic bags to be use in concrete mixes.

R L Ramesh et al. They have used waste plastic of low density poly ethylene as replacement to coarse aggregate to determine its viable application in construction industry and to study the behavior of fresh and harden concrete properties. Different concrete mix were prepared with varying proportions (0percentage, 20percentage, 30percentage& 40percentage) of recycle plastic aggregate obtained by heat treatment of plastic waste (160-200 centigrade) in plastic granular recycling machine. A concrete mix design with 1: 1.5: 3 proportions was used having 0.5 water/cement ratio having varying proportion of plastic aggregate as replacement of crushed stone. Proper mixing was ensured and homogeneous mixture was prepared. A clear reduction in compressive strength was reported with increase in percentage of replacing plastic aggregate with crushed aggregate at 7, 14 and 28 days of casted cubes (80percentage strength achieved by replacing waste plastic up to 30percentage). The research highlights the potential application of plastic aggregate in light weight aggregate. Their research was narrowed down to compressive strength of concrete with no emphasis given to flexural properties of concrete. They suggest future research scope on plastic aggregate with regard to its split tensile strength to ascertain its tensile behavior and its durability aspects for beams and columns.

Youcef Ghernouti et al. The study present the partial replacement of fine aggregate in concrete by using plastic fine aggregate obtained from the crushing of waste PVC pipes. Fine aggregate in the mix proportion of concrete was replaced with PVC waste sand at 10percentage, 20percentage, 30percentage and 40percentage whereas other concrete materials remain same for all four mixes. In fresh properties of concrete it was observed from the results of slump test that with increase of waste content workability of concrete increases which is favorable for concrete because plastic cannot absorb water therefore excessive water is available. Bulk density decreases with increase of PVC waste. In harden state, flexural and compressive strength were tested at 28 days and reductions in both strengths with increasing percentage of plastic bag waste sand in concrete mix. PVC waste increases the volume of voids in concrete which on other hand reduce the compactness of concrete simultaneously speed of sound in concrete is also decreased. Strength reduction in concrete mix was prime concern; however they recommend 10 to 20percentage replacement of fine aggregate with plastic aggregate.

3. MATERIAL AND DESIGN METHODOLOGY

3.1 GENERAL

The present chapter deals with the presentation of results obtained from various tests conducted on material used for the concrete. In order to achieve the objectives of present study, an experimental program was planned to investigate polyvinyl chloride on compression strength and split tensile strength of concrete. The various steps involved in our thesis are as follows,

1. Need for safety
2. Literature review
3. Identification of materials
4. Collection of materials
5. Testing of materials
6. Mix design preparation.
7. Specimen casting
8. Results and collection
9. Report preparation.

3.2 MATERIALS

The properties of materials used for making concrete mix are determined in laboratory as per relevant codes of practice. Different materials used in present study were cement, coarse aggregates, and fine aggregates, in addition to crushed PVC pipes. The aim of studying of various properties of material is used to check the appearance with codal requirements and to enable an engineer to design a concrete mix for a particular strength. The description of various materials which were used in this study is given below.

3.2.1 Ordinary Portland cement

Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. The function of cement is first of all to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. It constitutes only about 20 percent of the total volume of concrete mix; it is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Any variation in its quality affects the compressive strength of the concrete mix. Ordinary Portland cement is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 grade, 43 grade, 53 grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipment’s, maintaining better particle size distribution, finer grinding and better packing. Generally use of high grade cement offers many advantage for making stronger concrete.

Ordinary Portland cement (OPC) of 53 Grade (Ambuja cement) was used throughout the course of the investigation. It was fresh and without any lumps. The cement as determined from various tests confirming to Indian standards IS 8112:1989 as listed in table 3.1. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture. The various tests conducted on cement are initial and final setting time, specific gravity, fineness and compressive strength.

