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Re-Use of Hospital Plastic Waste for Replacement of Coarse Aggregate in Concrete

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Abstract: *An approximately about 1.3 billion tons of waste is being generated in the world annually. This waste is a cause of various diseases. Open dumping of waste also destroys valuable agricultural land. Various researchers have beneficially used plastic waste in cement concrete and asphalt concrete in the past. The main object of my project is the use of aggregates, made from different types of plastic waste, as replacement of coarse aggregates in concrete. For this purpose waste is collected from different hospitals of the city. Plastic waste is shredded, heated and after cooling, pulverizes manually and mechanically. The following properties of the plastic aggregate are going to find out: Specific gravity, Water absorption, Soundness values, Impact and crushing values. In this project, the replacement of natural aggregates by hospital wastage plastic aggregates is up to 40% as 10% replacement in the concrete grade of M30. And then compare the relative strengths of natural aggregate concrete and hospital wastage aggregate.*
Keywords:*Hospital Waste (HW), Plastic Waste, Waste Generation, Asphalt Stability, Plastic Aggregates*

I. Introduction

Solid waste is the waste arising from human and animal activities that is normally solid and is discarded as uses less or unwanted. According to World Bank Solid Waste Thematic Group, 1.3 billion tons per year of solid waste is being generated in world. This waste is likely to increase to 2.2 billion tons per year by 2025. World Health Organization (WHO) states that more than 1.5 million people die annually due to poor solid waste management. Waste poses severe hazard to public health through blocking of drainage system, formation of standing ponds, and creating breeding grounds for mosquitoes and flies. This triggers malaria and cholera. In addition, because of lack of proper dumping sites, most of the collected waste ends up in open pits, ponds, rivers, dumping grounds, and agricultural lands. A part of this waste gets decomposed in the environment at dumpsites but non-biodegradable waste stays there for years.

The quantum of hospital waste is ever increasing due to increase in population, developmental activities, changes in life style, and socio-economic conditions, Plastics waste is a significant portion of the total municipal solid waste (MSW). It is estimated that approximately 10 thousand tons per day (TPD) of plastics waste is generated i.e. 9% of 1.20 lacs TPD of MSW in the country. The plastics waste constitutes two major category of plastics; (i) Thermoplastics and (ii) Thermoset plastics. Thermoplastics, constitutes 80% and thermoset constitutes approximately 20% of total post-consumer plastics waste generated in India. The Thermoplastics are recyclable plastics which include; Polyethylene Terephthalate (PET), Low Density Poly Ethylene (LDPE), Poly VinyalCholoride(PVC), High Density Poly Ethylene (HDPE), Polypropylene(PP), Polystyrene (PS) etc. However, thermoset plastics containsalkyd, epoxy, ester, melamine formaldehyde, phenolic formaldehyde, silicon, urea formaldehyde, polyurethane, metalized and multilayer plastics etc. The environmental hazards due tomismanagement of plastics waste include the following aspects:

- Littered plastics spoils beauty of the city and choke drains and makeimportant public places filthy;
- Garbage containing plastics, when burnt may cause air pollution byemitting polluting gases;
- Garbage mixed with plastics interferes in waste processing facilitiesand may also cause problems in landfill operations;
- Recycling industries operating in non-conforming areas are posingunhygienic problems to the environment.

Figure.1. Hospital Plastic Waste

II. Admixture

Here we are going to use CONPLAST SP370 admixture. This is having the specific gravity of 3.15.

- Its use for producing fluid concrete facilities its installation and compacting and therefore reduces working costs.
- The reduction of W/C ratio increases durability producing a concrete with low permeability.
- Chloride free, suitable for use in reinforced and plastic waste concrete.

III. Methodology

Plastic Collection and Aggregate Formation, Plastic waste was collected from different hospitals of the city. The stages of making the plastic coarse aggregate, Shredded the waste and mixed well, Then heat the waste as come to the semi-solid form, At the stage of semi-solid form, cut at the regular intervals and further pulverized first manually then by the jaw crusher.

Fig-2

IV. Literature Review

Re-use of Hospital Wastage in Replacement of Coarse aggregate in Concrete. SyedShahan Ali Shah, Rawid Khan (2009)

There is no proper solid waste management system for Peshawar city. Mostly people throw the waste in their streets, where it is either picked up by scavengers or dumped there for years. In relatively developed areas of the city, scavengers collect the waste and dump it in an open area usually at a distance from densely populated area. Existing landfills of the city are not well designed. Open burning of waste on the dumpsites is observed. Major portion of the waste generated by the city is plastic. Plastic waste can be converted to aggregates by proper manufacturing setup. After performing different aggregates tests, it is found that plastic aggregates used in this research are exceptionally strong in impact, crushing and abrasion. Due to higher porosity of aggregates, soundnessvalues are little higher. In asphalt mixes, density and percent voids increased with increasing plastic aggregates content. Stability and flow also increase with increasing plastic aggregate content. But for this increase in stability, cost also increases. After 25% replacement, stability decreases while cost keeps on increasing. Therefore up to 20% of natural aggregates can be replaced by plastic aggregates.

Plastic Waste Management by AliKhan(2010)

Review of literature on this subject deals with the strengths of the concrete by replacing the plastic waste. Based on the replacement of plastic waste aggregate to the natural aggregate, after the replacement of 40% to the natural aggregate, the compressive strength was slightly decreased. In case of adding more than 40% replacement, adding the admixture to the concrete mix. By adding the admixture the compressive strength of concrete approximately increased compared to the conventional concrete.

Use of waste plastic in concrete mixture as aggregate replacement, Zainab Z. Ismail (2007)

The compressive strength values of all waste plastic concrete mixtures tend to decrease below the values for the reference concrete mixtures with increasing the waste plastic ratio at all curing ages. This may be attributed to the decrease in the adhesive strength between the surface of the waste plastic and cement paste. In addition waste plastic is hydrophobic material which may restrict the hydration of cement. The flexural strength values of waste plastic concrete mixtures tend to decrease below the values for the reference concrete mixtures with increasing the waste plastic ratio. A concrete mixture made of 20% waste plastic has the lowest flexural strength at 28 days curing age, viz. 30.5% below the value of the reference concrete mixture. The dry density values of waste plastic concrete mixtures at each curing age tend to decrease below values for the reference concrete mixture, but they remain averaged to that of the reference concrete mixtures. At 28 days curing age, the lowest dry density (2223.7 kg/m3) exceeds the range of the dry density of structural lightweight concrete. The slump values of waste plastic concrete mixtures showed a tendency to decrease below the slump of the reference concrete mixture. In spite of this decline in the slump of those mixtures, those mixtures are easy to work based on the consideration that workability has a broad range from very low to high workability for different applications.

Yogendra K Tandel et al (2009)

The utilization of such waste materials in road construction is of significant importance. During past decades attempts have been made by several investigators all over the world to explore the possible utilization of hospital waste. The bulk utilization of these wastes not only solves the disposal problem of the hospitals but also protects the environment. This paper discusses the initial properties of hospital wastages.

V. Equations, Formulae, Symbols, Units

Percentage of fineness
of give Sample of cement = (weight of residue / original weight) *100

Specific Gravity of cement = $\frac{W_2 - W_1}{[(W_2 - W_1) - (W_4 - W_3)] X 0.79}$

Specific Gravity of fine aggregate = W2-W1 / (W2-W1) – (W3-W4)

Fineness Modulus of Sand = ∑ (Cumulative % retained)/100

Bulk Density = Net Weight of aggregate in Container (Kg)/ Volume of Container (cumec) Kg/m3

Percentage of Water Absorption = $\frac{W_5 - W_6}{(W_6 - W_7)} X100$

Aggregate Impact Value =W2/W1
Aggregate Crushing Value = W2 / W1 X 100
Percentage of Attrition Value = W1 – W2 / W1 X 100
Water Absorption Value = W3 / W1 X 100 .