3.2.2 Aggregates

Aggregates constitute the bulk of a concrete mixture and give dimensional stability to concrete. To increase the density of resulting mix, the aggregates are frequently used in two or more sizes. The most important function of the fine aggregate is to assist in producing workability and uniformity in mixture. The fine aggregate is to assist the cement paste to hold the coarse aggregate particles in suspension. This action promotes plasticity in the mixture and prevents the possible segregation of paste and coarse aggregate, particularly when it is necessary to transport the concrete some distance from the mixing plant to placement. The aggregates provide about 75percentage of the body of the concrete and hence its influence is extremely important. They should therefore meet certain requirements if the concrete is to be workable, strong, durable and economical. The aggregate must be proper shape, clean, hard, strong, and well graded.

a)Coarse Aggregates:

The aggregates which is retained over IS sieve 4.75mm is termed as coarse aggregate. The coarse aggregates may be of following types:

Crushed graves or stone obtained by crushing of gravel or hard stone.Uncrushed gravel or stone resulting from the natural disintegration of rocks.Partially crushed gravel obtained as product of blending of above two types.The normal maximum size is gradually 10-20 mm; however particle sizes up to 40mm or more have been used in self compacting concrete. Regarding the characteristics of different types of aggregate, crushed aggregates tend to improve the strength because of interlocking of angular particles, while rounded aggregates improved the flow because of lower internal friction.

Locally available coarse aggregate having the maximum size of 20mm was used in this work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 383-1970. Specific gravity and other properties of coarse aggregates are given in table 3.1, 3.2. The sieve analysis of coarse aggregates was done. Table 3.3 shows the result of sieve analysis. Proportioning of coarse aggregates was done and fineness, modulus was obtained.

b).Specific Gravity

Specific gravity is used in design calculation of concrete mixes. With the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also required to be considered when we deal with light weight and heavy weight concrete.

Table 3.1 Specific Gravity of coarse aggregates

S.No	**Description**	**Trial –I (Kg)**	**Trial – 2 (Kg)**
1.	Weight of empty pycnometer (W_1)	0.656	0.654
2.	Weight of pycnometer + coarse aggregate (W_2)	1.262	1.252
3.	Weight of pycnometer + coarse aggregate + water (W_3)	1.872	1.865
4.	Weight of pycnometer + water (W_4)	1.487	1.485

Specific gravity = $(W_2-W_1)/ (W_4-W_1)-(W_3-W_2)$

Specific gravity = 2.76

c).Bulk Density

Empty weight of container (A) = 2.587kg

Weight of container + water (B) = 5.542 kg

Loose state,

Weight of Container + aggregate (C) = 7.954 kg

Dry rod bulk density = (C-A) / (B-A)

= (7.594-2.587)/ (5.542-2.587)

= 1816 kg/m^3

Table 3.2 Properties of coarse Aggregates

Characteristics	**Value**
Colour	Grey
Shape	Angular
Maximum Size	20 mm
Specific Gravity	2.76
Water absorption,%	0.5%
Flakiness index	26.9%
Elongation index	10.6 %

c).Fineness Modulus (Sieve analysis)

The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which we call gradation. The test consists of the simple operation of dividing aggregates into fractions, each consisting of particles of the same size. The sieve analysis on coarse aggregate was carried out as per IS2386 (Part I) -1963 and results are presented in table 3.3.

Table 3.3 Sieve analysis of coarse aggregate:

S.No	**Aperture size(mm)**	**Weight soil retained (kg)**	**Percentage of weight retained**	**Cumulative % retained**	**% of coarse aggregate**
1.	80	0.00	0.00	100	0.00
2.	40	0.00	0.00	100	0.00
3.	25	0.90	1.8	98.2	1.8
4.	20	1.307	26.4	73.6	28.2
5.	12.5	3.397	67.94	32.06	96.14
6.	10	0.132	2.64	97.36	98.78
7.	4.75	0.061	1.22	98.78	100
8.	Pan	0.00	0.00	0.00	
	Total	**5.00**		**SUM**	323.92