Abrasion value = $\frac{A-B}{A} X100$ (%)

Flakiness Index= $\frac{w1+w2+w3+\cdots}{W1+W2+W3+\cdots} X100$

Elongation Index = $\frac{w1+w2+w3+\cdots}{W1+W2+W3+\cdots} X100$

VI. Mix Design

6.1. Target mean strength 30

fck = fck +1.65 * s (s from table IS 10262-2007)
= 30+1.65*4
= 38.25N/mm2

6.2 Selection of W/C ratio

From the experience of designers 38.25N/mm2 can be achieved in 28 days using W/C ratio 0.6. W/C ratio = 0.4

6.3 Selection of water content

Table 1.2.3 for 20mm aggregate (IS 10262 -2007)
Max. Water content -186lit for slump up to 50mm (slump 150mm)
Estimated water content =186 litres+(186×(3/100))
= 191.6 l/m3
Water content /(W/C ratio)
= 191.6lit/ m3
= 479kg/m3

6.4 Proportion of volume of coarse aggregate & fine aggregate content

From table 5 of IS 10262- 2009 volume of coarse aggregate to 20mm size aggregate & fine aggregate (zone 2) for water cement ratio 0.4
In present case = W/C 0.4

6.5 Mix proportion/Ratio

V = [w+(c/sc/) +(1/p)(fa/SFA)] (1/1000)
Ca = (1-p/p)× fa ×(sca /sfa)
Amount of entrapped air 2%
0.98=[191.6+(479/3.15)+(1/0.315)×(fa/2.62)
(1/1000)
980 = 343.66+(fa/0.825)
Fa = 525kg/m3
Ca = (1-0.315/0.315)× 525× (2.62/2.62)
= 1141.66kg/m3
Water: Cement: Fine aggregate: Course aggregate
191.6: 479: 525: 1141.66
0.4: 1: 1.09: 2.38

VII. Mix Proportion

Table 1. Mix Proportion

Symbol	Name of the specimen
CS	0% Of Hospital Wastage Aggregate
CS10	10% Of Hospital Wastage Aggregate
CS20	20% Of Hospital Wastage Aggregate
CS30	30% Of Hospital Wastage Aggregate
CS40	40% Of Hospital Wastage Aggregate
CS50	50% Of Hospital Wastage Aggregate

7.1 Fresh Concrete Test

7.1.1 Slump Test

We were conducted the slump cone test for the required proportions and got the values, given in the Fig-3 and Table-2.

Table-2 Slump Cone Test

SAMPLE	SLUMP VALUE (mm)
Control Concrete	56
10% Of Hospital Wastage Aggregate	50
20% Of Hospital Wastage Aggregate	47
30% Of Hospital Wastage Aggregate	45
40% Of Hospital Wastage Aggregate	40
50% Of Hospital Wastage Aggregate	35

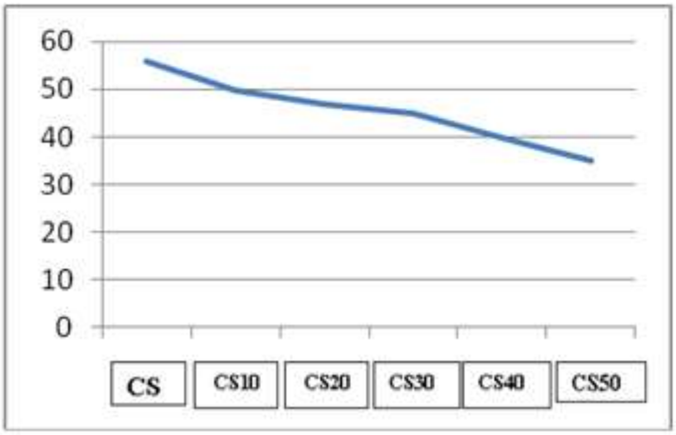

Fig-3 Slump Cone Test

7.1.2 Compaction factor Test

We were conducted the Compaction factor test for the required proportions and got the values, given in the Fig-4 and Table-3

Table-3 Compaction factor test

SAMPLE	COMPACTION FACTOR
Control Concrete	0.85
10% Of Hospital Wastage Aggregate	0.81
20% Of Hospital Wastage Aggregate	0.76
30% Of Hospital Wastage Aggregate	0.71
40% Of Hospital Wastage Aggregate	0.69
50% Of Hospital Wastage Aggregate	0.61

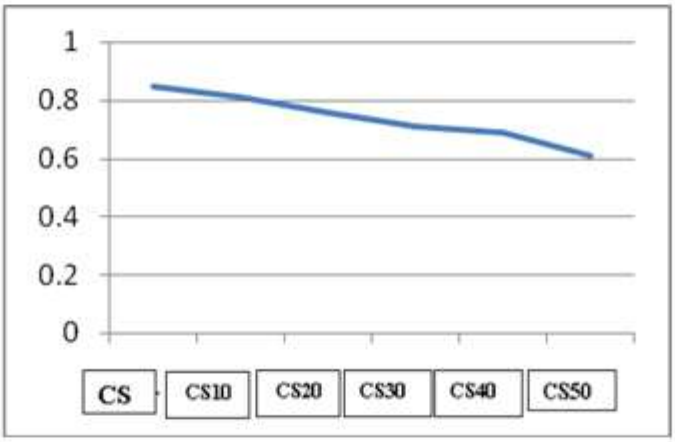

Fig-4 Compaction factor test

7.1.3 Flow Table Test

We were conducted Flow Table Test for the required proportions and got the values, given in the Fig-5 and Table-4.

Table-4 Flow Table Test

SAMPLE	FLOW (%)
Control Concrete	65
10% Of Hospital Wastage Aggregate	61
20% Of Hospital Wastage Aggregate	59
30% Of Hospital Wastage Aggregate	57
40% Of Hospital Wastage Aggregate	55
50% Of Hospital Wastage Aggregate	50

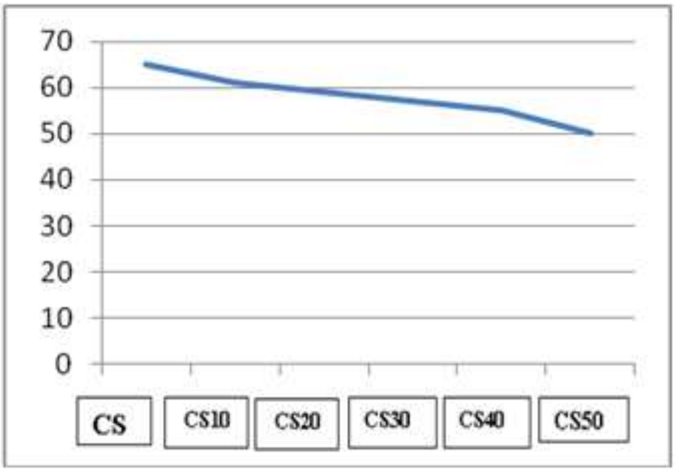

Fig-5 Flow Table Test

2.5.1.4 Vee-Bee Consistometer Test

We were conducted Vee-Bee Consistometer Test for the required proportions and got the values, given in the Fig-6 and Table- 5.