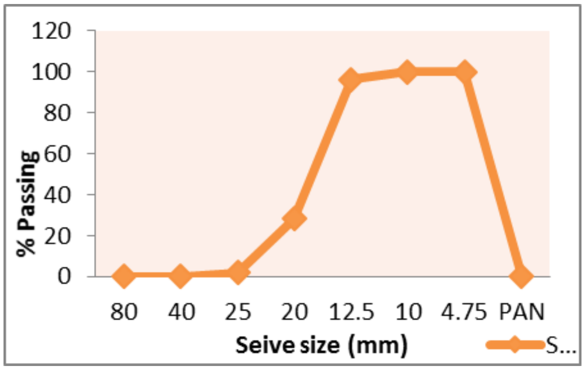

Fig 3.1 Fineness Modulus Graph for Coarse Aggregate

d).Crushing strength on aggregate:

Dimension of mould = 15.10cm

Height of mould $= (\pi x(15.1)^2)/(4x13)$

$= 2328.02cm^3$

Table 3.4: Crushing strength on aggregate

S. No	Total weight of aggregate (W_1)g	IS sieve 2.36mm passing materials (W_2)g	Aggregate crushing value (W_2/W_1)x100g
1.	2500	400	16.00
2.	2500	350	14.00

Calculation:

Total percentage:

= (16+14)/2 = 15%

e).Water absorption test:

Table No.3.5: water absorption test

S.No	Weight of oven dry specimen (g)	Weight of standard specimen(g)	Weight of water observed $W_3=W_2-W_1$g	% of water absorption $=W_3/W_1$ x100g
1.	200	210	10	5%
2.	200	210	10	5%

Calculation:

To find $W_3 = W_2-W_1 = 210-200$ = 10g

% of water absorption;$=W_3/W_1$x100g = 5%

f).Loss angle abrasion test on coarse aggregate

Table No.3.6 Abrasion test

Description	% of loss angle test(or) abrasion test
Let the original weight of aggregates (W_1) g	5000g
Weight of aggregate retained on 1.7mm IS sieve after test (W_2) g	4785g
Loss in weight due to wear (W_1-W_2) g	215 g
% of wear	((W_1-W_2)/w)x100 (5000-4785)/5000)x100 4.3%

g) Impact test on coarse aggregate

Table 3.7 Impact test on coarse aggregate

S.No	Details of sample	Trial-I	Trial-II
1.	Total weight of aggregate sample filling the cylinder measure (W_1)g	440	370
2.	Weight of aggregate passing 2.36mm sieve test(W_2)g	80	84
3.	Weight of aggregate retained 2.36mm sieve (W_3)g	360	286
4.	$(W_1-W_2+W_3)$	0	0

5.	Aggregate impact value (W_2/W_1)x100	18.18	22.70

Calculation: = (18.18+22.70+21.02)/3 = 20.63

3.3 Fine aggregate:

The aggregate most of which pass through 4.75mm IS sieve are termed as fine aggregates. The fine aggregate may be of following types:

Table 3.8. Specific gravity of natural sand

Description	**Trial-I**	**Trial -II**
Weight of empty pycnometer(W_1)	0.657	0.657
Weight of pycnometer+coarse aggregate(W_2)	1.472	1.489
Weight of pycnometer +coarse aggregate+ water(W_3)	1.985	1.990
Weight of pycnometer+water(W_4)	1.527	1.527
Specific gravity (G)	2.28	2.36

Specific gravity (g) $=(w_2-w_1)/(w_4-w_1)-(w_3-w_2)$

Specific gravity (g) = (2.28+2.36+)/2

(G) = 2.32

Table :3.9 Sieve analysis test for natural sand

Aperture size(mm)	**Weight soil retained (kg)**	**Percentage of weight retained**	**Cumulative % retained**	**% of natural sand**
4.75	0	0	100	0
2.36	0	0	100	0
1.18	0.092	9.2	90.8	9.2
0.600	0.307	30.7	69.3	39.9
0.300	0.044	4.4	95.6	44.3
0.150	0.040	4.0	96	48.3
Pan	0.026	2.6	97.4	50.9
Total	500.00		**SUM**	192.6

Calculation :

Fine modulus = total cumulative % / 100

= 192.6/100

= 1.926 %

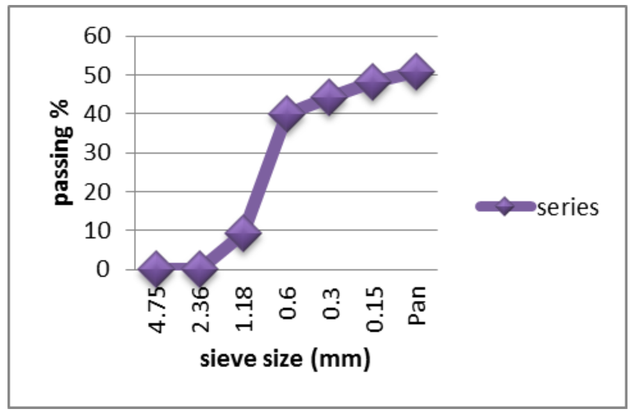

Fig 3.2 Graph for natural sand

3.2.3Water

Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contain marine life also usually is suitable.. Water from such sources should be avoided since the quality of the water could change due to low water or by intermittent tab water is used for casting. The portable water is generally considered satisfactory for mixing and curing of concrete in material testing laboratory. This was free from any detrimental contamination and was good potable quality.

4. Test Methods

The procedure of method used for testing cement, coarse aggregate , fine aggregate and concrete are given below:

a).Slump cone test

Slum is a measurement of concrete's workability, or fluidity. It's an indirect measurement of concrete consistency or stiffness.

A slump test is a method used to determine the consistency of concrete. The consistency, or stiffness ,indicate how much water has been used in the mix. The stiffness of the concrete mix should be matched to the requirement for the finished quality.

Type of Slump.

1.Collapse slump

2.Shear slump

3.True slump

Table 4.1 Test on slump value

CONCRETE MIX	SLUMP VALUE (MM)
Normal	94
15%	85
30%	80
50%	72

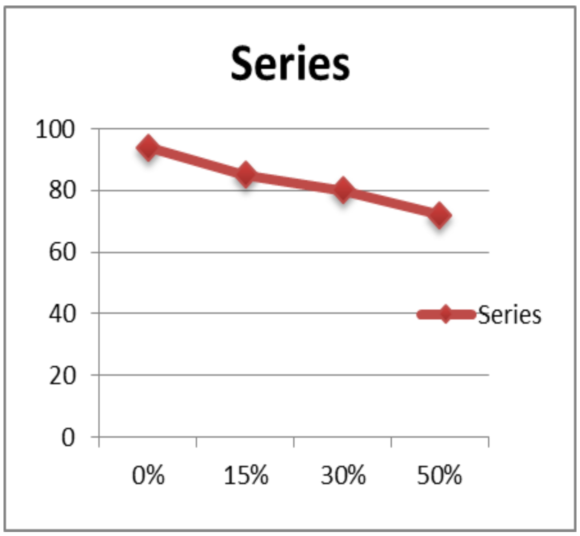

Fig 4.1 Graph for slump cone test

b).Compaction test on concrete

It is a test that is used to determine the compacting factor of the prepared concrete mix.

Table 4.2: compaction test on concrete

S. NO	Description	Compaction factor
1	Normal	93
2	15 %	86
3	30 %	79
4	50 %	68

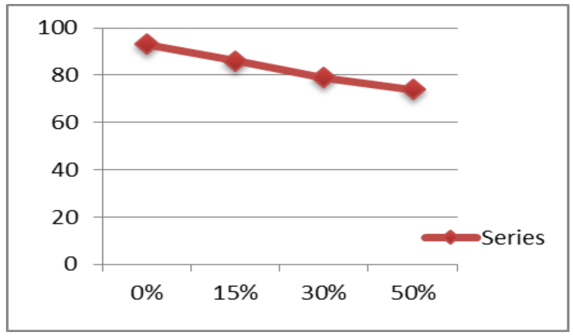

Fig 4.2 Graph for compaction test on concrete

Table No: 3.4 Physical properties of glass

Properties	Soda-lime glass (for containers)	Borosilicate (low expansion, similar to Pyrex, Duran)
Density at 20 °C, [g/cm^3], x1000 to get [kg/m^3]	2.52	2.235
Refractive index n_D at 20 °C	1.518	1.473
Dispersion at 20 °C, $10^4 \times (n_F - n_C)$	86.7	72.3
Young's modulus at 20 °C, GPa	72	65