Table-5 Vee-Bee Consistometer Test

SAMPLE	VEE-BEE DEGREE (Secs)
Control Concrete	24
10% Of Hospital Wastage Aggregate	27
20% Of Hospital Wastage Aggregate	30
30% Of Hospital Wastage Aggregate	33
40% Of Hospital Wastage Aggregate	38
50% Of Hospital Wastage Aggregate	30

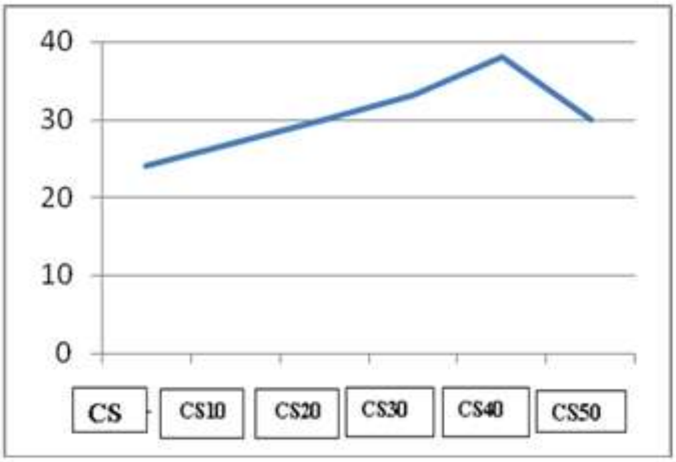

Fig - 6 Vee-Bee Consistometer Test

7.2 Hardened Concrete Test

7.2.1Compressive strength test

We were conducted Compressive strength Test for the required proportions and got the values, given in the Fig-7 and Table - 6

Table-6 Compressive strength test

CUBE	% Of Hospital Wastage Replacement	7 Days	14 Days	28 Days	60 Days
CS	0	7.5	12.8	31	41
CS10	10	8.2	14.2	32.6	43.2
CS20	20	9.11	15.7	34	44.5
CS30	30	11.20	17.5	36.5	46.0
CS40	40	13.5	19.0	39.5	48.5
CS50	50	11.5	17.3	34.5	43.7

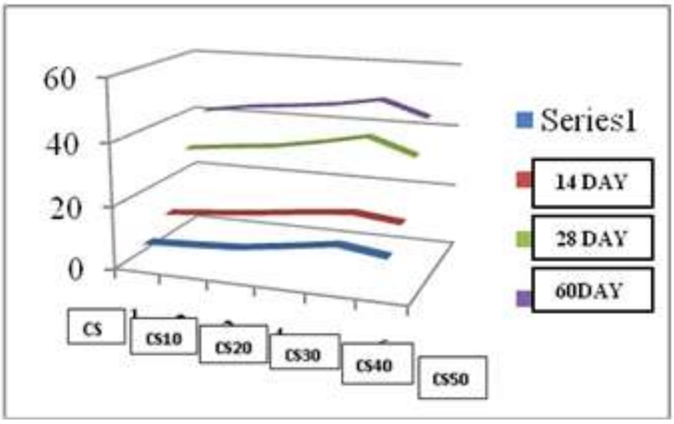

Fig-7 Compressive strength test

7.2.2 Split tensile strength test

We were conducted 2 Split tensile strength test for the required proportions and got the values, given in the Fig-8 and Table - 7

Table - 7 Split tensile strength test

BEAM	% Of Hospital Wastage Replacement	7 Days	28 Days	60 Days
CS	0	2.1	3.9	4.4
CS10	10	2.5	4.5	5.0
CS20	20	3.0	4.9	5.3
CS30	30	3.2	5.2	5.7
CS40	40	3.5	5.5	6.2
CS50	50	3.0	4.7	5.5