5. MIX DESIGN M30 GRADE

Table 4.1 Mix proportion

Water	Cement	Fine Aggregate	Coarse Aggregate
186 kg/m^3	465 kg/m^3	498.79 kg/m^3	1054.155 kg/m^3
0.5	1	1.072	2.267

Table 4.2 Mix Proportion with PVC

Mix	Water	Cement	PVC	Coarse Aggregate
Normal	0.5	1	0	3
15%	0.5	1	0.15	0.285
20%	0.5	1	0.2	0.280
25%	0.5	1	0.25	0.275

5. RESULTS AND DISCUSSION

The experimental program included the following:

1. Testing of properties of materials used for making concrete.
2. Design mix (M30).
3. Casting and curing of specimens.
4. Test to determine the compressive strength and split tensile strength of concrete.

5.1COMPRESSIVE STRENGTH

Test specimen of size 150mm x 150mm x 150mm was prepared and tested using the compressive testing machine. The concrete mixes with varying percentages (0%, 15%, 20%, and 25%) after 24 hours the specimen was removed from the moulds and placed in fresh water.

Fig 5.1 Compressive Strength tested Specimen

Table 5.1: Compressive strength of concrete measurement

MIX	Compressive strength (N/mm^2)		
	7 days	14 days	28 days
Normal	12.8	21.5	25.6
15%	21.67	23.44	27.67
20%	22.11	25.88	27.00
25%	21.33	2.33	25.88

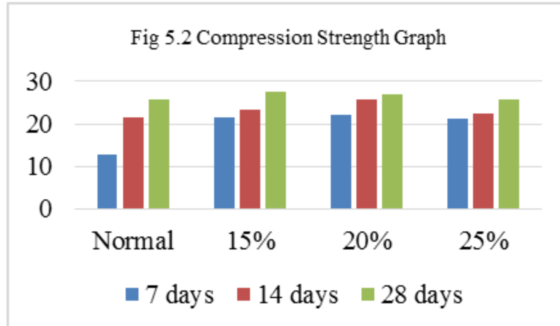

Fig 5.2 Compression Strength Graph

SPLIT TENSILE STRENGTH TEST

Split tensile strength studies were carried out at age of 7, 14 and 28 days. Test results are given in table 4.2. The split tensile strength tested specimen as shown in fig 4.3.1

Table 5.2: Split tension strength of concrete measurement

MIX	Split tensile strength (N/mm^2)		
	7 days	14 days	28 days
Normal	2.23	3.09	3.92
15%	2.49	3.02	5.08
20%	2.36	3.88	4.75
25%	2.79	3.19	3.89

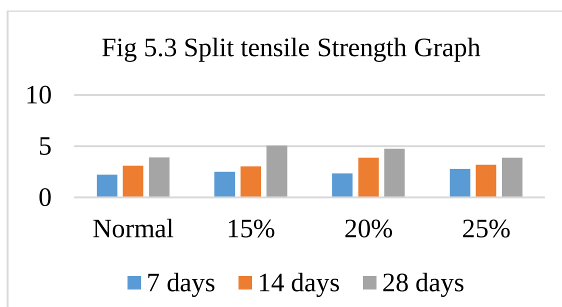

Fig 5.3 Split tensile Strength Graph

6. CONCLUSION

The strength and durability characteristics of concrete mixtures have been computed in the present work by replacing 15%, 20%, 25% PVC with the sand. On the basis of present study, following conclusions are drawn. After adding PVC at various percentages in the mix, there is an increase in strength after 7, 14 and 28 days as compared to the normal mix. By adding 15%PVC, compressive strength of concrete at 7 days increases by 27% and 59% at 28 days of testing,this indicates that compressive strength increases by the addition of poly vinyl chloride pipes.The compressive strength tend to increase with increase percentages of PVC in the mix. The split tensile also tends to increase with increase percentage of PVC in the mix.After adding PVC in the mix, there is increase in strength than the normal concrete, After 7, 14 and 28 days of testing.By adding 15% PVC, split tensile strength of concrete at 7 days increases by 8% and 18% at 28 days of testing, this indicates that compressive strength increases by the addition of poly

vinyl chloride pipes.

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