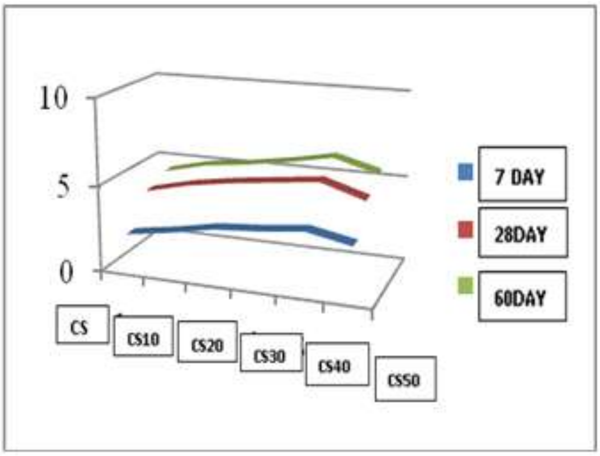

Fig-8 Split tensile strength test

7.2.3 Flexural Strength test

We were conducted Flexural Strength Test for the required proportions and got the values, given in the Fig-9 and Table-8.

Table-8 Flexural Strength test

BEAM	% Of Hospital Wastage Replacement	7 Days	28 Days	60 Days
CS	0	2.7	3.7	4.5
CS10	10	3.3	4.2	5.1
CS20	20	3.5	4.5	5.4
CS30	30	3.7	4.8	5.7
CS40	40	3.9	4.9	6.0
CS50	50	3.2	4.2	5.1

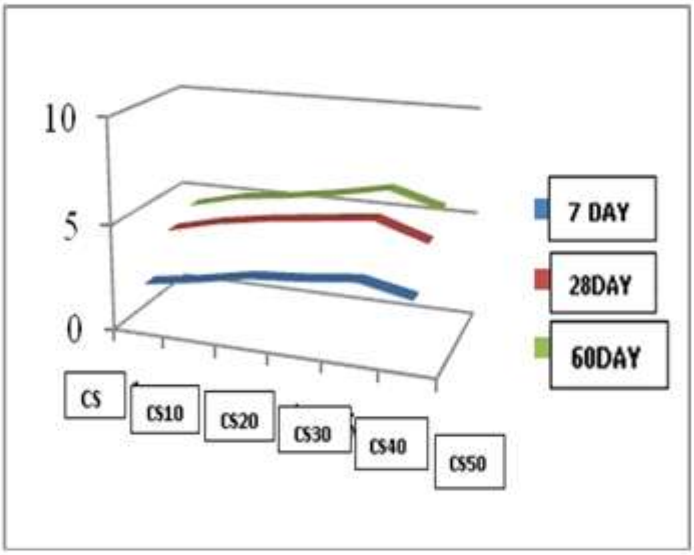

Fig-9 Flexural Strength test

7.3 Tests on Durability

7.3.1 Acid Attack test

We were conducted Acid Attack test for the required proportions and got the values, given in the Fig-10 and Table - 9.

Table-9 Split tensile strength test

Types of concrete	Average weight before put into acid kg		Average weight after taken from acid kg		Loss of weight in kg		Percentage loss	
	Days		Days		Days		Days	
	28	60	28	60	28	60	28	60
CC	8.22	8.21	8.19	8.17	0.026	0.043	0.32	0.52
CS10%	8.23	8.22	8.18	8.16	0.046	0.060	0.56	0.73
CS20%	8.36	8.35	8.30	8.27	0.057	0.075	0.68	0.90
CS30%	8.42	8.41	8.33	8.31	0.085	0.102	1.21	1.55
CS40%	8.58	8.57	8.48	8.45	0.105	0.121	1.22	1.41

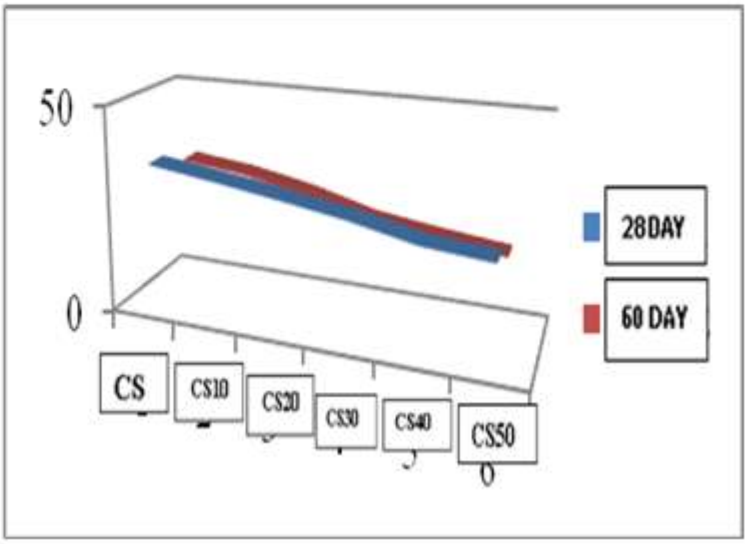

Fig-10 Flexural Strength test

7.3.2 Alkaline attack test

We were conducted alkaline attack test for the required proportions and got the values, given in the Fig-11 and Table-10.

Table -10 Alkaline attack test

Types of concrete	Average weight before put into alkaline kg		Average weight after taken from alkaline kg		Loss of weight in kg		Percentage loss	
	Days		Days		Days		Days	
	28	60	28	60	28	60	28	60
CC	8.23	8.22	8.20	8.19	0.023	0.032	0.28	0.39
CS10%	8.25	8.23	8.21	8.18	0.035	0.045	0.42	0.55
CS20%	8.34	8.35	8.29	8.26	0.049	0.062	0.59	0.74
CS30%	8.42	8.41	8.36	8.33	0.062	0.077	0.74	0.92
CS40%	8.58	8.57	8.51	0.48	0.078	0.093	0.91	1.09

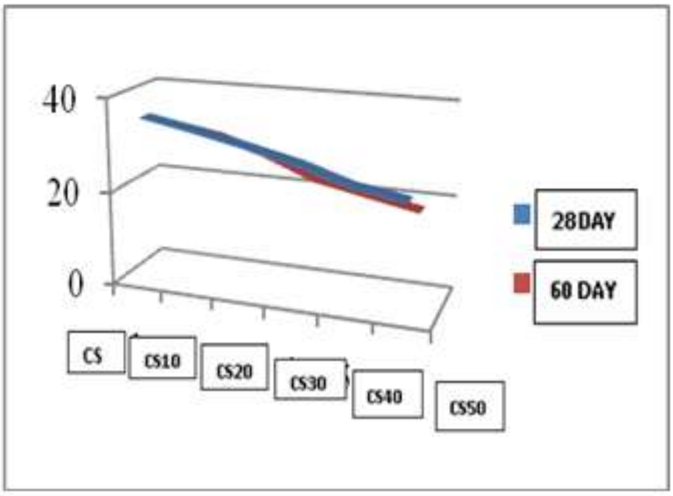

Fig- 11 Flexural Strength test

7.3.4 Sulphate Attack test

We were conducted Sulphate Attack test for the required proportions and got the values, given in the Fig-12 and Table-11.

Table-11 Sulphate Attack test

Types of concrete	Average weight before put into sulphate kg		Average weight after taken from sulphate kg		Loss of weight in kg		Percentage loss	
	Days		Days		Days		Days	
	28	60	28	60	28	60	28	60
CC	8.23	8.22	8.20	8.18	0.025	0.034	0.30	0.41
CS10%	8.25	8.23	8.19	8.17	0.038	0.058	0.46	0.58
CS20%	8.34	8.35	8.28	8.28	0.055	0.068	0.65	0.81
CS30%	8.42	8.41	8.35	8.33	0.073	0.082	0.87	0.97
CS40%	8.58	8.57	8.50	8.47	0.087	0.094	1.02	1.15

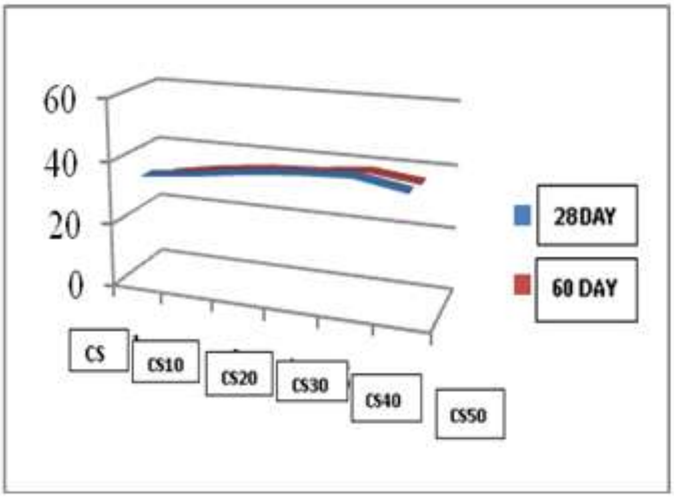

Fig-12 Sulphate Attack test

7.5 NDT Methods

7.5.1 Ultrasonic Pulse velocity

We were conducted Ultrasonic Pulse velocity Attack test for the required proportions and got the values, given in the Table-12.

Table-12- Ultrasonic Pulse velocity Test

% Of Hospital Wastage Replacement	Distance (mm)	Transit Time (Sec)	Pulse Wave Velocity (Km/Sec)	Quality Of Concrete
0	150	33.10	4.531	EXCELLENT
10	150	32.60	4.601	EXCELLENT
20	150	31.80	4.716	EXCELLENT
30	150	31.10	4.823	EXCELLENT
40	150	29.30	5.119	EXCELLENT
50	150	28.10	5.230	EXCELLENT

7.5.2 Rapid Chloride Permeability Test

We were conducted Rapid Chloride Permeability test for the required proportions and got the values, given in the Table-13.

Table-13- Rapid Chloride Permeability Test

% Of Hospital Wastage Replacement	Charge Passed in Coulombs	As per ASTM C1202 Chloride Penetration Rate
0	489.6	Very low
10	523.8	Very low
20	602.1	Very low
30	676.8	Very low
40	730.8	Very low
50	743.7	Very low

VIII. Conclusion

➢ **Comparison Of Compressive Strength**

* The compressive strength of 7th, 14th and 28th day test results of natural aggregate and hospital wastage aggregate was discussed.
* From the results we got, 7th day test results of replacement of 10%, 20%, 30% and 40% hospital wastage aggregate to the natural aggregate as increases 10%, 22%, 50% and 80% when compared to conventional concrete.
* From the results we got, 14th day test results of replacement of 10%, 20%, 30% and 40% hospital wastage aggregate to the natural aggregate as increases 11%, 23%, 36% and 49% when compared to conventional concrete.
* From the results we got, 28th day test results of replacement of 10%, 20%, 30% and 40% hospital wastage aggregate to the natural aggregate as increases 6%, 10%, 18% and 27% when compared to conventional concrete.
* From the results we got, 60th day test results of replacement of 10%, 20%, 30% and 40% hospital wastage aggregate to the natural aggregate as increases 6.4%, 11.3%, 14.5% and 17.3% when compared to conventional concrete.

➢ **Comparison Of Split Tensile Strength**

* From the results we got, split tensile strength of hospital wastage aggregate concrete has the more compressive strength than compared to the conventional concrete.

➢ **Comparison Of Flexural Strength**

* Similarly, flexural strength of hospital wastage aggregate concrete has the more compressive strength than compared to the conventional concrete.

➢ **Comparison Of Overall Strengths**

* The overall strength results of compressive strength, Split tensile strength and Flexural strength.
* From the results, the compressive strength of concrete is decreased after the 40% replacement of the hospital waste aggregate.
* Similarly, the Split tensile strength of concrete is decreased after the 40% replacement of the hospital waste aggregate.
* Also, the Flexural strength of concrete is decreased after the 40% replacement of the hospital waste aggregate.

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